



# Selected Chemical Composition of Deposited Sediments in the Flooded Areas of New Orleans Following Hurricane Katrina

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*Nearly 4 weeks after Hurricane Katrina passed through St. Bernard Parish, the U.S. Geological Survey's (USGS) Mid-Continent Geographic Science Center and the University of Missouri-Rolla's (UMR) Natural Hazard Mitigation Institute deployed a team of scientists to the region to collect perishable environmental and engineering data. The team collected 149 samples throughout the affected area to chemically characterize the Katrina depositional sediments. Preliminary results of this effort are presented here.*

## Background

After reaching landfall on the Mississippi River Delta near Buras, La., Katrina moved northward and past New Orleans, La., about 25 mi (46 km) east of St. Bernard Parish. The hurricane's 125-mi/hour (201-km/hour) winds created a storm surge within Lake Pontchartrain that pushed water over the city's protective



levees.

This overtopping caused segments of the levee system to erode to the point of failure.

The torrent of water that followed devastated the parishes in the New Orleans area. Houses at the levee failure points were completely destroyed and became large piles of moving debris. Vehicles, boats, electrical transformers, and household and automotive chemicals were dispersed throughout neighborhoods along with sediment from Lake Pontchartrain (figs. 1 and 2).

Structures that were unaffected by the debris flows and swift moving water became depositional areas for sediment. What remained in the wake of this event was the realization that both cleanup of the debris and sediment and longer term exposure to the repopulating residents could pose a substantial health hazard.

The contribution of water and associated sediment from Lake Pontchartrain during the hurricane may largely be responsible for the concentrations of contaminants detected in recent post-Katrina studies (Pardue and others, 2005; Presley

and others, 2006). Lake Pontchartrain has been a long-term sink for environmental contamination primarily because it receives all of the drainage from New Orleans' industry and population (Penland and others, 2002) during storms. In previous studies of Lake Pontchartrain, water-column samples contained several U.S. Environmental Protection Agency (EPA) priority pollutants (McFall and others, 1985), and herbicides were detected in large concentrations within the sediments from the lake (Yu and Cole, 1997). Furthermore, large concentrations of lead, chromium, and barium were detected in Lake Pontchartrain sediments by using the continuous sediment sampling and analysis system of Noakes and others (1985). Because of the extreme mixing of the sediment with the flood waters and because the surface-water level of the lake reached equilibrium with the water level in the flooded city, the sediment deposited within the dewatered areas will probably contain large concentrations of trace elements and organic compounds.

## Data Collection

In October 2005, nearly 4 weeks after Katrina when the floodwaters had been pumped from the city, a team of USGS and UMR scientists deployed to the area to collect perishable engineering and environmental data. The team collected 149 samples representing soil and deposited sediment that were either affected by or associated with the flood waters. Samples were collected to characterize contaminant stratification in a single sample to include the surface layer deposited and the native soil beneath in some and only surface layer of deposited sediment in others. In the sampling procedure, a hand-held soil core tool was used to collect both a surface-layer sample and a stratified sample. Samples were placed in 100-mL septum bottles and transported on ice during the 10-day deployment until placed under refrigeration at the UMR Environmental Research Center's laboratory, Rolla, Mo.

Selected chemical analyses were completed for 20 of the 149 grab composite samples that represented sediment deposited from the flood water (figs. 3 and 4). (Grab samples are collected without the use of a coring device; instead, they are scooped from the surface by using a precleaned hand shovel and then are deposited in a shipping container.) The selected analyses included a headspace gas chromatograph/mass spectral (GC/MS) analysis of petroleum-based organic compounds benzene, toluene, ethylbenzene, and xylene (BTEX) and a liquid-liquid extraction GC/MS analysis of sediment for pesticide compounds

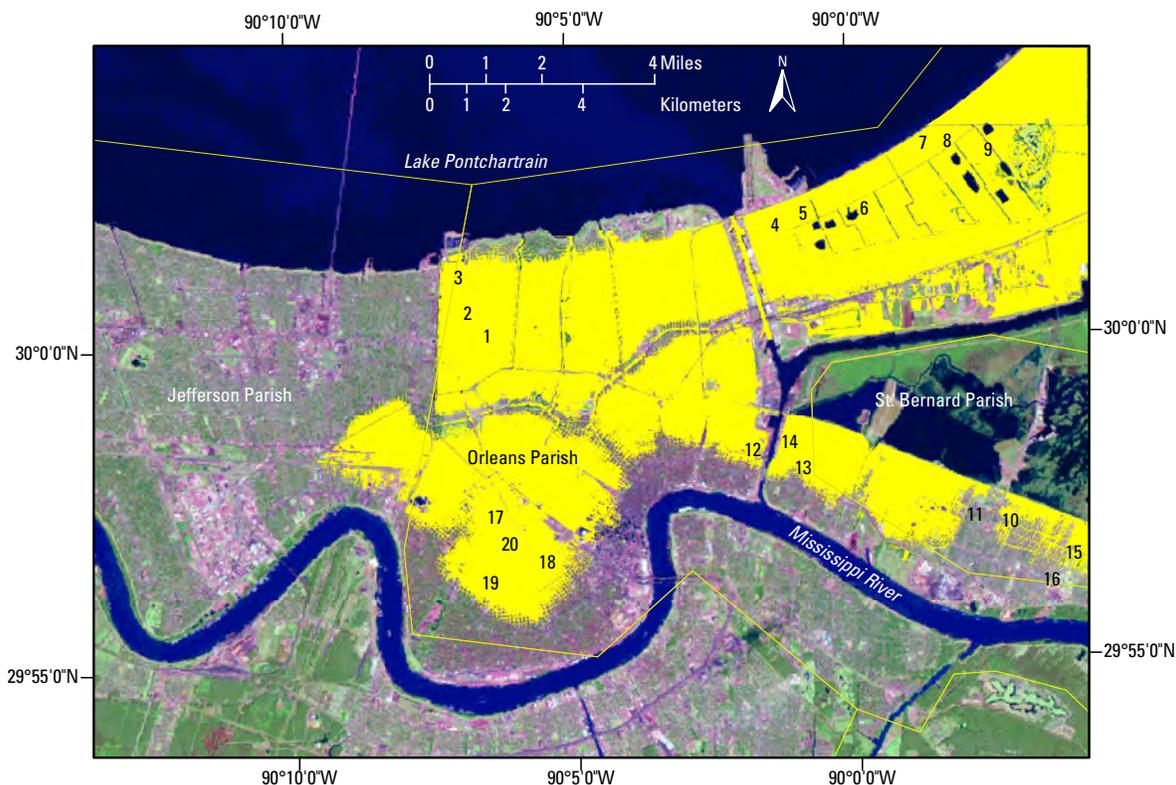
simazine, atrazine, methoxychlor, and prometon. A slightly modified EPA Method 1312 was used to obtain leachate samples to study the availability of trace metals under simulated acid rain conditions (U.S. Environmental Protection Agency, 1994). Selected trace elements arsenic, cadmium, chromium, copper, lead, and vanadium were determined from this leachate by using PerkinElmer, Inc., ELAN™ DRC-e Inductively Coupled Plasma Mass Spectrometry (ICP-MS). The concentrations of mercury were determined with a Tekran™ 2600 ultra-trace level mercury analyzer by using EPA Method 1631 (U.S. Environmental Protection Agency, 2002). These constituents and resulting analyses were selected to fit the team's observation of the most likely contamination to be incorporated in the sediments and to provide a starting point for characterizing additional analytical scenarios for the remaining samples and future New Orleans sampling efforts.



**Figure 1.** Photograph showing destruction of property and deposited sediment from flood waters in the Ninth Ward, New Orleans, La., after Hurricane Katrina in 2005.



**Figure 2.** Photograph showing aftermath of levee failure and flooding in the Ninth Ward, New Orleans, La., after Hurricane Katrina.



**Figure 3.** LandSat 7 mosaic showing estimated sediment depositional area (yellow) based on Lake Pontchartrain water-surface elevation during the peak of the flood, and locations of samples collected in the estimated sediment depositional areas of New Orleans, La.

## Chemistry of Deposited Sediments

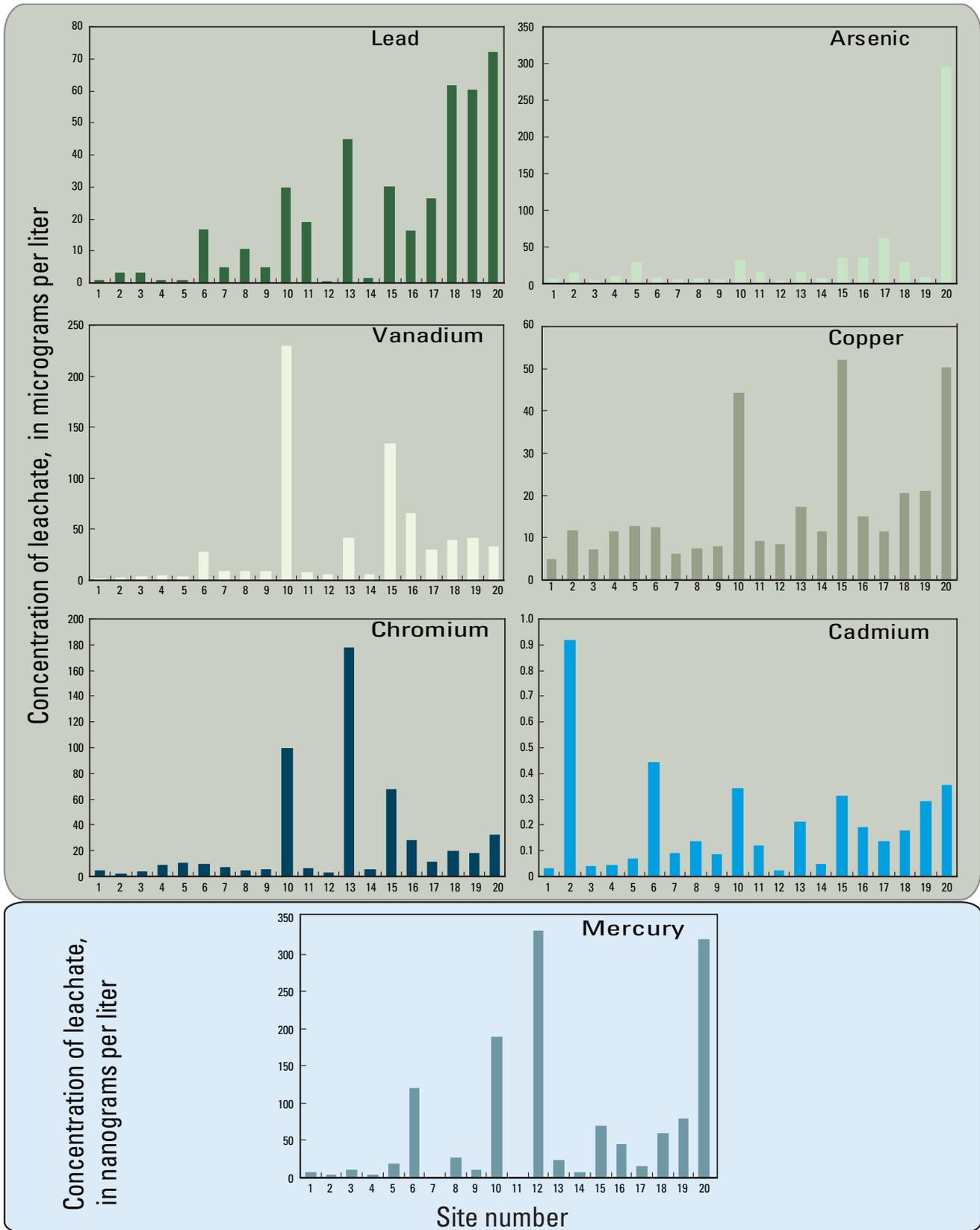
Samples for the determination of inorganic constituents were prepared in the laboratory to represent the concentration of leachable trace elements (those elements dissolved into solution under acidic conditions). This method provides the best assessment of how the dispersed contamination will most likely affect the repopulating residents. The prevailing rationale for using this technique is to understand the mechanism for contaminants in acidic fluids becoming transmitted by contact with skin and lung tissue and through involuntary ingestion during cleanup and debris removal operations. Also, dissolved trace elements will have a long-term effect on the native soils and will become a recurring problem when rainfall and runoff become the mobilizing mechanism. While this method of analysis can provide useful information for residents and those responsible for transporting sediment during the posthurricane rebuilding, this method does not quantify the total concentration of elemental trace metals in the solid phase, which may be quite large and may pose a greater long-term problem with respect to the flora and fauna of southern Louisiana.

## Results

This synoptic assessment of sediment chemistry within the flooded parishes surrounding New Orleans indicated the possibility of widespread contamination. In general, leachable concentrations of trace elements were detected in all samples (fig. 5). As a point of reference, at 10 of 20 sites both lead and



**Figure 4.** Photograph showing sediment deposited from flood waters in New Orleans, La., after Hurricane Katrina in 2005.



**Figure 5.** Bar graphs showing trace element concentration in leachate from samples collected in New Orleans, La., after Hurricane Katrina in 2005.

arsenic were found to exceed the drinking water standard of 15 and 10  $\mu\text{g/L}$ , respectively (U.S. Environmental Protection Agency, 2003). Furthermore, lead (71.8  $\mu\text{g/L}$ ) and arsenic (294  $\mu\text{g/L}$ ) values represented the largest concentrations for all analyzed samples within the floodwater depositional environment. Vanadium, copper, and chromium were present in all samples at relatively small concentrations and less than any maximum contaminant level for drinking water. Cadmium was detected at concentrations less than the minimum reporting level for all samples. The team expected to observe large concentrations of cadmium associated with the sediment because cadmium is inherently linked to fluid from automobiles, batteries, boats, and other machinery.

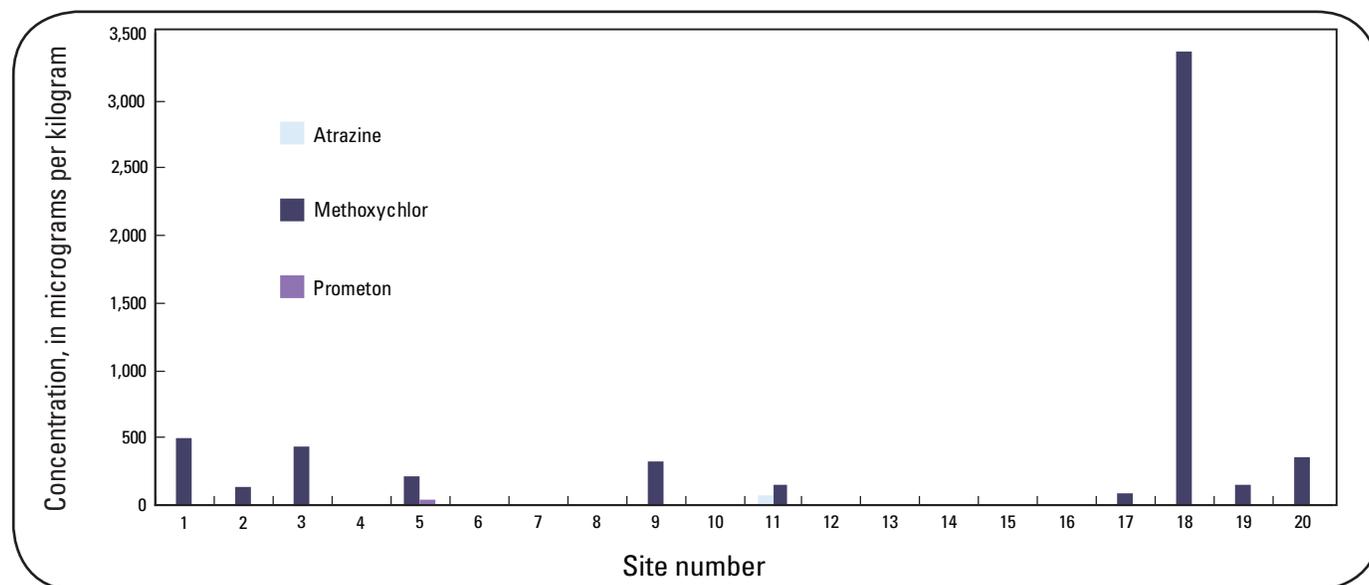
Of the 20 samples, 18 were analyzed for mercury. All mercury concentrations were substantially less than the drinking water standard of 2  $\mu\text{g/L}$  (U.S. Environmental Protection Agency, 2003). The largest concentration of mercury was analyzed at 330 nanograms per liter (ng/L), a unit of measure one whole magnitude less than the drinking water standard, and was found in a sample from site 12 (fig. 5).

The presence of BTEX and organic pesticide compounds was sporadic. Headspace gas was analyzed in 11 of 20 samples for BTEX and results did not detect any toluene, ethylbenzene, or xylene. Benzene, however, was found in 9 of 11 samples at concentrations slightly greater than the minimum detection level of 5  $\mu\text{g/kg}$ . Atrazine and prometon were detected in samples of sediment from sites 11 and 5 at comparatively small concentrations of 66 and 37  $\mu\text{g/kg}$ , respectively (fig. 6). Methoxychlor was the predominant

pesticide detected. The largest concentration, 3,359  $\mu\text{g/kg}$ , was found at site 18. Methoxychlor is an insecticide used to control flies, mosquitoes, cockroaches, and chiggers and is used on food crops, on farm animals and pets, and in home gardens (Agency for Toxic Substances and Disease Registry, 1995). This insecticide has not been shown to cause cancer, but it can enter the body through direct contact with the skin. Common pathways for contact include handling contaminated food, water, and soil. Insect control along the Gulf Coast by means of methoxychlor may explain the wide distribution of this compound in samples.

## Conclusion

Katrina and the resulting floods from levee failures clearly devastated many New Orleans communities. Understanding the distribution and degree of sediment contamination will be necessary to determine if there are areas of the city that are hazardous to human health and need to be made environmentally sound before they are developed and repopulated. The data collection and results presented here are limited and cannot be used to answer the contamination question; however, they do suggest that some levels of contamination exist, and it could be widely distributed. Only through followup studies that include many more samples and comprehensive laboratory analyses will it be possible to conclusively define this issue within New Orleans and other Gulf Coast communities that were affected by this event.



**Figure 6.** Bar graph showing pesticide concentrations for sediment samples collected in New Orleans, La., after Hurricane Katrina in 2005.

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