United States
Environmental Protection
Agency

Municipal Environmental Research
Laboratory
Cincinnati OH 45268

Research and Development

EPA-600/S2-81-224 Oct. 1981

EPA

Project Summary

Heavy Metal Sources and Flows in a Municipal Sewage System: Literature Survey and Field Investigation of the Kokomo, Indiana, Sewage System

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The mass flows of heavy metals (Cu, Cr, Cd, Zn, Ni, Pb) and cyanide in the Kokomo, Indiana, collection system and wastewater treatment plant were analyzed. The primary objectives were to determine the relative contributions of domestic and nondomestic sources to the total pollutant load in the system, and to assess the levels of discharge control required for the disposal of municipal sludge by landfill or agricultural landspreading. Sampling was conducted at point source locations, in major sewer trunklines and feeder lines, and at the treatment plant. Production and waste treatment data were presented for point sources sampled to characterize metal and cyanide discharges as a function of these parameters. A heavy metals mass balance was attempted for the treatment plant. Metal removal factors were presented for various plant operations.

With the exception of lead, metals were found to be largely from nondomestic sources. With the exception of nickel, the Kokomo treatment plant removed 80% to 90% of the influent metals. Required reductions in nondomestic sources of metals to meet EPA landspreading guidelines for sludge were 98% for cadmium, 84% for zinc, and 42% for copper.

A simple statistical approach was presented for the design of a cost-effective sampling program for correlating point source and trunkline pollutant sampling. The purpose was to minimize the amount of sampling required to account for pollutants seen in trunkline and treatment plant streams in terms of discharges from specific sources.

This Project Summary was developed by EPA's Municipal Environmental Research Laboratory, Cincinnati, OH, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).

Introduction

The disposal of municipal waste treatment system sludges is a major problem currently faced by many U.S. cities. The presence of contaminants in sludge, especially heavy metals, may preclude the least costly disposal alternative, e.g., landspreading. This study addressed the problems associated with the flow characterization and identification of sources of heavy metals

and cyanide in the Kokomo, Indiana, wastewater collection and treatment system. It was intended to be representative of the type of survey and analysis required to formulate source control policies for reducing metals and cyanide in municipal sludges to the point that landspreading is feasible.

A major impediment to the conduct of sewer system studies is the great cost involved in source characterization. This typically involves initial trunkline sampling to identify segments of a collection system carrying substantial pollutant loads. Ideally, this is followed by a series of simultaneous trunkline and point source sampling to determine whether or not suspected sources can account for trunkline pollutant loads. The resulting picture is often obscured by infiltration of the collection system following precipitation events and by street runoff containing heavy metals from rainstorms or snow melt. If trunkline and source sampling data fail to account for trunkline pollutant loads, then simultaneous trunk and feeder line sampling may be necessary to further define source locations. If pursued to the point of statistical certainty, such source identification sampling programs can become prohibitively expensive.

With the above in mind, the study exemplifies a protocol to assist communities in identifying, quantifying, and formulating regulatory policies for reducing heavy metal and cyanide discharges to publicly owned treatment works (POTW) to the point that land disposal of sludge is feasible. This protocol is discussed at length in the full project report.

Sampling Procedure

The prototype community selected for this study was Kokomo, Indiana. It is a medium-sized city with a population of 42,000 with (from the sampling and analysis point of view) a manageably sized combined sanitary and storm sewer treatment network that serves well-defined residential areas and a diverse industrial community. The industrial and commercial makeup of Kokomo includes such industrial categories as electroplating, metal fabricating, automotive manufacture, chemical processing and food processing.

Trunkline sampling was conducted from April 1978 to June 1979 at 12 locations in the Kokomo sewer network. The locations were chosen to characterize metal and cyanide input to the treatment plant. Automatic sequential samplers and continuous flow recorders were used at each sampling location to measure metal and cyanide mass flow rates.

Samples were obtained for each trunkline at 2-hour intervals for three 24-hour periods. Sampling was conducted on a Monday through Thursday schedule, when feasible, to avoid any unusual fluctuations in flow or metal and cyanide discharge due to variations in industrial work schedules or increased residential activity during the weekend.

Twelve known point sources of heavy metals and cyanide identified by Standard Industrial Classifications (SIC) were sampled in the study over a 3-month period in 1979.

Sampling at each source was conducted at 2-hour intervals for 24 hours over a consecutive 3-day period. Metal and cyanide samples were collected using an automatic sequential sampler. The nature of the point sources is summarized in Table 1.

Of the major collection system trunklines sampled, 3, defined as residential, served none of the 12 point sources sampled. Conversely, four of the major trunks served at least one of the point sources sampled; these are defined to be "nonresidential." The pollutant mass flows in the residential and nonresidential trunks are given in Table 2 with pollutant mass flows in the treatment plant influent. Note that for cadmium, the "nonresidential" trunkline metal flows are more than a factor of ten larger than the residential flows and that the sum of nonresidential and residential is lower by a factor of three than that seen in the treatment plant influent. For all other metals, the sum of the trunkline metal flows range from virtually as large to substantially larger than those detected in treatment plant influent. The lack of "balances" among the point source, trunkline, and treatment plant metal flows probably results from the nonsimultaneous sampling of trunklines and treatment plant influent as well as from infiltration and street runoff, especially for lead. It appears that the 12 point sources sampled are reasonably sufficient to acount for the loading of all metals in treatment plant influent except cadmium.

A 60 sampling program was conducted in the wastewater treatment plant to assess the flow of heavy metals among the various processes. The plant is a 30 mgd activated sludge-multi-media gravity filter facility. Table 3 gives metal concentrations in plant influent, secondary effluent, and plant effluent streams. For Kokomo sludge to be suitable for landspreading, substantial reductions in nonresidential sources of Cd, Cu, and Zn are necessary. The situation is portrayed in Table 4 where specific reductions necessary to achieve EPA sludge landspreading guidelines are indicated.

Results of the study confirm that accurate mass balances on sources of heavy metals and resulting flows in municipal wastewater collection systems require simultaneous long-term sampling. Such a program would, however, be prohibitively expensive for many medium-sized communities. An alternative proposed in the present work involves the analysis of data from short-term, nonsimultaneous source, and trunkline sampling. The method of analysis provides a basis for accounting for trunkline pollutants in terms of point source discharges. The study also suggests that a 60-day sampling period is sufficient to conduct a heavy metal balance for a municipal wastewater treatment plant.

Table 1. Point Source Inputs

No.	*Type*	*Pretreatment*
1	*Transmission and Die Casting*	*Batch*
2	*Circuit Board Plating*	*Batch*
3	*Radio and Semiconductor*	*Batch*
4	*Automotive*	*Batch*
5	*Rack and Barrel Plating*	*None*
6	*Wire Mill*	*Continuous*
7	*Hot Dip Galvanized Fence*	*Batch*
8	*Architectural Aluminum*	*Batch*
9	*Alloys*	*Batch*
10	*Metal Fabrication*	*None*
11	*Industrial Laundry*	*None*
12	*Printing*	*None*

Conclusions

The Kokomo treatment plant removed 80% to 90% of the Cd, Cr, Cu, Zn, and Pb in the plant influent, whereas only 30% of the Ni was removed. The gravity filters reduced the Cd, Cr, Cu, Zn, and Pb in the secondary effluent by approximately 50%, with a Ni reduction of 18%. The sludge heat treatment and vacuum filtration recycle streams did not increase metal concentrations in plant effluent. Finally, with only the domestic source of metals to the treatment system, Kokomo sludge could be applied to cropland at rates limited only by nitrogen addition to cropsoil, i.e., metals would not be a limiting factor.

The full report was submitted in fulfillment of Grant No. R805361-01 by Purdue University, West Lafayette, Indiana 47907 under the sponsorship of the U.S. Environmental Protection Agency.

Table 2. Summary of Inputs

Metal	Residential kg/day	Nonresidential kg/day	Total Residential Nonresidential kg/day	Treatment Plant Influent kg/day
Cd	0.054	0.630	0.684	2.15
Cr	0.604	44.4	45.4	51.8
Cu	5.37	10.8	16.2	11.0
Ni	3.89	6.94	10.8	7.58
Zn	6.82	278.	285.	136.
Pb	0.90	0.73	1.63	0.588

Table 3. Metal Concentrations in Treatment Plant Input and Output Streams

Metal	Plant Influent mg/l	Secondary Effluent mg/l	Plant Effluent mg/l	EPA Interim Primary Drinking Water Stds. mg/l
Cd	0.033	0.0124	0.0063	0.01
Cr	0.786	0.0773	0.0167	0.05
Cu	0.168	0.0574	0.0252	—
Ni	0.115	0.0988	0.0812	0.05
Zn	2.07	0.488	0.233	—
Pb	0.051	0.0053	0.0026	—
Fe	17.3	1.75	0.335	—

Table 4. Reductions in Nonresidential Sources of Metals Necessary to Achieve Compliance of Kokomo Sludge with EPA Landspreading Guidelines

Metal	Permissible Application kg/ha	Permissible by EPA Guidelines mg/kg	Total in Sludge mg/kg	Residential Contribution mg/kg	Required Reduction in Nonresidential Sources %
Cd	1	56	377	10	87
Cr	—	—	1060	12	—
Cu	25	1400	1790	870	42
Ni	10	560	533	273	0
Zn	50	2800	13600	680	84
Pb	100	5600	94	143	0

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The complete report, entitled "Heavy Metal Sources and Flows in a Municipal Sewage System: Literature Survey and Field Investigation of the Kokomo, Indiana, Sewage System," (Order No. PB 82-108 366; Cost: $21.50, subject to change) will be available only from:
National Technical Information Service
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