Evaluating Polymeric Sampling for Predicting the Bioaccumulation of Hydrophobic Organic Contaminants by Higher Trophic Level Organisms

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Background/Objectives. Recent research has shown that bioaccumulation of hydrophobic organic contaminants (HOCs) by benthic and sessile marine organisms can be accurately predicted by polymeric sampling (within a factor of 10). If at equilibrium, the bioaccumulation of HOCs can thus be explained by equilibrium partitioning for these lower trophic level organisms. Now, research is needed to assess the ability of polymeric sampling for predicting the bioaccumulation of HOCs by pelagic and mobile organisms (i.e., by higher trophic level organisms). The limited available research on the topic suggests that processes beyond simple equilibrium partitioning need to be considered to accurately estimate bioaccumulation by these organisms. The current (on-going) study reviews the scientific literature linking polymeric sampling data and bioaccumulation by higher trophic level shellfish and fish with the goal to investigate the (1) strength of the correlations between lipid-normalized concentrations and equilibrium polymer concentrations, (2) ability for predicting bioaccumulation using polymeric sampling techniques and data, and (3) advantages, limitations, applicability domain, and data gaps associated with this approach.

Approach/Activities. Generally, two polymeric (passive) sampling methods are used: (1) the ex situ equilibrium sampling method fully equilibrates a thin polymer with sediment during tumbling in the laboratory and (2) the in situ “pre-equilibrium” sampling method places a thicker polymer within the bulk water or sediment on site and then infers equilibrium concentrations through the use of performance reference compounds (PRCs). In this study, polymeric sampling is expressed as the polymer concentration at assumed, adjusted, or confirmed equilibrium with (interstitial) water (ng HOC g\(^{-1}\) polymer) while bioaccumulation is expressed as the lipid-normalized concentration in shellfish or fish (ng HOC g\(^{-1}\) lipid). Coherent data are plotted in a log-log system and fitted with a linear regression.

Results/Lessons Learned. Preliminary data analysis included a total of 18 regressions linking lipid-normalized concentrations in fish and equilibrium polymer concentrations (a complete literature search is on-going). The HOCs studied were hexachlorobenzene and polychlorinated biphenyls (PCBs), which were measured in the polymers polydimethylsiloxane (PDMS), polyoxymethylene (POM), and silicone DC1-2577 in addition to the fish species bream, eel, herring, perch, pike, pikeperch, roach, and zebrafish. Generally, strong log-log linear regressions existed between lipid-normalized concentrations in fish and equilibrium polymer concentrations across contaminants, polymers, and fish with mean coefficients of correlation \(r^2\) = 0.71 (range: 0.18 – 0.97), 83.3% of \(r^2 > 0.50\) and 55.6% of \(r^2 > 0.75\) (n = 18). Further, with a few exceptions, the regressions were within a factor of 10 from the 1:1 relationship, suggesting that the polymers accumulated a concentration comparable to the lipid-normalized concentration. In this way, the preliminary data analysis supports using equilibrium polymer concentrations as surrogates for lipid-normalized concentrations and thus using polymeric sampling as a tool for predicting fish bioaccumulation, without using bioaccumulation models for explicitly including trophic transfer and biomagnification. Ideally, this research will provide an assessment of the ability to predict bioaccumulation by higher trophic level organisms using polymeric sampling approaches. If successful, this research will serve as a tool for regulatory agencies (e.g., U.S. EPA) to assess risk associated with contaminated sediments in terms of their potential to contaminate commercially and recreationally important shellfish and fish.