Current Issues in Water and Sediment Quality Analysis

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Outline

• Study Development
• Toxicity Testing Overview
• Freshwater Water Column
  • Testing – *S. capricornutum, C. dubia, and P. promelas*
  • Monitoring
• Freshwater Sediment
  • Testing – *H. azteca*
  • Monitoring
• Pyrethroid Pesticides
• References
Study Development

- Preliminary data review - data/literature search
- Stakeholder contact/discussion/coordination
- Inter/intra agency/program contact/coordination
- Review coordination potential
- Review regional priorities
Toxicity Strategy

Toxicity Test

TIE

Additional Monitoring

Implementation Plan

Screen for toxicity

ID toxicant

Determine duration, frequency, magnitude, and source ID

Eliminate toxicity
Toxicity Testing Overview

What is a Toxicity Test?

• Sample collection (water or sediment)
• Organism exposure
• Biological response recorded
• Endpoints evaluated
• Sample determined toxic/non-toxic
Toxicity Testing

• Strengths
  – Aggregates toxicity
  – Unknown toxicants addressed
  – Bioavailability measured

• Limitations
  – Incomplete toxicity
  – Toxicity Identification Evaluations (TIEs) required for toxicant identification
EPA Freshwater 3-species Testing
*Selenastrum capricornutum*

Sensitive to herbicides (e.g., glyphosate and 2,4-D) and metals (e.g., Zn and Cu)
**Ceriodaphnia dubia**

- Lives about a month and can produce 15 broods
- *(A)*sexual reproduction around 3 days
- Sensitive to insecticides (e.g., diazinon and permethrin), some metals (e.g., Cu and Zn) and surfactants (e.g., R-11 and nonyphelnol)
Pimephales promelas

- Tested at larval stage
- Sensitive to ammonia and surfactants
Water Column Monitoring

• Regional Board (1988-1990)
  – Sacramento and San Joaquin Rivers

• Sacramento River Watershed Program (SRWP) (1998-present)
  – American River at Discovery Park Monitoring

• Surface Water Ambient Monitoring Program (SWAMP) (2006)
  – Upper American River Monitoring
Regional Water Board Monitoring

• American River at Watt Ave and Discovery Park
• *Selenastrum* impairment (40%)
• *Ceriodaphnia* impairment (56%)
• Fathead minnow impairment (17%)
• Lower American River on CWA 303(d) list
SRWP Monitoring

- American River at Discovery Park
- Consistently meets water quality goals and objectives for drinking water.
- 7% of samples had elevated levels of coliform bacteria
- Fish tissue data generally supports the need for consumption advisories
- Toxicity of Unknown Cause
SWAMP Monitoring

• May, September, and November 2006
• American River and its tributaries
• Watershed-based assessment with targeted sampling
• 96-hr Ceriodaphnia and fathead minnow testing
SWAMP Sampling Sites

- Bunch Creek
- Willow Creek
- Alder Creek
- Webber Creek
- White Rock Creek
- North Fork American River
- Middle Fork American River
- South Fork American River
- Hangtown Creek

Available Sediment Quality Data
Hyalella azteca

- Freshwater amphipod
- Epibenthic detritivore – burrows in upper 2 cm sediments
- Sensitive to chemical contaminants (including pyrethroid pesticides)
Sediment Toxicity Identification Evaluations

- Temperature reduction
- Piperonyl butoxide (PBO) addition
- Esterase enzyme addition
Other Sediment TIE Manipulations

• Metal-chelating resin treatment
• Zeolite addition
• Charcoal addition
• Ambersorb® addition
Chemical Analysis of Pyrethroids

- Concentrations don’t match toxicity test
- Pyrethroids often applied with PBO
- Method development/verification
Sediment Quality Assessments and Pyrethroids

Sediment toxicity testing identified pyrethroid pesticide issue in CA waterways

- agricultural waterways – 2002
- urban waterways – 2004

Growing use of pyrethrin and pyrethroid insecticides due to phasing out of organophosphorus pesticides (e.g., diazinon)
Pyrethrins vs. Pyrethroids

Pyrethrins

Natural derivative of chrysanthemums

Pyrethroids

Synthetic version of pyrethrins – more toxic and persistent

eamples: bifenthrin, cyfluthrin, cypermethrin, deltamethrin, esfenvalerate, lambda-cyhalothrin, permethrin
Pyrethroid Pesticides: Physical and Chemical Properties

- Uses: agriculture, mosquito control, landscape maintenance, professional pest control, homeowners (gardening, pets, sprays)
- Strongly hydrophobic and have a strong tendency to adsorb to particulate matter (high Koc) or bed sediments
- Half life in soils ranges from 11.5 - 425 days for various pyrethroids
Concentrations of Pyrethroid Pesticides in Urban Watershed Sediments and Toxicological Significance

Pyrethroid sediment concentrations in CA urban areas:

Sacramento area creeks: not detected – 437 ng/g

Eastern SF Bay creeks: not detected – 57 ng/g

Pyrethroid toxicological thresholds:

*Hyalella* LC$_{50}$’s: 3.8 – 15.4 ng/g

(permethrin = 108 ng/g)

• Typically used with synergist (PBO) to increase toxicity

• Multiple pyrethroids typically occur in sediment samples where toxicity is observed
References


Water Boards SWAMP Program (QAMP, SOPs)
http://www.waterboards.ca.gov/swamp/index.html
Tomorrow Afternoon in the Stormwater Section

Robert Holmes: Challenges in Stormwater Management-Sediment Toxicity/Pyrethroid Pesticides-Ambient Monitoring Data
Questions?
Water Sample Collection Considerations

• Holding times (species availability, set up, weekends/holidays, shipping)
• Temperature (sample transport and storage)
• Sample volume (multiple species, method type, TIEs, breakage)
• Sample containers
**S. capricornutum** Method

- 4 days, static non-renewal
- 4 replicates, 50 or 100ml
- Filtered sample
- Inoculated with nutrients and $10^6$ algal cells per ml
- Continuous illumination under $400\pm 40$ft-c
- Cell growth measured at test termination
- TAC: mean cell density of control $\geq 1\times10^6$ cells/ml and CV $<20\%$
**C. dubia Method**

**Acute**
- 4 replicates, 15ml
- 5 cerio, <24hr old
- Fed before test initiation and 2hr before renewal
- 25 ± 1°C, ambient light 16hr:8hr dark
- Mortality noted daily and at termination
- TAC: ≥90% survival in the controls

**Chronic**
- 10 replicates, 15ml
- 1 cerio, < 24hr old
- Fed & sample renewed daily
- 25 ± 1°C, ambient light 16hr:8hr dark
- Neonates counted & mortality noted daily & at termination
- TAC: ≥80% survival, 60% of surviving females have ≥3 broods and ave 15 neonates/surviving female
**P. promelas** Method

**Acute**
- 4 reps, 200ml
- 10 fish/rep, 1-14 days old, ≤ 24hr age range
- Fed before test initiation and 2hr before renewal
- 25 ± 1°C, ambient light 16hr:8hr dark
- Mortality noted daily and at termination
- TAC: ≥ 90% survival in controls

**Chronic**
- > 3 reps, 70ml
- 10 fish, <48hr old, ≤ 24hr age range
- Fed & sample renewed daily
- 25 ± 1°C, ambient light 16hr:8hr dark
- Mortality noted daily and at termination, dried & weighed after termination
- TAC: ≥ 80% survival in controls and mean control weight > 0.25mg/fish
**H. azteca** Sediment Method

- 10-d, whole sediment, renew overlying water every 12 hr
- 8 reps, 175ml overlying water, 100ml of sediment
- 10 hyalella per replicate, 7-14 days old
- Fed daily 1ml YCT per chamber
- 23 ± 1°C and 1080-10,800ft-c 16 hr:8 hr dark
- Aeration: None unless DO below 2.5 mg/L
- Mortality and growth noted at test termination
- TAC: ≥ 80% survival in the controls and measurable growth in control sediment organisms