ECO 14-15.2

Extending Research Progress on Bioaccumulation under TMF^2 (TMF^{2+})

Executive Summary

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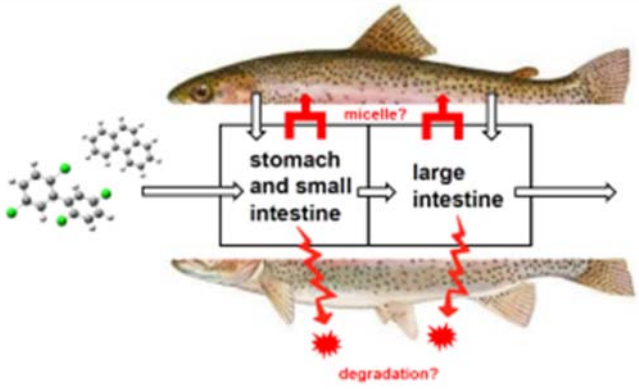
Potential for bioaccumulation is one of the key environmental hazard criteria for chemicals that is assessed under the European chemicals regulation REACH. The ECO14-15.2 research project, "Extending Research Progress on Bioaccumulation under TMF^2" aimed to improve the scientific basis for assessing chemicals for bioaccumulation potential on two research fronts. The project funded two years of research by a team at Stockholm University to investigate improved methods for assessing the bioaccumulation potential of organic chemicals in the laboratory and the field, and it reached a conclusion in December 2014.



A conceptual diagram of processes that control absorption efficiency of chemicals from food by fish. Figure created by Ruiyang Xiao, Stockholm University.

When a new chemical is being assessed for potential for bioaccumulation, one of the key sources of uncertainty is the efficiency of transfer of the chemical from food through the wall of the digestive tract. In particular, the absorption efficiency of chemicals by fish from food is a key parameter that drives the results of chemical assessments. To date, there is no standardized procedure for measuring absorption efficiency of chemicals by fish. Values that have been reported in the scientific literature are highly variable, but they were obtained with a wide range of different experimental protocols. In the ECO 14-15.2 project the team at Stockholm University applied and further refined a new, rapid method for measuring absorption efficiency of chemicals by fish. The new method relies on testing the absorption efficiency of chemicals alongside a set of chemicals with well-characterized absorption efficiencies. Results of the test for the new chemicals are then benchmarked against the well-characterized chemicals to reduce variability between different tests and between different individual test organisms. In the new measurements conducted in ECO 14-15.2 particular emphasis was placed on measuring absorption efficiencies of highly hydrophobic chemicals and on including super-hydrophobic chemicals which may be poorly absorbed, and for which there were few measurements prior to the project. In a complimentary activity, the research team developed a new computer model that simulates the uptake of chemicals by fish from their food. The model was applied to re-

interpret measurements of absorption efficiency that have been reported in the scientific literature in the past. Using the model the research team could estimate values of the absorption efficiency from past studies that are consistent with the values obtained from new measurements using the benchmarking approach. This research produced a new, self-consistent database of absorption efficiency values for 77 different hydrophobic organic chemicals that can be used as a basis to develop new predictive models for other chemicals.

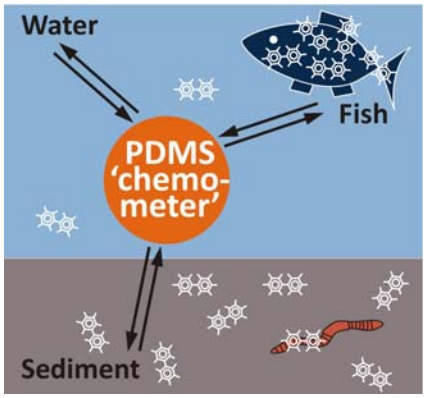


Illustration of the use of polydimethyl siloxane (PDMS) polymer as a "chemical thermometer" or "chemometer" to measure chemical biomagnification in fish in a lake.

The bioaccumulation of chemicals that are already present in a lake can be assessed by collecting samples and measuring chemical concentrations in water, sediment and fish from the lake. The key question in such a field-based assessment of bioaccumulation is whether the chemical is accumulating in fish preferentially compared to sediments or water. As a fish digests its food, some chemicals are driven from the food into the fish along with the lipids, proteins and nutrients that the fish is absorbing. Chemicals that bioaccumulate very strongly have been estimated to reach concentrations in living fish that are up to 10 times higher than would be expected in the body of a dead fish that was not actively digesting food. This phenomenon is called "biomagnification". As part of the ECO 14-15.2 project, the team at Stockholm University used a new technology, equilibrium passive sampling, to directly measure the extent of biomagnification of polychlorinated biphenyls (PCBs) in a Swedish lake. The PCBs were selected for this study since they are known to biomagnify in some systems, and they provide a useful test case for the new equilibrium passive sampling method. In the equilibrium passive sampling research, a standard reference material made of silicone polymer was brought into contact with sediments and the tissues of different fish species collected from the Swedish lake. After allowing chemicals to move from the sediment or fish tissue into the silicone polymer and come to equilibrium, the team determined the PCB concentrations in the polymer. Thus, the silicone polymer acts as a kind of "chemical thermometer" that measures the level of chemical in sediment and fish tissue in a way that can be directly compared. The results from this field study using passive equilibrium sampling indicated that PCBs are not biomagnifying from sediment in the Swedish lake. Future applications of this technology could allow rapid screening assessment of biomagnification of chemicals, and the technology could also be used to compare the bioavailable load of chemicals in sediments at different sites and prioritize clean-up actions.