

Passive Samplers as Sediment Surrogates in Toxicity Tests

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Extended Abstract

Narcosis has long been recognized as a mechanism of toxicity for aquatic animals exposed to hydrophobic organic chemicals (HOCs). This toxic effect can be understood as the disruption of membrane functions due to the inclusion of significant quantities of contaminating HOCs in the lipid bilayers of key cellular components. Due to their nonionic character, all HOCs can be accumulated in these nonpolar subcellular regions. Further, the evidence shows that mixtures of HOCs exhibit overall impacts that are the sum of the effects due to each of the individual components. Since contaminated sediments contain diverse HOC mixes (e.g., normal, branched, and cyclic alkanes from petroleum, PAHs in coal tars, PCBs in dielectric fluids, linear alkyl benzenes from surfactants), all such substances must be considered together in any site-specific assessment for narcosis.

Marine sediments and pore waters contaminated with HOCs act as a dynamic system, where the sediment is a constant source of HOCs to the surrounding environment and associated benthic fauna. Laboratory toxicity tests using pore water lack this sediment “buffering” capacity, possibly underestimating the potential toxicity of HOCs due to lack of the necessary mass of dissolved contaminants in pore water to achieve the critical body residue that would cause adverse biological effects. Inert media that absorb HOCs such as polyethylene (Adams et al., 2007) can be used as a constant source of HOCs in toxicity tests. The current study had the objective of assessing the use of such a HOC-absorbing medium as surrogate for sediment in porewater toxicity tests.

A thin film of polyethylene (PE) was used as the HOC-absorbing medium. Preliminary laboratory experiments were performed by exposure of PE to phenanthrene-saturated stock solutions in filtered seawater until the PE was loaded with the chemical. It was established that 1.2 mg of PE/mL seawater was necessary to maintain the test solution at near phenanthrene-saturation levels throughout a test exposure period.

The toxicity of phenanthrene was significantly higher in copepod 96-h hatching success tests (Nipper et al. 2005) that used PE as a source of phenanthrene than in tests using static systems initiated with a phenanthrene-saturated stock solution but in the absence of saturated PE (Figure 1). A control using only PE showed no significant toxicity.

Subsequently, a diverse suite of sediment samples was collected in Boston Harbor representing a range of toxicities previously seen by Long et al. (1996). PE was mixed with

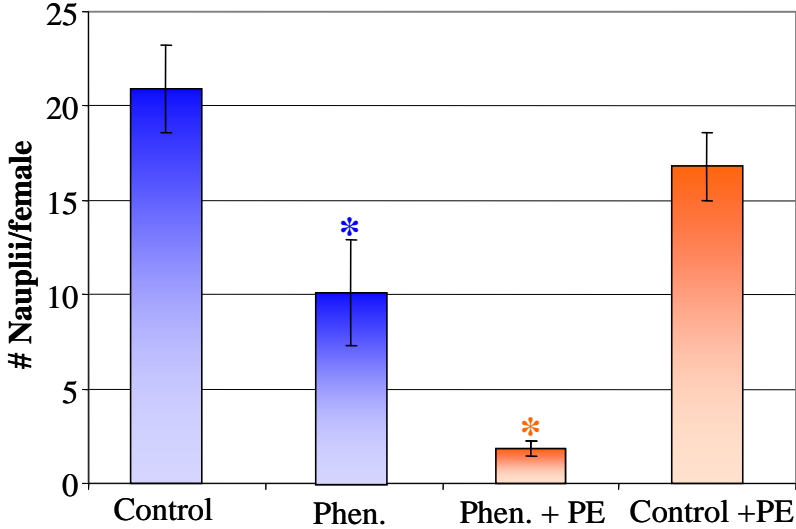


Figure 1. Comparison of phenanthrene toxicity to copepod nauplii contrasting controls (no phenanthrene in solution) with a known dissolved phenanthrene dose (second bar), a corresponding phenanthrene dose introduced and buffered via PE (third bar), and a clean PE control (fourth bar).

these sediments at room temperature for 9-days, rinsed with deionized water, and transferred to uncontaminated filtered seawater. After allowing 24 hours for desorption of HOCs from the PE to the seawater, sea urchin fertilization toxicity tests were done (Carr and Chapman 1992). This system allowed better control of the HOC dose concentration while removing complications from other potentially toxic pore water components such as metals, ammonia and sulfides. Pore water from the same sediments was also obtained by centrifugation and analyzed for toxicity in concurrent experiments. Toxicity of actual pore water differed from toxicity of HOC-loaded PE systems (Figure 2).

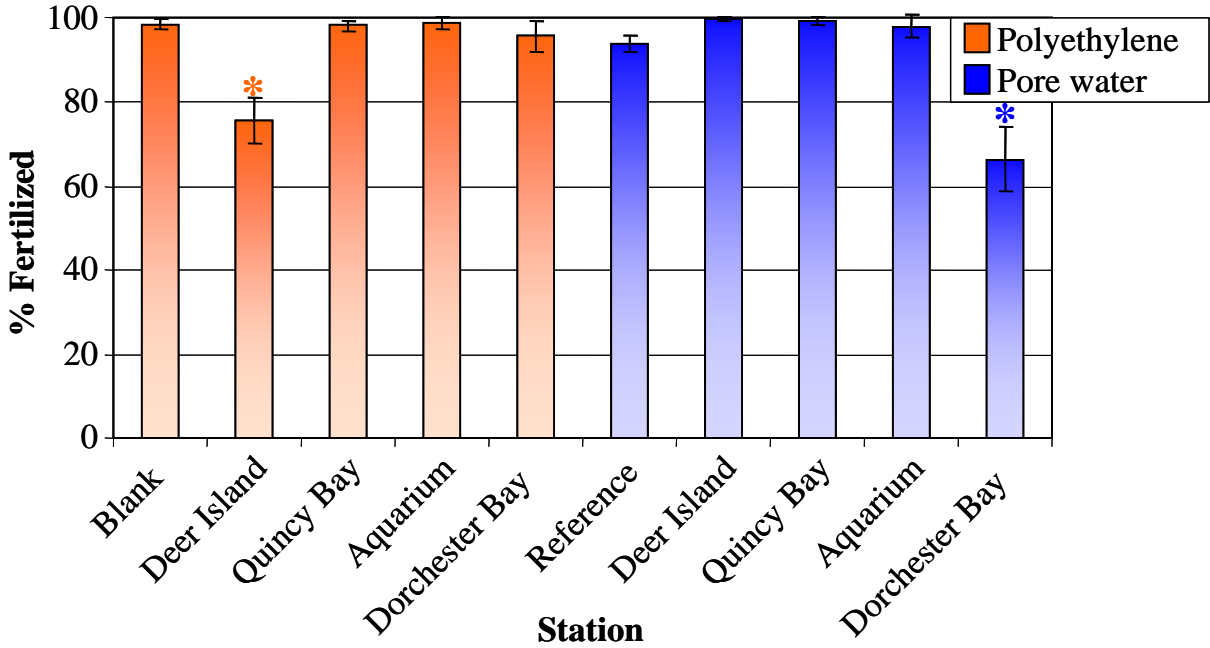


Figure 2. Comparison of porewater and HOC-loaded polyethylene toxicity to sea urchin fertilization success.

The higher toxicity of the Deer Island sample using PE as a sediment surrogate for HOC release, as opposed to pore water, suggests that HOCs were the main contaminants in this area of Boston Harbor. The concentration of HOCs in the pore water would have been depleted prior to reaching a critical body residue in the test organisms. Conversely, the higher toxicity of the pore water from the Dorchester Bay sediment indicated that categories of contaminants other than HOCs would have been responsible for the observed effect.

This toxicity data supports the hypothesis that thin films of PE exposed to HOC-contaminated sediments can act as sources of HOCs in toxicity tests, thus isolating HOC toxicity from effects caused by additional contaminants and confounding factors such as ammonia and sulfides.

References

- Adams, R.G., R. Lohmann, L.A. Fernandez, J.K. MacFarlane and P.M. Gschwend. 2007. Polyethylene devices: Passive samplers for measuring dissolved hydrophobic organic compounds in aquatic environments. *Environ. Sci. Technol.* 41:1317-1323.
- Carr, R.S. and D.C. Chapman. 1992. Comparison of whole sediment and pore-water toxicity tests for assessing the quality of estuarine sediments. *Chem. Ecol.* 7:19-30.
- Long, E.R., G.M. Sloane, R.S. Carr, K.J. Scott, G.B. Thursby and T.L. Wade. 1996. Sediment toxicity in Boston Harbor: Magnitude, extent, and relationships with chemical toxicants. NOAA Technical Memorandum NOS ORCA 96.
- Nipper, M., R.S. Carr, J.M. Biedenbach, R.L. Hooten and K. Miller. 2005. Fate and effects of picric acid and 2,6-DNT in marine environments: Toxicity of degradation products. *Mar. Pollut. Bull.* 50:1205-1217.

Keywords: hydrophobic organic compound, toxicity test, passive sampler, polyethylene, sea urchin, copepod