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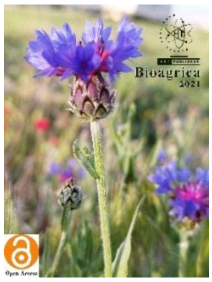

The effect of vermicompost and bentonite modified with surfactant on Cd concentration of the plant cultivated in a silt-loam soil

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Abstract

Soil pollution with heavy metals is one of the main environmental problems. This study aimed to investigate the effect of vermicompost and bentonite modified with surfactant for cadmium availability in silt-loam soil. Experimental treatments included the application of 0.15 and 30 mg/ha of vermicompost, compost-contaminated soil in the amounts of 0, 5, 10, and 15 mg Cd/kg soil and the application of surfactant modified bentonite clay in the amount of 0 and 30 g of soil. The plant used in this experiment was corn. After 60 days, Cd concentration in the corn was measured. The results of this study showed that the application of 30 g/kg of surfactant-modified clay and 30 t/ha of vermicompost had an effective role in reducing the amount absorbed by the soil, although the use of clay has been able to further reduce Cd that the plant absorbs. The overall results of this study indicate that in the long run, the decomposition of organic compounds may cause the re-entry of heavy metals into the soil. Still, the use of natural soil clays can help reduce the toxic effects of heavy metals on the plant.

1. Introduction

Soil pollution with heavy metals as one of the human environmental problems has been considered by many researchers in the last few decades (Zhang *et al*., 2020). Unlike organic pollutants, which may be decomposed into less harmful components as a result of biological or chemical processes, heavy metals are not degraded by natural and biological processes, especially when the metal is elemental. Currently, one of the main challenges in the environment is the gradual increase in the concentration of heavy metals due to their non-decomposition by microorganisms which can pose serious risks to human health and other living organisms (Zheng *et al*., 2020). On the other hand, discharge of industrial and agricultural effluents along with landfilling of sludge and consumption of sewage sludge or municipal waste compost in agricultural areas recorded many changes in the physical, chemical, and biological quality of soil and consequently increased uptake and contamination of heavy metals in plants and crops such as wheat and rice (Yang *et al*., 2018; Jafarinia *et al*., 2018). the most important contaminating minerals are heavy metals including lead, mercury, zinc, cadmium, chromium, copper, nickel, aluminum, etc (Heidarzadeh *et al*., 2020) which can affect both human food and animal forage quality (Ahmadi *et al*., 2013).

One of the main sources of heavy metal production in cities is automobiles, which pollute the soil around the roads by producing pollutants and introducing them into the environment, especially in the air. In addition, the release of heavy metals Pollutants, are smelting of industrial waste metals and sediments of car batteries. Among these, cadmium is one of the metals that due to high mobility can enter the groundwater (Wen *et al*., 2020). Therefore, it seems necessary to stabilize heavy metals in the soil and reduce their absorption by plants. In the meantime, the use of soil clays can be a good solution to reduce the availability of heavy metals in the soil. Also, the use of organic fertilizers such as vermicompost can help to increase the plant's resistance to abiotic stresses. This study was conducted with the aim of the effect of vermicompost and surfactant-modified bentonite on the availability of cadmium in silt-loam soil.

2. Materials and methods

This study was performed as a potting experiment with the aim of the effect of vermicompost and bentonite modified with surfactant as a factorial experiment. Experimental factors included the application of 0, 15, and 30 t/ ha of vermicompost, fertilizer, cadmium contaminated soil in the amounts of 0, 5, 10, and 15 t/ kg soil and the application of surfactant-modified bentonite clay in the amount of 0 and 30 g/ kg soil. To investigate the effect of the adsorption properties of vermicompost and clay on the ability of Cd sorption by plants, a soil with a low percentage of lime, organic carbon, and low electrical conductivity was selected. Selected physic-chemical properties are shown in Table 1.

Table 1. Selected physic-chemical properties of soil and vermicompost.

Soil		Vermicompost	
pH	7.1	pH	8.4
EC (dS^{-1})	1.3	EC (dS^{-1})	7.5
Organic Carbon (%)	0.2	Organic carbon (%)	23.4
Soil texture	Silty-Loam	Total N (%)	1.2
$CaCO_3$ (%)	7	Available Zn (mg kg^{-1})	111.17
Total Pb (mg kg^{-1})	ND	Available P (mg kg^{-1})	1.75
Total Cd (mg kg^{-1})	ND	Total Pb (mg kg^{-1})	3.1
CEC (c mol/ 100 g soil)	11.3	Total Cd (mg kg^{-1})	1.2

Surfactant-modified bentonite clay was added to the soil in the amount of 0 and 30 g and then the soil was contaminated with Cd at the rates of 0, 5, 10, and 15 mg Cd/kg soil and allowed for two weeks. On the other hand, vermicompost fertilizers in the amounts of 0.15 and 30 t/ ha were added to the soil after two weeks and the treatment moisture was maintained at 70% of the field capacity and the samples were wetted and dried regularly for two weeks. After this period, 5 kg pots were selected for sowing seeds of corn plants (single cross 704). During the growth of the plant, the pots were watered evenly every 3-4 days and during the experiment, all the plants were tried to be in the same environmental conditions. After 60 days, the plant was harvested and the cadmium concentration in the shoot was measured. Statistical analysis of data was performed using SAS software and comparisons of mean cadmium concentrations in plant organs were examined by the Duncan test and graphs were drawn using Excel software.

3. Results and discussion

The highest cation exchange capacity of the soil was observed in treatments of 30 t/ha vermicompost. A possible reason for this could be the high amount of organic carbon in vermicompost. Application of 15 and 30 t/ha vermicompost fertilizer caused an increase of 20.41 and 34.38% in the cation exchange capacity of soil compared to soil without vermicompost. Putwattana (2010) studied the effect of cow manure application on soil cation exchange capacity and concluded that the addition of cow manure increases the exchangeable cation capacity and thereby decreases the heavy metal availability (Putwattana *et al*. 2010). Bagheri (2015) in a study of the effect of iron slag and vermicompost on changing the availability of cadmium in a cadmium-contaminated soil concluded that the use of vermicompost increases the soil organic carbon and decreases the soil and plant Cd concentration (Bagheri *et al*. 2017). The results of the research of Baghaie *et al*. (2016) indicated that organic fertilizers can play a very important role in soil organic matter supply due to the large amounts of organic compounds (Baghaie *et al*. 2016; Hassanvand *et al*., 2019).

The highest shoot Cd concentration was observed in the treatment without receiving any organic amendments. Applying 15 and 30 t/ ha of vermicompost showed a decrease in plant Cd concentration by 14.61 and 25.98%, respectively (Figure 1).

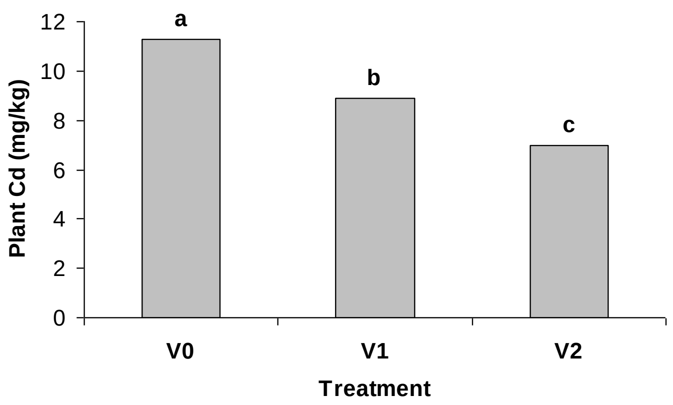

Figure1. Effect of treatments on plant Cd concentration, V0, V1 and V2 are applying 0, 15 and 30 Mg/ha vermicompost respectively.

Based on the results of this study, the application of vermicompost has been able to play an important role in reducing the absorption of cadmium by the plant, which can probably be attributed to the role of the application of this fertilizer in increasing soil absorption properties and thus reducing the availability of cadmium in soil and plants. Organic residues generally contain different compounds such as organic matter, metal oxides, and anions that lead to the adsorption or deposition of heavy metals and can reduce the availability of these elements in contaminated soils and prevent their transfer to plants (Baghaie, *et al*., 2018).

The results of this study showed that the simple effect of using surfactant-modified clay had an important role in reducing the uptake of cadmium by the plant (Figure 2). Based on the results of this study, the addition of 30 g/ kg soil-modified bentonite clay caused a 19.25% decrease in cadmium concentration compared to the treatment without clay. 2:1 clays, due to their high porosity and high adsorption properties, have increased the soil absorption capacity and reduced the availability of cadmium in the plant.

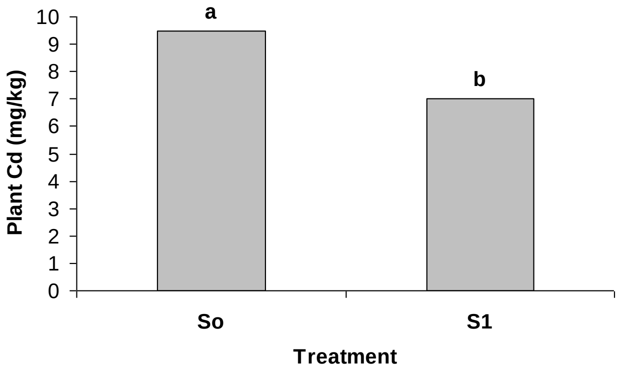

Figure2. The effect of applying clay on plant Cd concentration, S_0 and S_1 are clay applying at the rates of 0 and 30 kg clay/kg soil respectively.

The interaction effect of vermicompost and surfactant-modified clay application also had a significant effect on reducing the availability of cadmium in the plant (Figure 3). The highest amount of cadmium in the plant belonged to the treatment that did not contain vermicompost, and modified bentonite clay with surfactant, while the lowest amount of cadmium absorbed by the plant belonged to the treatment with the highest amount of vermicompost and clay. The results also show that clay had more reduced amount of cadmium absorbed by the plant compared to vermicompost, which can be considered a positive point in environmental studies, On the other hand, the decomposition of this fertilizer in the long run can cause the return of metals to the soil, which should be considered by environmentalists.

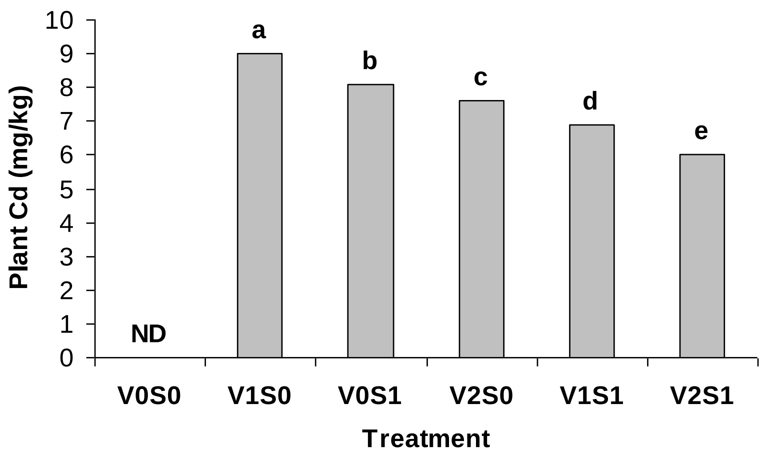

Figure3. the interaction effect of applying clay and vermicompost on plant Cd concentration, Vo, V1, and V2 are applying 0, 15, and 30 Mg/ha vermicompost, S0 and S1 are clay applied at the rates of 0 and 30 kg clay/kg soil respectively. Nd: Not detectable by atomic absorption spectroscopy.

4. Conclusion

Based on the results of this study, the simple effect of applying 30 t/ha of vermicompost and 30 g/kg soil surfactant-modified bentonite clay had a significant effect on reducing the uptake of cadmium by the soil. Also, the interaction effect of these treatments has shown similar results, which can be an important point in the environmental discussion. Since the solubility of heavy metals is affected by soil properties, it is necessary in future studies to investigate the role of soil properties in the availability of heavy metals in soil and plants.

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