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Effect of application of sewage sludge and two synthetic humic acids on selected chemical properties of three soils

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ABSTRACT: In order to compare the effects of sewage sludge and synthetic humic materials application on selected soil chemical properties, an incubation experiment was carried out in a completely randomized design with 10 treatments and three replications under greenhouse conditions. Results showed that the application of these organic materials increased EC, SOM and CEC but decreased pH significantly compared to the control. The extent of these changes depended on soil type, kind of treatment and application rates. the changes were usually significant at the application rate of 4%. In this regard, the effect of sewage sludge was more than humic acids.

Keywords: Humic acids, sewage sludge, soil chemical properties.

INTRODUCTION

In arid and semi-arid regions such as Iran, the distinct feature of most cultivated soils are low organic matter content and, generally, have poor productivity. Consequently, soil application of organic wastes and humic materials to supply at least a part of the plant nutrient requirement and improve the physical and chemical properties of soil is highly important (Maftoun and Moshiri, 2008). Use of wastes in agriculture and land reclamation has been increasingly gained importance for soil fertility, soil conservation and residue disposal. Using wastes in agriculture helps not only to dispose these materials economically, but also reduces negative effects of these materials on the environment. Sewage sludge, due to its high content of organic matter and plant nutrients, is considered as an effective material to improve soil fertility (Sort and Alcañiz, 1999; Tsadilas et al., 2005; Weber, 2007). Shuman (1998) reported that sewage sludge increased the soil's cation exchange capacity (CEC). Navas *et al.* (1998) reported that soil organic carbon content of soil changed from 0.81% in control to 1.38% in treatments as the result of high rates of sewage sludge application. Decomposition of organic matter in the wastes and production of organic acids, decreases the soil pH (Mkhabela and Warman, 2005) and consequently increases the availability of micronutrients for plant uptake (Brady and Weil, 1996). On the other hand, high soluble salt content of sewage sludge increases EC of soil, that is unsuitable for plants and microbial activities (Moldes *et al.,* 2007). Synthetic humic materials are relatively new soil amendments that can supply organic matter to soils and improve soil quality and productivity. Several studies have revealed that synthetic humic materials can improve roots, shoots and leaves growth by increasing the uptake of nutrients. In addition, the benefits of humic materials compared to organic wastes such as sewage sludge and manure are numerous. Synthetic humic materials do not contain heavy metals, soluble salts, weed seeds, pathogens, and pests (Maftoun and Moshiri, 2008).

Due to the severe limitation of the quantity and quality of organic fertilizers to amend agricultural soils in Iran, production and use of synthetic humic materials will be inevitable in future. The objective of this study was to compare the effects of 3 rates of a sewage sludge and 2 synthetic humic acids application on selected chemical properties of 3 soils.

MATERIAL AND METHODS

Soil samples: Soil samples were collected from soil surface (0-30 cm) of 3 soils in Khatoun abad farm (a silty clay), in Falavarjan region (a clay loam) and Zayandehrud bank (a sand). All soil samples were air-dried and sieved to <4 mm.

Sewage sludge and synthetic humic materials: Sewage sludge (SS) was collected from Zeinabieh sewage treatment facilities, located in North of Isfahan. Locally produced (Iranian) synthetic humic acid (LHA) produced from Leonardite by a Sabz Arsham Yazd company and imported synthetic humic acid (IHA) called Agri Hume produced by Black Earth company. Samples of SS, LHA and IHA were air-dried and passed 2 and 4-mm sieves for chemical analysis and incubation study, respectively.

Experimental: This study was conducted under greenhouse conditions at the greenhouse of Faculty of Agriculture of Islamic Azad University, Khorasgan Campus. An incubation experiment was conducted in a completely randomized design with 3 soils (a silty clay, a clay loam and a sand), 10 treatments and 3 replications. The treatments were the control (without addition of amendment) and application of SS, LHA and IHA at 3 rates (1, 2 and 4% of soil dry weight). Amendments were completely mixed with 2 Kg soil sub sample and transferred into the incubation containers and moistened to 60% of water holding capacity of each soil and incubated at greenhouse temperature (10-25°C) for 4 month. After the incubation period, soil of each container was air-dried and crush to pass 2-mm sieve and stored for chemical analysis.

Laboratory analysis: Soil organic carbon was determined by the Walkley-Black method (Walkley and Black, 1934). Cation exchange capacity (CEC) was determined using sodium acetate method (Shuman, 1998). pH and electrical conductivity (EC) were measured in the saturation extracts according to Demiralay (1993) and Rhoades (1996).

Data analysis: All the statistical tests were performed using SPSS software. The Duncan's multiple range test was used for mean separation, at the level of significance $\alpha = 0.05$.

RESULTS AND DISCUSSION

Selected soils and amendments properties are presented in Table 1.

A. Effect of treatments on soil pH

The results showed that SS, LHA and IHA application decreased pH of all 3 soils, however, the magnitude of the decrease depended both on the kind and rate of amendment used. The highest decrease was observed for SS and 4% rate in all 3 soils (Table 2). It can be due to the lower pH value and higher OM content of SS as compared to humic acids (Table 1). Decomposition of organic matter in SS produces organic acids in process of mineralization resulting in decreasing the pH (Veeresh *et al*, 2003). Soil pH reduction of soil as the result of organic wastes application has been reported by several researchers (Angin and Yaganoglu, 2011; Cheng *et al.*, 2007; Navas, 1998).

Effect of LHA on pH reduction was significantly higher than IHA (Table 2). pH is a critical soil parameter; Because it significantly affects the bioavailable forms of metals and consequently, plant growth and soil organisms activities (Guidi *et al.*, 1983).

Table 1: Selected properties of soils, SS, LHA and IHA used in the study.

Parameter	Unit	Soil Texture			SS	LHA	IHA
		SiC	CL	S			
Clay	%	42	39.5	4	-	-	-
Silt	%	45	45	1.5	-	-	-
Sand	%	13	15.5	94.5	-	-	-
EC	dS/m	4.5	4	3.2	7.05	6	1.64
pH	----	8.5	8.1	8.4	7.85	5.8	2.9
CEC	Cmol / kg	10.9	11.9	1.7	415	283.4	305.9
OM	%	-	-	-	54	36.4	48.8

SiC, silty clay; CL, clay loam; S, sand; SS, sewage sludge; LHA, locally(Iranian) produced humic acid; IHA, imported humic acid; OM, organic matter; CEC, cation exchange capacity; EC, electrical conductivity.

Table 2: Effects of sewage sludge and humic acids application on pH of soils.

Treatment	Rate (% of soil weight)	Soil Texture		
		Soil 1 (SiC)	Soil 2 (CL)	Soil 3 (S)
Control	0	8.7[abc]	7.7[a]	7.8[b]
LHA	1	8.6[bcd]	7.62[bc]	7.6[d]
	2	8.5[de]	7.61[bc]	7.5[e]
	4	8.3[f]	7.5[cd]	7.3[f]
IHA	1	8.9[a]	7.7[ab]	7.9[a]
	2	8.7[abc]	7.6[abc]	7.7[cd]
	4	8.6[cde]	7.5[d]	7.5[e]
SS	1	8.7[ab]	7.7[ab]	7.7[bc]
	2	8.5[de]	7.5[cd]	7.6[cd]
	4	8.4[ef]	7.3[e]	7.2[g]

SiC, silty clay; CL, clay loam; S, sand; SS, sewage sludge; LHA, locally(Iranian) produced humic acid; IHA, imported humic acid; OM, organic matter; cation exchange capacity; EC, electrical conductivity. Values followed by the same letter are not significantly different at $P < 0.05$.

B. Effect of treatments on soil EC

Application of all 3 amendments significantly increased soil EC at all 3 rates of application and in all 3 soils. The magnitude of increases depended on both the kind and rate of amendments applied. The highest and the lowest increases were the result of SS and IHA applications, respectively (Table 3). The amount of increases also depended on the initial EC (EC of control) of the soil. The increase in EC of soils was mainly due to the presence of soluble salts in amendments (Table 1). Presence of soluble salts that have originated from foods or detergent compositions in SS and soluble salts (containing N, P, K) in LHA are the reason for high EC of these amendments (Table 1). This also could be due to the mineralization of organic matter in the amendments especially SS that results in release of organic acids and other inorganic ions. Ahmed *et al.* (2010) reported that soil electrical conductivity increased significantly when sewage sludge was applied to soil. They attributed this to the formation of metallic salts (complexes of organic matter and heavy metals).

C. Effect of treatments on soil OM

Application of SS, LHA and IHA significantly increased OM content in all 3 soil, however, the magnitude of increases depended both on the kind and rate of amendment application in each soil (Table 4). The highest and the lowest increases were obtained by application of IHA and LHA, respectively with SS having intermediate effect. The magnitude of effect on OM content depended not only on the OM content of amendments (Table 1) but also on the amount of easily decomposable OM content of the amendment. Although SS contains the highest OM content (Table 1) but it is likely that a higher portion of its OM is easily decomposable as compared to IHA that has lower OM. Easily decomposable OM decomposes rapidly during the incubation period and therefore results in lower residual OM content after incubation. It seems that IHA has the highest amount of Similar results were reported by several researchers (Albiach *et al.,* 2001; Cheng *et al.,* 2007; Hernández-Apaolaza *et al.,* 2005; Tsadilas *et al.,* 2005).

Table 3: Effect of sewage sludge and humic acids application on EC (dS/m) of soils.

Treatment	Rate (% of soil weight)	Soil Texture		
		Soil1(SiC)	Soil2(CL)	Soil 3(S)
Control	0	4.1^{f}	5.2^{e}	1.9^{e}
LHA	1	5.6^{d}	6.0^{d}	3.9^{c}
	2	6.1^{c}	7.1^{c}	4.2^{c}
	4	7.9^{b}	7.6^{bc}	4.23^{c}
IHA	1	4.4^{ef}	5.3^{e}	2.4^{de}
	2	4.7^{e}	5.9^{d}	2.49^{d}
	4	4.9^{e}	6.2^{d}	2.57^{d}
SS	1	4.4^{ef}	6.28^{d}	4.4^{c}
	2	6.6^{c}	7.8^{b}	5.7^{b}
	4	8.7^{a}	8.6^{a}	7.8^{a}

SiC, silty clay; CL, clay loam; S, sand; SS, sewage sludge; LHA, locally(Iranian) produced humic acid; IHA, imported humic acid; OM, organic matter; cation exchange capacity; EC, electrical conductivity. Values followed by the same letter are not significantly different at $P < 0.05$.

Table 4: Effect of sewage sludge and humic acids application on OM content (%) of soils.

Treatment	Rate (% of soil weight)	Soil Texture		
		Soil 1 (SiC)	Soil 2 (CL)	Soil 3 (S)
Control	0	2.1^{d}	1.1^{d}	1.5^{d}
LHA	1	2.2^{cd}	1.3^{cd}	1.63^{cd}
	2	2.6^{bc}	1.5^{bc}	1.66^{bcd}
	4	2.8^{b}	1.6^{bc}	1.83^{bc}
IHA	1	3.3^{a}	1.7^{b}	1.8^{bc}
	2	3.4^{a}	2.2^{a}	1.9^{b}
	4	3.7^{a}	2.3^{a}	2.3^{a}
SS	1	2.5^{bcd}	1.4^{bcd}	1.6^{cd}
	2	2.8^{b}	1.5^{bc}	1.7^{bcd}
	4	3.7^{a}	2.3^{a}	2.5^{a}

SiC, silty clay; CL, clay loam; S, sand; SS, sewage sludge; LHA, locally(Iranian) produced humic acid; IHA, imported humic acid; OM, organic matter; cation exchange capacity; EC, electrical conductivity. Values followed by the same letter are not significantly different at $P < 0.05$.

They showed that organic matter content of soil was increased by application of sewage sludge application rates. Especially, the OM content become more important in sandy soils, due to increase cation exchange capacity (CEC), soil water holding capacity, improve soil physical properties and supply plant nutrients. Also the results also indicated that, at all application rates, the effect of IHA on OM content of soil was significantly higher than LHA (Table 4), apparently due to the higher OM content of IHA as compared to LHA (Table 1).

D. Effect of treatments on soil CEC

Application of all 3 amendments increased CEC in 3 soils. The increases, however, depended on the kind and rate of amendments application (Table 5) and was somewhat different in 3 soils. Increases were significantly higher compared to the control) for all 3 amendments and all 3 rates in soils 1 and 2. The increases were, however, higher in all treatments in soil 1 compared to soil 2. In soil 3 the increases were only significant for all rates of IHA and 4% rate of SS applications. The increases in CEC is apparently due to high CEC of amendments (Table 1) and amount of easily decomposable portion of OM in the amendments. SS has the highest CEC but increase in CEC of soils due to its application is more or less similar to the increase of IHA indicating higher easily decomposable OM in SS as compared to the humic acids. Angin *et al.* (2012) also reported that cation exchange capacity (CEC) of soil was increased by application of sewage sludge. This could be related to the high CEC value of sewage sludge itself and the increase of adsorption surfaces as the result of SS application.

Table 5. Effect of sewage sludge and humic acids application on CEC (Cmol/Kg) of soils.

Treatment	Rate (% of soil weight)	Soil Texture		
		Soil 1(SiC)	Soil 2 (CL)	Soil 3 (S)
Control	0	12^{f}	12.3^{f}	1.8^{e}
LHA	1	16.4^{de}	13.6^{de}	2.5^{cde}
	2	16.6^{cde}	13.9^{cde}	2.1^{cde}
	4	17.3^{bcd}	14.4^{ab}	2.2^{bcd}
IHA	1	17.2^{bcd}	14^{bcd}	2.3^{bc}
	2	17.5^{abc}	14.1^{bc}	2.5^{b}
	4	17.9^{ab}	14.4^{ab}	2.8^{a}
SS	1	15.9^{e}	13.5^{e}	1.9^{de}
	2	16.6^{cde}	14.1^{bc}	2.1^{cde}
	4	18.2^{a}	14.6^{a}	2.3^{bc}

SiC, silty clay; CL, clay loam; S, sand; SS, sewage sludge; LHA, locally(Iranian) produced humic acid; IHA, imported humic acid; OM, organic matter; cation exchange capacity; EC, electrical conductivity. Values followed by the same letter are not significantly different at $P < 0.05$.

CONCLUSIONS

Results obtained in this study showed that application of sewage sludge and humic acids increased EC, SOM and CEC and decreased pH in 3 soils with different textures. The extent of these changes depended on kind and rate of amendments application and soil texture. Since SS is less expensive and showed similar or sometimes better results in amending soil chemical qualities then it is economically preferable compared to the humic acids. However, application of SS can results in heavy metal, chemical and microbial pollution of soil and could be environmentally harmful in long run. With respect to limited sources of organic fertilizers in Iran use of synthetic humic materials is recommended. More research is required to investigate long term application of humic materials on soil physical, chemical and biological properties.

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