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Verification of vermural stabilization of ash from biomass and sewage sludge

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Abstract. The aim of this study was to find dependence on biofuels and sludge from sewage treatment plants in the vermicomposting process. In the framework of the research carried out at our workplace, a project aimed at finding an appropriate method for the reprocessing of problematic biodegradable waste and asphalt from combustion biomass was used as a raw material for the production of rectification substrate and sludge from sewage treatment plants that could be used as Secondary raw material.

1. Introduction

Soil degradation increases lately. The reason is primarily the development of civilized human society, agricultural development, and the increasing need to feed a large number of people. High productivity leads to imbalances in natural processes. Soil is the main medium of energy exchange and its resources are constantly being devalued by human activity, on this issue.

One of the best processes for processing biodegradable waste for to obtain good organic material is vermicomposting. This process, which processes the organic material by earthworms, has thanks to the resulting product a very positive effect on the quality of the soil and microbiological activity, when it changes a mineral substance the influence of the chemical, but also of biochemical transformations.

All member countries of the European Union are according to the European directive no 1999/31/EC on the landfill of waste required by 2020, gradually reduce the amount of deposited biodegradable municipal waste to 35 % of the original weight of this type of waste generated in 1995. Therefore, it is very important to find for these wastes, appropriate methods of processing and subsequent use.

However, due to the strategic EU documents (e.g. the waste Framework directive (98/2008/EC) prefers material to be used before the so-called removal of waste), is undoubtedly more appropriate and desirable solution to prioritize the evaluation and utilization of evaluated materials from landfills. For the purposes of putting into circulation, storage and use of fertilizers, auxiliary soil substances, auxiliary herbal preparations and substrates used in the present time in the Czech Republic act no. 156/1998 Sb.

2. Vermicompost

Vermicomposting is a natural process that can't be rushed. However, if the natural raw materials back to nature, it can have a very positive effect. One of the reasons why fertilize vermicompostem is that in comparison with chemical fertilizers leads to a better regeneration of the nutrient exhausted the soil system, reducing the cost of production and transportation of chemical fertilizers.



The process of vermicomposting is based on the decomposition of organic material using worms, the process is also one of the oldest and also the more advanced ways. The vermicomposting is utilized by earthworms („*Eisenia foetida*”), or also as in this case specially bred californian hybrids („*Eisenia Andrei*”).

Using earthworms is a material intensively processed, aerated and there is no need for outside intervention. The resulting product, vermicompost is a high-quality fertilizer, which contains large amounts of enzymes, organic substances, growth substances and nutrients. Enzymes which comes from the secretions of the earthworms, are an important component of vermicompost and thanks to the fact is in comparison with classic compost of better quality. The high amount of enzymes increases the bioavailability of mineral elements in the soil by almost 90%.

Other positive features of vermicompost as the ability to suppress the in plants the formation of certain types of diseases and fungi. Increases the pH values which are particularly suitable for acidic soils. Last but not least, the digestive tract of earthworms disposed of toxic, mutagenic or pathogenic substances.[1,2].

It is important to maintain these basic conditions during vermicompost [6]:

- Temperature 19-22 °C (below 7 °C and above 30 °C the earthworms are apathetic and die at temperatures below 0 °C and above 40 °C).
- Optimal substrate humidity ranging from 78 to 82% (humidity below 60% and more than 90% killing earthworms).
- Neutral pH (pH above 8 and below 6 has lethal effects on earthworms).

Other conditions that need to be adhered to are oxygen, weather protection (sun, wind rain) and protection from predators (birds, frogs, rodents).

3. Biodegradable waste

Biowaste are any aerobically or anaerobically degradable wastes in which the respiratory activity after four days (AT₄) is greater than 10 mg O₂ / g of dry matter, and the value of the dynamic respiratory index exceeds 1000 mg of oxygen per kilogram of combustible matter per hour [7]. In the total amount of municipal waste, the volume and weight are very important groups which, due to natural degradation, burden the environment with greenhouse gases as well as leachate containing hazardous residues [8]. The analysis of the Ministry of the Environment (MoE) shows that in municipal waste almost half of the volume is made up of biodegradable materials. Also included are municipal greenery and public catering facilities, which make up a significant part of the total volume of municipal waste [9,10].



Figure 1. Vermicompost beds / vermicompost of biowaste.

4. Testing the efficiency of fly ash from combustion of biomass and sludge from WWTP

The aim of the experiment was vermicomposition of ash from biomass and sludge combustion from WTPs. For this purpose, vermicompost beds (figure 1) were established for the processing of ash and sludge in different ratios as seen on table 1. These ratios were also observed when feeding the *Eisenia andrei* earthworms. The properties of the output materials of these processing methods (As, Cd, Cr, Cu, Hg, Mb, Ni, Pb, Zn, dry matter, pH, Ca, Mg, K, F, combustion, total nitrogen). As a base layer

(figure 2) for the establishment of the vermicomposting process, fertilized horse manure was used up to about 10 cm.

Table 1. Different ratios of vermicompost beds.

	1	2	3
Horse manure	50%	50%	50%
Ashes	-	20%	10%
Sludge from WWTP	50%	30%	40%

On the base layer of the compost were laid substrates with red calcareous earthworms (figure 1) and then ashes and sludge added in the given ratios. The final layers had a thickness of about 25 cm and were covered with a thick foil to prevent drying of the material. This film also provided sufficient protection for earthworms from direct sunlight and a temperature of about 20 °C for proper earthworm activity. The substrate with Californian earthworms contained about 25,000 individuals.

4.1 Entrance values of organic matter

Table 2. Input materials values.

Index	Manure Otice	Asbestos from biomass combustion	Sludge from sewage treatment plants	Unit
As	0.73	12.4	1.42	mg / kg in dry matter
Cd	0.49	8.09	1.46	mg / kg in dry matter
Cr	<2.50	42.9	38.2	mg / kg in dry matter
Cu	12.4	150	307	mg / kg in dry matter
Hg	0.023	0.244	2.73	mg / kg in dry matter
Mo	<0.50	x	x	mg / kg in dry matter
Ni	4.05	42.4	29.7	mg / kg in dry matter
Pb	4.35	54.9	30.6	mg / kg in dry matter
Zn	53.3	664	1160	mg / kg in dry matter
Ashes	21.92	84.25	26.77	%
pH	8	12.7	7.8	
Ca	7.93	87.1	40.7	g / kg in dry matter
Mg	3.61	10.7	4.65	g / kg in dry matter
K	20.5	33.4	1.7	g / kg in dry matter
F	3.6	3.88	30.5	g / kg in dry matter
Flammable substances	83.8	16.1	57.8	% in dry matter
Nitrogen total	1.5	0.22	4.33	% in dry matter
Ratio C: N	28	37	7	

The input materials were analyzed by an accredited laboratory MORAVA s.r.o. in Studenka. The base layer, which was composed of horse manure, was processed and imported from the riding section, which is located in Otice near Opava. The fly ash from biomass burning, which was necessary

for the experiment, was imported from the biomass incinerator. Stabilized sewage sludge was brought from the wastewater treatment plant in Olomouc.

4.2 Resultant vermicompost values

The resulting values of the vermicomposts are shown in Table III. Vermicomposts were divided into three categories (50/40/10, 50/30/20 and 50/50/0). The experiment ran from 17 May 2016 to 20 September 2016 near Ostrava on private land. As mentioned above, the hybrid Californian earthworms, ("*Eisenia andrei*") which are best suited to the vermicompost process, have been used for this experiment. At the time of the experiment, these earthworms could be found throughout the vermicompost area, even in the other two vermicompost beds, although they were only fed with ash and slurry in different ratios, see table 1. In order to compare these three vermicomponent beds, tests were performed and the resulting values are listed in table 3 below.

Table 3. Resulting values with different input material ratios.

Index	50/40/10	50/30/20	50/50/0	Unit
As	2,13	2,91	1,78	mg / kg in dry matter
Cd	2,53	3,91	1,26	mg / kg in dry matter
Cr	29,10	28,40	22,20	mg / kg in dry matter
Cu	168,00	160,00	156,00	mg / kg in dry matter
Hg	1,04	0,87	1,24	mg / kg in dry matter
Mo	3,09	2,22	3,30	mg / kg in dry matter
Ni	16,10	31,40	18,00	mg / kg in dry matter
Pb	30,00	32,70	30,20	mg / kg in dry matter
Zn	695,00	668,00	652,00	mg / kg in dry matter
dry matter	21,60	21,48	20,63	%
pH	7,60	7,70	7,30	
Ca	52,80	60,40	43,30	g / kg in dry matter
Mg	4,71	5,23	3,42	g / kg in dry matter

5. Discussion

Veristabilization of sewage sludge and fly ash from biomass took place without any difficulty. Due to vermicomposting, the sludge and fly ash values were significantly reduced, which is a favorable result for further sludge and fly ash handling. The pH value after completion of vermicomposting did not differ significantly in all three vermicomposts and ranged from 7.3-7.7. It was expected that the content of hazardous substances and elements in sludge and fly ash after vermicompost will decrease compared to the quantity of hazardous substances and elements in untreated sludge and fly ash. This theory was confirmed in all three vermicomposts. Vermicomposted sewage sludge and fly ash can be used on agricultural land in terms of the content of hazardous substances and elements in sludge as it complies with Decree No. 437/2016 Coll., Requirements and Criteria for Evaluation and Control of Outputs from Biowaste Facilities, See table 4.

The Decree of the Ministry of Agriculture No. 474/2000 Coll., States: "Limit values of risk elements in fertilizers, auxiliary soil substances, auxiliary plant preparations and substrates" [10] This decree compared the resulting values of vermicompost beds according to ČSN 46 5735 for industrial composts (table 5).

Comparison of the limit values according to the table for organic and farmyard fertilizers with dry matter is above 13%. If we compare these values, Table V, it is clear that the concentration of some elements is slightly exceeded (Cu, Zn, Hg, Cd). The reason for this exceedance can be found in the nature of stabilized sludge, where the concentration of these elements is higher.

Table 4. Comparison of the limit concentration of selected risk elements with Decree No. 437/2016 Coll., With output values of vermicomposts.

Index	Limit concentrations - 2 groups, III. class	Limit concentrations - 3 group, stabilized biowaste [mg/kg]	50/40/10 [mg/kg]	50/30/20 [mg/kg]	50/50/0 [mg/kg]
As	30	40	2.13	2.91	1.78
Cd	4	5	2.53	3.91	1.26
Cr	300	600	29.10	28.40	22.20
Cu	300	600	168.00	160.00	156.00
Hg	2	5	1.04	0.87	1.24
Ni	120	150	16.10	31.40	18.00
Pb	400	500	30.00	32.70	30.20
Zn	1500	1800	695	668	652

Table 5. Comparison of values with Decree 474/2000 Coll., With values of vermicomposts.

Index	value [mg/kg]	50/40/10 [mg/kg]	50/30/20 [mg/kg]	50/50/0 [mg/kg]
As	20	2.13	2.91	1.78
Cd	2	2.53	3.91	1.26
Cr	100	29.10	28.40	22.20
Cu	150	168.00	160.00	156.00
Hg	1.0	1.04	0.87	1.24
Ni	50	16.10	31.40	18.00
Pb	100	30.00	32.70	30.20
Zn	600	695	668	652
Mo	20	3.09	2.22	3.30

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