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COMPARING CONCENTRATIONS OF PCBs ACCUMULATED BY ZEBRA MUSSELS, CHANNEL CATFISH, AND SPMDs FROM CONTAMINATED SEDIMENT

The Raisin River in southeastern Michigan is typical of many large rivers in industrialized areas. It provides fishery and recreational opportunities but is also contaminated with organic pollutants. Portions of the water column and sediment in the lower 4.2 km of the river are heavily contaminated with polychlorinated biphenyls (PCBs), and this area has been designated as an Area of Concern. In 1991 an area (hot spot) of severe PCB sediment contamination (>40,000 ppm) was discovered by Michigan State University research staff. Caged zebra mussels (*Dreissena polymorpha*), channel catfish (*Ictalurus punctatus*), and Semi-Permeable Membrane Devices (SPMDs) were exposed to bottom sediment for 28 days. We compared relatively new monitoring organisms or devices (mussels and SPMDs) with an established biomonitor (catfish).

PCBs WERE ANALYZED IN MONITORS FROM INSIDE THE HOT SPOT AND REFERENCE SITE

In summer 1993, cages containing zebra mussels, channel catfish, and SPMDs were placed directly on the bottom of the river in four locations. Two sites were in the hot spot, one was at the upriver edge of the hot spot, and one site further upriver of the hot spot at a relatively uncontaminated area. PCBs in sediment samples from these sites ranged from 0.4 ppm at the upriver site to 300 ppm at site 1 in the hot spot (total PCBs were based on Aroclor mixture 1242, 1248, 1254, and 1260 1:1:1:1; concentrations were based on wet weight). PCBs in site 2, also in the hot spot, were at 65 ppm; and in site 3, at the upriver edge of the hot spot, were about 1 ppm.

Replicate subsamples of zebra mussels were collected at 4, 10, 18, and 28 days. Samples were composites (soft tissue only) of mussels with shell lengths of 15–25 mm. Catfish and

SPMDs were sampled only on day 28. Samples were processed for analysis by standard methods, and analyzed by GC/MS NCI for total PCBs and 24 PCB congeners, including 3,3',4,4'-tetrachlorinated biphenyl (PCB#077) and 3,3',4,4',5-penta chlorinated biphenyl (PCB#126).

ACCUMULATION OF PCBs CORRELATE WITH EXPOSURE DURATION

Although contamination of the river sediment is reportedly due primarily to historical discharges, exposed mussels accumulated extremely high concentrations of PCBs. Mussels at sites 1 and 2 accumulated more than 6 and 3 ppm PCBs, respectively, after only 4 days of exposure (Fig 1). Mussels continued to accumulate PCBs throughout the exposure period, reaching nearly 18 ppm in the most contaminated area at termination of the study. Surprisingly, even mussels introduced to the upriver reference site accumulated significant levels of PCBs after 4 days, and concentrations continued to increase with duration of exposure. A positive correlation was strong between duration of exposure and concentration of PCBs bioaccumulated by mussels in all sites. These findings suggest that zebra mussels are suitable for monitoring an extremely wide range of contaminated conditions. In addition to other advantages that resident zebra mussels possess (sedentary, large filtering capacity) they would be appropriate for identification of point source discharge of environmental contaminants.

ZEBRA MUSSELS BIOACCUMULATE PCBs TO LEVELS COMPARABLE TO OTHER MONITORS

In most instances, zebra mussels, channel catfish, and SPMDs accumulated comparable concentrations of total PCBs. The

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correlation was strong between sediment PCB concentration and concentration accumulated or sequestered by each monitor (Fig 2). However, PCB concentrations accumulated at highly contaminated sites differed. Concentrations of PCBs in catfish from the most contaminated site were no higher than those accumulated by fish in an area with significantly less contamination (site 2). Pre- and postexposure wet weight and lipid content did not differ. However, mortality of catfish in sites 1 and 2 was high (44% and 33%). Mortality of catfish in sites 3 and 4 was only 11% and 6% mortality. The high incidence of mortality at site 1 could be a result of the high PCBs in the sediment. Furthermore, contamination may have been high enough to expose caged fish to toxic (chronic) conditions, possibly interfering with physiology or behavior. This would account for high catfish mortality and lower than expected concentrations of accumulated PCBs. On the basis of these results, catfish do not seem to be suitable for testing at this level of contamination for this duration. On the other hand, zebra mussels and SPMDs continued to accumulate PCBs, indicating they may be good monitors when contaminant concentrations in the sediment are high and the duration of exposure is lengthy.

DIFFERENCES ARISE AT THE CONGENER LEVEL

Analysis of selected congeners showed that channel catfish and zebra mussels reflected the congener pattern in the sediment. This was true across homolog classes that ranged from trichlorinated biphenyls to octachlorinated biphenyls. However, concentrations of PCB#077 were as much as 5 times higher in zebra mussels than in catfish. Concentrations of this congener were about 9 times higher in SPMD than in catfish. Lower levels of this planar PCB in catfish may be due to the presence of detoxification enzymes in fish. If so, this could lead to false negative concerns for this potentially toxic compound.

Residue analysis revealed that SPMDs did not reflect sediment concentrations as well as the other biomonitors. As expected, SPMDs were more enriched with the lower chlorinated PCBs (tri- and tetrachlorinated biphenyls) than with the more highly chlorinated PCBs. SPMDs accumulate principally from the water column, and lower chlorinated PCBs are more soluble than higher chlorinated PCBs. Differences in routes of exposure between biomonitors like catfish and mussels (diet, absorption through gills or across membrane) and SPMDs (partitioning from water column) would account for these differences in congener profile. However, had SPMDs been deployed for a longer period, they would have sequestered higher levels of the more highly chlorinated PCBs.

EACH MONITOR HAS ADVANTAGES AND DISADVANTAGES

The use of zebra mussels and SPMDs as monitors of environmental contaminants has become widespread. Concerns that results from these potentially useful monitors may not concur with results from more commonly used fish species may have restricted their applications in the past. These findings primarily address comparability concerns. As

judged from total PCBs, results from all three show good agreement. At the congener level, zebra mussels show strong comparability with channel catfish. However, each monitor has problems that the investigator must consider. If investigators are considering these organisms or tools for monitoring, they may want to be aware of some additional findings. The handling of catfish and their transport to sites posed problems and incidental mortality. Processing zebra mussels required much labor (i.e., compositing and removing soft tissue) and more frequent GC/MS source cleaning. SPMDs, although simple to assemble, transport, deploy, and process, required regular site visits to remove silt and algae.

Difficulties aside, zebra mussels and SPMDs are likely to become common biomonitor species or tools for environmental contaminants.

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PCBs accumulated by mussels after 4, 10, 18 and 28 days of exposure

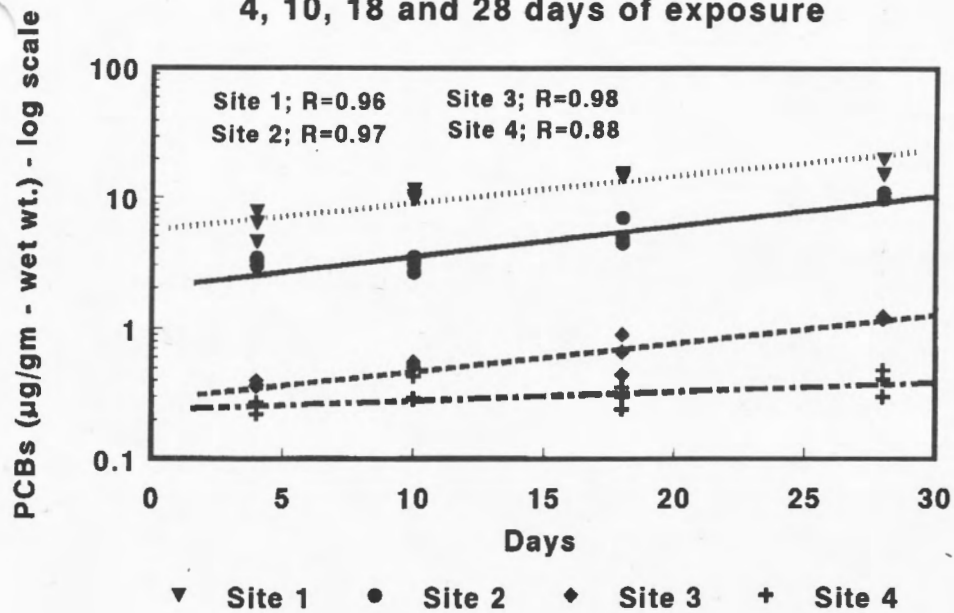


Fig. 1. PCBs accumulated by zebra mussels (*Dreissena polymorpha*).

Concentration of PCBs accumulated by monitors after 28 days plotted against PCBs in sediment

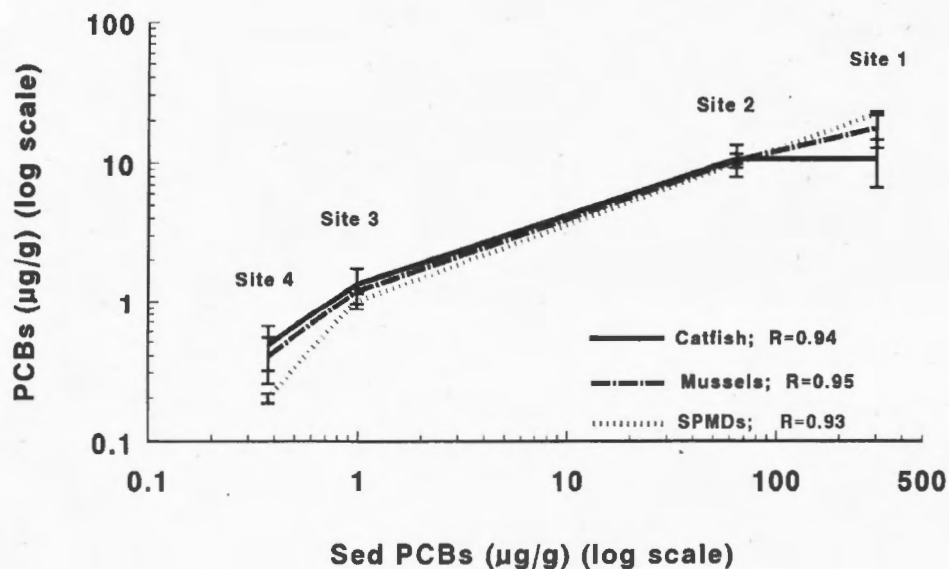


Fig. 2. PCBs accumulated by all monitors.