RESEARCHES CONCERNING THE HEAVY METAL TRANSLOCATION FROM THE SEWAGE SLUDGE IN SOIL AND PLANT

CERCETĂRI PRIVIND TRANSLOCAREA METALELOR GRELE PROVENITE DIN NĂMOLUL ORĂŞENESC ÎN SOL ŞI PLANTE

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***Abstract*:** Sewage sludge came from town water purification stations may constitute a source of nutritive elements for soils, but at the same time, by the content of heavy metals it may determine extremely big accumulations of these elements in soil and plant.The work presents the influence of sewage sludge upon heavy metals content in soil and their translocation in different plants organs for the dosis of 30t/ha, dosis which causes significant statistical changes.

Rezumat: *Nămolurile provenite de la stațiile de epurare orăşeneşti pot constitui o sursă de elemente nutritive pentru soluri, dar, totodată, prin conținutul ridicat de metale grele pot determina acumulări excesiv de mari în aceste elemente în sol şi plantă. Lucrarea prezintă influența nămolului orăşenesc asupra conținutului de metale grele din sol şi translocarea acestora în diferite organe ale plantelor pentru doza de 30 t/ha, doză de la care au apărut modificări statistice semnificative.*

Key words*: sewage sludge, heavy metal, soil, plants*
Cuvinte cheie*: nămol orăşenesc, metale grele, sol, plante*

INTRODUCTION

The ever higher quantities of sewage sludge came from the water purification stations need some viable solutions for both neutralization and valorization of its fertilizing elements. Lately, taking out of the agricultural circuit an ever large surface, by its storage, led to their use on agricultural fields. In order to be used on the agricultural fields, we have to take into account, when applying the dosis of soils characteristics, the content of elements possibly polluting from the sewage sludge and cultivated plant.

MATERIAL AND METHODS

In order to emphasize the influence of sewage sludge upon the reddish preluvosoil physical-chemical characteristics but also upon its production and quality, there have been organized experiments in vegetation pots, the experiments being materialized in the administration of sewage sludge increasing dose from 0 to 240 t/ha. When fertilizing with sewage sludge, we have to choose the plants which will assure the highest degree of valorization of the sludge fertilizing potential, having to gather smaller quantities of heavy metals in order to diminish the risk for the trophic chain. In order to follow the heavy metals accumulation from the sludge in the soil and their translocation in different plants organs, there have been used: maize, oats, soy, lettuce, beet, tomatoes.

The sewage sludge used in the experiments had the following concentrations of heavy metals: 558 mg/kg Cu, 3240 mg/kg Zn, 24167 mg/kg Fe, 630 mg/kg Mn, 375 mg/kg Mn, 48 mg/kg Cd, 28 mg/kg Co, 21 mg/kg Ni, 760 mg/kg Cr. Generally, the used sewage sludge surpassed the maximum admitted charge of heavy metals. The soil used in experiments has been reddish preluvosoil and it presented the following chemical traits: 6, 5 pH, 1, 89 % humus, 0,133 % NT, 57 mg/kg P mobile and 111 mg/kg K mobile.

RESULTS AND DISCUSSION

Research has shown that the plants cultivated on the same kinds of soil behave in a different way when applying the same treatment, they give different productions, they gather quantities of different polluting substances and they have different sprouting sensitivities. The sludge fertilization led to the significant increase of the reddish preluvosoil in humus, nitrogen and phosphorous but once with the significant increase of the soil content macroelements, it is acknowledged a significant increase of heavy metals once with the increase of the sludge dosis (table 1).

Table 1

Accumulation of heavy metal in redish preluvosoil fertilization with sewage sludge

Treatment	Cu mg/kg	Zn mg/kg	Pb mg/kg	Co mg/kg	Ni mg/kg	Mn mg/kg	Cr mg/kg	Cd mg/kg
Control	18,9	68,1	18,9	10,4	22,2	268	43	0,7
30 t/ha	21,9	69,3	20,9	10,8	24,2	257	49	0,9
60 t/ha	26,7	72,1	21,3	11,6	24,8	256	58	1,3
90 t/ha	28,0	75,3	21,5	11,5	25,5	242	75	1,6
120 t/ha	32,9	74,9	22,9	11,8	26,8	241	92	1,5
150 t/ha	34,0	79,1	22,2	11,8	27,2	236	83	2,1
180 t/ha	37,4	83,5	23,0	11,8	30,2	298	105	2,2
210 t/ha	49,3	85,2	26,9	12,0	32,5	309	122	2,3
240 t/ha	51,4	87,1	27,2	12,1	33,0	302	157	2,3
DL 5%	14	5	6	0,7	4	14	17	0,9
DL 1%	19	7	9	1,0	5	19	23	1,3
DL 0,1%	26	10	12	1,4	7	27	32	1,7

Generally, applying sludge on agricultural fields, one obtains production gains due to the content rich in fertilizing elements. All the effected research show a trend of production increase as a consequence of fertilization with sewage sludge for most of the crop plants, but once with the dosis increase, it takes place its reduction.

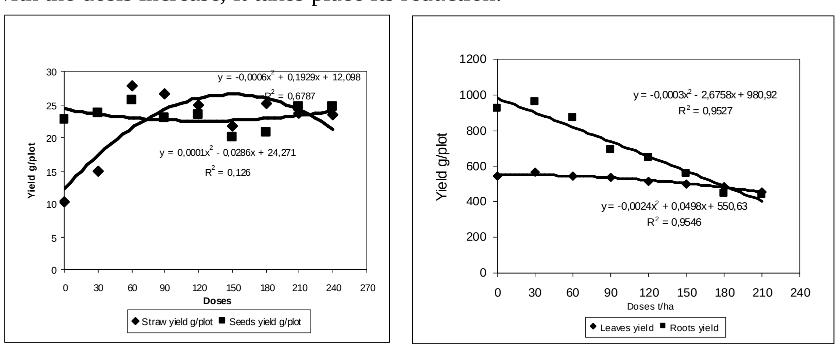


Figure 1 Influence of sewage sludge upon oats and sugar beet production

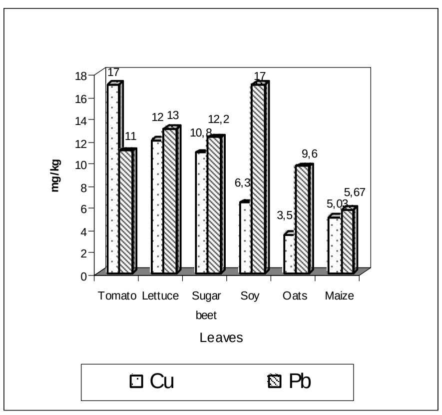
A special issue is represented by the heavy metals translocation in soil in different plant tissues. Most research has shown that inside the grains the metals concentration is seldom significant in order to cause using prohibitions in the animal feed. The effected research has shown that the first crop which follows after the sludge application has a higher content of metals in tissues. If the sludge aspplication doesn't repeat anylonger, the content in metals of successive crops will decrease until a stable level higher than the untreated control element. Even for the soils where the sludge application ceased a long time ago, the plants tissues continue to have high contents in heavy metals. For the sewage sludge, used in experiments, significant statistical changes asppeared for some crops when applying some bigger dosis of

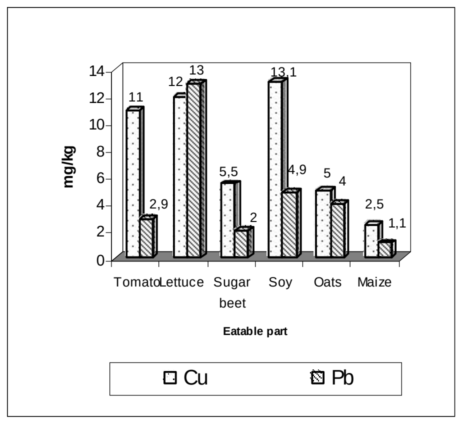
30 t/ha. On these accounts and in order not to apply high sludge quantities with risk of heavy metals accumulation in the soil and their translocation in the plant, it is requested the reduction of the applied dosis depending upon the heavy metals content which exist inside of it.

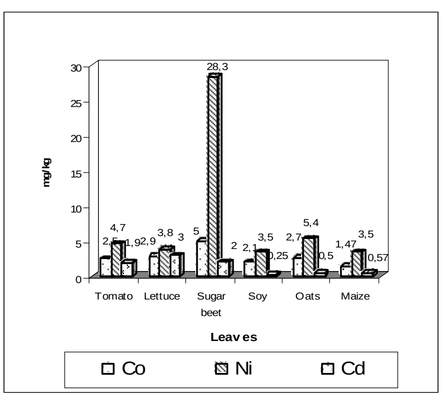
In order to estimate in an unitary way the influence of the sewage sludge on the plants, it has been calculated the tolerance index, the transfer coefficient, and the concentration index for the dosis of 30 t/ha, dosis where significant changes occured.

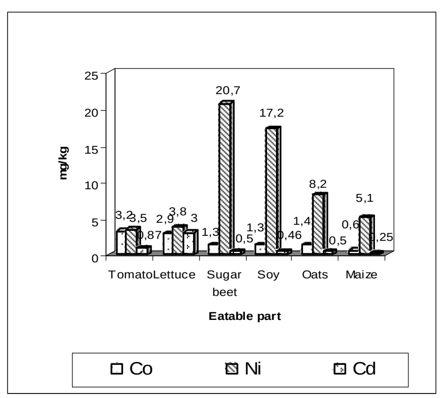
The quantity effect of heavy metals upon the plants growth is expressed by the tolerance index. Crops distribution depending upon the tolerance index, calculated as a report between the obtained production after the treatment in comparison with the production obtained without treatment lead to the following order: lettuce (1,70), maize (1,47), soy (1,39), oats (1,09), tomatoes (1,07) and sugar beet (0,94). Phytotoxicity and growth reduction are very different from one level to another. The copper is phytotoxical in relatively small quantities, while the smallest plants tolerate the lead. Perrenial grasses are relatively resistant to zinc, while the sugar beet is more sensitive.

The achieved results clearly emphasize the trend of heavy metals gathering in the soil (total and acccessible forms) and their tendency of translocation inside the plant. But, it appears an important variability concerning metals concentration in plants (Fig. no. 2).









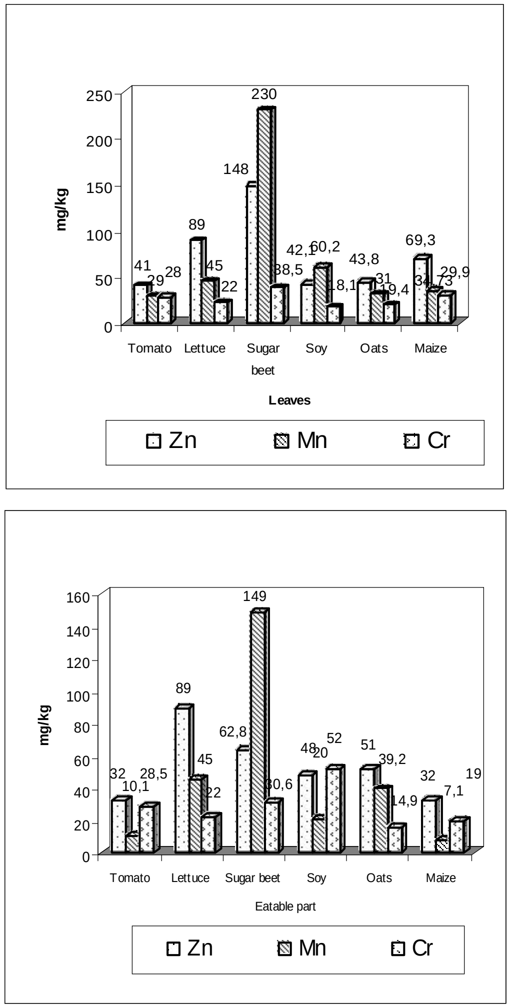


Figure 2 Concentration of heavy metal in different plant organs under application of a 30 t/ha dose of sewage sludge

Changing elements concentration in plants tissues on account of the soil enrichment represents a qualitative effect sewage sludge treatment which may be expressed by calculating the concentration index (the report between the concentration in the treated plants and the concentration in the untreated plants).

In table 2, there are presented the values of the concentration index for the analysed metals in the plants leaves and seeds used in the experiments. Calculating the concentration index for all the analysed metals has led to the crops distribution depending upon this index.

The obtained data emphasize the possibility of a bigger concentration of metals in the lettuce, beet and tomatoes leaves than in the leaves of oats, maize and soy and bigger concentrations in the eatable part of soy, beet and tomatoes plants.

Table 2

Concentration index for the analysed metals in the plants leaves
and seeds used in the experiments
(for 30 t/ha doses)

Cu mg/kg		Zn mg/kg		Pb mg/kg		Co Mg/kg		Ni mg/kg		Cr mg/kg		Cd mg/kg	
Leaves	Eatable part	Leaves	Eatable part	Leaves	Eatable part	Leaves	Eatable part	Leaves	Eatable part	Leaves	Eatable part	Leaves	Eatable part
Tomato 1,29	*Soy 1,39*	Sugar beet 1,48	*Maize 1,33*	Tomato 1,57	*Oats 1,14*	Soy 2,1	*Tomato 1,28*	Lettuce 1,52	*Oats 1,21*	Soy 1,19	*Tomato 1,32*	Lettuce 2,09	*Tomato 1,85*
Lettuce 1,20	*Tomato 1,10*	Maize 1,43	*Soy 1,20*	Lettuce 1,16	*Tomato 1,12*	Tomato 1,36	*Soy 1,26*	Maize 1,09	*Sugar beet 1,19*	Tomato 1,17	*Soy 1,13*	Oats 1,67	*Soy 1,39*
Sugar beet 1,16	*Sugar beet 1,09*	Soy 1,29	*Sugar beet 1,10*	Oats 1,14	*Soy 1,04*	Oats 1,17	*Maize 1,10*	Soy 1,06	*Tomato 1,17*	Lettuce 1,16	*Oats 1,11*	Sugar beet 1,42	*Sugar beet 1,0*
Maize 1,10	*Maize 1,04*	Tomato 1,28	*Tomato 1,10*	Maize 1,01	*Sugar beet 0,95*	Lettuce 1,16	*Oats 1,08*	Oats 1,04	*Soy 1,11*	Oats 1,03	*Sugar beet 1,03*	Maize 1,07	*Oats 1,0*
Oats 1,0	*Oats 0,94*	Lettuce 1,22	*Oats 1,06*	Soy 1,04	*Maize 0,8*	Sugar beet 1,1	*Sugar beet 1,0*	Sugar beet 1,04	*Maize 1,02*	Maize 1,02	*Maize 0,79*	Soy 1,0	*Maize 1,0*
Soy 0,91		Oats 1,19		Sugar beet 1.05		Maize 0,91		Tomato 0,96		Sugar beet 0,99		Tomato 0,88	

The obtained data concerning the concentration of heavy metals under the influence of the application of a 30 t/ha dosis of sewage sludge show an important variability concerning heavy metals concentration in different plants organs.

Heavy metals transfer from the soil in the plant is different depending upon the cultivated crop and it may be characterized by the transfer coefficient (the report between the increase of the heavy metals concentration in the plant and the metals concentration increase in the soil.)

These indexes show that it may take place the accumulation of some mobile elements (such as cadmium) in relatively big quantities before to become phytotoxical, while other elements such as copper and chromium are already phytotoxical for relatively small concentrations in plants. In table 3, it is presented the crops arrangement depending upon the transfer coefficient calculated for each of the analysed metals. The obtained data show the high risk of transferring in beet, lettuce and tomatoes plants in comparison with the maize and oats plants which gather a lower quantity of heavy metals in the leaves but also in the eatable part.

Table 3

The transfer of coefficient (raport from incresed plant concentration
plant and soil concentration)

Cu mg/kg		Zn mg/kg		Pb mg/kg		Co mg/kg		Ni mg/kg		Cr mg/kg		Cd mg/kg	
Leaves	Eatable part	Leaves	Eatable part	Leaves	Eatable part	Leaves	Eatable part	Leaves	Eatable part	Leaves	Eatable part	Leaves	Eatable part
Tomato	*Soy*	Sugar beet	*Soy*	Soy	*Soy*	Sugar beet	*Tomato*	Sugar beet	*Sugar beet*	Sugar beet	*Sugar beet*	Sugar beet	*Tomato*
Sugar beet	*Tomato*	Soy	*Oats*	Sugar beet	*Oats*	Oats	*Soy*	Oats	*Soy*	Maize	*Soy*	Tomato	*Oats*
Lettuce	*Sugar beet*	Lettuce	*Sugar beet*	Oats	*Tomato*	Lettuce	*Oats*	Lettuce	*Oats*	Oats	*Maize*	Lettuce	*Soy*
Soy	*Oats*	Maize	*Maize*	Tomato	*Sugar beet*	Tomato	*Sugar beet*	Soy	*Maize*	Tomato	*Oats*	Oats	*Sugar beet*
Maize	*Maize*	Oats	*Tomato*	Lettuce	*Maize*	Soy	*Maize*	Maiye	*Tomato*	Lettuce	*Tomato*	Maize	*Maize*
Oats		Tomato		Maize		Maize		Tomato		Soy		Soy	

CONCLUSIONS

Inside all the plants which have been used in experiments, it has been acknowledged a tendency of heavy metals accumulation. The biggest metals quantities have been recorded in the leaves, sometimes surpassing the zootoxical level.

The 30 t/ha sewage sludge didn't cause significant statistical changes of the studied plants chemical composition.

Arranging crops, taking into account the transfer coefficient show a very important risk of transferring heavy metals in the plants of beet, lettuce, and tomatoes, in comparison with the maize and oats plants which gather a lower quantity of heavy metals both in leaves as in the eatable parts. The calculus of the concentration index for the analyse metals emphasize the possibility of a bigger concentration of metals in the lettuce, beet and tomatoes leaves and low accumulations in oats, maize and soy leaves.

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