The Sources and Levels of Mercury in the Sewage of a University Campus

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Since the report that mercury and its inorganic compounds are converted in natural waters to biologically active organic species (JENSEN and JERNELÖV 1969, JERNELÖV 1970, WOOD et al. 1968), several reports have appeared concerning levels of mercury in surface and ground waters (MATIDA and KUMADA 1969, UNDERDAL and HASTEIN 1971) and the relationships of these levels of mercury to specific industrial sources (JOHNELS et al. 1967, UTHE et al. 1973). Recently EVANS et al. (1973) reported data which indicated that purely domestic sources may be as important as industrial sources of mercury in sewage in some cases. In a limited study of five central Illinois municipalities, the latter authors found background levels of 2 ppb mercury in the raw sewage of the communities which lack any significant industry. The values exceed the tolerance level for sewage established by the Illinois Pollution Control Board (Illinois PCB) which specifies "no effluent to any public sewer system shall include mercury or any of its compounds in excess of 0.0005 mg/l as Hg at any time."

It has been possible in this study to further evaluate the relative importance of industrial and domestic sources of mercury (total) in sewage. Because of the variety of laboratories which use mercury and its compounds in a manner which is similar to an industry (about 30 departments at this university use these substances) and because of the presence of a large married student housing area which has a sewer system completely separate from any non-domestic influent, this university campus provides an ideal location for such a study. In addition, the data presented may be useful in evaluating current and in establishing future sewer-discharge criteria for mercury (total).

MATERIALS AND METHODS

The determinations were performed by the HATCH and OTT (1968) procedure modified to include the addition of five-percent potassium persulfate as an oxidizing agent in addition to potassium permanganate. A Coleman Model 50 Mercury Analyzer was used to obtain the readout.

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A background reading was obtained just prior to the addition of aqueous tin(II) chloride to determine whether the sample contained undigested compounds which absorbed at 253.7 nm. The absorbance was subtracted from the final reading as a background correction. If the background transmittance was less than 90%, the sample was discarded.

The recommended digestion procedure of heating the sample to the boiling point and then allowing to cool to room temperature was shown to be sufficient for the samples. Each sample in a series of 20 typical samples was divided into two portions. One portion was subjected to the recommended digestion procedure, and the other portion was subjected to digestion at 80° C for various time periods up to 48 hours. The resulting mercury levels were independent of digestion time.

The chemicals used were A.C.S. Reagent Grade, except that J. T. Baker nitric acid and sulfuric acid "Suitable for Mecury Determination" were used. All chemicals were used without further purification. Blank determinations were run to insure that the reagents contributed less than 0.2 ppb mercury to the determined concentrations. Reagent blanks were subtracted from the respective absorbances.

Grab samples were obtained in Kimax 175-ml Milk Dilution bottles. Samples were generally analyzed within 90 minutes after collection. Standards were frequently interspersed as simulated samples in order to check on the quality of the sampling containers and on the calibration of the instrument.

RESULTS AND DISCUSSION

The initial phase of the study was a three-month survey (Table 1) of the level of mercury (total) in the main outfall sewer from the central campus (Site A). The arithmetic mean of the 152 trials, 7.9 ppb, exceeded the above-mentioned Illinois PCB sewer-discharge criterion. Subsequently, a program was established which consisted of the following: identifying the mercury users on the campus; informing the users of the establishment of a system in which the overall-university and individual-building sewer effluents would be monitored for mercury; and designating a central laboratory for reception and treatment of mercury-containing wastes.

The results (Table 1) obtained at Site A following the establishment of the program yielded an arithmetic mean of 3.9 ppb based on 787 trials. The importance of occasional high slugs was evident by the fact that when the highest 10% of the results were excluded, the mean was lowered to 0.83 ppb. Comparison of these results to the values reported by EVANS et al. (1973) demonstrates that the above program is sufficient to lower the mercury level in the sewage of a university to about the same level observed in a primarily residential community.

TABLE 1.

Effect of the Control Program on the Mercury Level in the Sewage of the Central Campus

conc. range, ppb	pre-control frequency	post-control frequency
0.00 - 0.25	0	80
0.26 - 0.50	0	158
0.51 - 0.75	6	151
0.76 - 1.00	2	124
1.01 - 1.25	6	57
1.26 - 1.50	8	41
1.51 - 1.75	7	36
1.76 - 2.00	11	26
2.01 - 3.00	30	41
3.01 - 4.00	11	28
4.01 - 7.00	19	20
7.01 - 20.0	36	14
20.1 - 1000	16	11
Total samples	152	787
mean, ppb	7.9	3.9

The proximate sources of some of the high slugs were identified by correlating the levels at Site A to high outputs from individual buildings. Data from the 30 highest slugs were examined; 13 samples did not correlate to monitoring times from individual buildings, but of the remaining samples, 12 corresponded to slugs from the Department of Chemistry and Biochemistry. Similarly, some slug data from a secondary-outfall sewer which carries most of the balance of the sewage from the central campus corresponded to slug data from a building which houses no laboratories utilizing mercury or its compounds. The building does contain photography laboratories, printing presses, and an x-ray laboratory which use chemicals which may contain mercury impurities. Whereas finding that the Department of Chemistry and Biochemistry was primarily responsible for slugs in the main-outfall sewer was not surprising, the facts that some slugs in the main-outfall sewer did not correlate to slugs from individual buildings and that occasional slugs of mercury occurred in the secondary-outfall sewer demonstrate that mercury sources can be quite subtle. Hence, even communities without heavy industries which directly utilize mercury can have significant non-domestic sources of mercury.

To insure that the mercury level in the absence of slugs was not due to a contaminated water supply, the university's water supply was studied. The average of 60 grab samples obtained over a one-month period was 0.20 ppb which demonstrated that the background level was less than the maximum specified by Illinois PCB water quality standards, 0.5 ppb.

The sewage solely from a large married student housing area of the campus contained mercury only slightly in excess of the above-declared background level. The average of 57 trials was 0.25 ppb and the maximum slug was 1.45 ppb. Hence, it is indicated that pure domestic sewage does not contain appreciable quantities of mercury. Whereas these results contradict the conclusion of EVANS, et al. (1973), it is noteworthy that one major difference exists between the domestic sources other than the possible perturbation of their results by the presence of small businesses or industries in a primarily residential community. The married student housing area does not have garbage grinders installed in the kitchens; thus, the above-named workers' hypothesis that these devices may be significant causes of high levels of mercury may indeed be valid, because the food wastes introduced into the sewers may contain quite high levels of mercury.

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