Prepared as part of the National Water-Quality Assessment Program, Source Water-Quality Assessment

Organic Compounds in Running Gutter Brook Water Used for Public Supply near Hatfield, Massachusetts, 2003–05

The 258 organic compounds studied in this U.S. Geological Survey (USGS) assessment generally are man-made, including pesticides, solvents, gasoline hydrocarbons, personal-care and domestic-use products, and pavement and combustion-derived compounds. Of these 258 compounds, 26 (about 10 percent) were detected at least once among the 31 samples collected approximately monthly during 2003–05 at the intake of a flow-through reservoir on Running Gutter Brook in Massachusetts, one of several community water systems on tributaries of the Connecticut River. About 81 percent of the watershed is forested, 14 percent is agricultural land, and 5 percent is urban land. In most source-water samples collected at Running Gutter Brook, fewer compounds were detected and their concentrations were low (less than 0.1 microgram per liter) when compared with compounds detected at other stream sites across the country that drain watersheds that have a larger percentage of agricultural and urban areas. The relatively few compounds detected at low concentrations reflect the largely undeveloped land use at Running Gutter Brook. Despite the absence of wastewater discharge points on the stream, however, the compounds that were detected could indicate different sources and uses (point sources, precipitation, domestic, and agricultural) and different pathways to drinking-water supplies (overland runoff, groundwater discharge, leaking of treated water from distribution lines, and formation during treatment). Six of the 10 compounds detected most commonly (in at least 20 percent of the samples) in source water also were detected commonly in finished water (after treatment but prior to distribution). Concentrations in source and finished water generally were below 0.1 microgram per liter and always less than human-health benchmarks, which are available for about one-half of the compounds detected. On the basis of this screening-level assessment, adverse effects to human health are expected to be negligible (subject to limitations of available human-health benchmarks).

Introduction

An investigation by the National Water-Quality Assessment (NAWQA) Program of the USGS characterizes the occurrence of 258 organic compounds in source water (defined as stream water collected at a surface-water intake prior to water treatment) and finished water (defined as water that has passed through treatment processes but prior to distribution) from the Hatfield Water Plant, a community water system that uses a flow-through reservoir on Running Gutter Brook as its primary source of water supply (fig. 1). Running Gutter Brook is a first-order tributary to the Connecticut River and drains a

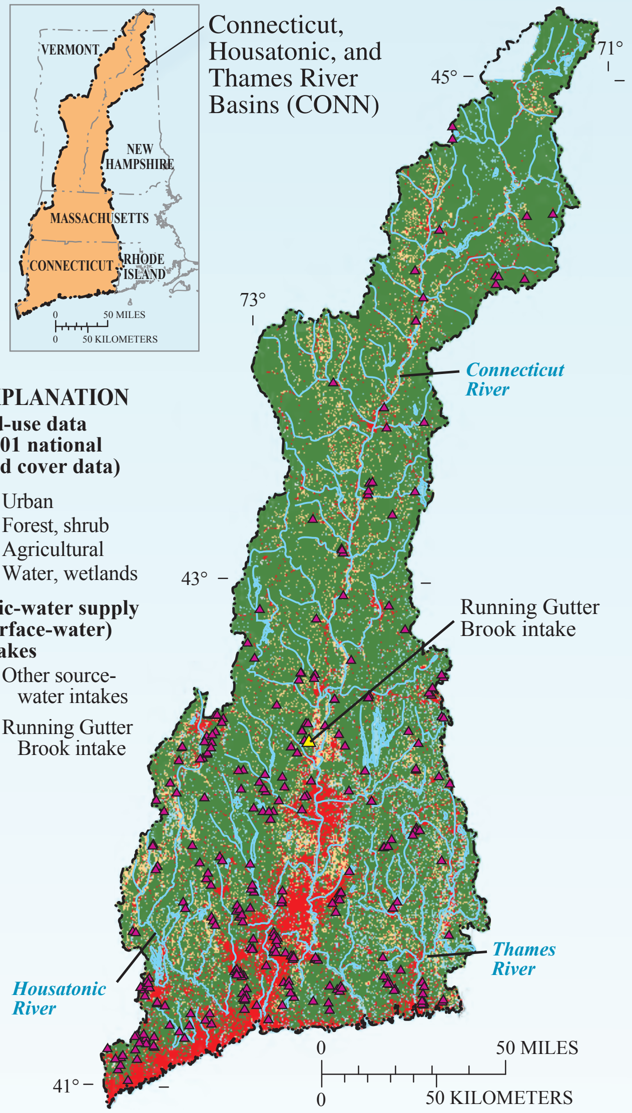

Figure 1. The Hatfield Reservoir on Running Gutter Brook is located in a small, relatively undeveloped watershed in the Connecticut River Valley. Most source-water intakes of surface water in the Connecticut, Housatonic, and Thames River Basins (CONN) study unit are located on reservoirs or lakes. Although urban and agricultural land in the CONN is concentrated along major valleys, the watershed for Running Gutter Brook is mostly forested (81 percent), with the remaining area agricultural (14 percent), and urban (5 percent). About 0.24 million gallons per day are taken directly from Running Gutter Brook at the community water system to serve the water needs of about 3,300 people.

mostly forested watershed that is adjacent to densely populated as well as sparsely populated watersheds (Rhodes and others, 2001). Running Gutter Brook is primarily fed by groundwater and by an ephemeral tributary stream, and about 1 square mile of the Running Gutter Brook watershed is upstream of the community water system intake. Discharge into the flow-through reservoir was measured as being about 1.3 million gallons per day or less during baseflow conditions. Samples were collected approximately monthly from the reservoir during 2003–05, and they included 31 source-water and 14 finished-water samples. The samples were analyzed for pesticides and selected pesticide degradates (breakdown products), solvents, gasoline hydrocarbons, disinfection by-products (DBPs), personal-care and domestic-use products, and other compounds. Community water systems are required to monitor finished water for compounds regulated under the Safe Drinking Water Act. Most of the compounds included in this study are not regulated under U.S. Environmental Protection Agency (USEPA) Federal drinking-water standards (U.S. Environmental Protection Agency, 2006). The Running Gutter Brook study is part of an ongoing NAWQA investigation of community water systems across the United States. More detailed information and references on the sampling design, methodology, specific compounds monitored, and the national study are described by Carter and others (2007). Additional USGS information on water quality in the Connecticut, Housatonic, and Thames River Basins (CONN) is available for the first cycle (1991 to 1995) of the NAWQA study (Garabedian and others, 1998).

Occurrence of Organic Compounds in Source Water

About one-tenth (26) of the 258 compounds studied were detected in at least one source-water sample. These compounds represent many different sources and uses and include pesticides, solvents, gasoline hydrocarbons, and personal-care and domestic-use products. Ten of the 26 compounds were commonly detected in source-water samples; chloroform was detected in all 31 source-water samples.

Recent advances in laboratory analytical methods have given scientists the tools to detect a wide variety of contaminants in the environment at low concentrations—typically 100 to 1,000 times lower than drinking-water standards (see inset, “What ‘Detections’ May Mean to Human Health”). Twenty-six of the compounds were detected in at least one source-water sample from Running Gutter Brook (Carter and others, 2007; Kingsbury and others, 2008).

Ten compounds were detected in at least 20 percent of the source-water samples (defined in this study as “commonly detected”; table 1). These included herbicides (atrazine and its degradates, and simazine), personal-care and domestic-use products (acetyl hexamethyl tetrahydro-naphthalene, or AHTN, caffeine, and hexahydrohexa-methylcyclopenta-benzopyran, or HHCB), a gasoline hydrocarbon (methyl *tert* butyl ether, or MTBE), and DBPs (chloroform and bromodichloromethane). The herbicides atrazine and simazine can be used for weed control in agricultural and residential areas in the Running Gutter Brook Watershed and across the Nation (Garabedian and others, 1998; Gilliom and others, 2006). Atrazine degradates including deethylatrazine (DEA) and deisopropyl-atrazine (DIA) also were commonly detected. The DBPs chloroform and bromodichloromethane were detected commonly in source-water samples; chloroform was detected in all of the source-water samples and may originate from the leakage of treated water from nearby supply lines. Several different personal-care and domestic-use products, including fragrances, detergent metabolites, and food or beverage ingredients, and other compounds, were detected in 47 percent of source-water intake samples. Their occurrence may be related to wastewater (Kolpin and others, 2002) from domestic septic-tank drainfields that leaches to groundwater and then discharges to Running Gutter Brook. Only about seven or eight houses are in the drainage basin and could contribute wastewater effluent to Running Gutter Brook, so the source of these compounds is unknown. Overall, the compounds detected most commonly in water from Running Gutter Brook are among those most commonly detected in ambient stream water across the Nation (Kingsbury and others, 2008).

What “Detections” May Mean to Human Health

The analytical methods used in this study have low detection levels—often 100 to 1,000 times lower than State and Federal standards and guidelines for protecting water quality. Detections, therefore, do not necessarily indicate a concern to human health but rather help to identify the presence of a wide variety of chemicals not commonly monitored in water resources and to track changes in their occurrence and concentrations over time. These findings complement ongoing drinking-water monitoring required by Federal, State, and local programs, which focus primarily on post-treatment compliance monitoring of contaminants regulated by USEPA in drinking water. Many of the compounds analyzed by USGS are not included in other source-water and finished-water monitoring programs such as the Unregulated Contaminant Monitoring Program (U.S. Environmental Protection Agency, 2007) and the U.S. Department of Agriculture’s Pesticide Data Program (U.S. Department of Agriculture, 2008).

Comparisons Between Source Water and Finished Water

Sixty percent of the compounds detected commonly in source water also were detected commonly in finished water, and generally at similar concentrations, typically less than 0.1 microgram per liter.

Comparisons between source water and finished water are not intended to characterize treatment efficacy, but to provide a preliminary indication of the potential importance of compounds found in source water to the quality of finished water prior to distribution (see inset, “Finished-Water Sampling, Water Treatment, and Significance of Comparisons to Source Water”).

Six of the 10 commonly detected compounds in source water also were detected commonly in finished water (fig. 2). Two groups of compounds in particular, DBPs and herbicides, were commonly detected in both source- and finished-water

Table 1. A total of 10 of 258 organic compounds were detected commonly (in at least 20 percent of the samples) in source water and 8 organic compounds were detected commonly in finished water.

[**Bold** check marks indicate detections in at least 20 percent of the samples; pesticide degradates are in *italics*; the levels of detection vary between compounds and are listed in Carter and others, 2007]

Compound	Detected in source water	Detected in finished water
Herbicides and herbicide degradates		
Atrazine	✔	✔
Deethylatrazine (DEA)	✔	✔
Deisopropyl-atrazine (DIA)	✔	✔
Simazine	✔	✔
Personal-care and domestic-use products		
AHTN (Acetyl hexamethyl tetrahydro-naphthalene)	✔	
Caffeine	✔	✓
HHCB (Hexahydrohexa-methylcyclopenta-benzopyran)	✔	✓
Gasoline hydrocarbons and additives		
MTBE (Methyl *tert*-butyl ether)	✔	
Solvents		
1,2-Dichloroethane (ethylene dichloride)		✔
Disinfection by-products		
Chloroform	✔	✔
Bromodichloromethane	✔	✔
Dibromochloromethane		✔

Finished-Water Sampling, Water Treatment, and Significance of Comparisons to Source Water

Water treatment of the community water system on Running Gutter Brook consists of slow filtration through a silica sand filter and disinfection using chlorine. The silica sand filter consists of a bed of sand that is graded by size, with coarse sand at the intake and fine grains at the outlet. Finished-water samples were collected at the community water supply approximately 48 hours after source-water samples to account for the retention time of the water in the treatment plant. Some differences between source- and finished-water quality might be attributable to changes in source-water quality that are not represented by the finished-water samples because of sample timing and variations in retention time, and potential analytic variability associated with low concentrations at or near laboratory reporting levels (Kingsbury and others, 2008). It is also possible that some compounds detected in source water were removed or transformed during the treatment process into compounds that were not monitored as part of this study. Source water from Running Gutter Brook is occasionally augmented by groundwater from supply wells after rainfall-runoff events when the stream is turbid. Groundwater, however, is added to the distribution system after finished water is sampled. Therefore, groundwater does not affect the samples of finished water collected for this study.

The study sampling design and resulting comparisons are not intended to characterize treatment efficacy, but to provide a preliminary indication of the potential importance of compounds found in source water to the quality of finished water prior to distribution. In general, the type of treatment used at Running Gutter Brook is not specifically designed to remove most of the organic compounds monitored in this study.

samples. Chloroform was detected in all source- and finished-water samples, although concentrations in source-water samples were low, generally at less than 0.1 microgram per liter (tables 1 and 2; fig. 2).

Four of the 10 most commonly detected compounds in source water, which include MTBE and personal-care products, were not detected as commonly, or at all, in finished water. The decreased detection of these compounds in finished water may be due to reaction with the preservatives (termed "quenching reagents") used to remove chlorine from samples (Valder and others, 2008), or possibly to sorption associated with sand filtration or degradation. An herbicide degradate, DIA, also was detected more commonly in source water than in finished water, and it too may be degraded or transformed during treatment.

Two compounds were detected commonly in finished water but not as commonly, or at all, in source water. These include a DBP, dibromochloromethane, and a solvent, 1,2-dichloroethane (table 2; fig. 2). The presence of DBPs in finished water is well documented, understood, and regulated, and is an expected outcome of disinfecting drinking water. The source of the detection of 1,2-dichloroethane is not known, but its occurrence in finished water may be a by-product of water treatment.

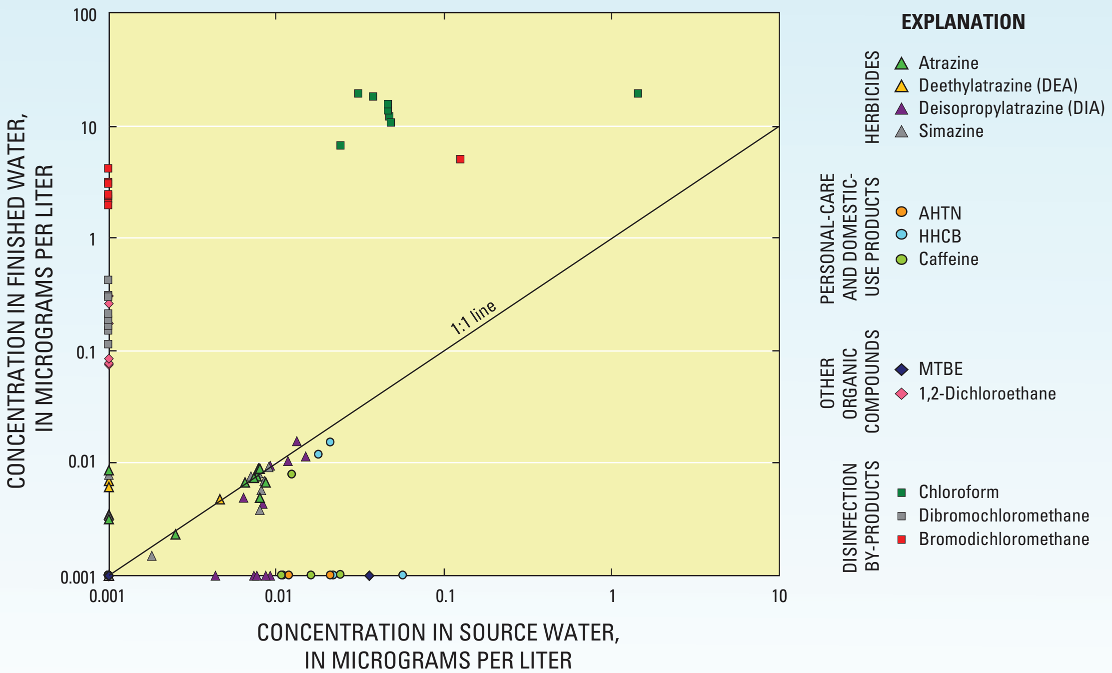

Figure 2. Six of the 10 compounds detected commonly in source water also were detected commonly in finished water for paired samples. Some compounds detected commonly in source water were not detected in finished water (x-axis). Other compounds were detected only in finished water (y-axis).

A Closer Look at Organic Compounds in a Relatively Undeveloped Watershed

Although Running Gutter Brook had no major wastewater input upstream from the sampling point, DBPs and personal-care products were detected commonly in source-water samples. Possible sources include chlorinated drinking water (for example, from lawn or tree-farm irrigation or leaking supply lines), septic systems (Ivahnenko and Zogorski, 2006), and also from natural sources such as from the formation of chloroform in soils by microbial processes (Laturnus and others, 2002). Caffeine and fragrance compounds AHTN and HHCB were commonly detected; in the absence of major wastewater discharges to Running Gutter Brook, septic-tank drainfields could be a possible source. An understanding of local hydrology and sources of contaminants is needed to fully characterize the quality of source water.

Commonly used herbicides and their degradates present in Running Gutter Brook could be from applying herbicides to agricultural lands, which include an ornamental tree farm and a small residential area within the watershed. Concentrations of atrazine and other herbicides and their degradates in Running Gutter Brook were one or more orders of magnitude less than concentrations at the other community water systems sampled by the USGS that included more agricultural land use in the contributing watersheds (Kingsbury and others, 2008). Transformation can result in the conversion of a parent compound to a compound that is commonly less toxic, but some degradates have toxicities that are similar to, or greater than, that of their parent pesticide (Gilliom and others, 2006). Herbicide degradate compounds are not regulated under the Safe Drinking Water Act.

Potential Effects on Human Health

Concentrations for all detected compounds in source and finished water generally were less than 0.1 microgram per liter and were always less than human-health benchmarks, which are available for about one-half of all compounds detected. On the basis of this screening-level assessment, adverse effects to human health are expected to be negligible (subject to limitations of available benchmarks, see inset "Human-Health Benchmarks Used in This Assessment").

Concentrations of eight compounds that were detected in source and (or) finished water (table 1) were greater than 0.1 microgram per liter (table 2). In general, compounds with concentrations greater than 0.1 microgram per liter, such as those used in personal-care products (methyl salicylate, nonylphenol diethoxylate total (NP2EO), and octylphenol monoethoxylate total (OP1EO)), reflect their abundant use in a relatively small area of urban land and their physical properties that allow them to persist in the environment (Gilliom and others, 2006; Zogorski and others, 2006). Concentrations did not exceed USEPA drinking-water standards (MCLs) for regulated compounds (table 2) in any sample. Concentrations also were less than USGS Health-Based Screening Levels (HBSLs) established for selected unregulated compounds (see inset, "Human-Health Benchmarks Used in This Assessment").

An important consideration in assessing potential effects for human health is the common occurrence of mixtures of organic compounds in source- and in finished-water samples. For example, the median number of compounds in source-water samples at Running Gutter Brook was 5. This is comparable to findings at community water systems on streams sampled by the USGS that drain relatively undeveloped watersheds (Kingsbury and others, 2008). Continued research is needed because human-health benchmarks are based on toxicity data for individual compounds, and the effects of mixtures of compounds at low concentrations are not well understood (Gilliom and others, 2006).

Human-Health Benchmarks Used in This Assessment

A screening-level assessment of the potential significance of detected compounds to human health was based on a comparison of measured concentrations to available human-health benchmarks. Specifically, concentrations of regulated compounds were compared to USEPA Maximum Contaminant Levels (MCLs), and concentrations of unregulated compounds that have USEPA published toxicity information were compared to USGS Health-Based Screening Levels (HBSLs), which were developed in collaboration with USEPA, New Jersey Department of Environmental Protection, and Oregon Health & Science University (Toccalino and others, 2007). About one-half of detected compounds do not have human-health benchmarks or adequate toxicity information for evaluating results in a human-health context. Human-health benchmarks are developed for individual compounds and not mixtures. The screening-level assessment provides an initial perspective on the potential importance of "man-made" organic compounds in source water; it is not a substitute for a comprehensive risk assessment, which includes many more factors, such as additional avenues of exposure.

Running Gutter Brook Findings in a National Context and Possible Implications

Many of the compounds detected most commonly in water from Running Gutter Brook (tables 1 and 2) are among those most commonly detected in ambient stream water and ground-water across the Nation (Gilliom and others, 2006; Zogorski and others, 2006). In addition, the occurrence and concentrations of compounds in source and finished water sampled from Running Gutter Brook were similar to those detected at other community water systems sampled for the USGS national investigation of rivers that do not receive any major upstream wastewater discharge and that drain relatively small areas of agricultural and urban land (Kingsbury and others, 2008). Findings in a national context, however, are considered preliminary because some compounds included in this study have only recently been monitored systematically in source and in finished water, including, for example, plant- or animal-derived biochemicals (such as cholesterol) and those used for personal-care, including AHTN, HHCB, caffeine, camphor, indole, methyl salicylate, menthol, NP2EO, OP2EO, and OP1EO. Continued research is needed to better understand sources, transport mechanisms, trends, fate in the environment, and possible linkages of these compounds to human health.

USGS will continue to collaborate with, and complement the work of, other Federal, State, and local organizations, and continue to communicate findings and possible implications and future needs, including, for example:

- Increased emphasis on watershed management and source-water protection strategies to help minimize the sources and transport of compounds to source water and ultimately to finished water.

Table 2. Only 8 organic compounds that were detected in source and (or) finished water had concentrations greater than 0.1 microgram per liter. None of these concentrations exceeded a human-health benchmark; however, benchmarks are available for only 4 of the 8 compounds shown in this table.

[µg/L, micrograms per liter; MCL, Maximum Contaminant Level; HBSL, Health-Based Screening Level; --, no data; E, estimated; ND, not detected]

Compound	Number of samples		Percent occurrence[1]		Reporting level (µg/L)	MCL or HBSL (µg/L)	Maximum concentration (µg/L)	
	Source water	Finished water	Source water	Finished water			Source water	Finished water
Personal-care and domestic-use products								
Methyl salicylate	27	11	3.7	0	0.5	4,000	E0.13	ND
NP2EO (Nonylphenol diethoxylate, total)	27	11	7.4	0	5	--	E2.2	ND
OP2EO (Octylphenol diethoxylate, total)	27	11	7.4	0	1	--	E0.25	ND
OP1EO (Octylphenol monoethoxylate, total)	27	11	7.4	0	1	--	E0.69	ND
Plant- or animal-derived biochemicals								
Cholesterol	27	11	3.7	9.1	2	--	E0.19	E0.4
Disinfection by-products								
Chloroform	25	9	100	100	0.24	80 total THMs[2]	1.5	19
Bromodichloromethane	25	9	20	100	0.048		0.13	4.9
Dibromochloromethane	25	9	0	100	0.18		ND	0.42

[1]Percent occurrence of samples with concentrations equal to or greater than 0.1 µg/L; estimated concentrations are used for compounds that have reporting level greater than 0.1 µg/L.

[2]MCL of 80 is for total trihalomethanes (THMs), including chloroform, bromoform, bromodichloromethane, and dibromochloromethane.

- Continued research to enhance toxicity information for commonly occurring unregulated compounds and mixtures that are detected commonly in source water and finished water.
- Current and future monitoring and assessment to identify compounds not typically monitored in source water, but commonly present in finished water, which may ultimately identify or lead to the development of treatment technologies for their removal.

Source Water Quality Assessments by the NAWQA Program Conducted Across the Nation

Beginning in 2002, NAWQA initiated "Source Water-Quality Assessments" (SWQAs) at selected community water systems across the United States (Delzer and Hamilton, 2007). The long-term goal is to complete as many as 30 SWQAs at systems that withdraw water from streams by 2012 using standard protocols and nationally consistent methods (U.S. Geological Survey, 1997–2006).

This fact sheet highlights findings from the Running Gutter Brook study, which is one of the first nine community water systems sampled. The fact sheet serves as a companion product to a USGS Scientific Investigations Report and Data Series Report that present findings for the nine systems across the United States (Carter and others, 2007; Kingsbury and others, 2008). http://water.usgs.gov/nawqa/swqa/.

Additional information on Running Gutter Brook Watershed Water-Quality Assessment is available on the World Wide Web at http://ct.water.usgs.gov/nawqa/.

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USGS Promotes Public Access to Water-Quality Information

This fact sheet, the USGS national data and investigations reports, and other information are available on the World Wide Web at http://water.usgs.gov/nawqa/swqa. Included at this Web site are downloadable data on organic compound occurrence, information on sampling designs and methodology, background on data analyses, and frequently asked questions.

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