MINAGRIS FACTSHEET

DO MICROPLASTICS AFFECT HOW EARTHWORM CASTS AGE?

This factsheet is based on a MINAGRIS paper which explored the influence that microplastics have on the bacterial community succession that takes place during earth worm cast aging.

HIGHLIGHTS

- How microplastics influence earthworm cast aging was studied
- Microplastics affected fresh earthworm casts but didn't have a long-term effect
- Biodegradable microplastics (PBAT) had a minor influence on bacterial communities according to RNA analysis
- Soil- and gut-related bacterial communities were more likely to be able to avoid the negative impacts of microplastics
- Earthworm casts which contain microplastics may not cause any additional effects on the soil microbiome

DID YOU KNOW?

Microplastics have been found in almost every corner of the earth - including in the Arctic and Antarctica!

WHAT ARE EARTHWORM CASTS?

Earthworm casts are essentially faeces! Earthworm faecal matter, mostly consisting of finely process soil, creates structures in the soil, which is important for soil health by creating pores.

INTRODUCTION

Previous research on the effects of microplastics on the soil microbiome has not looked at earthworm casts, which are more fertile than bulk soil. Once earthworm casts reach the soil, they begin to age, and eventually become part of the soil, releasing nutrients and microorganisms which can alter the soil microbiome. This makes it important to understand whether these casts are affected by the presence of microplastics due to the effects they may then have on the soil microbiome itself.

EARTHWORMS AND THE SOIL MICROBIOME

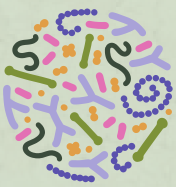
Earthworms play a key role in shaping the soil microbiome.

Earthworms consume, digest and produce casts (faeces), which can increase activity of soil microorganisms.

Microplastics have previously been found in earthworm casts, making it important to understand whether they are affecting the gut or soil microbiome.

WHAT IS A MICROBIOME?

When we talk about the **gut microbiome**, we're referring to the community of microorganisms that live in our digestive system, particularly in the intestines. These microbes help with digestion, support our immune system, and even influence our mood and overall health.



The **soil microbiome** consists of the microorganisms living in the soil. These microbes play a crucial role in breaking down organic matter, recycling nutrients, and supporting plant growth. Just like in the gut, a healthy soil microbiome is essential for the overall health of plants and the environment.

OBJECTIVES OF THIS STUDY

1. Explore the potential influence of microplastics on the physicochemical properties of earthworm casts
2. Reveal the impacts of microplastics on bacterial compositions in the earthworm gut and casts

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coordination@mail-minagris.eu
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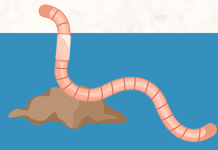


WHAT DID WE DO?

1. Collect soil samples
Containing no detectable microplastics. These samples were air dried and sieved.

2. Select earthworms
A key species of earthworm was chosen for the experiment

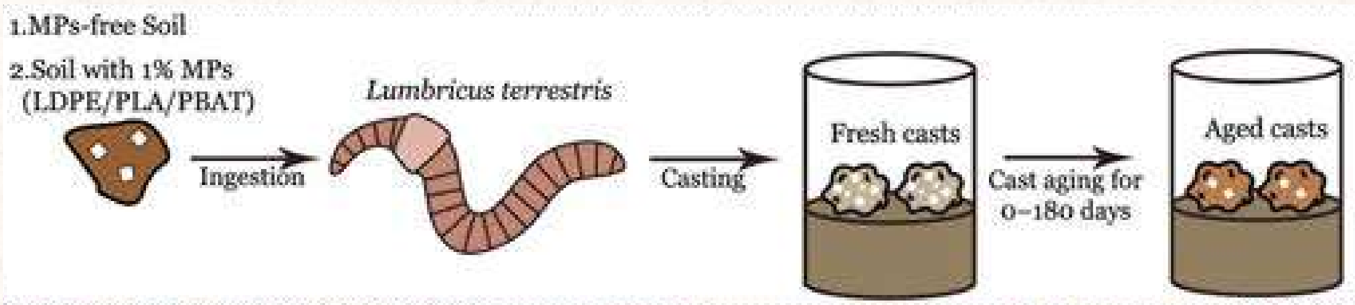
3. Select and prepare microplastics
Several types of plastic, including polyethylene, compostable plastic, and a fossil-based biodegradable plastic were selected. Microplastics were made from these in the lab by fragmenting them into very small pieces and sieving.

4. Lab-controlled environments created
Containing the earthworms, soil and microplastics. Four treatments were established:

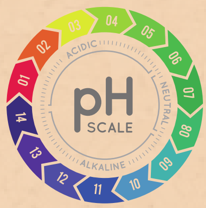
1. Control - microplastic-free soil
2. Polyethylene in the soil
3. Compostable plastic in the soil
4. Biodegradable plastic in the soil (PBAT)

5. Casts collected and aged
Earthworm casts were collected every 24 hours and transferred to containers for aging which contained microplastic-free soil. Cast aging was studied after 15 days, 60 days, and 180 days.

6. Analysis
Analysis of the soil (pre-ingestion), earthworms (by dissection) and aged earthworm casts took place using various laboratory techniques.



RESULTS



NH_4^+

Soil and Cast Properties
Over 180 days, the moisture in soil casts stayed stable, with only a slight increase when polyethylene was present. pH levels were higher (more alkaline) in fresh casts compared to soil, especially in those with microplastics, but this difference faded over time.

Ammonium and carbon levels
Ammonium and dissolved organic carbon were higher in fresh casts, particularly those with microplastics, and both decreased sharply within 60 days before stabilising. Nitrate and nitrite levels dropped after gut transit, especially in microplastic-treated casts, but eventually aligned with the control.

WHY DO AMMONIUM LEVELS MATTER?

Ammonium levels are crucial to soil health because ammonium (NH_4^+) serves as a readily available form of nitrogen for plants, which is essential for their growth and development.

Appropriate ammonium levels support optimal plant nutrition and soil fertility, while imbalances can lead to issues like nutrient leaching, soil acidification, or toxicities, potentially harming plant life and disrupting soil microbial communities.

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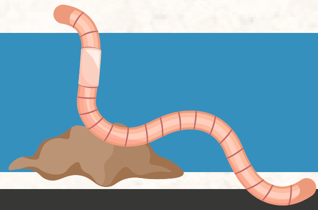


RESULTS

Bacterial Communities
Bacterial communities changed significantly between soil, gut, and casts. In the gut, ***Firmicutes*** and ***Actinobacteriota*** increased, then declined in the casts over time. Microplastics didn't significantly affect overall bacterial composition, though PBAT microplastics were linked to higher Proteobacteria at the RNA level.

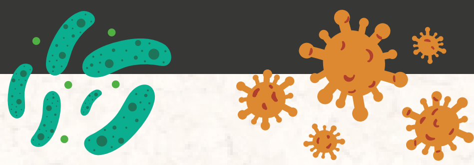
Bacterial Community Richness and Diversity
Analysis showed that bacterial communities differed more by location (soil, gut, cast) than by treatment. DNA-based communities had higher richness than RNA-based (active) ones, but diversity levels were similar.

Microplastics didn't affect bacterial diversity or richness in the long-term.
Richness and diversity of bacteria were lowest in 15 day-old casts formed in soils which contained microplastics, but these gradually returned to soil-like levels by 180 days. Active communities showed less variation, with the lowest richness in 15 day-old casts and lower diversity in the gut.

TWO KEY TYPES OF BACTERIA

Firnicutes: These bacteria have thick walls, can form spores, and are found in places like the human gut, helping with digestion.

Actinobacteriota: These bacteria are important in soil for breaking down organic matter and are also known for producing many antibiotics.



Bacteria levels in 180 day old casts produced in soils containing micro-plastics were generally similar to the levels seen in soils.

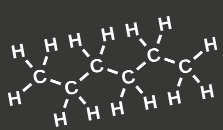
Functional Groups of Bacteria

Microplastics, particularly biodegradable PBAT, significantly enhanced the bacteria's ability to degrade hydrocarbons but didn't affect nitrogen cycling. Both the gut and casts aged 60 and 180 days showed increased potential for hydrocarbon degradation.

In general, bacterial functions were more influenced by the age of casts themselves than by microplastic treatment. For example, the gut had the highest capacity for degrading hydrocarbons, while casts aged for 15 and 60 days had more bacteria involved in denitrification and aerobic processes.

WHY IS HYDROCARBON DEGRADATION BY BACTERIA IMPORTANT?

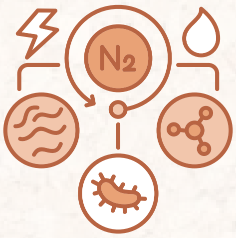
It's important that bacteria degrade hydrocarbons because this process helps break down pollutants like oil and other organic contaminants in the environment. By degrading hydrocarbons, bacteria play a crucial role in cleaning up soil and water, preventing long-term environmental damage, and maintaining ecosystem health.



WHAT IS NITROGEN CYCLING?

Nitrogen cycling in soil is the process where nitrogen moves between the air, soil, and living organisms.

Bacteria are key players in this cycle - they convert nitrogen from the air into forms that plants can use, like ammonium and nitrate. Other bacteria help break down waste and dead plants, returning nitrogen back to the soil. This cycle keeps the soil fertile and helps plants grow.



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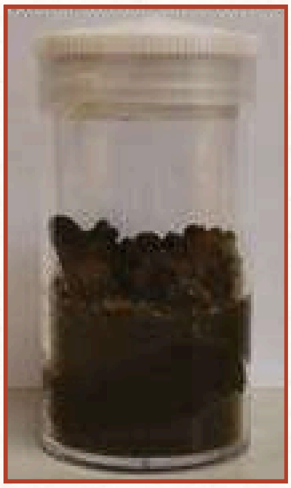
DISCUSSION AND CONCLUSION

This study has provided one of the first comprehensive looks at how microplastics (MPs) affect bacterial communities during the earthworm digestion process.

The key findings are:

1. Microplastics **may enhance differences in pH, ammonium, nitrate/nitrite, and dissolved organic carbon** levels between soil and fresh earthworm casts, but these **effects diminish as the cast ages**.
2. The **bacterial community in the casts was shaped more by the earthworm's gut and soil environment** than by the presence of microplastics.
3. A **stable core community in the soil and gut** may have helped **buffer the impact** of microplastics.
4. **PBAT**, a biodegradable type of plastic, showed specific effects, including **increasing bacteria related to hydrocarbon degradation**.
5. Microplastics in earthworm casts are **unlikely to have significant additional effects on soil microbial communities** when the casts mix with soil.

Further research is needed on how MPs influence microbial activity in earthworm guts and casts, especially in real-world, long-term field studies.



An earthworm cast 'microcosm', where they were left to age for over 80 days.

INTERESTED IN LEARNING MORE?

Read the full paper this factsheet is based on by scanning the QR code (right) or by **clicking here**.

You can also find out more about other findings from MINAGRIS by **visiting our website** and signing up to our biannual newsletter.

Click on the icons to connect with us on social media!

This factsheet was produced by Dr Charlotte Chivers of the Countryside & Community Research Institute, University of Gloucestershire.

The research itself was carried out by Dr Ke Meng, Dr Paula Harkes, Professor Esperanza Huerta Lwanga, and Professor Violette Geissen.

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