Sediment Quality within the Impounded Reaches of Cape Fear River Locks and Dams

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Abstract

In November 2006, we evaluated contamination and toxicity of sediments and pore waters from impoundments created by three locks and dams on the Cape Fear River (North Carolina, USA). Whole-sediment concentrations of elemental contaminants and polycyclic aromatic hydrocarbons were typically less than those associated with adverse effects to sensitive aquatic organisms. Whole sediments had no significant effect on survival or growth in 28-d toxicity tests with *Hyallela azteca* or in 10-d tests with *Chironomus dilutus*. Copper, lead, and zinc in sediment elutriates and pore waters frequently exceeded water quality standards and indicated that re-suspension of Cape Fear River sediments could temporarily impair surface water quality. In 2-d sediment elutriate tests with *Ceriodaphnia dubia*, statistically-significant reductions in survival occurred in four of nine exposures. Pairwise correlation analyses indicated several whole-sediment and elutriate water chemistry variables were significantly and negatively correlated with *C. dubia* survival. Of the correlated variables, elutriate manganese had among the strongest correlation ($r^2 = 0.79$, $p = 0.0006$) and the most plausible biological association with reduced *C. dubia* survival because some elutriate manganese concentrations exceeded reported lethal concentrations for *C. dubia*. We conclude that contamination of surface sediments behind Cape Fear River locks and dams is unlikely to be a concern unless the sediments are disturbed. Mobilization of sediments may result in short-term water column exposures of aquatic organisms based on the elutriate toxicity test and chemistry results. Sediment re-suspension and contaminant release in the elutriate tests may be near a worst case simulation of actual conditions following sediment disturbing activities. When specific sediment disturbing activities are proposed for the river (e.g., dredging, dam alterations, etc.), data on modeled or measured sediment re-suspension and chemical concentrations in near-sediment surface waters should be considered with the chemistry and toxicity testing results reported here in a sediment risk assessment and management plan.

Introduction

Figure 1. Lock and Dam #3, Cape Fear River, North Carolina *USFWS Photo*

- US Fish and Wildlife Service and US Geological Survey performed a sediment assessment at three Cape Fear River (North Carolina) locks and dams
- Locks and dams were built between 1915 and 1935 and impound 75 river miles. No longer used for commercial navigation, the Corps is interested in "decommissioning" the dams and is working with stakeholders to study options
- Objectives: 1) compare chemical quality of sediments behind the dams to toxicological screening values; and, 2) assess toxicity of whole sediments and sediment elutriates
- This poster is a project overview, a recent final report [1] is available:

http://www.fws.gov/nc-es/ecotox/reports.html

Methods

- Database and file reviews identified pollutants and areas of concern
- Twelve composite surface sediment samples collected (Figure 2)
- Bulk sediment analyses of elemental contaminants (ICP/MS) and polycyclic aromatic hydrocarbons (CG/MS)
- Pore water and elutriate analyses of elemental contaminants and major ions
- Toxicity tests on nine samples following ASTM and EPA methods:
  - Whole-sediment 28-d *Hyallela azteca* growth and survival
  - Whole-sediment 10-d *Chironomus dilutus* growth and survival
  - Elutriate 2-d *Ceriodaphnia dubia* survival

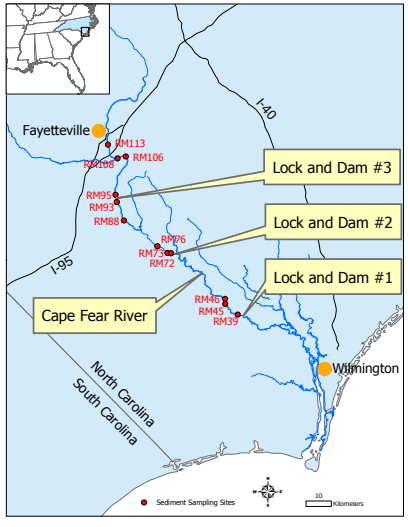

Figure 2. Lower Cape Fear River with sediment collection sites in the vicinity of three Corps of Engineers locks and dams

Results

- Metals in sediment less than threshold effects concentrations (TECs) of McDonald et al. 2000 [2] and considered toxicologically insignificant
- Sediment PAHs exceeded TECs at two sites (river mile 88 and 113). No samples exceeded probable effects concentrations
- No effect on survival or growth in tests with *H. azteca* or *C. dilutus* (Table 1)
- Reduced survival in four of nine *C. dubia* elutriate exposures (Table 1)
- Several whole-sediment and elutriate water chemistry variables were correlated with *C. dubia* survival (Table 2). Elutriate manganese had among the strongest correlation and most plausible biological association with reduced *C. dubia* survival (Figure 3) because some elutriate manganese levels exceeded a reported *C. dubia* LC50 of 14,500 µg/L at our hardness [3]
- Copper (max = 48.5 µg/L), lead (max = 366 µg/L) and zinc (max = 140 µg/L) in most sediment elutriates and pore water exceeded water quality standards

Table 1. Survival (%) and growth (mm) in 28-d *H. azteca* and 10-d *C. dilutus* whole-sediment exposures, and 2-d *C. dubia* elutriate exposures prepared from sediments from the Cape Fear River. Means with an asterisk are significantly different than the control (p <0.05).

River Mile	*H. azteca* Survival	*H. azteca* Growth	*C. dilutus* Survival	*C. dilutus* Growth	*C. dubia* Survival
113	98	4.25	93	0.99	20 *
108	100	4.37	75	0.74	0 *
106	93	4.04	85	1.03	70
93	90	4.12	88	1.08	80
88	98	4.10	88	1.03	80
76	98	4.34	98	0.86	0 *
72	100	4.03	95	0.93	80
45	98	3.96	93	0.93	40 *
39	95	4.32	95	1.04	80
Control	98	4.32	65	0.51	80

Table 2. Pearson's correlations for 2-d *C. dubia* survival in sediment elutriates versus elutriate composition. Thresholds based on LC50s for *Ceriodaphnia*, multiplied by 0.5 to estimate a level near or below the lethality threshold

Variable	Correlation to *C. dubia* survival R	Correlation to *C. dubia* survival *p*	Threshold	Samples exceeding threshold (%)
Hardness	-0.94	<0.0001		
Conductivity	-0.85	0.0021		
Manganese	-0.89	0.0006	7200 µg/L	56
Selenium	-0.88	0.0008	220 µg/L	0
Arsenic	-0.59	0.0738	760 µg/L	0
Ammonia	-0.74	0.0135	26 mg/L	0
Alkalinity	-0.77	0.0086		

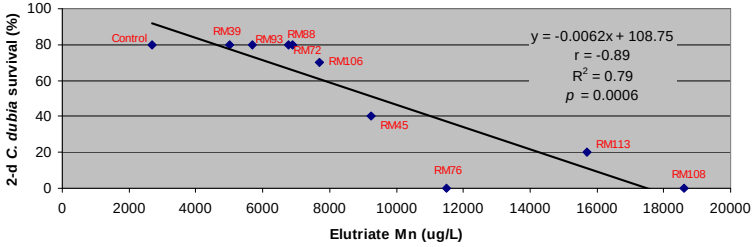

Figure 3. Relationship between elutriate manganese concentrations and *C. dubia* survival in 2-d elutriate exposures prepared from Cape Fear River sediments. Labels are River Mile (RM)

Conclusions

- Whole-sediment concentrations of metals and PAHs were less than levels of concern
- Whole sediments were not toxic to sensitive bottom-dwelling organisms
- Metals in sediment elutriates and pore water exceeded water quality standards
- Sediment re-suspension could temporarily affect water quality
- Half the elutriates were toxic to *C. dubia*, and toxicity was correlated with manganese
- Data can be used as part of sediment management plans for dredging or dam removal

References

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[2] MacDonald DD, CG Ingersoll and TA Berger. 2000. Development and evaluation of consensus-based sediment quality guidelines for freshwater ecosystems. *Arch Environ Contam Toxicol* 39: 20-31.

[3] Lasier PJ, PV Winger and KJ Bogenrieder. 2000. Toxicity of manganese to *Ceriodaphnia dubia* and *Hyalella azteca*. *Arch Environ Contam Toxicol* 38: 298–304.