

ACUTE TOXICITY IN AN URBAN CREEK RECEIVING RUNOFF FROM AN INDUSTRIAL FIRE

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Abstract. In July 2010, a firm producing janitorial chemicals in Athens, GA caught fire and was destroyed, releasing chemical-laden runoff from firefighting efforts into the east fork of Trail Creek, an urban creek that ultimately drains into the N. Oconee River. Water and sediment samples collected from Trail Creek over the next four months were monitored for acute toxicity to the microcrustacean *Ceriodaphnia dubia*, following US EPA protocols. Tests were also conducted to evaluate the effectiveness of activated carbon and sodium bisulfite to remove toxicity from Trail Creek water. Trail Creek water collected within two weeks of the incident was acutely toxic to *C. dubia* at dilutions ranging from 5-100%. Dilution to 1% creek water and treatment with activated carbon removed toxicity from the creek water samples, while addition of sodium sulfite was only moderately effective at toxicity abatement. Acute toxicity was mostly absent in creek water samples collected 8 weeks following the incident, with only one site showing low-level toxicity. However, significant toxicity remained in sediments collected four months after the fire. Results suggest that remediation treatments applied to Trail Creek (activated carbon filtration, air sparging) combined with natural degradation processes and dilution of the toxic chemicals by upstream water have been effective in removal of acute toxicity from the water column, but Trail Creek sediments continue to be a reservoir for future toxicity. Monthly monitoring of sediment toxicity is recommended to continue to evaluate Trail Creek's recovery.

INTRODUCTION

On July 27, 2010, J & J Chemical Company, a firm producing janitorial chemicals in Athens, GA, caught fire and was destroyed. Approximately 740,000 gallons of water were poured onto the blaze, and the chemical-laden runoff flowed into the east fork of Trail Creek. Following the incident, significant quantities of toxic chemicals from the manufacturing site were measured in Trail Creek, including dichlorobenzene, formaldehyde, glutaraldehyde, naphthalene and toluene, along with deodorizers and a blue dye that colored the creek for several weeks and was still detected in sediment samples four months after the fire.

Trail Creek is a first-order urban stream that flows 9.08 km from its origin to its confluence with the N. Oconee River, passing through multiple urban neighborhoods and two city parks before draining into the N. Oconee River. The N. Oconee River provides source water for drinking water purification for several local communities, including Athens, GA. Fortunately the confluence of Trail Creek and the N. Oconee River is downstream of the inlet for drinking water treatment in Athens, GA and subsequent drinking water treatment plants are more than 64 km downstream. Although water collected from the N. Oconee River had no detectable chemical contamination by one week following the spill, the GA Dept of Natural Resources (GADNR) reported measurable quantities of 1,4-dichlorobenzene, acetone and formaldehyde at multiple stations along Trail Creek one week after the fire. Trace quantities of these and several other volatile and semivolatile chemicals were still detected in Trail Creek five weeks after the fire. By one day after the fire, over 15,000 fish were reported killed in Trail Creek below the site of the industrial fire (O'Rourke, 2010). Significant damage to aquatic invertebrate populations in Trail Creek was also documented by the Upper Oconee Watershed Network (UOWN) during their quarterly monitoring conducted in August and November 2010 (Emanuel, 2011).

This study was conducted to evaluate the toxicity of water and sediments collected from Trail Creek over a four month period after the incident and to test the efficacy of several bench-scale treatments in reducing toxicity from Trail Creek water.

METHODS

Sampling: Water was collected from Trail Creek on three sampling dates at multiple locations down-gradient from the industrial site (Fig. 1). On 8/2/2010 water was only collected from Dudley Park (GPS coordinates: -83° 21.928, 33° 57.2752) and from the Oconee River approximately 200 meters downstream from its confluence with Trail Creek. On 8/9/2010 water was collected from Athena Drive (-83° 19.9009, 33° 58.6395). On 9/21/2010 water was collected from four sites: two sites on Athena Dr. (-83° 19.9009, 33° 58.6395, upstream and downstream of the air sparger), Peter St. (-83° 21.3249, 33° 57.8635) and

Dudley Park (-83° 21.928, 33° 57.2752) (Fig. 1). Water samples were returned to the lab in sealed plastic containers. Upon arrival in the lab, samples were transferred immediately to pre-cleaned glass containers for storage at 4°C prior to testing. Testing commenced within 1 to 48 h after collection. Sediments were collected with a petite ponar sampler on 11/29/2010 from Trail Creek at two sites down gradient from the site: Peter St., Olympic Drive (-83° 19.6704, 33° 58.6489) and from a wetland just below the J&J site (Olympic Upstream, -83° 19.5445, 33° 58.712). Water quality (pH, conductivity, and dissolved oxygen) was measured at each site prior to sampling.

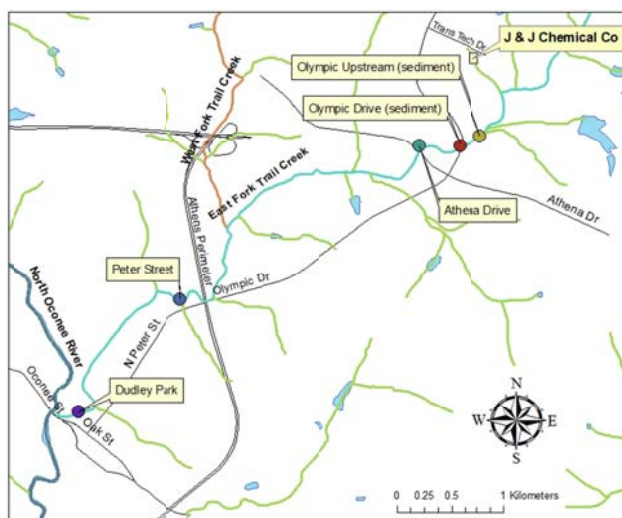


Figure 1. Sampling sites on Trail Creek, located in Athens, GA.

Acute toxicity tests: Water samples were tested for acute toxicity following EPA protocol for whole effluent toxicity (WET) (US EPA 2002). Briefly <24 hour old neonates of *Ceriodaphnia dubia* were exposed to control water (synthetically made moderately hard water, MHW) and multiple (5-100%) dilutions of Trail Creek water in moderately hard water for 48 hours. Mortality was recorded at 24 and 48 h and the median lethal concentration (LC50) was calculated for each sample with the Trimmed Spearman Karber method (US EPA 2002). Sediments were tested for acute toxicity using the elutriate test method. Moderately hard water was added to sediments in solvent rinsed glass jars at a 4:1 ratio (v/w) (Ankley et al, 1991; Nebeker et al., 1984). Sediment:water slurries were mixed for 12 h on a platform rocker, allowed to settle and the water layer was filtered (Millipore APFC, 1.2 µm pore size). The filtrate (elutriate) was diluted with MHW (25, 50 and 100% elutriate) for acute toxicity testing with *C. dubia* as previously described.

Remediation tests: To test for potential remediation strategies water samples collected from Trail Creek on 8/9/2010 were treated with either activated carbon or so-

dium bisulfite prior to toxicity testing. For the activated carbon treatment 100 g of granular activated carbon (size range = 2-3.4 mm) was added to 1 liter of Trail Creek water, stirred for 12 h, filtered over glass wool and the filtrate diluted to 1, 5, 10, 25% with MHW. Acute toxicity tests were conducted on treated Trail Creek water (1-25% dilutions + undiluted 100%) as previously described. In a separate experiment sodium bisulfite (Acros Organics, 99.7% purity) was added to Trail Creek water (final concentration =100 mg/L) and stirred until completely dissolved. Toxicity tests were conducted on dilutions and 100% sodium bisulfite-treated water as described for the carbon treatment. Both testing schemes employed an additional control (MHW control with added remediation agent at the highest (100%) concentration) to test for potential toxic effects of each remediation agent. Toxicity tests were also conducted on untreated Trail Creek water in parallel to these tests with potential remediation agents to provide a baseline for evaluating toxicity reduction.

RESULTS AND DISCUSSION

Six days following the fire, toxicity was 100% in water samples collected from Trail Creek at Dudley Park, the site farthest from the J & J chemical plant. Mortality of *C. dubia* was 100% in all dilutions (25-100%) within 24 hours of exposure (Table 1). Because there were no concentrations with surviving organisms, the median lethal toxicity value (LC50) could not be calculated. Water collected from the North Oconee River just below the confluence with Trail Creek on the same day showed no toxicity, due to the tremendous dilution of the Trail Creek waters by the Oconee River.

By 13 days following the fire, significant toxicity was still present in Trail Creek water sampled from Athena Dr., a site close to the J & J site (Table 1). The LC50 of this sample was 2.6% (95% confidence intervals = 2.13% - 3.19%), indicating that 50% of exposed organisms died in Trail Creek water diluted to 2.6 %. However, survival of *C. dubia* was 100% when this sample was diluted to 1% with control water. Additional aliquots of this water sample were used to test two potential remediation methods. Treatment of Trail Creek water with 10% (w/v) activated carbon completely removed toxicity from the water at all dilutions, including 100% Trail Creek water. This suggests that the toxic substances in the Trail Creek water were likely bound to the carbon, and removed from the filtered extract. Addition of sodium bisulfite to Trail Creek water was only marginally effective, eliminating toxicity only when the Trail Creek water was diluted to 5% with control water having a final concentration of 5 mg/L sodium bisulfite. Tests indicated that sodium bisulfite was highly toxic to *C. dubia* when added to control water at the highest test concentration (100 mg/L), with 60% mortality at that concentration. Because of this con-

founding toxicity and the significant dilution needed for toxicity removal, sodium bisulfite is not recommended as a toxicity abatement strategy. Based on these results *in-situ* treatment with activated carbon commenced on August 12, 2010, with carbon filtration units placed in Trail Creek at two sites downstream of the J&J site. Carbon treatment continued for nearly three weeks, although its effectiveness was likely impacted by high stream flows (Emanuel, 2011). Once carbon treatment was discontinued on Sept. 7, 2010, air sparging units were installed to remove residual volatile and semivolatile compounds from the water column. Sparging continued for three more weeks (Emanuel, 2011).

Trail Creek was resampled at four sites eight weeks after the fire. This sampling occurred following treatment with activated carbon and during the air sparging treatment, and included locations above and below the air spargers located at the Athena Drive site and two sites downstream (Fig 1). No toxicity was detected in water collected from three of the four sites sampled, including sites above and below the air spargers. Only slight mortality (13.3%) was detected in undiluted (100%) Trail Creek water collected from the Peter St. site (Table 1). This level of mortality is only slightly greater than control mortality limits of 10% and may not be significantly different from control mortality. Unfortunately confidence intervals could not be calculated to determine statistical significance. Because of an apparent lack of a toxicity gradient (e.g., decreased toxicity at sites farther from the J&J site), toxicity at this site may indicate localized toxicity due to differences in site conditions (e.g., composition of the sediments, amount of sediment disturbance or other site specific attributes) causing residual pockets of contamination that remained untreated by the remediation efforts. Alternatively this toxicity may be unrelated to contamination from the fire at the J&J site. The Peter St. site is adjacent to a major highway and toxicity could be related to contaminants washed from the road bed or from another unknown source.

By November 2010 no acute or chronic toxicity was detected in water samples from Trail Creek; however, a 30-day sediment toxicity test conducted with an epibenthic amphipod, *Hyalella azteca*, identified significant toxicity at one site (pers. comm., J. L. Shelton). To confirm this result we conducted elutriate tests on sediments collected from the same sites approximately one month later. Elutriate tests are designed to mimic the disturbance of sediments by dredging or other activities and allow for toxicity assessment of overlying water following sediment resuspension (Nebeker et al., 1984). After extraction, settling and filtration, elutriate water from the Olympic Drive site was blue, much like the water samples taken from Trail Creek within a week of the incident. The blue color remained even when diluted to 25% with control water. Besides retaining the blue color, the elutriate from the

Olympic Dr. sediment was significantly toxic to *C. dubia*, with an LC50 of 33% (% dilution of elutriate with control water) and 100% toxicity at the 50% dilution (Table 1). These results suggest that sediments still retain toxic contaminants (including the blue dye) from the J&J fire and upon resuspension, sediments may continue to release toxic components into the water column.

Table 1. Summary of toxicity test results.

Site	Distance ¹	Date	Test	Toxicity	LC50
Dudley Park	5	8/2/10	Acute	Y	<25%
N. Oconee	6	8/2/10	Acute	N	ND ²
Athena Dr.	2	8/9/10	Acute	Y	2.6%
Athena Dr.	3	9/21/10	Acute	N	ND
Peter St.	4	9/21/10	Acute	N	ND
Dudley Park	5	9/21/10	Acute	N	ND
Olympic Dr.	1	12/11/10	Elutriate	Y	33%
Peter St.	4	12/11/10	Elutriate	N	ND

¹Rank distance from J&J Chemical Corp.; 1=closest, 5=farthest.

²ND = Toxicity not detected

CONCLUSIONS

Toxicity testing conducted on water from Trail Creek, an urban stream severely impacted by chemicals released during an industrial fire, has shown continuous improvement of water quality in Trail Creek. By three months following the incident, acute and chronic testing of water samples with the aquatic macroinvertebrate, *C. dubia*, showed no toxicity of waters collected throughout the stream reach between the J&J facility and the N. Oconee River. However, sediment toxicity testing with the elutriate method still showed residual acute toxicity at 4.5 months following the incident. These tests confirmed previous toxicity findings by another lab that found reduced survival of an infaunal organism in whole sediments from the same site. In both cases, sediment toxicity is likely caused by the presence of residual toxic chemicals in the sediment pore waters. Until these toxic chemicals are biodegraded by sediment microbes and/or additional dilution of porewater takes place, sediments will be a continuing source of toxicity to the infaunal invertebrate community at the Olympic Dr. site of Trail Creek. Further remediation by dredging is not advised, due to the acute toxicity attained in the elutriate test. Unless porewaters could be removed without sediment resuspension, natural attenuation may be the best remediation strategy for contaminated sediments in Trail Creek. This incident underscores the vulnerability of small urban streams to land activities within their watersheds and especially highlights the potential for firefighting activities at industrial sites to

cause significant and long-lasting toxicity in nearby streams.

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