Occurrence of Pharmaceuticals in Shallow Ground Water of Suffolk County, New York, 2002–2005

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Prepared in cooperation with the Suffolk County Water Authority

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Abbreviations, Acronyms, And Datums

Abbreviated Units of Measurement

µg/L	micrograms per liter
µm	micrometer

List of Acronyms

MDL	Method detection limits
PhAC	Pharmaceutically active compound
PPCP	Pharmaceutical and personal-care products
SCWA	Suffolk County Water Authority
USGS	U.S. Geological Survey

Vertical coordinate information is referenced to the North American Vertical Datum of 1988 (NAVD 88).

Horizontal coordinate information is referenced to the North American Datum of 1983 (NAD 83).

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Abstract

Seventy (70) water samples were collected from 61 wells in the upper glacial and Magothy aquifers (9 wells were sampled twice) during 2002–05 and analyzed for 24 pharmaceuticals. Wells were selected for their proximity to known wastewater-treatment facilities that discharge to the shallow upper glacial aquifer. Of the 70 samples taken, pharmaceuticals were detected in 28, of which 19 contained one compound, and 9 contained two or more compounds. Concentrations of detected compounds were extremely low; most ranged from 0.001 to 0.1 microgram per liter (part per billion). The two most commonly detected compounds were carbamazepine (an antiepileptic drug) and sulfamethoxazole (an antibiotic). Occurrence of pharmaceutical compounds in Suffolk County ground water is less prevalent than in susceptible streams of the United States that were tested in 1998–2000, but the similarity of median concentrations of the detected compounds of the two data sets indicates that current wastewater practices can serve to introduce pharmaceuticals to this shallow aquifer.

Introduction

Aquatic environments that receive treated wastewater have been found to contain pharmaceutically active compounds (PhACs; Daughton and Ternes, 1999). This class of organic compounds includes prescription and non-prescription drugs, compounds (such as caffeine) that are added to consumables that elicit a biological effect, and (or) human metabolites of such compounds (for example cotinine, the primary human metabolite of nicotine). These compounds are discharged to the environment in the effluent from domestic or municipal wastewater-treatment systems, as well as from untreated sewage discharged during combined sewer overflow events or from leaky sewers. To date, the two most extensive studies of pharmaceutical occurrence in the United States have focused on surface waters that receive treated wastewater (Kolpin and others, 2002; Glassmeyer and others, 2005). In many areas of the United States, treated wastewater is discharged to the surficial aquifer, yet an extensive survey of PhAC contamination of ground water has not been conducted. Ground water is the sole source of drinking water for Suffolk County's population of 1.4 million. The shallow sand and gravel aquifer, commonly called the upper glacial aquifer, may be susceptible to wastewater contamination from discharges of wastewater-treatment facilities and domestic cesspools and septic tanks. About 75 percent of the wastewater entering the upper glacial aquifer comes from domestic cesspools and septic tanks; the remainder comes from municipal and private wastewater-treatment plants.

In 2002, the U.S. Geological Survey (USGS), in cooperation with the Suffolk County Water Authority (SCWA), began a 4-year study to document the occurrence of PhACs in ground-water wells throughout Suffolk County. This report summarizes the results from this study and relates the concentrations and frequencies of detection to those reported from a 1998–2000 nationwide study of streams that receive wastewater (Kolpin and others, 2002).

Methods

Seventy samples were collected from 61 wells close to wastewater-treatment facilities that discharge effluent to the upper glacial aquifer (fig. 1) to assess the occurrence of PhACs in shallow ground-water near the discharge points. All wells were within a mile of a wastewater treatment facility and were in partly unsewered areas that also contained domestic septic tanks and cesspools. All wells were sampled in accordance with established sampling methods (US Geological Survey, variously dated). Samples were collected in 1-liter bottles, filtered at the USGS office in Coram, N.Y. through Gellman 0.7 μm baked glass-fiber filters, then shipped overnight to the USGS National Water Quality Laboratory in Denver, Colo., for extraction and analysis of 24 compounds (table 1). The samples were solid-phase extracted and analyzed on a liquid chromatography-mass spectrometry system operated in selected-ion-monitoring mode. Details of the extraction and analysis method are given in Cahill and others (2004). Method detection limits (MDLs) were established as part of a long-term laboratory study and are available on the USGS

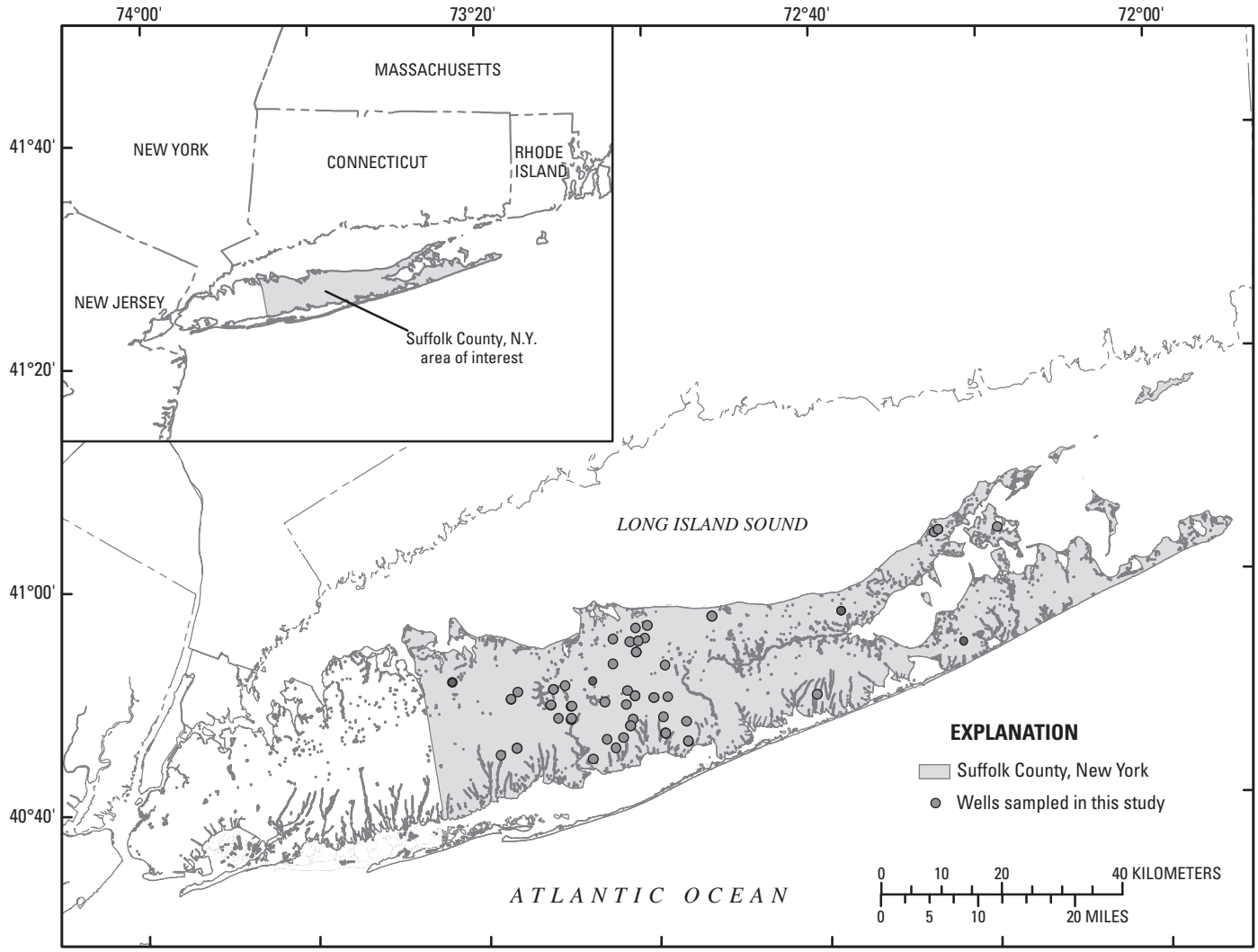

Figure 1. Locations of the 61 wells sampled during 2002–05 in Suffolk County, New York.

National Water Quality Web site (http://nwql.usgs.gov). Only concentrations greater than the MDL and greater than 10 times the concentration detected in a laboratory blank are reported herein. A total of 156 qualitatively identified detections were made, but only 54 quantified concentrations were reportable because 81 detections were less than the MDL, and 21 were less than 10 times the concentration in a corresponding laboratory blank.

Occurrence of Pharmaceuticals

More than half (42) of the 70 samples were free of all 24 compounds. Of the remaining 28 samples, 19 contained only one PhAC, and 9 contained two or more. The distribution of measured concentrations is plotted in figure 2, which includes median detected concentrations for the 139 susceptible streams sampled throughout the United States during 1998–2000 (Kolpin and others, 2002). In general, concentrations in the ground-water samples were similar to those reported in streams. Whether these concentrations represent amounts to which people are exposed from tap water is unknown because two studies (Adams and others, 2002; Boyd and others, 2003) have shown that chlorination of public-supply water before distribution to homes removes pharmaceuticals through chemical oxidation, whereas another study (Stackleberg and others, 2004) showed that some organic wastewater contaminants, including selected pharmaceuticals, persist through the drinking-water treatment process.

The frequency of detection for individual compounds is summarized in table 1. Only 13 of the 24 compounds for which the samples were analyzed were detected. Eleven of 24 compounds were not detected in any of the samples. The most frequently detected compounds were carbamazepine, a prescription antiepileptic drug (detected in 26 percent, or 18

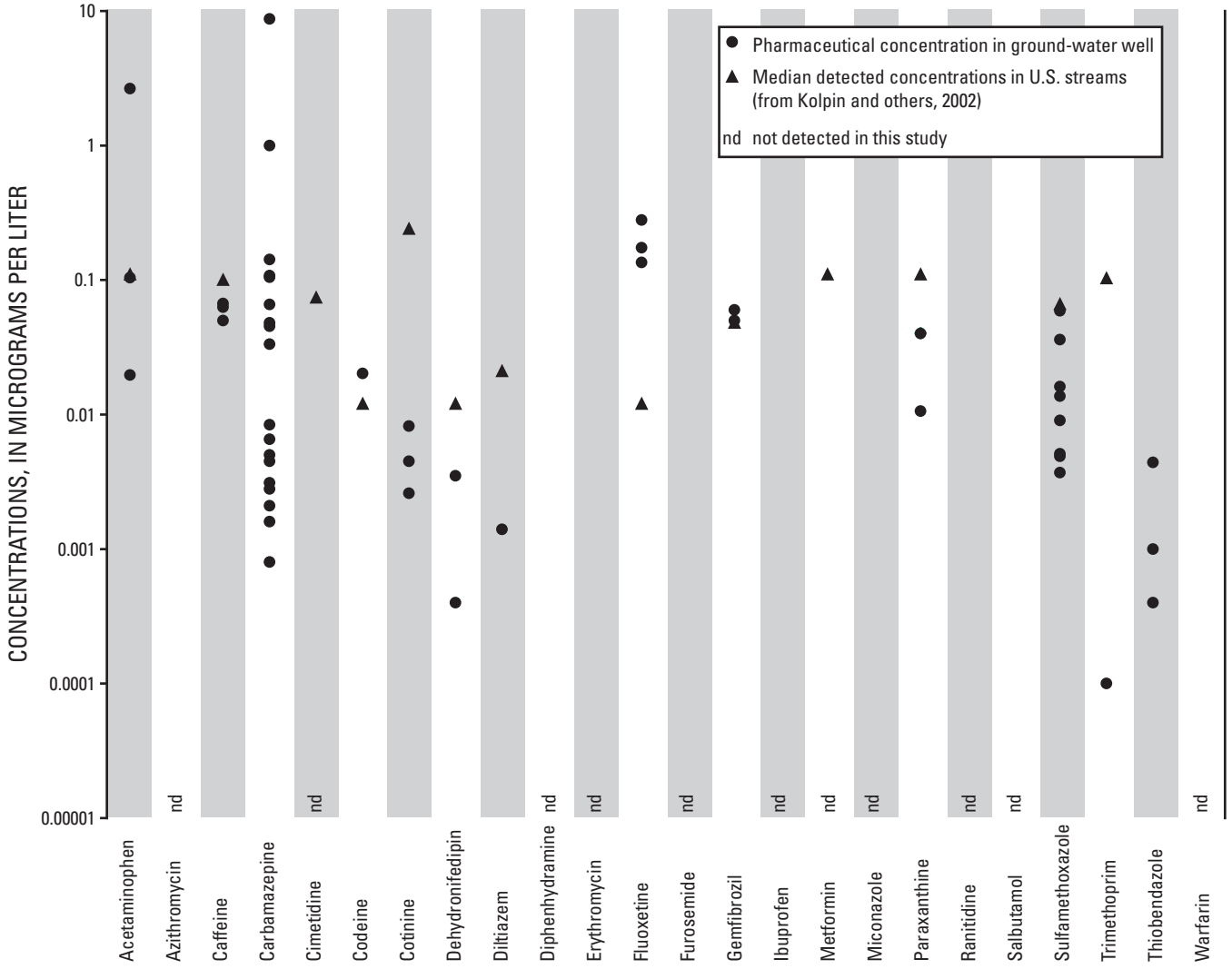

Figure 2. Concentrations of pharmaceuticals detected in 61 wells in Suffolk County, Long Island, N.Y. (Locations of wells are shown in figure 1).

of 70 samples) and sulfamethoxazole, a widely used antibiotic (detected in 13 percent, or 9 of 70 samples). These two compounds were found by other studies to be among the most commonly detected pharmaceutical contaminants (Kolpin and others, 2002; Clara and others, 2004; Bendz and others, 2005). None of the other 11 detected compounds were found in more than 10 percent of the samples.

Comparison of these results with those reported for susceptible streams in the United States (Kolpin and others, 2002) reveals two distinct trends (table 1). First, the median concentrations of detected pharmaceuticals in surface waters are similar to the median observed in Suffolk County ground water. Second, the detection frequency for the surface-water samples was higher than for ground-water samples. Of the 11 compounds detected in both studies (presented in bold), 5 had median concentrations that were similar (within a factor of 2) in both data sets; these compounds were acetaminophen, caffeine, codeine, cotinine, and gemfibrozil. Another five of the compounds detected in both samples had median concentrations more than three times greater in surface-water samples than in the Suffolk County ground-water samples; these compounds were dehydronifedipine, diltiazem, paraxanthine, sulfamethoxazole, and trimethoprim. Only one compound (fluoxetine) was found in greater concentration in ground water than in surface water: measured ground-water concentrations were roughly 10 times higher than the reported surface-water median concentration.

Comparison of the detection frequency of the 11 compounds present in both studies indicates that only 1 compound (sulfamethoxazole) was detected in more than 10 percent of the ground-water samples; the remaining 10 compounds detected in fewer than 10 percent of the samples were acetaminophen, caffeine, codeine, cotinine, dehydonifedipine, diltiazem, fluoxetine, gemfibrozil,

Table 1. Comparison of median detected concentrations and detection frequencies between pharmaceuticals in 61 ground-water wells in Suffolk County, Long Island, New York, 2002-2005, and 139 streams throughout the United States during 1998–2000.

[µg/L, micrograms per liter. Detection frequencies are the percentage of samples in which compound was detected; surface-water frequency values are percentage of 139 samples. Boldface denotes compounds detected in both data sets. nd, not detected. --, compound not reported in 2002 surface water publication. Surface-water data from Kolpin and others (2002)]

Compound	Suffolk County wells		U.S. streams	
	Median detected concentration (µg/L)	Detection frequency (percent)	Median detected concentration (µg/L)	Detection frequency (percent)
Acetaminophen	**0.10**	**4.3**	**0.11**	**23.8**
Azithromycin	nd	0	--	--
Caffeine	**0.067**	**4.3**	**0.081**	**61.9**
Carbamazapine	0.005	26	--	--
Cimetidine	nd	0	0.074	9.5
Codeine	**0.020**	**1.4**	**0.012**	**6.5**
Cotinine	**0.045**	**4.3**	**0.024**	**38.1**
Dehydronifedipine	**0.0004**	**4.3**	**0.012**	**14.3**
Diltiazem	**0.0014**	**1.4**	**0.021**	**13.1**
Diphenhydramine	nd	0	--	--
Erythromycin	nd	0	0.1	21.5
Fluoxetine	**0.17**	**4.3**	**0.012**	**1.2**
Furosemide	nd	0	--	--
Gemfibrozil	**0.055**	**2.9**	**0.048**	**3.6**
Ibuprofen	nd	0	0.20	9.5
Metformin	nd	0	0.11	4.8
Miconazole	nd	0	--	--
Paraxanthine	**0.040**	**4.3**	**0.11**	**28.6**
Ranitidine	nd	0	0.01	1.2
Salbutamol	nd	0	nd	0
Sulfamethoxazole	**0.0091**	**13**	**0.066**	**19.0**
Thiabendazole	0.0008	5.7	--	--
Trimethoprim	**0.0001**	**1.4**	**0.013**	**27.4**
Warfarin	nd	0	nd	0

paraxanthine and trimethoprim. The surface-water samples, in contrast, showed detection of 8 of the 11 compounds (acetaminophen, caffeine, cotinine, dehydronipedipine, diltiazem, paraxanthine, sulfamethoxazole, and trimethoprim), in more than 10 percent of samples; only codeine, fluoxetine, and gemfibrozil were found in fewer than 10 percent of samples.

The effects of treated municipal effluent, and domestic septic-tank and cesspool effluent on local ground-water supplies are unknown. The absolute PhAC concentration in the ground-water samples was low, that is, the mass of each compound in 1 liter of ground-water was 5 to 7 orders of magnitude (100,000 to 10,000,000 times) lower than a typical therapeutic dose, and any toxic effects associated with such concentrations are unlikely (Halling-Sorensen and others, 1998; Kolpin and others, 2002). PhACs have been suggested as reliable tracers of wastewater (Buerge and others, 2003; Clara and others, 2004). Their presence in Suffolk County ground water therefore indicates the presence of wastewater in the aquifer and, thus, potential contamination from nutrients and pathogens. Additional research is needed to define the fluxes of PhACs to ground water and define the relative amounts of contamination from municipal wastewater or domestic septic-tank and cesspool effluent.

Conclusions

Shallow ground water close to wastewater discharge points in Suffolk County contains low, but measurable concentrations of several PhACs. Of the 61 wells selected for sampling, 19 contained only one of the 24 compounds for which samples were analyzed and 9 samples contained two or more. Detected concentrations in ground-water wells were similar to those reported in susceptible streams sampled in a 1998–2000 study and 5 to 7 orders of magnitude below therapeutic doses. Detection frequency of individual compounds in ground water was generally lower than in the susceptible surface waters. Shallow ground water in areas in which treated wastewater is discharged to the underlying aquifer have the potential for contamination with PhACs.

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