JoinUS: Gliederung der Ausschreibung

Advisor: Prof. Dr. Sara Kleindienst

Research group / department: Department of Environmental Microbiology

Title of the proposed research project: Identification of surfactant impacts on microbial glyphosate degraders in freshwater sediments

Keywords: microorganisms, microbial community structure, microbial activities, cultivation, microcosms, herbicide formulations, glyphosate

Introduction / Background: Glyphosate is the most widely applied herbicide on Earth and accounts for 92% of the herbicide global use (Antier et al., 2020). In Europe, 25 – 64% of annual crop acreage was treated with glyphosate (Antier et al., 2020). This compound and its degradation by-products (mainly aminomethylphosphonic acid; AMPA) exhibit potential toxicity for the microbial communities as well as for humans (Wei et al., 2024; Zhan et al., 2018). Improper application of glyphosate causes its accumulation in terrestrial and aquatic environments as glyphosate can bind to soil particles leading it to be found in the upper soil layer and in freshwater sediments in proximity to agricultural fields (Zhan et al., 2018). Glyphosate is not used as single compound but as mixture, a formulation, with surfactants as the second most abundant ingredient (Villarreal-Chiu et al., 2017). While these surfactants are considered inert in terms of their effect on glyphosate efficacy (Mesnage et al., 2019), a critical knowledge gap exists regarding their impacts on microorganisms in the environment (Zabaloy et al., 2022). Previous studies show mixed results on the effects of surfactants on glyphosate biodegradation. For example, one study showed that a surfactant (Triton CG-110) has no effect on glyphosate mineralisation (Carretta et al., 2020), but a different kind of surfactant (quaternary ammonium cations) decreased glyphosate mineralization rates (Wilms et al., 2023).

The PhD project will identify glyphosate-based surfactant impacts on microorganisms from freshwater sediments, e.g., rivers or ponds, that are capable of degrading glyphosate. In particular, aerobic and anaerobic cultivation techniques will be used to enrich and isolate the target organisms. Subsequently, cultivation experiments will be used to unravel surfactant impacts on isolated microbial key players. Microcosm studies will be performed to identify surfactant impacts on complex microbial communities in freshwater sediments using a suite of biogeochemical and molecular tools (e.g., 16S rRNA gene sequencing, metagenomics, and metatranscriptomics). These interdisciplinary studies will further reveal if surfactants from glyphosate application can have effects on glyphosate persistence in the environment.

Research Environment: The Department of Environmental Microbiology at the Institute for Sanitary Engineering, Water Quality and Solid Waste Management (ISWA) at the University

of Stuttgart consists of an interdisciplinary, international, and dynamic team of environmental microbiologists, microbial ecologists, and chemists. The research group focuses on fundamental research with links to applied areas and studies topics related to microbial pollutant degradation. More information can be found on our webpage: https://www.iswa.uni-stuttgart.de/institute/em/. The PhD candidate will get the opportunity to be creative and innovative, and to work on a challenging and interdisciplinary topic.

Research goals:

- To unravel the interactions between surfactants present in glyphosate formulations and key freshwater sediment microorganisms involved in glyphosate biodegradation.
- To enrich and isolate novel microorganisms that drive glyphosate and AMPA biodegradation in the presence and absence of surfactants.
- To establish laboratory microcosms and to determine how surfactants change the microbial community of freshwater sediments and their ability to metabolize glyphosate and AMPA.

Methods to be used:

- Aerobic and anaerobic enrichment of glyphosate-degrading freshwater sediment microbial communities and isolates
- Quantification of physicochemical parameters, substrates, and products (e.g., via HPLC, IC, GC-MS)
- 16S rRNA gene amplicon sequencing
- Metagenomic and metatranscriptomic sequencing
- Statistical analysis of the obtained data sets

Prerequisites:

- Solid background in molecular ecology and environmental microbiology
- Ability to work independently and in a team
- Excellent management and communication skills
- Highly motivated and committed to pursuing interdisciplinary research
- Very good computer and language skills (English)

References

Antier, C., Kudsk, P., Reboud, X., Ulber, L., Baret, P. V., & Messéan, A. (2020). Glyphosate Use in the European Agricultural Sector and a Framework for Its Further Monitoring. *Sustainability*, *12*(14), Article 14. https://doi.org/10.3390/su12145682

Carretta, L., Cardinali, A., Masin, R., Zanin, G., & Cederlund, H. (2020). Decyl glucoside surfactant Triton CG-110 does not significantly affect the environmental fate of glyphosate in the soil at environmentally relevant concentrations. *Journal of Hazardous Materials*, *388*, 122111. https://doi.org/10.1016/j.jhazmat.2020.122111

Mesnage, R., Benbrook, C., & Antoniou, M. N. (2019). Insight into the confusion over surfactant co-formulants in glyphosate-based herbicides. *Food and Chemical Toxicology*, *128*, 137–145. https://doi.org/10.1016/j.fct.2019.03.053

Villarreal-Chiu, J. F., Acosta-Cortés, A. G., Kumar, S., & Kaushik, G. (2017). Biological Limitations on Glyphosate Biodegradation. In R. Singh & S. Kumar (Eds.), *Green Technologies and Environmental Sustainability* (pp. 179–201). Springer International Publishing. https://doi.org/10.1007/978-3-319-50654-8_8

Wei, X., Pan, Y., Zhang, Z., Cui, J., Yin, R., Li, H., Qin, J., Li, A. J., & Qiu, R. (2024). Biomonitoring of glyphosate and aminomethylphosphonic acid: Current insights and

future perspectives. *Journal of Hazardous Materials*, *463*, 132814. https://doi.org/10.1016/j.jhazmat.2023.132814

Wilms, W., Parus, A., Homa, J., Batycka, M., Niemczak, M., Woźniak-Karczewska, M., Trzebny, A., Zembrzuska, Dabert, M., Táncsics, A., Cajthaml, T., Heipieper, H. J., & Chrzanowski, Ł. (2023). Glyphosate *versus* glyphosate based ionic liquids: Effect of cation on glyphosate biodegradation, *soxA* and *phnJ* genes abundance and microbial populations changes during soil bioaugmentation. *Chemosphere*, *316*, 137717. https://doi.org/10.1016/j.chemosphere.2022.137717

Zabaloy, M. C., Allegrini, M., Hernandez Guijarro, K., Behrends Kraemer, F., Morrás, H., & Erijman, L. (2022). Microbiomes and glyphosate biodegradation in edaphic and aquatic environments: Recent issues and trends. *World Journal of Microbiology and Biotechnology*, *38*(6), 98. https://doi.org/10.1007/s11274-022-03281-w

Zhan, H., Feng, Y., Fan, X., & Chen, S. (2018). Recent advances in glyphosate biodegradation. *Applied Microbiology and Biotechnology*, *102*(12), 5033–5043. https://doi.org/10.1007/s00253-018-9035-0