ABSTRACT

Å. Arrhenius, 2005. ON THE ECOTOXICOLOGY OF CHEMICAL MIXTURES – The predictive power of the concepts CONCENTRATION ADDITION and INDEPENDENT ACTION in microalgal communities. Botanical Institute, Göteborg University, Sweden.
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Two basic concepts in predictive mixture toxicity assessment are Concentration Addition (CA), assumed to apply for similarly acting substances, and Independent Action (IA) assumed to apply for dissimilarly acting substances. Both concepts have been applied successfully in single species testing and in this thesis I investigate whether they can predict mixture toxicity also at a higher level of biological complexity using natural microalgal communities (periphyton and epipsammon).

Both short-term tests (inhibition of photosynthesis) and long-term microcosm experiments (algal community structure) were used for the evaluation. All experiments involved the following steps; analysing concentration-response functions for the individual substances, predicting mixture toxicity according to CA and IA, experimentally testing of mixtures, comparing predictions with observations, and finally assessing the applicability of CA and IA at the community level.

Reference mixtures were designed with sets of carefully chosen mixtures of substances with known structures and mechanisms of action specifically designed to fulfil the basic assumptions of CA and IA respectively. The short-term effect indicator was matched to the mechanisms of action of the tested substances. For similarly acting substances (paper I) the mixture toxicity was accurately predicted by CA. The results from the validation tests of IA with dissimilarly acting substances revealed some drawbacks of both concepts. IA described the mixture effects accurately until the effect region where stimulating (hormesis-like) effects were observed for two of the mixture components (paper II). At present, no concept is available for adequately describing or predicting the toxicity of mixtures of substances that individually cause hormesis. Further, both CA and IA assume no interactions among mixture components (in solution or biota), which became obvious in paper III, where both predictions failed to accurately predict the whole concentration-response curve.

The possibilities to make more ecologically meaningful predictions of mixture toxicities were studied using a flow-trough periphyton microcosm system (paper IV, V). The mixture effects of three dissimilarly acting antifoulants were evaluated with the attempt to transfer mixture toxicity approaches to a higher ecological level. Much to our surprise, both IA and CA accurately predicted the onset of mixture toxicity on species richness as a measure of community structure. The CA prediction was accurate also at higher effects levels where IA overestimated the mixture toxicity. Yet there is no sound scientific explanation for this and the correspondence with CA might be purely circumstantial.

Within this thesis evidence is provided that predictions on the basis of current mixture toxicity concepts are robust and in general suitable also for application in complex ecological contexts. However, hormesis and interactions cause problems for both concepts, thus the simplistic assumptions of both concepts sometimes collide with reality.

Keywords: mixture toxicity, joint toxicity, combined effects, microalgal communities, periphyton, epipsammon, model ecosystem, PICT, community testing, community structure, community function, herbicide, Irgarol, TBT, Sea-Nine, DCOIT, antifouling, tolerance, sensitivity