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ASSESSMENT OF SELECTED PARAMETERS OF VERMICOMPOST FROM HOUSE VERMICOMPOSTER

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Abstract

The aim of the present study was to assess the vermicomposting process in a household vericpomoster as a way of organic fraction of municipal solid waste (OFMSW) treatment. Household bio-waste of fruit, vegetable and indoor plants origin was composted at vertical continuous feeding vermireactor for almost two years. The vermicomposter contains four boxes placed above each other; the capacity of each box was 15 dm3. Only once a box has been filled, the waste was inserted into the following box. The dynamics of parameters pH and electrical conductivity (EC) were monitored in time. Values of pH were not modified significantly during vermicomposting and fell into the value range 6-8 as required for composts.

The values of EC in case of boxes 1 and 2 were initially relatively low (4-5 mS·cm-1) corresponding to the values of home composts while the initial value of EC of box 3 and later values of boxes 1 and 2 (7-9 mS.cm-1) corresponding to the values of industrial composts. The gradual addition of bio-waste, 12-15 kg of raw bio-waste can be composted in one box. The results of the study have shown that the use of a home vermicomposter is a viable way for OFMSW treatment.

Key words: vermicomposting, home vermicomposter, bio-waste, biodegradation

INTRODUCTION

Composting is one of the most environmentally friendly technologies for the management of the organic fraction of municipal solid waste (OFMSW) or bio-waste, allowing its material valorisation. At industrial level, composting of OFMSW has been extensively studied and the number of treatment facilities implemented has been increasing in the last years. Although less studied, home composting has been proposed as an alternative or a complimentary way to manage household OFMSW (Andersen *et al.* 2012, Martínez-Blanco *et al.* 2010). Recently, home and industrial composting have been studied and compared focusing on their environmental impact, mainly energy consumption and environmental burdens (Colón *et al.* 2010, Martínez-Blanco *et al.* 2010, Adhikari *et al*. 2013). Considering environmental aspects, home composting presents some potential benefits as the avoidance of collection and transportation of biowaste. However, the home composting of the OFMSW also presents some environmental concerns mainly due to the absence of gas treatment systems. Compost utilization can reduce the need of chemical fertilisers and pesticides (Martínez-Blanco *et al.* 2011). Also, it has a positive effect on soil structure that helps to reduce the requirements for water irrigation in periods of drought and to increase the potential of soils to retain moisture (Favoino and Hogg 2008). Furthermore, one of its highlighted aspects is the potential for sequestration of carbon in soils where compost has been applied (Favoino and Hogg 2008). For all these purposes, compost produced in households and industrial composting should be a high quality product to guarantee all the benefits of its application, otherwise its use could lead to a higher environmental impact or to reduce agronomic productivity (phytotoxicity). In fact, compost quality depends both on the original materials and the technology used (Tognetti *et al.* 2005). Compared with industrial composting, home composting implies a better control of the material treated, reducing impurities.

One of the possibilities of composting is also vermicomposting, i.e. composting using earthworms. Vermicomposting is emerging as a most appropriate alternative to conventional aerobic composting. This process is not only rapid, easily controllable, cost effective, energy saving, and zero waste process, but also accomplishes most efficient recycling of organics and nutrients (Eastman *et al.* 2001). Vermicomposting is a viable low-cost technology system for the processing and treatment of organic solid wastes (Hand *et al.* 1988). It involves the joint action of earthworms and mesophilic microorganisms and does not involve a thermophilic stage. In contrast to traditional waste processing, vermicomposting results in the bioconversion of the waste into two useful products: the earthworm biomass and the vermicompost. Numerous studies have shown the ability of certain earthworm species such as Eisenia fetida (also known as brandling, red wiggler or manure worm), Eisenia andrei (red tiger), Lumbricus rubellus (red worms), to process a wide variety of organic matter such as animal excreta, sewage sludge, crop residual and agricultural wastes (Benitez *et al.* 1999; Bansal and Kapoor 2000). Various physical/mechanical and biochemical processes are affected by earthworms. The physical processes include substrate aeration, mixing and actual grinding. The biochemical processes are affected by microbial decomposition of substrate in the intestines of the earthworms (Ndegwa *et al.* 2000). During this process, the important plant nutrients in the material are released and converted through microbial action into forms that are much more soluble and available to plants than those in the parent compounds (Ndegwa and Thompson 2001).

Numerous studies have shown the possibility of specific bio-waste vermicomposting processes (such as vermicomposting of cattle manure and sheep bedding Cestonaro *et al.* 2017, banana stem Khatua *et al.* 2018, sewage sludge Zhao *et al.* 2018 or paper cups Arumugam *et al.*2018) but composting process in house vermicomposters is comparatively little described. This is a composting variant solution for those who want to compost bio-waste themselves but it is impossible to compost bio-waste outdoor (in the garden). Existing operating experience is different; certainly not every house vermicomposting process is ending with successful. Moreover, the compost quality parameters were not monitored in this house system of bio-waste treatment.

It is necessary to give the optimal solution of house vermicomposting process, so the main novelty of this work was long-term monitoring and evaluation of measured parameters of the house vermicomposting process.

The aim of the present study was to assess the vermicomposting process in a household vermicomposter as a way of OFMSW treatment. For this, the experiment was realized in household conditions of processing.

MATERIALS AND METHODS

Composted materials

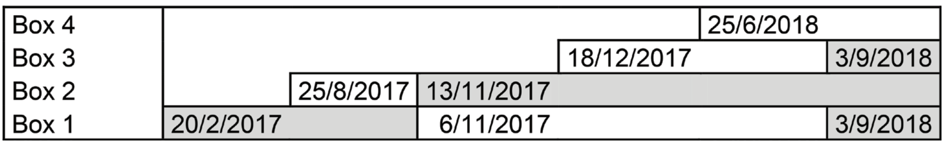
Since the aim of the work was to evaluate the function of the home vermicomposter, the input material for composting was formed of OFMSW. Household OFMSW was collected at a flat household in Brno (the Czech Republic). Composted bio-waste contained a mixture of kitchen vegetable and fruit waste and waste from maintenance of indoor plants but it did not contain any animal residues (like bones, meat cuts or rests of meal) or faeces of domestic flat animals (guinea pig, dwarf rabbit). The amount of input material is shown in Table 1.

Table 1. Mass of input material (summarized in quarterly terms) [kg]

Time of research	Mass of waste in the boxes			
	1	2	3	4
Q 1’2017	1.44			
Q 2’2017	0.95			
Q 3’2017	10.00	6.24		
Q 4’2017		7.79	2,78	
Q 1’2018			4.50	
Q 2’2018			6.33	4.82
Q 3’2018				7.47
October (2018)				2.72
Total amount	12.39	14.03	13.61	13.01

Vermicomposting process

The vermicomposting process was carried out in vertical continuous feeding vermireactor (VermiHut Worm Bin). This vermicomposter contains four boxes placed above each other; the capacity of each box was 15 dm^3. Only once a box has been filled, the waste was inserted into the following box. This construction allows continuous addition of biowaste and gradual removing of the compost without the need of mutual mixing. 2.5 kg of apple pomace vermicompost with earthworms *Eisenia foetida andredi* was used as an initial input material to vermicomposter. Apple pomace vermicompost and earthworms *E. andrei* were provided by Jakub Filip, Luzice u Hodonina (the Czech Republic). Biowaste for composting was filled in the vermicomposter irregularly, in varying amounts, just as it was produced in the household. In the case of the completely filled vermicomposter box (the vermicomposter box was full at the moment of bio-waste filling), the empty box was added and then was filled with bio-waste. A detail graphic explaining the procedure of vermicomposting process is given in Fig. 1.



White background – period without measurement
Grey background – measurement period

Figure 1. Description of the procedure used during the vermicomposting process

Compost sampling and chemical analysis

Compost samples were taken at week intervals (if possible). The samples were randomly taken from different locations of relevant boxes. The samples were then saturated with distilled water according to the saturation sample method as described by Johnsson and Muldowney (Johnsson *et al.* 2005, Muldowney 2011). The pH and electrical conductivity (EC) were measured using a multimeter HACH Q30d. Each parameter was measured three times and the result of measurement was determined as an arithmetic mean of these values.

Measurement of the observed parameters in Extension 1 was discontinued at the time when vermicompost stabilization was expected (based on compost structure and no earthworms). Parameter measurements were later restored.

RESULTS, COMMENTS AND DISCUSSION

As can be seen in Fig. 1, the rate of the bio-waste conversion to the substrate that is possible to be prepared as saturated sample (and subsequently to be evaluated) greatly varies. Significant increase of earthworm was seen during the first year of the experiment and the rate of bio-waste conversion was high in boxes 1 and 2. During the first, second and third quarters of 2018, however, the number of earthworms in the vermicomposter was greatly reduced and the experiment almost failed. Further development of earthworms was very gradual. This corresponds to a low biodegradation rate and a long delay from the addition of the new box until it was possible to determine the parameters (boxes 3 and 4).

The development of the pH and electrical conductivity (EC) parameters measured in the boxes 1, 2 and 3 is shown graphically in Fig. 2, Fig. 3 and Fig. 4, respectively. Boxes 1 and 2 show more dynamic composting process compared to box 3. It can be caused by a long period from putting box 3 into composting process to its compost parameters measurement. As can be seen, values of pH were not modified significantly during vermicomposting and fell into the value range 6-8, as suggested in “Guidelines for Specification of Quality Compost for Use in Growing Media” (Wrap 2011). The values of EC in case of boxes 1 and 2 were initially relatively low (4-5 $mS \cdot cm^{-1}$) and corresponded to the values of home composts (Barrena *et al.* 2014). The initial value of EC of box 3 and later values of boxes 1 and 2 (7-9 $mS \cdot cm^{-1}$) corresponds to the values of industrial composts (Stejskal *et al.* 2012, Barrena *et al.* 2014).

There was not any significant unpleasant odour during the experiment; occasionally drosophila flies were found, mostly inside the boxes.

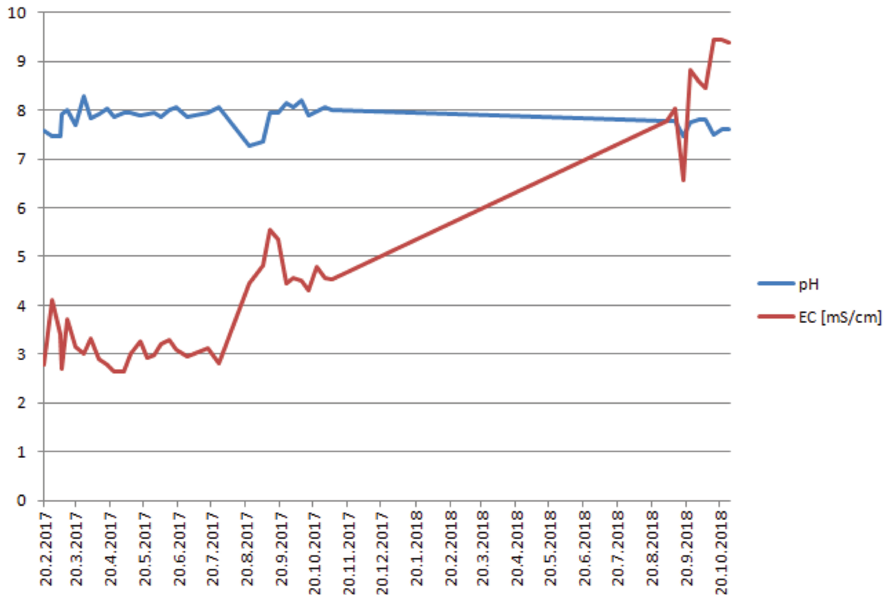


Figure 2. Development of pH and EC values of vermicompost from box 1

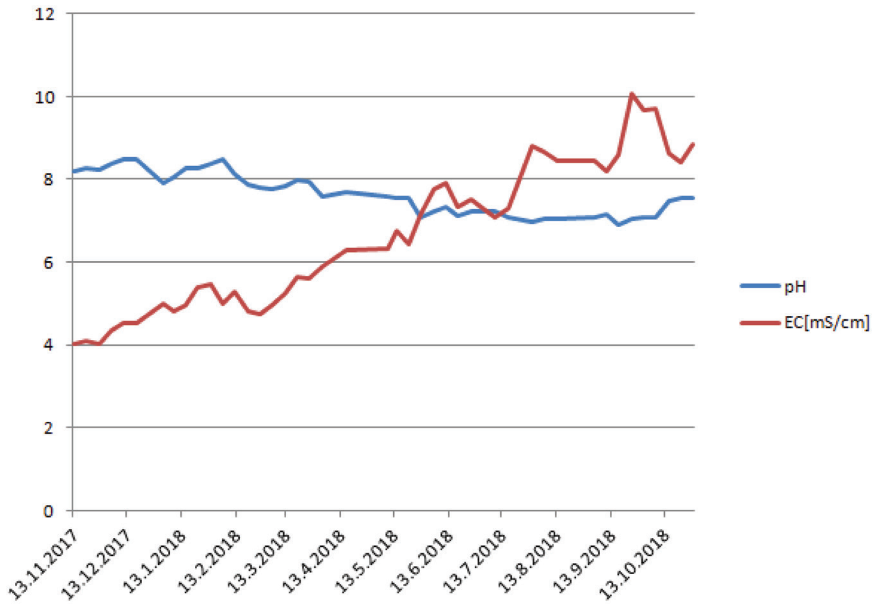


Figure 3. Development of pH and EC values of vermicompost from box 2

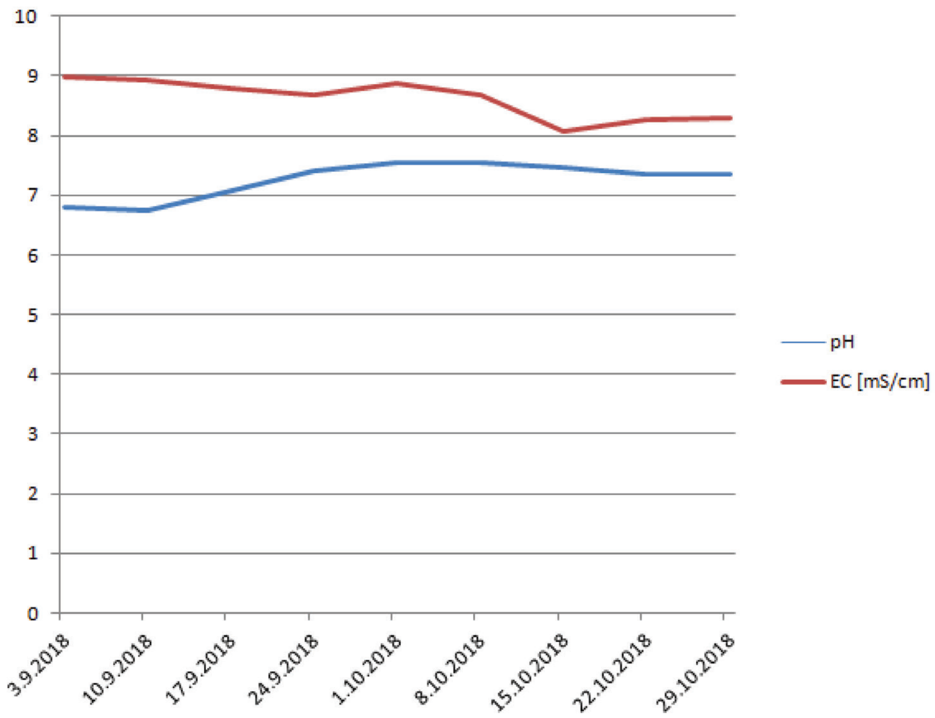


Figure 4. Development of pH and EC values of vermicompost from box 3

From operational experience, it is evident that not all household bio-waste is suitable to be composted in a home vermicomposter. The waste of some house plants (for example porcelain flower (*Hoya carnosa*) of golden photos (*Epiprem-num aureum*) or broccoli stalk required a long biodegradation time.

The poor experience of other operators of housing vermicomposters with the composting of potato waste (skins or sprouts) has not been confirmed. The addition of potato waste did not cause any negative effect on the occurrence of earthworms.

It has been shown that by the gradual addition of bio-waste, 12-15 kg of raw bio-waste can be composted in one box. This amount is quite sufficient for a typical flat household, because before the fourth box is filled, it is possible to remove the stabilized vermicompost from the first box.

CONCLUSIONS

Nearly two years of experience with the house vermicomposting operation has shown that this method of OFMSW composting is well-suited for use for households without the possibility of outdoor composting. The configuration of the vermicomposter into individual boxes stacked on each other allows its continuous operation. The amount of treated bio-waste corresponds to the production of compostable bio-waste of a common household. The quality parameters of compost pH and EC correspond to the values set for industrial composts. Regardless of roughly a 5-month period of low number of earthworms, the composting process did not collapse and the number of earthworms is increasing again.

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