Practice Abstract n°18: CLIMECS 3 (CLImatic Manipulation of ECosystem Samples) Experiment - The Impact of Microplastics on Soil Ecosystems

1. Aim of the Study

The CLIMECS (CLImatic Manipulation of ECosystem Samples) system was originally designed to study how climate change affects soil life under simulated natural conditions. In the PAPILLONS project, it was adapted to **examine the impact of microplastics in a controlled but realistic setting—somewhere between lab tests and field studies.** Led by Professor Kees van Gestel at Vrije Universiteit Amsterdam, this third experiment builds on previous tests already described in Practice Abstract 5.

2. Focus and Methodology of the Experiment

The third CLIMECS experiment **tested how two types of microplastics**—conventional (LDPE) and biodegradable (PBAT)—**affect soil ecosystems**. Different concentrations were added to natural soil under controlled conditions. Researchers realized a comprehensive assessment of the microplastics' effects on soil properties, microbial community, plants, and soil animals to understand the overall effects of these particles on soil health.

3. Main Results

- **Effects of microplastics on abiotic soil conditions** (i.e. the non-living physical and chemical properties): The 0.8% PBAT microplastics clearly raised soil pH, while LDPE microplastics had a smaller effect, only at the highest level. Both types increased soil carbon and reduced ammonium levels.
- **Effects on soil microbial communities**: Both microplastics changed the makeup of soil microbes, especially bacteria, with the strongest effects seen after 4 weeks and fading by week 13. Microbial activity was also affected: LDPE effects depended on concentration, while PBAT at 0.8% had a strong impact, seemingly coinciding to its effect on soil pH.
- **Effects on soil invertebrates**: Springtail species diversity and earthworm survival and reproduction were not affected by the tested microplastics. However, earthworm biochemical markers showed signs of stress, including impacts on energy metabolism and detoxification. Earthworms also accumulated microplastics, suggesting possible transfer through the soil food chain.
- **Effects on plants**: Lettuce plant growth and development were not affected by exposure to both types of microplastics at the concentrations tested, but

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101000210

https://www.papillons-h2020.eu

papillons@farm-europe.eu

biochemical tests showed changes in chlorophyll, sugars, nitrates, and ammonium levels in the leaves. Stress-related and defense processes were also impacted, suggesting the plants experienced stress and nutrient limitations from microplastic exposure.

- **Holistic approach**: Some measured effects, like microbial activity and soil pH, were closely linked. After adjusting for these, researchers used advanced statistical analysis to compare all treatments. The results showed that even the lowest microplastic concentration tested caused clear changes in soil ecosystem functioning.

4. Future Implications

The results of the third CLIMECS experiment show that already at field-realistic microplastic concentrations, the soil ecosystem may be affected, potentially harming its functioning. The holistic approach taken allowed unraveling some of the complexity of the interaction between microplastics, soil organisms and environmental conditions. With that, this CLIMECS experiment provides important information for the risk assessment of microplastic pollution to soil health and ecosystem functioning, which may also help define risk limits.

The results of the CLIMECS experiment also show that commonly applied single-species toxicity tests fall short in predicting the effects of microplastics on soil ecosystems, and that innovative experimental approaches like CLIMECS mesocosms are needed to advance the understanding of ecosystem responses under (simulated) natural conditions.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101000210

https://www.papillons-h2020.eu

papillons@farm-europe.eu