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Experimental Research of Vermicompost Made of Biowaste

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Abstract: We verified using of vermicompost made of biowaste and sludge from wastewater treatment plants by experimental tests. The test confirmed that this vermicompost has a positive effect on growth of plants. The properties of vermicompost were verified via a biological test of growth using a hybrid variety of ryegrass. Ryegrass was grown in the mixture of the formed vermicompost and soil in different proportions. All of the culture substrate and the grown plants were analyzed. Research was performed in VSB — Technical University of Ostrava and it has shown that the vermicomposting (composting using earthworms) is an effective technology of biowaste treatment. Quality product — vermicompost — obtained from vermicomposting may be applied as a fertilizer and amending product.

Key words: biowase, vermicompost, sawage sludge.

1. Introduction

Sludge from wastewater treatment plants (further referred to as sewage sludge) is biodegradable waste that forms as the primary product of wastewater treatment. The disposal of the sludge may be very problematic due to the possible content of hazardous substances. As the high production of the waste is a serious environmental issue, it is vital to search for its possible application methods [1]. It appears very promising to use the sewage sludge as an additional material in vermicomposting.

In the course of vermicomposting process, the capacities of earthworms to convert plant residues into a high quality organic fertiliser, i.e., vermicompost, is used. The vermicompost forms as the product of the earthworms' metabolism. Such obtained vermicompost has undergone a higher degree of conversion of the organic matter than common composts. For that reason, apart from the high proportions of humic substances, such formed organic fertilisers contain growth regulators, such as auxins, gibberellins and cytokinins [2].

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2. Experimental

A test bed was started for the experiment. The earthworm stock was placed into the layer of biowaste, which constituted of a layer of fermented manure. Subsequently, the bed was split into two sections.

Earthworms were fed with biowaste further on. In the first section of the bed only stabilized sludge from wastewater treatment was used and in the second section the stabilised sludge was mixed with waste grass. The proportion of grass mass and the sludge was 1:1. This way we obtained two types of final vermicomposts, labelled as Vermicompost I and Vermicompost II. The experimental vermicomposting lasted for 4 months. Next, samples of the vermicomposts were drawn for the laboratory analyses.

3. Biological Test of Ryegrass Growth

The properties of vermicomposts were verified via a biological test of growth using a hybrid variety of

Fig. 1 The two sections of the bed.

ryegrass. Ryegrass was grown in the mixture of the formed vermicompost and soil. Several pots were filled with different proportions of vermicompost and soil. The plant was harvested in due time and underwent laboratory analyses.

3.1 The Soil and Vermicompost

The characteristics of the soil used were determined subject to Appendix 5 of Regulation 275/1998 Coll., on agrochemical testing of farming land and determination of soil properties of forest land, as amended. The sampled farmland was assessed according to the content of available nutrients, especially macroelements (K, Mg, P, and Ca). Another indicator to classify the soil was the pH value. The content of potassium and magnesium was high, and the abundance of phosphorus was very high. The farmland was classified as intermediate soil of an alkaline soil reaction.

Table 1 gives the basic properties of the soil and the used substrate before and after the test (conductivity, content of organic matter, sample dry matter, total nitrogen and pH). Table 2 compares the available nutrients in the soil and the substrate before and after the test.

3.2 Test Methodology

A hybrid variety of ryegrass was selected for the experiment. The amount of seeds was weighed as 10 g per a pot. The experiments took place in 5 identical pots, and distilled water was used for watering. The overall experiment took place at the room temperature, and the pots were exposed to eastern sunshine. In the biological test the used soil was mixed with different additions of vermicomposts. The check sample pot contained pure soil. Sample "Vermicompost I" was mixed with soil in the proportions 1:1 and 1/3:2/3. The identical proportions were used also for sample "Vermicompost II" (see Table 3).

Table 1 Properties of the soil and substrate

Property	Values before the test	Values after the test	
	E0	C1	C2
pH/ CaCl2	7.47	7.13	6.56
total N [%]	0.13	0.13	0.58
sample dry matter [%]	98.87	98.90	97.28
organic matter [%]	3.58	3.15	10.89
conductivity [μS/cm]	133.30	135.70	1103

(*Note that E0 = check soil before the test, C1 = check soil after the test, C2 = mixture of vermicompost and soil in 1:1 proportion.)

Table 2 Available nutriens in the soil and substrate

Soil	Before the test	After the test	
Element	E0 [mg/kg]	C1 [mg/kg]	C2 [mg/kg]
Ca	4727	4018	5990
K	322	169	308
Mg	307.5	216.5	328.5
P	322.4	309.2	764.3

(* Note that E 0 = check soil before the test, C1 = check soil after the test, C2 = mixture of vermicompost and soil in 1:1 proportion.)

Table 3 Proportions of the soil and Vermicompost I and II

Sample	Ratios in Vermicompost I	Mass [kg]
Vermicompost I : soil	1 : 1	0.75 : 0.75
Vermicompost I : soil	1/3 : 2/3	0.5 : 1
Sample	Ratios in Vermicompost II	Mass [kg]
Vermicompost II : soil	1:1	0.75 : 0.75
Vermicompost II : soil	1/3 : 2/3	0.5 : 1

(*Note that "Vermicompost I" = stabilised sludge, "Vermicompost II" = stabilised sludge + garden waste.)

3.3 Week 1

For the experiment 10 g of seeds were selected. On the third day from seeding no signs of growth were observed in the pots. On the fifth day from seeding, ryegrass springs could be seen in the pots. The most prominent growth was observed in pure soil (check sample), which may be attributed to the soil characteristics, i.e., its fineness of grains.

3.2 Week 2

The most developed plants were in the mixture of Vermicompost I mixed with soil in 1:1 proportion, Vermicompost I mixed with soil in 1/3:2/3 proportion and Vermicompost II mixed with soil in 1:1 proportion. The least developed and the fewest in number were plants grown on Vermicompost II mixed with soil in 1/3:2/3 proportion. By the end of the week, the plants were of an identical height in all the pots.

The plants were harvest in due time. From each of the pots we separated the underground biomass, i.e., the root systems, and the shoots. All the parts were washed in distilled water in order to prevent the contamination of plants by soil for the laboratory analyses and to prevent distortion of the results. Next, the plants were dried in the open air at the room temperature, and they were weighed. The plants were stored in a dry place for further analyses.

Similarly to the plants, the sampled culture substrates were dried at the room temperature, and stored before further analyses. For the analyses the samples were labelled under the letter "C" - see Table 4 for the designations. Table 5 gives the amounts of available nutrients in the harvested ryegrass grown on the individual soils.

Fig. 3 Biological test of hybrid ryegrass growth in the weeks 4-6; from the left: check soil sample, mixture of Vermicompost I and soil (1:1), mixture of Vermicompost I and soil (1/3:2/3), mixture of Vermicompost II and soil (1:1), mixture of Vermicompost II and soil (1/3:2/3)

Table 4 Quantity of harvest plant mass on the individual soil mixtures.

Sample	Sampledesignation	Mixture ratios	Roots [g]	Shoots [g]
C1	Check - soil	100 % soil	2	2.5
C2	Vermicompost I	1:1	4	4
C3	Vermicompost I	1/3:2/3	3	3
C4	Vermicompost II	1:1	2	3
C5	Vermicompost II	1/3:2/3	2	2.5

(*Note that Vermicompost I = stabilized sludge, Vermicompost II = stabilized sludge + garden waste.)

Table 5 Analysis of available nutriens in the plant mass after the biological test.

Element	C 1 [%]	C 2 [%]
Ca	1.350	2.511
K	2.726	4.003
Mg	0.346	0.364
P	0.908	0.792
N	3.830	3.210

(*Note that C1 = check soil after the test, C2 = mixture of Vermicompost I and soil [1:1].)

4. Evaluation of the Biological Test of Hybrid Ryegrass

The top quantity of the harvested and dried plant mass was from the mixture of Vermicompost I and soil in 1:1 proportion. The lowest yield manifested in the check sample and in the mixture of Vermicompost II and soil in 1/3:2/3 proportion. Therefore, the laboratory analyses were carried out on the sample of plant mass grown in the mixture of Vermicompost I and soil in 1:1 proportion and the check sample for the purposes of comparison.

In the check soil sample there was a decrease in all the values of the available nutrients (Ca, K, Mg, and P) after the biological test, namely the drop in potassium and calcium was prominent. Next, the pH value fell and the conductivity rose slightly. The values of the mixture of Vermicompost I and soil are evaluated according to the percentage index. This index has been prepared on the grounds of the values of the check soil sample before the test, the value of which is 100 % for the purposes of the comparison. As opposed to the values of the check soil samples, in the mixture of

Vermicompost I and soil there was a decrease in pH, but a significant increases in calcium, phosphorus, conductivity and content of organic matter.

Conductivity is given by the content of dissolved inorganic and organic substances in the mixture or solution under examination. The results of the individual analyses demonstrate an increased content of the mentioned substances in the mixture of Vermicompost I and soil in 1:1 proportion. The enrichment of the farmland by Vermicompost I may have participated on the increase of conductivity the most. The values of the feed Vermicompost I classify it among heavily saline soils – 3610 μS/cm. However, the result values after the biological test fell among medium saline soil values – 1103 μS/cm, which points at the positive effect of the test.

Table 6 gives the percentage comparison of values of the check soil and of the mixture of Vermicompost I and soil after the test.

In the ryegrass grown on the mixture of Vermicompost I and soil a significant increase in calcium and potassium was observed. The only value

Table 6 Percentages of values in the check soil and mixture of Vermicompost I and soil after the test.

Element	Exhausted check soil [%]	Exhausted mixture of Vermicompost I and soil [%]
Ca	85.00	126.72
K	52.48	95.65
Mg	70.41	106.83
P	95.91	237.10
pH	95.44	87.80
conductivity	101.80	827.45
combustibles	87.98	304.18

(*Note that Vermicompost I = stabilised sludge.)

which decreased as for the macroelements was phosphorus. An important factor is the intake of nitrogen by plants, which was high in both the tested soils [3].

5. Conclusion

The results of the experiment confirm that the application of vermicompost produced from sewage sludge had a positive effect on the intake of nutrients. The sludge from the municipal wastewater treatment process is a heterogeneous mixture. The options for its use are limited and thus it is vital to research other methods of its application. According to the results discussed herein, vermicomposting appears as one of the options of its disposal. Vermicomposting is a disposal method of biodegradable wastes. Adhering to the major conditions of the process, it is a very efficient method which enriches the former waste with new properties. In line with the legal requirements, the enriched vermicomposts may be applied as fertilisers and soil amendments.

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