

Research Regarding the Accumulation in Soybeans of Heavy Metals from Anaerobic Composted Sewage Sludge Used as Organic Fertilizer

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Abstract

In sewage sludge from urban wastewater treatment stations can often be find high levels of Ni, Pb, Cu, Zn, Mn and Cd. Aerobic or anaerobic composting of this sewage sludge does not eliminate the possibility of bioaccumulation of these metals in plants through metabolic processes of phytoextraction type. Researches regarding the accumulation degree of heavy metals through phytoextraction processes were performed on soybean plants (*Glycine max*), Condor variety. Plants were fertilized with anaerobic composted sludge in amounts of 25 t / ha, 50 t / ha and 100 t / ha. The chemical analysis was done on an average sample of three repetitions. Metal concentration in soybeans was analyzed by reporting to the maximum allowance level for sheep, considered one of the most sensitive farm species to heavy metal toxicity. Our results showed a higher level than normal with 5.8 mg / kg only in the case of copper ions. Zn, Pb, Mn and Cd concentration in soybeans was below the maximum allowance limits set by the rules of feeding farm animals. Also, heavy metal content of soybeans was not affected by the amount of composted sludge used as fertilizer.

Keywords: anaerobic composted sludge, bioaccumulation, heavy metals, soybean

1. Introduction

Soil is a polidispersed system, structured and porous, consisting of three phases, solid, liquid and gas, which affect plant nutrient supply. The development of human society, but particularly agriculture, is closely related to soil characteristics. On the ground take place the majority of human social activities, and so, from a ecological point of view and so holistic, soil is the substrate of primary producers having a vital role in fixing solar energy [1, 2, 3].

The soil is therefore a vast factory of nature that produces a large amount of biomass that is the substrate for phytophagus consumers, including humans. For agriculture and forestry, soil is an important means of production on which man causes significant changes by ploughing, digging, geo-constructive reconfigurations, subsidence, etc. [3, 7].

It is estimated that annually a man transformed by ploughing about 3000 km³ of natural soils in the loose soils, changing the aeration and moisture conditions. In parallel, to increase the productive potential of arable land unit, the soils are added annually large amounts of organic chemicals to increase fertility. In this regard, administration of quality compost has a benefic effect not only on

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crops, due to increasing biomass production but also on soil processes due to stimulation of pedogenesis processes.

In sewage sludge, from urban wastewater treatment stations, can be find some higher values of heavy metal (Ni, Cr, Pb, Co, etc.). [8, 9] In Table 1 are presented the maximum permitted levels of heavy metals in sewage sludge used in agriculture in Romania, EU and USA.

In the literature, references are made to following seven usual heavy metals: cadmium, copper, nickel, lead, zinc, mercury and chromium.

The purpose of this research was to examine the bioconcentration of heavy metals in soybeans fertilized with different amounts of composted sewage sludge.

Table 1 – Maximum permitted levels of heavy metals in sewage sludge used in agriculture

Parameter	Maximum permitted levels (mg/kg dried substance)		
	România (Ord. 344/2004)	EU (86/278/EEC)	USA (EPA503/1999)
Cadmium	10	20-40	85
Copper	500	1000-1750	4300
Nickel	100	300-400	420
Lead	300	750-1200	840
Zinc	2000	2500-4000	7500
Mercury	5	16-25	57
Chromium	500	-	-
Cobalt	50	-	-
Arsenic	10	-	75
Molybdenum	-	-	75
Selenium	-	-	100

2. Materials and methods

Physical-chemical characterization of composted sewage sludge (C3) is presented in Table 2, after an analysis report made by ECOIND Bucharest.

Table 2 - Physical-chemical characterization of composted sewage sludge (C3)

Analysis	UM	Value	M.A.L Ord. 708/2004	Method
Dried matter	%	34.3		SR ISO 11465-98
pH	-	7.15		SR ISO 10523-97
Nt	mg/kg d.m.	17072		STAS 7184/2-85
P2O5	mg/kg d.m.	2306		STAS 3223/21-92
K2O	mg/kg d.m.	30114		SR ISO 11047-99
CaO	mg/kg d.m.	28667		SR ISO 11047-99
Cd	mg/kg d.m.	<0.02	10	SR ISO 11047-99
Cr	mg/kg d.m.	<0.1	500	SR ISO 11047-99
Cu	mg/kg d.m.	110	500	SR ISO 11047-99
Ni	mg/kg d.m.	<0.08	100	SR ISO 11047-99
Pb	mg/kg d.m.	62	300	SR ISO 11047-99
Zn	mg/kg d.m.	487	2000	SR ISO 11047-99
Co	mg/kg d.m.	<0.2	50	SR ISO 11047-99
As	mg/kg d.m.	<1.3	10	SR EN 12457-03 ISO 11969-96
Organic carbon	%	26.5	-	SR ISO 10694-98

Plants of soybean (*Glycine max*) belonged to Condor variety. Harvesting was made in full ripening stage. The research was conducted simultaneously in three repetitions (R1, R2, R3), each repeat consisting of 12 experimental plots (Table 3). For chemical analysis, a sample was the average of the three repetitions for each of the 12 experimental plots. Grain samples were analyzed in Laboratory for residues control at Platform for training and interdisciplinary research in the USAMVB Timisoara.

Table 3 - Explanations on experimental plots and experimental combination of factors

Experimental plot code	Experimental factors code	Explanations
1	a ₁ b ₁	Control variant, completely unfertilized
2	a ₁ b ₂	Control variant, mineral fertilized with 200 kg / ha
3	a ₁ b ₃	Control variant, mineral fertilized with 400 kg / ha
4	a ₂ b ₁	Fertilized variant with 25 t composted sludge / ha
5	a ₂ b ₂	Fertilized variant with 25 t composted sludge / ha and 200 kg / ha
6	a ₂ b ₃	Fertilized variant with 25 t composted sludge / ha and 400 kg / ha
7	a ₃ b ₁	Fertilized variant with 50 t composted sludge / ha
8	a ₃ b ₂	Fertilized variant with 50 t composted sludge / ha and 200 kg / ha
9	a ₃ b ₃	Fertilized variant with 50 t composted sludge / ha and 400 kg / ha
10	a ₄ b ₁	Fertilized variant with 100 t composted sludge / ha
11	a ₄ b ₂	Fertilized variant with 100 t composted sludge / ha and 200 kg / ha
12	a ₄ b ₃	Fertilized variant with 100 t composted sludge / ha and 400 kg / ha

3. Results and discussion

Were determined content in crude protein, Cu, Ni, Zn, Mn, Pb and Cd. Method of analysis and results are presented in Table 4.

Data presented represent the average of three successive determinations, which meets the requirements of Order 344/2004, which specifies the number of determinations for Cd, Cr, Cu, Hg, Ni, Pb, Zn, Co, As. [11]

Values were analyzed according to Standards of quality and health parameters in production, import, quality control, marketing and use of

concentrated feed, simple, compound, feed additives, premixes, energy substances, mineral substances and special fodder. [10]

This legislation provides the following limits:

- Cu - 15 mg / kg (limit for sheep, as the most sensitive species)

- Ni - No data

- Zn - 250 mg / kg

- Mn - 250 mg / kg

- Pb - 10 mg / kg

- Cd - 1 mg / kg

The results are graphically presented in part for each metal species (figures 1-5).

Table 4 – The contents of heavy metals from soybeans

Sample	Crude protein (%)	Cu (mg/g)	Ni (µg/g)	Zn (mg/g)	Mn (mg/g)	Pb (µg/g)	Cd (µg/g)
Method	SR EN ISO 5983-1, 2003	SR EN ISO 6869,2002	SR EN ISO 6869,2002	SR EN ISO 6869,2002	SR EN ISO 6869,2002	SR EN ISO 6869,2002	SR EN ISO 6869,2002
1	25.24	0.025	4.82	0.055	0.025	0.78	0.059
2	23.35	0.023	4.71	0.056	0.025	0.64	0.034
3	26.18	0.021	4.48	0.055	0.024	0.71	0.033
4	23.84	0.022	4.99	0.054	0.026	0.47	0.027
5	25.25	0.021	5.00	0.068	0.024	0.84	0.056
6	25.68	0.020	4.45	0.055	0.025	0.30	0.028
7	26.02	0.022	5.18	0.062	0.026	0.70	0.036
8	24.12	0.020	4.12	0.071	0.024	0.29	0.027
9	24.85	0.012	4.68	0.054	0.023	0.25	0.028
10	26.06	0.020	4.36	0.057	0.024	0.23	0.027
11	19.88	0.023	4.14	0.055	0.023	0.25	0.030
12	22.86	0.021	4.53	0.057	0.025	0.35	0.036

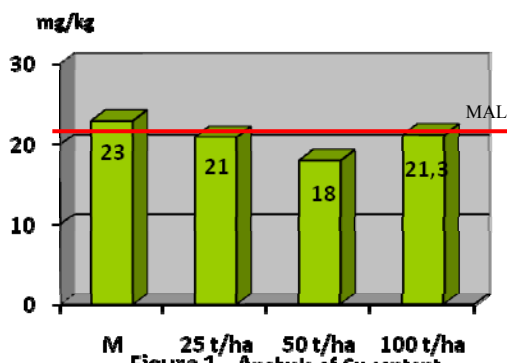


Figure 1 - Analysis of Cu content

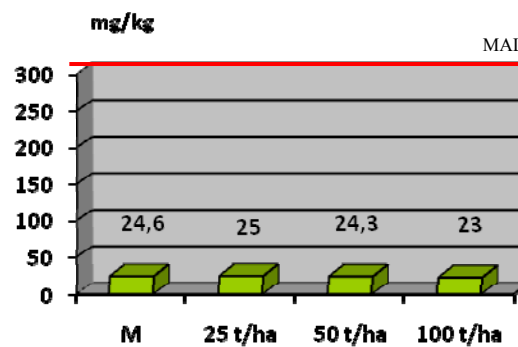


Figure 3 - Analysis of Mn content

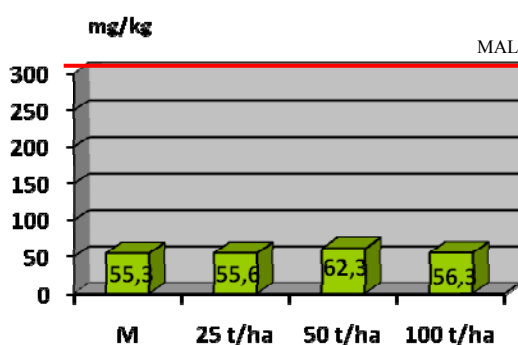


Figure 2 - Analysis of Zn content

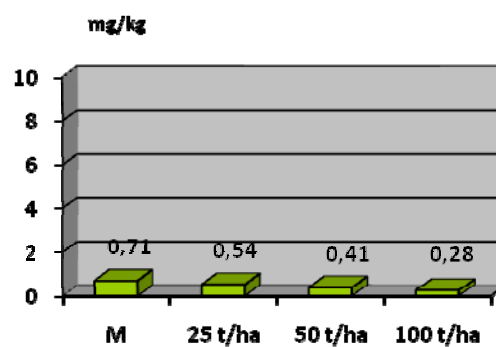


Figure 4 - Analysis of Pb content

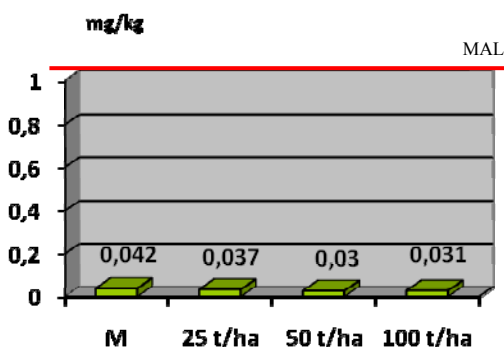


Figure 5 - Analysis of Cd content

From the presented data can be found that adding composted sludge as fertilizer in quantities of 25 tonnes, 50 tonnes and 100 tonnes per ha the maximum permissible limit are exceeded only for Cu. This limit is set only for sheep, considered the most sensitive species. In case of other species and categories of farm animals, the values found by us are below limits set by the rules.

The contents of Zn, Mn, Pb and Cd from soybeans grown on soil fertilized with composted sludge are lower than permissible limits specified by the

rules. For this reason, they can be used without reservation as feedstock for the production of forage used in farm animal's alimentation.

4. Conclusions

After fertilization of soil with composted sewage sludge in quantities of 25 t, 50 t and 100 t per hectare, was concluded:

1. The content of Cu in soybeans exceeds the limit set by rules for sheep, but is below the limit values for all other species and categories of farm animals.
2. The contents of Zn, Mn, Pb and Cd in soybeans is lower than the maximum permitted levels, set by the quality standards for raw material processed to obtain forage for livestock alimentation.

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