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ASSESSING MERCURY LEVELS IN THE WASTEWATER OF AN AGING RESEARCH LABORATORY BUILDING

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Abstract

Increasingly stringent restrictions on mercury concentrations in wastewater discharge may be problematic for aging research laboratory facilities. Relatively high levels of mercury compounds may exist and concentrate deep in the plumbing system and their sediments, resulting in elevated wastewater concentrations. This study was conducted to assess total mercury levels in an aging laboratory building wastewater system. Wastewater outflow, sink trap water, and pipe sediment samples were collected from the building. The Jerome 431™ Mercury Vapor Analyzer was assessed as a tool for screening lab sink trap drains for mercury deposition. Results revealed that the three day average for mercury discharge from this single structure, if not diluted by other waters, would be above the local total release parameters to the wastewater treatment plant. The sink traps did not contain a majority of the mercury; however, the pipe sediment and outflow samples revealed consistently elevated concentrations.

IMPLICATIONS

Mercury levels in wastewater and sediments from the plumbing system of aged research laboratories can become a source of mercury discharge. Safety precautions, waste management, and hazardous waste determinations should be incorporated into planning renovations and decommissioning of aging research laboratories with similar use and history. Researchers should be encouraged to seek out non-mercury containing alternatives, or avoid sink disposal of any mercury containing products altogether. Mercury deposition in the plumbing system may make adherence to local and state discharge limits difficult. The Jerome 431™ Mercury Vapor Analyzer was not a useful tool in predicting contamination in laboratory sink traps.

INTRODUCTION

The negative effects of mercury deposition into the environment have been well documented¹. Mercury reduction technology can be very expensive and there is an interest in investigating potential sources and sinks of mercury for potential future attenuation.

The interior environment of the plumbing system of an old laboratory has the potential to accumulate mercury that has been slowly introduced through common laboratory reagents and household products. Some of these products contain mercury compounds as a preservative or

as a contaminant in their formulations. For example, the common preservatives thiomerosal and merthiolate are used in many laboratory products, reagents, and vaccines.

Treatment methods to remove mercury contamination from wastewater include: Copper shavings², clay³, activated carbon⁴, some bacteria such as *pseudomonas putida*⁵, and ferric sludges⁶. It is feasible that these same treatment materials exist in the sludge and sediment of old copper and iron plumbing and have the potential to accumulate and concentrate mercury over time.

In 2002, researchers at the National Institute of Health (NIH) in Bethesda, Maryland presented the results of a study designed to develop a protocol for decommissioning aging National Cancer Institute (NCI) laboratory buildings in Bethesda⁷. Elemental mercury was found in approximately 10% of the sink traps tested. According to the research presentation, "Mercury in plumbing is usually contained in the traps adjacent to the plumbing fixture such as sinks, drains, and toilets⁷." Mercury levels in the sink traps were high enough to warrant disposal of the drains as hazardous waste.

At the National Cancer Institute at Frederick (NCI-Frederick), the outflow from a single building has never been measured. NCI-Frederick is located within the Ft. Detrick U.S. Army facility in Frederick, Maryland. The NCI-Frederick campus discharges wastewater to a Federally Owned Treatment Works (FOTW) along with the wastewater of the United States Army Garrison (USAG) and their tenants. FOTWs generally operate under stricter discharge limits than Publicly Owned Treatment Works (POTW), so controlling mercury inputs to the system is a concern. The NCI-Frederick must abide by Fort Detrick Regulation 200-7, Environmental Quality Non-Domestic Wastewater Control, which currently states that the maximum daily average value for mercury discharged to the wastewater is 0.0009 mg/L⁸. This standard was recently revised in May 2006 from the former level of 0.0131 mg/L. This level is generally sampled at, or close to, the wastewater treatment plant where the effluent from the entire campus converges. This study focused on quantifying the mercury levels a single aging research structure contributes to the entire campus effluent.

NCI-Frederick building 539 was completed in 1955, contains approximately 23,442 square feet of laboratory space, and has been in constant use as a research lab since its completion (Figure 1). The building was first used by the United States Army for biological warfare research from 1955–1973. Then, in 1973, the building was transferred to the NCI-Frederick for cancer research. Building 539 was chosen for this study because of the ease of sampling the wastewater effluent (Figure 2), as well as the age of the structure. Since mercury may accumulate in sink traps and plumbing over time, the original plumbing of this building may be a "worst case" at Ft. Detrick/NCI-Frederick.

The only instrument available to monitor mercury on-site at the NCI-Frederick is the Jerome 431™ Mercury Vapor Analyzer. This instrument can detect elemental mercury vapors in air and is used as a tool to ensure adequate clean-up of elemental mercury spills. The Jerome 431 has also been used to detect mercury vapor above solution in the laboratory⁹. However, the Jerome 431 can not detect bound mercury compounds that do not vaporize easily, or mercury levels in liquid¹⁰. Additionally, the instrument may give false positives in the presence of high concentrations of mercaptans, chlorine, ammonia, and hydrogen sulfide. These compounds may exist in plumbing systems at concentrations that cause interference. The instrument is designed and calibrated to elemental mercury vapor only and may not detect other mercury forms or compounds.

METHODS AND MATERIALS

Testing consisted of three phases including: hourly outflow sampling; sink trap sampling with corresponding air monitoring; and a single grab sample after 80 days of sediment settling time. Phase 1 consisted of hourly building outflow sampling conducted after an initial 5 minute flush of the line 24 hours prior. Hourly grab sampling was conducted for 3 days, encompassing a typical 8-hour work day (9 hours total) starting at 8:00am. Grab samples were collected from the sampling port directly into new 500ml HDPE sample bottles. The hourly sampling was conducted for three work days in order to find any patterns to the concentrations. The third day was chosen to be Monday, as mercury levels are expected to peak due to a reduction in water flow over the weekend, as relatively few employees work over the weekend in this building. Within 30 minutes of collection, a pH measurement was recorded from the sample bottles using Eutech Instruments, Oakton, Acorn series pH and temperature meter. The samples were sent to Fredericktowne Labs Inc., a certified water quality laboratory accredited by the State of Maryland Department of Health and Mental Hygiene. Samples were analyzed for total mercury content using EPA Method 245.1, Manual Cold Vapor Atomic Absorption for Mercury, within 28 days of collection.

Phase 2 consisted of sink trap screening and sampling. The composition of the sink traps in the building varied from welded steel, aluminum, and polyvinyl chloride (PVC). In order to establish mercury levels in the incoming water, a background sample was collected from a random lab sink in Building 539. The sample was collected from a cool water tap into a 1000 ml HDPE sample bottle.

Twenty sink traps were sampled for mercury deposition. The evening prior to sampling each sink was flushed for two minutes with cold tap water. The sink was then placed out of service for 24 hours. After 24 hours, ten readings were recorded with an Arizona Instruments, Jerome Mercury Vapor Analyzer, model 431-X, two to four inches directly above the sink drain. The sink trap was dismantled and the contents poured into a new, clean, HDPE tray. Ten more readings were recorded with the Jerome meter, two to four inches directly above the solution in the tray, using a left-to-right, top-to-bottom pattern. A visible examination of the tray contents was made and any visible droplets of elemental mercury were noted. The contents of the tray were decanted into one 1000 ml sample bottle, and pH recorded.

In phase 3 the sediment was allowed collect in the “dead leg” of the sampling port for 80 days. The sampling port was then emptied into a new, clean HDPE five gallon bucket and allowed to settle for three hours. The water was decanted and the sediment scraped into a 1,000ml HDPE sample bottle using a new disposable plastic spatula. The sample was sent to Fredericktowne Labs Inc., for mercury analysis using EPA Method 245.1.

RESULTS

The results of the 3 day sampling (Table 1) reveal that the average daily value for each of the three days was above the discharge standard of 0.0009 mg/L. There were grab samples as high as 0.032 mg/L. The three day average was 0.008 mg/L, which is well above the current local discharge standards of <0.0009 mg/L for the campus.

The results from the pH profile collected from the 3 day sampling were within the acceptable maximum daily average values of pH, between 5.0 and 11.0, as described in Ft. Detrick Regulation 200-7. Statistical regression analysis revealed no relationship between pH and mercury content.

Table 2 describes the categories assigned for analysis by Fisher's Exact and Pearson's Chi-Square Tests. These tests revealed that there was absolutely no relationship between the

mercury content of the sink traps and the Jerome mercury vapor readings above the sink traps (p -value = 0.8087). The meter was found to have an approximate 50% misidentification rate for this study.

The majority of the sink traps tested contained either mercury below the limit of detection or <0.001 mg/L. Only three of the twenty sinks sampled contained elevated mercury levels greater than the discharge standard of <0.0009 mg/L (Table 3).

Data in this study were analyzed by contingency table methods, correlation and regression analysis, and simple graphical techniques. Probability values below 0.05 were considered significant.

CONCLUSION

According to results from the sink trap air monitoring, the Jerome 431™ Mercury Vapor Analyzer is not well suited for screening sink traps for mercury concentration.

According to the results from the sink trap water sampling, the traps do not contain a majority of the mercury concentration in the plumbing system (Table 3). Since the grab sample of sediment from the outflow was elevated (2.7 mg/kg), it is likely that a majority of the mercury is located in sediments deeper in the plumbing system.

Hourly outflow sampling results indicate that the highest mercury levels are typically in the morning. The grab sample of plumbing sediments had a mercury concentration of 2.7 mg/kg. This mercury load in the sediment could increase the wastewater concentrations by dissolution over time. The rate of dissolution may depend on the microbial and physical environment of the lines.

The highest water mercury concentration detected was collected on a Monday. Water in the plumbing may have remained stagnant and in contact with the sediment for a longer period of time. Monday morning's increased occupancy, and the corresponding probability of increased water usage, may have the potential to flush higher concentrations of mercury to the outflow. If water is allowed to remain in contact with the sediments, and the environment favors dissolution, the mercury can increase the water concentration near or above the regulatory limit.

All of the hourly samples collected from this building were above the local discharge standard. It is clear that the average daily discharge (0.008mg/L), if not diluted by other campus waste, would be above what is allowable at the wastewater treatment plant. To date, however, the NCI-Frederick has been in compliance with mercury discharge levels at the wastewater treatment plant. If the total wastewater levels ever need to be attenuated, structures of similar use and age can be focused on as potential point sources for reduction of mercury.

It is possible that sediments could contain high enough mercury concentrations in the wastewater system of aging research laboratories to warrant increasing personal protective equipment (PPE) of employees involved in any renovations or decommissioning of structures. Mercury concentrations in sewer plumbing and sediments could also exceed the threshold for classification as a characteristic hazardous waste. Disposing of sewer components as hazardous waste would be extremely costly.

This study highlights the importance of a good waste management plan that limits the amount of mercury into the system in the first place. Non-mercury product substitution should be stressed in order to lower the amount of mercury into the sewer systems. Even small amounts

of mercury in products disposed down the sinks could accumulate in the sediments and cause future safety, health, and disposal problems.

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Biography

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Figure 1.
Outside View of Building 539

Figure 2.
Basement Outflow Sampling Port

Table 1

Results of Phase 1

Time	BUILDING 539 WASTEWATER GRAB SAMPLES			
	Day 1 (mg/L)	Day 2 (mg/L)	Day 3 (mg/L)	Time of Day Average (mg/L)
8:00 AM	0.021	0.014	0.032	0.022
9:00 AM	0.014	0.0044	0.0086	0.009
10:00 AM	0.013	0.0087	0.0009	0.008
11:00 AM	0.011	0.0024	0.0036	0.006
12:00 PM	0.0029	0.0027	0.0021	0.003
1:00 PM	0.0039	0.0026	0.0013	0.003
2:00 PM	0.0024	0.0019	0.0037	0.003
3:00 PM	0.0027	0.022	0.0058	0.010
4:00 PM	0.0031	0.021	0.0009	0.008
Daily Averages	0.0082	0.0089	0.0065	
3 Day Average	0.008			

Table 2
Classification of categories for Fisher's and Chi-Square Tests.

	Lab Analysis-LOW (<0.001 mg/L)	Lab Analysis -HIGH (>0.001 mg/L)
Jerome Readings (average of 10 readings <0.005 mg/m ³) -LOW	7	2
Jerome Readings (average of 10 readings >0.005 mg/m ³) -HIGH	6	1

*Jerome data for 4 sink traps were lost and not included in statistical analysis

Table 3

Results of Sink Trap Concentrations