WATER-QUALITY AND ECOLOGICAL ASSESSMENT OF ROTTENWOOD AND SOPE CREEKS, MARIETTA, GEORGIA, 2002

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REFERENCE: *Proceedings of the 2003 Georgia Water Resources Conference*, held April 23–24, 2003, at the University of Georgia. Kathryn J. Hatcher, editor, Institute of Ecology, The University of Georgia, Athens, Georgia.

Abstract. Discharge of volatile organic compounds from ground water into Rottenwood Creek near Marietta, Georgia, has been documented. In response to a need for information of the effects of these discharges on the aquatic biota of Rottenwood Creek, the U.S. Geological Survey in cooperation with U.S. Air Force Aeronautical Systems Center conducted an assessment of water quality and ecological health of the stream and compared it with a nearby stream, Sope Creek. Aquatic macroinvertebrate, habitat, and water-quality data were collected in Rottenwood and Sope Creeks to assess water-quality conditions and ecosystem health. To assess potential bioavailability and toxicity of lipophylic compounds in Rottenwood and Sope Creeks, semipermeable membrane devices were deployed and Microtox®* microscale toxicity testing was conducted on extracts from each site. The water-quality conditions of the two streams were similar and reflected the urban conditions of both watersheds. Chlorinated solvents were detected in Rottenwood Creek but not in Sope Creek. Aquatic communities in Rottenwood and Sope Creeks were similar in composition. Both creeks contained pollution-tolerant EPT taxa. However, Rottenwood Creek contained more species from the order Trichoptera, whereas Sope Creek contained more species from the order Ephemeroptera. In Sope Creek, 50 percent or more of the community at each reach was comprised of Dipterans, suggesting that Sope Creek has slightly more degraded habitat, water-quality, or flow conditions.

INTRODUCTION

U.S. Air Force Plant 6 (AFP6), located adjacent to Dobbins Air Reserve Base in Marietta, Georgia, has specialized in aircraft production and repair since 1942 (Fig. 1). As part of operations, large quantities of oils, lubricants, chlorinated solvents, and protective coatings have been used during production, which have resulted in the release of volatile organic compounds (VOCs), primarily trichloroethylene (TCE), and metals into the soil and ground water at the plant site due to past manufacturing practices (B&V Waste Science and Technology Corporation, 1994). In 1995, dissolved TCE was detected in ground water collected from an unused irrigation well on the Southern Polytechnic State University campus, which is located adjacent to AFP6 (Stewart, 2000). Since then, Gonthier and Waddell (2001) reported TCE at 21 sites on Rottenwood Creek, which flows along the northeastern boundary of AFP6. The highest concentration of TCE (9.7 µg/L) was detected in a diffusion sampler placed on a tributary of Rottenwood Creek that flows from the AFP6 area and enters Rottenwood Creek just upstream from reach C (Fig. 1). This tributary may be a source of TCE contamination in Rottenwood Creek. However, it is not known if the TCE affects the aquatic communities in Rottenwood Creek. The objective of this paper is to describe the water quality and macroinvertebrate communities of Rottenwood Creek and to compare water quality and macroinvertebrate communities with those in Sope Creek, an adjacent stream with a similar basin size and land uses.

Study Area

Rottenwood and Sope Creeks are urban streams with highly developed watersheds and large areas of impervious surfaces including roads, parking lots, and buildings (Fig. 1). Both streams are tributaries of the Chattahoochee River in Metropolitan Atlanta. The Rottenwood Creek watershed encompasses an area of 19.6 square miles (mi^2) and the Sope Creek watershed encompasses an area of 35.4 mi^2. Rottenwood and Sope Creeks are classified for fishing use and are currently on Georgia's Section 303(d) Impaired Waterbodies List (Georgia Environmental Protection Division, 2002) for not meeting the indicator bacteria standards for the designated use. Both tributaries flow directly into the Chattahoochee River National Recreational Area and have the potential to affect water quality within the recreational area where water use is classified as recreational.

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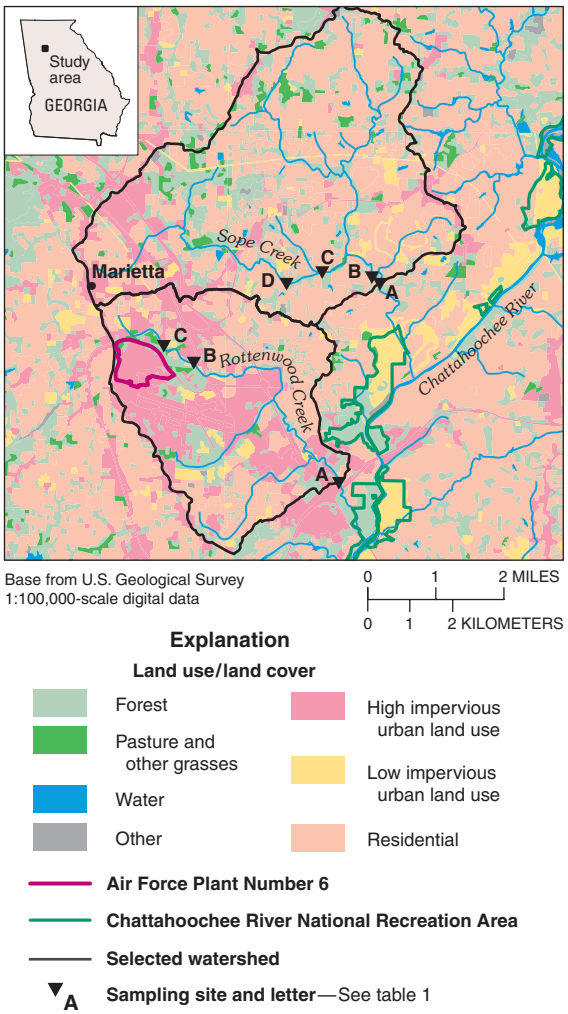

Figure 1. Sampling sites and land use/land cover in Rottenwood and Sope Creek watersheds (land use/land cover source: unpublished land cover classification prepared by U.S. Geological Survey based on 1992–94 satellite imagery).

METHODS

Water Quality

Water-quality data were collected quarterly at three sites on Rottenwood Creek and monthly to bimonthly at one site on Sope Creek during November 2001–October 2002. All samples were collected during baseflow conditions to maximize the ground-water input and potential ground-water contaminant input. Samples were analyzed for field parameters (temperature, specific conductance, pH, and dissolved oxygen), major ions, nutrients, pesticides, volatile organic compounds, trace metals, and waste-water tracers. Samples were collected using protocols developed for the U.S. Geological Survey National Water-Quality Assessment program (Shelton, 1994; Wilde and others, 1999) and were analyzed at the USGS National Water-Quality Laboratory (NWQL) in Denver, Colorado.

Invertebrates

Quantitative macroinvertebrate samples were collected from three sites along Rottenwood Creek below the confluence with a tributary flowing from AFP6 and from four sites along Sope Creek (Fig. 1) during June 2002. Methods followed USGS protocols reported in Moulton and others (2002). The Biological Group at the USGS NWQL conducted taxonomic identification. Taxa were identified to the lowest taxonomic group possible and enumerated. Insect taxonomic ambiguities were resolved to the genus or family level when no genera were present. Noninsect taxonomic ambiguities were resolved to the family level. Resolutions were made on a sample-by-sample basis by deleting ambiguous parent taxa and retaining the children. For example, if the taxonomic list for a site contained Baetidae, *Baetis* sp., and *Plauditus* sp., then Baetidae abundance would be deleted and the abundances for *Baetis* sp. and *Paluditus* sp. would be retained. Metrics suggested for use in Piedmont streams (Georgia Department of Natural Resources, 1997) were calculated to assess the relative health of the stream sites and included taxa richness, total abundance, Ephemeroptera-Phecoptera-Trichoptera (EPT) index, number of Chironomidae taxa, percent dominant taxon, percent Diptera, and the North Carolina Biological Index (NCBI).

Semipermeable Membrane Device Toxicity Testing

Semipermeable membrane devices (SPMDs) consist of low-density polyethylene lay-flat tubing that contains triolein, a synthetic fatlike material that absorbs lipophylic compounds. The SPMDs were housed in small aluminum carriers, which were used to fasten the devices to stable pieces of wood or rebar and driven into the streambed. SPMDs were deployed at three sites in Rottenwood Creek and at reaches A, C, and D in Sope Creek in June 2002, allowed to equilibrate for 30 days, and retrieved in July 2002. Microtox® analysis (Johnson, 1997) consisted of extraction of the lipophylic compounds from the triolein and exposure of extracts to a luminescent strain of bacteria (*Photobacterium phosphoreum*). Decline in luminescent output indicates bacteria mortality and was used to calculate an EC_{50} (effective concentration at which 50 percent reduction of light output was observed) for each site. The EC_{50} was used to calculate a relative toxicity index (Fig. 2), which can be used to compare the toxicity of the extract among sites. The EC_{50} provides an indication of relative toxicity of the extracted material that accumulated in the SPMD. Quality assurance consisted of two atmospheric blanks, which were opened at each site while the SPMDs were being installed, and a blind replicate at one site. The relatively small amount of toxicity

observed in the atmospheric blanks was subtracted from actual sample data prior to calculation of the relative toxicity index for each site.

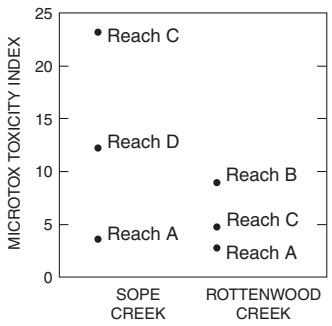

Figure 2. Range of relative toxicity of semi-permeable membrane device extract in Rottenwood and Sope Creeks, June–July 2002.

RESULTS

Water Quality

Analysis of water-quality samples shows that Rottenwood and Sope Creeks contain trace metals and organic compounds that are associated with urban development (Terracciano and O'Brien, 1997; U.S. Geological Survey, 1999). These include metals, such as copper, lead, nickel, and zinc, herbicides, insecticides, and volatile organic compounds. All of the compounds and metals were detected at low concentrations, generally less than 1 microgram per liter (µg/L). Only two pesticides, diazinon and chlorothalonil, exceeded aquatic life criteria (International Joint Commission, 1978; Canadian Council of Ministers of the Environment, 2001). Both detections that exceeded the criteria were from samples collected in Sope Creek and were collected on different days.

In general, the median concentrations of most metals, pesticides and volatile organic compounds detected in Sope and Rottenwood Creeks were similar, with the exception of the occurrence of chlorinated solvents in Rottenwood Creek. Solvents 111-trichloroethane, 1,1-dichloroethane, 1,1-dichloroethylene, cis-1,2-dichloroethene, trichloroethylene, and tetrachloroethylene were detected frequently in Rottenwood Creek, but were not detected in any samples in Sope Creek. The occurrence of some of these compounds in Rottenwood Creek due to contaminated ground-water discharge was documented by Gonthier and Waddell (2001). Some pesticides had higher median concentrations in one of the creeks; specifically, simazine was higher in Sope Creek and tebuthiuron was higher in Rottenwood Creek. The concentrations of these compounds did not exceed aquatic life criteria.

Invertebrates

Overall, 3,314 individuals representing 35 taxa and 6,657 individuals representing 45 taxa were collected in Rottenwood Creek and Sope Creek, respectively. The dominant orders of invertebrates in Rottenwood Creek were Trichoptera and Diptera. The dominant orders in Sope Creek were Ephemeroptera and Diptera. *Hydropsyche* and *Baetis* were the most dominant genera at all three Rottenwood Creek sites. *Hydropsyche* and *Polypedilum* were the most dominant genera at all sites in Sope Creek, except Sope Creek Reach C where Chironomids, *Robakia* and *Cricotopus*, were dominant. An increase in the number of EPT taxa and a decrease in taxa richness and in the number of Chironomidae taxa was observed in Rottenwood Creek downstream of the tributary draining AFP6 and closer to the confluence with the Chattahoochee River (Table 1, Fig. 1). In Sope Creek, taxa richness, the number of EPT taxa, and the number of Chironomidae are higher at sites closer to its confluence with the Chattahoochee River than those upstream. NCBI values were similar among sites in Rottenwood and Sope Creeks but, overall, were slightly higher in Sope Creek.

Table 1. Metrics calculated from benthic macroinvertebrate data

[EPT, Ephemeroptera, Plecoptera, Trichoptera; NCBI, North Carolina Biological Index; %, percent]

	Rottenwood Creek		
Metric	**Reach C**	**Reach B**	**Reach A**
Total abundance	896	488	1930
Taxa richness	22	18	15
EPT index	4	4	8
Chironomidae taxa	9	7	2
% Dominant taxon	53	42	45
% Diptera	14	6	3
NCBI	4.6	4.8	4.6

	Sope Creek			
Metric	**Reach D**	**Reach C**	**Reach B**	**Reach A**
Total abundance	31	90	4,838	1,698
Taxa richness	14	17	23	31
EPT index	2	5	6	10
Chironomidae taxa	8	8	12	12
% Dominant taxon	22	14	25	26
% Diptera	63	72	52	50
NCBI	5.6	5.0	5.9	5.0

Semipermeable Membrane Device Toxicity Testing

Higher levels of toxicity were measured in extracts from SPMDs from Sope Creek than in extracts from Rottenwood Creek. The SPMD extracts collected in the upper reaches of Sope Creek, which drains large areas of impervious surfaces, including commercial and residential areas, had the highest levels of toxicity (Figs. 1 and 2). In contrast, the upper reaches of Rottenwood Creek were of slightly lower toxicity even though the upper reaches of this stream also drain large areas of

impervious surfaces including runways for Dobbins Air Reserve Base. In both streams, the downstream most site had the lowest toxicity levels.

DISCUSSION

Rottenwood and Sope Creeks are representative of highly altered systems with high levels of urban land use and documented water-quality problems resulting in multiple 303(d) listings throughout the 1990s. Water-quality conditions are similar between the two streams and reflect the urban conditions of both watersheds. Trace metals, pesticides, and volatile organic compounds were detected in both streams but at low concentrations. Chlorinated solvents were detected frequently in Rottenwood Creek, but not in Sope Creek. Aquatic life criteria standards were exceeded only in Sope Creek for diazinon and chlorothalonil, pesticides generally used in suburban areas. Invertebrate abundances and EPT index tended to be highest in both Sope and Rottenwood Creeks in the downstream most reaches. These areas had higher gradients and more stable, cobble-sized substrate, which provided better habitat conditions than upstream areas, and may have influenced the invertebrate indices. Based on NCBI values, the invertebrate communities in Sope Creek were slightly more tolerant than communities collected from Rottenwood Creek, suggesting that habitat, flow, or water-quality conditions were slightly more degraded. Also, a high percentage of dipterans, which are generally indicative of degraded water-quality conditions, comprised 50 percent or more of the communities collected from Sope Creek but less than 15 percent of communities collected from Rottenwood Creek. The presence of chlorinated solvents in the upstream reaches of Rottenwood Creek did not have an obvious effect on the invertebrate communities in the stream; however, many factors simultaneously affect aquatic communities in urban streams. The effects of habitat and streamflow alteration resulting from increased impervious surfaces introduces variability that was not accounted for in this study.

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