Impact of agricultural run-off and climate warming on key organisms and ecosystem functions in shallow aquatic ecosystems

Elisabeth M. Gross[1], Vinita Vijayaraj[1], Joséphine Leflaive[2], Bastian Polst[3], Joey Allen[2], Nora Kipferler[4], Stéphanie Bouletreau[2], Vincent Jassy[2], Martin Laviale[1], Mechthild Schmitt-Jansen[3], Herwig Stibor[4], and Sabine Hilt[5]

[1]Université de Lorraine, LIEC UMR 7360 CNRS, Metz, France; [2]Université de Toulouse, ECOLAB UMR 5245 CNRS, Toulouse, France; [3]Helmholtz-Centre for Environm. Research – UFZ, Dept. Bioanal. Ecotoxicology, Leipzig, Germany; [4]Ludwig-Maximilians University Munich, Department of Biology, Munich, Germany; [5]Leibniz-Institute of Freshwater Ecology and Inland Fisheries, Berlin, Germany; **E-mail contact: gross5@univ-lorraine.fr**

Introduction

- Shallow aquatic systems such as small lakes or slow flowing streams are providing pivotal ecosystem functions and services.
- They are exposed to multiple stressors such as climate warming and agricultural run-off (ARO).
- Predicting the outcome of multiple stressor exposure challenging because of complex feedback mechanisms between different primary producers and consumers.
- Degraded shallow freshwater systems are dominated by either phytoplankton or periphyton.

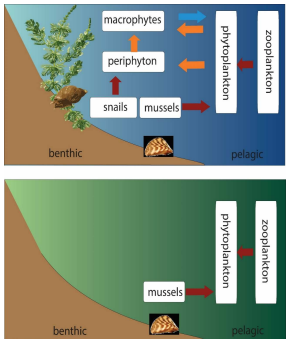

Fig. 1: Benthic-pelagic coupling in shallow freshwater ecosystems. The upper picture shows biotic interactions in an undisturbed system, the lower picture a system that is dominated by phytoplankton blooms.

Material and methods

- Microcosm experiments were performed in 8-L vases at 22 and 26°C, a photoperiod of 16:8 L:D at 60–80 µmol photos m^{-2} s^{-1}.
- Sediment was based on OECD TG 239, water was either Volvic water (Exp. I-IV) and well water from Munich (Exp. IV).
- ARO composed of nitrates, copper and three organic pesticides (Terbuthylazin, Pirimicarb, Tebuconazole)
- Macrophytes*: Elodea nuttallii, Myriophyllum spicatum* and *Potamogeton perfoliatus*.
- Periphyton and phytoplankton: culture strains of cyanobacteria, chlorophytes and diatoms.
- Consumers: *Daphnia magna, Dreissena polymorpha* and *Lymnaea stagnalis*.
- Response factors based on performance of respective organism group (growth, abundance, pigments, stoichiometry,…)
- Alder leaf litter degradation used as marker of ecosystem response.
- Experiment I: Only primary producers; dose-response curve of ARO
- Experiment II and III: ARO single or pulsed doses, without or with consumers.
- Experiment IV: ARO with or without nitrates; different water source; primary producers and consumers
- Testing ARO components on individual organism groups.

Results

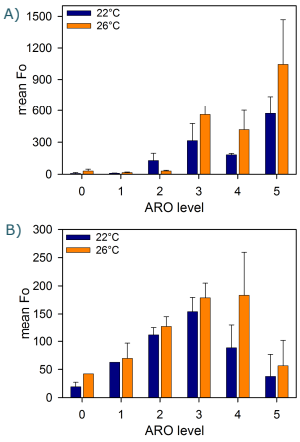

Fig. 2: Dose-response effect of ARO on phytoplankton (A) and periphyton (B) at 22°C and 26°C (Exp. I).

- Without consumers, phytoplankton or periphyton development increased with ARO (Exp. I, II; Fig. 2a, 2b).
- In the presence of consumers, *Daphnia* and *Lymnaea* controlled phytoplankton and periphyton development, respectively (Exp. IV; Fig. 3).
- ARO and temperature affected alder leaf litter degradation (Exp. II; Fig. 4).
- Negative effect of ARO and relevant components on *Daphnia* (Fig. 5a) and *Lymnaea* (Fig. 5b).

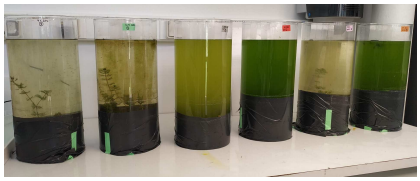

Fig. 3: Microcosm experiment at LIEC, Metz: From left to right: Control (Volvic) – Nitrates (Volvic) – ARO without nitrates (Volvic) – ARO with nitrates (Volvic) – Control (Munich well water) – ARO with nitrates (Munich well water) – (Exp. IV: primary producers and consumers).

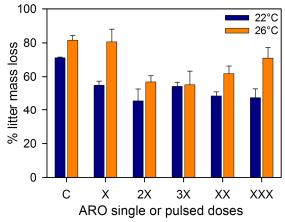

Fig. 4: Effect of single or pulsed doses of ARO at two different temperatures on alder leaf litter degradation in microcosms (Exp. II).

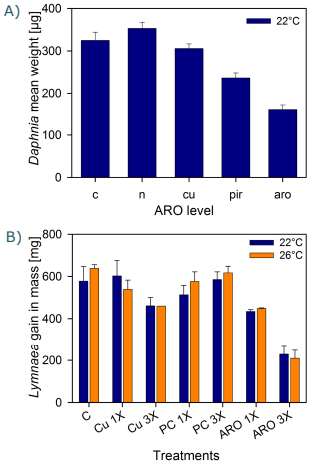

Fig. 5: Effect of complete ARO or copper, pirimicarb or nitrates (only *Daphnia*) on consumers. A) Effect on *Daphnia*. B) Effect of *Lymnaea stagnalis*.

Conclusions & Perspectives

- Agricultural run-off composed of a mixture of nitrates, copper and organic pesticides enhances the development of phytoplankton in microcosms composed of typical representatives of shallow freshwater systems.
- This observation was made both in the absence and presence of consumers. Negative effects of ARO and its individual components on consumers seem to enhance positive effects on phytoplankton.
- Relevant ecosystem functions such as trophic transfer (consumption rate) and degradation of organic matter (alder leaf litter degradation) are affected by ARO.
- In summer 2019, upscaling to outdoor mesocosm experiments using natural plankton communities will be done.
- For complementary information, see poster TU134 and presentation 227 (Room 206, Tue 9:35).

CLIMSHIFT is funded by the French ANR and German DFG (2018-2021)
The thesis of V. Vijayaraj is supported by the ‚ZA Moselle' / CNRS