DYNAMICS OF SOME HEAVY METALS CONTENT IN FUR ANIMAL EXCRETA DURING COMPOSTING PROCESS

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ABSTRACT

Fur animal excreta, due to their high content of biogenic elements as well as the possibility of microbiological and parasitologic contamination, should not be applied directly as a fertilizer. The excreta properties can be improved in composting process. European Union legislation permits fertilization use of composted fur animal excreta.

The aim of the research was to determine the dynamics of some heavy metals content (Fe, Mn and Ni) during the composting process of coypu and chinchilla excreta. Composted were excreta without additions (control) as well as excreta with 20% and 40% addition of leaves and straw. The composting process was conducted in PVC containers in a closed place. The composting lasted 25 weeks. During that time moisture of the materials was kept at a constant level, and every two weeks the materials were mixed for aeration purpose. Samples of the materials were taken after 11, 13, 15, 23 and 25 weeks of the composting process. Heavy metals content was determined by ICP-AES method.

The heavy metals content in the examined composts was decreasing in order: Fe>Mn>Ni. While analyzing the heavy metals content in composts, as a rule the lowest content of elements was determined in composts with straw addition. Moreover, from among the three components used to prepare composts (excreta, leaves, straw), straw had the lowest content of heavy metals. In the whole composting period the compost without additions had the highest manganese content. Dilution of manganese content was observed in the composts with additions (manganese was the only of the analyzed elements whose content was higher in excreta than in both structural materials). Between the first and the last time of analyses (that is 11th and 25th week of composting) an increase in the content of the analyzed heavy metals in composts was observed as a rule. The increase ranged from 1% to 26% of the beginning content of particular elements. The increase in the content of heavy metals in composts can be explained by an organic matter mineralization process occurring during composting.

Key words: fur animal excreta, compost, iron, manganese, nickel

INTRODUCTION

Composting leads to improvement of smell and structure of the processed material, modification of its chemical composition and element bioavailability [Drozd et al. 1996, Drozd et al. 1999] but it also eliminates or diminishes the number of pathogenic microorganisms present in the composted substrate [Czekała et al. 2006, Wolna-Maruwka and Czekała 2007]. Fur animal excreta reveal a high content of biogenic elements [Kuźniewicz and Filistowicz 2006] and they are also often a carrier of pathogenic microorganisms and parasites. Because of their properties, unprocessed excreta from fur animals should not be used as a fertilizer. One of the methods the excreta properties improvement is their composting. Fertilizer application of fur animal manure processed through composting is permitted by the European Union legislation [Regulation (EC) of the European Parliament and of the Council of 3 October 2002 laying down health rules concerning animal by-products not intended for human consumption]. Also Polish legislation makes possible the use of compost produced from fur animal excreta (counted among organic fertilizers), however unprocessed excreta are not considered a fertilizer [Ustawa z dnia 10 lipca 2007 r. o nawozach i nawożeniu].

Chemical and biological properties of the material obtained in result of composting should be assessed before its environmental application, since composting not always diminishes the pathogenic microorganisms count [Wolna-Maruwka i Dach 2009]. Moreover, if the compost contains high concentrations of heavy metals, its fertilizer application may lead to soil contamination thereby causing heavy metal accumulation in plant and animal organisms [Filipek-Mazur 2004].

The investigations aimed at determining the dynamics of heavy metal (Fe, Mn and Ni) content in fur animal excreta subjected to composting with an addition of tree leaves and cereal straw.

MATERIAL AND METHODS

Coypu and chinchilla excreta were composted without supplements (the control objects) and with a 20 % and 40 % admixture of tree leaves and cereal straw. The dose of added structural materials was determined in relation to the excrement dry weight. The initial excreta weight in each object was 2 kg. The composts were placed in PCV containers and the composting process was conducted in a closed room for 25 weeks. During this period of time the material moisture was maintained on a constant level (the moisturizing degree was assessed organoleptically) and every two weeks the materials were mixed for aeration. The material samples for chemical analyses were collected after 11, 13, 23 and 25 weeks of the process duration. Detailed description of the composting conditions and chemical composition of components used for compost preparation were presented in a paper by Filipek-Mazur and Gondek [in print].

Heavy metal content (Fe, Mn and Ni) in the composts was assessed using ICP-AES method in JY 238 Ultrace apparatus. Dry and ground material was mineralized (8h, 450 ^{o}C) and subsequently evaporated with a mixture of concentrated HNO_3 acid and bidistilled water mixed in a 1:2 volumetric ratio. Following the renewed incineration (5h, 450 ^{o}C), the material was evaporated with 20 % HCl and subsequently with a mixture of HNO_3:H_2O (1:2). The remains were dissolved in a HNO_3:H2O mixture (1:2) and transferred, using bidistilled water, to measuring flasks. The assessments were made in two replications for each sample.

RESULTS AND DISCUSSION

Concerning the studied heavy metals, analyzed materials revealed the highest content of iron and the lowest of nickel (Tab.1-3). Heavy metal content in the composts was diminishing in the following order: Fe>Mn>Ni.

Tab. 1 The content of iron in the analyzed composts [mg · kg^{-1} d.m.]

Compost composition		Composting time [weeks]				
		11	13	15	23	25
Excreta		1150,82	1179,67	1292,16	1247,38	1446,17
Excreta with addition	20% leaves	1125,85	1145,27	1119,21	1113,88	1395,94
	40% leaves	1253,27	1279,83	1288,77	1415,50	1473,84
	20% straw	1245,53	1175,59	1143,91	1218,45	1349,43
	40% straw	1042,01	1026,37	1008,29	1167,82	1226,93

Tab. 2 The content of manganese in the analyzed composts [mg · kg^{-1} d.m.]

Compost composition		Composting time [weeks]				
		11	13	15	23	25
Excreta		229,66	239,44	242,36	296,71	276,64
Excreta with addition	20% leaves	224,79	234,54	223,12	237,20	256,06
	40% leaves	215,59	203,54	228,88	243,88	259,56
	20% straw	203,14	202,95	214,59	210,57	247,08
	40% straw	189,63	175,62	198,81	212,46	225,89

Tab. 3 The content of nickel in the analyzed composts [mg · kg^{-1} d.m.]

Compost composition		Composting time [weeks]				
		11	13	15	23	25
Excreta		4,30	3,98	4,20	4,32	4,36
Excreta with addition	20% leaves	3,22	3,15	4,29	3,40	3,51
	40% leaves	3,92	4,14	3,74	3,15	3,58
	20% straw	2,97	3,18	3,71	3,63	3,51
	40% straw	2,91	2,69	3,33	3,31	3,56

Analysis of chemical composition of the components used for compost preparation showed the smallest amounts of the studied heavy metals in cereal straw, which contained 121.53 mg Fe, 24.25 mg Mn and 0.66 mg Ni · kg^{-1} d.m. [Filipek-Mazur, Gondek – in print]. Tree leaves and fur animal excreta contained relatively approximate heavy metal contents. 972.53 mg Fe, 192.39 mg Mn and 3.94 mg Ni · kg^{-1} d.m. were found in the excreta, while the tree leaves contained 989.92 mg Fe, 125.99 mg Mn and 4.0 mg Ni · kg^{-1} d.m. [Filipek-Mazur, Gondek – in print].

Analysis of heavy metal content conducted in the subsequent weeks of composting revealed that the composts containing straw (particularly compost with a 40 % admixture) were generally characterized by lower concentrations of microelements than the composts with leaf supplement or without any admixtures (Tab. 1-3). It resulted from diluting heavy metal content in composts with a straw addition in effect of introducing to the excreta a structural material containing low amounts of microelements. During the whole period of composting, the compost without admixtures contained the highest amounts of manganese (Tab.2). In composts with straw and leaf admixture this element content became diluted (manganese was the only one among the analyzed elements, whose higher content was assessed in the excreta than in both structural materials). Excreta and leaves contained approximate quantities of iron and nickel, therefore combining these materials did not lead to any considerable diversification of iron and nickel content in the obtained composts (however, slightly higher iron concentration was noticeable in the composts with a 40 % leaf supplement than in the compost without any supplements or with a 20 % leaf admixture) (Tab.1, 3).

Increase in the analyzed heavy metal concentrations, between 1 % and 26 % of the initial content of respective microelements, was registered between 11th and 25th week of composting (Tab.1-3). The exception was compost with a 40 % leaf admixture, in which a 9 % decrease in nickel content was noticed (Tab.3). Increasing the mineral element content (including heavy metals) in compost results from organic matter decomposition [Czekała et al. 1999]. Also cadmium, lead, copper and zinc concentrations were assessed in the presented composts and these also generally were increasing during composting [Filipek-Mazur and Tabak – in print]. Kalembasa and Wysokiński [2004] also revealed such tendency of changes (concerning copper and zinc) during farmyard manure composting conducted for 3 months. On the other hand, after 90 days of chicken manure composting with wheat straw increased copper, zinc, iron and lead concentrations were registered at the lack of changes in manganese but a decline in cadmium, chromium and nickel contents [Drozd et al. 1999]. Both the increase and decrease in metal content during farmyard manure composting was noted by Larney et al. [2008]. Studies on composting of urban waste and sewage sludge (composted with structural organic materials) generally revealed elevation of heavy metal content (although in some cases a decline in microelement content was registered, too) [Czekała et al. 1999, Czekała and Sawicka 2006, Drozd et al.1996, Tabak – in print].

Presented investigations revealed a seasonal decrease in iron, manganese and nickel content (Tab. 1-3). Similar changes were observed also for the content of other heavy metals assessed in the discussed composts [Filipek-Mazur and Tabak – in print]. Occasional diminishing of heavy metal concentrations was observed also during composting of manure [Drozd et al. 1999, Larney et al. 2008], sewage sludge [Tabak – in print] and urban wastes [Drozd et al.1996].

Considering the three analyzed heavy metals, only permissible nickel content (60 mg Ni · kg^{-1} d.m.) was determined by Polish legislation [Rozporządzenie Ministra Rolnictwa i Rozwoju Wsi z dnia 18 czerwca 2008 r. w sprawie wykonania niektórych przepisów ustawy o nawozach i nawożeniu]. The studied composts contained considerably smaller concentrations of this metal (from 2.69 to 4.36 mg Ni · kg^{-1} d.m.). In view of nickel content all composts were allowed for the use in agriculture.

CONCLUSIONS

1. In the composts produced from fur animal excreta the highest among the analyzed microelements content of iron and the lowest content of nickel were determined. Heavy metal content in the composts was diminishing in the following order: Fe>Mn>Ni.
2. Admixture of structural material (straw) with a lower heavy metal content than assessed in fur animal excreta led to a decrease in these metal content in composts.
3. An increase in the content of analyzed heavy metals was revealed in the composts generally between the first and the last date of analyses (i.e. between 11th and 25th week of composting).

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