Effect of Soil Organic Matter on Pb and Cd Enriched Waste Water after Passing through a Calcareous Soil

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Abstract: *Groundwater contamination and plant uptake which may result in an accumulation of heavy metals in the food chain and thus in adverse effects on living organisms are of major concern. Heavy metals may pose various risks to the environment. This study was conducted to evaluate changes of chemical properties of Pb and Cd enriched municipal wastewater after passing through soil columns with different levels of vermicompost in Yasouj University in 2012. Polyethylene columns (80 cm in length and 8 cm in diameter) filled with a clay loam soil. A completely randomized design was used. Enriched municipal wastewater with Pb (40 mgl^{-1}) and Cd (20 mgl^{-1}) was added to soil columns during 8 periods of 10 days followed by the measurement of chemical properties of drainage water in each stage. After the final stage soil samples were taken from the depths of 0-20 and 40-60 cm of soil columns and were analyzed. Experimental treatments consisted of 3 levels of vermicompost comprising control (V1), 2% (V2) and 4% wt (V3) and time in 8 levels with 3 replications. The results indicated that vermicompost and time have significant effects on chemical properties of drainage water. Treatment V3 showed a significant effect on pH, EC, cations and anions concentrations, P (soluble), N (nitrate), total organic carbon and the amount of Pb and Cd in drainage water. All measured properties except for pH showed decreasing trends with time. Nitrate and chlorine concentrations exhibited a great increase in drainage water of the two last stages. A decreasing trend was observed in drainage pH until the sixth stage followed by an increase. Cd concentration in drainage water was larger in the first two stages of experiment compared to Pb (especially in treatment V3). The results of the soil analyses showed that soil depth has significant effect on soil chemical properties. The effect of vermicompost on the amounts of Na, K, Ca, Mg, Cl, HCO_3^-,pH (Pb column), P, organic carbon and Cd was significant. Significant increase of Na and K (treatments V2 and V3), Cl (treatment V1), nitrate and phosphate (treatments V2 and V3), organic matter (treatment V3 of Cd column), Cd and Pb (treatment V1) was observed at surface depth of 0-20 cm compared to lower depth of 40-60 cm. Larger contents of pH, Cl (treatment V3) and HCO_3^- (treatment V3 of Cd column) was measured in depth of 40-60 cm. It seems that organic matter has a drastic effect on increasing mobility of Cd and Pb as well as on the other studied characteristics, hence soil organic matter content should be considered in the usage management of wastewater in soils rich in organic matter.*

Keywords: *calcareous soil, cadmium, drainage water, lead, vermicompost, waste water.*

1. Introduction

The application of sewage sludge to land is, in principle, an effective disposal method. Not only does it provide a solution to the sludge disposal problem, but it can prove to be beneficial to agricultural productivity[1]–[2]. The presence of heavy metals, such as Cd, Zn, Cu, Ni, Cr and Pb, is the most critical long-term hazard when applying sludge to land [3]. Soils accumulate heavy metals when sewage sludge is applied to land for disposal or intended beneficial use.Sewage sludge contains organic matter and nutrients that have the potential to enhance forest productivity and several soil characteristics [4]–[5]. However, sewage sludge addition always poses a risk to the environment resulting from nutrient imbalances and toxic element accumulation and leaching. Metal transfer from sewage sludges to soil and subsequently to groundwater and plants represents potential health and environmental risks [6]–[7]. Heavy metals are often highly persistent in soil, with residence times as long as thousands of years [8]. Metals applied with sewage sludge may be retained in the soil as a result of their adsorption on hydrous oxides, clays, and organic matter; the formation of insoluble salts; or the presence of residual sewage sludge particles[9]. Moreover, soil $CaCO_3$ has often been found to increase soil metal retention [10]; thus, in basic soils metal persistency is expected to be generallyvery high.Because of the concern

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over the environmental danger that these sludge-borne metals could represent if mobilized, many studies have been performed in an attempt to clarify the different factors that contribute to metal solubility, plant uptake and leachability. The objectives of this study were to determine the effect of organic matter (vermicompost) on the amount of adsorption of heavy metals (Pb and Cd) by the soil columns as well as chemical changes of the municipal wastewater after passing through soil columns.

2. Materials and Methods

This study was conducted in Yasouj University in 2014. Polyethylene columns (80 cm in length and 8 cm in diameter) filled with a clay loam soil (Fig.1). Table I presents general characteristics of the studied soil. A completely randomized design was used. Enriched municipal wastewater with Pb (40 mgl^{-1}) and Cd (20 mgl^{-1}) was added to soil columns during 8 periods of 10 days followed by the measurement of chemical properties of drainage water in each stage. After the final stage soil samples were taken from the depths of 0-20 and 40-60 cm of soil columns and were analyzed. Experimental treatments consisted of 3 levels of vermicompost comprising control (V1), 2% (V2) and 4% wt (V3) and time in 8 levels with 3 replications.

Fig. 1: Polyethylene columns filled with the soil.

TABLE I: General characteristics of the studied soils

Sand	Silt	Clay	Texture	Calcium carbonate	pH (paste)	EC	CEC	OC	P (olsen)	K	N (nitrate)	Pb	Cd
%	%	%		%		dSm^{1-}	$cmol_{(+)}$ Kg^{-1}	%	mgl^{1-}	mgl^{1-}	mgl^{1-}	mgl^{1-}	mgl^{1-}
14.6	36.7	48.7	Clay loam	37.6	7.7	0.4	37	0.06	5.3	212	5.2	nd	nd

3. Results and Discussion

The results indicated that vermicompost and time have significant effects on chemical properties of drainage water. Treatment V3 showed a significant effect on pH, EC, cations and anions concentrations, P (soluble), N (nitrate), total organic carbon and the amount of Pb and Cd in drainage water. All measured properties except for pH showed decreasing trends with time. Nitrate and chlorine concentrations exhibited a great increase in drainage water of the two last stages. A decreasing trend was observed in drainage pH until the sixth stage followed by an increase. Cd concentration in drainage water was larger in the first two stages of experiment compared to Pb (especially in treatment V3). The results of the soil analyses showed that soil depth has significant effect on soil chemical properties. The effect of vermicompost on the amounts of Na, K, Ca, Mg, Cl, HCO_3^-,pH (Pb column), P, organic carbon and Cd was significant. Significant increase of Na and K (treatments V2 and V3), Cl (treatment V1), nitrate and phosphate (treatments V2 and V3),organic matter (treatment V3 of Cd column), Cd and Pb (treatment V1) was observed at surface depth of 0-20 cm compared to lower depth of 40-60 cm. Larger contents of pH, Cl (treatment V3) and HCO_3^- (treatment V3 of Cd column) was measured in depth of 40-60 cm (Figs. 2 and 3).

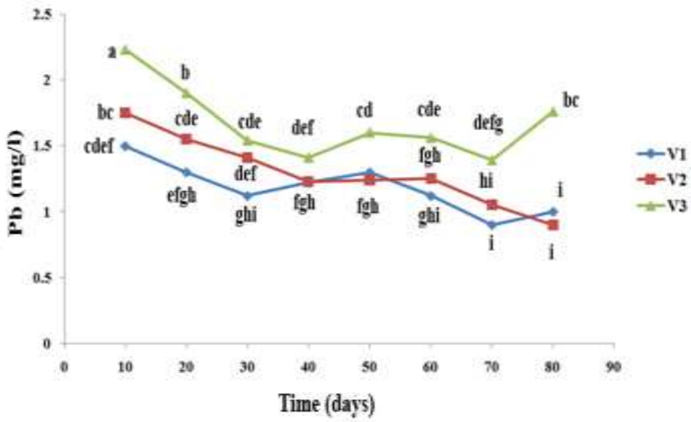

Fig. 2:Changes in the concentration of Pb in the outlet of the soil columns.

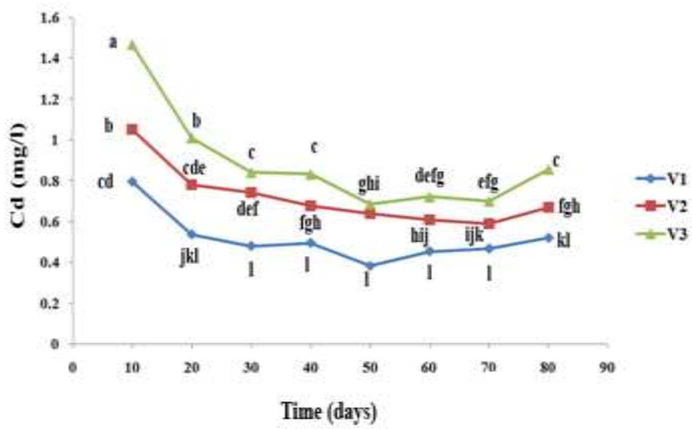

Fig. 3: Changes in the concentration of Cd in the outlet of the soil columns (Means having similar letter are statistically non-significant at 5% level)

4. Conclusion

Totally, the results showed that the maximum concentration of Pb and Cd, TOC and EC of the drainage water was in the first period and this trend was reduced in the subsequent periods. The reverse trend was observed for the pH. The highest concentration of Pb and Cdwas measured at a depth of0-20cmin soil columndue tothelowmobilityoftheseelements in thesoil profile. In both depths (surface and deep), more concentrations of Pb and Cd were adsorped by soil particles, in control treatment (V1), suggesting the positive role of vermicompost in enhancement of the mobility of these elements and more removal from soil columns. Higher ratio of Pb concentration in surface to deep layers compared with Cd showed lower mobility of this element. Therefore, care should be taken for the use of heavy metal containing wastewaters with high organic matter. More research is needed to evaluate the effect of different organic matters on mobility of heavy metals in the calcareous soils with different texture and organic carbon.

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6. References

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