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Heavy Metals Removal from Sewage Sludge and Municipal Solid Waste (MSW) by Co-Composting Process

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Background & Aims of the Study: One of the most important pollutants in drinking water, air and soils is heavy metals. It is very harmful for humans and other live organisms. The purpose of this study was the usage of a co-composting process for removal of heavy metals from municipal solid waste and sewage sludge.

Materials and Methods: This experimental study was a conducted sewage sludge and municipal solid waste. For collection of samples from urban solid waste composting and wastewater treatment plant, a 200 mL polyethylene bottles was used, samples after acidification were stored in a dark place at 4°C temperature until the metals analysis the heavy metals values remaining in the samples was measured by graphite furnace absorption spectrometer method (Varian, SpectrAA 240, Australia). In this study, we used SPSS version 16 for data processing; and they were also analyzed by descriptive statistics.

Results: Result of this study showed that values of C/N in the first, second and third stage compost were 31.7, 27.3 and 41.8, respectively. Based on the result of this study the value of removal of Cd with 9.8 mg kg^{-1} in first stage and Cr, Cu and Zn with 89, 21 and 87.6 mg kg-1 in third stage were highest treatment.

Conclusion: Our results show that co-composting process between many treatment processes having to be cost effective for heavy metal removal from solid waste and wastewater treatment.

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Background

In recent years, Municipal Solid Waste (MSW) and Sewage Sludge (SS) were two main factors in urban population (1,2). The residual material removed from wastewater treatment facilities is defined as a sewage sludge (3,4). Megacities in development countries opposed to MSW and SS (1,5). Composting process is one of the most important methods for removal of the organic and heavy metals content of solid waste (6-8).

Co-composting process was used for treatment of Heavy Metal (HM) from MSW and SS (7,8). Based on the result of different studies, the main parameters in the control of a composting process are moisture content, temperature, pH, C/N ratio, particle size, nutrient content and aeration (5,8-10). The major industries that use co-composting processes are olive mill wastes, winery and distillery wastes (8,11-13). Composting of Wastewater Treatment Plants (WTPS) has been practiced but co-composting of SS and MSW is not wide spread (14-16). Improving soil structure (soil conditioner or fertilizer) is the most important use of Compost material (17,18).

Aims of the study:

The aim of this study was the usage of a co-composting process for removal of heavy metals from municipal solid waste and sewage sludge in Mazandaran province (northern Iran), in 2015.

Materials & Methods

Experimental Design

In this study, an in-vessel system has been widely applied in Mazandaran province (northern Iran), in 2015. Samples were collected from urban WTP and Solid Waste Composting (SWC). Duration of composting process and nutrient contents are two important factors in the compost products, using bioreactor system. Samples were collected, using 200 mL polyethylene bottles that were washed two times with deionized water. All samples (60 samples) were acidified after transferring to the laboratory. Then, prepared sample stored in a dark place at 4°C temperature. Before analysis, we used filters by 0.45μm Millipore. Finally, Cr, Cd, Zn and Cu were measured by graphite furnace absorption spectrometer (AAS) method (Varian, AA 240, Australia) (19). Figure 1 shows the schematic of a typical in-vessel process.

Statistical Analysis

In this study, the collected data were entered into SPSS version 16. Data analysis were performed, using descriptive statistics (frequency, mean and standard deviation for each variable).

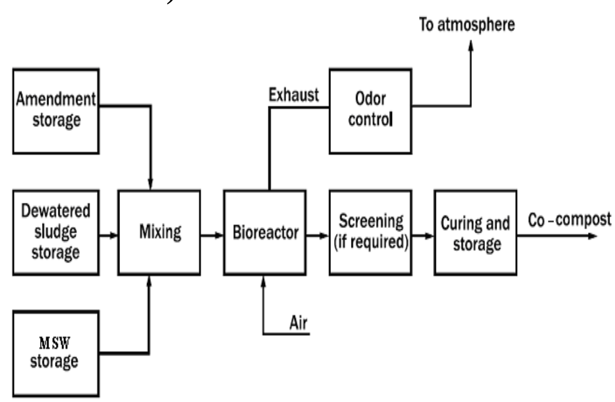

Figure 1) Schematic of in-vessel composting process

Results

In this study, the data of co-composting process for HM removal from MSW and SS was described. In-vessel systems is one of the expensive methods for composting process that can developed and widespread used for the safety of the production of green bio wastes. In Table 1 the chemical composition of clinoptilolite is presented (wt/wt%).

In Table 2, the value removal efficiencies of Cr, Cd, Zn and Cu is shown. C/N ratio in three co-composting stages showed in Figure 2. According to the result of this study, values of C/N in the first, second and third stage compost were 31.7, 27.3 and 41.8, respectively.

Table 1) The chemical and physical profile of clinoptilolite

Chemical content	
Mn	38.0 ppm
Cu	2.90 ppm
Zn	24.20 ppm
Sr	233.00 ppm
Mo	<1.00 ppm
Cr	6.00 ppm
Zr	22.50 ppm
Ba	65.00 ppm
B	<10.00 ppm
Salinity %	0.03
Lime	1.06
Water	45.60
Physical properties	
Balk density	1000-1200 Kg m-3
Unit volume weight	2150-2250 Kg m-3
Visible porosity (%)	39.40-44.20

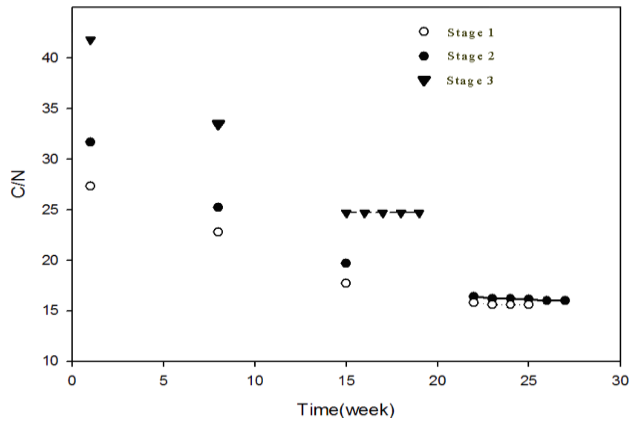

Figure 2) Time course of C/N ratio during stage 1 to stage 3

Table 2) Comparison of the removal of heavy metal at different stages with sludge

Heavy metals	Cd	Cr	Cu	Zn
	dry weight (mg kg^{-1})	dry weight (mg kg^{-1})	dry weight (mg kg^{-1})	**dry weight (mg kg^{-1})**
Stage 1	9.08	29.5	11.3	**42**
Stage 2	1.6	31.2	5.78	**37.8**
Stage 3	0.0	0.0	0.0	**2.17**
Sludge	1.42	89	21	**87.6**

Discussion

One of the most dangerous substances in waters, soils and sediments is heavy metals. Clinoptilolite usually used the most often compare to another natural zeolites. $(K_2, Na_2, Ca)_3$ $[Al_6Si_{30}O_{72}]$ • 24 H_2O is formula this zeolite (20). Semnan city of Iran is a center of concentrated natural clinoptilolite, selecting diameters of < 5 mm, which were washed by distilled water to remove turbidity and dried at room temperature. According to the result of this study, by adding the amount of sawdust in the third stage, C/N ratio causes an increase and reduction in the duration of compost production. Based on several studies, exposure to HM had toxic effects for humans and environment (2,13,21). Result of our study showed that co-composting process can be used as a cost-effective method for removal of other pollutants from solid waste and wastewater. Soil microbial biomass (SMB) and various enzyme activities can accumulated HM reduce. Clinoptilolite that is one of the natural zeolites, by ion exchange processes are effectively used for HM removal applications (2,4,5,8,13,19,21,22). Recycle of clinoptilolite not seemed to be valuable at first glance because of low cost mineral. However, developments of sustainable treatment technologies oblige no further waste production in addition to conservation of resources. Subsequently, regeneration of clinoptilolite would enable the recovery of both the sorbent and metal from the resulting concentrated regenerate solution. HM treatment by clinoptilolite can be used both forms natural/as-received and chemically modified/pretreated (2,4,5,8,13,19,21,22). Using clinoptilolite decreases heavy metals from SS in compost (Table 1). Sawdust dilutes metals and it also causes a decrease in concentrations of heavy elements in combined compost mass.

Conclusion

According to the result of this study, co-composting process between many treatment processes having to be cost-effective for solid waste and wastewater treatment. Result of this study showed that it can be used to design the co-composting process experiments for removal of wide range of heavy metals in solid waste and wastewater. The data presented here will be useful for the managers for proper treatment of produced SS and MSW.

Footnotes

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Conflict of Interest:
The authors declared no conflict of interest.

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