

# 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 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 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 (H<sub>2</sub>O) 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 <sub>4</sub> -N mg/kg	8,4	9,2	5,8	6,7
NO <sub>3</sub> -N mg/kg	8,8	18,7	1,8	2,5
P <sub>2</sub> O <sub>5</sub> mg/100g	3,7	1,9	5,4	6,4
K <sub>2</sub> O 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 <sub>2</sub> O/	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	Relay yield %	g/per pot	Relay yield %	g/per pot	Relay yield %	g/per pot	Relay 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.						
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.

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