On the use of Bayesian inference to improve routine ecotoxicological data analysis

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The standardized aquatic toxicity tests performed in laboratories [1] are usually analysed by calculating No Observed Effect Concentration (NOEC) or x% Effect Concentration (ECx), from which can be derived safety thresholds. However, this approach supplies very poor information compared to the material and human costs of such tests. In order to better profit from the data, without increasing the experimental design, biology-based methods have been proposed and are now encouraged in guidelines. For instance, the DEBtox approach [2] deals with energy balance between physiological processes, and gives insight on how tested compounds disturb it. Moreover, the involved parameters have a biological meaning (for instance the maximum body length), as the DEBtox models are based on mechanistic assumptions. We propose to further improve data analysis, by estimating these parameters with a Bayesian approach. Indeed, the big expertise available in laboratories and literature can be translated into prior probability distributions and consequently integrated in the estimation process. As Bayesian inference provides estimates as posterior probability distributions, we are able to deduce punctual estimates, but also credibility intervals, much more intuitive than confidence intervals in a risk assessment outlook. Besides, we aspire to extrapolate the toxic effects observed at the individual level to the population level, a more relevant endpoint on an ecological point of view. For that purpose, we integrate both lethal and sublethal toxic effects into a matrix population model, to calculate the finite rate of population change as a function of exposure concentration. Making use of the joint posterior distribution allows us to deal with potential correlations between parameters, and to build a credibility band for the populational endpoint which take into account both variability and uncertainty. Finally, we base on this credibility band to predict critical exposure concentration with regard to population health. We demonstrate the meaningful conclusions allowed by this methodology through the analysis of 21 day *Daphnia* reproduction tests.

References

[1] OECD (1998). *Daphnia magna* reproduction test, Guideline 211. Paris, France.

[2] Kooijman SALM, Bedaux J (1996). *The analysis of aquatic toxicity data*. Amsterdam: VU University Press.