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EVALUATION OF IMPACT OF FERTILIZATION WITH MANURE, MUNICIPAL SEWAGE SLUDGE AND COMPOST PREPARED FROM SEWAGE SLUDGE ON CONTENT OF Mn, Zn, Cu, AND Pb, Cd IN LIGHT SOIL

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Abstract

The aim of the research was to estimate the impact of fertilizing with manure, sewage sludge and compost prepared from sewage sludge on the content of total and soluble forms of Mn, Zn, Cu as well as Pb and Cd in light soil.

A pot experiment was set up with the split plot method in 2006. The first factor objects were types of fertilizers: manure, municipal sewage sludge, compost prepared from sewage sludge. The second factor consisted of doses of manure and organic fertilizers incorporated into the soil, expressed as amounts of nitrogen (0.26 and 0.52 g N per pot). In the second year mineral fertilizing was applied in a dose of 0.30 g $N \cdot pot^{-1}$ and 0.72 g $K \cdot pot^{-1}$. Soil used in the experiment was taken from Ap level and had grain size distribution of light loamy sand. The soil was acidic (pH in 1 mol $KCl \cdot dm^{-3}$ – 5.13) and moderately abundant in available phosphorus, potassium and magnesium. The content of microelements in soil before the experiment was below the permissible concentrations given in the Ordinance of the Minister of Environment of 9.09.2002 on quality standards of soils and ground (Journal of Law, 2002, no. 165 item 1359). As regards the contamination of soil with Cu, Mn, Ni, Pb, Zn, the content of these heavy metals, according to IUNG classification, was 0, which stands for natural content, although the content of Cd was raised up to I^{o}.

It has been found out that fertilizing with manure, sewage sludge and compost prepared from sewage sludge increased, in direct and successive effect, the content of total and soluble in 1 mol $HCl \cdot dm^{-3}$ forms of microelements. In the case of soil fertilized with organic fertilizers, first degree contamination with cadmium and nickel occurred (exceeding na-

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tural content in soil). The application of manure and sewage sludge, in turn, raised the content of lead.

On the basis of the mean share of soluble forms in the total content in soil from objects fertilized with organic fertilizers, the microelements could be ranked as follows: Cu > Pb > Ni > Cd > Mn > Zn in the first year of the research, and Cd > Pb > Cu > Mn > Zn > Ni in the second year.

Key words: manure, sewage sludge, sewage sludge compost , light soil.

OCENA WPŁYWU NAWOŻENIA OBORNIKIEM, KOMUNALNYM OSADEM ŚCIEKOWYM I KOMPOSTEM Z OSADU ŚCIEKOWEGO NA ZAWARTOŚĆ Mn, Zn, Cu, ORAZ Pb I Cd W GLEBIE LEKKIEJ

Abstrakt

Celem badań była ocena wpływu nawożenia obornikiem, komunalnym osadem ściekowym i kompostem z osadu ściekowego na zawartość form ogólnych i rozpuszczalnych: Mn, Zn, Cu, oraz Pb i Cd w glebie lekkiej.

W 2006 r. założono metodą split plot doświadczenie wazonowe. Obiektami pierwszego czynnika były rodzaje nawozów: obornik, komunalny osad ściekowy, kompost z niego wyprodukowany, obiektami II czynnika – dawki obornika i nawozów organicznych zastosowane do gleby w przeliczeniu na ilość wniesionego azotu (0,26 i 0,52 g N na wazon). W drugim roku badań zastosowano nawożenie mineralne w dawce 0,30 g N na wazon, 0,24 g P na wazon oraz 0,72 g K na wazon. Gleba użyta w doświadczeniu pobrana została z warstwy Ap i miała skład granulometryczny piasku gliniastego lekkiego pylastego. Odczyn gleby był kwaśny (pH w 1 mol $KCl \cdot dm^{-3}$ – 5,13), zawartość fosforu, potasu i magnezu przyswajalnego była średnia. Zawartość mikroskładników w glebie przed założeniem doświadczenia była poniżej wartości dopuszczalnych stężeń w glebie podanych w RMŚ z dnia 9 września 2002 r. w sprawie standardów jakości gleby oraz standardów jakości ziemi (DzU z 2002 r. nr 165 poz. 1359). Pod względem zawartości Mn, Zn, Cu, Ni, Pb stopień zanieczyszczenia gleb tymi pierwiastkami według klasyfikacji IUNG wynosił 0, co oznacza zawartość naturalną, natomiast zawartość Cd była podwyższona i stanowiła I^{o}.

W badaniach stwierdzono, że po nawożeniu obornikiem, osadem ściekowym i kompostem z osadu ściekowego zwiększyła się w glebie – w działaniu bezpośrednim i następczym – zawartość form ogólnych i rozpuszczalnych w 1 mol $KCl \cdot dm^{-3}$ mikroskładników oraz Pb i Cd. W przypadku nawożenia gleby nawozami organicznymi nastąpiło zanieczyszczenie I stopnia kadmem i niklem (przekroczenie naturalnej zawartości w glebie), natomiast po zastosowaniu obornika i osadu ściekowego nastąpił wzrost zawartości ołowiu.

Na podstawie średniego udziału formy rozpuszczalnej w formie ogólnej z obiektów nawożonych nawozami organicznymi pierwiastki można było uszeregować następująco: I rok badań – Cu > Pb > Ni > Cd > Mn > Zn, II rok badań – Cd > Pb > Cu>Mn > Zn > Ni.

Słowa kluczowe: obornik, osad ściekowy, kompost z osadu ściekowego, gleba lekka.

INTRODUCTION

Agricultural use of sewage sludge and composts prepared from sewage sludge, in accord with all binding laws connected with environmental protection, is one of the methods of recycling. Rational fertilizing with waste and composts increases organic substance in light soil as well as the content of macro- and microelements. Every batch of sewage sludge intended to be used in agriculture must fulfill qualitative standards such as the maximum permissible amounts of trace elements Cd, Pb, Cu, Zn, Ni, Hg, Cr and counts of live intestinal parasite eggs and *Salmonella* bacteria (Rozporządzenie Ministra Środowiska w sprawie komunalnych osadów ściekowych DzU z 2002 r. nr 134 poz. 1140).

The aim of the research was to estimate the impact of fertilizing with manure, sewage sludge and sewage sludge compost on the content of total and soluble forms in 1 mol $HCl \cdot dm^{-3}$ of Mn, Zn, Cu, Pb and Cd in light soil.

MATERIAL AND METHODS

In 2006, a pot experiment was set up with the split plot method in a greenhouse at the University of Agriculture in Szczecin. The capacity of the pots was 9 dm^3 of soil. The first factor objects were types of fertilizers: manure, municipal sewage sludge and compost prepared from sewage sludge. The second factor objects were doses of manure and organic fertilizers incorporated into the soil expressed as amounts of nitrogen (0.26 and 0.52 g N per pot). The objects fertilized exclusively with NPK received 0.18 g of nitrogen (the first dose) and 0.36 g of nitrogen per pot (the second dose). All of the fertilized objects received 0.12 g P and 0.26 g K per pot. In the second year, mineral fertilization consisted of 0.30 g $N \cdot pot^{-1}$, 0.24 g $P \cdot pot^{-1}$ and 0.72 g $K \cdot pot^{-1}$. The soil reaction was was acid (pH in 1 mol $KCl \cdot dm^{-3}$ – 5.13) and the content of available phosphorus, potassium and magnesium in soil was average. Table 1 shows the content of microelements as well as Pb and Cd in the soil before the experiment was set up. The test plant in the first year of the experiment was spring rape and in the second one – spring triticale.

The content of microelements in soil before setting up the experiment was below the value of permissible concentration given in the Ordinance of the Minister of Environment of 9.09.2002 on quality standards of soils and ground (Journal of Law, 2002, no. 165 item 1359) As regards the contamination of the soil with Cu, Mn, Ni, Pb, Zn, the content of these metals, according to the IUNG classification, was 0, which stands for natural content, although the content of Cd was raised up to I^{o}.

RESULTS AND DISCUSSION

The content of microelements as well as Pb and Cd in soil after the harvest of spring rape increased on the objects fertilized with manure and organic fertilizers, in comparison with the initial values (Tables 1 and 2). In soil of the objects with organic and mineral fertilizers applied, in comparison with the control, manganese rose by 19.40%, zinc by 15.70%, copper by 23.89%, nickel by 29.27%, lead by 41.91% and cadmium by 76.75%. As a result of fertilization with sewage sludge, the content of manganese, lead and cadmium increased most profoundly, whereas the application of manure increased the content of zinc and copper (Table 2).

Table 1

Content of some microelements in soil before the experiment

Total content ($mg \cdot kg^{-1}$ d.m.)					
Mn	Zn	Cu	Ni	Pb	Cd
225.1	26.1	6.30	8.25	19.8	0.42
Soluble forms ($mg \cdot kg^{-1}$ d.m.)					
68.2	4.15	1.92	2.30	8.75	0.12

In the second year of the experiment, the total content of microelements as well as Pb and Cd in soil after the harvest of spring triticale was likewise higher than the initial values (Table 3). In the successive impact, the highest mean content of manganese, lead and cadmium was in soil fertilized with sewage sludge, while that of copper and nickel was the highest after the application of compost.

Having analyzed the content of soluble forms in 1 mol $HCl \cdot dm^{-3}$ in soil after the harvest of spring rape, it was stated that, soil fertilized with sewage sludge compost contained the lowest content of soluble forms of manganese (65.9 $mg \cdot kg^{-1}$), zinc (4.76 $mg \cdot kg^{-1}$) and copper (2.28 $mg \cdot kg^{-1}$). Fertilizing with manure, however, enhanced solubility in 1 mol $HCl \cdot dm^{-3}$ of manganese (66.4 $mg \cdot kg^{-1}$) and zinc (8.38 $mg \cdot kg^{-1}$), copper (5.18 $mg \cdot kg^{-1}$) and cadmium (0.216 $mg \cdot kg^{-1}$, Table 4).

The data presented in Table 5 show that the experimental factors, i.e. the type of fertilizers (manure, sewage sludge and compost prepared from sewage sludge) and their doses, had no influence on shaping the content of forms soluble in 1 mol $HCl \cdot dm^{-3}$ of manganese, zinc, copper, nickel and cadmium in soil after the harvest of spring triticale. The content of lead in soil fertilized with manure was statistically significantly higher in comparison with its content in soil taken from the other fertilizing objects.

Table 2

Content of total forms of microelements in soil after the harvest of spring rape ($mg \cdot kg^{-1}$ d.m.)

Specification	Mn			Zn			Cu			Ni			Pb			Cd		
	1*	2*	$\overline{x}$	1*	2*	$\overline{x}$	1*	2*	$\overline{x}$	1*	2*	$\overline{x}$	1*	2*	$\overline{x}$	1*	2*	$\overline{x}$
Manure	263.3	283.4	273.4	39.3	31.9	35.6	8.95	9.35	9.15	11.30	10.65	10.98	32.9	30.5	31.7	0.765	0.783	0.774
Sewage sludge	271.2	299.6	285.4	33.2	30.5	31.9	8.22	8.55	8.38	9.95	11.98	10.96	59.1	57.8	58.4	0.785	0.832	0.809
Compost	264.1	277.6	270.8	28.8	27.8	28.3	6.52	7.08	6.80	10.94	12.58	11.76	25.6	25.4	25.5	0.568	0.585	0.577
NPK	260.5	265.7	263.1	28.4	30.3	29.3	6.75	9.20	7.98	12.46	12.76	12.61	23.2	22.2	22.7	0.452	0.455	0.454
Mean	264.8	281.6	273.2	32.4	30.1	31.2	7.61	8.54	8.08	11.16	11.99	11.58	35.2	34.0	34.6	0.643	0.664	0.654
Control	220.2			26.3			6.15			8.19			20.1			0.370		
$LSD_{0.01}$ I factor II factor IxII	n.s. n.s. n.s.			n.s. n.s. n.s.			n.s. n.s. n.s.			n.s. n.s. n.s.			7.777 n.s. n.s.			0.142 n.s. n.s.		

1*dose I;
2*dose II

Table 3

Content of total forms of microelements in soil after the harvest of spring triticale ($mg \cdot kg^{-1}$ d.m.)

Specification	Mn			Zn			Cu			Ni			Pb			Cd		
	1*	2*	$\overline{x}$	1*	2*	$\overline{x}$	1*	2*	$\overline{x}$	1*	2*	$\overline{x}$	1*	2*	$\overline{x}$	1*	2*	$\overline{x}$
Manure	261.2	281.1	271.2	36.85	29.52	33.18	8.88	8.50	8.69	11.58	9.46	10.52	32.35	29.29	30.82	0.735	0.759	0.747
Sewage sludge	269.0	295.6	282.3	29.88	28.35	29.11	8.88	8.31	8.60	9.53	11.19	10.36	49.89	56.89	53.39	0.732	0.814	0.773
Compost	263.5	276.1	269.8	27.42	28.91	28.16	6.11	7.89	7.00	11.12	11.84	11.48	24.90	25.38	25.14	0.513	0.514	0.514
NPK	258.3	269.5	263.9	28.07	29.51	28.79	6.91	9.18	8.04	11.94	11.02	11.48	22.90	22.20	22.55	0.416	0.414	0.415
Mean	263.0	280.6	271.8	30.55	29.07	29.81	7.70	8.47	8.08	11.04	10.88	10.96	32.51	33.44	32.97	0.599	0.625	0.612
Control	219.7			26.75			6.22			5.49			19.72			0.314		
$LSD_{0.01}$																		
I factor	n.s.			n.s.			n.s.			1.56			n.s.			n.s.		
II factor	n.s.			n.s.			n.s.			n.s.			n.s.			n.s.		
IxII	n.s.			n.s.			n.s.			n.s.			n.s.			n.s.		

1*dose I; 2*dose II

Table 4

Content of forms soluble in 1 mol $HCl \cdot dm^{-3}$ of microelements after the harvest of spring rape ($mg \cdot kg^{-1}$ d.m.)

Specification	Mn			Zn			Cu			Ni			Pb			Cd		
	1*	2*	$\overline{x}$	1*	2*	$\overline{x}$	1*	2*	$\overline{x}$	1*	2*	$\overline{x}$	1*	2*	$\overline{x}$	1*	2*	$\overline{x}$
Manure	66.7	66.0	66.4	8.28	8.48	8.38	4.85	5.50	5.18	2.53	2.81	2.67	9.58	12.81	11.20	0.207	0.224	0.216
Sewage sludge	65.1	67.0	66.0	6.22	6.82	6.52	3.71	3.31	3.51	3.64	3.66	3.65	12.73	15.39	14.06	0.171	0.202	0.187
Compost	65.2	66.6	65.9	4.50	5.03	4.76	2.26	2.31	2.28	2.37	4.26	3.32	9.78	9.23	9.50	0.146	0.184	0.165
NPK	66.8	66.4	66.6	4.70	8.48	6.59	2.14	2.41	2.28	4.78	5.33	5.06	9.06	8.53	8.80	0.119	0.124	0.122
Mean	66.0	66.5	66.2	5.92	7.20	6.56	3.24	3.38	3.31	3.33	4.02	3.68	10.29	11.49	10.89	0.161	0.184	0.173
Control		64.3			4.07			1.88			2.15			8.22			0.098	
$LSD_{0.01}$ I factor II factor IxII		n.s. n.s. n.s.			n.s. n.s. n.s.			2.13 n.s. n.s.			1.56 n.s. n.s.			n.s. n.s. n.s.			n.s. n.s. n.s.	

1*dose I;
2*dose II

Table 5

Content of forms soluble in 1 mol HCl·dm^{-3} of microelements in soil after the harvest of spring triticale (mg·kg^{-1}d.m.)

Specification	Mn			Zn			Cu			Ni			Pb			Cd		
	1*	2*	$\overline{x}$	1*	2*	$\overline{x}$	1*	2*	$\overline{x}$	1*	2*	$\overline{x}$	1*	2*	$\overline{x}$	1*	2*	$\overline{x}$
Manure	110.2	111.7	111.0	6.14	7.72	6.93	2.99	4.82	3.90	1.38	1.99	1.68	14.97	15.09	15.03	0.432	0.301	0.367
Sewage sludge	105.5	98.0	101.8	6.67	7.69	7.18	3.05	3.34	3.20	1.33	1.63	1.48	11.14	11.82	11.48	0.228	0.268	0.248
Compost	92.6	95.8	94.2	5.71	7.44	6.58	2.57	2.81	2.69	1.55	1.70	1.63	10.38	10.84	10.61	0.257	0.255	0.256
NPK	96.7	101.9	99.3	6.67	6.48	6.58	2.55	2.50	2.53	1.49	1.49	1.49	10.53	10.16	10.34	0.274	0.270	0.272
Mean	101.2	101.8	101.6	6.30	7.33	6.82	2.79	3.37	3.08	1.44	1.70	1.57	11.75	11.98	11.86	0.300	0.274	0.286
Control	92.8			6.18			2.52			1.18			10.36			0.262		
$LSD_{0.01}$																		
I factor	n.s.			n.s.			n.s.			n.s.			2.39			n.s.		
II factor	n.s.			n.s.			n.s.			n.s.			n.s.			n.s.		
IxII	n.s.			n.s.			n.s.			n.s.			n.s.			n.s.		

1*dose I;
2*dose II

Table 6

Mean share of forms soluble in 1 M HCl in the total form (total form=100%)

Specification	Mn		Zn		Cu		Ni		Pb		Cd	
	rape	triticale	rape	triticale	rape	triticale	rape	triticale	rape	triticale	rape	triticale
Manure	24.29	40.96	23.54	20.89	56.61	44.88	24.32	15.97	35.33	48.77	27.91	57.83
Sewage sludge	23.12	36.06	20.44	24.66	41.88	37.21	33.30	13.92	24.08	21.50	23.11	32.08
Compost	24.34	34.91	16.82	23.37	48.01	38.43	28.23	14.11	37.25	42.20	28.60	49.80
NPK	25.31	37.63	22.41	22.86	28.57	31.34	40.13	12.98	38.77	45.85	26.87	65.54
Mean	24.26	37.39	20.80	22.94	43.77	37.97	31.50	14.24	33.86	39.58	26.62	51.31

On the basis of the mean share of forms soluble in 1 mol $HCl \cdot dm^{-3}$ in the total content, it was stated that in the two-year period availability of manganese, zinc, lead and cadmium increased and that of copper and nickel decreased (Table 6).

Increase in the total and soluble forms of manganese, zinc, copper and nickel in soil was reported by IŻEWSKA et al. (2006), who tested sewage sludge and composts. JAKUBUS (2006) and JAMALI et al. (2008) also demonstrated increase in the total content of manganese, zinc, copper in soil after application of sewage sludge. However, CZYŻYK, KOZDRAŚ (2004) confirmed loss of soluble nickel in soil after application of composts prepared from sewage sludge.

The content of microelements as well as Pb and Cd in soil after two years of the experiment testing application of manure, sewage sludge, compost prepared from sewage sludge and NPK did not exceed the values of permissible concentrations given in the Ordinance of the Minister of Environment of 9.09.2002 on quality standards of soil and quality standards of ground (Journal of Law, 2002, no. 165 item 1359).

CONCLUSIONS

1. After fertilization with manure, sewage sludge and compost prepared from sewage sludge, the content of total content and forms soluble in 1 $mol \cdot dm^{-3}$ HCl of microelements as well as Pb and Cd under direct and successive impact increased in comparison with the initial content.

2. Fertilizing with organic fertilizers caused first degree contamination of soil with nickel and cadmium (exceeding their natural content in soil).

3. On the basis of the mean share of forms soluble in 1 mol $HCl \cdot dm^{-3}$ in the total content in soils taken from objects fertilized with organic fertilizers, the elements could be ranked as follows: Cu > Pb > Ni > Cd > Mn > Zn in the first year and Cd > Pb > Cu>Mn > Zn > Ni in the second year of the research..

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