VERMICOMPOSTING OF DISTILLERY RESIDUES IN A VERTICAL-FLOW WINDROW SYSTEM

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Introduction

Distillery residues

- Distillery residues are the main waste product of ethanol production.
- In the production of 1 L of ethanol, 15 to 20 L of distillery residues are produced.
- The handling of distillery residues can cause environmental problems due to their seasonal production and polluting characteristics.
- Direct application of distillery residues into the soil may be problematic due to their inappropriate physico-chemical properties, especially low pH.

Introduction

Vermicomposting

- The vermicomposting of distillery residues is one of the possible solutions for handling this feedstock.
- Vermicomposting is an environmentally friendly technology using earthworms
- The process involves the bio-oxidation and stabilization of organic materials by the joint action of earthworms and microorganisms.
- Final product – vermicompost - is nutrient rich but also contains high quality humus, plant growth hormones, enzymes, and substances which are able to protect plants against pests and diseases.

Introduction

Vermicomposting

Small-scale vermicomposting

Large-scale vermicomposting

Objectives

- **The aim of the study was to evaluate the feasibility of vermicomposting of distillery residues under outdoor conditions.**

- **The study sought to contribute to the understanding of the processes occurring in a vertical-flow windrow vermicomposting system.**

Material and Methods

Feedstocks

- The composition of the distillery residues corresponded to the just processed fruit in a grower distillery
- For the experiment, dry wheat straw from compacted bales with 90% dry matter content was used

	Dry matter [%]	pH/H_2O	EC [µS cm^{-1}]	C_{tot} [%]	N_{tot} [%]	C/N	$P_{tot.}$ [%]	$K_{tot.}$ [%]	$Ca_{tot.}$ [%]	$Mg_{tot.}$ [%]
Distillery residues	5.7	4.9	0.48	45	2.2	20	0.25	1.61	0.75	0.17
Straw	90	7.4	1.5	46	0.6	77	0.02	0.47	0.28	0.03

Selected agrochemical parameters of feedstocks used (pH and EC were determined in wet matter; other parameters in dry matter)

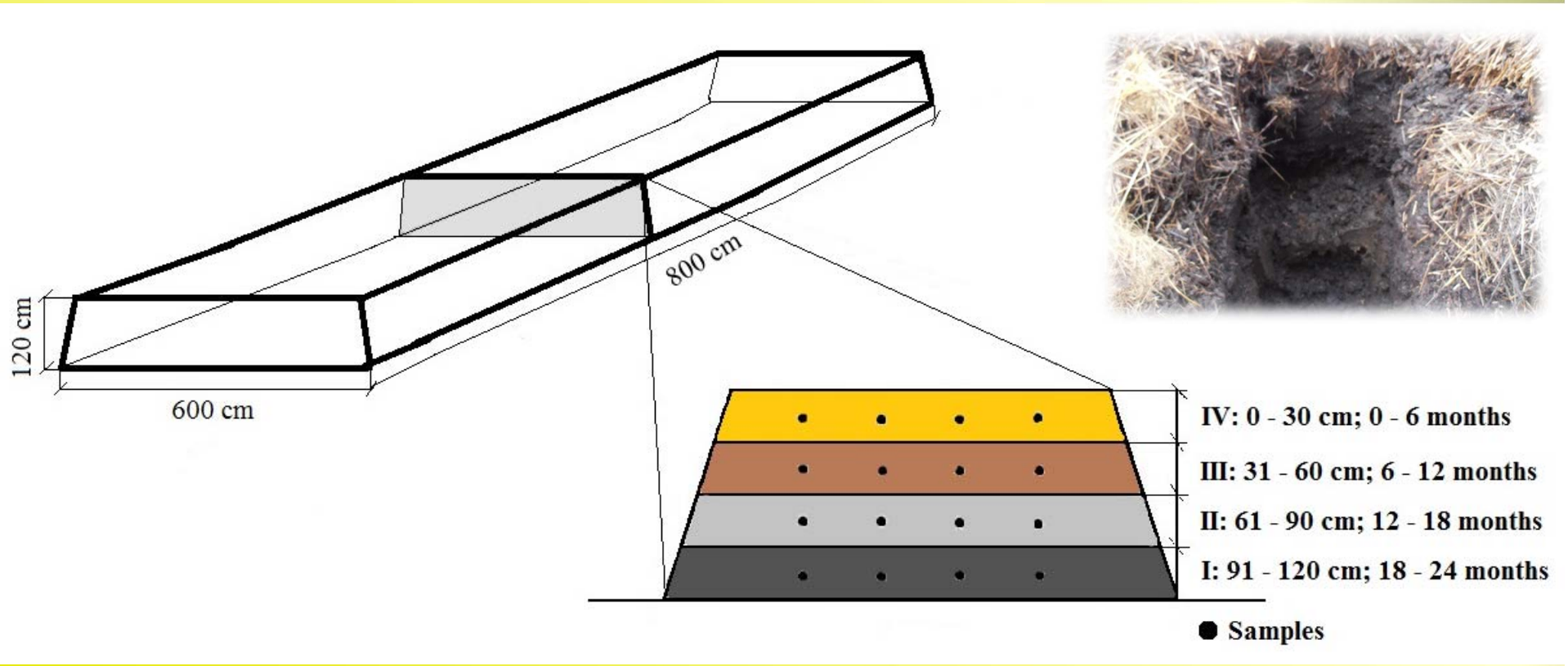
Material and Methods

Description of experiment

- The experiment was set up under operating conditions at a family grower distillery
- The vermicompost pile occupied a ground plan 6 x 8 m.
- A bedding layer consisting of precomposted beef manure and grape marc with earthworms (*Eisenia andrei*), with a density of about 50 earthworms per liter, was placed first on a flat surface.
- Wheat straw layers were added at half-year intervals. Distillery residues were applied on these layers every two weeks.
- After 2 years from the beginning of the experiment, samples were taken up from cross profiles.

Materials and Methods

- **Samples were taken up from cross profiles of different depths and ages in the 4 replications**



Materials and Methods

Samples processing

- Potential earthworms were separated, counted, weighted, and lyophilized.
- The resulting vermicompost sample without earthworms was divided into 3 parts and treated as required for laboratory analyses.
- One part of the vermicompost sample was stored at 4°C until the pH and electrical conductivity (EC) could be determined.
- The second part was dried at 30°C to a constant weight and ground. This was then used for analyses of the total and available contents of elements and the ion exchange capacity (IEC).
- The third part of the vermicompost sample was frozen at -20°C and then lyophilized for subsequent determination of the groups of microorganisms by the PLFA method and for enzyme activity.

Results and Discussion

Agrochemical parameters

Basic agrochemical parameters of layers in the large-scale vertical-flow windrow vermicomposting system

IV: 0–30 cm, 0-6 months; III: 31–60 cm; 6–12 months; II: 61–90 cm; 12–18 months; I: 91–120 cm; 18–24 months

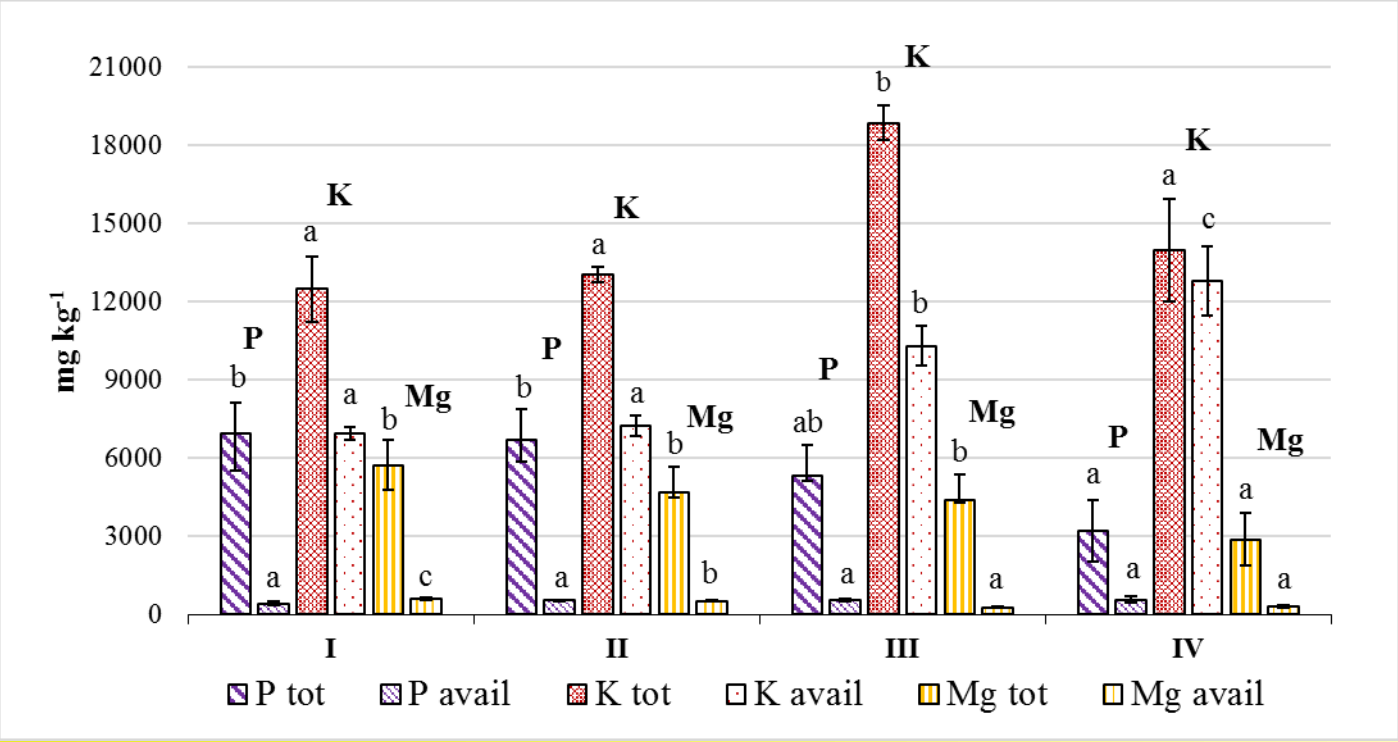
Layer	Dry matter [%]	pH/H_2O	EC [µS cm^{-1}]	C_{tot} [%]	N_{tot} [%]	C/N
IV	15.3 ± 2.42 ^{a}	7.41 ± 0.07 ^{a}	1162 ± 644 ^{a}	34.01 ± 5.45 ^{a}	2.25 ± 0.35 ^{a}	15.30 ± 2.80 ^{b}
III	25.8 ± 1.52 ^{b}	7.72 ± 0.04 ^{b}	976 ± 39 ^{a}	29.93 ± 1.35 ^{a}	2.37 ± 0.09 ^{a}	12.64 ± 0.76 ^{a}
II	25.9 ± 1.38 ^{b}	7.64 ± 0.10 ^{b}	683 ± 51 ^{a}	31.94 ± 3.08 ^{a}	2.73 ± 0.25 ^{a}	11.72 ± 0.55 ^{a}
I	28.3 ± 0.65 ^{b}	7.92 ± 0.09 ^{c}	760 ± 23 ^{a}	28.45 ± 2.42 ^{a}	2.62 ± 0.17 ^{a}	10.85 ± 0.24 ^{a}

Values are the means ± SD (n=4). Different letters in a column indicate significant differences (Tukey's HSD test, $P \leq 0.05$).

Results and Discussion

Agrochemical parameters

Changes in the total and available P, K, and Mg (mg kg^{-1}) in layers I - IV of the large-scale vertical-flow windrow vermicomposting system



The values are the means ± SD (n=4). Different letters above bars within the same element denote significant differences (Tukey´s HSD test, P<0.05).

Results and Discussion

Parameters of maturity

Effect of depth and age of the profile on the selected maturity indicators

IV: 0–30 cm, 0-6 months; III: 31–60 cm; 6–12 months; II: 61–90 cm; 12–18 months; I: 91–120 cm; 18–24 months

Layer	$N\text{-}NH_4^+$ [mg kg^{-1}]	DOC [mg kg^{-1}]	IEC [$mmol_+$ $100g^{-1}$]	IEC/C_{tot}
IV	162.05 ± 54.45 ^{c}	8799 ± 983 ^{c}	55.0 ± 3.27 ^{a}	1.64 ± 0.23 ^{a}
III	83.66 ± 21.62 ^{b}	6564 ± 379 ^{b}	60.2 ± 2.87 ^{a}	2.01 ± 0.10 ^{b}
II	21.27 ± 4.23 ^{a}	5347 ± 183 ^{a}	71.2 ± 7.37 ^{b}	2.23 ± 0.09 ^{b}
I	22.30 ± 1.92 ^{ab}	5228 ± 320 ^{a}	57.2 ± 3.20 ^{a}	2.02 ± 0.19 ^{b}

Values are the means ± SD (n=4). Different letters in a column indicate significant differences (Tukey's HSD test, $P \leq 0.05$).

Results and Discussion

Earthworms

Quantitative (number and biomass) and nutrient parameters of the earthworms in the windrow layers

IV: 0–30 cm, 0-6 months; III: 31–60 cm; 6–12 months; II: 61–90 cm; 12–18 months; I: 91–120 cm; 18–24 months

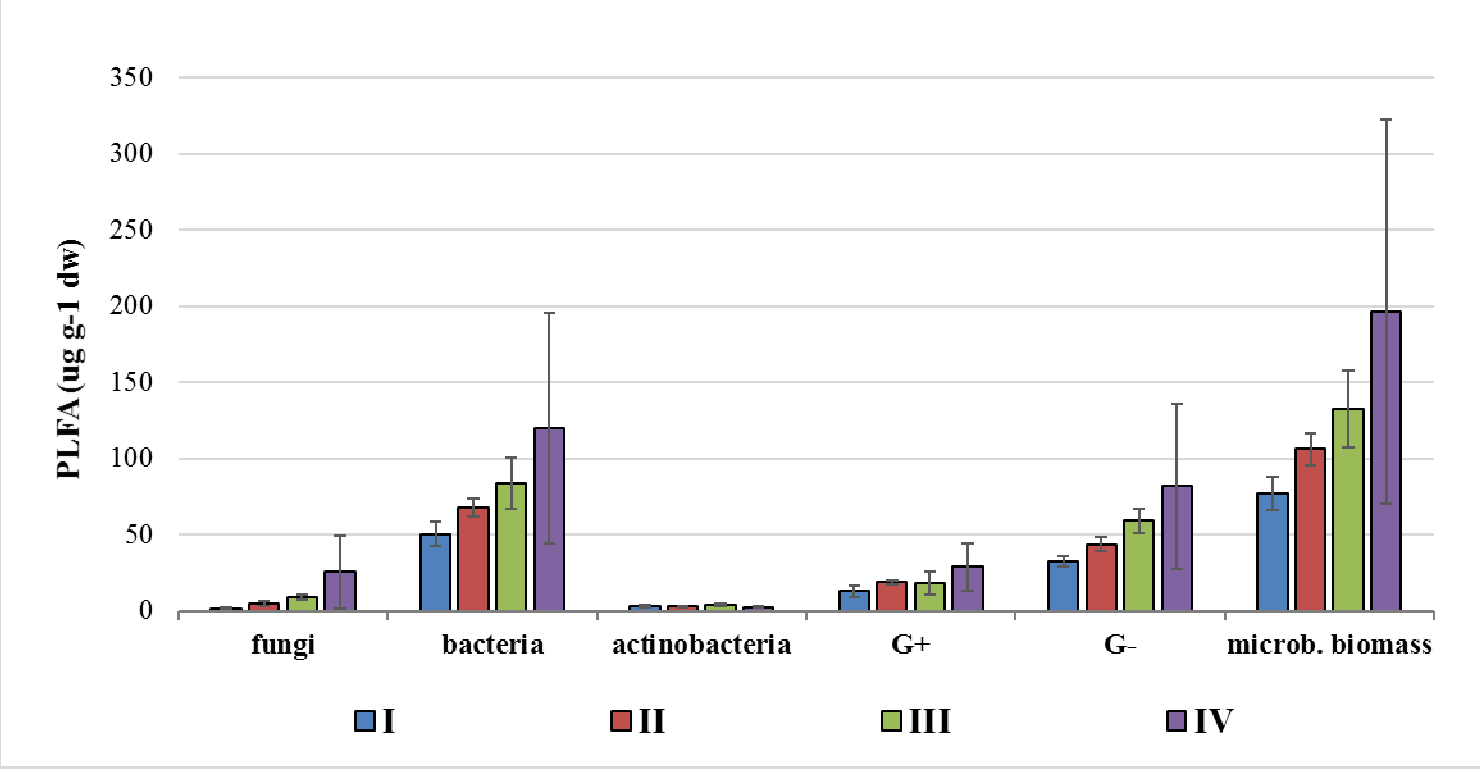
Layer	Number [in 1 kg]	E. Biomass [g kg^{-1}]	P_{tot} [mg kg^{-1}]	K_{tot} [mg kg^{-1}]	Mg_{tot} [mg kg^{-1}]
IV	5.9 ± 1.9 ^{a}	2.5 ± 0.8 ^{b}	5776 ± 855 ^{a}	3201 ± 777 ^{a}	696 ± 156 ^{a}
III	5.8 ± 2.2 ^{a}	2.6 ± 1.0 ^{b}	6904 ± 1062 ^{a}	6434 ± 1183 ^{a}	1447 ± 264 ^{a}
II	1.6 ± 1.7 ^{b}	0.5 ± 0.7 ^{a}	9036 ± 1517 ^{b}	7929 ± 2603 ^{b}	2186 ± 893 ^{b}
I	1.4 ± 0.6 ^{c}	0.4 ± 0.2 ^{a}	7226 ± 481 ^{a}	5548 ± 398 ^{a}	1514 ± 98 ^{a}

Values are the means ± SD (n=4). Different letters in a column indicate significant differences (Tukey's HSD test, $P \leq 0.05$).

Results and Discussion

Microorganisms

Changes in fungal PLFAs, bacterial PLFAs, and total microbial PLFAs biomass in the layers of the vertical-flow windrow vermicomposting of distillery residues

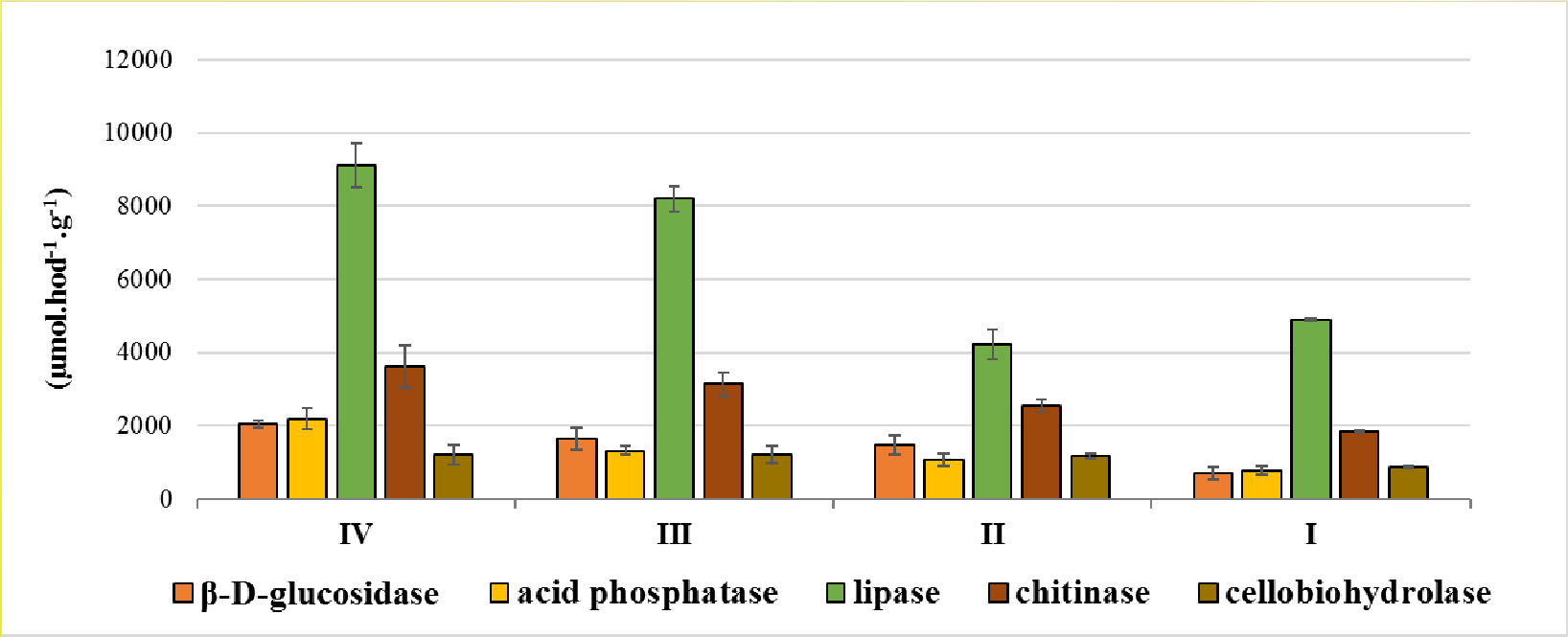


Values are the means ± SD (n=4)

Results and Discussion

Enzymatic activity

Enzymatic activity of β-D-glucosidase, acid phosphatase, lipase, chitinase, cellobiohydrolase in all layers during vermicomposting. The values are the means ± SD (n=4).



Units are µmol of specific substrate $g^{-1}.h^{-1}$. Substrates for β-D-glucosidase: 2.75 mM 4-methylumbellyferyl-β-D-glucopyranoside (MUFG); acid phosphatase: 2.75 mM 4-methylumbellyferyl-phosphate (MUFP); lipase: 2.50 mM 4-methylumbellyferyl-caprylate (MUFY);chitinase: 1.0 mM 4-methylumbellyferyl-N-acetylglucosaminide (MUFN); cellobiohydrolase: 2.50 mM 4-methylumbellyferyl-N-cellobiopyranoside (MUFC).

Conclusions

Characteristics of the layers

- **The top and so youngest layer**
- partially decomposed organic matter with a great amount of earthworm biomass, which was confirmed by parameters such as humidity, C_{tot}, N_{tot} and C/N.

- **The lower layers**
- greater maturity (low content of microbial biomass and activity of hydrolytic enzymes, slightly alkaline pH, lesser values for N-NH_4^+ and dissolved organic carbon, which was indirectly proportional to ion-exchange capacity).
- Of the total and available nutrients studied, potassium was the greatest, followed by phosphorus and magnesium.

Conclusions

Practical use of the layers

- The top layer is suitable for a new windrow and for the preparation of aqueous extracts.
- The older layers are suitable for use as an organic fertilizer.

- *The results obtained could encourage companies to effectively use this valuable biowaste that is currently, unfortunately, often unnecessarily removed.*

Thank you for your attention!