EFFECT OF EARTHWORMS ON THE QUALITY OF ORGANIC MATTER AND CHEMICAL PROPERTIES DURING DECOMPOSITION OF A MIXTURE OF SEWAGE SLUDGE WITH MOULDED PULP

Ales Hanc, Tereza Hrebeckova, Milan Hrcka, Ondrej Sedlar

Department of Agro-Environmental Chemistry and Plant Nutrition, Czech University of Life Sciences Prague, Prague, 165 00, Czech Republic

Abstract

A large amount of sewage sludge is produced as a by-product in the process of biological wastewater treatment. The moulded pulp consists of environmentally friendly material for packaging use. It is made from wastepaper and water, so it is biodegradable. Vermicomposting is a bio-oxidizing and stabilizing process of organic materials degradation, which, unlike classical composting, uses interactions between the intensive activity of earthworms and microorganisms and does not include a thermophilic phase of decomposition.

The aim of the study was to characterize vermicompost of different age and to determine the effect of earthworms on quality of organic matter and chemical properties.

The novelty was use of packaging made of moulded pulp in vermicomposting.

The input raw materials were two sewage sludges and moulded pulp (egg liners). Sludge 1 and 2 came from wastewater treatment plants with size category > 100,000 and 10,000 to 100,000 equivalent inhabitants, respectively. The input raw materials were mixed in the ratio of 6 tons of sewage sludge and 2.5 tons of moulded pulp to achieve the C:N ratio 30:1. The mixture was first pre-composted for one month to reduce the ammonia content in sewage sludge. Two piles with earthworms and two without earthworms were established. New layer was added from original pre-composted pile once a month. At the end of the experiment each control and vermicomposted pile had 6 layers. Three samples were taken from each layer for treatment and subsequent analyses.

The earthworms thrived in these mixtures. In this continuous feeding system, the earthworms climb into the upper layers for new feed. This was evidenced by the fact that there were approximately 6 times more earthworms in the top youngest layer than in the bottom oldest one. The number and biomass of earthworms was approximately double in the pile with sludge 1 than 2. The lowest bacteria/fungi ratio was found in top layers. Dissolved organic carbon (DOC) slightly increased in bottom layers which may have been due to leaching but was below 1%. The proportion of DOC in C_{tot} was around 2%. There was a decrease towards the older layers in the following parameters evaluating the quality of organic matter: E_4/E_6, E_{ET}/E_{BZ}, E_2/E_6. These ratios were lower in the extraction using mixtures of NaOH with $Na_4P_2O_7$ than in the extraction of NaOH itself. The value of dry matter, pH, $N\text{-}NH_4^+$ and P_{avail} increased with the age of the layers. On the contrary, there was a decrease in $N\text{-}NO_3^-$, K_{avail} and

Mg_{avail}. There were differences in the trends of total contents of P, K, Mg and Ca depending on the origin of the sludge.

Vermicomposting is a suitable method for sewage sludge and moulded pulp handling. We assume that this vermicompost will have a positive effect on the quality of the soil and it will contribute to sustainable agriculture.

Financial support for this work was provided by the Ministry of Agriculture of the Czech Republic under the NAZV project number QK1910095.

Keywords: Sewage sludge; moulded pulp; earthworms; vermicompost; organic matter

Session number: 4

Oral presentation: YES

IHSS 2023
21st CONFERENCE - CHILE

EFFECT OF EARTHWORMS ON THE QUALITY OF ORGANIC MATTER AND CHEMICAL PROPERTIES DURING DECOMPOSITION OF A MIXTURE OF SEWAGE SLUDGE WITH MOULDED PULP

Ales Hanc, Tereza Hrebeckova, Milan Hrcka, Ondrej Sedlar

- Czech University of Life Sciences Prague, Czech Republic

Czech University of Life Sciences Prague

IHSS NATURAL ORGANIC MATTER RESEARCH

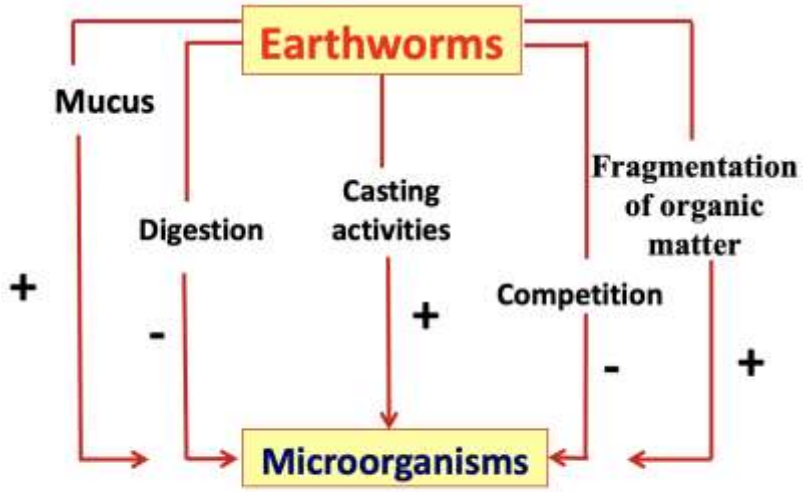
UC | Chile

Facultad de Ciencias Agronómicas Universidad de Chile

UOH Universidad de O'Higgins

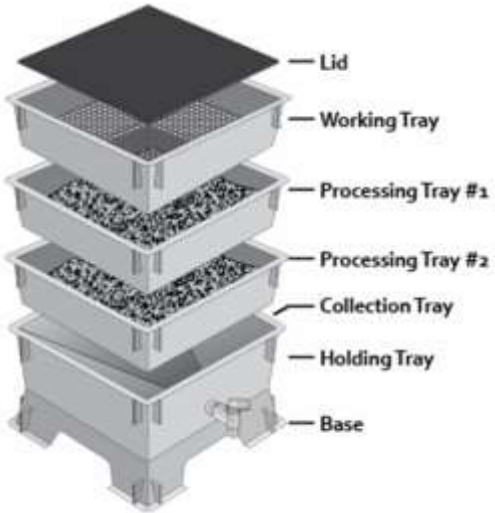
Vermicomposting

- It uses the interaction between the intensive activity of earthworms and microorganisms
- Earthworms - digging, fragmentation and aeration, increase in surface area of particles → significant increase in microbial activity (active phase)
- Microorganisms - biochemical decomposition of organic matter (they follow earthworms - maturation phase)
- Environmentally friendly



Positive (+) and negative (-) effects of earthworms on microbial biomass and its activity

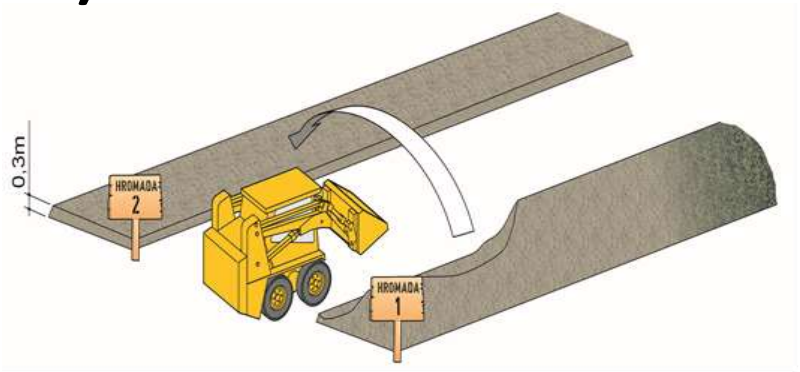
- Vermicomposting systems
  - Small-scale production
    - Trays
      - One time feeding
      - Continuous vertical feeding
      - **Continuous horizontal feeding**
  - Large-scale production
    - Windrow
    - Bordered beds
    - System with a continuous-flow process



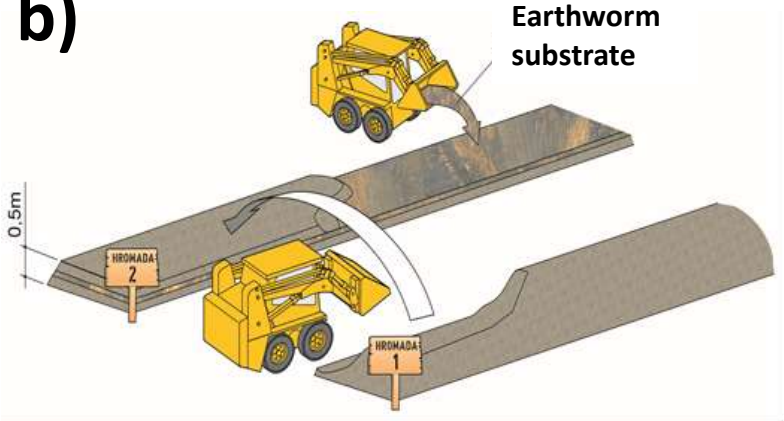
IHSS 2023
21st CONFERENCE - CHILE

Design of vermicomposting in windrow (large-scale)

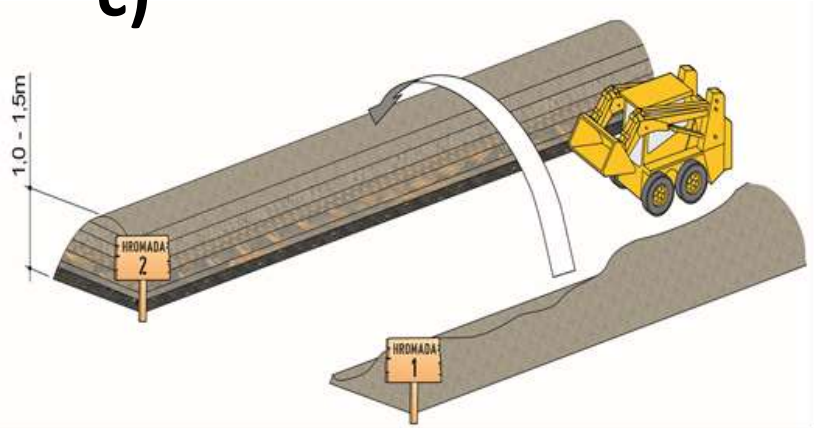
a)



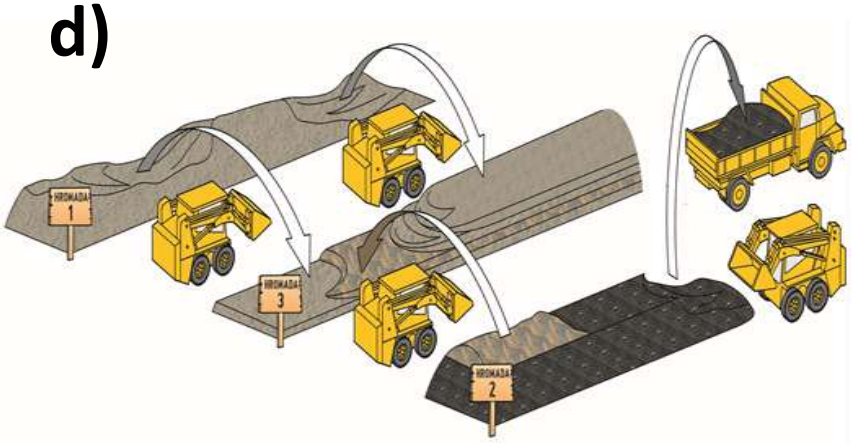
b)



c)



d)



IHSS Natural Organic Matter Research

UC | Chile

Facultad de Ciencias Agronómicas Universidad de Chile

Universidad de O'Higgins

EXPERIMENTAL STUDY

The aim of the study was to characterize vermicompost of different age and to determine the effect of earthworms on quality of organic matter and chemical properties.

The novelty was use of packaging made of moulded pulp in vermicomposting.

Material and Methods

Sludge 1 came from wastewater treatment plants with size category > 100,000 equivalent inhabitants

Moulded pulp (egg liners)

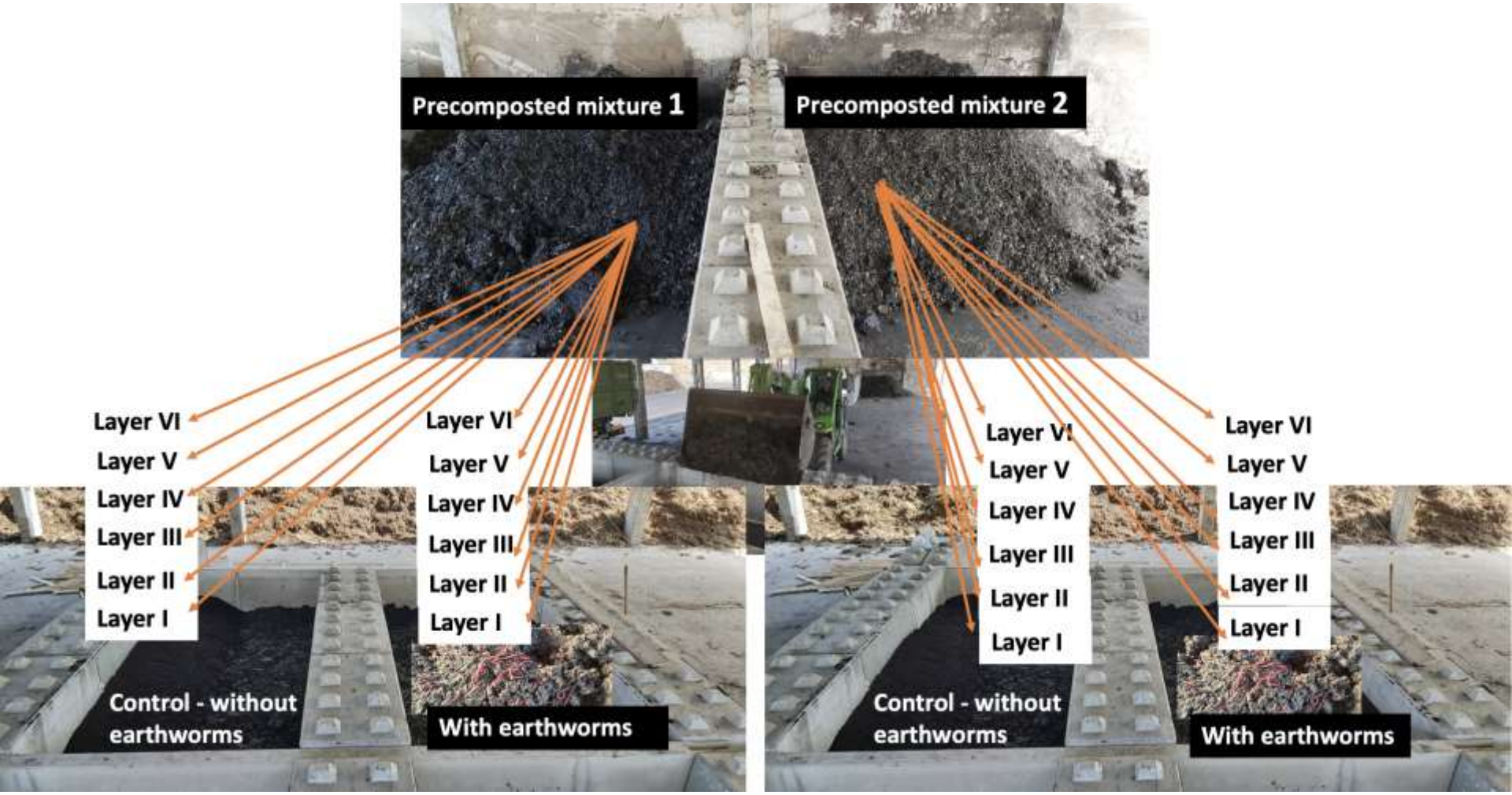
Sludge 2 came from wastewater treatment plants with size category 10,000 to 100,000 equivalent inhabitants

Moulded pulp (egg liners)

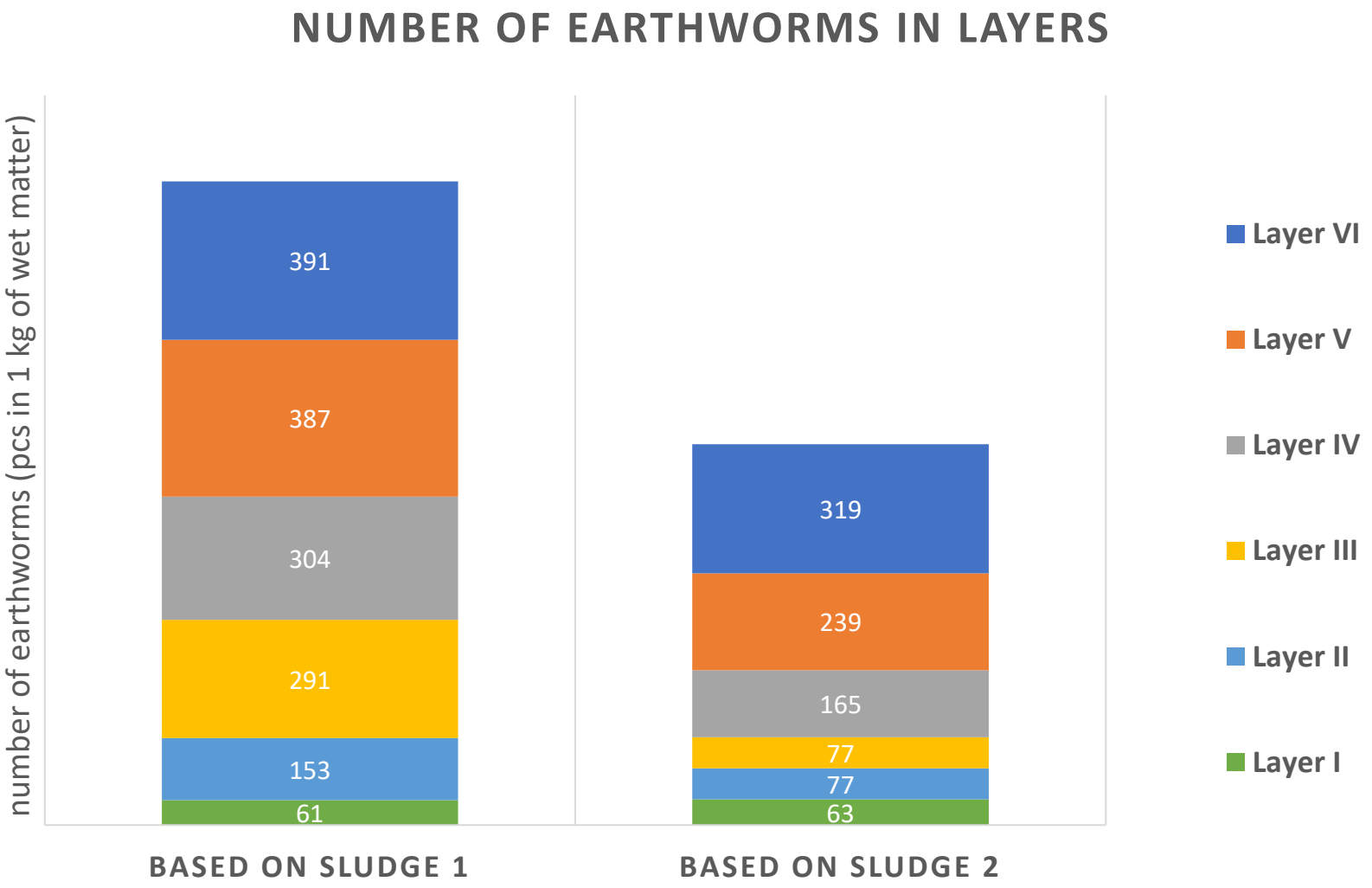
Mixture 1

Mixture 2

Material and Methods



Results and Discussion



Bacteria / fungi rate

Sewage sludge 1	Sewage sludge 2	Moulded pulp
14.46 ± 2.07	16.49 ± 0.59	n.d.

decrease

Mixture 1 after precomposing	Mixture 2 after precomposting
9.59 ± 0.18	10.57 ± 0.56

Layers	Control 1	Vermicompost 1	Control 2	Vermicompost 2
VI	16.15 ± 1.04	18.30 ± 1.88	15.24 ± 1.72	12.15 ± 1.83
V	19.15 ± 2.34	22.62 ± 2.13	16.63 ± 4.36	20.87 ± 1.63
IV	25.64 ± 2.03	21.78 ± 2.14	16.65 ± 3.12	26.93 ± 1.26
III	25.70 ± 2.66	24.05 ± 0.97	21.19 ± 1.58	22.24 ± 3.46
II	31.70 ± 1.87	28.71 ± 0.43	23.97 ± 2.00	27.12 ± 3.57
I	27.43 ± 2.72	24.49 ± 2.91	25.40 ± 0.83	22.82 ± 0.28

increase

Quality of organic matter

Mixture 1	Control 1	Vermicompost 1
DOC [mg.kg^{-1}dw]		
VI (39 days)	6650.00 ± 374.70	6140.00 ± 215.17
I (195 days)	6916.67 ± 250.27	7023.33 ± 275.38
DOC/C		
VI (39 days)	0.02 ± 0.00	0.02 ± 0.00
I (195 days)	0.02 ± 0.00	0.02 ± 0.00

Mixture 2	Control 2	Vermicompost 2
DOC [mg.kg^{-1}dw]		
VI (39 days)	6743.33 ± 170.98	7773.33 ± 1103.28
I (195 days)	7460.00 ± 308.06	9406.67 ± 526.97
DOC/C		
VI (39 days)	0.02 ± 0.00	0.03 ± 0.00
I (195 days)	0.02 ± 0.00	0.03 ± 0.00

- Dissolved organic carbon (DOC) slightly increased in bottom layers which may have been due to leaching but was below 1%.
- The proportion of DOC in Ctot was around 2%.

Quality of organic matter

Mixture 1	Control 1	Vermic. 1
E4/6 NaOH		
VI (39 days)	4.12 ± 2.91	11.69 ± 1.52
I (195 days)	5.11 ± 1.87	12.52 ± 0.40
EET/EBz NaOH		
VI (39 days)	3.39 ± 3.52	2.55 ± 0.17
I (195 days)	2.68 ± 0.79	2.50 ± 0.20
E2/E4 NaOH		
VI (39 days)	0.38 ± 0.08	0.59 ± 0.06
I (195 days)	0.40 ± 0.11	0.51 ± 0.05
Q4/6 NaOH + Pyro		
VI (39 days)	6.41 ± 1.26	6.54 ± 1.40
I (195 days)	5.50 ± 1:37	5.87 ± 1.29
EET/EBz NaOH + Pyro		
VI (39 days)	2.05 ± 0.32	2.22 ± 0.10
I (195 days)	1.59 ± 0.55	1.96 ± 0.11
E2/E4 NaOH + Pyro		
VI (39 days)	0.43 ± 0.01	0.32 ± 0.01
I (195 days)	0.58 ± 0.36	0.42 ± 0.12

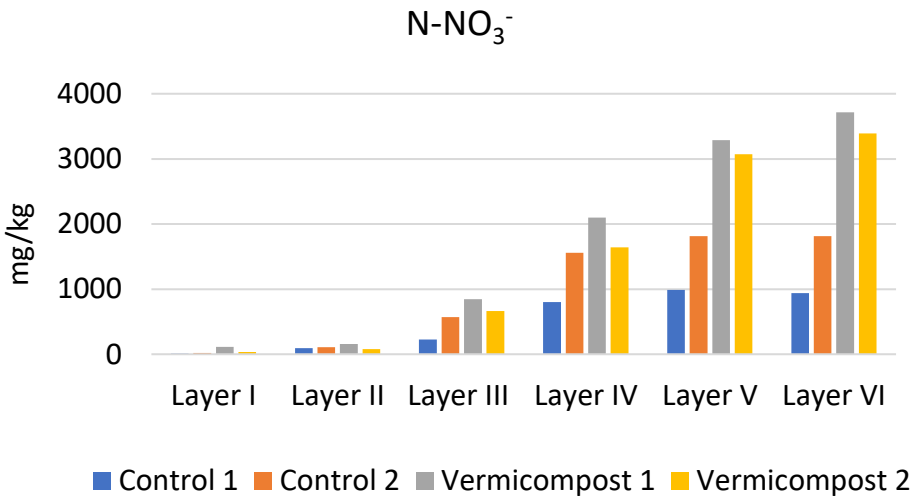
Mixture 2	Control 2	Vermic. 2
E4/6 NaOH		
VI (39 days)	7.35 ± 1.57	11.54 ± 1.34
I (195 days)	5.77 ± 1.86	4.17 ± 0.40
EET/EBz NaOH		
VI (39 days)	2.46 ± 0.31	1.97 ± 0.54
I (195 days)	2.07 ± 0.36	1.68 ± 0.09
E2/E4 NaOH		
VI (39 days)	0.46 ± 0.01	0.60 ± 0.06
I (195 days)	0.45 ± 0.03	0.45 ± 0.05
Q4/6 NaOH + Pyro		
VI (39 days)	4.69 ± 0.43	5.38 ± 0.17
I (195 days)	5.29 ± 0.80	5.32 ± 0.90
EET/EBz NaOH + Pyro		
VI (39 days)	1.63 ± 0.12	1.57 ± 0.18
I (195 days)	1.95 ± 0.25	1.72 ± 0.03
E2/E4 NaOH + Pyro		
VI (39 days)	0.40 ± 0.04	0.44 ± 0.06
I (195 days)	0.36 ± 0.00	0.57 ± 0.15

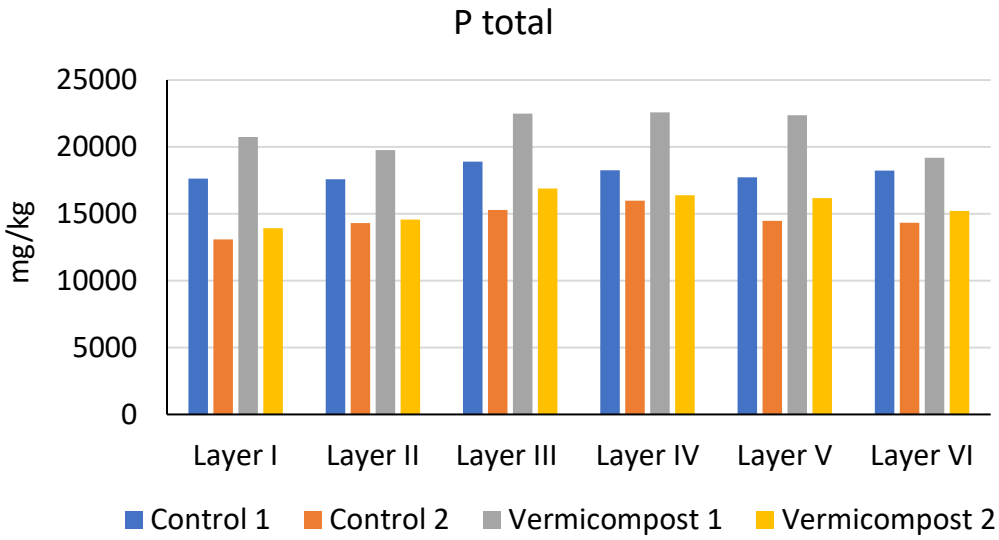
There was a decrease towards the older layers in the following parameters evaluating the quality of organic matter: E4/E6, EET/EBZ, E2/E6.

These ratios were lower in the extraction using mixtures of NaOH with $Na_4P_2O_7$ than in the extraction of NaOH itself.

Chemical properties

- The value of dry matter, pH, N-NH_4^+ and P avail **increased** with the age of the layers.
- On the contrary, there was a **decrease** in N-NO_3^-, K avail and Mg avail.





- There were differences in the trends of total contents of P, K, Mg and Ca depending on the **origin of the sludge.**

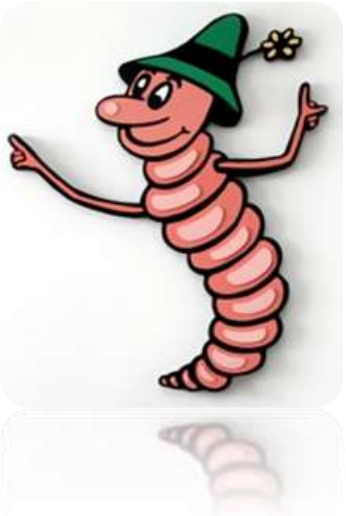
Conclusion

- Mostly insignificant differences among layers were due to the increasing age of the pre-composted pile from which new layers were added = practical conditions

- Vermicomposting is a suitable method for sewage sludge and moulded pulp handling.

- We assume that this vermicompost will have a positive effect on the quality of the soil and it will contribute to sustainable agriculture.

THANK YOU FOR YOUR ATTENTION!



- Financial support for this work was provided by the Ministry of Agriculture of the Czech Republic under the NAZV project number QK1910095.