PhD Scholarship in ecotoxicological modelling

Titre / Title: Effets de mélanges d'éléments traces métalliques sur les interactions écologiques au sein d'un microcosme : la modélisation prédictive en soutien à l'évaluation des risques écologiques / *Effects of mixtures of metallic trace elements on the ecological interactions within a microcosm : predictive modelling in support of ecological risk assessment*

Encadrants / Supervisors:
Bernard CLEMENT, LEHNA-IPE, ENTPE (ecotoxicology, microcosm bioassays)
http://umr5023.univ-lyon1.fr/
Denise BLANC-BISCARAT, DEEP, INSA Lyon (chemical modelling)
http://deep.insa-lyon.fr/
Sandrine CHARLES, LBBE-MEPS, UCBL (ecotoxicological modelling, Bayesian inference)
http://lbbe.univ-lyon1.fr/

Problematic and context:
Ecological risk assessment due to contaminants is today most often carried out based on single-species toxicity tests applied to single chemicals. However, real ecosystems are composed of multiple interacting species exposed to mixtures of contaminants. Numerous studies from 1980 until today have tried to predict the ecotoxicity of mixtures from that of each component with the application of either a model of Concentration Addition (CA, Loewe and Muischnek, 1926), or a model of Independent Action (IA, Bliss, 1939).
A recent work associating LEHNA-IPE and LBBE-MEPS has led to the development of a model of a 3-species microcosm (daphnids, micro-algae, duckweeds) submitted for 2 or 3 weeks to a single contaminant (cadmium) (Lamonica et al., 2016a, 2016b). The model is based on ordinary differential equations describing the main processes occurring in the microcosm (survival, growth, interactions between species) and the action of the toxicant (direct and indirect effects). The model parameters are estimated from experimental data by Bayesian inference.
In line with this previous work, it would be valuable to apply microcosm modelling to ecological risk assessment of a mixture of contaminants such as metallic trace elements present in most aquatic ecosystems. Such a research would help to predict the effects of mixtures on chosen ecological interactions within a micro-ecosystem by taking into account the fate (chemical speciation and partitioning between abiotic and biotic compartments, Clément and Lamonica 2018) together with direct as well as indirect effects of components in a dynamical system. For simplification, it would be wise to focus on a mixture of contaminants with the same mode of action and the same physiological target sites, under the assumption of the CA model.

Proposed work:
The research will focus on the effects of a mixture of metallic trace elements (Cu, Cd, Zn). Concentration ranges will be chosen to mimic as far as possible the concentrations found in rainwater and in the same time leading to sublethal effects (growth inhibition, inhibition of daphnid grazing) on the species within the microcosm (*Daphnia magna, Pseudokirchneriella subcapitata, Lemna minor*).
In a first step, microcosm assays (2-L beakers filled with a synthetic medium continuously aerated under 16-h illumination/day) will be carried out on 1 or 3 species with concentration ranges corresponding to the most sensitive species or conversely to the 2 least sensitive species according to the method proposed by Lamonica *et al*., in press. Measurements of metallic concentrations in the various compartments (water and biota) as well as determination of chemical speciation using a geochemical modeling approach will ensure a better assessment of dose-effect relationships and a more relevant modelling at the microcosm level. These assays will involve each metal tested separately (single-toxicant assay), with the aim of providing data necessary and sufficient for inferring the microcosm model parameters.

The three metal-specific models will then be combined into a whole model involving interactions between metals (either CA or IA model) so as to carry out simulations on different combinations of metal mixtures within tested concentration ranges in single-toxicant assays. Model predictions will help to define appropriate model-guided experiment designs for microcosm assays on metallic mixtures that will be then carried out with the same protocol as for single-toxicant assays. The experimental data collected with metallic mixtures will be used to validate the model predictions of the effects of metallic mixtures, and to test the assumption of concentration addition regarding the interactions of metals on the interactions between microcosm species.

Main references:

Bliss CI (1939) The toxicity of poisons applied jointly. *Annals of Applied Biology* 26: 585–615

Clément B., Lamonica D. (2018). Fate, toxicity and bioconcentration of cadmium on *Pseudokirchneriella subcapitata* and *Lemna minor* in mid-term single tests, *Ecotoxicology*, DOI: 10.1007/s10646-017-1879-z (accepted nov 2017)

Lamonica D., Clément B., Herbach U., Orias F., Charles S., Lopes C., (2016a). Mechanistic modelling of daphnid-algae dynamics within a laboratory microcosm, *Ecological Modelling* 320 : 213-230.

Lamonica D., Clément B., Charles S., Lopes C. (2016b). Modelling algae-duckweed interaction under chemical pressure within a laboratory microcosm, *Ecotoxicology and Environmental Safety*: 128, 252-265.

Lamonica D., Clément B., Charles S., Lopes C. (in press). How less but better designed experiments may benefit parameter inference of a dynamic microecosystem model, Ecological Modelling.

Loewe S, Muischnek H (1926) Combinated effects I Announcement - Implements to the problem. Naunyn-*Schmiedebergs Archiv fur Experimentelle Pathologie und Pharmakologie* 114: 313–326

Profile:

We are looking for a highly motivated student with outstanding or excellent Master's degree or equivalent qualification who is interested to work in an inter-disciplinary project. The main scientific cores are: experimental ecotoxicology, modelling, Bayesian inference, chemistry.
Skills with the R software will be a clear plus.
Interpersonal skills, dynamism, rigor and teamwork abilities will be appreciated.
Fluent English will be appreciated, together with high-level editorial skills.

Contacts:

Bernard CLEMENT, LEHNA-IPE, ENTPE: bernard.clement@entpe.fr Tel +33 (0) 4 7204 7062
Sandrine CHARLES, LBBE-MEPS, UCBL: sandrine.charles@univ-lyon1.fr Tel +33 (0) 4 7243 2900