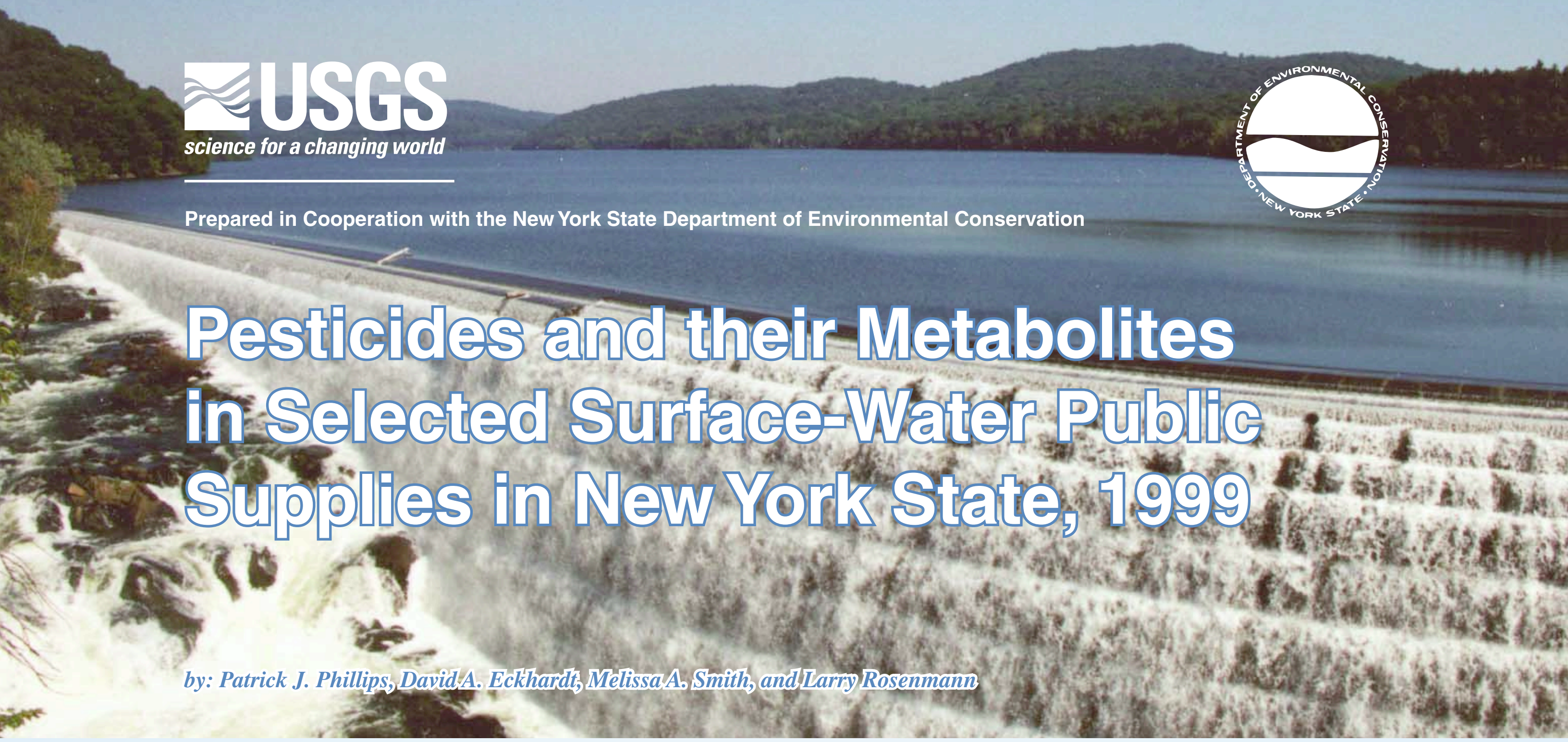

Prepared in Cooperation with the New York State Department of Environmental Conservation

Pesticides and their Metabolites in Selected Surface-Water Public Supplies in New York State, 1999

by: Patrick J. Phillips, David A. Eckhardt, Melissa A. Smith, and Larry Rosenmann

Sixteen different pesticides or their metabolites (degradations products) were detected in water samples collected in 1999 from three networks of lakes and reservoirs in upstate New York that are sources of public water supply. The networks sampled included the New York City network (10 reservoirs); the Finger Lakes – Great Lakes network (three Finger Lakes and two Great Lakes that supply large and small cities) and the western New York reservoir network (three reservoirs that supply small cities or towns).

The concentrations of the compounds detected in the samples generally were low. Only a few of the compounds detected had a concentration exceeding 1 µg/L (microgram per liter), and no compounds detected in the New York City reservoirs network had concentrations exceeding 0.05 µg/L. None of the compounds detected exceeded any Federal or State water-quality standard. Compounds that were most frequently detected, and whose concentrations were highest, were the three herbicides atrazine, metolachlor, and simazine, and two herbicide metabolites (the atrazine metabolite deethylatrazine, and the metolachlor metabolite metolachlor ESA). Most of these compounds, or their parent compounds, are used on corn or other row crops.

Median total pesticide and metabolite concentration for each network ranged from less than 0.02 µg/L for the New York City reservoirs network to more than 2 µg/L for the western New York reservoir network; the median for the Finger Lakes – Great Lakes network was about 0.1 µg/L. These differences reflect the amount of agricultural land use within each of the three networks, although other factors can affect pesticide and metabolite concentrations. The watersheds of the New York City reservoirs have the lowest percentage of agricultural land, and those of the western New York reservoirs have the highest. The highest herbicide or herbicide-metabolite concentrations among the New York City reservoirs were in the Cannonsville reservoir, whose watershed has a high percentage of agricultural land. The highest pesticide concentrations of the Lake sites were in Cayuga Lake, and the highest pesticide concentrations of the western New York reservoir sites were at the LeRoy Reservoir.

The drought conditions in 1999 resulted in a general decrease in median total concentrations, and in the median number of detected compounds, in all networks, from January through September. Pesticide concentrations at the western New York reservoir sites were lower in 1999 than in 1998, as a result of the late-spring and early-summer drought conditions in 1999. Concentrations of pesticides in surface-water supplies are likely to be higher during years with normal or high streamflows than in years of drought, and the small reservoirs are likely to show a greater change in pesticide concentrations from drought year to nondrought years than the larger water bodies.

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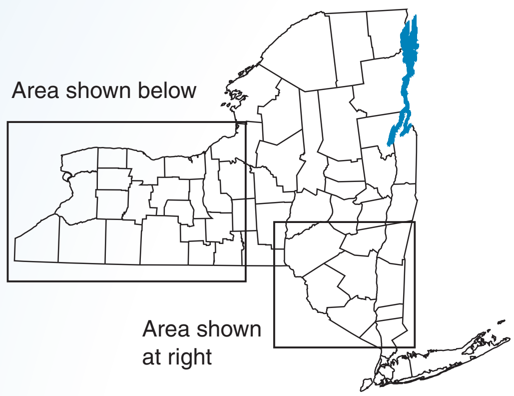
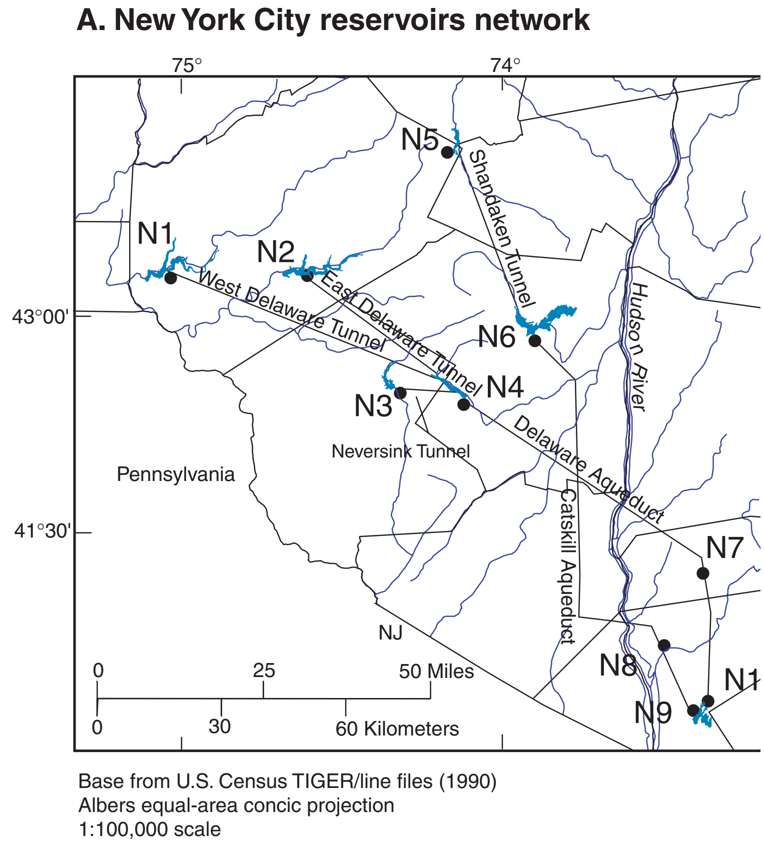


EXPLANATION

- N5-Prefix N denotes New York City reservoirs network
- L1-Prefix L denotes Finger Lakes-Great Lakes network
- W1-Prefix W denotes western New York reservoirs network



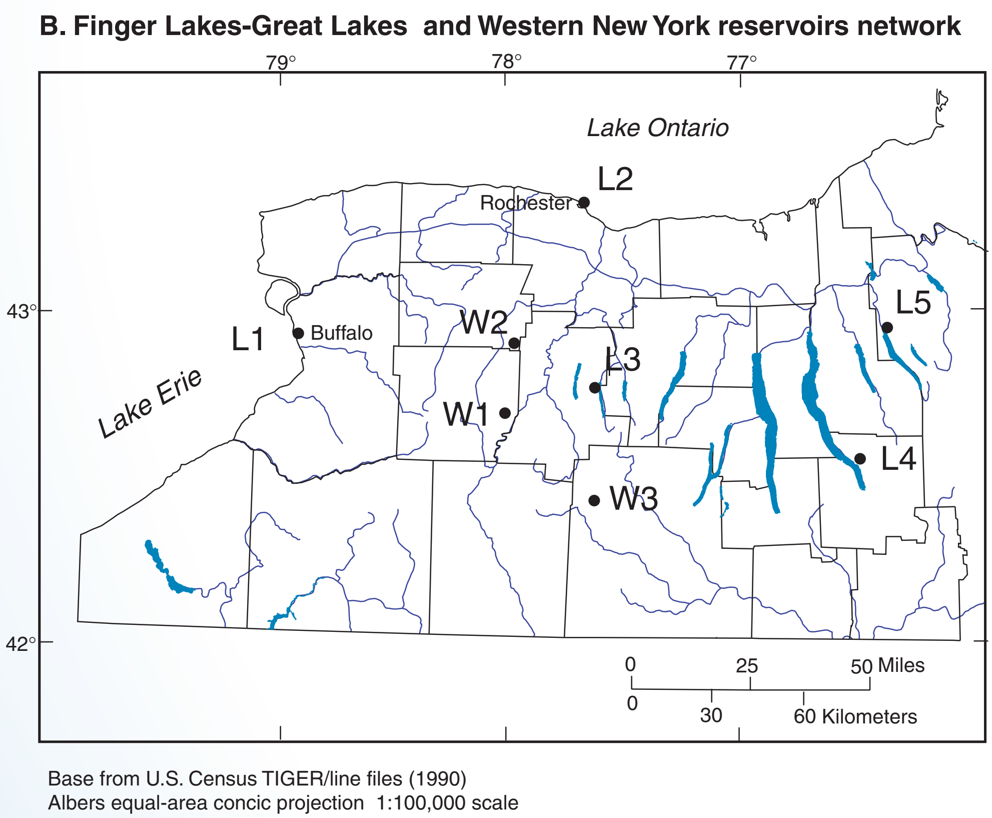


Figure 1. Locations of public-water supply sites in New York sampled from January 1999 through September 1999. A. New York City reservoirs network. B. Western New York reservoirs network and Lakes network.

INTRODUCTION

In 1997, the U.S. Geological Survey (USGS), in cooperation with the New York State Department of Environmental Conservation (NYSDEC), began a statewide monitoring program to assess the occurrence of pesticides in ground water and surface waters of New York State, including Long Island. A part of the monitoring program investigates the occurrence of pesticides and their metabolites in public-water-supply reservoirs. Water samples were collected from three networks or reservoirs during 1999 — the 10 New York City water-supply reservoirs (referred to as the New York City reservoirs network); three Finger Lakes, Lake Erie, and Lake Ontario (referred to as the Finger Lakes-Great Lakes network); and three small reservoirs in western New York that supply small cities or towns (referred to as the western New York reservoirs network).

The reservoirs of the three networks serve a large population and represent a wide range in size and land use. The New York City reservoirs and the Finger Lakes-Great Lakes sites were chosen for study because they serve large metropolitan populations. The Finger Lakes-Great Lakes sites and the western New York reservoirs were chosen because many of their watersheds contain substantial amounts of agricultural land. The western New York reservoirs were chosen because routine monitoring by the New York State Department of Health (NYSDOH) has indicated that they contain higher concentrations of pesticides than many other water-supply reservoirs in New York (Paul Kaczmarczyk, New York State Department of Health, oral commun., 1999). A previous USGS-NYSDEC study of pesticides in the same three western New York reservoirs and their tributaries in 1998 detected many herbicides and herbicide metabolites (Phillips and others, 1999), although none of the compounds were detected at concentrations that exceeded Federal or State water-quality standards at water-supply intake sites.

The purpose of the 1999 study was to relate the occurrence and concentrations of pesticides and their metabolites within the selected public-supply Lakes and reservoirs across New York to (1) Federal and State water-quality standards; (2) the percentage of agricultural land within the watersheds; and (3) the season of sampling. The study entailed sampling at 18 sites from January 1999 through September 1999. All samples were collected at water-supply intakes, where water is withdrawn for public supply. The sampling sites, and the land use within the watershed of each sampling site are summarized in table 1.

The study addressed a larger number of pesticides and metabolites, and used far lower analytical detection limits, than those typically used in routine pesticide monitoring in public-water supplies. Of particular interest in this study were two metabolites of the commonly used herbicide metolachlor — metolachlor ESA (ethanesulfonic acid) and metolachlor OA (oxanilic acid). These two metabolites have frequently been detected in surface waters in agricultural areas of New York and other states (Phillips and others, 1999; Eckhardt and others, 1999; Kahlkoff and others, 1998), and the concentrations of these metabolites in lakes and reservoirs are frequently much higher than those of the parent compounds from which they are derived (Phillips and others, 1999; Eckhardt and others, 1999).

STUDY METHODS

Each site was sampled at a point where water is diverted for water supply. Locations of the sampling sites are shown in figure 1; the site names, drainage area, and land-use characteristics of the corresponding watersheds are given in table 1. The samples consisted of raw, untreated water collected at intake sites, thus, the analytical results do not represent treated (finished) water that is provided to consumers. All sites were sampled once in January, May, July, and September 1999 except those on Lake Erie and Lake Ontario (sites L1 and L2), which were sampled only in July and September 1999.

Samples were analyzed in USGS laboratories for 60 pesticides and metabolites through methods described by Zaugg and others (1995), Zimmerman and Thurman (1999), and Ferrer and others (1997) (table 2). The analytical method described by Zaugg and others (1995) was developed in cooperation with the U.S. Environmental Protection Agency and was designed to include some of the most commonly used pesticides in the nation. The detection limits of the laboratory methods used to analyze samples for the compounds monitored in this study ranged from 0.001 to 0.2 µg/L (table 2). This range is much lower than that obtained by analytical methods typically used in public-water-supply monitoring programs and provides much higher rates of detection than would be possible with the less sensitive analytical methods.

Land-use characteristics for the watersheds above each sampling site were identified through satellite imagery data collected in 1994 (U.S. Geological Survey, 1998). Land use in the Lake Erie and Lake Ontario watersheds (sites L1 and L2 in fig. 1) was not determined because these lakes receive water from the other Great Lakes.

Table 1. Land use in drainage areas above the 18 water-supply sources in the three public water-supply networks in New York that were sampled from May 1998 through September 1999

[Locations are shown in fig. 1. Land-use data based on USGS satellite-imagery data, 1998. Dashes indicate data do not apply.]

Site name	Symbol in figs. 1-4	Drainage area (square miles)	Percentage of drainage area		
			Agriculture	Residential	Forest
New York City Reservoirs Network					
Delaware System					
Cannonsville	N1	455	20	0.89	78
Pepacton	N2	371	9.1	0.45	88
Neversink	N3	92	1.8	0.21	96
Rondout	N4	95	3.1	0.42	93
Catskill System					
Schoharie	N5	316	9.0	.95	89
Ashokan	N6	256	1.2	1.2	93
Receiving Reservoirs					
New Croton [1]	N8	375	6.6	14	69
West Branch [2]	N7	43	1.8	5.0	81
Kensico - Delaware [2]	N9	13	2.3	16	55
Kensico - Catskill [3]	N10	13	2.3	16	55
Lakes Network					
Lake Erie - Buffalo	L1	-	-	-	-
Lake Ontario - Monroe County Water Authority	L2	-	-	-	-
Hemlock Lake - Rochester	L3	43.5	25	0.43	68
Cayuga Lake - Ithaca (Bolton Point)	L4	785	49	2.2	39
Skaneateles Lake - Syracuse	L5	72.8	34	2.7	44
Western New York Reservoirs Network					
Silver Lake - Perry	W1	17.4	73	2.0	17
LeRoy Reservoir - LeRoy	W2	3.33	83	0.10	12
Hornell Reservoir - Hornell	W3	13.0	41	0.19	58

[1] Receives minor amounts of water from Delaware system.
[2] Receives water from Delaware system
[3] Receives water from Catskill system

WHAT ARE METABOLITES?

Metabolites are formed through the metabolic degradation of a parent compound mainly during contact with soil. The metabolites can be present in water at concentrations higher than those of the parent compound. Some metabolites can form through the degradation of more than one compound. For example, deisopropylatrazine can form from the degradation of either atrazine or simazine (Thurman and others, 1994). Other metabolites are derived from only one parent compound. For example, metolachlor ESA and metolachlor OA are derived solely from the parent compound metolachlor (table 3).

Table 2. Detection limits for the 60 pesticide and pesticide degradates for which samples from the three public water-supply sampling networks in New York were analyzed, January through May 1999

[ESA, ethanasulfonic acid; OA, oxanilic acid. Detection-limit concentrations (in parentheses) are in micrograms per liter. Laboratory methods used in this study resulted in low and (or) inconsistent recovery for five pesticides—carbaryl, carbofuran, deethylatrazine, terbacil and azinphos-methyl; concentrations reported for these compounds are considered estimates and may be lower than the true concentration (Chris Lindley, U.S. Geological Survey, written commun., 1994.)]

Pesticide	Detection limit	Pesticide	Detection limit	Pesticide	Detection limit	Pesticide	Detection limit
A. Gas Chromatography/Mass Spectrometry U.S. Geological Survey National Water Quality Laboratory, Denver, Colo.							
Acetochlor	(0.002)	Deethylatrazine*	(0.002)	Metolachlor	(0.002)	Pronamide	(0.003)
Alachlor	(0.002)	Diazinon	(0.002)	Metribuzin	(0.004)	Propachlor	(0.007)
alpha-HCH	(0.002)	Dieldrin	(0.001)	Molinate	(0.004)	Propanil	(0.004)
Atrazine	(0.001)	Disulfoton	(0.017)	Napropamide	(0.003)	Propargite	(0.013)
Benfluralin	(0.002)	EPTC	(0.002)	*p,p'*-DDE*	(0.006)	Simazine	(0.005)
Butylate	(0.002)	Ethalfluralin	(0.004)	Parathion	(0.004)	Tebuthiuron	(0.010)
Carbaryl	(0.003)	Ethopropos	(0.003)	Parathion-methyl	(0.006)	Terbacil	(0.007)
Carbofuran	(0.003)	Fonofos	(0.003)	Pebulate	(0.004)	Terbufos	(0.013)
Chlorpyrifos	(0.004)	Lindane	(0.004)	Pendimethalin	(0.004)	Thiobencarb	(0.002)
Cyanazine	(0.004)	Linuron	(0.002)	*cis*-Permethrin	(0.005)	Tri-allate	(0.001)
DCPA	(0.002)	Malathion	(0.005)	Phorate	(0.002)	Trifluarlin	(0.002)
2,6-Diethylanaline*	(0.003)	Methyl azinphos	(0.001)	Prometon	(0.017)		
B. High Performance Liquid Chromatography U.S. Geological Survey Organic Research Laboratory, Lawrence, Kansas							
Acetachlor ESA*	(0.2)	Alachlor ESA*	(0.2)	Hydroxyatrazine*	(0.2)	Metolachlor OA*	(0.2)
Acetachlor OA*	(0.2)	Alachlor OA*	(0.2)	Metolachlor ESA*	(0.2)		
C. Gas Chromatography/Mass Spectrometry U.S. Geological Survey Organic Research Laboratory, Lawrence, Kansas							
Ametryn	(0.05)	Deisopropylatrazine*	(0.05)	Propazine	(0.05)		
Cyanazine Amide*	(0.05)	Prometryn	(0.05)	Terbutryn	(0.05)		

* degradation product

Sampling for herbicide metabolites in this study was motivated in part by (1) findings in the midwestern United States that the concentrations of many metabolites in surface water and ground water commonly equaled or exceeded those of the parent compound (Kahlkoff and others, 1998; Thurman and others, 1994; Clark and others, 1999), and (2) similar findings in New York State (Eckhardt and others, 1999; Phillips and others, 1999). Little is known about the health effects of these metabolites, and no Federal water-quality standards for the herbicide metabolites detected in this study have been established. Metabolites represented more than half of the total mass of pesticides and metabolites detected in many samples collected in this study.

CONCENTRATIONS OF PESTICIDES AND THEIR METABOLITES

Of the 60 pesticides and pesticide metabolites for which samples were analyzed, 16 (27 percent) were detected, 8 of which were herbicides, and 8 were herbicide metabolites. No insecticides were detected. Pesticide and metabolite concentrations in samples from each of the three networks and their relation to Federal and State water quality standards are summarized in figure 2. Concentrations of the compounds detected in this study were generally low; although 11 compounds were detected at concentrations exceeding 0.05 µg/L in one or more samples, only three compounds were detected at a concentration exceeding 1 µg/L. None of the compounds in samples from the New York City reservoir network exceeded a concentration of 0.05 µg/L. Of the 11 compounds whose concentrations exceeded 0.05 µg/L, three were herbicides (atrazine, metolachlor, and cyanazine) and eight were herbicide metabolites (deethylatrazine and hydroxyatrazine, alachlor ESA, alachlor OA, metolachlor ESA, metolachlor OA, deisopropylatrazine, and cyanazine amide) (fig. 3). The relation between the parent compounds and their metabolites, and the predominant use of each parent compound, are shown in table 3. All 11 of these compounds were detected at concentrations exceeding 0.05 µg/L at least once in the western New York reservoir network (fig. 3); five of these (atrazine, deethylatrazine, alachlor ESA, metolachlor ESA, and metolachlor OA) were detected at a concentration exceeding 0.05 µg/L in more than half of the samples from this network. Four of these five compounds (excluding alachlor ESA) were detected at these concentrations at least once in samples from the Finger Lakes-Great Lakes network. The maximum concentration of metolachlor ESA, metolachlor OA, and hydroxyatrazine exceeded 1 µg/L; each of the corresponding samples was from either the LeRoy reservoir or Silver Lake in western New York. The herbicides and herbicide metabolites detected are discussed in the following sections in order of decreasing frequency of detection.

Atrazine, Metolachlor, Deethylatrazine, Metolachlor ESA, and Simazine

These compounds, or their parent compounds, are used on corn and other row crops, and simazine is also used in orchards, vineyards, and rights-of-way (table 3). All of these compounds except metolachlor ESA were detected in samples from at least one site in each of the three networks. Atrazine, metolachlor, and deethylatrazine were detected in all samples from the Finger Lakes–Great Lakes and western New York reservoir networks, and in more than half of the samples from the New York City reservoirs network. Metolachlor ESA and simazine were detected in at least 38 percent of the samples from the Finger Lakes-Great Lakes and western New York reservoir networks, but in less than 10 percent of the samples from the New York City reservoir network. Concentrations of each of these five compounds in the three networks ranged from less than 0.01 µg/L to nearly 4 µg/L.

Cyanazine, Metolachlor OA, and Prometon

Cyanazine and the parent compound of metolachlor OA are used on corn and other row crops (table 3). Prometon is used for nonagricultural purposes, such as along rights-of-way and as an additive in asphalt. These three compounds were detected in 28 to 75 percent of the samples from the Lakes and western New York reservoir networks. Prometon was detected in only 5 percent of the New York City reservoir samples. Concentrations of each of these compounds ranged from less than 0.005 µg/L to 2.4 µg/L.

Alachlor ESA, Alachlor OA, Deisopropylatrazine, Alachlor, and Hydroxyatrazine

All of these compounds, or their parent compounds, are used on corn and other row crops (table 3). These compounds were detected in 17 to 44 percent of the samples from the western New York reservoir network, but not in samples from any other network. Except for alachlor, the concentrations of these compounds, when detected, ranged from 0.05 to 1.3 µg/L; the concentration of alachlor did not exceed 0.01 µg/L.

DCPA, Cyanazine Amide, and EPTC

All of these compounds, or their parent compounds, are used on corn and other row crops. DCPA is used in agricultural and nonagricultural settings and was detected in 13 percent of the samples from the Lakes network, but not in samples from any other networks. Cyanazine amide and EPTC were detected in less than 10 percent of the samples from the western New York reservoir network, and in no samples from any other network. Concentrations of DCPA and EPTC were less than 0.02 µg/L, and those of cyanazine amide were more than 0.2 µg/L.

PESTICIDE CONCENTRATIONS IN THE THREE NETWORKS IN RELATION TO FEDERAL AND STATE WATER-QUALITY STANDARDS

The samples analyzed in this study contained no pesticides at concentrations that exceeded any Federal or State water-quality standards (fig. 2). The maximum concentrations of the most frequently detected pesticides were between 5 and 25 percent of the lowest applicable water-quality standard. Maximum concentrations in samples from the New York City reservoir network ranged from less than 1 percent to 5 percent of the lowest applicable water-quality standard. No Federal drinking-water standards have been established for many of the compounds detected. The water-quality standards referenced in this report are summarized in the box on page 13.

DIFFERENCES IN PESTICIDE CONCENTRATIONS AND NUMBER OF COMPOUNDS DETECTED AMONG NETWORKS

The samples from the western New York reservoir network had higher pesticide concentrations and a larger number of pesticides detected than samples from the other two networks. The western New York reservoir samples had the highest median number of pesticides and metabolites detected (7 compounds) (fig. 4), and the samples from the New York city reservoir network had the lowest (3). The samples from the Finger Lakes–Great Lakes network had an intermediate median (4.5). The samples from the western New York reservoirs network also had the highest pesticides and metabolite concentrations (more than 2 µg/L), and the samples from the New York City reservoir network had the lowest (0.02 µg/L). Those from the Finger Lakes-Great Lakes network were intermediate (0.1 µg/L) (fig. 4). This difference is attributable to differences in the percentage of agricultural land with the watersheds of the three networks — the New York City reservoir watersheds have the lowest percentage of agricultural land, and the watersheds in the western New York reservoirs network have the highest. Factors other than land use that can also affect pesticide and metabolite concentrations in surface water are soil type, geology, hydrologic conditions, and proximity of pesticide applications to the surface-water bodies.

DIFFERENCES IN PESTICIDE CONCENTRATIONS AND NUMBER OF COMPOUNDS DETECTED WITHIN NETWORKS

Pesticide and metabolite concentrations among sites within each network differed, depending on the principal land use within the watersheds. The following sections describes the concentrations of three herbicides (atrazine, simazine, and metolachlor) and three herbicide metabolites (deethylatrazine, metolachlor OA, and metolachlor ESA) within each network.

New York City Reservoirs Network

Samples from the Cannonsville reservoir had the highest herbicide or herbicide metabolite concentrations (fig. 5) presumably because of the higher percentage of agricultural land use in its drainage area than in the other New York City reservoir watersheds. The Pepacton and Schoharie reservoirs, which have relatively high percentages of agricultural land in their watersheds, also had high concentrations of atrazine and metolachlor relative to many of the other New York City reservoir samples. In contrast, the Neversink reservoir, the New York City reservoirs whose watershed contained the least amount of agricultural land, contained no detectable amounts of pesticides or metabolites.

The relation between land use and pesticide concentrations in the New York City reservoirs is complicated by the transfer of water among reservoirs (the connections are shown in fig. 1). Three of the sites — West Branch, Kensico-Delaware, and Kensico-Catskill (sites N7, N9, and N10 in fig. 1) receive substantial amounts of water from upstream reservoirs. West Branch (site N7) receives water from the Rondout reservoir (site N4), and one of the Kensico reservoir sites (site N9) receives water from the Rondout reservoir (site N4), which serves the Delaware system, whereas the other Kensico Reservoir site (site N10) receives water from the Ashokan reservoir (site N6), which serves the Catskill system. Thus, the pesticides present at these sites are probably derived from sources outside the immediate drainage areas of these reservoirs. The watersheds that surround the Ashokan, Rondout, and Neversink reservoirs contain little agricultural land; nevertheless, atrazine, deethylatrazine and metolachlor were detected in samples from two of these reservoirs (Ashokan and Rondout). This is probably because these two reservoirs receive

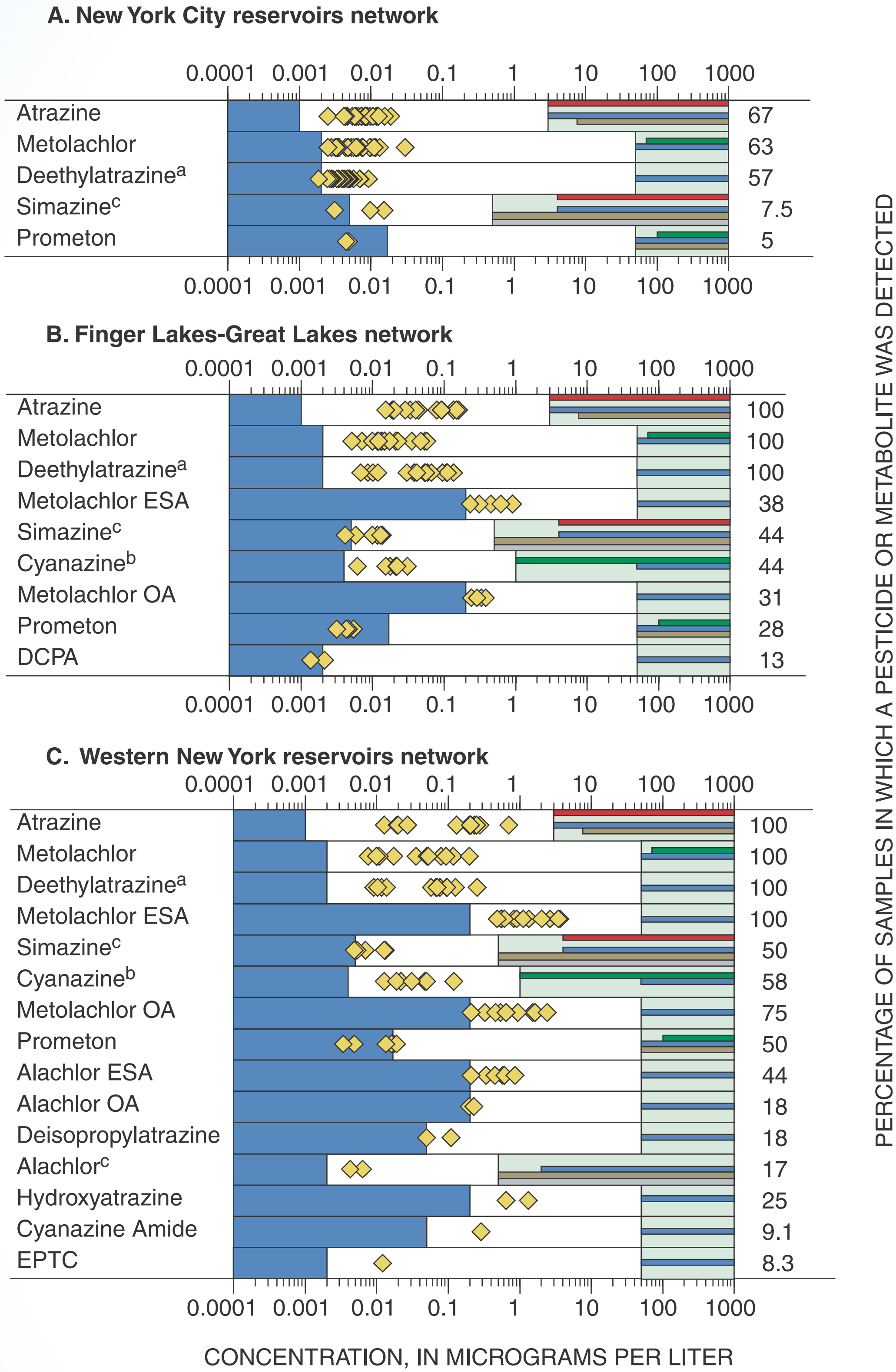
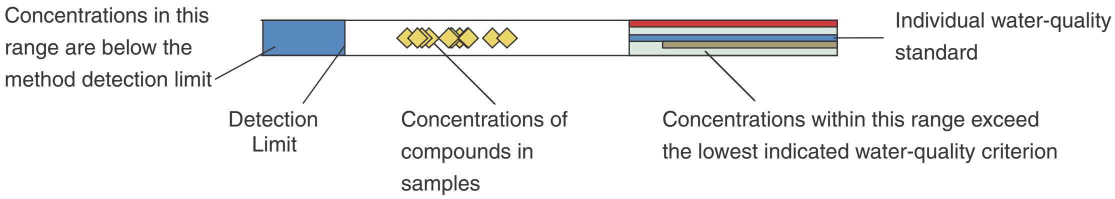


Figure 2. Concentrations of pesticides and metabolites detected in water samples from the three public-supply networks in New York, the relation of detected concentrations to applicable water-quality standards, and percentage of samples in which each compound was detected.

EXPLANATION



Water-quality criteria:

- Federal Maximum Contaminant Level (MCL)
- Federal Lifetime Health Advisory (HA)
- New York State Maximum Contaminant Level
- New York State Class GA
- New York State Surface-Water Standard

NOTE: Percentage values and constituent range include quantifiable detections below method detection limits. Percentage values may not be comparable between pesticides due to different detection limits and the number of quantifiable detections below the method detection limit.

Footnotes

[a] - Estimated concentration because of low and/or inconsistent recovery.

[b] - Draft Federal Lifetime Health Advisory

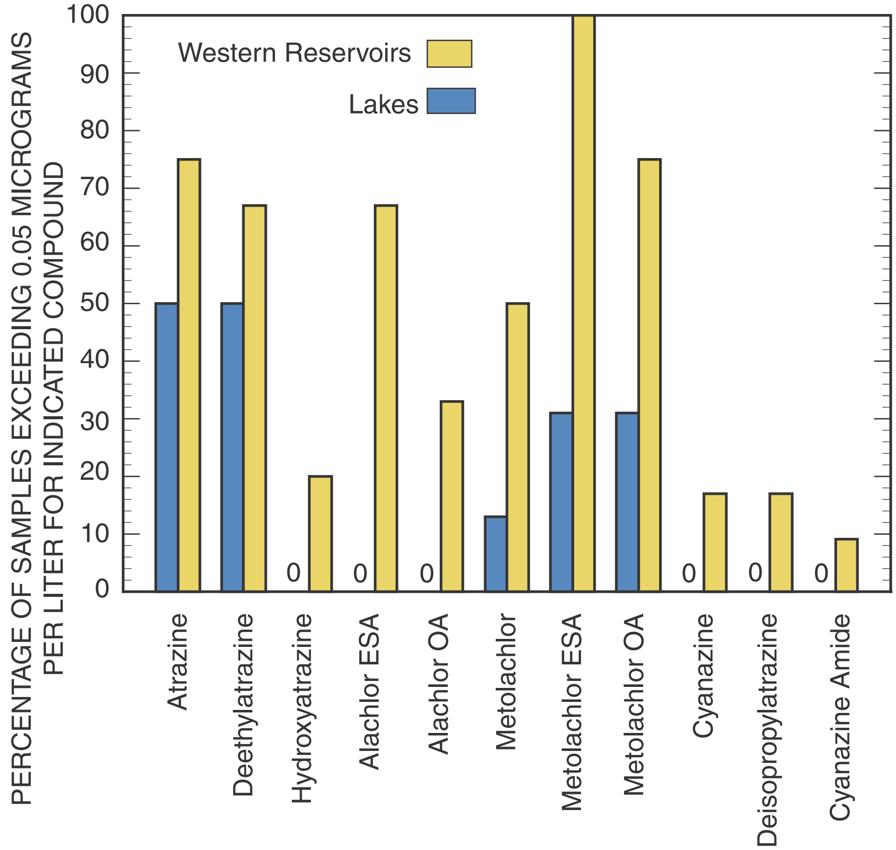
[c] - New York State Surface Water Standard equals Class GA Standard

State MCLs are similar to Federal MCLs but include general standards that apply to any organic chemical contaminant that does not have a specific MCL listed in regulation. These include (1) a standard of 5 µg/L for Principal Organic Contaminants (POCs), (2) a standard of 50 µg/L for any other organic contaminant (Unspecified Organic Contaminant, UOC), and (3) a standard of 100 µg/L for the total of POCs and UOCs. New York State water-quality standards are based on New York State Department of Health (1998). Federal water-quality standards are based on U.S. Environmental Protection Agency (1996). Federal MCL standards are based on a one-year average concentration of more than one sample.

water from reservoirs whose watersheds contain substantial amounts of agricultural land. The Ashokan reservoir receives water from the Schoharie reservoir, and Rondout reservoir receives water from the Cannonsville and Pepacton reservoirs.

The New York City reservoir whose watershed contains the largest amount of urban and residential land is the New Croton reservoir (table 1), which receives more than 90 percent of its inflow from its own watershed, and less than 10 percent of its inflow from the Delaware system reservoirs. The pesticides detected in the New Croton reservoir mainly reflect the large amount of urban land within this watershed but may also reflect agricultural land within and outside this watershed. Concentrations of atrazine and deethylatrazine in samples from the New Croton reservoir ranged from 0.002 to 0.009 µg/L and were lower than those from the Cannonsville reservoir, but the concentration of simazine was higher (0.016 µg/L) than in the Cannonsville reservoir, the only other New York City reservoir in which simazine was detected. The New Croton reservoir also was the only reservoir in the New York City network in which the herbicide prometon was detected, which can be attributed to urban sources within the watershed

Figure 3. Percentage of samples with a pesticide or pesticide metabolite concentration exceeding 0.05 µg/L, in Finger Lakes – Great Lakes network and western New York reservoir network samples, by compound. (No compounds in the New York City reservoir network samples had a concentrations exceeding 0.05 µg/L.



Finger Lakes-Great Lakes Network

The highest concentrations of pesticides and metabolites detected within the Finger Lakes-Great Lakes network were in samples from Cayuga Lake (fig. 5); this is attributed to the relatively high percentage of agricultural land within the Cayuga Lake watershed. Concentrations of atrazine, deethylatrazine, and metolachlor ESA and metolachlor OA exceeded 0.1 µg/L in nearly all samples from Cayuga Lake, and concentrations of metolachlor in many samples exceeded 0.05 µg/L. Metolachlor ESA was detected only in samples from Cayuga Lake and Hemlock Lake, and metolachlor OA was detected only in samples from Cayuga Lake.

Concentrations of atrazine and deethylatrazine in samples from Skaneateles Lake, the Lake Erie intake at Buffalo, and the Lake Ontario intake near Rochester, ranged from 0.02 to 0.1 µg/L. Concentrations of these compounds in samples from Hemlock Lake ranged from 0.006 to 0.02 µg/L, and were lowest of any lakes in this network. Concentrations of metolachlor in samples from these four sites ranged from 0.004 to 0.02 µg/L; the lowest concentrations were in samples from Skaneateles Lake, and the highest in samples from Lake Erie at Buffalo and Lake Ontario near Rochester. Simazine was detected in at least one sample from each Finger Lakes-Great

Table 3. Metabolites detected in samples from public water-supply sites in New York, January through May 1999, and their parent compounds and typical uses of parent compounds

Metabolite	Parent compound(s)	Typical use of parent compound
Deisopropylatrazine	Simazine	orchards, vineyards, rights-of-way
	Atrazine	corn and other row crops
Deethylatrazine	Atrazine	corn and other row crops
Hydroxylatrazine	Atrazine	corn and other row crops
Cyanazine amide	Cyanazine	corn and other row crops
Metolachlor ESA	Metolachlor	corn and other row crops
Metolachlor OA	Metolachlor	corn and other row crops
Alachlor ESA	Alachlor	corn and other row crops
Alachlor OA	Alachlor	corn and other row crops
	EPTC	corn and other row crops
	Prometon	rights-of-way, asphalt additive
	DCPA	agricultural and nonagricultural

Federal and State Water-Quality Standards used in this study

The concentrations of pesticides and pesticide metabolites detected in this study are described in relation to five Federal and State standards. The standards are based on concentrations of individual pesticides and do not account for mixtures of pesticides. Websites with additional information on the Federal Standards are included in the paragraphs below.

Federal Maximum Contaminant Levels (MCLs) are the maximum permissible level of a contaminant in water that is delivered to any user of a public water system under the Federal Safe Drinking Water Act (U. S. Environmental Protection Agency, 1996). MCLs are set as close as feasible to the level at which no known or anticipated adverse effects on health are expected to occur. **http://www.epa.gov/ost/drinking/standars/**

Federal Health Advisory Levels (HALs) are established by U.S. Environmental Protection Agency under the Safe Drinking Water Act when adequate scientific information is available but an MCL has not yet been officially set. **http://www.epa.gov/ost/drinking/standars/**

New York State Maximum Contaminant Levels are established under the New York State Department of Health Public Water Systems Regulations (New York State, 1998). State MCLs are similar to Federal MCLs but include general standards that apply to any organic chemical contaminant that does not have a specific MCL listed in regulation. These include (1) a standard of 5 µg/L for Principal Organic Contaminants (POCs), (2) a standard of 50 µg/L for any other organic contaminant (Unspecified Organic Contaminant, UOC), and (3) a standard of 100 µg/L for the total of POCs and UOCs.

New York State Surface-water-quality standards have been established by the NYSDEC for (1) the protection of aquatic species, humans, and wildlife using the resource, and (2) preservation of the quality of water for use as a potential drinking-water source or for fishing. These standards are designed to protect these waters from health-based and aesthetic impacts.

New York State Class GA Standards are set by NYSDEC on the basis of health-based or aesthetic-based procedures established in New York State (New York State, 1998) to protect ambient ground waters that are a potential source of drinking water. Class GA Standards are used for protection of the resource rather than as a limit for water consumption and use. Accordingly, these risk-based standards typically are more stringent than drinking-water MCLs.

USE OF LOW DETECTION LIMITS

The use of analytical methods that have low detection limits for many of the pesticides addressed in this study resulted in a higher frequency of detection than less sensitive methods would have produced. The use of analytical methods with such low detection limits not only aids in the identification of trace amounts of pesticides and metabolites in water and delineation of their trends, it also allows researchers to discern relations between pesticide exposure and human health. This is particularly important in the monitoring of insecticide concentrations because insecticides, when present, generally are found only at extremely low concentrations. No insecticides were detected in this study. These low detection limits increase the likelihood that pesticides not detected in the analysis are truly absent from the waters sampled.

Lakes site except Skaneateles Lake, but no simazine concentration exceeded 0.02 µg/L.

The patterns of pesticide concentrations at the three Finger Lake sites reflect the extent of agricultural land use in the respective watersheds (table 1). Cayuga Lake, the largest of the three lakes, had higher concentrations for all detected pesticides and metabolites because its watershed has a higher percentage of agricultural land. A previous study also found that Cayuga Lake has higher pesticide concentrations than the Hemlock and Skaneateles Lakes (Eckhardt and Burke, 1999).

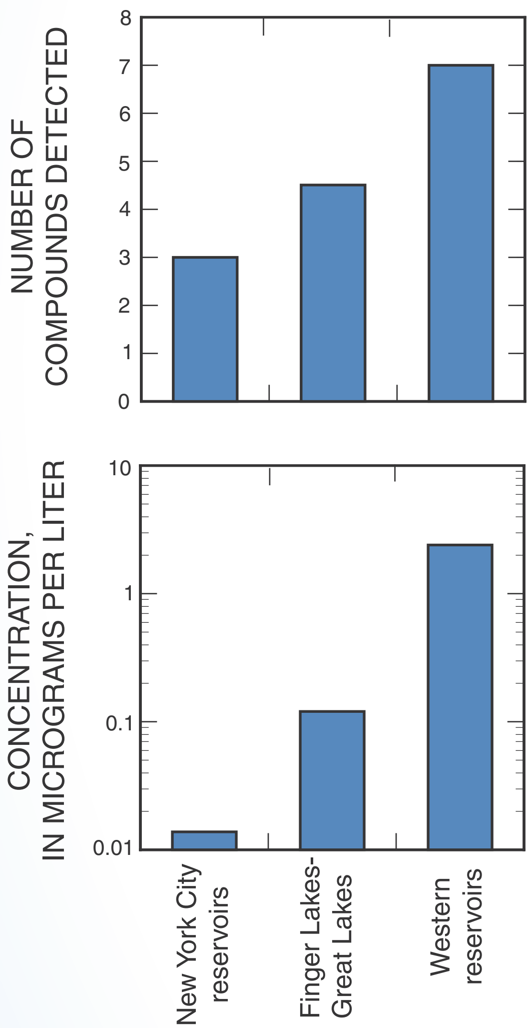


Figure 4. Median total concentration and median number of pesticides and metabolites detected, in the three networks in New York, 1999.

The concentrations of atrazine, deethylatrazine, and metolachlor in samples from Lake Erie were slightly higher than in samples from Lake Ontario; this is consistent with the findings of Schottler and Eisenreich (1994), who attributed much of the herbicide presence in Lakes Erie and Ontario to herbicide transport from agricultural land surrounding tributaries to Lake Erie (which drains into Lake Ontario). Simazine also was found in this study at low concentrations (0.01 to 0.02 µg/L) in samples from Lake Erie and Lake Ontario. Pesticides in the Great Lakes may be derived partly from atmospheric sources (Miller and others, 2000).

Western New York Reservoirs Network

Pesticide concentrations detected in samples from the three sites in the western New York reservoirs network in a previous (1998-99) study (Phillips and others, 1999) were highest at the LeRoy site and lowest at the Hornell site (fig. 5). Results from the present study were similar, except that concentrations of atrazine and deethylatrazine at LeRoy were closer to those at Silver Lake in 1999 than in 1998. The lower pesticide and metabolite concentrations in the Hornell reservoir than at LeRoy or Silver Lake in both years are attributed to the low percentage of agricultural land in the Hornell watershed (table 1). Samples from the LeRoy site contained the highest concentrations of metolachlor and metolachlor ESA measured in this study, probably a consequence of the high percentage of agricultural land in this watershed.

SEASONAL CHANGES IN PESTICIDE AND METABOLITE CONCENTRATIONS

The median total pesticide concentrations among all samples, and the median number of compounds detected among all samples, generally decreased from January through September 1999 (fig. 6). This decrease is of interest because previous studies have indicated that pesticide concentrations in streams generally are greatest in late June or early July, after the first storm runoff that follows pesticide application (Wall and Phillips, 1998; Eckhardt and others, 1999). This decrease also differs from the trend observed among the western New York reservoir sites in 1998, when the concentrations of most herbicides, including atrazine and metolachlor, were greatest in July and August (Phillips and others, 1999).

Pesticide and metabolite concentrations in samples from the LeRoy reservoir and Cayuga Lake sites in

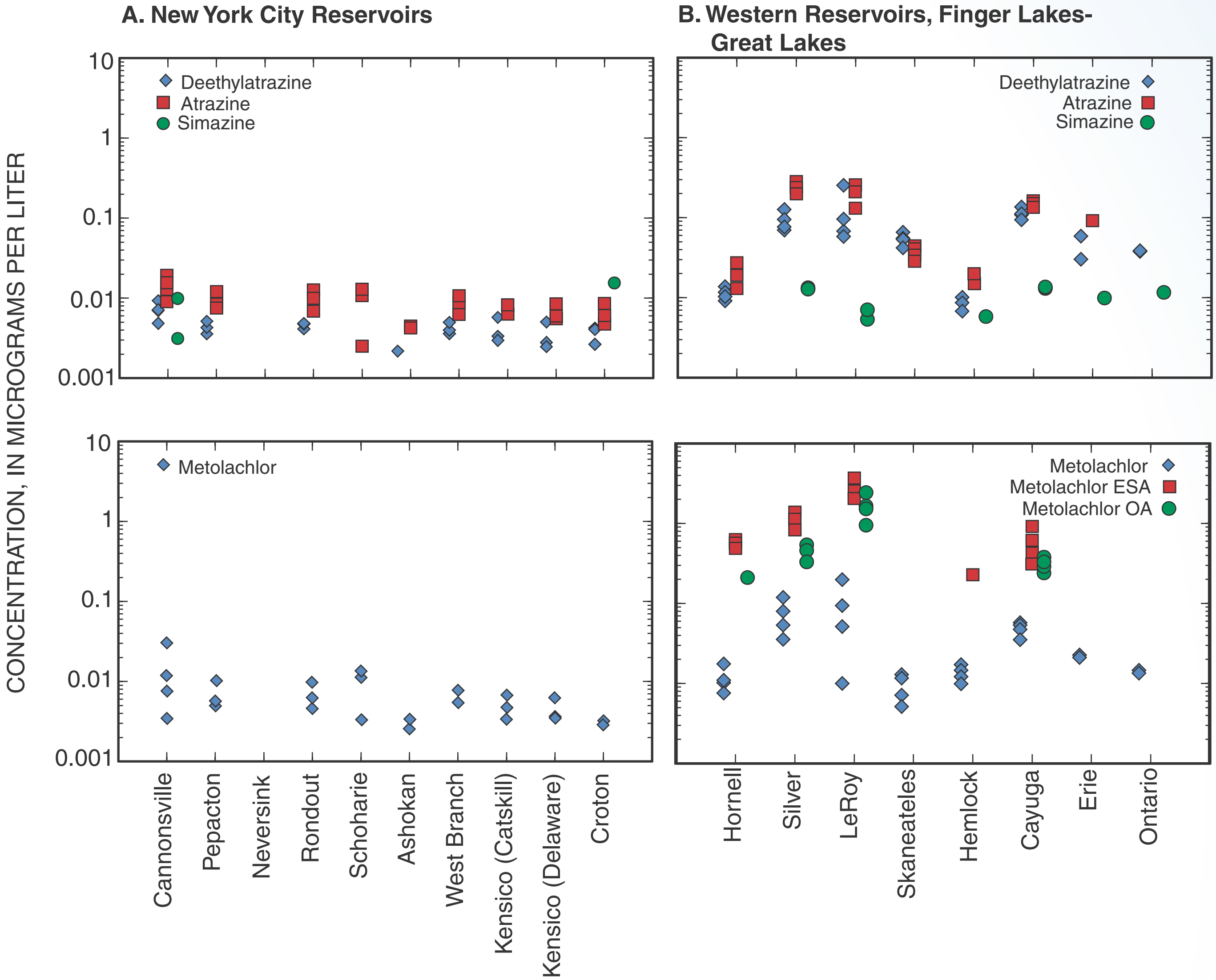


Figure 5. Concentrations of selected herbicides and metabolites in the three public supply-sampling networks in New York, January 1999 through September, 1999: A. New York City reservoirs networks. B. Western New York reservoirs network and Finger Lakes-Great Lakes network. Metolachlor metabolites were not detected at New York

1999 typically were much lower than those in 1998. Concentrations of atrazine at the LeRoy site decreased from more than 1 µg/L in July 1998 to less than 0.3 µg/L by May 1999 (fig. 7), and the concentrations in the July and August 1999 samples from this site were the lowest of any samples collected in the 1999 study. Unlike 1998, there was no increase in atrazine concentrations observed in the Lake LeRoy Reservoir sampled collected between April and July 1999. The relatively low pesticide concentrations in 1999 probably reflect the drought conditions of 1999, which resulted in low runoff and decreased pesticide transport in tributaries that drain to these lakes.

Concentrations of pesticides in Cayuga Lake samples varied less than those in the LeRoy reservoir samples, probably because the lake is bigger – thus, the effect of drought on pesticide concentrations in post-application runoff is more prominent in small reservoirs such as LeRoy than in large ones. For example, the decrease in atrazine concentration from January through September 1999 at Cayuga Lake (from 0.16 µg/L to 0.14 µg/L) was much smaller than that at LeRoy (from 0.71 µg/L to 0.13 µg/L). Cayuga Lake contains much more water than LeRoy reservoir and has a much longer water-retention period (about 10 years); thus, the shorter retention time of pesticides in the LeRoy reservoir than in Cayuga Lake can result in greater seasonal changes in pesticide concentrations.

The steady decrease in atrazine concentrations at the LeRoy reservoir since January 1998 (fig. 7) in response to the widespread drought conditions indicates that the results of the 1999 investigation may not be indicative of other years with more normal rainfall. Summer concentrations of pesticides during years with normal or high streamflows are likely to be higher than those in other years, especially if storm runoff in June or July after the spring pesticide applications is substantial.

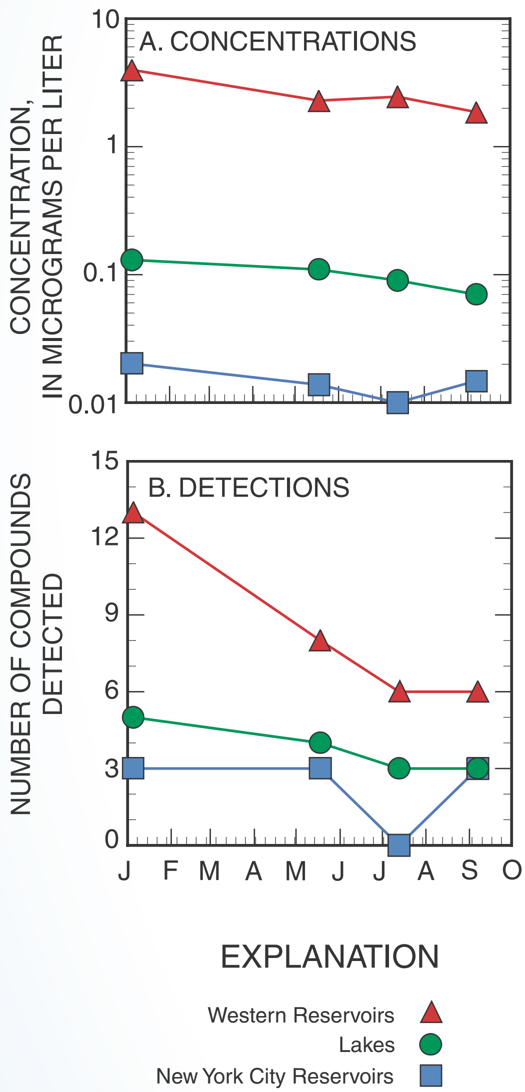


Figure 6. Seasonal variations in median total concentrations and median number of pesticides and metabolites detected per sample, January through September 1999, from the three networks.

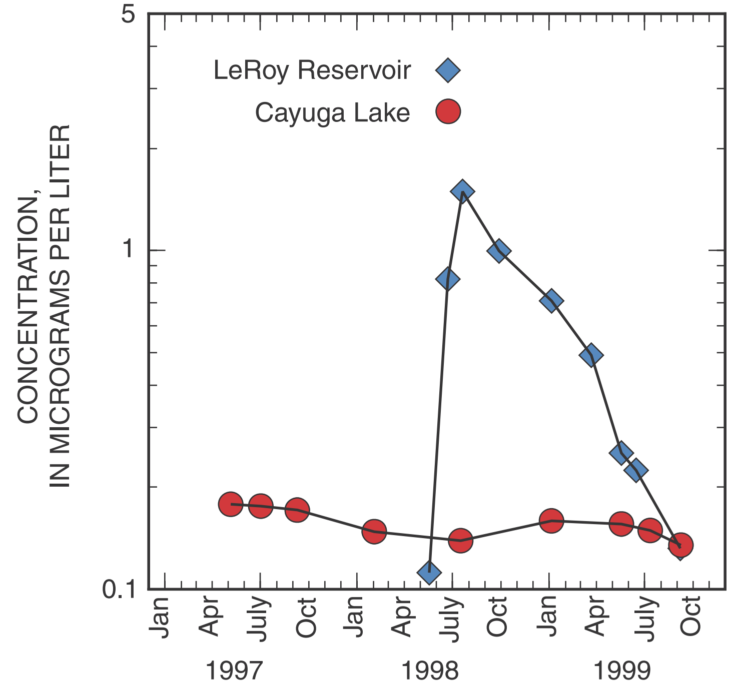


Figure 7. Concentrations of atrazine in samples from the LeRoy Reservoir and Cayuga Lake sampling sites, May 1997 through September 1999.

SUMMARY

This study presents the 1999 results of the statewide USGS-NYSDEC monitoring program that investigates the occurrence of pesticides and their metabolites in public-water-supply reservoirs in New York. Three sampling networks were sampled from January 1999 through July 1999; these encompass

-New York City water-supply reservoirs (10 reservoirs owned by New York City),

-Lakes that supply cities in western New York State (3 Finger Lakes and 2 Great Lakes), and

-Western New York reservoirs that supply small cities or towns (3 small reservoirs).

Of the 60 pesticides and pesticide metabolites for which samples were analyzed, 8 herbicides and 8 herbicide metabolites were detected. Concentrations of the compounds detected generally were low — only three compounds exceeded a concentration of 1 µg/L, and 11 compounds exceeded a concentration of 0.05 µg/L. No concentrations exceeded any Federal or State water-quality standards.

The 11 compounds detected at concentrations greater than 0.05 µg/L include three herbicides (atrazine, metolachlor, and cyanazine) and eight herbicide metabolites (the atrazine metabolites deethylatrazine and hydroxyatrazine, the alachlor metabolites alachlor ESA and alachlor OA, the metolachlor metabolites metolachlor ESA and metolachlor OA, the atrazine and simazine metabolite deisopropylatrazine, and the cyanazine metabolite cyanazine amide). The most frequently detected compounds were atrazine, metolachlor, simazine, deethylatrazine, and metolachlor ESA. These compounds, or their parent compounds, are used on corn and other row crops. Simazine also is commonly used in orchards, vineyards, and rights-of-way. All of these compounds except metolachlor ESA were detected in at least one sample from each of the three networks. Concentrations of these five compounds in samples from the three networks ranged from less than 0.01 µg/L to nearly 4 µg/L.

The western New York reservoir samples contained more pesticides and metabolite compounds, and at higher concentrations, than samples from the other networks, and the New York City reservoir samples contained the fewest compounds and the lowest concentrations of the three networks. These differences reflect the percentage of agricultural land within each network — the watersheds of the western New York reservoirs have the highest percentage of agricultural land, and the watersheds of the New York City reservoirs have the lowest. Within each network, pesticide and metabolite concentrations varied locally according to predominant land use within the watersheds. For example, samples from the Cannonsville reservoir, within the New York City reservoir system, had the highest herbicide or herbicide metabolite concentrations, and a far higher percentage of agricultural land in its watershed than do those of the other New York City reservoirs. Although agricultural use of pesticides is the likely source of pesticides and metabolites found in most New York City reservoirs, pesticides and metabolites detected in the New Croton reservoir (including atrazine, deethylatrazine, simazine, and prometon) are attributed to urban and residential uses of pesticides. Other factors, such as geologic and hydrologic conditions, soils, and proximity of water bodies to pesticide application, can also affect pesticide and metabolite concentrations in lakes and reservoirs.

Cayuga Lake had the highest pesticide and pesticide metabolite concentrations of the five sites in the Finger Lakes-Great Lakes network, probably a consequence of the high percentage of agricultural land in the Cayuga Lake watershed. Concentrations of atrazine, deethylatrazine, and metolachlor ESA and metolachlor OA exceeded 0.1 µg/L in nearly all samples from Cayuga Lake, and concentrations of metolachlor in many samples exceeded 0.05 µg/L. Within the western New York reservoirs network, the LeRoy reservoir had the highest pesticide concentrations, and the Hornell reservoir the lowest.

The median total concentrations and the median number of detected compounds for all samples in all networks generally decreased from January through September 1999, largely as a result of the summer drought and the attendant decrease in pesticide transport to lakes and reservoirs. Summer concentrations of pesticides in lakes are likely to be higher during years with normal or high streamflows, especially if storm runoff in June or July is substantial. Concentrations of atrazine at the LeRoy site decreased from more than 1 µg/L in July 1998 to less than 0.3 µg/L by May 1999, and the samples in July and August 1999 had the lowest concentrations of any samples collected. Concentrations of pesticides in Cayuga Lake samples during 1999 did not vary as much as in the smaller LeRoy reservoir. Cayuga Lake contains a much larger volume of water than LeRoy reservoir, and has a far greater water-retention period — about 10 years. The greater seasonal changes in concentrations of pesticides in the LeRoy reservoir than in Cayuga Lake further indicate that the size of reservoir or lake can affect the magnitude of changes in pesticide concentrations, especially during drought years.

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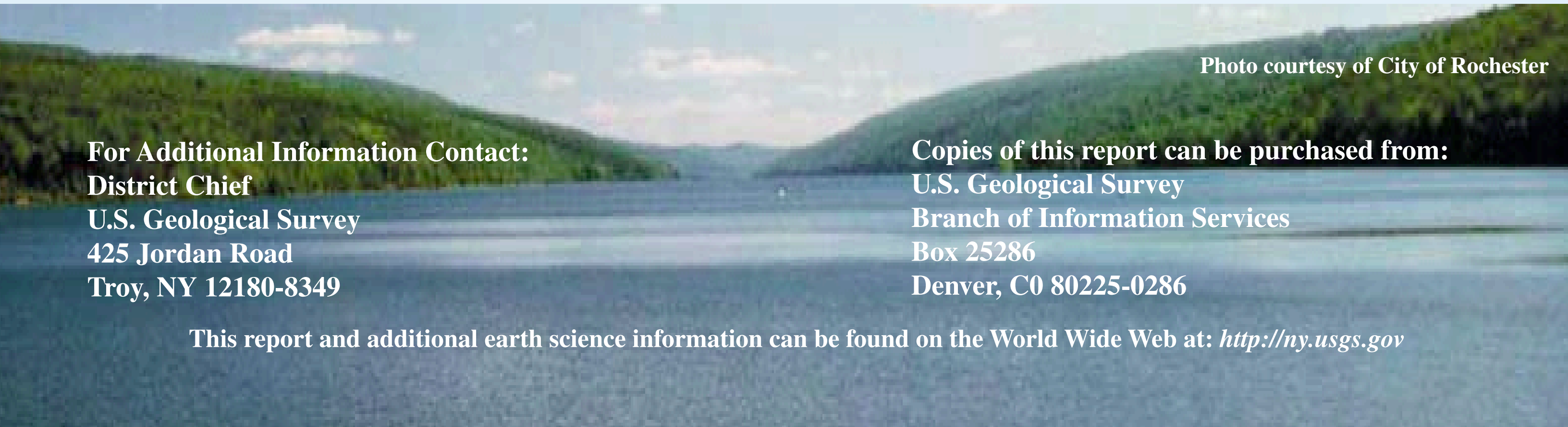

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