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In cooperation with the Edwards Aquifer Authority and the Nature Conservancy of Texas

Quality of Stormwater Runoff from an Urbanizing Watershed and a Rangeland Watershed in the Edwards Aquifer Recharge Zone, Bexar and Uvalde Counties, Texas, 1996–98

Encroachment of urban development on the outcrop of the Edwards aquifer (the recharge zone), particularly in Bexar County, has raised the issue of possible contamination of water that enters the aquifer. Increasing residential and commercial development on the recharge zone increases the potential for runoff containing toxic substances, oil spills, or leakage of hazardous materials to contaminate the regional drinking water supply.

The Edwards aquifer is a dipping sequence of extensively faulted, fractured, and dissolutioned limestone and dolostone that yields large quantities of water to wells and springs. The recharge zone is essentially coincident with the area in which the aquifer crops out. Recharge to the aquifer is derived mainly from seepage from streams crossing the recharge zone and by direct infiltration of precipitation on the outcrop.

In 1996, the U.S. Geological Survey, in cooperation with the Edwards Aquifer Authority and the Nature Conservancy of Texas, began a study to compare stormwater runoff from two sites in the recharge zone in watersheds of similar size and different land use. One site is located on Lorence Creek, a tributary to Salado Creek in northern Bexar County, and the other site is on an unnamed tributary of the Frio River in northern Uvalde County (fig. 1). Flow at the two sites results only from storm runoff.

Both watersheds have similar climate, topography, soils, and vegetation. Land use in the Lorence Creek watershed is primarily single-family residential, commercial, and transportation. Land use in the watershed of the Frio River tributary is primarily rangeland. The drainage area of each watershed is less than 2 square miles.

Sample Collection

A stormwater-gaging station equipped with an automatic sampler and a tipping-bucket rain gage was installed at each site in May 1996. Samples of stormwater runoff during the 2-year period 1996–98 were collected for analysis of nutrients, major cations and anions, suspended sediment, trace elements, and pesticides. In addition to the automatically collected samples, two grab samples (from different storms) were collected at the Lorence Creek site for analysis of volatile organic compounds (VOCs). Samples were obtained for analysis when meteorologic criteria regarding antecedent conditions and storm characteristics for U.S. Environmental Protection Agency (EPA) National Pollutant Discharge Elimination System stormwater sampling were met (U.S. Environmental Protection Agency, 1990). Rainfall and streamflow were measured during the storm events. Discrete samples were collected at the two sites throughout the storm duration and composited for analysis. Water-quality samples were processed according to National Water-Quality Assessment Program guidelines (Shelton, 1994).

Eight storms that yielded from 0.5 to 2 inches of rainfall were sampled at the Lorence Creek site. Only one storm was sampled at the Frio River tributary site, as measurable runoff at that site is rare. For runoff to occur at that site, 3 to 4 inches of rain must fall on the watershed in a short period of time. The storm that was sampled at the Frio River tributary site yielded 3.4 inches of rain.

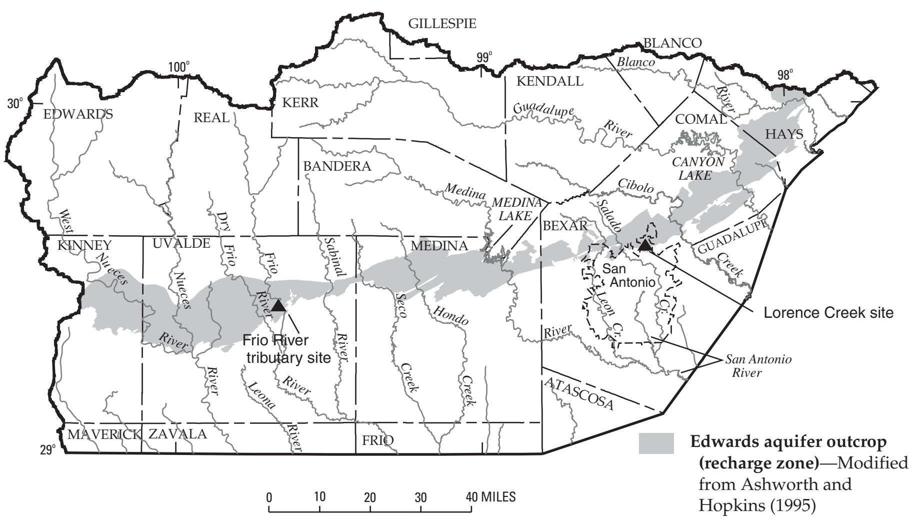

Figure 1. Location of sampling sites.

Water-Quality Differences Between the Watersheds

The most notable difference in the quality of stormwater runoff from the urbanizing watershed and the mostly rangeland watershed is the number of pesticides detected (table 1). Nineteen pesticides were detected at the Lorence Creek site; three pesticides (atrazine, deethylatrazine, and azinphos-methyl) were detected at the Frio River tributary site.

The most commonly detected pesticides at the Lorence Creek site were atrazine, deethylatrazine, simazine, chlorpyrifos, diazinon, and carbaryl. Atrazine, commonly used to kill broadleaf weeds, is the most widely used herbicide in Texas corn and grain sorghum production. It also is commonly used in many “weed and feed” products for home lawn and commercial turfgrass weed control (Baumann and Ketchersid, 1998). Deethylatrazine is a transformation (breakdown) product of atrazine. Like atrazine, simazine is an herbicide commonly used to kill broadleaf weeds in crops and turfgrass. Chlorpyrifos, diazinon, and carbaryl are insecticides commonly used to kill fire ants and a variety of other farm and household pests. Azinphos-methyl is an insecticide used on a variety of fruits and vegetables, cotton, and ornamental trees. EPA announced measures to reduce dietary and worker risk from exposure to azinphos-methyl in August 1999 (U.S. Environmental Protection Agency, 1999a).

Six VOCs were detected in the two grab samples collected at the Lorence Creek site. Four of the six VOCs detected (1,2,4-trimethylbenzene, benzene, ethylbenzene, and xylenes) are used as gasoline additives (Lucius and others, 1992).

Concentrations of all pesticides and VOCs detected for which EPA has established maximum allowable or recommended concentrations for drinking water were less than those maximums (U.S. Environmental Protection Agency, 1999b).

Table 1. Selected properties and constituents, Lorence Creek and Frio River tributary sites

[mg/L, milligrams per liter; --, no standard; µS/cm, microsiemens per centimeter at 25 degrees Celsius; <, less than; µg/L, micrograms per liter; ND, not detected; NA, not analyzed]

Property or constituent	No. of detections at Lorence Creek site	Minimum concentration at Lorence Creek site	Maximum concentration at Lorence Creek site	Average concentration at Lorence Creek site	Concentration at Frio River tributary site	Drinking water maximum allowable or recommended concentrations[1]
pH, lab (standard units)	8	7.3	8.3	7.8	8.0	6.5–8.5
Alkalinity, lab (mg/L)	8	31.0	76.0	50.0	70.0	--
Specific conductance, lab (µS/cm)	8	64	100	84	113	--
Suspended sediment (mg/L)	6	12	437	104	200	--
Nitrogen, ammonia, dissolved (mg/L)	8	.04	.12	.08	<.02	--
Nitrogen, ammonia plus organic, dissolved (mg/L)	8	.20	.60	.35	.28	--
Nitrogen, ammonia plus organic, total (mg/L)	8	.24	2.0	.71	1.1	--
Nitrogen, nitrite, dissolved (mg/L)	8	.01	.05	.02	<.01	1
Nitrogen, nitrite plus nitrate, dissolved (mg/L)	8	.19	.74	.36	.30	10
Phosphorus, dissolved (mg/L)	8	.05	.15	.09	.06	--
Phosphorus, total (mg/L)	8	.08	.37	.14	.23	--
Phosphorus, orthophosphate, dissolved (mg/L)	8	.05	.17	.10	.06	--
Calcium, dissolved (mg/L)	8	7.7	15	12	19	--
Magnesium, dissolved (mg/L)	8	.27	.59	.46	.88	--
Sodium, dissolved (mg/L)	8	.48	1.3	.92	.64	--
Potassium, dissolved (mg/L)	8	1.3	3.8	2.1	5.0	--
Chloride, dissolved (mg/L)	8	.82	2.5	1.4	.95	250
Sulfate, dissolved (mg/L)	8	.67	3.9	2.5	1.2	250
Fluoride, dissolved (mg/L)	0	<.10	<.10	<.10	<.10	2.0
Silica, dissolved (mg/L)	8	1.3	6.2	2.5	8.8	--
Aluminum, dissolved (µg/L)	8	12	39	21	8.8	[2]50–200
Antimony, dissolved (µg/L)	0	<1.0	<1.0	<1.0	<1.0	6
Arsenic, dissolved (µg/L)	1	<1.0	1.0	1.0	<1.0	50
Barium, dissolved (µg/L)	8	3.6	7.4	5.8	9.6	2,000
Beryllium, dissolved (µg/L)	0	<1.0	<1.0	<1.0	<1.0	4
Cadmium, dissolved (µg/L)	0	<1.0	<1.0	<1.0	<1.0	5
Chromium, dissolved (µg/L)	2	<1.0	1.5	1.4	<1.0	100
Cobalt, dissolved (µg/L)	0	<1.0	<1.0	<1.0	<1.0	--
Copper, dissolved (µg/L)	8	1.0	4.3	2.3	1.1	1,000
Iron, dissolved (µg/L)	8	5.0	15	9.9	8.8	300
Lead, dissolved (µg/L)	0	<1.0	<1.0	<1.0	<1.0	15
Manganese, dissolved (µg/L)	8	1.0	4.7	2.1	1.0	50
Molybdenum, dissolved (µg/L)	0	<1.0	<1.0	<1.0	<1.0	--
Nickel, dissolved (µg/L)	0	<1.0	<1.0	<1.0	<1.0	--
Selenium, dissolved (µg/L)	0	<1.0	<1.0	<1.0	<1.0	50
Silver, dissolved (µg/L)	0	<1.0	<1.0	<1.0	<1.0	100
Zinc, dissolved (µg/L)	8	3.0	7.4	5.0	5.2	5,000
Alachlor (µg/L)	1	.011	.011	.011	ND	2
Atrazine (µg/L)	8	.010	.24	.09	.007	3
Azinphos-methyl (µg/L)	1	.042	.042	.042	.054	--
Benfluralin (µg/L)	1	.0042	.0042	.0042	ND	--
Carbaryl (µg/L)	4	.044	.19	.10	ND	--
Chlorpyrifos (µg/L)	6	.0080	.023	.013	ND	--
DCPA (µg/L)	3	.00090	.010	.0043	ND	--
DDE (µg/L)	2	.0024	.0032	.0028	ND	--
Deethylatrazine (µg/L)	6	.0028	.029	.0081	.001	--
Diazinon (µg/L)	7	.030	.53	.17	ND	--
DNOC (µg/L)	1	.13	.13	.13	ND	--
Malathion (µg/L)	3	.0060	.059	.026	ND	--
MCPA (µg/L)	2	.16	.24	.20	ND	--
Metolachlor (µg/L)	2	.0060	.012	.0090	ND	--
Metribuzin (µg/L)	1	.014	.014	.014	ND	--
Prometon (µg/L)	2	.0045	.0069	.0057	ND	--
Propargite (µg/L)	1	.030	.030	.030	ND	--
Simazine (µg/L)	4	.0080	.19	.060	ND	--
Trifluralin (µg/L)	1	.0042	.0042	.0042	ND	--
1,2,4-Trimethylbenzene (µg/L)	2	.018	.023	.025	NA	--
Acetone (µg/L)	1	5.3	5.3	5.3	NA	--
Benzene (µg/L)	1	.015	.015	.015	NA	5
Ethylbenzene (µg/L)	1	.010	.010	.010	NA	700
Methyl isobutyl ketone (µg/L)	1	.23	.23	.23	NA	--
Xylenes (µg/L)	1	.013	.013	.013	NA	10,000

[1] U.S. Environmental Protection Agency, 1999b.
[2] 50 µg/L is the recommended standard; 200 µg/L is an acceptable standard.

The movement of pesticides and VOCs in the environment is complex. Their potential for entering the Edwards aquifer depends on factors such as their persistence in the soil, their exposure to sunlight and bacteria, their volatility, their solubility in water, and local soil and hydrogeologic conditions.

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