CHEMICAL/BIOLOGICAL BEHAVIOR OF WATER-BORNE AROMATIC HYDROCARBONS

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Polynuclear aromatic hydrocarbons (PAHs) include known or suspected carcinogens, cause toxic effects, and persist in the environment. Seven of 68 locations in the Mississippi Sound were found to have levels of PAHs that were 25 to 50 times background values. Though toxicity tests were conducted on these sediments, we did not examine for chronic pathological effects, and the exposure media were too complex to establish definite relationships between PAH concentration and toxicity. Separate studies not treated here have shown a relationship between PAHs and tumor induction in small aquarium fish. Assessing PAH concentrations in these studies, however, depends on several interacting factors. These involve solubility, light stability, particle size in suspensions, and biological interaction.

Fluorescence and gas chromatographic procedures have been applied to dimethylbenzanthracene (DMBA), benzo(a)pyrene (BaP) and benzo(e)pyrene (BeP) to measure actual solubility in water, photo-oxidation rates, distribution of particle size in PAH suspensions, and stability of aqueous preparations in the presence of test organisms. PAHs prepared under a variety of conditions mimicking those that would occur in nature were used as exposure media for guppies and Japanese medaka.

In 5 μg/L (ppb) solutions of the three compounds, DMBA proved to be most light sensitive, dropping to less than 1 ppb after three days of high-light exposure. Under low-light conditions, DMBA exhibited no perceptible loss. Only about 10 percent loss in BaP could be seen after a three-day high-light exposure. BeP showed no loss from photo-oxidation during this test.

Suspensions of the test PAHs were prepared at a nominal concentration of ca. 500 ppb and then filtered through a series of membrane filters to examine distribution of particle size and to test whether biological activity responds only to that fraction of PAHs in true solution. These suspensions were filtered through Nuclepore filters varying in porosity from 0.1 to 10.0 μ. Most of the particles in suspension were above 5.0 μ in size; very few particles occurred in the less than 0.4 μ size although there was no size range that was devoid of particles, even 0.1–0.2 μ sizes. In exposures of fish to these filtrates (all with the same soluble level of PAHs) tumor incidence increased in those media with greater quantities of suspended particles, suggesting that suspensions of PAHs may have had tumorigenic activity.

Unless particle size distribution in a particular exposure experiment is well documented, concentration values have limited value. In examining particle size distribution of PAHs suspensions, we discovered that different suspensions of a particular PAH can have identical total concentrations but different distributions of particle size. A change in PAH-particle-size-distribution occurs during the progress of an exposure, complicating interpretations. Treating suspensions as special-case solutions can lead to erroneous assertions; therefore, reports of sub-lethal effects studies must be accompanied by more than total PAH concentration data for proper assessment and interpretation.

In tests designed to follow loss of PAHs due to presence of exposure organisms, we obtained some rather surprising results and determined that fish affected concentration values. With or without added solvent carrier, DMBA, BaP and BeP at or somewhat higher than solubility levels (1–20 ppb) showed marked decline during 24 hours, resulting from test organisms in the exposure tanks. BeP showed the greatest light-stability, and it was lost most rapidly from biological activity. At the highest total concentrations (1 to 4 mg/L or ppm), the ability of fish to bind, sequester, or degrade low levels of all three PAHs is masked by another effect. A higher total concentration of PAHs occurred in tanks with fish than occurred after 24 hours in tanks without fish; no loss of PAHs was seen during the 24 hours in tanks with fish. We suggest that excretory products or mucus secretions enhance the solubility or suspension-stability of the media with high concentrations of PAHs. Perhaps fish exposed to emulsions or suspensions at sufficiently high concentrations serve to prolong high exposure dosages in the media.