Article 83

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Trace Metal Bio-Accumulation in the Aquatic Community of Stormwater Ponds

Stormwater managers have always been concerned that pollutants trapped in stormwater pond sediments could re-enter the aquatic food web. Prior research has demonstrated that trace metals and hydrocarbons are taken up and incorporated into the tissues of wetland plants. Is there also a risk that pond macro-invertebrates can take up metals trapped in pond sediments? Can they ultimately move upward in the food web into the fish and wading birds that feed on them? If so, is the metal bio-accumulation great enough to warrant concern about toxicity? Is it safe to eat fish that are caught from stormwater ponds? Does it make sense to design stormwater ponds to attract wildlife? Two recent studies begin to shed some light on these troubling questions.

Karouna-Reiner conducted comprehensive macro-invertebrate surveys at 18 stormwater ponds and wetlands in suburban Maryland over a one-year period. Most of the ponds were a half-acre to one-acre in size, and most were constructed within five years of the study. All had a permanent pool up to six feet deep; many also contained extensive emergent wetlands. The pond's contributing watersheds were dominated by either commercial, residential or industrial land uses. In addition, Karouna-Reiner selected two constructed ponds that did not receive urban runoff to serve as reference controls. During the course of her year-long study, Karouna-Reiner monitored trends in the pond macro-invertebrate community in the littoral zone and sampled metals in pond water, sediments and macro-invertebrate tissue. In addition, she designed a bioassay system to test for toxicity in a sensitive amphipod, *Hyallela azteca*, exposed to typical stormwater pond sediments over a 10-day period.

In general, the sediment macro-invertebrate community in stormwater ponds was dominated by snails, midges, damselflies, skimmers, backswimmers and various diving and crawling beetles. Although diversity in individual stormwater ponds was quite variable, the pond macro invertebrate community was only slightly degraded in comparison to the reference ponds, according to two biological metrics, and was not different according to two others (abundance and percent chironomids - see Table 1). Statistical analysis also showed that the type of land use has no influence on the diversity of the pond community. Much of the variability in diversity was attributed to differences in wetland coverage and hydrology among the ponds. The stormwater pond macro-invertebrate community was more diverse than those sampled by Galli (1988) and Yousef *et al.* (both of whom concentrated more on the composition of deeper water sediments).

Karouna-Reiner detected copper, lead and zinc, and occasionally cadmium in the tissues of snails, damselflies, and a composite sample of other macro-invertebrates collected from the stormwater ponds (Table 2). While clear bio-accumulation was noted for copper, zinc and cadmium, the metal levels found in sediments and macro-invertebrate were generally within, or reasonably close to those for other unpolluted pond and wetland systems. In addition, the bioassay work did not indicate any acute toxicity for the amphipod, *H. azteca*, that were exposed for 10 days.

Campbell (1995) investigated trace metal levels in sediment and fish tissue in seven stormwater ponds in located in Central Florida. He studied three fish species that had different feeding habits: the bottom-feeding redear sunfish (*Lepomis microlophus*), the predatory

Table 1: Comparison of Macro-Invertebrate Diversity in Stormwater and Reference Ponds (Karouna-Reiner, 1995)

Pond Diversity Metric Mean of ponds sampled	Stormwater Ponds N = 18	Reference Ponds N = 2
Taxa Richness	15.8	18.6
EPOT *	5.17	6.33
Abundance	247.1	229.72
Percent chironomids	10 %	15.5 %

* taxa richness of Ephemeroptera, Plecopetera, Odonata and Trichoptera

Table 2: Trace Metal Levels in Macro Invertebrates and Fish in Stormwater Ponds (All values mg/kg dry weight unless otherwise indicated)

Organism	N	Cadmium	Copper	Lead	Zinc
Snails[1]	18	NA	44.4	1.56	73.14
Damselflies[1]	18	NA	23.55	3.25	101.13 *
Composite[1]	18	3.4	30.53	0.49	169.58 *
Redear Sunfish[2]	7, wet	1.64 *	6.37 *	15.78 *	42.42 *
Largemouth Bass[2]	7, wet	3.16 *	3.81	12.04	29.99 *
Bluegill Sunfish[2]	7, wet	0.006	2.08 *	0.70	36.61

Sources: [1.] Karouna-Renier 1996 [2.] Campbell 1995 (whole fish samples)

Note: An asterisk indicates that the stormwater sample was significantly higher than the control site at the 95% confidence interval.

largemouth bass (*Micopterus salmoides*), and the omnivorous bluegill sunfish (*Lepomis macrochirus*). The metal level in the tissue of 15 fish of each species were sampled from stormwater ponds, and compared to an equal number of fish caught at unpolluted control sites. As might be expected, Campbell found that the redear sunfish, which feeds off macro-invertebrates located in pond sediments, had the greatest accumulation of metals in its tissues (Table 2). The predaceous largemouth bass had moderate metal accumulation, while the omnivorous bluegill had lower metal levels. In most cases, however, metal levels in the three fish species sampled in stormwater ponds were significantly higher than control sites, often by a factor of five to ten. The degree of bio-accumulation was influenced, but not directly related to, the metal levels found in the bottom sediments.

The studies imply that trace metals in trapped pond sediments can and do move into the pond food web, probably starting with the macro-invertebrates that live and feed among pond sediments. Bottom-feeding fish that consume these macro-invertebrates appear to take up metals, which in turn may move further along the food web into the predatory fish that consume them. It was not clear, however, whether the metal levels were high enough to exert toxic effects. Preliminary evidence suggests that metal levels were *not* great enough to exert acute toxic effects in the aquatic community of stormwater ponds. Though it should be stressed that pond sediment metal levels in the study ponds were well below the mean levels observed in a national survey of stormwater ponds (see Table 3, and article 80).

Clearly, more research is needed to determine if greater metal uptake occurs in other stormwater pond food webs before an unequivocal conclusion can be reached. At the present time, it seems prudent to restrict human consumption of fish from stormwater ponds until a larger sample size has been tested. Research needs to be gathered on bioaccumulation in rough fish like carp that are vegetarian or scavengers. More research is also needed to examine if metals are bioaccumulating in wading birds, such as herons and egrets, that feed on all three trophic levels.

—TRS

References

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Yousef, Y., Lin, J. Sloat and K. Kaye. 1991. *Maintenance Guidelines for Accumulated Sediments in Relation/Detention Ponds Receiving Highway Runoff.* Univ. Central Florida, FL Dept of Transportation. 210 pp.

Table 3: Comparison of Trace Metal Levels in Stormwater and Sediments (All values mg/kg dry weight unless otherwise indicated)

Investigators	N	Cadmium	Copper	Lead	Zinc
Karouna-Renier	18	0.26	8.6	10.92	28.03
Campbell	7 (wet)	0.28	14.11	4.91	28.82
Schueler	36	5.24	18.0	111	97.8