Regime shifts in freshwater ecosystems exposed to multiple stressors by increasing temperature, fertilisers and pesticides (CLIMSHIFT)

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Context

- Shallow freshwater ecosystems provide vital ecosystem functions but are threatened by multiple stressors acting at different spatial and temporal scales.
- While a response to global climate change might be gradual, abrupt changes are possible when critical thresholds by additional effects of local stressors are exceeded.
- The French-German project CLIMSHIFT aims for a mechanistic understanding of stressor interactions acting on shallow aquatic systems vulnerable to climate warming and agricultural run-off.

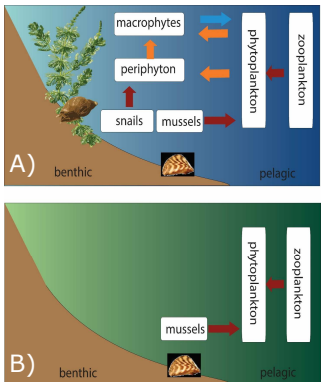

Fig. 1: Benthic-pelagic coupling in shallow freshwater ecosystems. A) Biotic interactions in an undisturbed macrophyte-dominated system. B) System dominated by phytoplankton.

Major objectives

- To understand and predict the response of complex interacting benthic-pelagic systems to multiple stressors by global warming and "agricultural run-off" (ARO) based on a mechanistic understanding of stressor interactions.
- To evaluate if both stressors act additively, synergistically or antagonistically on organism performance and physiology, and on community and ecosystem processes.
- To determine potential thresholds for shifts in ecosystem functions (metabolism, energy transfer, flux of elements) for single and combined stressors.

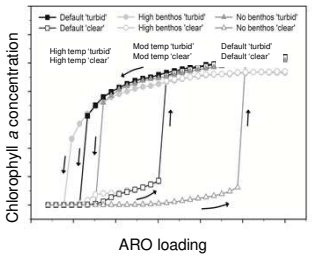

Fig. 2: Shallow freshwater ecosystems show a hysteresis in the response to eutrophication or other stressors. If a certain threshold is passed, the system will switch from macrophyte dominance with clear water to the turbid, phytoplankton dominated state. Climate warming should reduce the threshold for ARO loading.

Experimental and modelling approach

- The impact of climate warming (+4°C) and ARO is tested in a series of lab microcosm experiments and a large-scale, outdoor mesocosm experiment (Fig. 3).
- ARO (Fig. 4) based on common occurrence of pollutants with concentrations based on published data and SSDs (species-sensitivity distributions) for an estimated low (sublethal) effect on all organism groups. Nitrates based on levels found in shallow freshwater systems.
- Common submerged macrophytes and benthic and pelagic strains of cyanobacteria, chlorophytes and diatoms will be used in microcosms; a natural phytoplankton community in mesocosms.
- Consumers are *Daphnia magna, Lymnaea stagnalis* and *Dreissena polymorpha* in microcosms. In mesocosms, use of natural zooplankton.
- Microcosm experiments applied dose-response or pulsed application of ARO, and tested the relative impact of nitrate or individual pollutants.
- Integrative dynamic modelling will be applied to simulate potential outcomes and critical thresholds, and predict stressor interactions.

Fig. 3: Upper picture: Microcosms are 8-L vases, with an insert of ~ 1L for sediment. Plastic strips are appended for periphyton development. Lower picture: Mesocosms (~600 L) fixed to a wooden frame. Periphyton plastic strips visible in the centre.

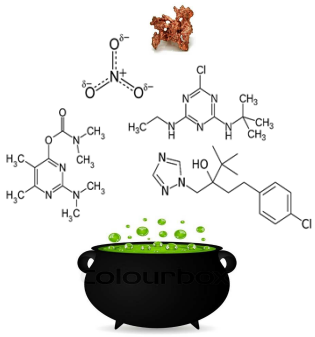

Fig. 4: The Agricultural run-off (ARO) cocktail used is composed of nitrates, copper and three organic pesticides (Terbuthylazin, Pirimicarb, Tebuconazole)

Project challenges and deliverables

- Ecotoxicology is more and more focusing on effects at higher ecological levels, asking for experimental and modelling approaches to account for complexity.
- Effects of multiple stressors on shallow freshwater systems will result in various direct and indirect effects. Pollutants will act differently on certain organism groups; direct toxic effects will be accompanied by indirect effects due to changed biotic interactions such as competition or consumption.
- The five project partners of CLIMSHIFT cover a wide range of expertise in ecotoxicology and ecology of shallow freshwater systems.
- The project aims to define 'safety margins' for the use of fertilisers and mineral or organic pesticides in a world of climate warming.
- First results show a shift towards phytoplankton dominance under ARO; this effect is enhanced in the presence of consumers (Fig. 5).
- For further results, see poster TU037 and presentation 227 (Room 206, 9:35).

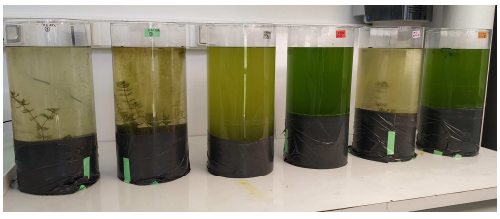

Fig. 5: Microcosm experiment at LIEC, Metz: From left to right: Control (Volvic water) – Nitrates (Volvic) – ARO without nitrates (Volvic) – ARO with nitrates – Control (Munich well water) – ARO with nitrates (Munich well water).

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