# The sanitation effect of vermicomposting of sewage sludge from a medium-sized WWTP with and without the pre-composting phase – a case study

P. Innemanová[1,2], Z. Fojtová[2]

[1]DEKONTA, a.s., Dřetovice 109, Stehelčeves, 273 42, Czech Republic
[2]Institute for Environmental Studies, Faculty of Science, Charles University, Benátská 2, Prague 2, 12801, Czech Republic
Keywords: sewage sludge, composting, vermicomposting, sanitation
Presenting author email: petra.innemanova@dekonta.cz

Sewage sludge that does not contain overly high initial concentrations of heavy metals can be used as a fertilizer on agricultural land under certain conditions. In addition to compliance with selected organic pollutant limits, it is also necessary to fulfill the relevant sanitation criteria. Composting is able to ensure the favorable destruction of pathogenic organisms during the thermophilic phase. Moreover, vermicomposting results in a quality product with a higher content of available nutrients and a higher microbial activity (Tognetti *et al*, 2005; Sinha *et al*, 2010). Due to the absence of the thermophilic phase during vermicomposting, the potential for combining the two processes - composting and vermicomposting – was tested with respect to the treatment of sewage sludge.

The study describes the subjecting of anaerobically stabilized dewatered sewage sludge taken from a medium-sized WWTP to the vermicomposting process with and without the pre-composting phase under field conditions. A material that was composted only was tested as the control. We monitored the fate of selected pathogens during the sludge treatment process via composting, vermicomposting and the combination of the two processes. One cubic meter of sewage sludge was taken from a 33-thousand population-equivalent (p.e.) WWTP located in the South Bohemia region of the Czech Republic and mixed with 1.5 $m^3$ of wood chips. The resulting mixture (with a final volume of 2.5 $m^3$) was divided into two parts. One cubic meter of the mixture was placed directly in segment B of a three-chamber field vermicomposter with a total volume of 9.5 $m^3$ (experimental segments A and B with a volume of 3 $m^3$ each and a backup segment C with a volume of 3.5 $m^3$). The remaining mixture (with a volume of 1.5 $m^3$) was subjected to pre-composting in a covered hall. The pre-composting process was regulated by the oxygen concentration in the bed. Data from 3 temperature sensors and 1 oxygen sensor was recorded and collected. The maximum temperature exceeded 60°C. After 2 weeks, 1 $m^3$ of the pre-composted mixture was placed in segment A of the field vermicomposter and the remaining 0.5 $m^3$ was left in the plastic container in the hall as a control material without the presence of earthworms. The vermicomposting took place within a so-called wedge system in which earthworms from an inoculum migrated to the new bed horizontally. Vermicomposted sewage sludge mixed with straw one year previously served as the inoculum. The sanitation potential of these processes was tested using specially-prepared polyethylene cartridges containing a sterile medium (a mixture of vermicompost and sludge) and an *E. coli* inoculum with an initial concentration of (2.7±0.4) x$10^6$ CFU/g placed inside the composted and vermicomposted piles. The perforation of the cartridge (PC) allowed the earthworms to move in and out freely. In order to distinguish the effect of earthworm activity and other factors, the same number of cartridges containing a polyester fabric (PCF) was added so as to prevent the earthworms from entering (see Figures 1). Five parallel samples were taken for each variation (PC and PCF) during each of the sampling campaigns for all three treatments (composting only, vermicomposting only, vermicomposting with pre-composting). The same amount of artificially-contaminated medium in five parallels for each sampling campaign was left in closed Petri dishes under laboratory conditions as the control. To date, a total of 3 sampling campaigns have taken place (initial sampling, after 14 days of composting, after 6 months of experimentation). The final sampling campaign is currently underway.

Figure 1. The two types of cartridges with artificially-added *E. coli* – allowing and not allowing for earthworm activity, and the on-site installation process

In addition to testing with artificially-introduced *E. coli*, the following parameters of the treated mixture were monitored during the experiment: Salmonella sp., *E. coli*, the total heterotropic bacteria and enterococci contents, selected hazardous substances as set out in Czech legislation (the concentrations of As, Cd, Cr, Cu, Hg, Ni, Pb, Mo, Zn, the sum of 12 selected polyaromatic hydrocarbons, the sum of 6 selected polychlorinated biphenyls, AOX), as well as other composting parameters, and the quality and biological stability of the final product (pH, EC, $AT_4$, C:N ratio, concentration of N- total, $N\text{-}NO_3^-$, $N\text{-}NH_4^+$ P, K, Mg, Ca and TOC).

The sanitation effect in the cartridges with the artificially added *E. coli* measured after the first 4 weeks of experimentation (the duration of the pre-composting phase) decreased as follows: composted mixture>vermicomposted mixture with PC >vermicomposted mixture with PCF >control. After 6 months of experimentation, the required sanitation effect (a decrease of 5 orders of magnitude) was achieved for all the variants (the vermicomposted mixture with PC and PCF in segment B and the vermicomposted and pre-composted mixture with PC and PCF in segment A). All the tested variants fulfilled the criteria for the application of treated sludge to agricultural land according to Czech legislation (Ministry of the environment, 2021) after 6 months of experimentation. Moreover, the quality of the compost complied with the requirements of the ČSN 465735 standard, with the exception of the exceeding of the required C:N ratio range, which was due to the relatively high proportion of wood chips in the test material. The 1:1.5 (v:v) ratio selected for the experiment was based on previous experience with the bio-drying of sewage sludge according to Pilnáček *et al* (2019) aimed at attaining a sufficient temperature profile during the thermophilic phase. However, our results suggested that vermicomposting alone (without the pre-composting phase) also provides for a sufficient sanitation effect. Thus, it appears possible to completely omit the pre-composting phase and to significantly reduce the proportion of the bulking material, or to test the vermicomposting of sludge without blending, thus ensuring a suitable final C:N ratio. The suggestion of omitting the pre-composting phase was also supported by the fact that, based on the AT4 values recorded after 6 months of experimentation, the material that was vermicomposted only evinced the highest level of biological stability.

Although the final sampling campaign is ongoing and samples are being processed for additional analysis purposes concerning e.g. the content of selected enzymes, it is already clear from the field trial that the bio-stabilization of dewatered sewage sludge using earthworms provides an effective technology for the management of noxious wastewater treatment products.

AKNOWLEDGEMENTS

The "Use of Vermicomposting to Eliminate Micropollutants for the Safe Application of Sewage Sludge on Agricultural Land" project (No. QK1910095) was financially supported by the Ministry of Agriculture of the Czech Republic as part of the "ZEMĚ" program.

REFERENCES

Ministry of the environment of the Czech Republic. 2021. Vyhláška č. 273/2021 Sb., vyhláška o podrobnostech nakládání s odpady. In: Sbírka zákonů ČR, volume 2021, Number 273. https://www.zakonyprolidi.cz/cs/2021-273

Pilnáček, V., Innemanová, P., Šereš, M., Michalíková, K., Stránská, Š., Wimmerová, L., Cajthaml, T. (2019): Micropollutant biodegradation and the hygienization potential of biodrying as a pretreatment method prior to the application of sewage sludge in agriculture. *Ecological Engineering 127*, pp 212-219, doi.org/10.1016/j.ecoleng.2018.11.025

Sinha, R.K., Herat, S., Bharambe, G., Brahambhatt, A. 2010. Vermistabilization of sewage sludge (biosolids) by earthworms: converting a potential biohazard destined for landfill disposal into a pathogen-free, nutritive and safe biofertilizer for farms. Waste Management & Research, 2010:28. 872-881. doi.org/10.1177%2F0734242X09342147

Tognetti, C., Laos, F., Mazzarino, M.J., Hernández, M.T. 2005. Composting vs. Vermicomposting: A Comparison of End Product Quality, Compost Science & Utilization, 13:1. 6-13. doi: 10.1080/1065657X.2005.10702212