Toxicodynamic models for predicting metal toxicity in aquatic environments: proof of concept on cadmium and zinc in the sentinel species Gammarus fossarum.

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Résumé

In France, monitoring of the chemical and ecological status of watercourses complies with the European Water Framework Directive (WFD). The ecological status is based on biological indices involving the diversity and composition of biological communities. The chemical status is evaluated by comparing concentrations of priority pollutants with Environmental Quality Standards (EQS) outlined in the WFD. More recently, the WFD promotes the use of biota to assess levels of chemical contamination, allowing to focus on the bioaccumulative and bioavailable fraction of contaminants in receiving waters, which are of direct ecotoxicological relevance. Thanks to previous scientific developments, the gammarid *Gammarus fossarum* is preconized through an active biomonitoring method standardized by AFNOR (NF T90-721). This method consists in encaging calibrated males for 21 days directly *in situ*. Subsequently, the concentrations of substances bioaccumulated by gammarids, including priority metals, are measured to assess contamination levels in rivers. However, interpreting the concentrations of contaminants bioaccumulated by biota in terms of toxic impacts remains a challenge.

The general aim of this study is to propose a toxicodynamic model for interpreting bioaccumulated concentration data, in terms of toxicity on the survival of adult and embryonic

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gammarids. The relevance of this approach will be demonstrated using data obtained during national biomonitoring. The results presented herein will primarily focus on two metals, cadmium (non-essential) and zinc (essential), to demonstrate the proof-of-concept of our approach in environmental risk assessment.

For this, we were carried out laboratory experiments where gammarids were exposed to a range of cadmium and zinc concentrations. The effects on adult and embryonic survival were measured at different time steps throughout exposure (up to 21 days). The link between metal concentrations bioaccumulated by gammarids and their effects on adult survival and reproduction (summarized by embryonic survival) during time was established through the development and calibration of a toxicodynamic (TD) model based on the General Unified Threshold model for Survival (GUTS) formalism. Preliminary results indicate a difference in the sensitivity of gammarids to the two metals, and a differential toxicity between adult and embryonic survival.
The application of this tool on biomonitoring data will then be exemplified by mapping more than 500 French stations monitored since 2017. These results will complete the risk assessment done presently only through bioavailable contamination levels by including toxicity.

Mots-Clés: water monitoring, toxicity, metals, bioassay, TKTD model, GUTS, bioaccumulation