Evaluating the Influence of Microplastics on Soil Microbial Community Composition through DNA Stable Isotope Probing

Maggie Krein [1, 2], Nathan Blais [1, 2], and Jessica Ernakovich [1, 2]
1. Department of Natural Resources, University of New Hampshire, Durham, NH 2. Center for Soil Biogeochemistry and Microbial Ecology

Introduction

- Microplastic pollution is increasing plastic concentration in agricultural soil, potentially affecting agroecosystem function.
- Microplastic can alter soil respiration[2], organic matter decomposition[5], and nitrification[5], facilitate dissolved organic matter accumulation[1], and decrease below-ground biomass[4].
- The mechanisms driving these changes are unclear.

QUESTIONS

1) How do microplastics affect the composition of the active microbial community in agricultural soil?
2) Do low-density polyethylene (LDPE) microplastics alter the soil respiration in classic New Hampshire agricultural soil?

Design/Methods

We ran an 8-week incubation with soil from UNH's Kingman Farm. Amended treatments with microplastics.

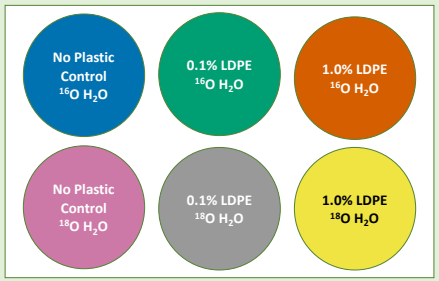

Figure 1: Treatments and controls used in experiment. Two levels of plastic treatment, with four replicates of each treatment and control.

We measured soil respiration and utilized ^{18}O DNA Stable Isotope Probing (SIP) to observe the active microbial community.

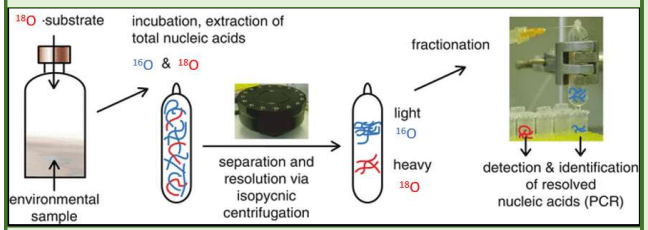

Figure 2: Overview of the DNA SIP. We collected 8 fractions from each sample after centrifugation. The use of a heavy isotope allows us to identify active taxa as their DNA becomes enriched and they end up in a heavier fraction relative to the ^{16}O control [3].

There was little distinction in the density range for the fractions, likely owing to insufficient incorporation of the ^{18}O isotope.

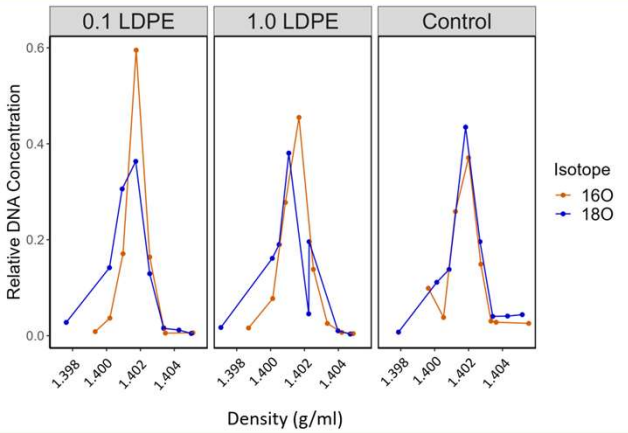

Figure 3: Average DNA concentration in each density fraction relative to the total DNA in a sample across density fractions.

Results/Discussion

In contrast to previous research, soil respiration did not increase significantly in the microplastic treatments. This may be due to overall low carbon, particularly labile carbon sources, in the soil.

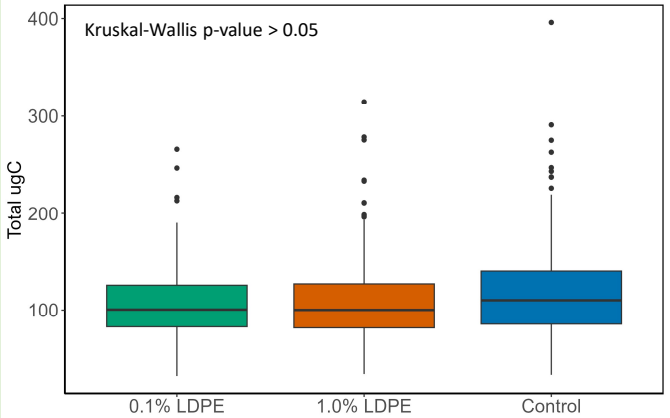

Figure 4: Total carbon respired from the treatments over the course of the incubation. Treatments with completely different letters are significantly different.

Microbial communities significantly differed only between fractions. The lack of distinction between ^{16}O and ^{18}O samples further indicates low ^{18}O incorporation.

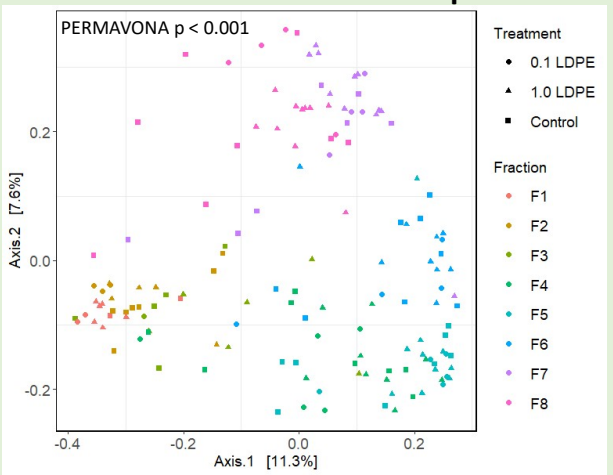

Figure 5: PCoA ordination using Bray-Curtis dissimilarity of bacterial 16S amplicon data. Each point represents the microbial community from a DNA fraction.

Conclusions

- Results may indicate microplastics have little to no impactful in relatively dry, low carbon soil, in the absence of plants and their inputs.
- We did not see increased abundance of known plastic degraders with plastic addition.
- It is possible if more fractions were collected (12 or 16 instead of 8), we may have seen a greater distinction in the density ranges across fractions and subsequent signals of DNA incorporation.

Next Steps

We will assess whether certain taxa were enriched between ^{16}O and ^{18}O treatments. Further, sequencing data will be combined with quantitative PCR to assess taxa specific growth rates (quantitative stable isotope probing).

References

1. Liu, X. et al. (2017). Response of soil dissolved organic matter to microplastic addition in Chinese loess soil. *Chemosphere, 185*, 907–917.
2. Liu, X. et al. (2023). Effect of nonbiodegradable microplastics on soil respiration and enzyme activity: A meta-analysis. *Applied Soil Ecology, 184*, 104770.
3. Lueders, T. (2015). DNA- and RNA-Based Stable Isotope Probing of Hydrocarbon Degraders. In: McGenity, T., Timmis, K., Nogales , B. (eds) Hydrocarbon and Lipid Microbiology Protocols. Springer Protocols Handbooks.
4. Tong, Y. et al. (2022). Microplastics affect activity and spatial distribution of C, N, and P hydrolases in rice rhizosphere. *Soil Ecology Letters, 5*(3), 220138.
5. Zhou, J. et al. (2021). Microplastics as an emerging threat to plant and soil health in agroecosystems. *Science of The Total Environment, 787*, 147444.

Acknowledgements

Many thanks to Dr. Jessica Ernakovich for her advising and support on this project. A special thanks to Nathan Blais for his tremendous help in creating and conducting this research and for his constant guidance. Thank you to the Hamel Center and NH AES for funding this project.