USGS
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NATIONAL WATER-QUALITY ASSESSMENT PROGRAM

Atrazine in Southern Louisiana Streams, 1998-2000

INTRODUCTION

The landscape of southern Louisiana has been sculpted by the Mississippi River. The historical and ongoing riverine processes of delta lobe formation and abandonment have produced the swamps, marshes, and alluvial plains that are typically associated with southern Louisiana. The Mississippi River drains the midcontinental United States, which covers 41 percent of the continental United States, and the riverine deposits transported by the Mississippi River to southern Louisiana over the last 7,500 years have resulted in highly fertile soils for agriculture. Important crops in Louisiana are sugarcane in the southeastern area, corn in the south-central area, and rice and sugarcane in the southwestern area. These crops, especially corn and sugarcane, are routinely treated with the herbicide atrazine for broadleaf weed control. Atrazine can be applied at different times of the year, early in the growing season as a preplanting or pre-emergent herbicide for control of most germinating broadleaf weeds, or later in the growing season for post-emergent weed control. Atrazine acts as a selective herbicide by inhibiting photosynthesis (U.S. Environmental Protection Agency, 2002, 1986).

Sugarcane in the upper Terrebonne Basin.

Slow-flowing bayou in the Barataria Basin.

Issues

In 1996, atrazine (6-chloro-N-ethyl-N'-(1-methylethyl)-1,3,5-triazine-2,4-diamine) was the most heavily applied herbicide in the United States, with a total use of about 33 million kilograms (Capel and Larson, 2001). Atrazine is a highly soluble herbicide. The greatest area of use is in the Corn Belt of the upper Midwest, including the upper Mississippi and Illinois River Basins (Meade, 1995). The waters in these basins are sources of drinking water downstream either directly from the Mississippi River mainstem at New Orleans or by way of distributaries draining the lower Mississippi River such as Bayou Lafourche and the Gulf Intracoastal Waterway (GIWW) (fig. 1). The U.S. Environmental Protection Agency (USEPA) has established a maximum contaminant level (MCL) of 3 µg/L (micrograms per liter) for atrazine in drinking water. However, because MCL's are based on annual average concentrations of quarterly samples, one or more exceedances don't necessarily indicate noncompliance. Currently (2003) atrazine is classified as "not likely to be carcinogenic to humans" (U.S. Environmental Protection Agency, 2002). There is some evidence that atrazine may have endocrine disruption (feminization) effects on amphibians at concentrations less than 1 µg/L (Hayes and others, 2002). Additional information on atrazine can be found at URL http://www.epa.gov/pesticides/reregistration/atrazine

The U.S. Geological Survey (USGS), as part of the National Water Quality Assessment Program (NAWQA), is investigating the occurrence, distribution, and transport of pesticides, including atrazine, in southern Louisiana. The Louisiana Department of Agriculture and Forestry has an atrazine monitoring program in the upper Terrebonne Basin. The Louisiana Department of Environmental Quality (DEQ) has identified Bayou Grosse Tete, a tributary in the basin, as a stream of concern due to elevated atrazine concentrations. Because of this stream's location in the upper part of the Terrebonne Basin, the waterway is hydrologically isolated from

Herbicide	Solubility, in milligrams per liter	Soil half-life, in days	Maximum contaminant level, in micrograms per liter	Health advisory level, in micrograms per liter
Atrazine	33	60	3	3

Meade, 1995.

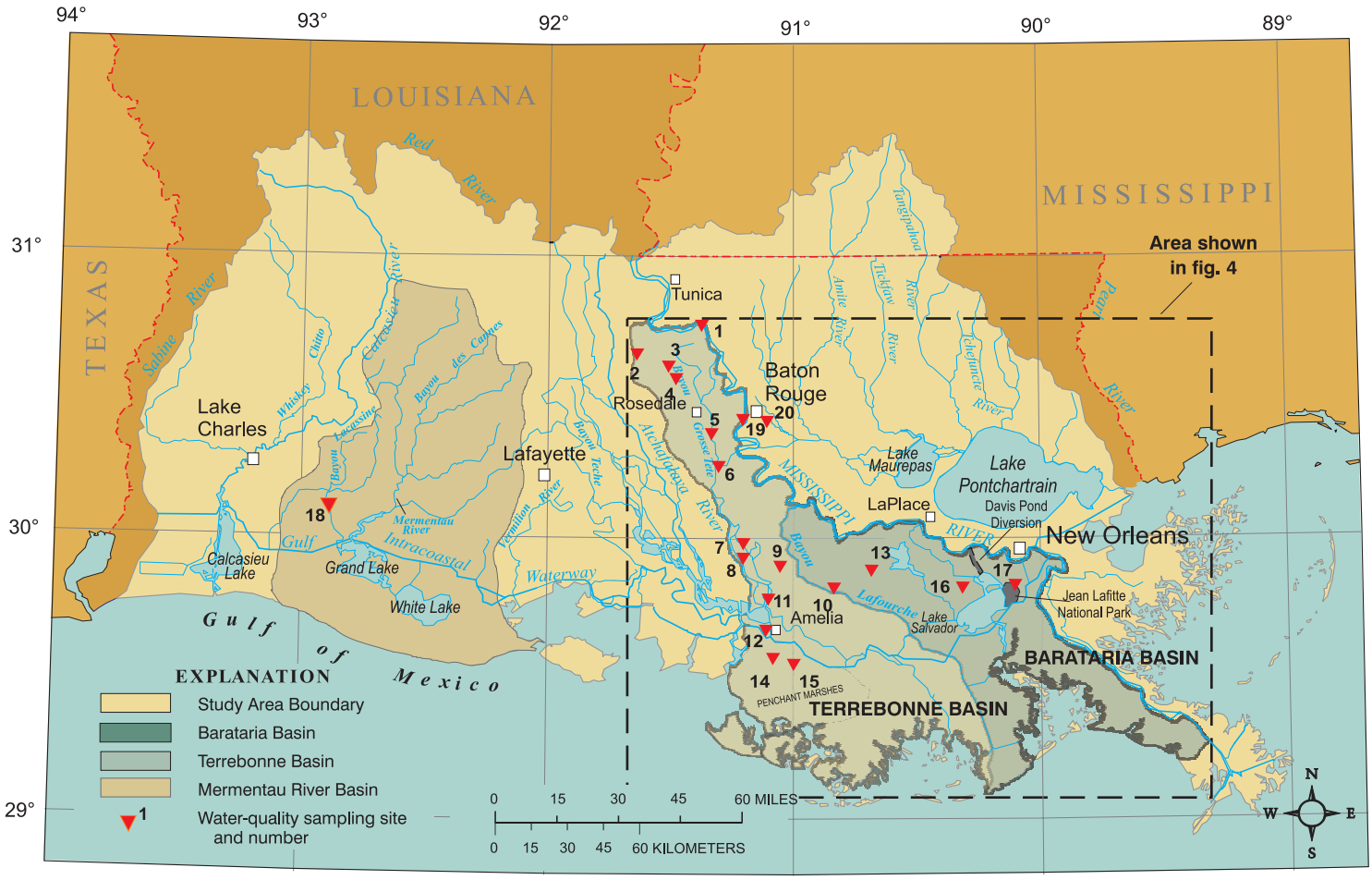


Figure 1. Location of study area in southern Louisiana.

the Mississippi River, and concentrations of atrazine in the waterway almost certainly originate from local inputs.

This report presents atrazine data collected at 20 sites in 1998-2000 from selected streams in the NAWQA Acadian-Pontchartrain Drainages study area (fig. 1). These data are compared to atrazine data from the Mississippi River at Baton Rouge to evaluate seasonal fluctuations in the concentrations and to determine the sources of atrazine in streams in the study area.

Study Area

The Acadian-Pontchartrain Drainages study area comprises most of southern Louisiana, excluding the Pearl and Sabine River Basins (fig. 1). Basins in the study area include the Barataria, Terrebonne, and Mermentau River.

The Barataria and Terrebonne Basins consist of a series of interdistributary basins separated by natural and constructed levees. Jean Lafitte National Historical Park, located in the Barataria Basin, has been isolated from direct Mississippi River inputs due to natural processes of levee formation and a complex series of artificial levees constructed primarily for flood control. However, this hydrologic isolation has changed with the completion in July 2002 of the Davis Pond Diversion. As much as 10,000 ft^3/s (cubic feet per second) will be diverted from the Mississippi River through the diversion into the upper Barataria Basin during the spring and early summer. Bayou Lafourche, which as recently as 300 years ago was a major distributary of the Mississippi River, was hydrologically isolated from the river in 1904. During 1998-2000, about 200 to 250 ft^3/s were either pumped or siphoned from the river into Bayou Lafourche for drinking-water supply and industrial uses.

In addition to the Mississippi River, the hydrology of southern Louisiana also is influenced by the Atchafalaya River, a distributary of the Mississippi River. The Atchafalaya River flows through south-central Louisiana to the Gulf of Mexico (fig. 1). Some of the Atchafalaya River water is distributed east and west through the GIWW. The amount of water moving through the GIWW and into canals and bayous of the Terrebonne Basin can reach 12,000 ft^3/s (C.M. Swarzenski, USGS, written commun., 2002). The sources of this water can be from the upper Mississippi, the Missouri, and the Ohio Rivers or other tributaries to the Mississippi River in Mississippi, Alabama, and Louisiana.

The Penchant marshes, located in the Terrebonne Basin, receive freshwater from the Mississippi River by way of the Atchafalaya River into the GIWW. The GIWW distributes a west-to-east flow of Atchafalaya River water from the Terrebonne Basin across Bayou Lafourche and into the Barataria Basin.

The Mermentau River Basin is located in southwestern Louisiana. Locally, the area is called Coastal Prairie or Wet Prairie. The Mermentau River Basin is characterized by a heavy clay soil and low gradient streams. There were originally 2.5 million acres of wet prairie in Louisiana, and less than 100 acres of undisturbed wet prairie remain in the Mermentau River Basin (Allain and others, 2000). Most of the basin now is primarily used for growing rice, sugarcane, and soybeans.

SOURCES AND INTERACTIONS

Southern Louisiana is unique in that there is a combination of atrazine inputs from local sources and from sources in the midcontinental United States (midcontinental sources). The amounts and timing of these local inputs in Louisiana streams differ from the other regions of the Nation, where atrazine concentrations increase in early spring and then gradually decline to concentrations near minimum detection levels. Therefore, an assessment of the occurrence and distribution of atrazine concentrations in southern Louisiana streams must take into account the timing, probable sources, and routes of atrazine introduction into the environment.

The Mississippi River

Figure 2 shows the pattern of atrazine concentrations in the Mississippi River at Baton Rouge (site 19), 1999-2000. The graph includes data from February to May 2000 from the Mississippi River near St. Francisville, located about 30 river miles upstream from Baton Rouge. The graph indicates a relatively consistent seasonal pattern of peak concentrations arriving in Louisiana in May and June. This period of increased atrazine concentrations in streams and rivers has been referred to as the spring flush. The increased concentrations are the result of usage, rainfall, and subsequent runoff in agricultural areas of the midcontinental United States. The amplitude and duration of the concentration peaks are the result of the timing of pesticide applications and rainfall patterns for that particular year. For example, reduced-rainfall years in the midcontinental United States such as occurred in 2000, will produce lower peaks as compared to wet years as less pesticide will runoff into receiving waterbodies.

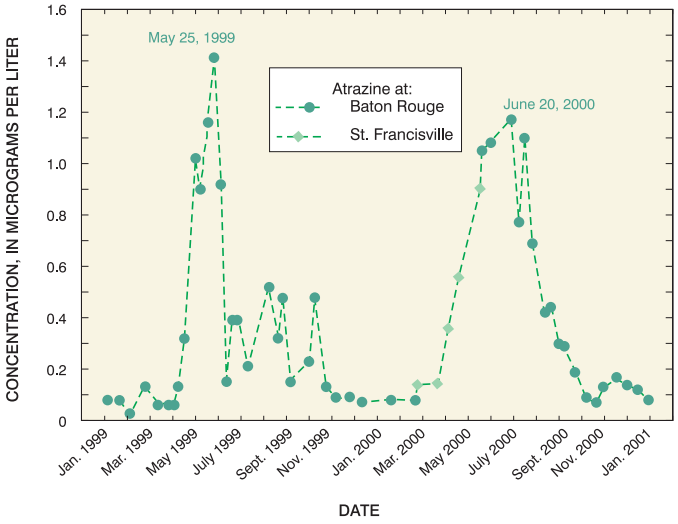


Figure 2. Atrazine concentrations in the lower Mississippi River near St. Francisville and at Baton Rouge.

Bayou Grosse Tete

Bayou Grosse Tete at Rosedale (site 4) is located in an agricultural area in the northern part of the Terrebonne Basin. Corn, sugarcane, and soybeans are the predominant crops. The bayou was sampled monthly or twice monthly for atrazine during 1999-2000. Figure 3 shows the pronounced peaks in April after atrazine had been applied to corn and sugarcane. The peak concentration determined in 1999 at site 4 was 41.3 µg/L on April 9. In comparison, the peak concentration determined in the Mississippi River at Baton Rouge (site 19) was 1.41 µg/L on May 25, over a month later. Similarly in 2000, the peak concentration determined at site 4 was 37.7 µg/L on April 10, and the peak concentration determined at site 19 was 1.17 µg/L on June 20. The annual pattern in Louisiana, especially the amplitude of the peak, will vary with the type of crop, acreage planted, and the timing and amount of rainfall. The primary use of atrazine on both corn and sugarcane is as a pre-emergent herbicide (Louisiana State University Agricultural Center, 1998), but there may be several additional applications in the northern Terrebonne Basin during the growing season to control broadleaf weeds. The acreage planted in either sugarcane or corn can vary greatly in response to prices and crop disease (Larry LeJeune, Louisiana Department of Agriculture and Forestry, oral commun., 1999).

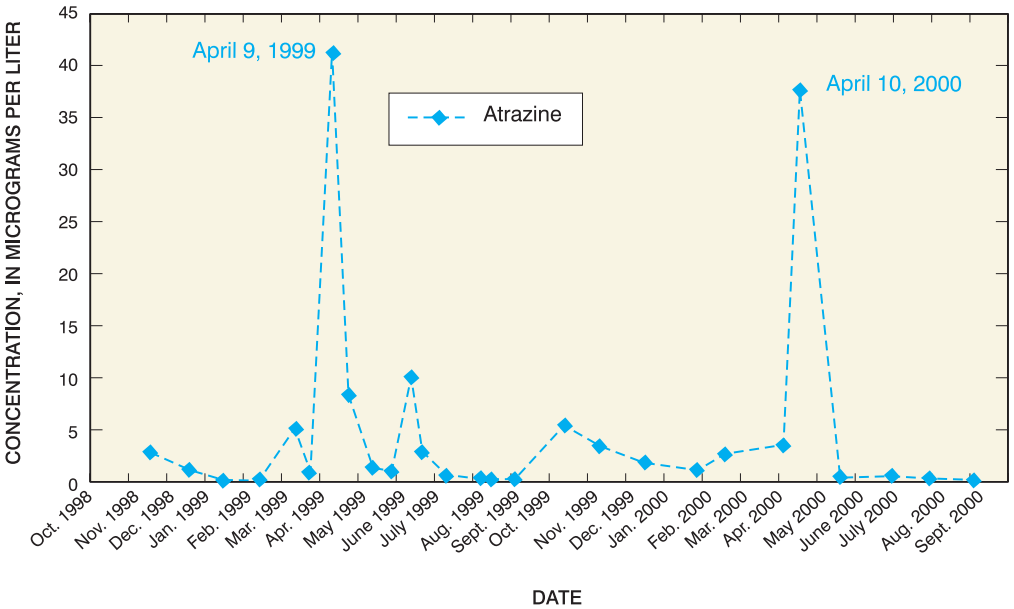
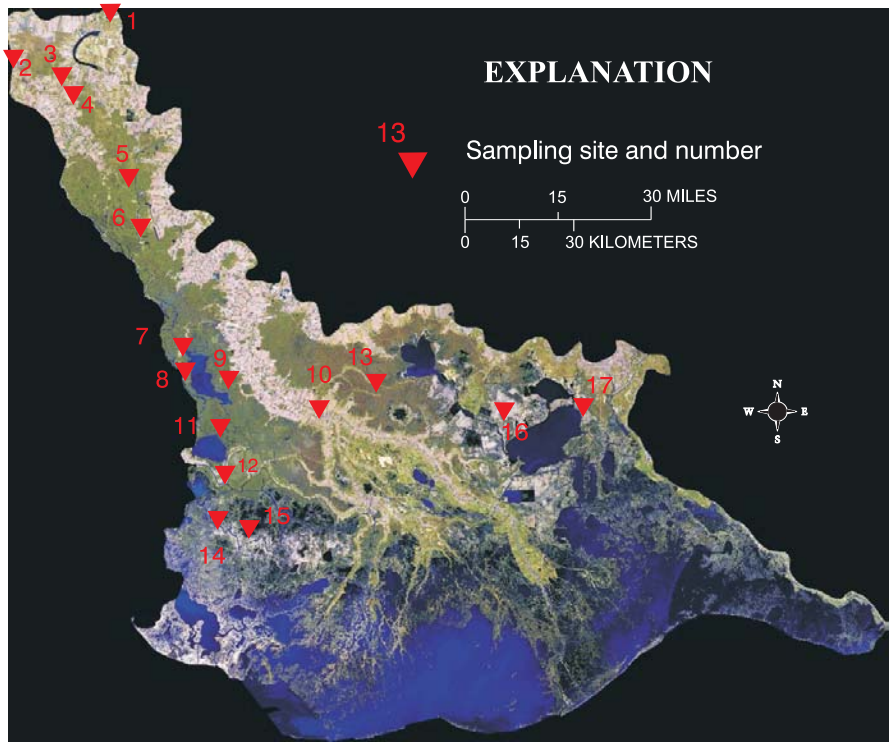


Figure 3. Atrazine concentrations representing local sources at Bayou Grosse Tete at Rosedale in the northern Terrebonne Basin.



Source: Louisiana Oil Spill Coordinator Office of the Governor, Louisiana GIS CD: A Digital Map of the State, Version 1.0

Site number	Site name	Atrazine, in micrograms per liter							
		March		May		June		August	
		Date	Concentration	Date	Concentration	Date	Concentration	Date	Concentration
1	Mississippi River near St. Francisville	3-30	0.11	5-6	1.31	6-24	0.41	8-5	0.21
2	Atchafalaya River at Melville	3-16	.13	5-7	1.04	6-28	.19	8-5	.22
3	Bayou Grosse Tete at Frisco	3-21	.81	5-10	.37	6-18	.35	8-30	.20
4	Bayou Grosse Tete at Rosedale	3-21	.88	5-10	1.36	6-18	2.80	8-30	.21
5	Choctaw Bayou near Brusly	3-21	7.20	5-10	1.73	6-21	2.06	8-30	.19
6	Gulf Intracoastal Waterway at Jack Miller Landing	3-21	1.84	5-11	1.44	6-21	1.06	8-30	.43
7	Bayou Pierre Part at Pierre Part	3-22	3.44	5-11	1.20	6-22	.71	8-31	.36
8	Belle River at Belle River	3-22	3.50	5-11	.80	6-22	.65	8-31	.42
9	Cancienne Canal at Bayou Crab	3-22	6.82	5-12	1.02	6-22	1.02	8-31	.20
10	Bayou Lafourche at Thibodaux	3-21	.18	5-11	15.60	6-22	.69	8-31	.31
11	Grassy Lake at Simon Pass	3-23	1.84	5-12	1.07	6-22	.91	8-31	.39
12	Bayou Boeuf at Amelia	3-22	.68	5-12	1.18	6-22	.79	8-31	.50
13	Bayou Chevreuil near Chackbay	3-21	.38	5-11	.17	6-22	.84	8-31	.14
14	Turtle Bayou near Bayou Penchant	3-22	.01	5-10	.05	6-9	.41	8-25	.18
15	Bluebird Canal near Bayou Copesaw	3-22	.13	5-10	.12	6-9	.63	8-25	.10
16	Interior Canal at Salvador Wildlife Management Area	3-22	.01	5-10	.10	6-9	.02	8-25	.07
17	Keyhole Six near Westwego	3-22	.01	5-10	.09	6-9	.01	8-25	.09

Figure 4. Distribution of atrazine concentration at selected suface-water sites in the Barataria and Terrebonne Basins, March through August 1999.

Barataria and Terrebonne Basins

Four atrazine surveys were conducted in the upper to mid reaches of the Barataria and Terrebonne Basins at approximately 6-week intervals from March to August 1999. Atrazine concentrations at 11 sites (sites 3-13, fig. 4) were compared to atrazine concentrations at the Mississippi River near St. Francisville (site 1) and the Atchafalaya River at Melville (site 2).

The results for March show elevated atrazine concentrations at sites 3, 4, 5, and 6, ranging from 0.81 to 7.20 µg/L. These sites are located in a mixed corn- and sugarcane-producing area. Similarly, sites 7, 8, 9, and 11, with concentrations ranging from 3.44 to 6.82 µg/L, are located in predominantly sugarcane-producing areas. When compared to atrazine concentrations of 0.11 and 0.13 µg/L from the Mississippi and Atchafalaya Rivers, respectively, the concentrations and timing indicate local sources of atrazine.

The results for May indicate mixed sources of atrazine in southern Louisiana streams. Atrazine concentrations in the Mississippi and Atchafalaya Rivers are higher than in March (1.31 and 1.04 µg/L), and concentrations at sites 3, 5, 6, 7, 8, 9, and 11 are all lower than in March. However, the concentration in Bayou Lafourche (site 10) increased from 0.18 to 15.6 µg/L. As this bayou receives water directly from the Mississippi River, this increase is caused by a combination of local and midcontinent sources, with local sources apparently predominating. The March and May surveys missed the April peak concentrations measured in Bayou Grosse Tete (fig. 3), but atrazine concentrations derived from local sources probably peaked between late March and mid-May. Atrazine concentrations peaked in the Mississippi River during late May.

In June, atrazine concentrations at the 11 sites are generally less than the earlier peaks, but the concentrations continue to remain well above detection limits, from 0.35 to 2.80 µg/L. This indicates that by June the interaction of local sources, midcontinental sources, hydrologic modifications, and low gradients in the coastal zone have produced a mixture of prolonged low-level and elevated atrazine concentrations. This scenario is more complex than the traditional concept of a spring flush, illustrated most clearly by the Mississippi River mainstem.

The concentrations in late August, although at a lower level than June, show that atrazine is still present in the hydrologic system. Atrazine concentrations continue to be greater than 0.3 µg/L at sites 6, 7, 8,10, 11, and 12.

Barataria-Terrebonne Interior Marsh

Atrazine from the flush of pesticides from midcontinental sources enters coastal parts of the Barataria and Terrebonne Basins through the Lower Atchafalaya River. Locally-applied atrazine also enters the same coastal wetlands primarily through Bayou Boeuf and Bayou Lafourche. Atrazine from both sources flows into the GIWW and is carried east and south into the interior marshes by the natural hydraulic gradient. Locally-applied atrazine enters the GIWW (site 6) in late March (figs. 4, 5), and the flush from midcontinental sources arrives more than a month later as evidenced by concentrations in the Atchafalaya River.

Freshwater wetlands in the western part of the Terrebonne Basin, therefore, receive water from two sources, both containing substantial quantities of atrazine at different times. In contrast, the hydrologically-isolated freshwater wetlands in the eastern part of the Barataria Basin do not receive water containing elevated levels of atrazine. For example, atrazine concentrations measured in June at two locations in the Terrebonne Basin, sites 14 and 15, were elevated, whereas atrazine concentrations measured at sites 16 and 17 located in the eastern part of the Barataria Basin were not (figs. 4, 5). The marsh type that dominates in both basins is peat marsh, locally referred to as flotant for its buoyant properties. Currently it is unknown if the herbicide atrazine has any adverse effects on flotant. Peat accumulation and substrate integrity are largely the result of root productivity, and atrazine is known to inhibit root productivity.

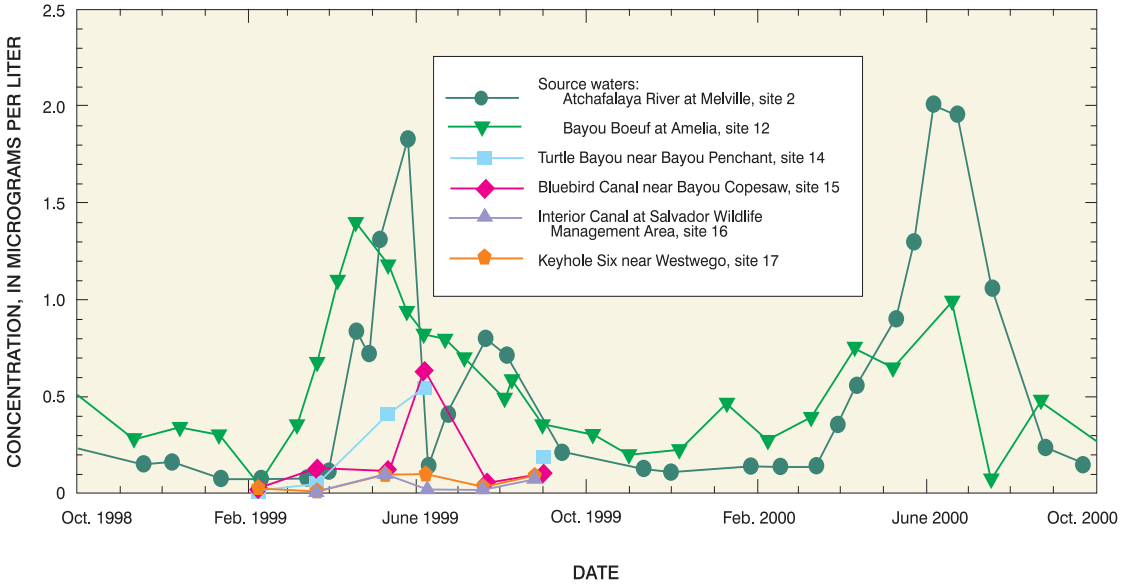


Figure 5. Atrazine concentrations, Barataria and Terrebonne Basins.

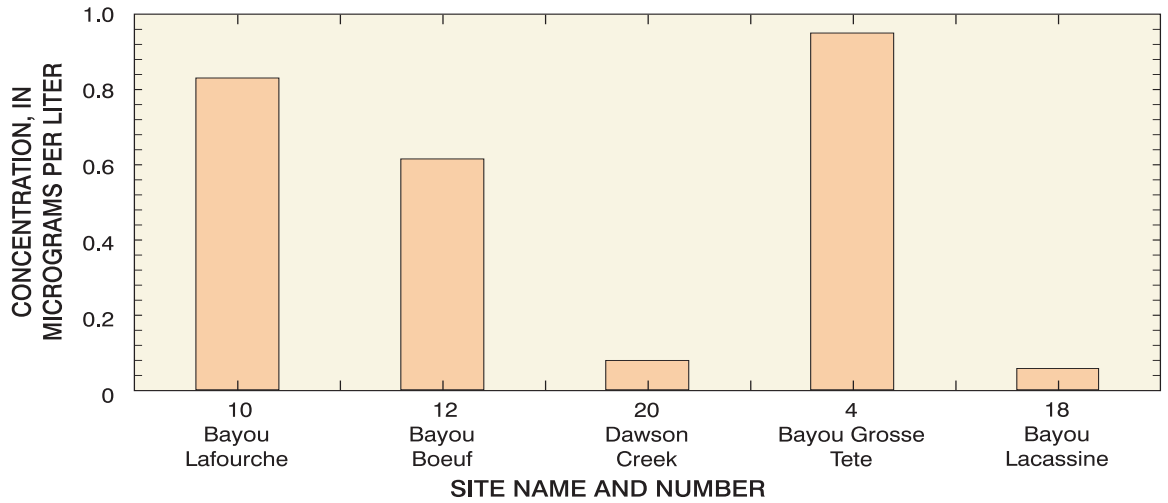


Figure 6. Atrazine concentrations after Tropical Storm Francis, Sept. 12-13, 1998.

Tropical Storm Francis

Atrazine concentrations were measured at five sites immediately after Tropical Storm Francis passed through southern Louisiana in September 1998 (fig. 6). Although there is no widespread application of atrazine in southern Louisiana in September and the streams sampled were bank-full or flooding, atrazine concentrations were still elevated, ranging from 0.62 to 0.95 µg/L at the three sites (Bayous Lafourche, Boeuf, and Grosse Tete) in the Terrebonne Basin. Dawson Creek (site 20), located in the City of Baton Rouge, and Bayou Lacassine (site 18), located in the Mermentau River Basin, had concentrations of 0.06 and 0.08 µg/L, respectively. Atrazine is applied in Baton Rouge as a landscaping herbicide and in the Mermentau River Basin for general broadleaf weed control. The results indicate that these streams might be affected by low levels of atrazine. Apparently atrazine is retained within these basins for months and is flushed out during storms.

CONCLUSIONS

The occurrence and distribution of atrazine in streams in southern Louisiana is the result of mixing of local and midcontinental sources. The combination of low-gradient coastal plains and interbasin hydrologic connections, in conjunction with spring flush inputs from the Mississippi and Atchafalaya Rivers, result in a prolonged period of low-level and elevated atrazine concentrations in local streams. This may have disturbing implications for cumulative environmental effects from prolonged exposure to low-level concentrations of atrazine. Amphibian populations may be particularly at risk from atrazine effects as an endocrine disrupter through the prolonged impact of low-level atrazine concentrations below 1 µg/L .

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