Sediment Quality in Urban Wetlands

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Introduction

Wetlands provide many critical functions in urban ecosystems, including habitat for wetland-dependent fauna and enhancement of water quality. Interest in restoring or creating wetlands to enhance these functions is increasing due to the scale and extent of wetland loss and water quality problems associated with urbanization. One of the most pressing questions associated with urban wetland restoration is to what extent urban wetlands tend to concentrate contaminants, and if so, whether there is an associated risk to wildlife. The goal of this study was to better understand these potential risks, and the associated trade-offs with using wetlands to passively or actively treat urban runoff.

Study Objectives

- Quantify the sediment chemistry, toxicity and macroinvertebrate species richness of urban wetland sediments
- Determine the contaminants responsible for observed toxicity, as indicated by sediment chemistry and sediment toxicity identification evaluations (TIEs)

Methods

- Sediment toxicity, chemistry and benthic macroinvertebrate richness were characterized for 21 freshwater urban wetlands and 2 reference sites in southern California.
- Sediments were collected at a location nearest to the primary source of urban runoff within the wetlands in order to characterize the greatest potential effect.
- All samples were analyzed for trace metals and organics (PCBs, PAHs, chlorinated pesticides and pyrethroid pesticides). These measurements were assessed by comparing the values to freshwater Probable Effects Concentrations (PECs), or mean LC50 values for pyrethroid pesticides.
- Toxicity was assessed using the *Hyalella azteca* 10-day survival test. Most locations that exhibited toxicity were subsequently testing with preliminary sediment TIEs. The TIE treatments for this evaluation specifically targeted pyrethroid pesticides, based on available chemistry data of the samples tested.

FIGURE 1. Locations of the wetland sites sampled. County borders have been added for reference.

Figure 2. Two of the urban wetland sampling locations, Ballona Fresh Water Marsh (left), and UCI pond 11 (right).

Results

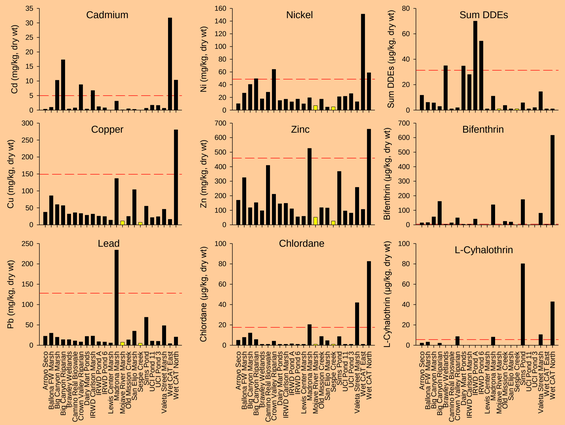

Figure 3. Sediment concentrations for select contaminants. The dashed line indicates the Probable Effects Concentration (metals, DDE, chlordane) (MacDonald et al. 2000), or the average sediment LC50 for *H. azteca* from Amweg et al., 2005 (bifenthrin, L-cyhalothrin). The reference sites are highlighted in yellow.

Sediment Contaminants

- In most wetlands, at least one constituent exceeded a freshwater sediment quality guideline.
- The metal and chlorinated pesticide constituents that exceeded a sediment quality guideline tended to vary among the sites.
- Pyrethroid pesticide contamination (bifenthrin, L-cyhalothrin) was prevalent at most sites, with concentrations exceeding the average sediment LC50 by as much as a factor of 137.

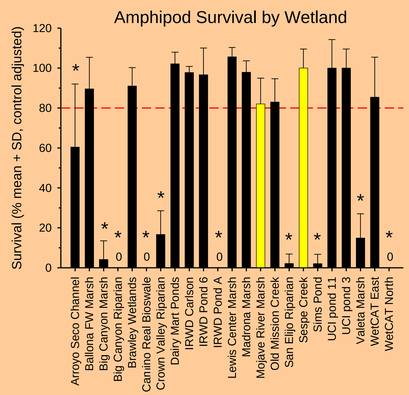

Figure 4. Survival of *H.* azteca exposed to wetland sediments. The reference sites are highlighted in yellow. Sites that are significantly different and had a survival rate <80% of the control value are considered to be toxic (indicated by *).

Sediment Toxicity

- Sediments from about half of the wetland sites were toxic to amphipod survival.
- Survival in the toxic sediments tended to be much lower (<20%) than the 80% toxicity threshold.

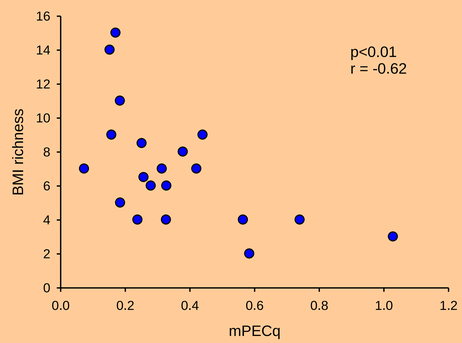

Figure 5. Benthic macroinvertebrate diversity vs. the mean Probable Effects Concentration quotient (an index of degree of sediment contamination).

BMI Diversity

- Benthic macroinvertebrate diversity was found to negatively correlate with the mean Probable Effects Concentration quotient.

Table 1. Summary of constituents exceeding sediment quality guideline thresholds, the toxicity tests with *H. azteca*, and the sediment TIEs. Partial = pyrethroids implicated in the toxicity, but other contaminants may have also been responsible.

Wetland site	Sediment Quality Guideline Exceedances				Toxicity	Indication of pyrethroid toxicity
	Metals	Chlorinated pesticides	PAHs	Pyrethroid pesticides		
Arroyo Seco Channel				Yes	Yes	Partial
Ballona Fresh Water Marsh				Yes		
Big Canyon Marsh	Yes			Yes	Yes	Yes
Big Canyon Riparian	Yes			Yes	Yes	Yes
Brawley Wetlands		Yes				
Camino Real Bioswale				Yes	Yes	Yes
Crown Valley Parkway Riparian	Yes			Yes	Yes	Partial
Dairy Mart Ponds		Yes				
IRWD Carlson Marsh	Yes					
IRWD Pond 6		Yes				
IRWD Pond A		Yes		Yes	Yes	
Lewis Center Marsh						
Madrona Marsh	Yes	Yes		Yes		
Old Mission Creek				Yes		
San Elijo Marsh				Yes	Yes	Yes
Sims Pond			Yes	Yes	Yes	Yes
UCI Pond 11						
UCI Pond 3						
Valeta Street Marsh		Yes		Yes	Yes	Yes
Wet CAT East	Yes					
Wet CAT North	Yes	Yes		Yes	Yes	Yes
Mojave River Marsh						
Sespe Creek						

Contaminants Responsible for Toxicity

- Most sites had some type of sediment quality guideline exceedance or had toxic sediments, or both.
- TIE results indicated pyrethroid pesticides may have been responsible for much of the toxicity.

Summary

- Most sites (18 out of 21 urban wetlands) posed a risk of sediment chemistry or toxicity, or both.
  - Data probably represent conservative estimates, since samples were collected near freshwater input sources.
- Pyrethroid pesticides may have been responsible for much of the toxicity.
  - Metals, PAHs, DDE, and chlordane were elevated and could have caused toxicity, but at fewer sites.
- Benthic macroinvertebrate species richness was negatively correlated with sediment contamination, suggesting that toxicity may have affected organisms at the base of the food web in some of these wetlands.

Management Recommendations

- Reduce potential for exposure and toxicity to contaminants by incorporating low impact development (LID), source control and best management practice (BMP) implementations to capture contaminants upstream of wetlands.
- Use a pretreatment system (e.g., forebay) to allow sediment and associated contaminants to settle out prior to entering the wetland.
- Use consistent monitoring protocols, including analysis of sediment chemistry and toxicity, in order to be able to compare among sites and track changes over time.

References

Amweg, E.L., D.P. Weston and N.M. Ureda, 2005. Use and toxicity of pyrethroid pesticides in the Central Valley, California, USA. *Environmental Toxicology and Chemistry* 24:966-972.

Brown, J.S., M. Sutula, C. Stransky and J. Rudolph, 2008. Sediment contaminant chemistry and toxicity of freshwater urban wetlands. pp. 271-287 in: S. Weisberg and K. Miller (eds.), Southern California Coastal Water Research Project Annual Report 2008. Costa Mesa, CA.

MacDonald, D.D., C.G. Ingersoll and T.A. Berger, 2000. Development and evaluation of consensus-based sediment quality guidelines for freshwater systems. *Archives of Environmental Contamination and Toxicology* 39:20-31