DESERT

Desert
Online at http://desert.ut.ac.ir

Desert 20-1 (2015) 39-46

Effects of nano iron oxide powder and urban solid waste compost coated sulfur on chemical properties of a saline-sodic soil

A. Ghodsi, A.R. Astaraei, H. Emami*

Soil Science Department, Faculty of Agriculture, Ferdowsi University of Mashhad, Mashhad, Iran

Received: 23 June 2014; Received in revised form: 14 December 2014; Accepted: 6 January 2015

Abstract

The main limiting factors in saline-sodic soils are high amounts of salts, low soil organic matter (SOM) and low availability of macro and micro-nutrients. The effect of different amounts of nano iron oxide powder and urban solid waste compost coated sulfur (USWCS) on the chemical properties of a saline-sodic soil was investigated. The experiment was conducted using a randomized complete block design with factorial arrangement and three replications, in a farm near Qom city. Treatments used in this study included USWCS (0 and 15 ton/ha) and nano iron oxide powder (0 and 20 mg/kg); treatments were applied to treated plots of 4 m^2 and sunflower seeds were sown. The results show that 20 mg/kg of nano-iron oxide, significantly ($P<0.05$) increased electrical conductivity of saturation extract (ECe), availability of nutrient elements (5.26, 30, 18.18% for phosphorous (P), iron (Fe), and copper (Cu), respectively) in soil, while nitrogen (N), pH and sodium adsorption ratio (SAR) in soil decreased significantly ($P < 0.05$). Fifteen (15) tons/ha of USWCS significantly increased soil ECe (6.1%), micro and macro-nutrients amounts (8.3, 21.1, 46.6, 45. 5, and 14.9% for N, P, Fe, Cu, and Manganese (Mn) respectively), but significantly ($P < 005$) decreased the soil pH and SAR, compared to the control. The combined effect of 20 mg/kg of nano iron oxide and 15 ton/ha of USWCS increased micro-nutrient availability, but decreased soil pH and SAR significantly. It was concluded that the combined application of USWCS and nano iron oxide increased the availability of nutrients in saline-sodic soil.

Keywords: Sodicity; Salinity; Nutrient element; Compost; Nano material

1. Introduction

Soil degradation due to the salinity and sodicity of irrigation water, and improper management of lands threaten agricultural lands (Astaraei and Chauhan, 1992a, b; Astaraei and Chauhan, 1994). Although the low fertility of saline/sodic soils is attributed to high amounts of salts, low soil organic matter (SOM) and low availability of nutrients especially nitrogen (N), phosphorous (P), potassium (K), and micro-nutrients, are the main limiting factors in saline/sodic soils (Astaraei and Chauhan, 1992a, b; Astaraei and Chauhan, 1994). Therefore, salinity/sodicity risks and deteriorating of agricultural ecosystems is needed to develop specific management practices for improving soil fertility and productivity. In many parts of Iran, the deficiency of micro-nutrients especially iron (Fe), due to high pH values, high soil calcium carbonate, poor irrigation water, and low SOM in soils have been reported (Mohajer Milani, 1996). Ehtesham Nia (2008) reported that with increasing soil salinity, the uptake and transport of most nutrients (including micro-nutrients) by plants decreased. Page *et al*. (1990) found that the maximum availability of micro-nutrients depends on pH, electrical potential of soil solution, and adsorption sites on the surface of organic and inorganic particles. In saline-sodic soils, the degree of solubility of micro-nutrients, especially Fe and zinc (Zn), is low and plants growing in these soils often

* Corresponding author. Tel.: +98 51 3876365,
Fax: +98 51 3876365.
E-mail address: hemami@um.ac.ir

show deficiency of these nutrients (Astaraei and Chauhan, 1994).

Waste iron oxide powder resulted in a decrease in soil pH, thereby increasing the availability of micro-nutrients (i.e. DTPA extractable elements) in soil (Foruhar, 1990). Nano-particles of iron oxide increase the surface area and enhance reactions with complexes such as OM, resulting in an increase in Fe availability for plants (Mazaheri Nia *et al*., 2010). Urban solid waste compost coated sulfur (USWCS) contains high OM and improves soil aggregates and structure (Emami and Astaraei, 2012; Wong, 2008). In addition, it can provide high amounts of macro and micro-nutrients to plants growing in such soils. The organic matter in USWCS will decrease soil pH, and form soluble complexes, that will result in increasing micro-nutrients availability (De Hann, 1981; Astaraei and Almasian, 2010; Mazaheri Nia *et al*., 2010). The supply of some nutrients, such as, N, P, and K for plant uptake, will be through the work of bacteria and fungi during plant growth. Melero *et al*. (2007) reported that the application of urban waste compost as an amendment to semi-arid Mediterranean soils, increased organic carbon, N, P, microbial biomass, and the activity of soil enzymes.

Beshrati (1998) reported that the use of sulfur powder with *Tiobacilus spp.* in soil, increased the availability of Fe and P elements in soil, due to reduction in soil pH. Higher uptake of Fe and P in plants, was recorded after treatment using sulfur powder with *Tiobacilus*, this resulted in the highest dry matter yield of the plants. Gyamati *et al*. (2009) studied the effects of four treatments (control soil, sulfur powder (1 ton/ha), urban solid waste compost (20 ton/ha) and urban solid waste compost (20 ton/ha) + sulfur powder (10% of USWC w/w) on soil properties and sugar beet crop. They reported that both sulfur powder and USWC treatments reduced soil pH significantly, compared to the control soil. Sulfur powder treatment reduced soil ECe significantly by 36.6% compared to USWC + Sulfur powder treatment. Also, this treatment reduced Na concentration in soil solution significantly by about 71%, compared to USWC treatment. USWC and Sulfur powder treatments showed higher amount of total nitrogen and available P in soil.

Iran has both arid and semi-arid regions and most of the soils are deficient in SOM, (being the main problem under these conditions), it is therefore essential to apply organic materials to improve sustainable agriculture. Urban and industrial wastes are usually used to supply the nutrients and increase crop yield (Astaraei and Almasian, 2010; Mazaheri Nia *et al*., 2010). This research aimed to study the effects of USWCS and nano iron oxide on soil chemical properties as well as the fertility status of saline-sodic soil.

2. Material and methods

The study area is located in the agricultural field of Qanavat part, Qom Province (Iran) with longitude 50º 59' and latitude 34º 37'. A field experiment was conducted using a randomized compete block design with a factorial arrangement and three replications during the year 2010 and USWCS was considered as the main factor while nano iron oxides were considered as subfactors. USWCS was prepared from Mashhad municipal solid waste factory. Two levels of USWCS (0 and 15 ton/ha) and nano iron oxide (0 and 20 mg/kg), were considered as experimental treatments. Iron wastes were obtained from iron sheets during the acid-washing process (Zobeahan Factory of Isfahan, Iran), having particle sizes ranging from 0.02-0.06 mm in diameter, and were treated by a mechanical method (ball mill) for 48 h to produce nano iron oxide. The diameter of prepared nano iron oxide powder was determined using a Transmission Electron Microscope (TEM) in the Central Research Laboratory of Ferdowsi University of Mashhad. The diameter range of nano iron oxide obtained by TEM was between 80 to 250 nm. The chemical properties of nano iron oxide are presented in Table 1. Experimental treatments were mixed at 0-30 cm soil depth in 4 m^2 plots and 20 sunflower seeds (*Record cultivar*) were sown in two rows 70 cm apart, in each plot (5000 plants per ha) in June 2010 (Ghodsi *et al*., 2012). Before the application of treatments, soil samples were collected from 0-30 and 30-60 cm soil depths and their properties were measured (Table 2). Soil bulk density was determined by core samples (10 cm in diameter, and 10 cm in height) (Blake and Hartge, 1986). The Beerkan infiltration method was used for measuring the final infiltration rate (Lassabatere *et al*., 2006). Saline-sodic irrigation water was used for this study and the chemical properties analyzed are presented in Table 1.

After sunflower harvest, soil samples were collected from 0-30 cm depths from each treatment, and analyzed for chemical properties. pH was determined from saturated paste, electrical conductivity of saturation extract (ECe) (Page *et al*., 1982), soluble calcium (Ca^{+2}) and magnesium (Mg^{+2}) concentrations by titration method with EDTA (Rayan *et al*., 2001), soluble sodium (Na^{+}) and K^{+} by Flame photometer apparatus (JENWAY PFP 7 Model), soluble carbonate (CO_3^{-2}) and bicarbonate (HCO_3^{-}) by titration method with 0.01 N sulfuric acid (Klute *et al*., 1986), soluble chloride (Cl-) by titration method with 0.01 N $AgNO_3$ (Klute *et al*., 1986) and soluble sulfate by turbidometery method (Patel *et al*., 1996) were used. Also, total N by Kejeldal method (Patel *et al*., 1996), available P (Olsen, 1954) and available K by Ammonium Acetate (Klute, 1986) were determined in soil samples. In addition, DTPA extractable micro-nutrients (Zn, Fe, Mn, and Cu) were measured by atomic absorption apparatus (Shimadzu AA-670) in soil samples (Lindsay and Norvell, 1978).

The data obtained were analyzed in SAS 9.1 software, and treatment means were compared, using Duncan's Multiple Range Test (DMRT) at P≤0.05.

Table 1. Chemical structure of studied nano iron oxide and properties of urban solid waste compost coated sulfur

Nano iron oxide	Fe_2O_3	FeO	CaO	Na_2O	Zn	Mn	Cu	L.O.I [a*]	
	(%)								
	0.78	0.005	0.16	0.0022	0.14	0.04	1.4	94.7	
USWCS	pH	EC (1:5 Water : USWCS)	N	P	K	Fe	Mn	Zn	Cu
	-	dSm^{-1}	--------------(%)-------------			-----------------($mgkg^{-1}$)---------------			
	6.5	4.7	1.3	0.2	0.2	7.7	201.95	8.3	212.3

*:Loss on ignition (%)

Table 2. Properties of surface (0-30 cm) and subsurface (30-60 cm) of studied soil before cultivation and irrigation water

properties	Soil depth (cm)		Irrigation water
	0-30	30-60	
Texture	Clay Loam	Clay Loam	-
pH	8.2	8.2	8.0
ECe (dS/m)	8.6	9.3	7.1
SAR	15.4	16	14.6
Organic Carbon (%)	0.81	0.65	-
N (%)	0.09	0.08	-
P_{ava}(mg/kg)	15	10	-
K_{ava} (mg/kg)	305	298	-
Fe (mg/kg)	5.5	4.5	-
Mn (mg/kg)	11.7	13.7	-
Cu (mg/kg)	0.64	0.86	-
Zn (mg/kg)	1.8	2.1	-
CO_3^{-2}(mmol/l)	-	-	-
HCO_3^{-} (mmol/l)	4.4	4.3	4.2
Cl^{-} (mmol/l)	51	51.4	52.4
SO_4^{-2}(mmol/l)	42.5	38	31.3
Ca^{+2}+Mg^{+2} (mmol/l)	52.8	32.1	34.1
Na^{+} (mmol/l)	79.13	64.1	60.29

3. Results and discussion

Application of 20 mg/kg nano iron oxide decreased soil pH significantly (P≤0.05) compared to the control (Table 3), and the same result was recorded for the 15 ton/ha USWCS treatment (Table 4). Application of nano iron oxide powder with a strong acidic nature- pH=2.4 (1:100 nano iron oxide to distilled water suspension) into soil, resulted in soil pH decrease (Mazaheri Nia *et al*., 2010). Mohamadi Nia (1995) found that SOM decomposition produces organic acids such as citric and malic acids, that decreases soil pH. Application of 20 mg/kg nano iron oxide increased soil ECe significantly (P≤0.05) compared to the control (Table 3). A similar result was obtained with 15 ton/ha USWCS application (Table 4). Application of 20 mg/kg nano iron oxide decreased SAR significantly (P≤0.05) compared to the control (Table 3). Since the studied soil was alkaline (pH=8.2), and due to the acidic nature of nano iron oxide, the solubility of Ca-compounds increased, and the activity of CO_3^{-2} and HCO_3^{-1} ions in soil solution also decreased, due to the precipitation of low soluble constituents. Similar results were reported by Mashhadi and Rowell (1978). The increasing soil acidity due to nano iron oxide increased the concentrations of Ca^{+2} and

Mg^{+2} ions leading to decrease in Na^{+} concentration, thereby lowering soil SAR.

The interaction between 15 ton/ha USWCS and 20 mg/kg nano iron oxide resulted in a significant (P≤0.05, Fig. 1) decrease in soil pH. The acidic nature of nano iron oxide coupled with the decomposition of USWCS in the studied soil, produced organic acids because of sulfur oxidation from USWCS and resulted to a decrease in soil pH (Mazaheri Nia *et al*., 2010). The interaction of 15 ton/ha USWCS and 20 mg/kg nano iron oxide increased soil ECe significantly (P≤0.05, Fig. 2), probably due to high concentration of salts in USWCS along with nano iron oxide, similar results were reported by Mazaheri Nia *et al*. (2010). They observed that nano iron oxide increased the availability of soil nutrients and solubility of inorganic compounds, concentration of soluble salts, thereby, leading to higher soil ECe. Also, USWCS have many soluble constituents and its application leads to higher soil ECe (Astaraei and Almasian, 2010). Vazquez Montiel (1996) reported that increase in soil ECe because of compost addition, depends on the total amounts of dissolved salts present in compost and addition of compost results in the accumulation of soluble salts in soil.

Table 3. Effect of Nano iron oxide on soil chemical properties

Nano iron oxide (mg/kg)	pH	ECe (dS/m)	SAR
0	7.9	9.8	10.25
20	7.8	10.05	9.95
P value	*≤ 0.0001*	*≤ 0.0001*	*≤ 0.02*

Table 4. Effect of urban solid waste compost coated sulfur on soil chemical properties

USWCS (ton/ha)	pH	ECe (dS/m)	SAR
0	7.9	9.8	10.25
15	7.6	9.2	9.9
P value	*≤ 0.0001*	*≤ 0.0001*	*≤ 0.0004*

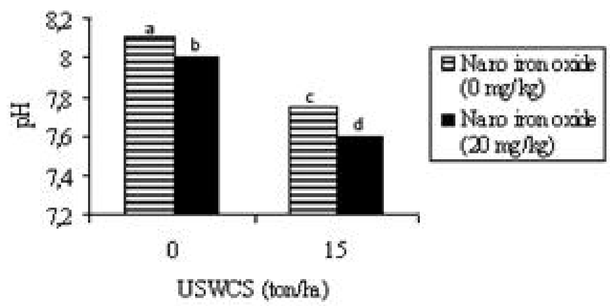

Fig. 1. Interaction effects of nano iron oxide and urban solid waste compost coated sulfur on soil pH

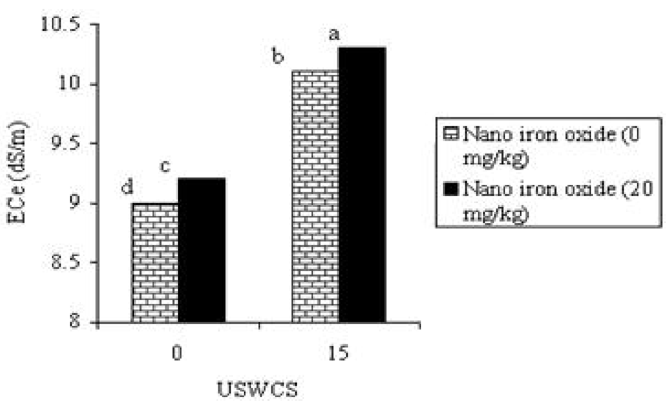

Fig. 2. Interaction effects of nano iron oxide and urban solid waste compost coated sulfur on ECe (Same letters are not significant at *P<0.05*)

The interaction of 20 mg/kg nano iron oxide and 15 ton/ha USWCS decreased SAR significantly (P≤0.05, Fig. 3). The addition of OM to soil for reclaiming soil physico-chemical properties and to increase the availability of nutrients in sodic soils should be regarded after considerable reduction of Na and pH in these soils (Gupta *et al*., 1984). Sodic soils due to high pH and high calcium carbonate can release more Ca into soil solution, thereby reducing the harmful effects of Na (Chorom and Rengassamy, 1997). Therefore, the simultaneous application of USWCS and nano iron oxide to soil, in addition to increasing acidic strength and higher solubility of Ca-compounds, increased infiltration rate and Na-leaching and as a result, decreased SAR in the studied soil.

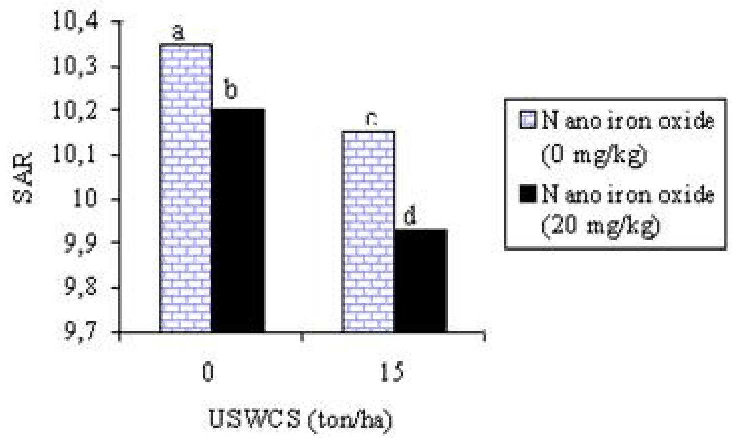

Fig. 3. Interaction effects of nano iron oxide and urban solid waste compost coated sulfur on SAR (Same letters are not significant at *P<0.05*)

Application of 20 mg/kg nano iron oxide increased concentrations of soil micro-nutrients, soil available P and K, while total N concentration in the soil (Table 5) decreased significantly (P≤0.05). Mazaheri Nia *et al*. (2010) reported that application of nano iron oxide powder increased micro-nutrients concentrations in calcareous soils. By acidifying soil media, nano iron oxides increased the solubility of micro-nutrients. Soil P availability is strongly affected by pH, and maximum availability of P is found in pH range of 6.5-7 (Engelstand and Terman, 1980). Therefore, with decreasing soil pH (Tables 3 and 4) after addition of USWCS and nano iron oxide, P availability increased in soil (Tables 5 and 6).

Table 5. Effect of Nano iron oxide on concentration of nutrients in a studied soil

Nano iron oxide (mg/kg)	N	P	K	Fe	Zn	Cu	Mn
	(%)	----------------------------------(mg/kg)--------------------------------------					
0	0.12	19	320	7.0	4.3	1.1	16.8
20	0.11	20	321	9.1	4.7	1.3	17.5
P value	≤ 0.004	≤ *0.0001*	≤ 0.004	≤ 0.0001	≤ 0.0001	≤ 0.0001	≤ 0.0001

Table 6. Effect of urban solid waste compost coated sulfur on concentration of nutrients in a studied soil

USWCS ton/ha)	N	P	K	Fe	Zn	Cu	Mn
	(%)	---------------------------------(mg/kg)-------------------------------					
0	0.12	19	320	7.3	4.3	1.1	16.8
15	0.13	23	324	10.7	5.8	1.6	19.3
P value	≤0.0001	≤0.0001	≤0.001	≤0.0001	≤0.0001	≤0.0001	≤0.0001

The concentrations of nutrients in soil increased significantly (P≤0.05) with the addition of USWCS (Table 6). Increasing the concentrations of N, K, and P in soil, after USWCS addition is probably due to the high concentrations of these nutrients in USWCS (Astaraei and Almasian, 2010). The results of Engelstand and Terman (1980) show that P availability increased by applying OM into soil. Muhammad *et al*. (2007) also found that by application of 1% compost to soil, soil P extractable by Na-bicarbonate increased. During the decomposition of organic matter, probably humic acid is produced and unavailable P is transformed to available forms. Application of OM to soil increases microbial biomass and activity, thereby increasing the availability of urease, β-Glycosidase, and phosphatase alkaline enzymes in the soil (Liang *et al*., 2005). Lakhar (2008) reported that the application of compost into saline-sodic soils increased the concentrations of micro and macro-nutrients in rhizosphere and reduced the negative interaction effects among nutrients. Khoshgoftar Manesh and Kalbasi (2000) reported that urban waste compost containing organic and inorganic acids; decreases soil pH because of their acidity, thereby indirectly increasing the availability of micro-nutrients.

The interaction between 15 ton/ha USWCS and 20 mg/kg nano iron oxide increased the concentrations of DTPA extractable micro-nutrients (Table 7) significantly (P≤0.05). The results show that the combined application of nano iron oxide and USWCS had significantly higher effect on availability of micro-nutrients, than when each treatment was applied alone. Therefore, the concentrations of Fe, Mn, Cu, and Zn in soil increased by 24, 4, 14, and 10%, respectively as a result of the combined application of nano iron oxide and USWCS, compared to separated application of USWCS (Table 6). Compost can provide a source of nutrients and releases them gradually for plant uptake, about 10% of N in compost is available for plants in the first year, after its application (De Hann, 1981). Iglesis and Alvarez (1993) reported that 21% of N in compost as NH_4NO_3 was available for plants to utilize after 6 months. Crowly *et al*. (2001) found that by applying OM, the concentration of siderophores increased in the soil and as a result, Fe solubility also increased. Tombacz and Rise (1999) reported that OM is able to form soluble complexes with micro-nutrients, thereby increasing their solubility in soil. In addition, the application of compost containing soluble P to soil, considerably increased soil available P (Perez, 2007). Rahimi *et al*. (1992) found that the application of urban waste compost to some soils in Isfahan, Iran, resulted in an increase in available N and P. Furthermore, the use of urban waste compost in Mediterranean semi-arid lands, increased N, P, K, and organic carbon in the rhizosphere (Melero *et al*., 2007).

Table 7. Interaction effects of nano iron oxide and urban solid waste compost coated sulfur on concentration of nutrients in a studied soil

USWCS	Nano iron oxide	N	P	K	Fe	Zn	Cu	Mn
(ton/ha)	(mg/kg)	(%)	-------------------------------(mg/kg)-------------------------------					
0	0	0.09^c	16^d	318^d	5.4^d	3.4^d	0.9^d	15.2^d
	20	0.08^b	17^c	319^c	7.4^c	3.8^c	1.0^c	15.8^c
15	0	0.13^a	22^b	322^b	8.6^b	5.1^b	1.4^b	18.4^b
	20	0.13^a	23^a	324^a	10.7^a	5.6^a	1.6^a	19.1^a

Same letters in each column are not significant at $P \leq 0.05$

4. Conclusion

The results of this research show that the application of nano iron oxide to soil increased the concentrations of Fe, Mn, Cu, and Zn to 30, 4, 18, and 9% respectively, compared to the control. Most Iranian soils are deficient in micro-nutrients especially Fe, as a result of different reasons such as salinity, alkalinity, calcareous and low contents of SOM. Therefore, the application of nano iron oxide can play an important role towards increasing the availability of micro-nutrients. Application of USWCS increased the amounts of Fe, Mn, Cu, and Zn to 32, 20, 60, and 45% respectively, compared to the control. In addition, the interaction effect of USWCS and nano iron oxide resulted in maximum availability of micro-nutrients in the studied saline-sodic soil, as the concentrations of Fe, Mn, Cu, and Zn increased by 94, 39, 86, and 160%, respectively, compared to the concentrations before sunflower sowing. In addition, the application of USWCS increased the concentration of N, P, and K by 44, 43, and 2% respectively, compared to the control. The application of USWCS increased SOM, improved soil structure and due to improved micro and macro-nutrients availability, increased crop yield. Based on the results obtained, the combined application of USWCS and nano iron oxide, even with the use of saline-sodic irrigation water, can be used to increase the availability of nutrients in saline-sodic soil for plant uptake and increase the yield of sunflower.

References

Astaraei, A.R., R.P.S. Chauhan, 1992a. Effect of waters varying in Mg/Ca ratio, Sodium adsorption ratio and Salinity on Physico-Chemical of Soils. Indian Journal of Agriculture Research, 26; 205-209.

Astaraei, A. R., R.P.S. Chauhan. 1992b, Effect of Ca:Mg ratio on soil sodicity at different levels of Sodium adsorption ratio and electrolyte concentration. Australian Journal of Soil Research, 30; 751-60.

Astaraei, A.R., F. Almasian, 2010, Effect of municipal solid waste compost leachate on the soil properties, yield and yield components of wheat. Environmental Sciences. 7; 181-191.

Astaraei, A.R., R.P.S. Chauhan, 1994. Effect of water varying in Ca/Mg ratio, Salinity and SAR on yield and composition of wheat. Indian Journal of Agriculture Research, 28; 201-208.

Besharati, H., 1998. Effect of sulfur and tio-bacillus inoculation on availability of nutrients in soil. M. Sc. Thesis, Soil Science Dept., Tehran University. Tehran, Iran.

Bhattacharyya, P., K., Chakrabarti, A., Chakraborty, D.C. Nayak, 2005. Effect of municipal solid waste compost on phosphorous content of rice straw and grain under submerged condition. Soil Science, 51; 363-370.

Blake, G.R., K.H. Hartge, 1986. Bulk density. In: Klute, A., (Ed.), Methods of soil analysis. Part1-Physical and mineralogical methods. Seconds edition. Agronomy No.9. America Society of Agronomy, Inc. Soil Science Society of America, Madison, Wisconsin. USA.

Chorom, M., P. Rengasamy, 1997. Carbonate chemistry, pH, and physical properties of sodic soil as affected by various amendments, Australian Journal of Agriculture Research, 35; 149–161.

Crowley, D., 2001. Function of siderophore in the plant rhizosphere. In: Pinton R, Varanini Z, Nannipieri, P, editors. The Rhizosphere. New York: Marcel Dekker, Inc. p. 223-261.

De Haan, S., 1981. Results of municipal waste compost research over more than fifty years at the institute for soil fertility at Haren Groningen, the Netherlands. Journal of Agricultural Science, 29; 49–61.

Ehtesham Nia, A., J.S. MoosaviZadeh, M.M. Sharifani, K. Mashayekhi, 2007. Importance of zinc utilization in fruit garden of Iran. Proceeding of 2ndNational Congress of Ecological Agriculture. 17-18 Oct. Gorgan, Iran. Pp. 300-314.

Emami, H., A.R. Astaraei, 2012. Effect of organic and inorganic amendments on parameters of water retention curve, bulk density and aggregate diameter of a saline-sodic soil. Journal of Agricultural Science and Technology. 14; 1625-1636.

Engelstad, O.P., G.L Terman, 1980.Agronomic effectiveness of phosphate fertilizer, in: The Role of Phosphorus in Agriculture, Khasawneh, FE, Sample, EC, Kamprath, EJ, Editors. American Society of Agronomy, Madison, Wisconsin, USA. p. 311-332.

Foruhar, M, 1999. Possibility of using iron oxide waste from acid pickling line as iron fertilizer. M. Sc. Thesis, Soil Science Dept., Industrial University of Isfahan. Isfahan, Iran.

Ghodsi, A., A.R. Astaraei, H. Emami, M.H. Mirzapour, 2012. Effects of Nano iron oxide powder and urban solid waste compost coated sulfur on sunflower yield and yield components in saline- sodic soil. Environmental sciences, 9; 111-118.

Gupta, R.K., D.K. Bhumbla, I.P. Abrol, 1984. Effect of sodicity, pH, organic matter, and calcium carbonate on the dispersion behavior of soils: Soil Science, 137; 245-251.

Gyamati, G., A.R. Astaraei, G.R. Zamani, 2009. Effect of urban solid waste compost and sulfur on sugar beet yield and soil chemical properties. Iranian Journal of Field Crops (Center of Excellence for Special Crops). 7(1); 155-164.

Iglesias-Jimenez, E., C.E. Alvarez, 1993. Apparent availability of nitrogen in composted municipal refuse. Biology and Fertility of Soils, 16; 313–318.

Klute, A., 1986. Method of Soil Analysis (part l): Physical and Mineralogical Methods. 2nd edition. ASA. SSSA. Madison. Wisconsin. USA.

Khoshgoftarmanesh, A.H., M. Kalbasi, 2000. Effect of municipal waste leachate on soil properties and growth and yield of rice. Communications in Soil Science and Plant Analysis, 33; 2011-2020.

Lakhdar, A., C. Hafsi, M. Rabhi, A. Debez, F. Montemurro, C. Abdelly, N. Jedidi, Z. Ouerghi, 2008. Application of municipal solid waste compost reduces the negative effects of saline water in Hordeummaritimum L. Bioresource Technology, 99; 7160–7167.

Lakhdar, A., M.Rabhi, T. Ghnaya, F. Montemurro, J. Naceur, A. Chedly, 2009. Effectiveness of compost use in salt-affected soil. Journal of Hazardous Materials, 171; 29–37.

Lassabatere, L., R. Angulo-Jaramillo, J.M. SoriaUgalde, R. Cuenca, I. Braud, R. Haverkamp, 2006. Beerkan estimation of soil transfer parameters through infiltration experiments-Best. Soil Science Society of America Journal, 70; 521-532.

Liang, Y., M. Nikolic, Y. Peng, W. Chen, and Y. Jiang. 2005. Organic manure stimulates biological activity and barley growth in soil subject to secondary salinization. Soil Biology & Biochemistry, 37: 1185–1195.

Lindsay, W.L., W.A. Norwell, 1978. Development of DTPA soil test for zinc, iron, manganese, and copper. Soil Science Society of America Journal, 42; 421-428.

Malik, R.S., A.P. Gupta, S. Hanelaus N.E. Bassam, 1999. Role of phosphorus (32p) in inducing salt tolerance in sunflower, Landbau for Schang – volkenrode. 49 (49); 169-17.

Mashhadi, A.S., D.L. Rowell, 1987. Soil Alkalinity. I.equilibria and Alkalinity development. Journal of soil science, 29; 65-75.

Mazaheri Nia, M., A.R. Astaraei, A. Fotovat, A. Monshi, 2010. Nano iron oxide particles efficiency on Fe, Mn, Zn, Cu concentrations in wheat plant. World Applied Science Journal, 7; 36-40.

Melero, S., E. Madejon, J.C. Ruiz, J.F. Herencia, 2007. Chemical and biochemical properties of a clay soil under dry land agriculture system as affected by organic fertilization. European Journal of Agronomy, 26; 327–334.

Mohajer Milani, P., 1996. How using of saline lands. Introduction to soil salinity. Thecnical journal. Soil and water research institute of Iran.

Mohamadi Nia, G., 1995. Chemical compounds of waste leachate and compost and their effect on soil and plant. M.Sc. thesis. Soil Science Dept., Industrial University of Isfahan. Isfahan. Iran.

Muhammad, S., T.R. Muller, G. Jorgensen, 2007. Compost and P amendments for stimulating microorganisms and maize growth in a saline soil from Pakistan in comparison with a non saline soil from Germany. Journal of Plant Nutrition and Soil Science, 170, 745–751.

Olsen, S.R., C.V. Cole, F.S. Wattenberg, L.A. Dean, 1954. Estimation of available phosphorus in soil by extraction with sodium bicarbonate. U.S. Dep. Agric. Cirs. 939. USA.

Page A.L., R.H. Miller, D.R. Keeney. 1982. Method of Soil Analysis. Part 2. Chemical and Microbiological properties (2nd edition). America Society of Agronomy Soil Science of America Publisher. Madison. Wisconsin. USA.

Page, A.L., A.C. Chang, D.C. Adriano, 1990. Deficiencies and toxicities of trace elements. Agricultural salinity assessment and management, Chapter 7, ASCE manuals and reports on Eng. Practice No. 71, ASCE, p. 138-160.

Patel, B.S., S.G. Sadaria, J. Patel, 1996. Influence of irrigation, nitrogen and phosphorus on yield, nutrient uptake and water-use efficiency of blond psyllium (Plantagoovata). Indian journal of Agronomy, 41; 136-139.

Perez, D.V., S. Alcantara, C.C. Ribeiro, R.E. Pereira, G.C. Fontes, M.A. Wasserman, T.C. Venezuela, N.A. Meneguelli, J.R. De Macedo, C.A.A Barradas, 2007. Composted municipal waste effects on chemical properties of a Brazilian soil. Bioresource Technology, 98; 525-533.

Rahimi, G., 1992. Study effect of compost on soil salinity, pollution, and amount of heavy metals uptake by maize in composted soils. M. Sc. thesis. Soil Science Dept., Industrial University of Isfahan. Isfahan. Iran.

Rayan, J.R., G. Stefan, A. Rashid, 2001. Soil and Plant Analysis Laboratory Manual. (2nd edition). ICARDA. Syria.

Ross, S.M., 1994. Toxic Metals in Soil-Plant System. John Wiley and Sons 138- Quality. (J.W. Doran and A.J. Jones). Soil Science Society of American. Spec. Publication # 49, SSSA. Madison, WI. Inc. England. p. 103,189.

Sanyal, S.K., S.K. De Datta, 1991. Chemistry of phosphorus transformations in soil, Advanced Soil Science. 16; 11–20.

Tombacz, E., J.A. Rise, 1999. Changes of colloidal state in aqueous systems of humic acids .In: Ghabbour, E.A.anddavies, (eds). Understanding Humic Substances: Advanced Methods, Properties and Applications. Society of Chemistry. Cambridge, UK. p. 69-77.

Vazquezmontiel, O., N.J. Horan D.D. Mara, 1996. Management of domestic waste water for reuse in irrigation. Water Science Technology, 33; 355-362.

Wong, V.N.L., 2008. Soil organic carbon fluxes in salt-affected soils. The Australian National University; currently Geoscience. 2nd International Salinity Forum. Salinity, water and society–global issues, local. Australia, Canberra, ACT.