Research Journal of

Soil Biology

ISSN 1819-3498

Academic
Journals Inc.

www.academicjournals.com

Research Journal of Soil Biology 7 (2): 46-55, 2015
ISSN 1819-3498 / DOI: 10.3923/rjsb.2015.46.55

Effect of Sewage Sludge Urban Application on Concentration of Fe, Mn and Some Nutrient Element in Parsley

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ABSTRACT
Sewage sludge application on agricultural land as an organic fertilizer the recycling of valuable components such as many plant nutrients. Sewage sludge is rich in macro and micronutrients. However, high concentrations of heavy metals in sludge may cause pollution of soil, groundwater and the human food chain because of toxic metal uptake by crops. The objective of this research was to investigate the effect of sewage sludge application on concentration of iron and manganese in parsley. This study were carried out in a factorial experiment in a completely randomized design with three replications in greenhouse condition. The amounts of 0, 1, 2, 4, 8 and 16% of the soil dry weight of the sewage sludge were added to the pots having soil of three areas (Baharan, Najvan and Shakrekord). Parsley seeds were planted in the pots and was harvested in five leaf stage. The sewage sludge application did not significantly affect soil pH, but EC was increased by 71-107% in 16% of sewage sludge in the three soils. Also, sewage sludge application significantly increased by 22-54 and 23-27% the concentrations of P and K in soils, respectively. In Shakrekord area, using the sewage sludge had a significant effect on concentration of Fe in parsley and increased by 27% in 16% of sewage sludge. In Najvan area, the application of sewage sludge (with the exception of 16% level) significantly increased by 5-17% the concentrations of Mn in parsley.

Key words: Sewage sludge, parsley, iron, manganese

INTRODUCTION
In arid and semi-arid climate which forms the main part of Iran, lack of enough and appropriate vegetation leads to reduction of herbal remains in soil and lack of organic matters so that more than 60% of Iran's soils have less than 1% of organic matters. Soil of these areas, due to having the alkali property and high percent of lime, suffers from lack of the alimentary elements' absorbable form especially the low-consumption elements for plants. The 30% of the world under-cultivation soil suffers from lack of iron (Cakmak, 2002). Doing an experiment in a field during two years, Balali *et al.* (1995) reported that 37% of the Iran's soils suffer from lack of iron, 40% from lack of zinc, 25% from lack of manganese and 24% from lack of copper. Deficiency of iron leads to the problem of chlorosis which is observable in most of Iran's soils and plants. The plant iron plays a role in making important proteins such as enzymes having iron, veg-hemoglobin and chlorophyll. In addition, iron is essential in respiration and the plants' reactions of oxidation and reduction. Manganese has an effect on production of chlorophyll and photosynthesis and takes a part in the plants' synthetic systems. It plays a role in reactions of transferring electron and

production of chlorophyll. Like iron, manganese is a sedentary element in plants and signs of its shortage are firstly come out in young leaves of trees. The most important sign of manganese shortage is the formation of chlorosis in leaves which usually surrounds the all top parts of the tree. Unlike iron, in shortage of manganese, the top and margins of the leaves remains green. One of the factors of determining the soil productivity is the condition of its alimentary elements. Using the organic garbage in appropriate amounts can improve the condition of alimentary elements and other properties of the soil (Vaseghi *et al*., 2003). As an organic fertilizer, the sewage sludge has had a special stance in agriculture from long ago and its usage for providing the herbal low-consumption and high consumption elements and the soil organic matters have been paid attention to. Sewage sludge enjoys high-consumption elements including nitrogen, phosphor and potassium and low-consumption elements including iron, zinc, copper and manganese. Among the alimentary elements needed for plant, the low-consumption elements are needed in low amounts but their shortage can make new problems in production and health of human an animal's (Gupta *et al*., 2008).

Using the sewage sludge in farmlands has been spread in most countries and Iran, too (Behbahaninia *et al*., 2009). Increase of concentration of the low-consumption elements such as Cu, Zn, Mn and Fe in soil and plant along with the application of the urban sewage have been proved by several studies (Bigdeli and Seilsepour, 2008) because sewage and sewage sludge always have more amounts of these elements in comparison with the soil. Although the aforementioned elements are used by plant, excessive and continuous usage of the sewage sludge may lead to toxicity of some plants (Chang *et al*., 1982). In some cases, using the sewage sludge eliminates the need of plants to low-consumption elements more effective than other resources. For example, compensation of the zinc shortage in corn by sewage sludge is more effective than use of zinc sulfate (Sommers, 1997). Various studies revealed that the organic garbage, like sewage sludge, has a remarkable amount of the aforementioned elements naturally which, due to presence of a lot of organic matters, are in the form of organic kalats and lead to increase of solubility and absorbability of these elements in soil (RazaviToosi, 2000). Obviation of the shortage of the low-consumption alimentary elements by organic matters is because of their complexing power. Therefore, for improving the productivity and fertility of the soil and increasing the plant growth and function, especially in arid lands, usage of organic manure is of great importance but its traditional finite resources cannot obviate the increasing need of the agriculture section to manure. Adding organic garbage to farm lands in recent years has been paid attention to. It is due to increase of the energy needed for production of chemical fertilizers and expensive expenditure as well as environmental problems as a result of burying the organic remains (Kumar *et al*., 2002).

Fertilizing value of the organic garbage has been revealed in different studies of various counties. Rezaenejad and Afyuni (2001) reported that the organic manure led to a significant increase in the soil organic matters and absorbability of zinc, copper, iron, phosphor, potassium and nitrogen in soil. Studying the effect of sewage and sewage sludge on the concentration of some elements and function wheat, barley and corn, Nazari *et al*. (2006) reported that using sewage and sewage sludge causes an increase in concentration of iron, zinc, manganese and copper. Most concentration of these elements was observed in sludge treatment which is probably due to increase of absorbability of these metals by organic matters of sludge. According to report of Weber *et al*. (2007), usage of compost causes the increase in amount of the absorbable phosphor, potassium, manganese and zinc by plant. According to a report, using sewage sludge led to remarkable increase in concentration of iron, zinc and manganese in leaves of apple tree. This study aimed to examine the effect of using urban sewage sludge on concentration iron and manganese and in parsley.

MATERIALS AND METHODS

Experimental design: This study was done in research greenhouse of agriculture faculty in Islamic Azad University, Isfahan (Khorasgan) branch in 2012. The soils collected from vegetable cultivation areas of Najvan, Baharan Isfahan and Kiar located in Isfahan and Chaharmahal va Bakhtiari provinces. The soil samples were selected from the depth of 0-30 cm and transferred to the laboratory. Some soil characteristics were shown in Table 1 and 2. The sewage sludge was provided from the Isfahan northern refinery of Zeynabie district which was a kind of digested and anaerobic. Chemical components of the used sewage sludge are shown in Table 2. Effect of application of the sewage sludge on parsley was examined by using the treatments of 0, 1, 2, 4, 8 and 16 in soil of Baharan, Najvan and Shahrekord. Parsley, as a vegetable used in people diet, was selected for this experiment. It was done in the form of factorial and a completely randomized design with three replications. The sewage sludge was added to the soil individually and poured in the plastic vase having 1 kg capacity. In each vase, 3 or 4 parsley transplanting was

Table 1: Selected physical and chemical properties of three soils

	Sampling region		
Soil characterizes	Najvan	Baharan	Shahrekord
Clay (%)	28.0	46	50
Silt (%)	66.5	16	45
Sand (%)	5.50	38	5
Texture	Clay	Silty clay loam	Silty clay
$CaCO_3$ (%)	38.5	37.5	44
Organic matter (%)	0.63	0.46	1.03
CEC (cmol kg^{-1})	12.55	12.97	13.61
EC (dS m^{-1})	0.65	2.38	1.77
pH	8.25	8.21	8.60
Total N (%)	0.16	0.02	0.16
Available P (mg kg^{-1})	26.5	125	90
Available K (mg kg^{-1})	360	447	147
Pb	21.0	16	11.5
DTPA-extractable Pb	3.0	2.8	2.0
Cd	3.5	3.5	2.5
DTPA-extractable Cd	0.31	0.18	0.23

Table 2: Chemical properties of used sewage sludge

Component	Amount
pH	7.85
EC (dS m^{-1})	7.05
OM (%)	54.0
N (%)	1.87
P (mg kg^{-1})	750
K (mg kg^{-1})	1080
Pb (mg kg^{-1})	90
Ni (mg kg^{-1})	34
Cu (mg kg^{-1})	173
Zn (mg kg^{-1})	655
Cd (mg kg^{-1})	3.0

planted. After that, the numbers of plants were decreased in 5. During growth period, the vases were irrigated monotonously according to the plant need. The wedding and fighting with pests diseases were done manually.

Sampling and analysis: Two month later, reaching to the 4-leaf stage, the plants were harvested and the vases soil sampled gathered. Having transferred to the laboratory, the samples were beaten and passed from a two-mm sieve. Their pH and electric conduct were measured in 1:2 suspensions of distilled water and saturation extract respectively. The soil texture (hydrometer method, the cation exchange capacity (sodium acetate method), the available P (Olsen method), the available K (ammonium acetate method), the organic matters (wet oxidation method), the total nitrogen (Kjeldahl method), the available of lead and cadmium (0.005 N DTPA) were determined via procedures described in Baruah and Barthakur (2001). Their total concentration and the sewage sludge were extracted by digestion by the help of concentrated nitric acid and 30% hydrogen peroxide (Pyatt, 1999). Then, their concentration in the extracts was determined by Perkin Elmer Analyst 800. After harvesting the samples, the yield of wet weight was determined. Then, they were dried in ventilation oven in 65°C for 48 h and were weighted again. For determining the concentration of lead and cadmium, the plants samples were powdered at first and the wet oxidation method, having concentrated nitric acid and hydrogen peroxide, was used for digestion. These metals concentration in extracts were analyzed using Atomic Absorption Spectrometry (Perkin Elmer Analyst 800).

Statistical analysis: In order to analyze the data, SAS software were used. Means were compared by Least Significant Difference (LSD).

RESULTS AND DISCUSSION

Effect of sewage sludge application on some soil properties

Soil pH: In this research, the application of sewage sludge decreased the soils' however different was not statistically significant (Fig. 1). It may be as a result of the soil calcareous property and its high buffering power. The decrease of soil pH due to adding the organic waste to farmlands was reported by many researchers. Mohammad and Athamneh (2004) reported the reduction of soil pH

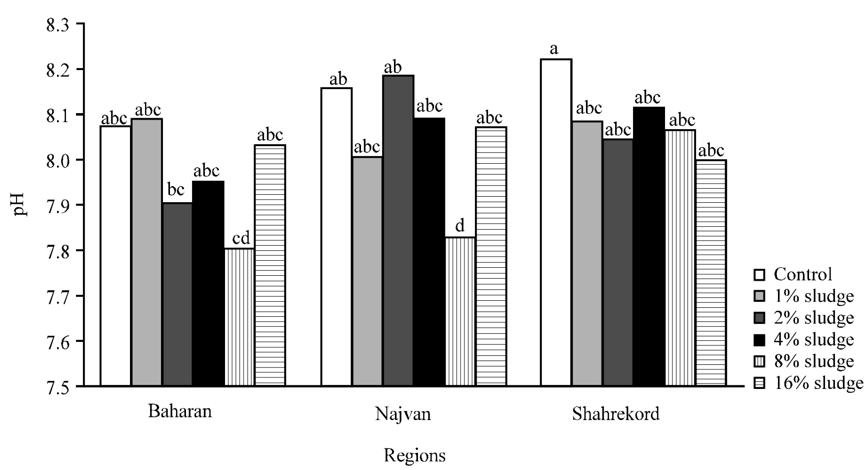

Fig. 1: Effect of sewage sludge on soil pH. Means with different letters are significantly different at 5% level test (LSD = 0.31)

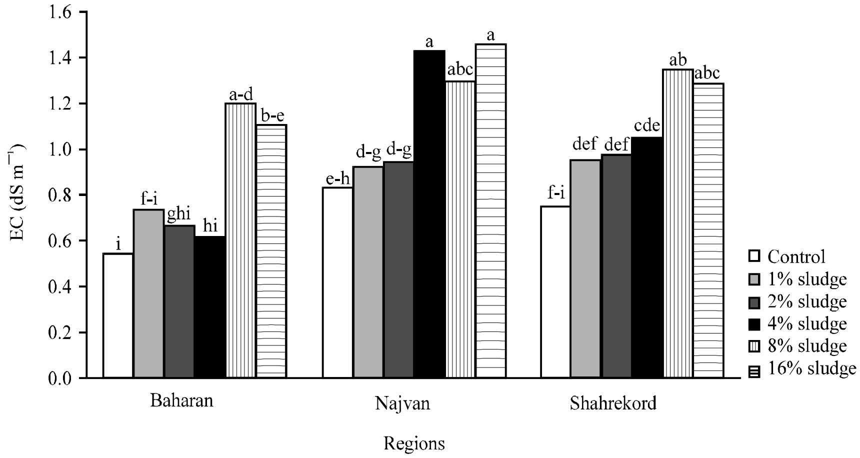

Fig. 2: Effect of sewage sludge on soil electrical conductivity. Means with different letters are significantly different at 5% level test (LSD = 0.28)

from 8.15-7.22 after adding 160 t sewage sludge in a hectare because of degrading and mineralizing the organic matters leading to releasing the amine acids. Generally, in calcareous soils, because of highness of the soil buffering capacity, the soil pH is very low due to application of sewage sludge (Karami *et al*., 2009).

Soil electrical conductivity: As shown in Fig. 2, application of sewage sludge increased the soils electrical conductivity, although this increase was significant in Baharan soil in amount of 8% amore and in Shahrekord soil in amount of 4% and more ($4). The most amount of electrical conductivity was related to the treatment 16% in Najvan soil and the least one were related to the treatment 4% in Baharan soil. Gaskin *et al.* (2003) revealed that soil electrical conductivity was increased with application of sewage sludge. In all treatments, this increase in surface soil was more than subsurface. Adding 90 t haG[1] of sewage sludge and compost to light texture calcareous soil led to a significant increase in soil electrical conductivity due to releasing the ions during the mineralization of the organic matters. Asagi *et al.* (2007) found that the Electrical Conductivity (EC) of the chemical fertilizer treated soil was higher than that of the soils in the sewage sludge treatments.

Soil available P: Usage of sewage sludge increased the soil available phosphor in comparison with the control group (Fig. 3). This increase in Baharan soil in amount of $1% and Shahrekord soil in amount of $2% was significant in comparison with the control group. The most increase of the soil available phosphor, in comparison with the control group, was related to the treatment of 16% of sludge in the three soils. Increase of the available phosphor is probably because of increase of organic matters and reduction of the soil pH leading to reduction of absorption and fixation of phosphor in soil and as a result, the available phosphor was increased. Wong *et al.* (2007) reported that usage of sewage sludge increased the concentration of phosphor and nitrogen in soil. Some researchers believed that organic manure plays a role in more availability of some elements such as phosphor. Hussein (2009) reported that soluble potassium and available phosphorous were increased in sandy and calcareous soils with increasing sewage sludge application rate.

Soil available K: Comparison of the averages revealed that usage of sewage sludge in soil of Najvan and Shahrekord increased the amount of soil available potassium (Fig. 4). This increase

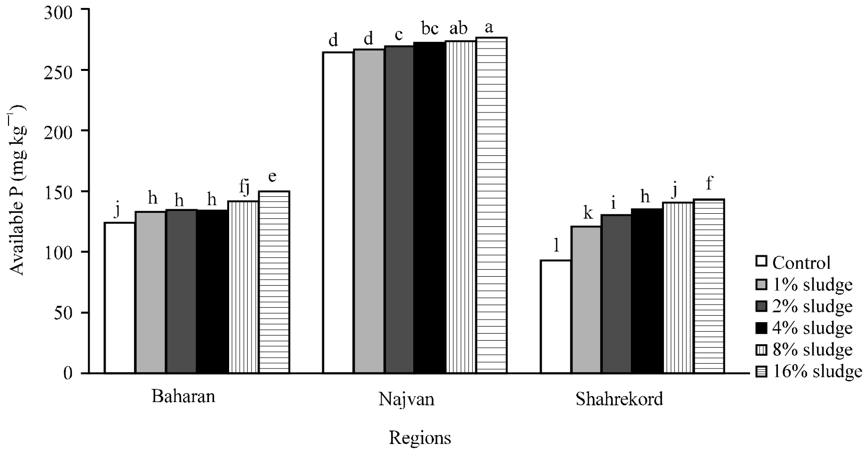

Fig. 3: Effect of sewage sludge on soil available P. Means with different letters are significantly different at 5% level test (LSD = 13.21)

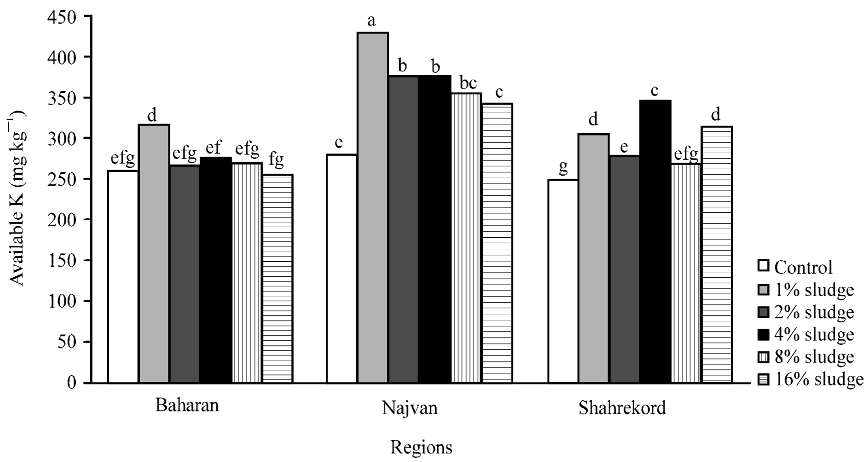

Fig. 4: Effect of sewage sludge on soil available K. Means with different letters are significantly different at 5% level test (LSD = 21.96)

in Shahrekord soil in usage of 4, 2, 1 and 16% of sludge was significant in comparison with the control group. The least and most amount of available potassium was found in Baharan and Najvan soils, respectively. No increase in available potassium of Baharan soil is probably because of the richness of available potassium soil. As a result, the amount of added potassium by sewage sludge could not have significant effect on this soil available potassium.

Therefore, it is important to consider the use of sewage sludge can influence positively the physico-chemical properties of soils (Kasmi *et al*., 2012).

Effect of sewage sludge application on concentration of Fe and Mn in plant

Concentration of Fe in plant: Usage of sewage sludge in Shahrekord soil and in usage treatment of 8% of Najvan soil and in usage of 1% of Baharan soil led to concentration of iron in plant (Fig. 5). By formation of solvable organic complexes, the organic matters prevent from sediment of iron oxides and increase the scattering of iron toward the plant root (De Santiago and Delgado, 2007; Bar-Ness and Chen, 1991). Mbatha (2008) reported the increase of iron

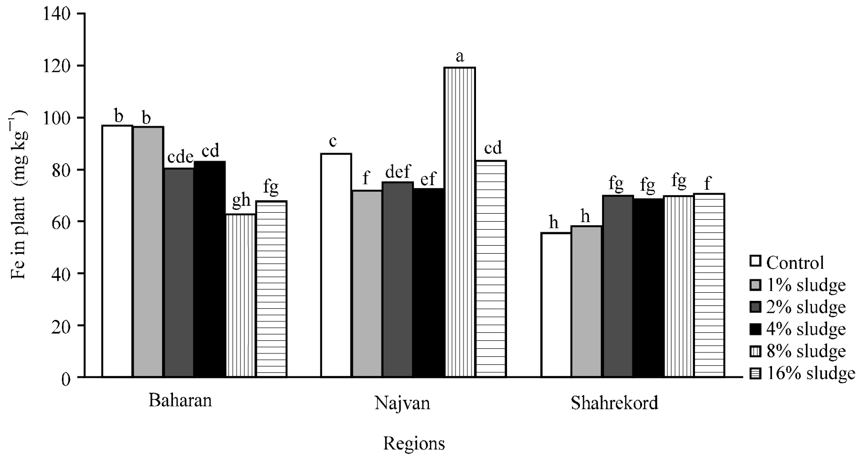

Fig. 5: Effect of sewage sludge on Fe concentration of parsley. Means with different letters are significantly different at 5% level test (LSD = 8.31)

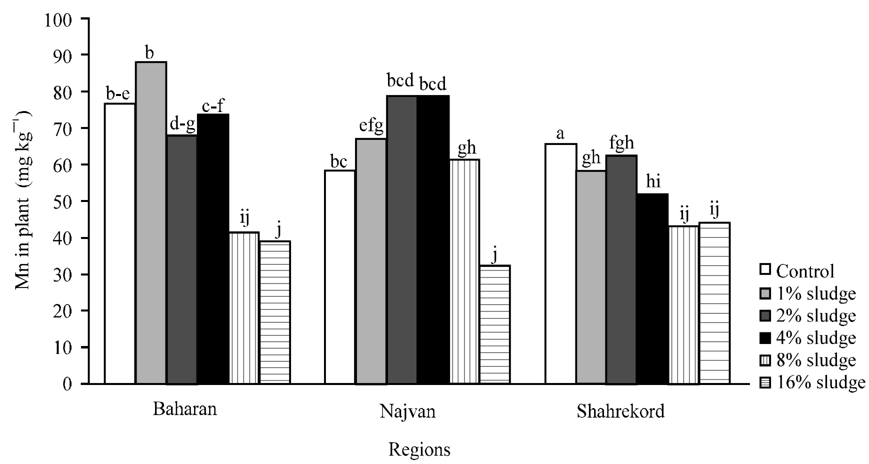

Fig. 6: Effect of sewage sludge on Mn concentration of parsley. Means with different letters are significantly different at 5% level test (LSD = 11.48)

concentration in vegetables received organic manure in comparison with those which were treated only by chemical fertilizer. Effect of organic manure on iron absorption can be due to the fact that organic manure enjoys low-consumption elements such as iron and is a kind of energy source for soil microorganisms. In addition, by releasing the organic acids during the process of mineralization, organic manure leads to local reduction of the soil pH and increase of iron absorption by plant (Ouda and Mahadeen, 2008).

Concentration of Mn in plant: Comparison of the averages revealed that usage of sewage sludge on concentration of the plant manganese had no clear procedure (Fig. 6). In Baharan soil, usage of 1% led to increase of the plant manganese concentration which was not significant. In Najvan soil, usage of sewage sludge in amount of 1, 2, 4 and 8% increased the plant manganese which was significant only in usage of 8 and 1%. Based on the report of Dolgen *et al*. (2007), using sewage sludge, increased the amount of manganese, zinc and iron in leaves of cucumber.

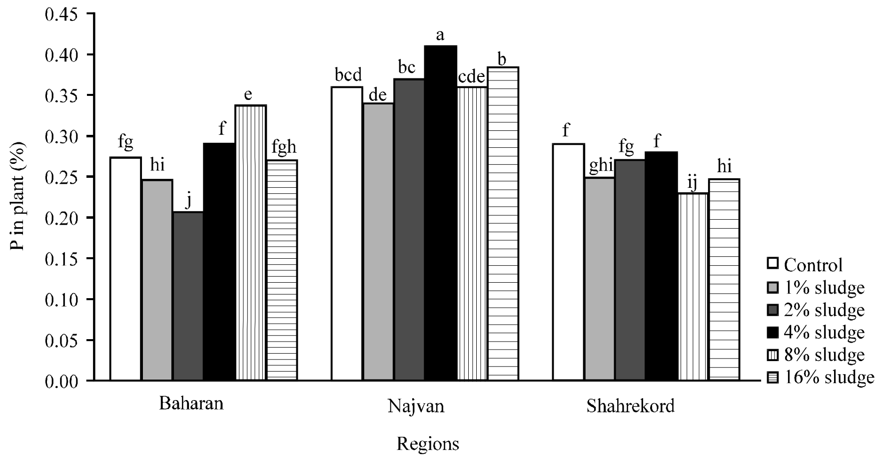

Fig. 7: Effect of sewage sludge on P concentration of parsley. Means with different letters are significantly different at 5% level test (LSD = 0.025)

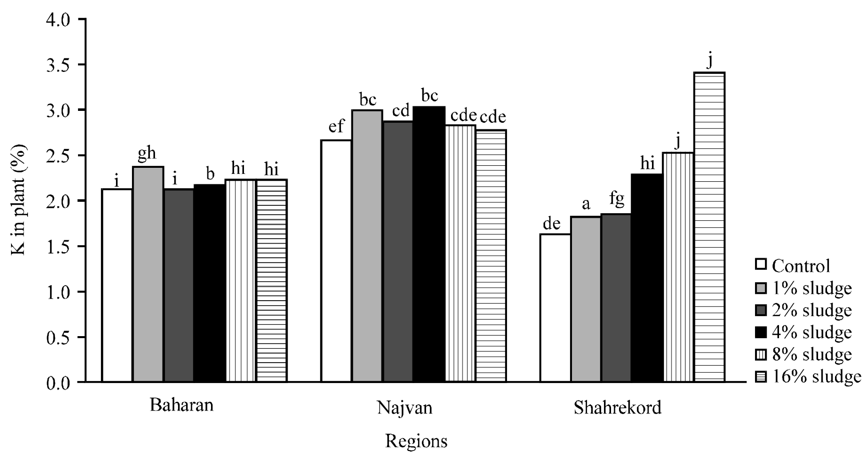

Fig. 8: Effect of sewage sludge on K concentration of parsley. Means with different letters are significantly different at 5% level test (LSD = 0.20)

Concentration of P in plant: Comparison of the averages revealed that in soils of Najvan and Baharan, usage of sewage sludge on concentration of the plant phosphor had no clear procedure. Only in treatment usage of 8, 4, 2 and 1% of Najvan soil and usage of 8, 4 and 16% of Baharan soil, the concentration of phosphor in plant was increased (Fig. 7). In Shahrekord soil, usage of sewage sludge in amount of $1% increased the plant phosphor, although this increase was significant just in usage of 1, 8 and 16% of sewage sludge. The studies showed that increase of organic matters can improve the phosphor absorbability and increase its usage efficiency Cherr *et al*. (2006). Different researchers reported the increase of plant phosphor concentration because of addition of sewage sludge (Morera *et al*., 2002).

Concentration of K in plant: As shown in Fig. 8, usage of sewage sludge in the three soils increased the plant potassium concentration which was significant in Baharan soil in usage of 1% and 4% and in Najvan in treatment usage of 2, 1 and 4% in comparison with control group (Fig. 8). The most concentration of the plant potassium was related to the treatment of 16% of

Shahrekord with amount of %3/40. Increase of the potassium concentration is probably because of its high concentration in sewage sludge and increase of organic matter. Cogger *et al*. (2001) reported that sewage sludge led to increase of potassium in herbal tissues but it was not significant.

CONCLUSION

Using the sewage sludge can increase its electrical conductivity in comparison with the control. These variations were in accordance with the amount of sludge usage generally. In Shahrekord area, application of sewage sludge increased concentrations of Fe in parsley. However, sewage sludge application significantly decreased by 51-95% the concentrations of Mn in three soils.

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