CHARACTERIZATION OF ANTHROPOGENIC ORGANIC COMPOUNDS IN THE SOURCE WATER AND FINISHED WATER FOR THE CITY OF ATLANTA, OCTOBER 2002–SEPTEMBER 2004

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Abstract. As part of the Source Water-Quality Assessment (SWQA)—one of several study components within the U.S. Geological Survey's National Water-Quality Assessment Program—the source water and finished water for the City of Atlanta are being analyzed for the presence of more than 270 anthropogenic organic compounds representing a diverse group of extensively used chemicals. During the first phase of the study, 17 source-water samples were collected from October 2002 through December 2003 at the City of Atlanta drinking-water intake. As part of the second phase of the study, 16 paired samples from the drinking-water intake and finished water at the Chattahoochee Water Treatment Plant (CWTP) are being collected from July 2004 through May 2005. This paper characterizes the occurrence of anthropogenic organic compounds in the source water and finished water for the City of Atlanta, based on results from the first phase and the first three paired samples from the second phase of the study. Thirty-seven pesticides, 11 pesticide degradates, 37 organic wastewater compounds, and 16 volatile organic compounds were detected; multiple anthropogenic organic compounds were detected in each sample collected.

Concentrations of anthropogenic organic compounds detected in source-water samples for the City of Atlanta generally were low, and SWQA samples included in this report did not exceed Federal drinking-water standards or health advisories, although such standards or advisories have not been established for most of these compounds. Maximum concentrations measured in source-water samples for the herbicides simazine and MCPA and the insecticide diazinon ranged from 81 to 12 percent of available standards and advisories. For all other anthropogenic organic compounds with available drinking-water standards or health advisories, the maximum concentrations measured in source-water samples ranged from 10 to 100,000 times less than available standards and advisories.

Fewer anthropogenic organic compounds were detected in the finished water from the CWTP than in source water, and concentrations generally were less than concentrations in source water by one to three orders of magnitude, with the notable exception of total trihalomethane (THM). THMs are common disinfection by-products, especially when surface water is chlorinated to protect against bacterial contamination. Concentrations of total THMs detected in finished water generally were low (from 35 to 38 micrograms per liter) and compare well with the CWTP's consumer confidence reports. There were no exceedences of Federal drinking-water standards or health advisories in the first three finished-water samples. For all other anthropogenic organic compounds with available drinking-water standards or health advisories, the maximum concentrations measured in finished-water samples ranged from 100 to 100,000 times less than available standards and advisories.

INTRODUCTION

The Chattahoochee River is one of Georgia's most utilized water resources—supplying drinking water to a large percentage of the Metropolitan Atlanta population and serving as a receiving body for treated wastewater, as well as untreated urban runoff. Because of the heavy use and variety of nonpoint and point sources of inflow to the river, several studies have examined which organic wastewater contaminants have been detected in the Chattahoochee River, from Buford Dam to downstream from the City of Atlanta (Kolpin and others, 2002; Gregory and Frick, 2001; Henderson and others, 2001; and Frick and others, 2001). As part of these studies, 22 organic wastewater compounds (OWCs) were detected in the Chattahoochee River, of which 92 percent were at very low concentrations, less than 1 microgram per liter (µg/L) (Frick and Zaugg, 2003).

During 2002, the U.S. Geological Survey (USGS) began a national study to assess the status of drinking-water sources (surface water and groundwater, depending on local use) in selected locations as part of the National Water-Quality Assessment (NAWQA) Program. These Source Water-Quality Assessments (SWQAs) are 2-year studies. The first phase involves sampling source water at the municipal water treatment plant intakes and analyzing samples for a comprehensive list of anthropogenic organic compounds, dissolved organic carbon, and *Escherichia coli* (*E. coli*). The second phase of sampling focuses on sampling source water and finished water for those anthropogenic organic compounds detected most frequently in source waters during the first phase of sampling. One of the nine SWQA studies selected was the source water for the City of Atlanta, within the Apalachicola–Chattahoochee–Flint (ACF) River Basin. Atlanta is one of several relatively large cities in the continental United States with treated effluent discharged upstream from drinking-water intakes included in the SWQA.

As part of the SWQA in the ACF River Basin, two sites were selected for sampling source water and finished water, respectively: the City of Atlanta drinking-water intake and the Chattahoochee Water Treatment Plant (CWTP) (Fig. 1). The City of Atlanta drinking-water intake is downstream from four major (greater than 1 million gallons per day [Mgal/d]) water pollution control plants (WPCPs) (Crooked Creek, Johns Creek, City of Cumming, and Big Creek) (Fig. 1), has the capacity to pump 180 Mgal/d, and withdraws all the untreated drinking water for the City of Atlanta and most of Fulton County from the Chattahoochee River. The CWTP receives all its source water from the City of Atlanta drinking-water intake and has a design capacity to filter almost 65 Mgal/d, supplying 35 percent of the drinking water for the City of Atlanta (City of Atlanta Bureau of Water, accessed November 21, 2004, at *http://apps.atlantaga.gov/citydir/water/systemoverview.htm*). Water processed at the CWTP is treated with chlorine as a disinfection agent and undergoes the physical and chemical treatment processes displayed in Figure 2.

The USGS NAWQA SWQA studies are different and distinct from the U.S. Environmental Protection Agency

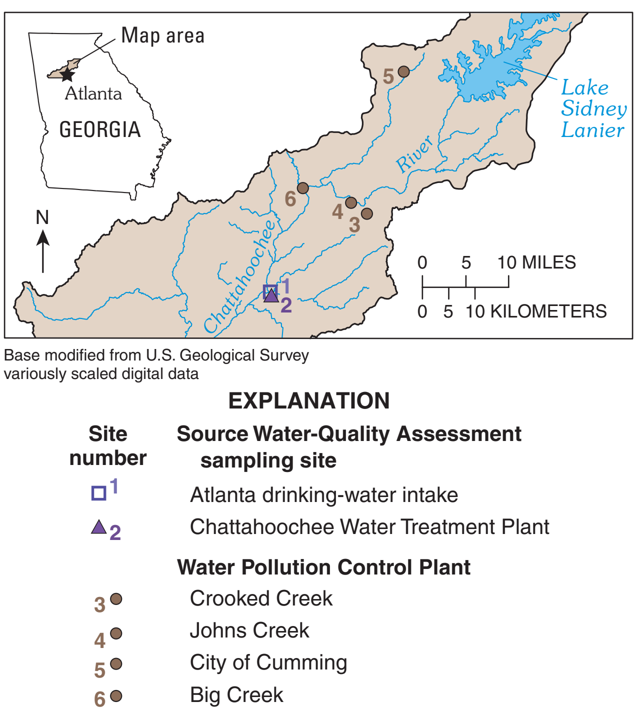

Figure 1. Location of Source Water-Quality Assessment sampling sites and upstream water pollution control plants that discharge more than 1 million gallons per day.

Source Water Assessment Programs (SWAPs) that every state is required to implement as part of the 1996 Safe Drinking Water Act Amendments (U.S. Environmental Protection Agency, accessed February 4, 2005, at *http://www.epa.gov/safewater/sdwa/index.html*). SWAPs, completed by the State or the public water system, identify (1) the area of the watershed from which public water system's drinking water is drawn, (2) areas most critical for protection, and (3) possible sources of contaminants that could affect water quality and how likely they are to cause a problem. Public water systems that supply communities must report their assessment results in their annual water-quality report (consumer confidence report) (U.S. Environmental Protection Agency, accessed February 4, 2005, at *http://epa.gov/region8/water/swap/index.html*).

METHODS

During the first phase of sampling, 17 source-water samples were collected at the City of Atlanta drinking-water intake from October 2002 through December 2003. Samples were collected using standard water-quality sampling field protocols (U.S. Geological Survey, variously dated). These samples were analyzed for pesticides, OWCs, volatile organic compounds (VOCs), *E. coli*, dissolved organic carbon, as well as field properties of temperature, pH, specific conductance, and dissolved oxygen.

The second phase of sampling includes paired source- and finished-water samples collected at the drinking-water intake and CWTP, respectively. In an attempt to allow for the retention time of water within the CWTP, finished-water samples were collected 5 hours after drinking-water intake samples to account for the approximately 5 hours of retention it takes water pumped from the Chattahoochee River to be treated and released to the distribution system as drinking water from the CWTP (Kathy Crews, Chattahoochee Water Treatment Plant, oral commun., 2004). These paired samples also were collected by using standard water-quality sampling field protocols (U.S. Geological Survey, variously dated). In addition, samples collected from the CWTP were processed using ascorbic acid and a pH buffer to account for free chlorine resulting from the disinfection process. Sixteen samples, to be collected between July 2004 and May 2005, include 10 fixed-interval samples, as well as 6 additional samples targeted to maximize the likelihood of the occurrence of selected compounds. With the exception of discontinuing *E. coli* sampling, the same compounds were analyzed in the first and second phases for this SWQA. As of December 2004, seven paired samples have been collected; however, only data from the first three samples (July through September 2004) were available for evaluation in time for this publication. Samples from both sampling phases were collected during a wide range of flow conditions (Fig. 3).

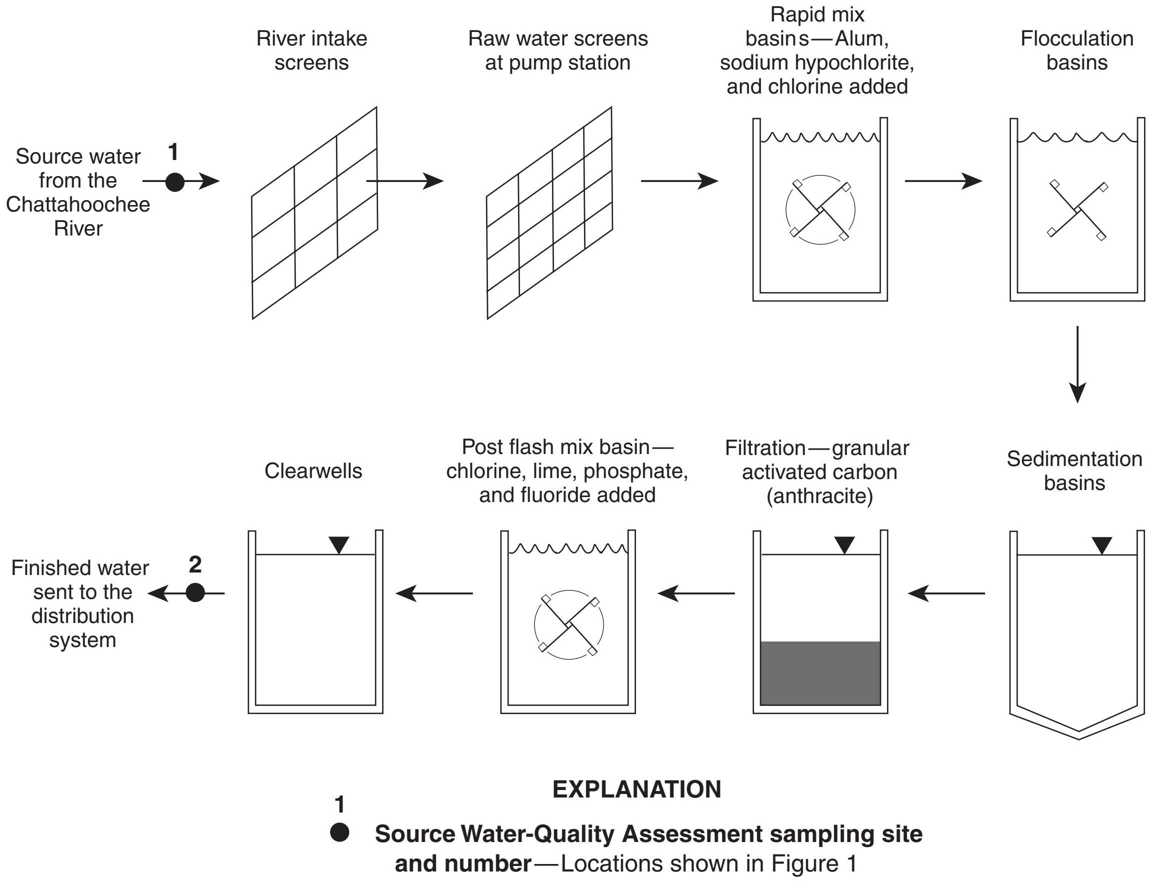

Figure 2. Schematic diagram showing physical and chemical processes used to produce finished drinking water at the Chattahoochee Water Treatment Plant (Thomas Kopanski, City of Atlanta Division of Water, written commun., 2004; Stackelberg and others, 2004).

Phenol data were excluded from analyses because of relatively frequent detections in blank samples, and concentrations measured in blank samples were in a similar range as concentrations measured in environmental samples (James A. Kingsbury, Jessica A. Hopple, and Gregory C. Delzer, U.S. Geological Survey, written commun., 2005).

RESULTS

A total of 37 pesticides, 11 pesticide degradates, 37 OWCs, and 16 VOCs were detected in the 17 source-water samples collected during the first phase and in the first three paired source- and finished-water samples collected during the second phase of the SWQA study. Concentrations of anthropogenic organic compounds detected in source- and finished-water samples for the City of Atlanta generally were low. No SWQA samples included in this report exceeded Federal drinking-water standards or health advisories, although such standards or advisories have not been established for most of these compounds. The subset of anthropogenic organic compounds detected that have available drinking-water standards, life-time health advisory levels, or drinking-water advisories (U.S. Environmental Protection Agency, 2004) is listed in Table 1; maximum concentrations measured in source- and finished-water samples are plotted versus available standards in Figure 4. Human- and aquatic-health standards and criteria are based on the toxicity of individual compounds; however, little is known about potential effects associated with chronic exposure to trace concentrations of many anthropogenic organic compounds or to mixtures of these compounds (Stackelberg and others, 2004).

Source-Water Samples

Low concentrations of several anthropogenic organic compounds were detected in each source-water sample. For example, from 9 to 26 pesticides and pesticide degradates, from 3 to 26 OWCs, and from 1 to 8 VOCs were detected in each source-water sample. Concentrations of anthropogenic organic compounds detected in the source water for the City of Atlanta generally were less than 1 µg/L, and there were no exceedences of available Federal drinking-water standards or health advisories (U.S. Environmental Protection Agency, 2004) (Table 1 and Fig. 4).

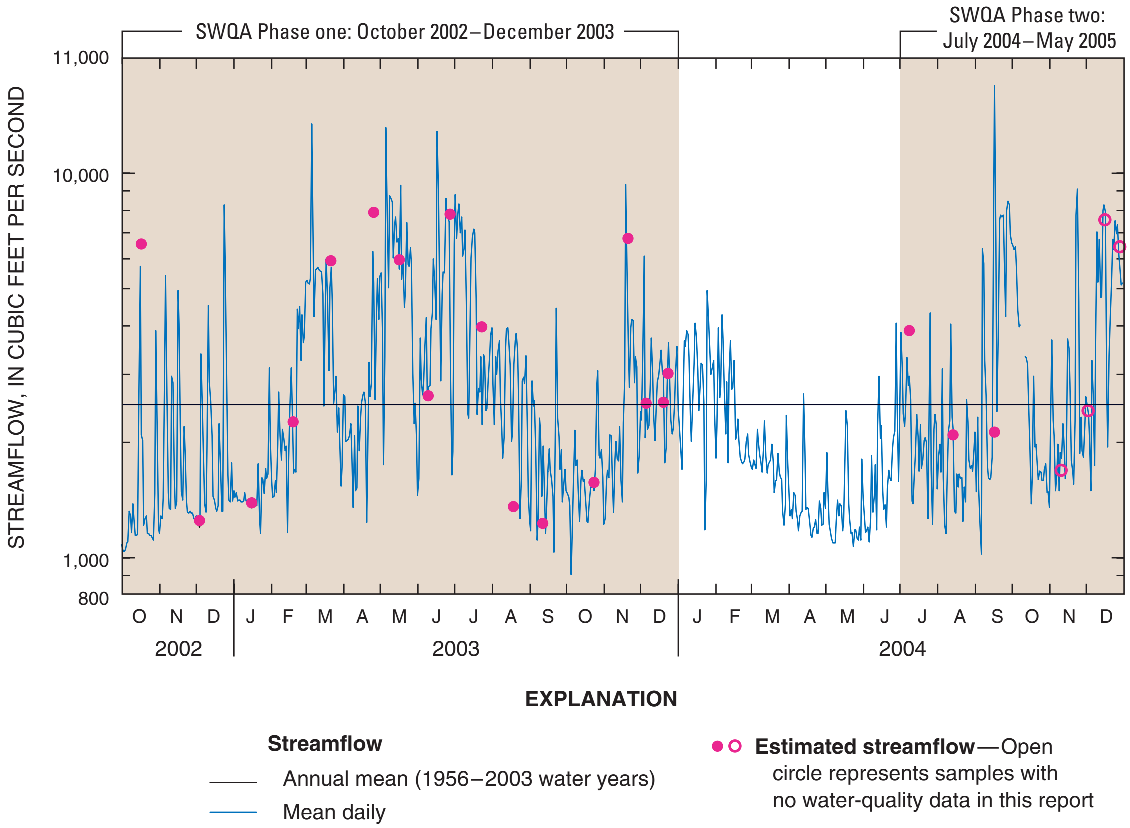

Figure 3. Annual-mean and mean-daily streamflow in the Chattahoochee River at Atlanta (USGS site 02336000, 2.4 miles upstream from Atlanta drinking-water intake) and estimated streamflow for Source Water-Quality Assessment (SWQA) samples collected at the Atlanta drinking-water intake (USGS site 02336020), October 2002–December 2004. [USGS, U.S. Geological Survey]

There are no concentrations in SWQA samples included in this report that plot to the left of the 1:1 line in Figure 4, which represents the line along which the maximum concentration of a compound is equal to available drinking-water standards or health advisories. The maximum concentration in source-water samples for the herbicide simazine was 81 percent of the maximum contaminant level (MCL) of 4 µg/L, for the insecticide diazinon the maximum concentration was 14 percent of the life-time health advisory level (HAL) of 0.6 µg/L; and for the herbicide MCPA, it was 12 percent of the HAL of 4 µg/L (U.S. Environmental Protection Agency, 2004). For all other anthropogenic organic compounds with available drinking-water standards or health advisories, the maximum concentrations measured in source-water samples ranged from 10 to 100,000 times less than available standards and advisories.

Finished-Water Samples

A smaller subset of anthropogenic organic compounds were detected in each finished-water sample compared to those measured in source-water samples, and their concentrations tended to be one or more orders of magnitude lower in finished-water samples. From 9 to 16 pesticide and pesticide degradates, from 3 to 6 OWCs, and from 4 to 7 VOCs were detected in the first three finished water samples. Concentrations of anthropogenic organic compounds detected in the finished water from the CWTP generally were less than 0.1 µg/L, with the notable exception of total THM concentrations, which ranged from 35 to 38 µg/L. There were no exceedences of Federal drinking-water standards or health advisories in the first three finished-water samples.

Total THMs were the only anthropogenic organic compounds with larger concentrations measured in finished water than source water (Fig. 4*B*). THMs are a common disinfection by-product resulting from chlorination of water, which is the disinfection method used at the CWTP. The sum of concentrations for the three THMs detected (from 35 to 38 µg/L) in finished-water samples (trichloromethane [chloroform], bromodichloromethane, and dibromochloromethane) is within the range of 17–64 µg/L reported by the City of Atlanta for 2003 (City of Atlanta Water-Quality Report, 2003, accessed November 24, 2004, at *http://apps.atlanta.ga.gov/citydir/water/WQR2004.pdf*).

Table 1. Anthropogenic organic compounds that have available drinking-water standards, health advisories, and (or) drinking-water advisories were detected in source- and (or) finished-water samples, City of Atlanta, October 2002–September 2004.

[AOC, anthropogenic organic compounds; USGS, U.S. Geological Survey; µg/L, microgram per liter; <, less than; >, greater than; MCL, maximum contaminant level; HAL, health advisory, lifetime; E, estimated; M, presence verified, not quantified; t, below the long-term method detection level (MDL); n, below the laboratory reporting level (LRL) and above the long-term MDL; DWA, drinking-water advisory; —, not plotted in Figure 4]

AOCs use classification	USGS laboratory schedule(s)[1]				Figure 4 labels	Name of AOCs detected (USGS parameter code listed if more than one laboratory method)	Minimum reporting level(s), in µg/L	Drinking-water standard or advisories[2], in µg/L	Maximum concentration, in µg/L [shaded where detected]	
	2003	2060	2020	1433					Source water[3]	Finished water[4]
Pesticides										
Herbicide		x			1	2,4-D	0.01, 0.02, 0.03	70 MCL	0.57	0.20
Herbicide	x	x			2	Atrazine	0.007	3 MCL	0.187	0.024
Herbicide		x		x	3	Bromacil	0.03, 0.5	90 HAL	0.09	< 0.03
Herbicide		x			4	Dicamba	0.01, 0.12	200 HAL	0.22	< 0.01
Herbicide		x			—	Dinoseb	0.01	7 MCL	M	< 0.01
Herbicide		x			5	Diuron	0.01	10 HAL	0.18	0.02
Herbicide		x			6	MCPA[5]	0.02	4 HAL	0.47	E 0.02
Herbicide	x			x	7	Metolachlor	0.006, 0.013	100 HAL	E 0.005t	< 0.013
Herbicide	x				8	Metribuzin	0.006	200 HAL	E 0.009	< 0.006
Herbicide	x			x	9	Prometon	0.01, 0.5	100 HAL	0.02	0.02
Herbicide	x				10	Propyzamide (Pronamide; Kerb)	0.004	50 HAL	0.010	< 0.004
Herbicide	x				11	Simazine	0.005	4 MCL	3.23	0.042
Herbicide	x	x			12	Tebuthiuron	0.02	500 HAL	0.03	< 0.02
Herbicide	x				13	Trifluralin	0.009	5 HAL	E 0.005	< 0.009
Insecticide		x			14	Carbaryl (P49310)	0.03	700 HAL	0.05	E 0.01t
Insecticide	x			x	15	Carbaryl (P82680)	0.041	700 HAL	E 0.092	E 0.018t
Insecticide	x			x	16	Chlorpyrifos	0.005, 0.5	20 HAL	E 0.003	< 0.005
Insecticide	x			x	17	Diazinon	0.005, 0.5	0.6 HAL	0.086	< 0.005
Insecticide	x				18	Malathion	0.027	100 HAL	E 0.018n	< 0.027
Volatile organic compounds (VOCs)										
Petroleum hydrocarbons – Benzene, toluene, ethyl-benzene, and xzylene (BTEX)			x		19	Benzene	0.02, 0.04	5 MCL	E 0.02	< 0.02
BTEX			x		20	Toluene	0.05	1,000 MCL	0.10	E 0.03t
Oxygenate			x		21	Methyl tert-butyl ether (MTBE)	0.2	20 DWA odor 40 DWA taste	E 0.1	< 0.2
Solvent			x		22	Dichloromethane	0.1, 0.2	5 MCL	M	E 0.1n
Solvent			x		23	Tetrachloroethene	0.03, 0.06	5 MCL	E 0.02t	< 0.06
Total trihalomethanes (disinfection by-products)			x		24	Trichloromethane, bromodichloromethane, dibromochloromethane	sum: 0.25, 0.35	80 MCL[6]	E 0.16	37.9
Organic wastewater compounds										
Moth repellant, fumigant, deodorant				x	—	1,4-Dichloro benzene	0.5	75 MCL	M	< 0.5
Solvent				x	—	Isophorone	0.5	100 HAL	M	< 0.5

[1] USGS Laboratory schedules: sh2003, selected pesticides and degradates; sh2060, polar pesticides and metabolites; sh2020, VOCs; sh1433, organic wastewater compounds

[2] Source: U.S. Environmental Protection Agency, 2004

[3] 20 total samples: 17 phase one, 3 phase two

[4] 3 total samples: 0 phase one, 3 phase two

[5] 4(chloro-2-methoxyphenoxy)acetic acid

[6] MCL of 80 µg/L is for total trihalomethane (sum of trichloromethane (chloroform), bromodichloromethane, dibromochloromethane, and tribromomethane (bromoform)). Tribromomethane was not detected.

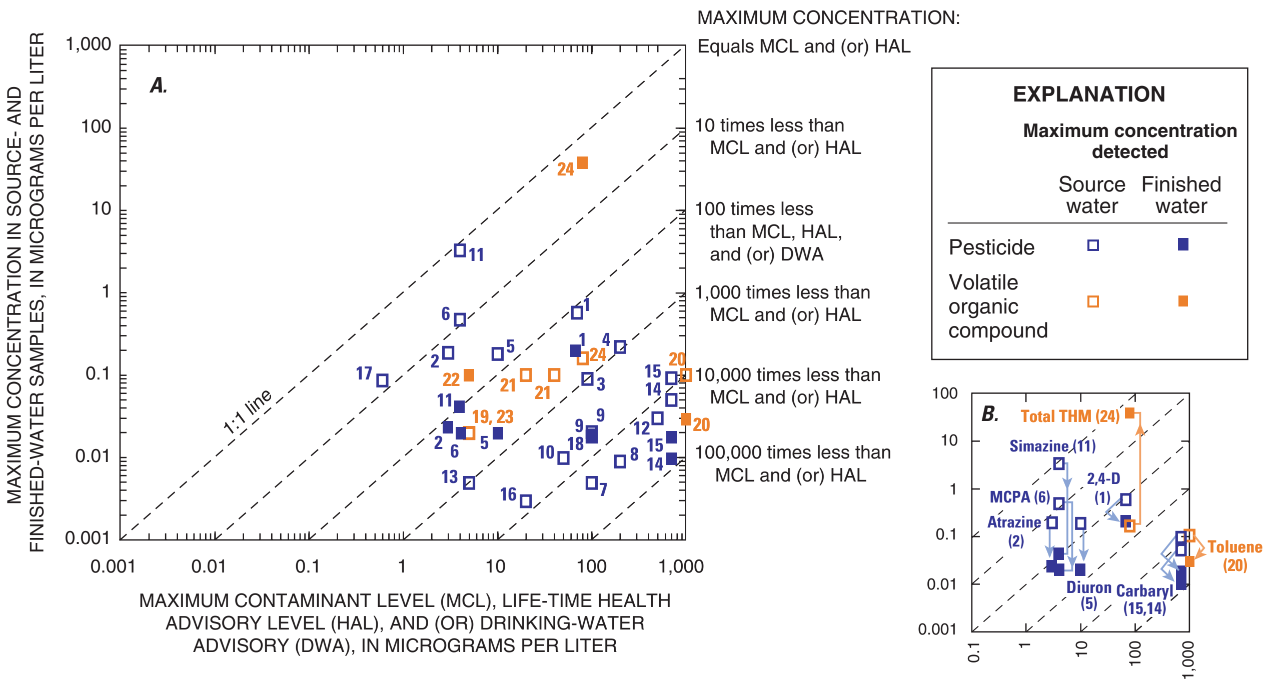

Figure 4. **(*A*) Maximum concentrations of anthropogenic organic compounds (AOCs) detected in source- and finished-water samples compared with available drinking-water standards and health advisories, and (*B*) maximum concentrations of AOCs detected in source-water samples compared to finished-water samples for AOCs detected in both sample types [THM, trihalomethane; MCPA, 4(chloro-2-methoxyphenoxy) acetic acid], October 2002–September 2004 (see Table 1 for description of number).**

These concentrations of total THMs in City of Atlanta finished water are all less than the MCL of 80 µg/L (U.S. Environmental Protection Agency, 2004) and are within the most common range of total THM concentrations reported for 201 community water systems that use surface water as their sole source in the Northeastern and Mid-Atlantic regions of the United States (Grady and Casey, 2001).

The maximum concentration in finished-water samples for total THMs was 47 percent of the MCL of 80 µg/L, for the herbicide simazine it was 1 percent of the MCL of 4 µg/L; and for the VOC dichloromethane, it was 1 percent of the MCL of 5 µg/L (U.S. Environmental Protection Agency, 2004). For all other anthropogenic organic compounds with available drinking-water standards or health advisories, the maximum concentrations measured in finished-water samples ranged from 100 to 100,000 times less than available standards.

After all the paired samples are collected and results are available, then concentrations and compounds detected in finished water and the apparent removal efficiencies from source water to finished water for the City of Atlanta can be compared to results from water treatment plants in other highly urbanized areas.

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