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ALUMINUM, LITHIUM, AND COBALT CONTENTS IN ORGANIC MATERIALS OF DIFFERENT ORIGINS

ZAWARTOŚĆ GLINU, LITU I KOBALTU W MATERIAŁACH ORGANICZNYCH RÓŻNEGO POCHODZENIA

Abstract: The study included bovine manure, bovine manure composts, bovine manure vermicomposts, sewage sludge and peat vermicomposts, vermicomposts with sewage sludge, peat, and poultry droppings addition, as well as mushroom substrate. Mean aluminum, lithium, and cobalt contents were as follows (in mg $\cdot$ kg^{-1} d.m.): bovine manure 755, 18.30, and 0.76, manure composts 2775, 16.3, and 1.15, manure vermicomposts 1039, 21.9, and 1.03, sewage sludge vermicomposts with peat 7135, 5.96, and 3.77, sewage sludge, peat, and poultry droppings vermicomposts 6187, 5.58, and 3.19, mushroom substrate 1686, 26.3, and 6.42.

Keywords: compost, vermicompost, mushroom substrate

Concentration, mechanization, and specialization of plant and animal production, progressive development of city agglomerations along with more strict sanitary requirements make that more and more biomass is shifted from agricultural ecosystems to urbanized ones, where they are accumulated as post-processing wastes. Among many ways to neutralize wastes, namely organic, their agricultural utilization is probably the most common. Increasing number of new and modernized sewage treatment plants in Poland causes that enormous amounts of sewage sludge with varied chemical composition and different levels of toxicity are disposed to the environment every year [1]. Neutralization of sewage sludge at maximum utilization of nutrients contained along with meeting the environment protection requirements, is a main purpose of searching for efficient ways of their processing [2].

Composting and vermicomposting of organic wastes may be a solution for part of wastes processing problem, and at the same time fertilizers with advantegous physico-chemical properties can be produced [1, 3–5].

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The interests in mushroom production have recently grew in Poland, namely in Siedlce region, which makes that larger quantities of mushroom substrate (or after composting process – mushroom compost) are disposed to a subsoil. The mushroom substrate is a source of humus and nutrients for plants, it is characterized by good consistence and tolerated ground-like scent. Taking all these into account, Kryńska et al [6] recommended its utilization as an organic fertilizer. Due to the lack of wider reports referring to rational opportunities of utilizing that waste material forces the need to undertake studies within that scope.

The study aimed at determining the aluminum, lithium, and cobalt contents in selected organic waste materials of different origin.

Material and methods

Experiments included following organic materials:

A – fresh bovine manure – 9 samples;

B – composts made of bovine manure (composted for 2 and 4 months) – 6 samples;

C – vermicomposts made of bovine manure (vermicomposted for 2 and 4 months) – 6 samples;

D – vermicomposts made of sewage sludge (75 %) and peat (25 %) (vermicomposted for 2 and 4 months) – 6 samples;

E – vermicomposts made of sewage sludge (75 %), peat (12.5 %), and poultry droppings (12.5 %) (vermicomposted for 2 and 4 months) – 6 samples;

F – mushroom substrates – 18 samples.

Fresh bovine manure, sewage sludge from mechanical-biological municipal sewage treatment plant in Siedlce, tall peat, and droppings from hatching hens were the main substrates for composts and vermicomposts production. After initial preparation, these materials were mixed in appropriate proportions and subjected to composting and vermicomposting by *Eisenia fetida* (Sav) earthworms.

Vermicomposts used in present study were achieved by applying technology given in a patent by Kalembasa et al [7]. Under laboratory conditions (20–25 ^{o}C), corresponding organic mixtures were placed in boxes of 20 dm^3 each and wetted to maintain the optimum humidity of 70–75 % (by weight). After several days of preliminary decomposition (to remove the ammonia excess), acidity of the substrate was adjusted to pH 6.8–7.2 using calcium carbonate. Then, *Eisenia fetida* earthworms were introduced to such prepared subsoils. Two and four months later, earthworms were removed and achieved vermicomposts were used for further studies.

The mushroom substrate samples (mushroom compost) were collected from several mushroom-producing farms near Siedlce. All organic materials samples (bovine manure, composts, vermicomposts, and mushroom substrate) were dried at 105 ^{o}C and ground.

To determine the contents of selected elements, the samples were combusted in a muffle furnace at 450 ^{o}C. Digested material was flooded in crucibles (placed on a sand bath) with hydrochloric acid solution ($HCl : H_2O$ = 1:1) to decompose carbonates and separate silicates. Obtained chlorides were transferred using 10 % HCl solution into the measuring flask of 100 cm^3 capacity by separating silicates on a filter paper. Such prepared solutions were subjected to determinations for Al, Li, and Co contents by means of emission atomic spectrometry combined with inductively coupled plasma (ICP-AES) on OptimaRL device (Perkin Elmer).

Results and discussion

Contents of determined elements in analyzed organic materials can be ordered in a following sequence [$mg \cdot kg^{-1}$]: Al (604–8490) > Li (3.36–27.1) > Co (0.56–5.67).

The highest mean aluminum concentration (Table 1) was found in vermicomposts made of the sewage sludge with peat addition (D) – 7135.0 $mg \cdot kg^{-1}$ and peat plus poultry droppings addition (E) – 6187.5 $mg \cdot kg^{-1}$. Aluminum level in vermicomposts made of sludge and peat (D) oscillated from 5150 to 8490 $mg \cdot kg^{-1}$, while in vermicomposts made of sludge, peat, and droppings (E) from 3760 to 8070 $mg \cdot kg^{-1}$ at the variability coefficients of 15.6 % and 24.7 %, respectively.

Table 1

The content of aluminium [$mg \cdot kg^{-1}$] in analysed different waste organic materials

Organic materials	The content of aluminium [$mg \cdot kg^{-1}$]				
	Mean	Minimum	Maximum	Standard deviation	Variable coefficiant
	[$mg \cdot kg^{-1}$]				[%]
A	755	604	906	151	20.0
B	2775	1010	4540	1123	40.4
C	1039	658	1230	232	22.4
D	7135	5150	8490	1111	15.6
E	6187	3760	8070	1530	24.7
F	1685	818	2065	456	27.0

Explanations: A – fresh bovin manure, B – compost made of bovin manure, C – vermicompost made of bovin manure, D – vermicompost made of sewage sludge and peat, E – vermicompost made of sewage sludge, peat and poultry droppings, F – mushroom substrate.

Bovine manure (A) contained the least aluminum (755 $mg \cdot kg^{-1}$) at variability coefficient of 20 %. Its higher content (average) was recorded in composted manure (B) – 2775 $mg \cdot kg^{-1}$ and vermicomposted manure (C) – 1039.0 $mg \cdot kg^{-1}$.

The most varied aluminum contents were found in mushroom substrates (F) – 818–1686 $mg \cdot kg^{-1}$, at mean level 1686 $mg \cdot kg^{-1}$ and variability coefficient 27 %.

Lithium concentrations in analyzed organic materials greatly varied (Table 2) with mean level from 5.88 in vermicomposts made of sewage sludge, peat, and poultry droppings (E) to 26.3 in mushroom substrates (F). The variability coefficient for lithium concentrations in these materials amounted to 19.4 and 24.5 %, respectively.

Table 2

The content of lithium [mg · kg^{-1}] in analysed different waste organic materials

Organic materials	The content of lithium [mg · kg^{-1}]				
	Mean	Minimum	Maximum	Standard deviation	Variable coefficiant
	[mg · kg^{-1}]				[%]
A	18.3	17.4	19.2	0.90	4.92
B	16.3	3.36	25.3	7.81	47.9
C	21.9	18.0	27.1	3.34	15.2
D	5.96	4.26	8.22	1.30	21.8
E	5.88	3.98	6.83	1.14	19.4
F	26.3	4.30	17.2	6.46	24.5

Lithium levels in fresh bovine manure (A), composted manure (B), and vermicomposted manure (C) reached from 16.3 mg · kg^{-1} (B) to 21.9 mg · kg^{-1} (C), although variability coefficient value was the lowest for (A), and the highest for (B) (4.92 % and 47.9 %, respectively).

Among studied organic materials, the highest mean cobalt concentrations (6.42 mg · kg^{-1}) and its widest differentiation (from 0.62 to 16.3 mg · kg^{-1}) at variability coefficient of 93.6 %, were recorded for mushroom substrate samples (F) (Table 3).

Table 3

The content of cobalt [mg · kg^{-1}] in analysed different waste organic materials

Organic materials	The content of cobalt [mg · kg^{-1}]				
	Mean	Minimum	Maximum	Standard deviation	Variable coefficiant
	[mg · kg^{-1}]				[%]
A	0.76	0.62	0.89	0.13	17.1
B	1.15	0.56	2.50	0.78	67.8
C	1.03	0.96	1.11	0.05	4.85
D	3.77	2.92	5.67	1.51	40.0
E	3.19	2.86	3.55	2.35	73.6
F	6.42	0.62	16.3	6.01	93.6

The least cobalt amounts were determined in fresh manure samples (A) 0.76 mg · kg^{-1}, while slightly more in manure composts (B) and vermicomposts (C) (1.15 and 1.03 mg · kg^{-1}, respectively). Similar average cobalt concentrations were recorded in vermicomposts made of sewage sludge with peat addition (D) 3.77 mg · kg^{-1} as well as peat plus poultry droppings (E) 3.19 mg · kg^{-1}, at variability coefficients 40,0 and 73.6 %, respectively.

Contents of studied elements in analyzed composts and vermicomposts were similar to those determined by Gąsior et al [8], Kalembasa [9], Kostecka and Kołodziej [10], as well as Kotowska [11], while referring to mushroom substrates – to those found in earlier studies by Kalembasa and Wiśniewska [12].

Conclusion

Analyzed organic materials contained the most aluminum, while the least cobalt. Highest levels of aluminum were found in vermicomposts, whereas lithium and cobalt – in mushroom substrates. The lowest amounts of aluminum and cobalt were determined in fresh bovine manure. In most cases, composting and vermicomposting of manure increased aluminum, lithium, and cobalt contents.

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ZAWARTOŚĆ GLINU, LITU I KOBALTU W MATERIAŁACH ORGANICZNYCH RÓŻNEGO POCHODZENIA

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Abstrakt: Badaniami objęto obornik bydlęcy, komposty z obornika bydlęcego, wermikomposty z obornika bydlęcego, wermikomposty z osadu ściekowego i torfu, wermikomposty z dodatkiem osadu ściekowego, torfu i kurzeńca oraz podłoża po uprawie pieczarek. Średnia zawartość glinu, litu i kobaltu wynosiła odpowiednio ($mg \cdot kg^{-1}$ s.m.): w oborniku bydlęcym 755; 18,30 i 0,76; w kompostach obornikowych 2775; 16,3 i 1,15; w wermikompostach obornikowych 1039; 21,9 i 1,03; w wermikompostach z osadu ściekowego z dodatkiem torfu 7135; 5,96 i 3,77; w wermikompostach z osadu ściekowego, torfu i kurzeńca 6187; 5,58 i 3,19; w podłożu popieczarkowym 1686; 26,3 i 6,42.

Słowa kluczowe: kompost, wermikompost, podłoże popieczarkowe