# ESTABLISHING THE INFLUENCE OF HEAVY METALS IN THE SLUDGE, ON THE YIELD AND QUALITY OF PRODUCTION ON SEVERAL SOIL VARIETIES

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***Abstract:*** *The aim of this experiment is to determine to what levels of toxic load with heavy metals reached different soil types under varied levels of sludge application. Determine the effects of different toxic loading soil on biomass yield and heavy metals content in crop production. The pot experiments are with two cropsperco(Brassica ssp. spantaula) and rye grass(Loliummultiflorum), in two swaths as an after-effect on the yield on four soil types: Carbonate Fluvisols,Leached Vertisols, Leached Cinnamon Forest and gray Forest.The different percentage of sludge level relative to the weight of soil was tested.*
*It was found, that loading of various soils types with sludge up to 10% supported increasing effect of fertilization with sludge in perco and rye grass and to the same extent accumulation of heavy metals in them. Their concentrations, however, do not have phytotoxicity.*
KEYWORDS: HEAVY METALS

## *1. Introduction*

During biological cleaning of wastewater a large amount of sludge is obtained. A numerous studies have shown that sludge possess fertilizer properties and added to the soil increases its productivity. An important conclusion of the experiments is when heavy metals content in sludge is below sub critical level and then the soil can bear significant loads without signs of phytotoxicity (Marinova, S.1989; 2008). Scientific interest represent, conducting the experiments with similar level of sludge application in soil in which the content of heavy metals is above critical.
The aim of this experiment is to determine to what levels of toxic load with heavy metals reached different soil types under varied levels of sludge application. Determine the effects of different toxic loading soil on biomass yield and heavy metals content in crop production.

## *2. Material and methods*

The pot experiments are with two crops perco (*Brassica ssp. spantaula*) and rye grass (*Lolium multiflorum*), in two swaths as an after-effect on the yield on four soil types: Carbonate Chernozems from region Trustenik, Leached Smolnica from Pleven, Leached Cinnamon Forest from Bojurishte, Sofia district and Gray Forest from Nikolaevo- Pleven.
The experimental variants are:

1. Control without sludge;
2. 1% sludge /30g/ air dry sludge content;
3. 2% /60g/ air dry sludge content;
4. 4% /120g/ air dry sludge content;
5. 10%/300g/ air dry sludge content;

They were used pots of 3 kg in 3 replication. The sludge was taken from Varna Waste Water Treatment Plant (WWTP). The sludge and soil were analyzed for main macronutrients and heavy metals content (Ordinance N339). During the experiment was maintained soil moisture to 70% of field capacity. After each swath the biomass was measured and determined the content of Zn, Cu, Cd, Pb in yield (Kostatikov, V. 1991, Toncheva et al., 2014).

## *3. Results and discussion*

The sludge characteristic is shown fertilizer effect, because it contains 22 kg/t total nitrogen, 1.1 kg/t phosphorus and 2.4 kg/t potassium. The acidity of the sludge from Varna WWTP is pH (H2O) is 7.2. The values of Cd is 318 mg/kg dry mater, Pb -210 mg/kg dry mater, Cr-1338 mg/kg dry mater, Cu -1705 mg/kg dry mater, Zn-4450 mg/kg dry mater and Ni-900 mg/kg dry mater in sludge are significantly high and exceed the maximum permissible concentration. In different soil types, soil acidity is taken in all around the range - from slightly alkaline - to acidic soil (tabl.1). This defines the different types of interactions between heavy metals and soil and different microbiological treatment of soil to sludge and its organic matter.

***Table 1*** *Chemical characteristic of the soil samples which are used for vegetation experiments with sludge from Varna WWTP*

| Indic. | Carbonate Chernozem | Gray Forest | Cinnamon Forest | Leached Smolnica |
|---|---|---|---|---|
| Total N % | - | - | 0,11 | 0,13 |
| $NH_4$-N mg/kg | 8,4 | 9,2 | 5,8 | 6,7 |
| $N0_3$-N mg/kg | 8,8 | 18,7 | 1,8 | 2,5 |
| $P_20_5$ mg/100g | 3,7 | 1,9 | 5,4 | 6,4 |
| $K_20$ mg/100g | 27,5 | 15,6 | 35,0 | 36,2 |
| Zn mg/kg | 100 | 75 | 166 | 128 |
| Cu mg/kg | 30 | 20 | 55 | 36 |
| Pb mg/kg | 26 | 31 | 22 | 40 |
| Ni mg/kg | 45 | 33 | 40 | 30 |
| Co mg/kg | 15 | 15 | 12 | 18 |
| Cr mg/kg | 63 | 56 | 100 | 117 |
| Cd mg/kg | - | - | 0,23 | 0,25 |
| Mn mg/kg | - | - | 737 | 985 |
| pH /$H_20$/ | 7,5 | 3,9 | 4,2 | 7,0 |

On Table.2 are presented the results of yield from perco and rye grass on the 4 soil types. Table shows that fertilize effect on both crops grow when sludge rate is increased. Differences between two soils types are observe only at the levels of expression of the effect. This can be seen more clearly by comparing the relative yield between two crops. For example, yields from perco and rye grass on the Carbonate Chernozem grow without major differences between them to higher supplements (Marinova, S., 2012; 2013;.Zlatareva, E. 2015).
After this the perco shown tendency to decrease level of responsiveness. On cinnamon forest soil, perco formed relatively higher yield - fertilize effect is amplified considerably. Even more clear differences between the two crops and in their response to fertilization with sludge to settle on Leached Smolnica. The results show that on none of the soil types, the crops did not show any signs of yield "depression" even under maximum load with sludge.

Obviously, under these conditions, high levels of heavy metals in sludge do not cause phytotoxic effect.

*Table. 2 Average yields from vegetation experiment with perco and ryegrass - fresh weight from two swaths on different soils types.*

| Var. | Gray Forest | | Leached Smolnica | | Cinnamon Forest | | Carbonate Chernozem | |
|---|---|---|---|---|---|---|---|---|
| g/ per pot sludge | g/ per pot | Relay ield % | g/ per pot | Rela yield % | g/ per pot | Rela . yield % | g/ per pot | Rela . yield % |
| Perco | | | | | | | | |
| 0 | 33,8 | 100 | 9,9 | 100 | 5,1 | 100 | 30,5 | 100 |
| 30 | 42,2 | 125 | 14,1 | 141 | 8,8 | 172 | 32,1 | 105 |
| 60 | 49,3 | 146 | 24,2 | 244 | 13,3 | 300 | 34,7 | 114 |
| 120 | 75,2 | 222 | 38,9 | 392 | 30,1 | 590 | 68,1 | 223 |
| 300 | 125 | 371 | 77,4 | 782 | 67,8 | 1330 | 71,6 | 235 |
| Rye grass | | | | | | | | |
| 0 | 9,3 | 100 | 4,6 | 100 | 2,7 | 100 | 9,9 | 100 |
| 30 | 11,1 | 118 | 6,5 | 141 | 5,6 | 207 | 11,6 | 117 |
| 60 | 13,7 | 147 | 7,1 | 152 | 7,5 | 277 | 11,1 | 112 |
| 120 | 18,2 | 195 | 11,1 | 239 | 14,3 | 530 | 15,3 | 154 |
| 300 | 27,3 | 293 | 27,8 | 604 | 23,9 | 885 | 29,1 | 294 |

Table 3 presents data of comparative assessment on heavy metals accumulated (Zn, Cu, Cd and Pb) in crops biomass. It is seen, that with increasing level of sludge application, the concentration of heavy metals in plants increases. The rate of accumulation is influenced by soil differences and suggests a special correlation with the soli acidity.

This is seen most well Zn, Cu, and Cd accumulation in perco, in the comparison between the Carbonate Chernozem and Gray Forest soil. It is seen that on Leached Smolnica, this crops accumulates small amounts of heavy metals, while the Gray Forest soil accumulates more. That neutral Smolnica stronger reduces assimilation of Cd and Cu in compared to slightly alkaline soil carbonate, possibly related to the high cation exchange capacity of montmorillonite in the soil. The accumulation of Pb seems different. Its contents in perco on Leached Smolnica and Gray forest soils are very close. Also, rye grass contrary to expectations, accumulate more Pb on Carbonate Chernozem than in the Gray forest soil.

***Table 3*** *Contents of heavy metals in perco and rye grass depending on the imported sludge on different soils types (average of two swaths)*

| Var | **Zn** | | **Cu** | | **Cd** | | **Pb** | |
|---|---|---|---|---|---|---|---|---|
| | Per. | Rye gr. | Per. | Rye gr. | Per. | Rye gr. | Per. | Rye gr. |
| Carbonate Chernozem | | | | | | | | |
| 0 | 34 | 89 | 4,7 | 6 | 0,8 | 0,5 | 2,1 | 1 |
| 30 | 41 | 110 | 5,2 | 7 | 1 | 0,7 | 2,2 | 1,8 |
| 60 | 49 | 105 | 5,5 | 6 | 1,9 | 0,5 | 2,3 | 1,6 |
| 120 | 59 | 137 | 5,3 | 7,5 | 5 | 1,2 | 2,2 | 2,7 |
| 300 | 73 | 213 | 13,4 | 11 | 8,3 | 5 | 2,9 | 2,8 |
| Gray Forest | | | | | | | | |
| 0 | 290 | 150 | 10,4 | 4,8 | 7,5 | 1 | 2,2 | 0,5 |
| 30 | 317 | 106 | 12,4 | 7,2 | 9,5 | 3,3 | 2,4 | 0,9 |
| 60 | 342 | 155 | 12 | 7 | 10 | 3,2 | 2,1 | 1,3 |
| 120 | 398 | 194 | 13,5 | 7,5 | 19 | 4,9 | 2,6 | 1,9 |
| 300 | 387 | 228 | 46 | 13,1 | 20 | 6,5 | 2,8 | 1,4 |
| Leached Smolnica | | | | | | | | |
| 0 | 50 | 50 | 5,4 | 5,4 | 1 | 0,1 | 0,13 | 0,13 |
| 30 | 59 | 71 | 5 | 8,3 | 1,1 | 0,13 | 2 | 1,6 |
| 60 | 52 | 74 | 5,4 | 8,4 | 1,7 | 0,29 | 2,1 | 2,8 |
| 120 | 77 | 135 | 6,9 | 10 | 2,6 | 0,8 | 1,8 | 2,8 |
| 300 | 76 | 150 | 6,4 | 15,2 | 2,6 | 1 | 2,2 | 3 |
| Cinnamon Forest | | | | | | | | |
| 0 | 50 | 53 | 5,8 | 6 | | 0,5 | 1,3 | 1 |
| 30 | 100 | 94 | 7,4 | 7,9 | 2 | 0,8 | 2 | 2,2 |
| 60 | 81 | 110 | 8,1 | 9,8 | 2,5 | 0,5 | 2,6 | 1,7 |
| 120 | 88 | 160 | 7,7 | 8,6 | 2,6 | 0,9 | 3,3 | 3,6 |
| 300 | 115 | 195 | 10,9 | 11 | 3,5 | 1,1 | 3,8 | 4,5 |

It can be assumed, that the Pb form complexes with organic matter in sludge into simple digestible for chemical plant species and weakly alkaline reaction of the Carbonate Chernozems is weakly affect their mobility. Moreover, it is well known, that the Pb is equipped with such a tendency to form organic forms. It is also known, that Pb is accumulated primarily in the roots and hardly moves to the over ground parts of the plants. That's why the sharp acid differences between soil types is not so important compared to that observed in Zn and Cd accumulation. If you refer to limit concentrations of heavy metals in sludge the Cd is 15 times higher than limit, while Zn is only 2 times more. As might be expected, the slight mobility of Cu in the soil and a relatively low content in the sludge are closely related with its accumulation (Marinova, S. et al. 1999).

## *4. Conclusions*

Different soils loading with sludge up to 10% supported increasing effect of fertilization in perco and rye grass at the same level as accumulation of heavy metals in them. Their concentrations, however, do not have phytotoxic. Toxic concentrations for animals are observed only on Grey forest soil (Cd and Zn) in whole range of experiments and on Carbonate Chernozem (Cd) at high level of sludge application. On cinnamon forest soil concentrations of heavy metals in plants emerge high, but not toxic, but on Smolnica are relatively lower.

## *5. Reference*

1. Kasatikov V. A., 1991. Criteria for soil and plant pollution with microelements and heavy metals during their use as a sludge as a fertilizer. Agrochemistry N11.
2. Marinova, S. 2008. Sludge from WWTP and rules for their use. Edit by "Publish SaiSet-Eko". ISBN 978-954-749-076-5.
3. Marinova, S. et all. 1989. Characteristic of WWTP sludge in country and preparation of technological; designs for their use. ISSAPP archive
4. Marinova, S., R. N. Kathijotes, E. Zlatareva, D. Stoicheva, V. Kolchakov. 2013. Comparative assessment of sludge from different places of treatment in wastewater plant in Sofia regard to their use in agriculture. ISB-INMA TEN Agriculture and Enginering. 1st - 3rd November 2013, 193-200
5. Marinova, Sv., R. Toncheva, N. Kathijotes, E. Zlatareva, Hr. Pchelarova. 2012. Agricultural use sludge and treated wastewater from sewage treatment. Int. conf. -interdistsiplinna Environmental science and practice, 25 to 26 October, 2012. Proceedings, part two, 498-503 ved.
6. Odense N339/14.12.2004. Approval of Ordinance on procedure and manner of utilization of sludge from ashamed by their use in agriculture. SG 112

7. Tontcheva R., H. Pchelarova E. Zlatareva. 2014. Comparative effects of using poultry manure and sewage sludge as a soil improver. Soil Agro-chemistry and ecology. 3-4, 31-37
8. Zlatareva E., K. Audinali, St. Marinova. 2015. Chemical changes in soil at establishing with a comparative effect of the use of sludge and poultry manure as a soil improver. Int. conf., "The soil and agricultural technology in a changing world" May 11 to 15, Sofia
9. Marinova, S. and Chuldyan, H., 1999**.** Estimation the Effect of the Sludge from Waste Water Treatment Station over the leached Smolniza and degraded Chernozem. Extended abstracts, Soil with Mediterranean Type of Climate, 6th International Meeting, Barcelona, 4-9 July, 1999; 286 – 288.