REMEDIATION OF SEVERAL CHEMICAL PROPERTIES OF SOIL THROUGH EARTHWORM ACTIVITY

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Abstract: *The great contribution of earthworms to soil quality was often demonstrated, under aspects concerning its physical and chemical properties, but numerous studies showed also the bioremediator potential of these animals living into the soil. The study consisted of laboratory experiments and was conducted at the University of Agricultural Sciences and Veterinary Medicine of Banat (UASVMBT), from Timişoara city, Romania. The experiment consisted of several plastic vats filled with soil classified as Chernozem (FAO System) purchased from the Didactic and Experimental Station of UASVMBT. There were used earthworms from species Eisenia foetida (Savigny, 1826). The experimental variants were the control variant and the variant with organic fertilisation. The organic fertiliser consisted of swine sludge which was added at once in the beginning of experiment. The analyzed factors were pH, NH_3, NO^-_3, NO^-_2, PO^+_4, Zn^{2+}, and Cu^{2+}. Ulterior, in each vat were added 50 adult worms which were weighed previously. Monitoring of the chemical parameters of soil was realised after one and respectively two months since earthworms were added. The obtained results show that each analyzed chemical parameter of the soil was modified both after the first and the second month. Testing of the bioremediator potential of the earthworm species Eisenia foetida (Savigny, 1826), in laboratory conditions, led to the following conclusions: earthworms assimilated very well the swine sludge as food source, at the end of experiment no earthworm was found dead; after one month of experiment, the concentrations of the analyzed chemical factors of the soil were lower than those recorded at the beginning of experiment in the swine sludge; after two months of experiment there was found that each analyzed chemical parameter of the soil was modified, in the sense of their decrease, both after the first and the second month, being recorded decreases of their concentrations, which led to conclusion that earthworms can represent a solution to bio-remediate the polluted agricultural soils.*

Key words: *bioremediation, earthworms, swine sludge, pH, nitrates, ammonia, heavy metals*

INTRODUCTION

The great contribution of earthworms to soil quality was often demonstrated, under aspects concerning its physical and chemical properties, but numerous studies showed also the bioremediator potential of these animals living into the soil. Thus, researchers investigated the earthworm actions upon the soil environment and how they might influence the fate and behaviour of soil associated organic contaminants, and they found an improving bioremediation potential [HICKMAN AND REID, 2008].

Bioremediation could be an interesting biological technology to recover polluted environments while ensuring the conservation of the ecosystem's biophysical properties [CECCANTI AT AL., 2006]. Bioremediation is defined by Microbiology American Academy as "the use of living organisms to reduce or eliminate environmental hazard resulting from accumulation of toxic chemicals and other hazardous wastes" [ADRIANO ET AL., 1999; HICKMAN AND REID, 2008].

In the last time, there was increasingly investigated the bioremediation techniques which accelerate the naturally occurring biodegradation processes in order to activate coil biota. Researches concerning the earthworm potential of biodegradation were performed by several scientists [CONTRERAS-RAMOS ET AL., 2006; HICKMAN AND REID, 2008; SAFWAT ET AL., 2002; SCHAEFER ET AL., 2005; SINGER ET AL, 2001]. These and numerous others showed the efficacy of different earthworm species in degradation of a wide range of pollutant substances affecting the environment.

MATERIAL AND METHOD

The study consisted of laboratory experiments and was conducted at the University of Agricultural Sciences and Veterinary Medicine of Banat (UASVMBT), from Timişoara, Romania.

The experiment consisted of several plastic vats filled with soil classified as Chernozem (FAO System) purchased from the Didactic and Experimental Station of UASVMBT. The physical and chemical analyses of the experimental soil are listed in the table 1.

Table 1

Analytical data regarding the main physical, hydro-physical and chemical properties of the Chernozem [8]

DEPTH OF PEDOLOGICAL HORIZON (cm)	0-16 cm	16-32 cm	32-45 cm	45-63 cm	63-85 cm	85-125 cm	125-150 cm	150-230 cm
Rough sand (2.0-0.2 mm) (%)	0.5	0.4	0.2	0.3	0.3	0.3	0.7	0.4
Fine sand (international system) (0.2-0.02mm) (%)	34.1	32.6	30.8	32.8	31.5	36.3	32.1	34.9
Dust (international system) (0.02-0.002 mm) (%)	26.4	26.8	28.1	26.3	28.5	26.3	23.8	22.4
Clay (<0.002 mm) (%)	39.0	40.2	40.9	40.6	39.7	37.1	43.4	42.3
Physical clay (<0.01 mm) (%)	49.3	51.8	52.8	52.5	51.1	47.4	52.9	52.8
Texture	TT	TT	TT	TT	TT	TT	TT	TT
Density ($g \cdot cm^{-3}$)	2.69	2.73	2.68	2.75	-	-	-	-
Bulk density ($g \cdot cm^{-3}$)	1.50	1.39	1.35	1.34	-	-	-	-
Total porosity (%)	44.23	49.08	49.62	51.27	-	-	-	-
Aeration porosity (%)	11.09	15.26	15.71	17.43	-	-	-	-
Compaction degree (%)	13.86	4.78	3.94	0.66	-	-	-	-
Hygroscopic coefficient (%)	8.59	8.90	9.12	9.17	-	-	-	-
Blight coefficient (%)	12.88	13.35	13.68	13.75	-	-	-	-
Water field capacity (%)	22.09	24.33	25.11	25.25	-	-	-	-
Water total capacity (%)	29.49	35.31	36.76	38.26	-	-	-	-
Useful water capacity (%)	9.21	10.98	11.43	11.49	-	-	-	-
Hydraulic conductivity ($mm \cdot h^{-1}$)	0.72	1.25	1.50	1.60	-	-	-	-
pH in water (pH unities)	6.16	6.46	6.47	6.18	8.10	8.42	8.42	8.44
$CaC0_3$ (%)	-	-	-	-	13.1	16.7	15.7	14.7
Humus (%)	2.68	2.31	2.18	1.73	-	-	-	-
Exchangeable bases ($meq \cdot 100\ g^{-1}$ soil)	25.19	26.66	23.90	-	-	-	-	-
Na^+ exchangeable (% of total)	-	-	-	-	-	2.12	-	-
H^+ exchangeable ($meq \cdot 100\ g^{-1}$ soil)	15.1	14.3	15.8	-	-		-	-
Cationic exchange capacity ($meq \cdot 100\ g^{-1}$ soil)	30.0	31.43	28.07	-	-	17.40	-	-
Base saturation (% of total)	83.96	84.82	85.14	-	-	-	-	-
Cl^- ($meq \cdot 100\ g^{-1}$ soil)	-	-	-	-	-	0.6	-	-
SO_4^{-2} ($meq \cdot 100\ g^{-1}$ soil)	-	-	-	-	-	0.5	-	-
CO_3H^- ($meq \cdot 100\ g^{-1}$ soil)	-	-	-	-	-	0.85	-	-
Ca^{++} exchangeable ($meq \cdot 100\ g^{-1}$ soil)	-	-	-	-	-	1.0	-	-
Mg^{+2} ($meq \cdot 100\ g^{-1}$ soil)	-	-	-	-	-	1.0	-	-

In order to perform the proposed study were used earthworms from species *Eisenia foetida* (Savigny, 1826) introduced into the plastic vats. In each plastic vat was added 40 kg soil. The experimental variants were the control variant and the variant

with organic fertilisation, each of them with five replicates. The organic fertilisation consisted of swine sludge in amount of 335 g for each plastic vat, added at once in the beginning of experiment. The analyzed factors were pH, NH_3, NO^-_3, NO^-_2, PO^+_4, Zn^{2+}, and Cu^{2+}.

RESULTS AND DISCUSSION

Before starting the experiment, there were made chemical analyses of the control soil and of the swine sludge for the following parameters: pH, NH_3, NO^-_3, NO^-_2, PO^+_4, Zn^{2+}, and Cu^{2+}. The obtained results are shown in the table 2.

Table 2

Analytical data concerning the studied chemical indices before the experiment settlement

Crrt. no.	Chemical index	Measurement unit	Value	
			Control soil	Swine sludge
1	pH	pH units	7.50	8.55
2	NH_3	ppm	6.60	480
3	NO^-_3		110	180
4	NO^-_2		0	200
5	PO^+_4		40	560
6	Zn^{2+}		45	53
7	Cu^{2+}		15	17

In the figure 1 it can be shown the graphical representation of concentrations for each analyzed factor.

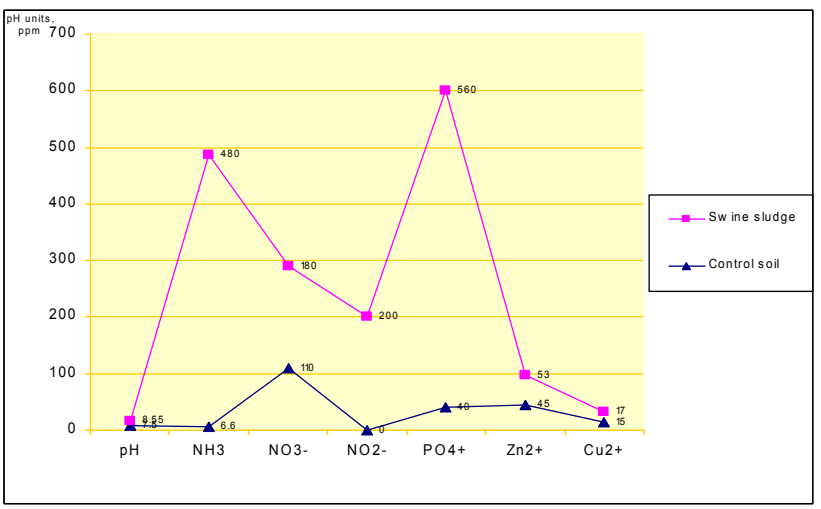

Figure 1. Concentrations of the chemical indices of soil and swine sludge in the beginning of experiment

Ulterior, in each vat were added 50 adult worms which were weighed previously. The means of the total weight of the earthworms introduced in the control vats and in the vats with swine sludge were 41.88 g and respectively 41.19 g (table 3).

Table 3

Descriptive statistics of the variable "earthworm weight" in the experimental variants

Crrt. no.	Experimental sample	Number of samples	Minimum earthworm weight	Maximum earthworm weight	Mean	Standard deviation
1	Control	5	40.97	42.92	41.8880	0.7623
2	Swine sludge	5	40.95	41.61	41.1960	0.2675

Monitoring of the chemical parameters of soil was realised after one and respectively two months since earthworms were added. The obtained results show that each analyzed chemical parameter of the soil was modified both after the first and the second month as can be observed in the table 4.

Table 4

Results concerning the studied chemical indices of soil in the variants with organic fertilisation (swine sludge) after one and two months, respectively

Crrt. no.	Chemical index	Measurement unit	Value		Comparison one month/two months (%)
			One month	Two months	
1	pH	pH units	8.00	7.50	93.75
2	NH_3	ppm	419	390	93.07
3	NO^-_3		140	110	78.57
4	NO^-_2		180	120	66.66
5	PO^+_4		510	440	86.27
6	Zn^{2+}		48	41	85.41
7	Cu^{2+}		14	12	85.71

Thus, after two months of experiment it was found a pH decrease by 6.25%, which is very important, because earthworms prefer pH about 6.00. Also, the concentrations of nitrates and nitrites decreased with 6.93% and 21.43%, respectively, fact attributed to earthworms, because they consume large amounts of nitrogen in their digestion, and thus they release the soil in these poisonous substances.

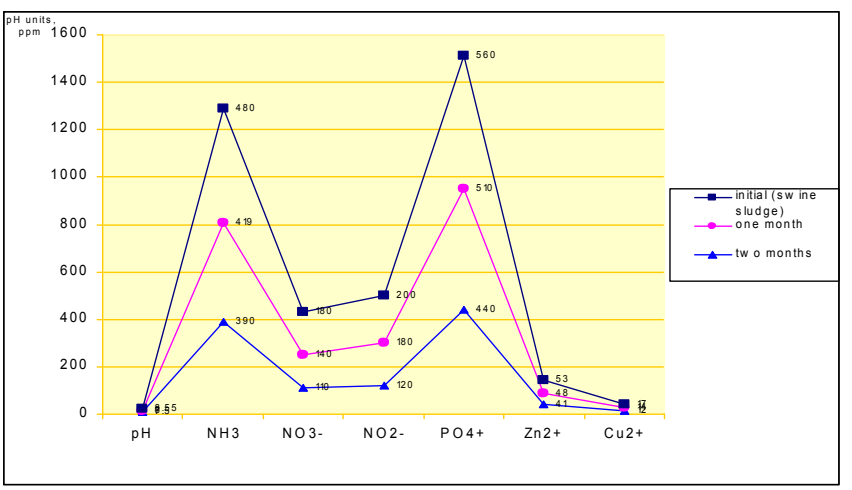

Figure 2. Concentrations of the analyzed indices of soil after one and respectively two month of exposure to earthworm activity

Very important is the decrease of the heavy metal content after two months, namely the concentrations of Zn^{2+} and Cu^{2+}, with 14.59 and respectively 14.29%, being well-known the problems arising from usage of the swine sludge as organic fertiliser, which abound in these heavy metals. The amount of phosphates became lower after two month (-13.73%) of earthworm activity, which could be a solution of bioremediation, because one issue of the farm functioning is the phosphate pollution (figure 2).

CONCLUSIONS

Testing of the bioremediator potential of the earthworm species *Eisenia foetida* (Savigny, 1826), in laboratory conditions, led to the following conclusions:

• Earthworms assimilated the swine sludge as food source, at the end of experiment no earthworm was found dead.

• After one month of experiment, the concentrations of the analyzed chemical factors were lower than those recorded at the beginning of experiment in the swine sludge.

• After two months of experiment was found that each analyzed chemical parameter of the soil was modified both after the first and the second month, being recorded decreases of their concentrations, which led to conclusion that earthworms can represent a solution to bio-remediate the polluted agricultural soils.

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