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REDUCING THE ACCUMULATION OF LEAD, ZINC AND CADMIUM FROM TRITICALE CROP BY CALCARIC FLUVISOL, USING BLACK SEA SAPROPELLES

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Abstract

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It was investigated the influence of Black Sea sediments (sapropelles) on the accumulation of Pb, Zn and Cd from alluvial-meadow soil (Calcaric Fluvisol). The survey was carried out with triticale crop by two years pot plants experiment. The result obtained was shown that at an amount 10 $g.kg^{-1}$ and 30 $g.kg^{-1}$, sapropelles decrease the accumulation of Pb, Zn and Cd from the tested crop at a rate from 5.30 % to 100%.

Key words: sapropelles, accumulation, alluvial-meadow soil, triticale, Pb, Zn, Cd
Abbreviations: DTPA - diethylentriaminepentaacetic acid; MCL - Maximum concentration limit

Introduction

The presence of heavy metals in soils leads to a number of abnormal for the environment phenomena. From the soil they pass into the plants and pollute the plant production. According Kabata et al. (2001) even in higher concentrations they influent unfavourable on the physiological and biological processes in a plant organism. An important condition for producing of pure agriculture production is to avoid or decrease the accumulation of heavy metals to the cultivated crop. It is well known that the mobility of heavy metals depends on the soil pH. By the acid soils the number of mobile forms is more that the neutral or slightly alkaline soils.

According to Dimitrov (1988, 2000), (N. Nikolov, Personal communication, 2000) Black Sea sediments, called sapropelles neutralize vastly the acidity of toxic acid soils. An idea for application of Black Sea sapropelles in the agriculture practice grounds on the experience of application of lake and marsh sapropelles by Bmins (1994). A study on the influence of some river sapropelles on the accumulation of heavy metals has been carried out by Vashkov (1996). Cholakov (2003) (N. Nikolov Personal communication, 2003) showed that the sapropelles as a natural organo-mineral fertilizer increase the yield of tomatoes in greenhouse conditions and could be used in vegetable cultivation.

The aim of present work is to establish the lock ability of sapropelles on the mobile forms of heavy metals Pb, Zn, Cd at alluvial-meadow soil (Calcaric Fluvisol).

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Material and Methods

Pot plants experiment

The pot experiment was conducted at the experimental field of Plovdiv Agricultural University in a greenhouse conditions. The pots were 15 cm in diameter, holding 2.0 kg of dry soil. An alluvial-meadow type of soil (Calcaric Fluvisol) was used. The experience was embedded in three replications, as every of them contain three pots. In every pot at the 20th October were planted 10 seeds of triticale crop. After germination the number of plants in every pot was reduced to three plants. During the vegetation period were made all necessary agrotechnical activities - feeding with an ammonium nitrate at the beginning of March and regular irrigation regime. Harvesting of plants under the form of green mass was made on the 20 th of May.

Heavy metals analysis

Plant analysis. The content of Pb, Zn and Cd at the tested triticale crop in different parts (roots, stems and leaves), after their dividing and drying as an air-dry mass, was determined by using of dry mineralization method. A 1g sample was weighed into a quartz crucible and put into a furnace (373 – 673 K) until ashing has occurred. After cooling to a room temperature 1 ml HNO_3 (1:1) was added, evaporated in a sand bath and put again into the furnace (673 K). The procedures were repeated until the ash was white. It was finally dissolved in 2 ml 200 g.kg^{-1} HCl, transferred in a graduated 10 ml flask and brought to volume with bidistilled water.

Soil analisis*:* Total content of heavy metals in soils was determined after decomposed over sand bath heater for 3 h with 21 ml 370 g.kg^{-1} HCI + 7 ml 650 g.kg^{-1} HNO_3. After cooling, it is transferred into a 50 ml flask and water is added to the mark.

To determine the heavy metals content in the soil and plant samples, as well as the content of micro- and macro-elements in the sample used sapropelles, inductively coupled emission spectrometry (Jobni Yvon Emission - JY 38 S. France) was used. The quantitative measures were carried out with apparatus ICP. The working wave lengths for the tested heavy metals were as follows: Zn -213.9 nm; Pb - 220.4 nm: Cd – 214.4 nm.

The pH values (H_2O) of the tested alluvial-meadow soil (Calcaric Fluvisol) and the soil samples containing sapropelles, after a month of incubation, were determined with a pH meter, Model OP-211 / 1, (ISO 10390)

The processing of results obtained was made by statistical program ANOVA.

Results and Discussion

Tables 1 and 2 illustrate the content of macro and microelements in the used sample of sapropelles. The loss by heating at 1273 K was 199.7 g.kg$^{-1,}$ due mainly to a content of organic matter – salts of humic and fulvo acids. Together with the inorganic components – Ca, Mg etc. it influents favorable for increasing of pH to slightly alkaline medium, where according Giurov et al. (2001) the mobility of the heavy metals decreases vastly.

The soil properties as depth horizon, chemical composition, pH etc. are shown in Table 3. The soil characteristics and especially the soil reaction after addition of sapropelles are favorable to low metal availability to plants and DTPA - extractable Pb, Zn and Cd concentrations are low for Zn and moderate for Pb and Cd. The total content of Pb, Zn and Cd is high and considerably exceeding the MCL (Table 4). After a month incubation of sapropelles in the soil pH value increase to slightly alkaline medium - from 7.23 to 7.86 by 10 g.kg^{-1} incubated sapropel and to 8.12 pH units by 30 gkg^{-1} incubated sapropel respectively.

The obtained results for the content of heavy metals in the studied crop are given in Table 5. There were ascertained considerable differences in the distribution of tested metals in the separate parts of the plants. In all three elements the main part was accumulated in the roots. This could be explained with the fact that by the penetration in the plasma the inactivation and the precipitation of considerable quantities of heavy metals takes

Table 1

Chemical composition of sapropelles. Content of microelements

№	Sample oxides	Cr, g/t	Mo, g/t	Zn, g/t	Mn, g/t	Pb, g/t	Cu, g/t	Ni, g/t
1	Sapropel	50.00	36.4	65.82	383.42	28.22	36.63	49.75

Table 2

Chemical composition of sapropelles. Content of micro- and macroelements

Sample Oxides	SiO_2, $g.kg^{-1}$	TiO_2, $g.kg^{-1}$	Al_2O_3, $g.kg^{-1}$	FeO, $g.kg^{-1}$	MnO, $g.kg^{-1}$	CaO, $g.kg^{-1}$	Na_2O, $g.kg^{-1}$	K_2O, $g.kg^{-1}$	Loss by 1273 K, $g.kg^{-1}$
Sapropel	397.6	7.0	116.9	45.7	0.4	26.80	154.6	21.30	199.7

Table 3

Soil properties and pH of samples after introduction of sapropelles

Clasification	Depth, cm	pH /H_2O/	Humus, $g.kg^{-1}$	CaCO3, $g.kg^{-1}$	Clay, $g.kg^{-1}$	pH after addition of sapropelles	
						10 $g.kg^{-1}$	30 $g.kg^{-1}$
Calcaric Fluvisol	0-20	7.23	2.20	3.85	37.60	7.86	8.12

Table 4

Extractable and total content of Pb, Zn and Cd in the soil (Calcaric Fluvisol)

№	Element	DTPA extracta-ble, mg/kg	Total content, mg/kg	DTPA-extractable/ total content, $g.kg^{-1}$	MLV, mg
1	Pb	106.8	217.7	393	80
2	Zn	145.0	621.8	233	340
3	Cd	3.40	7.60	447	2.50

place, probably as a result of formation of less mobile compounds with the organic substances. In the roots of triticale, the contents of Pb varied from 24.0 mg/kg to 32.1 mg/kg, Zn - from 124.2 mg/kg to 192.4 mg/kg and Cd from 1.5mg/kg to 2.4 mg/kg.

The movement and accumulation of the heavy metals in the vegetative organs of the studied crop differed significantly. Their quantities in the stems of the studied crop were considerably lower compared to the root system, which showed that their movement through the conductive system was strongly restricted. The contents of Pb varied from 1.3 mg/kg to 1.9 mg/kg, Zn -from 23.1 mg/kg to 69.5 mg/kg and Cd - from 0.06 mg/kg to 0.5 mg/kg. Heavy metal contents in the leaves of the studied crop were lower compared to the root system. The contents of Pb varied from 4.3 mg/kg to 7.8 mg/kg, Zn - from 24.9 mg/kg to 131.8 mg/kg, and Cd - from 0.1 mg/kg to 3.2 mg/kg. Additionally are given the percents of decreasing of Pb, Zn and Cd accumulation in the

Table 5

Content of Pb, Zn and Cd in the investigated soil and plant samples

№	Plant parts	Content of Pb. Zn and Cd in the samples, mg/kg					
		Control	soil + 10 $g.kg^{-1}$ sapropel	Decrea-sing to control, %	Soil + 30 $g.kg^{-1}$ sapropel	Decrea-sing to control, %	Soil
Content of Pb							
1	root	32.1	30.0	6.5	24.0	25.2	
2	steams	1.9	1.8	5.3	1.3	31.58	217.7
3	leaves	7.8	6.9	11.5	4.3	44.88	
Content of Zn							
4	root	192.4	150.3	29.9	124.2	35.42	
5	steams	69.5	49.1	29.36	23.1	58.78	621.8
6	leaves	131.5	69.5	47.15	24.9	81.1	
Content of Cd							
7	root	2.4	1.9	21.84	1.5	37.5	
8	steams	1.5	0.3	80	0.06	96.0	7.6
9	leaves	3.2	0.1	96.87	0.00	100	

tested sapropel containing samples. The percent of decreasing of accumulation vary in large borders from 5.3 % to 100 % (Table 5).

The results obtained show that the sapropelles present a great interest for the purposes of phytostabilization. It was established significantly decreasing of Pb, Zn and Cd accumulation from the separate parts of tested culture triticale by introduction of sapropelles in the used alluvial-meadow soil (Calcaric Fluvisol).

Conclusions

In content from 10 $g.kg^{-1}$ to 30 g,kg^{-1} sapropelles decrease of Pb, Zn and Cd accumulation by triticale. The evaluation of their potential, however, requires further studying of both the physical-mechanical and chemical characteristics, as well as their effect on a wider range of agricultural crops.

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