In cooperation with the Texas Natural Resource Conservation Commission

Occurrence of Selected Volatile Organic Compounds and Soluble Pesticides in Texas Public Water-Supply Source Waters, 1999–2001

Fisherman at Donna Reservoir, Hidalgo County.

Surface-Water Findings

- VOCs were detected in 75 percent of reservoirs sampled
- MTBE was the most frequently detected VOC
- Pesticides were detected in 96 percent of reservoirs sampled
- Atrazine was the most frequently detected pesticide compound

During 1999–2001, the U.S. Geological Survey, in cooperation with the Texas Natural Resource Conservation Commission, collected samples of untreated water from 48 public water-supply reservoirs and 174 public water-supply wells. The samples were analyzed for volatile organic compounds (VOCs) and soluble pesticides; in addition, well samples were analyzed for nitrite plus nitrate and tritium. This fact sheet summarizes the findings of the source-water sampling and analyses. Both VOCs and pesticides were detected much more frequently in surface water than in ground water. The only constituent detected at concentrations exceeding the maximum contaminant level for drinking water was nitrate. These results will be used in the Texas Source-Water Assessment Program to evaluate the susceptibility of public water-supply source waters to contamination.

Ground-Water Findings

- VOCs were detected in 9 percent of wells sampled
- Toluene (methylbenzene) was the most frequently detected VOC
- Pesticides were detected in 33 percent of wells sampled
- Deethylatrazine was the most frequently detected pesticide compound

USGS personnel sampling ground water from a public water-supply well, Big Bend National Park.

U.S. Department of the Interior
U.S. Geological Survey

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Volatile Organic Compounds

Five VOCs were analyzed in public water-supply source waters: benzene, toluene, ethylbenzene, and xylene (known collectively as BTEX), and methyl *tert*-butyl ether (MTBE). BTEX compounds are constituents of gasoline, and MTBE is an oxygenate added to gasoline to reduce air pollution. MTBE is more soluble, less volatile, and less reactive than BTEX and therefore more persistent in aqueous environments (Squillace and others, 1997). Samples were collected from the middle of 48 public water-supply reservoirs in July 1999; four of those reservoirs also were sampled in June 1999. Samples were collected from 174 public water-supply wells during November 1999–January 2001 (fig. 1).

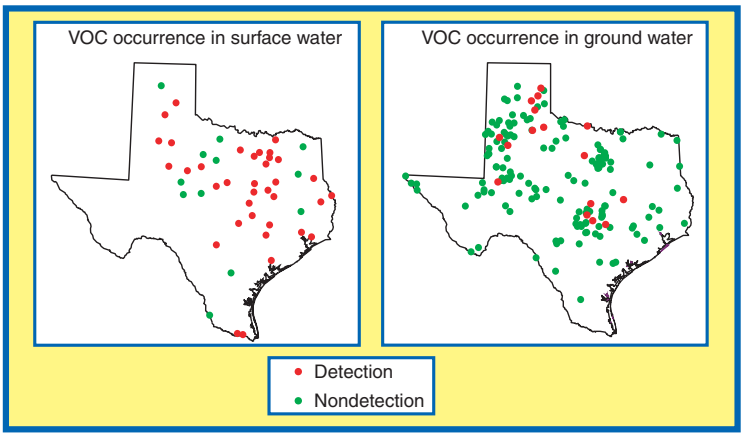

Figure 1. Locations of public water-supply reservoirs and wells sampled for VOCs. Sites with one or more detections shown in red, sites with no detections shown in green.

Overall, VOCs were detected much more frequently in surface water than in ground water (fig. 1). Occurrence of MTBE in reservoirs was widespread at low concentrations (fig. 2). The oxgenate was detected in 34 reservoirs (73 percent of samples, including detections in both samples from each of the four reservoirs sampled twice), but only 11 reservoirs had concentrations that exceeded 1.0 microgram per liter. The highest concentration detected was 4.1 micrograms per liter, a concentration well below the U.S. Environmental Protection Agency (USEPA) drinking-water advisory level of 20 to 40 micrograms per liter, issued for reasons of taste and smell (U.S. Environmental Protection Agency, 1997). In contrast, only two of the 174 public water-supply wells sampled contained a detectable concentration of MTBE (fig. 2).

BTEX compounds also were detected more frequently in surface water than in ground water. Toluene, the most frequently detected BTEX compound, was detected in 19 reservoirs (38 percent of samples, including detections in both samples from one of the four reservoirs sampled twice) and in 13 wells (7 percent). In surface water, toluene was detected less frequently than MTBE, but in ground water the reverse was true. This might occur because ground water is usually older than surface water, and MTBE did not come into widespread use until the 1990s. The other BTEX compounds were detected in no more than 23 percent of samples from reservoirs and no more than 1 percent of wells. In no case did the concentration of VOCs detected exceed the USEPA maximum contaminant levels (MCLs) for drinking water (U.S. Environmental Protection Agency, 1996).

To investigate the influence of recreational use of gasoline-powered vehicles on VOC concentrations, four reservoirs with high recreational use were sampled twice, before and just after the 1999 Fourth of July weekend (table 1). MTBE was detected at all four reservoirs before and after the holiday weekend and increased in concentration. In all but one case, the BTEX compounds either remained below detection limits before and after the holiday weekend, went from a nondetection to a detection, or increased in concentration.

Table 1. VOC concentrations in four reservoirs sampled before and after the Fourth of July weekend, 1999

[In micrograms per liter; <, less than; E, estimated]

Site	Sample date	Benzene	Toluene	Ethylbenzene	Xylene	MTBE
Lake Travis	06–28–99	<0.2	0.28	<0.2	E0.12	1.22
	07–06–99	.34	.80	<.2	E.11	2.29
Lake Waco	06–30–99	<.2	<.2	<.2	<.2	E.15
	07–07–99	.17	.64	.11	.67	.92
Lake Belton	06–30–99	<.2	<.2	<.2	<.2	.53
	07–07–99	<.2	.37	.13	.75	.80
Granger Lake	06–30–99	<.2	<.2	<.2	<.2	E.10
	07–06–99	<.2	<.2	<.2	<.2	.37

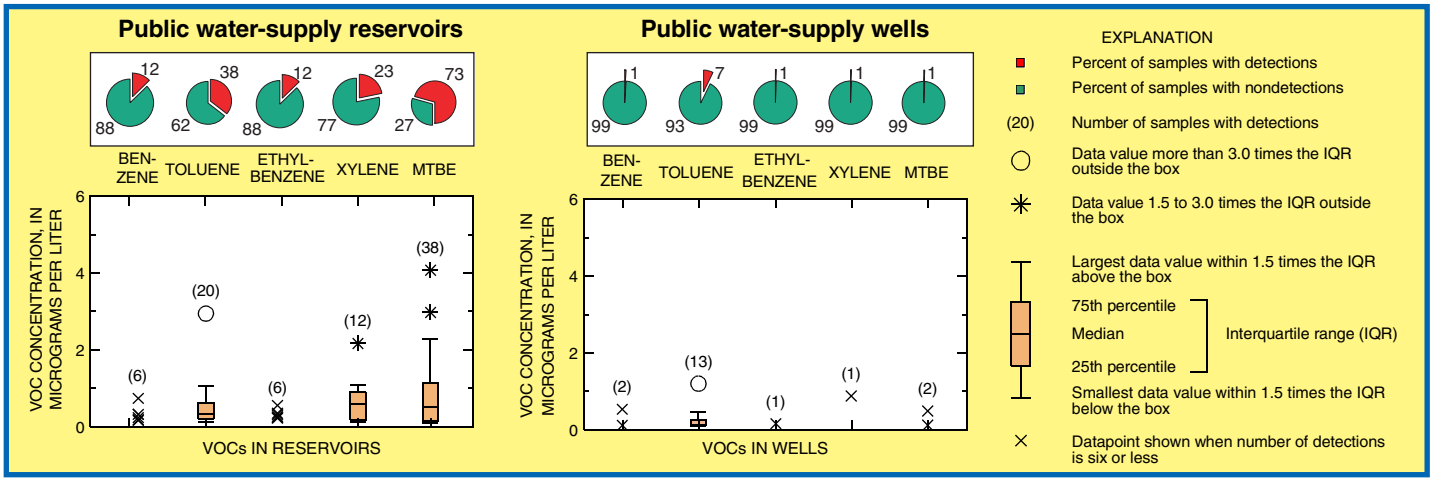

Figure 2. The percentage of samples in public water-supply reservoirs and wells with one or more VOC detections are shown as pie graphs. The range of concentrations in samples with detections are shown as boxplots. Four reservoirs were sampled twice—toluene and xylene were detected in both samples from one reservoir, and MTBE was detected in both samples from all four reservoirs.

Soluble Pesticides

Eighty-three commonly used soluble pesticides were analyzed in public water-supply source waters (Mahler, 2000). Pesticides analyzed included herbicides, such as atrazine, and insecticides, such as diazinon. Samples were collected at the same time as VOC samples. Overall, pesticides were detected much more frequently in surface water than in ground water (fig. 3). In general, concentrations were low (fig. 4). No concentrations exceeded regulatory limits.

Pesticides commonly occurred in mixtures. Of the 46 reservoirs with pesticide detections, 98 percent had detections of two or more pesticides, and 59 percent had detections of five or more pesticides. The most pesticides detected in any reservoir was 12. Of the 58 wells with pesticide detections, 66 percent had detections of two or more pesticides, and 9 percent had detections of five or more pesticides. The most pesticides detected in any well was six.

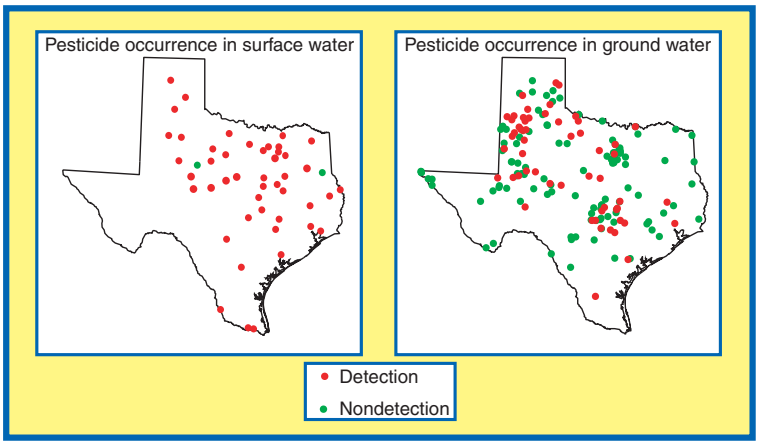

Figure 3. Locations of public water-supply reservoirs and wells sampled for pesticides. Sites with one or more detections shown in red, sites with no detections shown in green.

Atrazine and its breakdown product deethylatrazine (DEA) were the most frequently detected compounds (fig. 4). Atrazine was detected in 46 reservoirs (96 percent) and 27 wells (16 percent). DEA was detected in 43 reservoirs (90 percent) and 38 wells (22 percent). The highest concentration of DEA detected, 1.73 micrograms per liter, was in a ground-water sample. The herbicides simazine, metolachlor, and prometon were the next most frequently detected pesticides in surface water. In ground water, the herbicides prometon and simazine and the insecticide diazinon were the next most frequently detected pesticides. These results are consistent with those reported in a national study of pesticides in surface and ground water, in which atrazine, simazine, prometon, and diazinon were frequently detected (U.S. Geological Survey, 2001).

Tritium and Nitrate

Tritium, a radioactive isotope of hydrogen, was analyzed in the ground-water samples to determine if its presence was related to the occurrence of pesticides. Tritium levels in the atmosphere increased by a factor of about 1,000 during nuclear weapons testing in the 1950s to mid-1960s. The presence or absence of tritium is an indication of how recently water was in contact with the atmosphere; surface water recharging an aquifer before 1952 would contain natural background levels of tritium (Bradbury, 1991). The hypothesis tested here was whether pesticides would be detected in "old" water—that is, in samples in which tritium was at background levels. Of the 168 wells for which tritium was analyzed, tritium was below the detection level in 58. Pesticides were detected in nine of those wells (16 percent). In contrast, pesticides were detected in 47 of the wells in which tritium was detected (43 percent). Thus, although nondetection of tritium was not a guarantee of nondetection of pesticides, pesticides were more than twice as likely to be detected in samples containing detectable tritium.

Nitrite plus nitrate was analyzed in all the ground-water samples. Nitrate has both natural and anthropogenic sources. For example, nitrate is produced by the decomposition of organic matter and also is a component of most fertilizers. Nitrate exceeded the MCL of 10 milligrams per liter as nitrogen in 14 wells (8 percent).

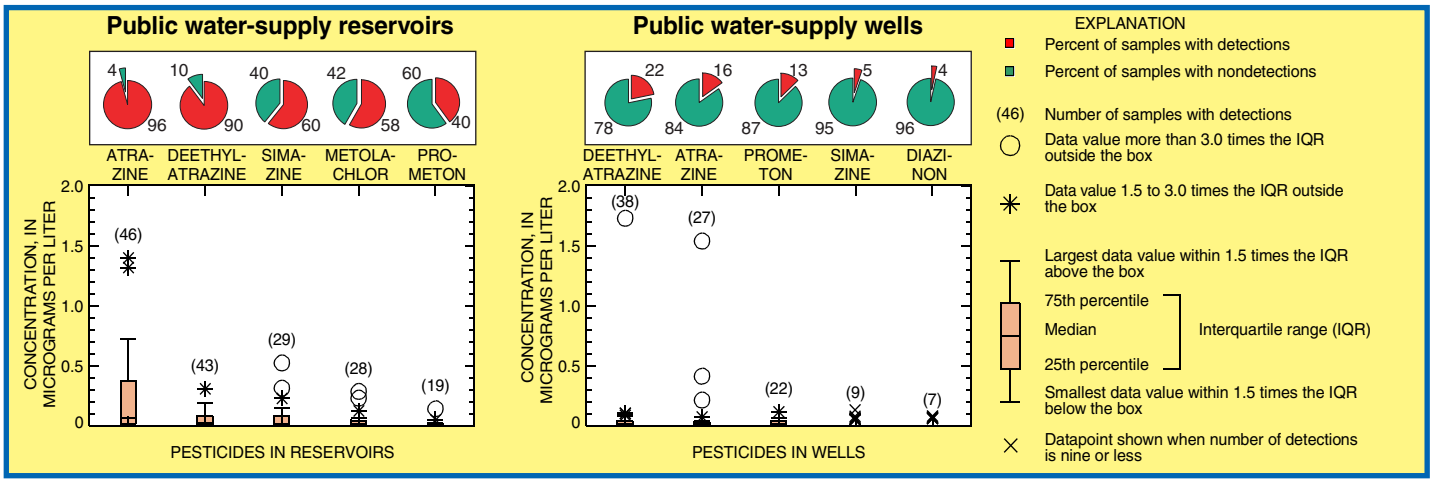

Figure 4. The percentage of samples in public water-supply reservoirs and wells with one or more pesticide detections are shown as pie graphs. The range of concentrations in samples with detections are shown as boxplots.

Site Selection and Sample Collection

Sites were selected to provide the water-quality database needed to assess the susceptibility of public water supplies to contamination. Only reservoirs that provide public water supply and that have a volume of 5,000 acre-feet or more were sampled, except for two small reservoirs in South Texas (La Feria and Donna Reservoirs). Reservoirs were chosen to give as much spatial coverage of the State as possible. Reservoirs also were chosen to reflect a range of land uses in the contributing basins. Public water-supply wells with well-log information were considered for sampling. The wells were selected to cover a broad areal extent and to represent the variety of rock types in Texas aquifers. Most of the wells penetrate unconfined aquifers. Their contributing areas include a wide range of environmental characteristics that might act as explanatory variables for contaminant occurrence.

Samples were collected following protocols established by the USGS National Water-Quality Assessment (NAWQA) Program or developed in consultation with NAWQA water-quality specialists. Specifics on sampling can be found in Koterba (1998), Koterba and others (1995), and Shelton (1997).

Reservoirs were sampled from a point over the pre-reservoir channel midway between the dam and the upper end of the lake. VOC samples were collected by dipping pre-cleaned vials 0.5 meter below the surface. The pesticide samples were collected as a vertical composite, then filtered through a 0.7-millimeter glass-fiber filter. Field properties (dissolved oxygen, pH, specific conductance, and temperature) were recorded for the vertical profile.

At wells, field properties were monitored and the sample collected after the properties had stabilized. All samples were collected directly from the spigot before any treatment. VOC samples were collected to avoid contact with the atmosphere as much as possible. Pesticide samples were filtered as described above. The nitrite plus nitrate sample was filtered through a 0.5-millimeter cellulose-acetate filter. No filtering or treatment was required for the tritium sample.

All analyses except tritium were done at the USGS National Water Quality Laboratory (NWQL) in Denver, Colo. VOCs were analyzed by gas chromatography/mass spectrometry (GC/MS) as described by Connor and others (1998). Pesticide samples were extracted onto solid-phase columns at the USGS laboratory in Austin, Tex., and then analyzed at the NWQL by GC/MS as described by Zaugg and others (1995). Nitrite plus nitrate was analyzed by colorimetry and cadmium-reduction and by diazotization as described by Fishman (1993). Tritium analyses were done at the USGS National Research Program Laboratory in Menlo Park, Calif., by electrolytic enrichment and liquid scintillation (Thatcher and others, 1977). Results of all analyses are included in Mahler and others (2002).

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