Occurrence and Distribution of Selected Metals in Streams Near Huntsville, Alabama

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ABSTRACT

Arsenic, cadmium, chromium, cobalt, lead, mercury, and zinc are widely distributed around Huntsville, Ala. However, concentrations of these metals in streamflow in the vicinity of the Huntsville municipal water intake during June, August, and September 1971 did not exceed the limits recommended for a public drinking water supply. The occurrence of these metals in general is related to man's activities.

Information gained during this study suggests that cadmium and the other metals are associated with and transported with suspended sediment, bed material, and airborne dust particles. Lead and zinc were the most abundant of the selected metals in streamflow, bed material, and rainwater samples. The highest concentration of cadmium was detected downstream from an industrial park in the Flint River basin; rainwater samples also contained a relatively high level of cadmium.

INTRODUCTION

A nationwide reconnaissance of selected metals in surface waters of the 50 States and Puerto Rico was made by the U.S. Geological Survey in cooperation with the U.S. Bureau of Sport Fisheries and Wildlife during autumn 1970. The results of that reconnaissance (Durum, Hem, and Heidel, 1971) showed that streamflow samples collected at four of the 18 sites sampled in Alabama had cadmium concentrations that equaled or exceeded the 10 μg/l (micrograms per liter) limit recommended by the National Technical Advisory Committee on Water Quality Criteria (Federal Water Pollution Control Administration, 1968) for surface water used for public water supplies and that samples at three sites contained 10 μg/l or more of arsenic.

A short-term study was initiated to determine possible sources of high concentrations of the metals (cadmium in particular). The purpose of the study was to obtain additional data on the source or sources and the pattern of occurrence of selected metals in the vicinity of Huntsville, Ala. The purpose of this report is to present the results of this study.

ACKNOWLEDGMENTS

The authors are grateful to the personnel of the Huntsville filtration plant for collecting the rainwater samples and for their aid and cooperation in collecting streamflow samples from the Tennessee River intake. Appreciation is also acknowledged to personnel of the Alabama Water Improvement Commission for information which proved useful in selecting sampling stations.

STUDY PLAN

A reconnaissance of the area (fig. 1) was made to locate points of withdrawal and waste effluent entering either the Tennessee River or tributaries to the Tennessee River. These points were plotted on a map and sampling sites were selected (fig. 2). The uppermost sampling sites were selected to represent natural streamflow conditions or to serve as a base for comparison with other samples collected from the same streams farther downstream.

Although metals in surface water can originate from natural sources such as airborne dust, rainfall, and solution of rock and soil, there is some evidence that abnormal concen-

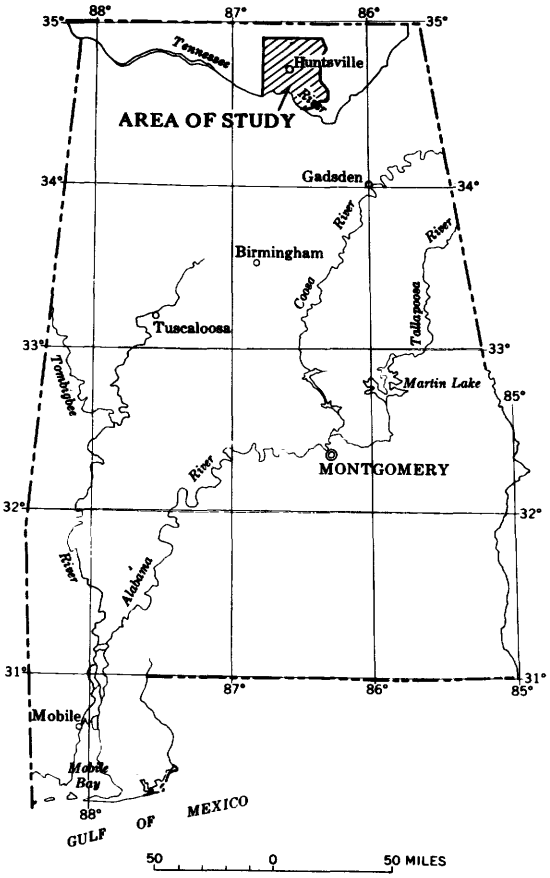

FIGURE 1.—Location of study area.

tration levels are related to man's activities (Durum and others, 1971). Sampling sites, therefore, were selected at or close to points where waste effluent was entering the streams. Samples collected during the study consisted of rainwater, surface water, suspended sediment, and streambed material. All samples except rainwater were collected during medium or low streamflow conditions and immediately after a storm event to define the relation between stream discharge, runoff, and concentration of the metals of interest.

SAMPLING PROCEDURE AND ANALYSES

Streamflow samples were collected using depth-integrating sampling techniques whenever possible. Two types of depth-integrated samples were collected at most stations. One type of sample (hereafter referred to as type A sample) was collected at the midpoint of flow using the weighted-bottle depth-integrated technique. The other type of sample (type B sample) was collected using modified suspended-sediment samplers and the multiple-vertical technique. The suspended-sediment sampler was modified by replacing the brass nozzle with a Teflon nozzle and the rubber gasket with a silicone-rubber gasket and by painting the inside of the nose of the sampler with unpigmented epoxy paint in order to minimize contamination of the samples by the sampler.

Bed-material samples were collected where the streambed could be reached using a hand-held plastic scoop.

Rainwater sampling equipment consisted of plastic bottles and funnels. These samplers were not placed until after the rain began falling and were located so that water from buildings, trees, or other structures could not drop or splash into the bottles.

Concentrations of the selected metals in the streamflow were determined in two forms—dissolved and total (water-suspended sediment mixture). Dissolved concentrations represent only the amount of the metals in solution (dissolved); suspended material was removed by filtering the sample through a 0.45-micron membrane-type filter immediately after sample collection. Total concentrations were determined from unfiltered samples and represent the amount of the metal carried in the water-suspended sediment mixture. U.S. Geological Survey analytical methods (Brown and others, 1970) were followed in analyzing the samples.

RESULTS

STREAMFLOW

Streamflow samples were collected from Huntsville Spring Branch, Aldridge Creek, Indian Creek, Flint River, and Tennessee River at the sampling stations shown in figure 2. The results of selected metal analyses are given in table 1. Samples were collected during three sampling periods. The first period, June 7–11, 1971, was preceded by several days of little or no rainfall. Samples were collected during the second period, August 26–27, 1971, primarily to substantiate data obtained during the first period and to obtain additional bed-material samples. Streamflow conditions were similar to those of the first sampling period. Samples were not collected at every station during the second

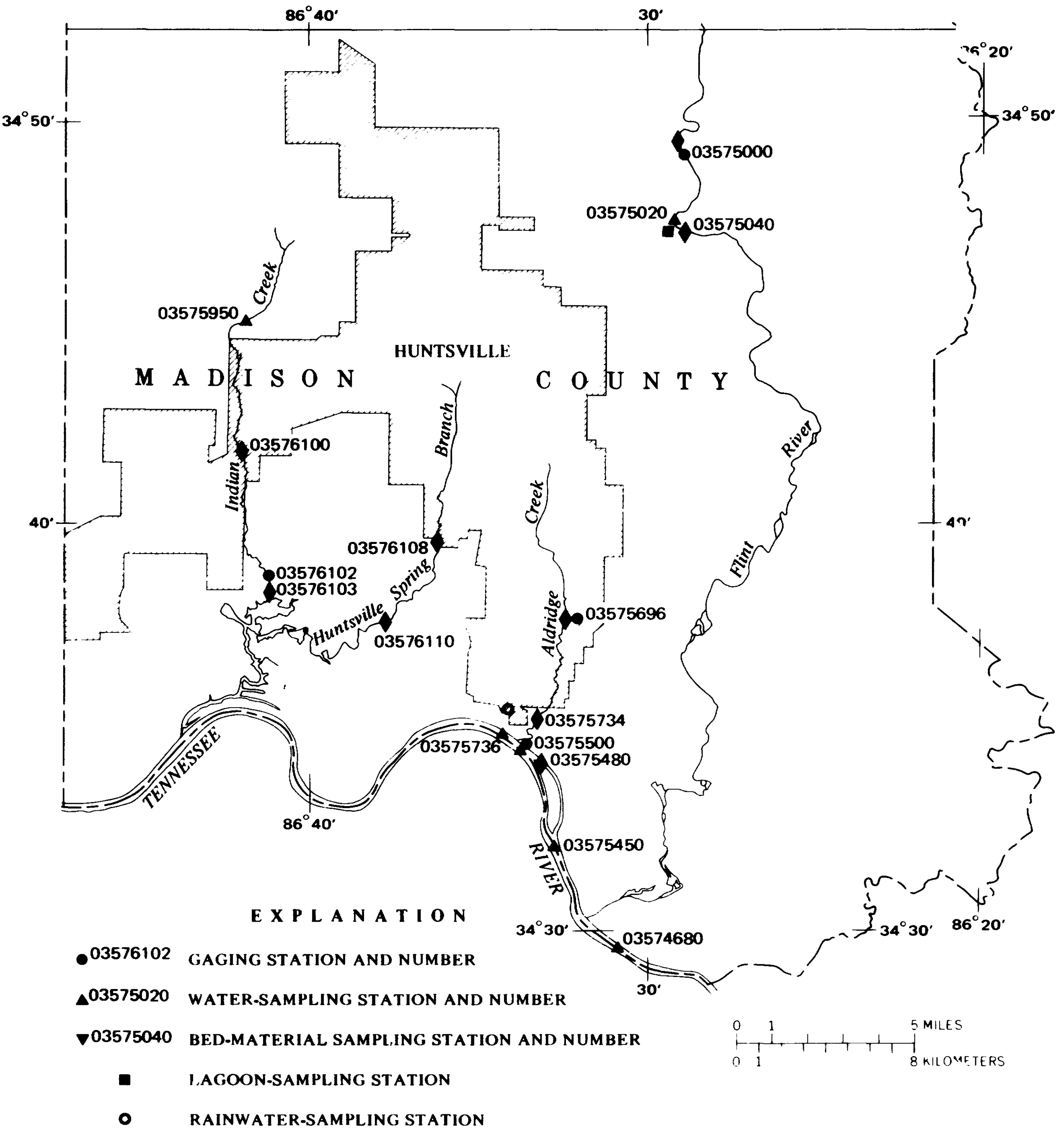

FIGURE 2.—Location of sampling stations in the vicinity of Huntsville.

period. The third period, September 17–20, 1971, was immediately after a storm.

MINOR ELEMENTS

ARSENIC

Arsenic concentrations were less than the lower limit of detection (10 μg/l) for samples collected during the June and August periods, but concentrations of as much as 10 and 20 μg/l were detected at four stations (see table 1) during the September period. Arsenic concentrations did not appear to be related to suspended sediment because total arsenic concentrations were no higher than dissolved concentrations. The distribution of arsenic did not correlate with locations of known waste outfalls.

CADMIUM

Cadmium concentrations in the filtered samples were less than 1 μg/l. Cadmium was detected, however, in measurable concentrations in unfiltered samples collected at five stations (table 1), which include the two stations on Huntsville Spring Branch. The source of the cadmium in Huntsville Spring Branch is upstream from the upstream sampling station (03576108) at Martin Road. The increase in cadmium concentration at the Martin Road station from 2 μg/l on June 9 to 7 μg/l on September 18 is proportional to the increase in sediment concentration from 48 mg/l (milligrams per liter) on June 9 to 134 mg/l on September 18. This relation and the fact that none of the filtered samples contained detectable concentrations of cadmium suggest that cadmium is being transported down Huntsville Spring Branch associated with suspended-sediment particles. Because cadmium was not detected at station 03575734 on Aldridge Creek (a point where primarily municipal waste enters the stream), was detected only once downstream from the municipal and industrial waste outfalls on Indian Creek, and was detected in the industrial lagoon effluent near Ryland, it appears that cadmium is not associated with municipal wastes in the Huntsville area, but probably is of industrial origin.

CHROMIUM

Chromium concentrations were determined either as the total amount present (all oxidation states) or as the amount which was present in the hexavalent state. Chromium concentrations were less than 10 μg/l except for the lagoon effluent near Ryland and at Huntsville Spring Branch at Martin Road (03576108). Thus, chromium does not seem to be generally distributed throughout the study area and does not appear to be associated with municipal wastes.

COBALT

Cobalt concentrations were generally less than the 1 μg/l detection limit in the study area. The highest concentration was observed at Indian Creek near Huntsville (station 03576103) which is below the outfall of an industrial lagoon. The concentration was 6μg/l on September 17, 4 μg/l on June 10, but less than 1 μg/l on August 27. Streamflow at all other stations contained 2 μg/l or less cobalt. Cobalt concentrations in the dissolved form were always 1 μg/l or less, thus suggesting that cobalt is associated with suspended sediment.

LEAD

Lead was widely distributed in the study area and in three unfiltered water samples exceeded the 50 μg/l limit recommended for drinking water. The concentration of lead was 61 μg/l at station 03575040, Flint River near Mount Carmel on June 7; 95 μg/l at station 03576108, Huntsville Spring Branch at Martin Road near Huntsville on September 18; and 75 μg/l at station 03576110, Huntsville Spring Branch at Patton Road near Huntsville on September 18. These three stations are downstream from industrial waste outfalls. All other water-suspended sediment samples contained concentrations generally less than 20 μg/l, and most filtered samples contained less than 10 μg/l.

MERCURY

All the streams sampled had measurable concentrations of mercury at one or more stations during one or more of the sampling periods. However, the pattern of occurrence was erratic and did not correlate with known waste outfalls. Mercury in water was also entering the study area from sources upstream from station 03574680, Tennessee River near Morgan City. The maximum concentration of mercury was detected at this station. Mercury was detected in the dissolved form at only one station in concentrations exceeding the 0.5 μg/l detection limit. Mercury in excess of 0.5 μg/l was detected in the unfiltered samples at several stations indicating that mercury is transported by suspended-sediment particles. The maximum concentration was 1.3 μg/l.

ZINC

Zinc commonly occurred in higher concentrations than the other metals; however, it did not exceed the recommended drinking water limit

(5,000 μg/l). The maximum zinc concentrations were observed at Huntsville Spring Branch at Martin Road (station 03576108) on September 18 (380 μg/l) and at Tennessee River near Hobbs Island (station 03575450) on June 9 (190 μg/l). Other zinc concentrations ranged from less than the detection limit (10 μg/l) to 60 μg/l. Unlike the other metals the dissolved form of zinc was generally a significant proportion of the total amount. Zinc concentrations downstream from waste outfalls were generally about the same as those found upstream from the outfalls and tended to be greater during the first sampling period than during the following two sampling periods.

SAMPLING TECHNIQUES

Metals are generally associated with suspended sediment, and a representative water-suspended sediment mixture should be obtained. The multiple-vertical suspended-sediment sampler technique is designed to obtain a water-suspended sediment mixture (type B sample) which is more representative of the suspended sediment concentration and particle size distribution than the sample (type A sample) obtained by the single-vertical weighted-bottle depth-integrated technique.

Samples were collected using the two sampling techniques during this study. Lead and zinc were the only metals present in measurable concentrations in enough of the samples to allow comparisons of the sampling techniques. In seven of 18 pairs of samples (excluding pairs of samples where equal concentrations were reported in both samples), the lead concentrations of the unfiltered type A samples were greater than lead concentrations of unfiltered type B samples. A similar situation was noted for three of eight pairs of unfiltered zinc samples. Data for these samples do not prove that a significant difference exists between metals concentrations obtained by the two sampling techniques in this study. However, the tendency for the type A samples to contain lower concentrations of lead and zinc than the type B samples supports the principle that a sample collected by the suspended-sediment sampler technique should be used in determining concentrations of metals. Suspended-sediment concentrations obtained in this study were relatively low, therefore minimizing the effect of sampling techniques.

SUSPENDED SEDIMENT

Suspended sediment concentrations (table 2) ranged from 12 to 391 mg/l but generally were in the 15 to 80 mg/l range. The highest concentrations were generally observed during the September period. However, metals concentrations observed during this period were generally comparable to those determined on previous trips. The concentrations of metals in the unfiltered samples generally were several times the concentrations in the dissolved phase, indicating that the selected metals transport was related to the quantity of sediment in suspension. More samples are needed during various streamflow conditions, including numerous samples during rises, to define the relation between suspended sediment and metals concentrations.

Lead and zinc discharges, in pounds per day, transported by streamflow at the time of sample collection are given in table 3. Lead discharges associated with suspended sediment generally were several times greater than lead discharges in solution. Zinc discharges in solution, however, commonly exceeded zinc discharges associated with suspended sediment.

Data from Aldridge Creek near Whitesburg (station 03575734) indicate an interesting anomaly. The suspended-sediment concentration at this station was much lower during the September sampling period than during the previous two sampling periods. Streamflow at this station was affected by backwater from the Tennessee River during the June and August periods, and stream velocities were very slow. Backwater conditions were not present during the September trip. The reversal in the usual relation of velocity and suspended-sediment concentration may mean that much of the suspended material in the stream during the June and August periods was organic, probably plankton growth stimulated by nutrients entering the stream from the sewage-treatment plant and accumulating in the ponded stream. If this is true, substantial amounts of the suspended material in some fertile streams may be organic in nature. Metals associated with organic matter probably would be passed up the food chain faster and in greater quantities than metals sorbed on inorganic material that is in suspension or on the streambed. Wastes entering Aldridge Creek were mostly of municipal origin, and metals concentrations were relatively low.

RAINWATER

Rainwater samples were collected during two storms (June 16 and July 6, 1971) at the Huntsville filtration plant. Results of the analyses are tabulated in table 4, and the sampling station is shown in figure 2. Both rainwater samples contained measurable concentrations of cadmium, lead, and zinc. Arsenic, chromium, cobalt, and mercury were below the detection limits. The rainwater sample collected on June 16 contained the highest concentrations of cadmium, lead, and zinc. Cadmium and zinc concentrations (6 and 100 μg/l respectively) were relatively high when compared to cadmium and zinc concentrations in streamflow in the Huntsville area. Cadmium concentrations in streamflow were generally less than 1 μg/l except in areas affected by waste disposal where they ranged from 1 to 7 μg/l. Zinc concentrations in streamflow were generally less than 40 μg/l except in areas affected by waste disposal where they were generally less than 60 μg/l, but two samples were as high as 250 and 380 μg/l.

The second rainwater sample, collected on July 6, contained 2 μg/l cadmium, 3 μg/l lead, and 20 μg/l zinc. Concentrations of lead and zinc were about the same as concentrations of lead and zinc in the streamflow.

The first of the two rainstorms was reported to have been the heaviest rain in several days and was moving from the west-northwest to the east-southeast. A rainstorm moving in that direction would cross several miles of an urbanized region before reaching the filtration plant. The second rainstorm was reported to have been moving from south to north. A rainstorm moving in that direction would cross a predominantly rural region before reaching the filtration plant.

Consideration of the movement of the storms and comparison of the two rainwater analyses suggest that cadmium, lead, and zinc are added to the atmosphere as a result of urbanization and industrialization. These metals are then washed from the atmosphere by rainwater.

BED MATERIAL

Samples of bed material were collected from Huntsville Spring Branch, Aldridge and Indian Creeks, and the Flint and Tennessee Rivers. Sampling stations are shown in figure 2, and the results of the analyses are given in tables 5 and 6. In general, bed material at or downstream from a point of waste disposal contained the higher concentrations of metals. The occurrence of these metals, however, is related probably to the type of waste entering the stream. Relatively high concentrations of cadmium, copper, lead, and zinc seem to be characteristic of waste in the Huntsville area.

A lagoon for the treatment of sewage and industrial waste in the central part of the Flint River basin discharges effluent into a high-water channel of the Flint River. The confluence of the high-water channel with the main channel of the Flint River is about 700 feet downstream from the lagoon effluent outfall. Bed material from the high-water channel contained the highest concentrations of cadmium. Cadmium concentrations were 5,600 μg/kg (micrograms per kilogram) on June 7, <100 μg/kg on August 26 and 3,000 μg/kg on September 18. Variations in the concentrations may have resulted from (1) industrial operations within the industrial park, (2) methods of sampling bed material, (3) point of collection at the station, (4) climatic conditions prior to the collection of the sample, and (5) transport of cadmium in the stream system. The concentrations of cadmium, when samples were collected, were about the same in bed material upstream and downstream from the point where the effluent enters the main channel of the Flint River.

The fact that relatively high concentrations of cadmium were observed in two of three samples of bed material at the discharge pipe of the lagoon suggests that cadmium is associated with and transported with bed material. A hypothesis, therefore, would be that cadmium is concentrated on bed material and that during periods of high streamflow the cadmium associated with the finer particles of bed material is resuspended and moved downstream to a point where the streamflow velocities are slow enough to allow deposition on the streambed once again. The lower reach of the Flint River provides an ideal setting for this hypothesis because the streamflow velocities are slow as a result of backwater from the Tennessee River. During periods of low streamflow on the Flint River, suspended material probably is deposited and accumulated until periods of high streamflow when the accumulations are transported into the Tennessee River.

Relatively high concentrations of cadmium were observed in bed material at two other stations. A sample from Indian Creek (station 03576103) contained 1,300 μg/kg of cadmium and a sample from Huntsville Spring Branch (station 03576108) contained 1,400 μg/kg. Both sampling stations were downstream from waste-disposal points.

Bed material of Aldridge Creek, Flint River, Huntsville Spring Branch, and Indian Creek generally contained much lower concentrations of metals than did suspended sediment (table 5), probably because suspended-sediment particles are finer than bed-material particles. Since fine particles have greater surface areas per unit weight upon which metals can be sorbed than coarse particles, extreme care should be exercised in sampling suspended sediment, water-suspended sediment mixtures, and bed material so that fine particles are not lost from the samples.

CONCLUSIONS AND RECOMMENDATIONS

There is no indication of dangerous concentrations of any of the selected metals in drinking water supplies in the study area. Analyses of streamflow, bed material, and rainwater samples indicate that the selected metals are widely distributed in the Huntsville area and in general are related to man's activities. Although lead was not found in high concentrations near any water-supply intake, it was found in some samples remote from any water-supply intake in concentrations that exceeded the recommended limit for a drinking water supply.

The highest concentrations of cadmium were detected at or downstream from points of industrial waste disposal and in samples of rainwater. However, dissolved cadmium concentrations greater than 1 μg/l were not detected during this study. Cadmium concentrations of as much as 7 μg/l were detected in the unfiltered samples, as much as 5,600 μg/kg in bed material, and as much as 6 μg/l in rainwater. The information gained in this study leads to the hypothesis that slugs of cadmium in solution and associated with sediment enter the Flint River. Under certain conditions, some of the cadmium will remain in solution and move down the Flint River into the Tennessee River, but primarily the cadmium is associated with and transported with bed material, suspended sediment, and airborne dust particles.

Firm conclusions regarding the source or sources and pattern of occurrence of the selected metals cannot be drawn from this study; however, some possibilities have been pointed out that should be studied in greater detail. Future studies should include the following:

1. More thorough sampling of bed material is needed, especially of the finer particles.
2. A more comprehensive sampling of suspended sediment is needed to define the manner in which metals are associated with suspended sediment.
3. Analyses are needed to determine the form in which the metals exist.
4. A more complete understanding of operational procedures is needed at points of waste disposal to determine the form in which the metals are introduced as wastes and the schedule (if any) used in discharging wastes.
5. Additional climatic information is also needed such as (a) time interval from one storm event to another, (b) intensity of rainfall, (c) duration of rainfall, (d) direction and rate of movement of storm, (e) area covered by storm, and (f) comparison of rainwater collected at different locations in the Huntsville area.
6. A time-of-travel study is needed on the Flint and Tennessee Rivers to understand how an accidental spill or slug release of toxic materials moves. The movement of bed material and suspended sediment as well as the water itself should be included in the study. Information gained from a time-of-travel study could be essential to the planning of emergency programs for accommodating accidental spills or releases of toxic materials which could contaminate the Huntsville surface-water supply.

7. Further research is needed to define the concentration of suspended organic matter in streams contaminated with wastes that are high in nutrients, define the affinity of suspended organic matter for metals, define the effect of sorbed metals on the food chain, and investigate the feasibility of disposing of wastes containing high concentrations of nutrients and metals at the same location. Huntsville Spring Branch would be a suitable stream for such research since relatively high concentrations of nutrients and metals were detected during this study.

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Durum, W. H., Hem, J. D., and Heidel, S. G., 1971, Reconnaissance of selected minor elements in surface waters of the United States, October 1970: U. S. Geol. Survey Circ. 643, 49 p.

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TABLES 1-6

TABLE 1.—*Analyses of selected metals in streamflow, Huntsville, Ala., area*

[Station numbers correspond to those in fig. 2. Sampling method: A, single-vertical weighted-bottle depth-integrated at midpoint of flow; B, multiple-vertical depth-integrated using suspended-sediment sampler; C, from effluent pipe; D, from raw-water intake. Concentrations of sample constituents given in micrograms per liter. a, concentration is less than lower limit of detection as follows: Arsenic, chromium, and zinc, <10; cadmium, cobalt, and lead, <1; mercury, <0.5]

Station No.	Station name	Date of collection	Discharge (cfs)	Sampling method	Dissolved constituents (filtered sample)							Water-suspended sediment mixture (unfiltered sample)						
					Arsenic	Cadmium	Chromium, hexavalent	Cobalt	Lead	Mercury	Zinc	Arsenic	Cadmium	Chromium, hexavalent	Cobalt	Lead	Mercury	Zinc
	Aldridge Creek																	
03575734	Aldridge Creek near Whitesburg	6-10-71	30	A	--	-	---	-	--	--	--	a	a	a	a	2	a	40
				B	a	a	a	a	1	a	50	a	a	a	a	10	a	---
03575696	Aldridge Creek near Lily Flagg	8-27-71	.8	B	a	a	[1]a	a	2	a	a	a	a	[1]a	a	2	a	20
03575734	Aldridge Creek near Whitesburg	8-27-71	2.5	A	a	a	[1]a	a	5	a	10	a	a	[1]a	a	13	0.5	50
03575696	Aldridge Creek near Lily Flagg	9-19-71	2.3	A	a	a	a	a	a	a	a	a	a	[1]a	a	a	a	a
				B	a	a	a	a	a	a	10	a	a	[1]a	a	5	a	30
03575734	Aldridge Creek near Whitesburg	9-19-71	7.5	A	a	a	a	a	a	a	10	a	a	[1]a	a	2	a	30
	Flint River basin																	
03575000	Flint River near Chase	6-11-71	172	A	--	-	---	-	--	--	--	a	a	a	a	a	a	10
				B	a	a	a	a	1	a	40	a	a	a	a	13	0.7	---
03575040	Flint River near Mount Carmel	6- 7-71	175	A	--	-	---	-	--	--	--	a	a	a	a	61	.5	10
				B	a	a	a	a	1	a	50	a	a	a	a	14	.7	---
03575000	Flint River near Chase	8-26-71	124	A	a	a	[1]a	a	2	a	10	a	a	[1]a	a	2	a	10
				B	a	a	[1]a	a	5	a	10	a	a	[1]a	a	--	a	30
03575020	Flint River near Cedar Gap	8-26-71	135	A	a	a	[1]a	a	3	a	a	a	a	[1]a	a	--	a	20
--------	Lagoon effluent near Ryland	8-26-71	.2	C	a	a	[1]420	a	3	a	20	a	2	---	a	3	a	60
03575040	Flint River near Mount Carmel	8-26-71	136	A	a	a	[1]a	a	4	a	a	a	a	[1]a	a	--	a	10
				B	a	a	[1]a	1	7	a	10	a	a	[1]a	-	--	a	10
03575000	Flint River near Chase	9-18-71	230	A	10	a	a	a	a	a	10	-	a	[1]a	a	2	a	10
				B	a	a	a	a	a	a	10	a	a	[1]a	a	2	a	---
03575020	Fint River near Cedar Gap	9-18-71	277	A	a	a	a	a	a	a	10	a	a	[1]a	1	5	a	10
				B	a	a	a	a	a	a	a	a	a	[1]a	a	5	a	10
--------	Lagoon effluent near Ryland	9-18-71	.1	C	a	a	a	a	a	a	a	a	4	[1]83	a	3	a	60
03575040	Flint River near Mount Carmel	9-18-71	278	A	a	a	a	a	a	a	10	a	a	[1]a	2	9	a	20
				B	a	a	a	a	a	a	20	a	a	[1]a	a	1	a	---
	Huntsville Spring Branch																	
03576108	Huntsville Spring Branch at Martin Road near Huntsville.	6- 9-71	50	A	--	-	---	-	--	--	--	a	2	a	a	11	a	30
				B	a	a	a	a	2	0.8	60	a	2	a	a	14	-	60
03576110	Huntsville Spring Branch at Patton Road near Huntsville.	6-11-71	130	A	--	-	---	-	--	--	--	a	1	a	1	7	0.6	60
				B	a	a	a	a	2	a	60	a	1	a	1	20	.5	---
03576108	Huntsville Spring Branch at Martin Road near Huntsville.	9-18-71	58	A	a	a	a	a	1	a	20	a	7	[1]127	2	95	1.3	380
				B	a	a	a	1	1	a	30	a	5	[1]20	-	38	.7	250
03576110	Huntsville Spring Branch at Patton Road near Huntsville.	9-18-71	140	A	a	a	a	a	2	a	20	a	a	[1]a	2	9	a	20
				B	a	a	a	a	2	a	10	a	1	[1]a	a	75	a	10
	Indian Creek																	
03576103	Indian Creek 700 feet downstream from Martin Road near Huntsville.	6-10-71	40	A	--	-	---	-	--	--	--	a	2	a	4	16	0.5	10
				B	a	a	a	a	2	a	60	a	2	a	4	15	a	---
03575950	Indian Creek near Huntsville	8-27-71	5.6	B	a	a	[1]a	a	5	a	a	a	a	[1]a	a	--	a	a
03576100	Indian Creek near Madison	8-27-71	5.1	B	a	a	[1]a	a	10	a	a	a	a	[1]a	a	--	a	30
03576103	Indian Creek 700 feet downstream from Martin Road near Huntsville.	8-27-71	22	A	a	a	[1]a	a	5	a	10	a	a	[1]a	a	6	a	20
				B	a	a	[1]a	a	a	a	a	a	a	[1]a	a	2	a	a
03576100	Indian Creek near Madison	9-17-71	50	A	a	a	a	a	2	a	10	a	a	[1]a	2	7	.5	10
03576103	Indian Creek 700 feet downstream from Martin Road near Huntsville.	9-17-71	192	A[2]	10	a	a	a	1	a	10	10	a	[1]a	6	16	a	10
	Tennessee River																	
03574680	Tennessee River near Morgan City.	6- 8-71	45,000	A	--	-	---	-	--	--	--	a	a	a	a	8	1.3	10
				B	a	a	a	a	1	a	40	a	a	a	a	6	.7	---
03575450	Tennessee River near Hobbs Island.	6- 9-71	43,200	A	--	-	---	-	--	--	--	a	1	a	a	13	a	40
				B	a	a	a	a	1	a	40	a	a	a	1	8	a	190
03575480	Tennessee River at Huntsville Pumping Station.	6- 9-71	24,800	D	a	a	a	a	1	a	40	a	a	a	a	15	a	---
				A	--	-	---	-	--	--	--	a	a	a	a	5	a	a
03575500	Tennessee River at Whitesburg	6- 9-71	48,300	A[3]	--	-	---	-	--	--	--	a	a	a	a	13	a	10
				B	a	a	a	1	1	a	50	a	a	a	-	10	a	---

See footnotes at end of table.

TABLE 1.—*Analyses of selected metals in streamflow, Huntsville, Ala., area*—Continued

Station No.	Station name	Date of collection	Discharge (cfs)	Sampling method	Dissolved constituents (filtered sample): Arsenic	Cadmium	Chromium, hexavalent	Cobalt	Lead	Mercury	Zinc	Water-suspended sediment mixture (unfiltered sample): Arsenic	Cadmium	Chromium, hexavalent	Cobalt	Lead	Mercury	Zinc
	Tennessee River—Continued																	
03575736	Tennessee River near Farley	6–10–71	42,300	A	--	-	---	-	--	--	--	a	a	a	a	1	a	a
				B	a	a	a	a	a	a	40	a	a	a	a	4	a	---
03575480	Tennessee River at Huntsville Pumping Station.	8–26–71	49,200	D	a	a	[1]a	a	14	a	a	a	a	[1]a	a	--	a	20
03574680	Tennessee River near Morgan City.	9–20–71	35,300	A	a	a	a	a	7	a	20	a	a	[1]a	a	--	.9	30
				B	a	a	a	a	a	a	20	a	a	[1]a	a	4	.6	---
03575450	Tennessee River near Hobbs Island.	9–20–71	47,000	A	10	a	a	a	a	a	a	10	a	[1]a	a	1	a	20
				B	a	a	a	a	a	a	10	a	a	[1]a	a	2	a	20
03575480	Tennessee River at Huntsville Pumping Station.	9–19–71	43,200	D	a	a	a	a	1	a	10	a	a	[1]a	a	11	a	20
03575500	Tennessee River at Whitesburg	9–20–71	50,600	A	a	a	a	a	a	a	10	a	a	[1]a	a	3	a	20
				A[3]	a	a	a	a	a	a	20	a	a	[1]a	a	6	a	20
				B	a	a	a	a	a	a	a	a	a	[1]a	a	4	a	20
03575736	Tennessee River near Farley	9–20–71	52,000	A	20	a	a	a	a	a	a	-	a	[1]a	a	a	a	10
				B	10	a	a	a	1	a	10	-	a	[1]a	a	5	a	20

[1] Chromium, total. [2] Near left bank. [3] Near right bank.

TABLE 2.—*Suspended sediment of streams, Huntsville, Ala., area*

[Station numbers correspond to those in fig. 2]

Station No.	Station name	Date of collection	Time (24 hr)	Discharge (cfs)	Sediment concentration (mg/l)
03574680	Tennessee River near Morgan City	6– 8–71	1300	45,000	12
		9–20–71	0945	35,300	19
03575000	Flint River near Chase	6–11–71	1000	172	29
		8–26–71	0830	124	39
		9–18–71	0815	230	50
03575020	Flint River near Cedar Gap	9–18–71	1230	277	57
03575040	Flint River near Mount Carmel	6– 7–71	1600	175	46
		8–26–71	1200	136	43
		9–18–71	1115	278	54
03575450	Tennessee River near Hobbs Island	6– 9–71	1045	43,200	12
		9–20–71	1230	47,000	23
03575500	Tennessee River at Whitesburg	6– 9–71	1415	48,300	12
		9–20–71	1400	50,600	28
03575696	Aldridge Creek near Lily Flagg	8–27–71	1530	.8	52
		9–19–71	0830	2.3	36
03575734	Aldridge Creek near Whitesburg	6–10–71	1330	30	252
		8–27–71	1800	2.5	391
		9–19–71	1215	7.5	51
03575736	Tennessee River near Farley	6–10–71	1000	42,300	26
		9–20–71	1500	52,000	24
03576108	Huntsville Spring Branch at Martin Road near Huntsville.	6– 9–71	1645	50	48
		9–18–71	1420	58	134
03576110	Huntsville Spring Branch at Patton Road near Huntsville.	6–11–71	1245	130	62
		9–18–71	1630	140	78
03575950	Indian Creek near Huntsville	8–27–71	1030	5.6	18
03576100	Indian Creek near Madison	8–27–71	0900	5.1	23
		9–17–71	1630	50	135
03576103	Indian Creek 700 feet downstream from Martin Road near Huntsville.	6–10–71	1690	40	162
		8–27–71	1300	22	43

TABLE 3.—*Lead and zinc discharges of streams, Huntsville, Ala., area*

[Station numbers correspond to those in fig. 2]

Station No.	Station name	Date of collection	Time (24 hr)	Discharge (cfs)	Discharge (lb/day): In solution: Lead	Zinc	Associated with suspended sediment: Lead	Zinc
03574680	Tennessee River near Morgan City	6- 8-71	1300	45,000	240	---	1,200	---
		9-20-71	0945	35,300	<190	3,800	665 ±95	1,900
03575000	Flint River near Chase	6-11-71	1000	172	.9	---	11	---
		8-26-71	0830	124	1.3	6.7	0	13
		9-18-71	0815	230	<1.2	12	1.8 ±0.6	0
03575020	Flint River near Cedar Gap	8-26-71	----	135	---	<7.3	---	11 ±4
		9-18-71	1230	277	<1.5	---	6.8 ±0.8	---
03575040	Flint River near Mount Carmel	6- 7-71	1600	175	.9	---	12	---
		8-26-71	1200	136	---	7.3	---	0
		9-18-71	1115	278	---	15	---	15
03575450	Tennessee River near Hobbs Island	6- 9-71	1045	43,200	230	9,300	1,600	3,500
		9-20-71	1230	47,000	<250	2,500	380 ±130	5,500
03575500	Tennessee River at Whitesburg	6- 9-71	1415	48,300	260	---	2,300	---
		9-20-71	1400	50,600	<270	<2,700	960 ±140	4,100 ±1.400
03575696	Aldridge Creek near Lily Flagg	8-27-71	1530	.8	.01	<.04	0	.06 ±0.02
		9-19-71	0830	2.3	<.01	.1	.06 ±0.01	.2
03575734	Aldridge Creek near Whitesburg	6-10-71	1330	30	.2	---	1.5	---
		8-27-71	1800	2.5	.07	.1	.1	.5
		9-19-71	1215	7.5	<.04	.4	.06 ±0.0[illegible]	.8
03575736	Tennessee River near Farley	6-10-71	1000	42,300	<230	---	800 ±110	---
		9-20-71	1500	52,000	280	2,800	1,100	2,800
03576108	Huntsville Spring Branch at Martin Road near Huntsville.	6- 9-71	1645	50	.5	16	3.2	0
		9-18-71	1420	58	.3	9.4	12	69
03576110	Huntsville Spring Branch at Patton Road near Huntsville.	6-11-71	1245	130	1.4	---	13	---
		9-18-71	1630	140	1.5	7.6	55	0
03576100	Indian Creek near Madison	8-27-71	0900	5.1	---	<.3	---	.7 ±0.1
		9-17-71	1630	50	.5	2.7	1.4	0
03576103	Indian Creek 700 feet downstream from Martin Road near Huntsville.	6-10-71	1600	40	.4	---	2.8	---
		8-27-71	1300	22	<.1	---	.2 ±0.1	---
		9-17-71	----	192	1.0	10	16	0

TABLE 4.—*Analyses of selected metals in rainwater collected at Huntsville filtration plant*

[Concentrations are given in micrograms per liter. a, concentration is less than lower limit of detection as follows: Arsenic and chromium, <10; cobalt, <1; mercury, <0.5]

Date of collection	Arsenic	Cadmium	Chromium, hexavalent	Cobalt	Lead	Mercury	Zinc
6-16-71	a	6	a	a	16	a	100
7- 6-71	a	2	a	a	3	a	20

TABLE 5.—*Analyses of selected metals in bed material and suspended sediment, Huntsville, Ala., area*

[Station numbers correspond to those in fig. 2. Values are concentrations of metals in bed material unless given in parentheses. Values in parentheses are computed concentrations of metals associated with suspended sediment. Concentrations are given in micrograms per kilogram. a, concentration is less than lower limit of detection: 100 micrograms per kilogram]

Station No.	Station name	Date of collection	Arsenic	Cadmium	Chromium hexavalent	Chromium, total	Cobalt	Copper	Lead	Mercury	Zinc
					Aldridge Creek						
03575734	Aldridge Creek near Whitesburg.	6-10-71	7,500	300	300	---	6,200	---	40,000 (36,000)	140	120,000
03575696	Aldridge Creek near Lily Flagg.	8-27-71	4,400	100	600	---	3,200	4,000	6,000 (0)	---	16,000 (285,000) (±95,000)

TABLE 5.—*Analyses of selected metals in bed material and suspended sediment, Huntsville, Ala., area*—Continued

Station No.	Station name	Date of collection	Arsenic	Cadmium	Chromium hexavalent	Chromium, total	Cobalt	Copper	Lead	Mercury	Zinc
				Aldridge Creek—Continued							
03575734	Aldridge Creek near Whitesburg.	8–27–71	1,600	300	a	------	3,000	12,000	6,700 (20,000)	--------	34,000 (100,000)
03575696	Aldridge Creek near Lily Flagg.	9–19–71	3,800	100	----	14,000	1,800	4,000	9,900 (125,000) (±15,000)	--------	11,000 (560,000)
03575734	Aldridge Creek near Whitesburg.	9–19–71	3,800	400	----	26,000	3,200	15,000	14,000 (30,000) (±10,000)	--------	26,000 (390,000)
				Flint River basin							
--------	Lagoon effluent near Ryland.	6– 7–71	1,000	5,600	9,000	------	5,000	-----	6,400	50	82,000
03575000	Flint River near Chase ----	8–26–71	8,200	a	a	------	4,600	7,000	9,200	--------	28,000 (510,000)
--------	Lagoon effluent near Ryland.	8–26–71	9,300	a	3,000	------	6,600	33,000	13,000	--------	110,000
03575040	Flint River near Mount Carmel.	8–26–71	11,000	a	a	------	4,800	7,000	10,000	--------	32,000 (0)
03575000	Flint River near Chase ----	9–18–71	27,000	500	----	110,000	8,100	8,000	99,000 (30,000) (±10,000)	--------	26,000
03575020	Flint River near Cedar Gap.	9–18–71	8,600	800	----	89,000	6,400	6,000	22,000 (79,000) (±9,000)	--------	24,000
--------	Lagoon effluent near Ryland.	9–18–71	19,000	3,000	----	30,000	9,600	20,000	30,000	--------	60,000
03575040	Flint River near Mount Carmel.	9–18–71	18,000	400	----	80,000	11,000	4,000	40,000 (9,500) (±9,500)	--------	18,000
				Huntsville Spring Branch							
03576108	Huntsville Spring Branch at Martin Road near Huntsville.	9–18–71	4,100	1,400 (33,500) (±3,500)	----	54,000	8,900	19,000	16,000 (280,000)	-------- (3,350) (±1,850)	100,000 (1,600,000)
03576110	Huntsville Spring Branch at Patton Road near Huntsville.	9–18–71	11,000	800	----	68,000	4,600	32,000	70,000 (940,000)	--------	92,000 (0)
				Indian Creek							
03576103	Indian Creek 700 feet downstream from Martin Road near Huntsville.	6–10–71	900	1,300 (14,900) (±5,100)	a	------	15,000 (34,000) (±5,000)	-----	97,000 (130,000)	250	99,000
03576100	Indian Creek near Madison -	8–27–71	11,000	a	a	------	5,200	12,000	12,000	--------	48,000 (1,085,000) (±215,000)
03576103	Indian Creek 700 feet downstream from Martin Road near Huntsville.	8–27–71	9,900	a	a	------	4,600	11,000	12,000 (35,000) (±12,000)	--------	30,000

TABLE 6.—*Analyses of selected metals in bed material, Tennessee River, Ala.*

[Concentrations are given in micrograms per kilogram. a, concentration is less than lower limit of detection: 100 micrograms per kilogram]

Station No.	Station name	Date of collection	Arsenic	Cadmium	Chromium, hexavalent	Chromium, total	Cobalt	Copper	Lead	Mercury	Zinc
03575480	Tennessee River at Huntsville Pumping Station	8–26–71	2,700	a	a	------	4,600	8,000	5,200	--------	30,000

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