Mercury Work Group
Phase I Reports >> Executive Summary

MWRA\MASCO HOSPITAL MERCURY WORK GROUP
STEERING COMMITTEE

EXECUTIVE SUMMARY REPORT
June 23, 1995

Introduction

The Massachusetts Water Resources Authority (MWRA) is concerned about the level of mercury being discharged into Boston Harbor due to the possible effect elevated levels might have on aquatic life. Elevated levels of mercury can also affect the quality of fertilizer pellets manufactured by the MWRA making it more difficult to market this recycled commodity.

Mercury is discharged in small quantities by a variety of industrial sources and it is also present in trace amounts in some process chemicals and household products, such as bleach. MWRA regulations specifically prohibit the discharge of mercury to the sewer system and the MWRA currently enforces this prohibition at a level of five (5) times the method detection limit (MDL) of 0.2 parts per billion (ppb). This results, at the present time, in an effective discharge limitation of 1.0 ppb from MWRA regulated sources, including hospitals and institutions.

For the past year, the MWRA has been working with area hospitals and MASCO (a consortium of Longwood Medical and Academic Area Institutions) in a collaborative process that stresses cooperation and the pooling of resources to identify and address the problem of mercury contained in hospital and medical facilities' wastewater streams. This Hospital Mercury Work Group is a unique public-private partnership that places us ahead of the rest of the country in the effort to deal effectively with the mercury discharge issue.

The Work Group has approached the problem from three directions. The Operations Subcommittee has been working to identify sources of mercury contamination and develop recommendations for their control. The Infrastructure Subcommittee has focused on developing guidelines for the removal of residual mercury from hospital wastewater conveyance systems. The End of Pipe Alternatives Subcommittee concentrated on the identification and evaluation of potential mercury pretreatment systems.

The Case of Hospitals

From the outset, hospitals have shared the MWRA's and the public's concern about the presence of mercury in the wastewater stream, particularly in light of their roles as health care providers. Collectively (as part of the Hospital Mercury Work Group) and individually, area hospitals have contributed enormous amounts of time and resources to address this problem. Thousands of hours of hospital staff time have been devoted to this project and more than $1 million has been spent, to date, in search of solutions.

Meeting the MWRA's standard for discharge presents a formidable challenge for hospitals because of the nature of the testing and equipment used by health care providers in their effort to effectively diagnose and treat disease. Key substances used in research and diagnostic work, reagents in particular, contain trace amounts of mercury that are usually not listed in the content descriptions. These trace amounts of mercury tend to collect in the organic material (biomass) that may be present in the piping systems and, as a consequence, can slough off into the wastewater stream at any time. This problem is further complicated by the fact that laboratory testing procedures vary significantly, depending upon the type of testing or research being conducted, making standardization of procedures exceedingly difficult if not impossible.

At the outset of the process, it was believed that the medical community was, perhaps, the single largest contributor of mercury into the MWRA Sewerage System. Some, in fact, had estimated that up to 20 percent of the current mercury loading to the MWRA's Deer and Nut Island facilities was being generated by the Hospitals and Institutions served by the MWRA. Subsequent analysis of historical flow information augmented by "Real Time" sampling and documentation of actual flows from several institutions participating in the Work Group seems to indicate that this initial perception overstated the hospital problem. The current data base, as compiled by the Hospital Mercury Work Group in conjunction with the MWRA, appears to indicate that the hospitals' collective contribution of mercury to the MWRA sewerage system is actually only 1 to 2 percent of the daily influent mercury loading (estimated by the MWRA to be 3/4 of a pound). This amount translates to approximately 1/4 of an ounce in 1 million gallons per day of total wastewater flow from 28 medical institutions participating in the Work Group.

Sources of Mercury

The three Subcommittees were each charged with the responsibility of developing and implementing their own workplans. One common objective of the Subcommittees was to document where the mercury was coming from and how much of it existed. In the course of their work, the Subcommittees drew from public data bases, performed analytical testing of products to assess mercurial content, issued letters to chemical manufacturers requesting their support, completed facility audits, reviewed Material Safety Data Sheets (MSDS), conducted interviews of suppliers of wastewater pretreatment systems and technologies, generated new analytical data from actual points of discharge from its members' facilities and researched the literature in an attempt to prepare the most comprehensive database dealing with mercury discharge problem that is currently available anywhere in the United States.

Clinical & Research Laboratories

Some of the more obvious sources of mercury were readily identified, such as thermometers, manometers and chemicals identified by their MSDS to contain mercury. A bit more work was involved in identifying mercury present in certain reagents, stains, immunodiagnostics, disinfectants and cleaning solutions. Based on actual sampling results, some bleaches, soaps/cleaners, x-ray photographic chemicals, hematoxylins and acid zinc formalin were also identified as containing mercury. It was also surprising to discover that "significant levels" were found in laboratory petri dishes, wastewater pretreatment chemicals and several saline solutions and T3 kits containing Thimerisol. In addition, embedded tissues which had been fixed in mercury containing fixatives were found to leach mercury that contaminated other areas of the histology laboratories. To date, the Operations Subcommittee has compiled an electronic database of some 5,504 products used by the hospitals and institutions participating in the survey. Of these, approximately 781 have, thus far, been confirmed to contain some level of mercury. There are 72 records which indicate a mercury content of between 1 - 10 ppb and 469 records noting a concentration above 10 ppb.

An additional 75 of the most commonly used products from the database suspected of containing mercury have been selected for analysis. This data, and other product information submitted by hospitals and institutions will be added to the electronic database. This "work in progress" will be updated semi-annually and copies will be provided to active participants of the MASCO Hospital Mercury Work Group in either the dBase III Plus Format, dBase III Plus Hg Application, or the ASCII Format. An attempt is also being made to work with the suppliers to identify suitable mercury free alternatives to products currently being used. However, progress on this front is complicated due, primarily, to the lack of known suitable substitutes and people's concern over the liability of using new (and often untested) alternatives.

Medical Waste Incinerators

In an effort to help minimize the impact of off-site solid waste disposal, many institutions have installed and routinely operate medical waste incinerators. The "Red Bag" wastes disposed of in these units may contain syringes, blood products, tissues, bags and other materials which may contain residual quantities of mercury. Disposal of obvious sources of mercury, such as thermometers or mercury bearing stains can also occur if proper waste management directives are not followed.

These medical waste incinerators are typically supplied with fume scrubbing capabilities which help to reduce the amount of mercury, along with other regulated contaminants, from entering the ambient air environment through the incinerator stack. These contaminants may reenter the water phase via the recirculating scrubber liquor and, subsequently, enter the sewer system via the scrubber bleed-off discharge (typically 0.1 gallon per minute per 1,000 scfm of exhaust capacity). Though not having the same wastewater characteristics as the heavily organic laden clinical and research laboratory wastewaters, the fume scrubber discharge stream can be a significant source of mercury contamination to the sewer system.

Infrastructure

Perhaps the most intriguing source of mercury discovered (and possibly the most difficult to deal with) is the presence of mercury contained in a facility's infrastructure piping system. By this, we mean in the network of traps, pipes and tanks installed within the building between a facility's laboratory sinks and the point at which these liquid wastes would leave the building and enter the sewer system. Several institutions have found mercury of various forms in numerous conveyance plumbing locations. It is not uncommon for a 10-15 year old trap, when removed, to contain elemental mercury (Hg0) which is easily identified as a pool of silvery liquid within the base of the trap. Elemental mercury usually gets into laboratory sinks and floor drains as a result of broken laboratory equipment. Some elemental mercury sources included old mercury thermometers, thermostats and blood pressure manometers.

A more significant finding than the presence of elemental mercury in traps was that organic material present in the wastewater discharged to a facility's "Special Waste" system, would encourage the development and growth of biological material (biomass) within the infrastructure itself where mercury would either settle out, be physically adsorbed or, in the presence of bacteria living in the piping, undergo a transformation to methyl mercury after which it becomes adsorbed into the biomass. Many of the older institutions were able to document the presence of mercury in biomass growth from discharges that began over 50 years ago. Testing performed by the Infrastructure Subcommittee documented a mercury concentration of nearly 1,000 parts per million (ppm) in the biomass removed from one Institution's infrastructure.

Since methyl mercury is readily concentrated in living tissue, some facilities found that even minimum, or non detectable levels of one form of mercury going down the pipe would, after a period of time, show up in the biomass at significant concentrations. As bits of these biosolids periodically break off and are flushed out of the systems, they carry the concentrated mercury with them. It is these elevated levels of mercury contained in the biosolids that are frequently detected during compliance sampling.

Locating and removing this biomass from the pipes can prove to be quite difficult due to the inaccessibility of much of the system. This biomass formation is very difficult to remove and control due to its location within the piping in locations and lengths sometimes within institution walls. Consequently, it is not uncommon to have the biomass build up to a point where it restricts or prevents flow. When this occurs, there are only two options:

1. Remove the piping and literally cut and scrap the biomass away or
2. Replace the piping with new materials.

For less severe situations, the Infrastructure Subcommittee has developed a Maintenance Guidebook that contains some recommended procedures for the control of this biomass growth; these include trap cleaning, powerwashing and chemical cleaning.

Approaches to the Problem

End-of-Pipe Alternatives

Complexities in hospital laboratory wastewater composition and variations in hydraulic loading require a multiple technological approach to the design of any end-of-pipe pretreatment system. Designing systems to achieve a "non-detect" limit presents additional problems since any time effluent monitoring data confirms the presence of mercury, the Professional Engineer who designed the system {MGL 21, Section 27 (13) and 248 CMR 2.13} could lose his or her license. A system designed to remove mercury from a hospital wastestream would also have to be able to remove nearly all other pollutants from the wastestream as well, due to deleterious impacts of both conventional and non conventional contaminants upon pretreatment system components. For example, chlorine bleach, used as a hospital disinfectant, can cause a rapid deterioration of the membranes used in nanofiltration and reverse osmosis based systems. Oil and grease can cause an almost immediate failure of ion exchange media. The organic material and biological activity present in the raw wastewater will use activated carbon as a food source, in turn, causing premature failure of the media.

Equipped with that knowledge, the End of Pipe Alternatives Subcommittee proceeded to evaluate the following technologies for potential application to the mercury problem:

- Simple Filtration
- Reverse Osmosis
- Chemical Reactions
- Disinfection
- Membrane Microfiltration
- Ion Exchange
- Absorption
- Evaporation

Over the course its fifteen (15) meetings, the Subcommittee heard presentations of these technologies by engineers, equipment manufacturers/suppliers and application specialists. From these interviews, it became apparent that not very much historical case study information was available so the Subcommittee attempted to solicit information from preliminary field trials being completed by some of the equipment suppliers at both Member and Non-Member Institutions.

Infrastructure Maintenance

In Massachusetts, "Special Wastes" include, but are not limited to, organisms containing recombinant DNA molecules, chemicals, nuclear, radioactive, acids, alkalines, perchloric solvents and other such wastes that could be considered detrimental to the public sewer system and which do not comply with limitations established by the Publicly Owned Treatment Works such as the MWRA. All "Special Wastes" must be conveyed in a separate waste and vent piping system. These systems are to be constructed of approved code materials. The design, methods, materials, type of neutralization, testing, and inspections required for "Special Waste" piping systems serving laboratories and industrial activities are governed under 248 CMR 2.13 of the Massachusetts State Plumbing Code. All plans and specifications for "Special Waste" piping and pretreatment systems shall be prepared by a Registered Professional Engineer for submission to the local Plumbing Inspector, MWRA, DEP or other authorities for review and approval.

Neutralizing sumps or tanks (chip tanks) can be used for the pretreatment of wastewaters containing dilute acids and alkalines from laboratory sinks. These sumps are not allowed to adjust the pH for wastewater generated by biomedical laboratories. These sumps similarly cannot be used in facilities discharging significant quantities of organic materials into the "Special Waste" System or the biomass which is found will coat the marble chips rendering the media useless.

As previously explained, mercury accumulation within "Special Waste" conveyance piping systems containing biomass growth with mercury creates a complicated wastewater compliance issue. Two techniques through institution efforts have proved to be very successful with biomass removal and mercury sources identification are trap cleaning and conveyance pipe powerwashing.

Trap cleaning and removal will accomplish the following objectives: trap location / identification, removal of elemental mercury (Hg0) and removal of biomass growth. Trap cleaning procedures require that all traps be located and identified so that, prior to cleaning, a notification to the building occupants, explaining the details of the cleaning procedures, can be provided. The cleaning procedures simply require that a trap be removed, the contents be collected for off-site disposal and the trap then cleaned with a rag or brush prior to being placed back into operation.

The powerwashing procedure is a way to provide a physical scouring effect on the accumulated biomass adhered to plumbing and piping infrastructure. Powerwashing is an effective, but not permanent, method for removing biomass and preventing biosolids from appearing in the effluent discharges. Powerwashing techniques are most efficient when performed on glass piping but, with thermoplastic piping, some technique modification is required. Powerwashing activities are usually, at a minimum, using a two (2) person team; an operator of the powerwasher and a observer of the nozzle and hose as it moves through the conveyance piping.

Since trap cleaning and conveyance pipe powerwashing will not permanently remove biomass, periodic cleanings will be necessary to help ensure recurring growth is removed. As a result of compliance sampling, several institutions have proven the effectiveness of trap cleaning and powerwashing.

Source Control

It is extremely difficult to determine which products actually contain mercury. MSDS are not required to list any compound present at less than a 1% (or 0.1% for carcinogens) concentration or component of the product. For mercury, this means that a product might contain up to 10,000 ppb and the MSDS would not have to indicate its presence. The easier way to discover which products should be controlled due to their mercury content requires a good faith effort by manufacturers and suppliers of reagents to the medical community to step forward and voluntarily report the actual concentrations of mercury present in their products, regardless of whether or not they are above the MSDS listing threshold. Toward this end, 153 questionnaires were issued to the major suppliers of chemical reagents and immunodiagnostics to the medical community asking them to voluntarily divulge the mercury content of their products. To date, 61 responses have been received containing various degrees of useful information. Due to the voluntary nature of such a request, the results were as expected.

Analytical testing is the other means that can be used to identify the mercury content of a product. This can be very expensive, time consuming and complicated. Work on this front is proceeding but progress will be slow.

Public Awareness Training

Protocol and training efforts are critical components of the mercury equation. Many areas have seen dramatic reductions in end-of pipe concentrations through an initial information session explaining to the general workforce of what impacts certain procedures have on discharge limits. The 80/20 rule may apply here (meaning that the initial 20% of effort applied will achieve an 80% reduction). One errant disposal, however, can negate all progress made.

The protocol and training task force effort put forth by the Operations Subcommittee has developed an outline for hospitals and institutions to follow when educating their employees. The document contains an introduction, problem statement, identification of goals, an explanation of prohibited substances and an explanation of discharge limitations. The mercury identification process flow diagram explains the importance of a good chemical inventory control system. The section on management of mercury sources includes identification, reduction, and substitution initiatives. Mercury contamination and sampling is also discussed as well as educational approaches, training programs, and educational resources.

Accomplishments

Increased awareness and application of some of the lessons learned through the Hospital Mercury Work Group process have already led to a significant reduction in the amount of mercury being discharged to the MWRA sewerage system by institutions participating in the Work Group. An analysis of historical testing data from the MWRA's files shows that there has been a 70% reduction in the total mass of mercury being discharged into the system (2.36 to 0.47 ounces per day) by these institutions and that the average discharge concentration of mercury coming from the membership has been similarly reduced by more than 80% during the past year (21.4 to 4.3 ppb). Notably, only 15% of the 76 recorded discharge locations currently remain at concentration levels that exceed the aggregate membership average of 4.3 ppb.

Interpretation of the data after substituting current flow information and removing analytical Non-Detects (NDs), yields an even more positive measure of performance. The aggregate mass of mercury being discharged by the Membership is reduced by 87% to only 0.31 ounces per day. Clearly this data is significant and demonstrates the dramatic impact that source reduction and infrastructure measures have had upon the overall mercury discharge issue.

The Infrastructure Subcommittee has been able to document the presence of significant levels of mercury in the pipes, traps and conveyance systems of the hospitals. Procedures for the methodical identification, removal and cleaning of these systems have been compiled and presented in the Subcommittee's Infrastructure Maintenance Guidebook which can be followed

by any facility in the event that a problem is identified. The collaborative efforts employed by the members of this Subcommittee in preparing this manual have led to the development of a practical, "hands on" approach to helping institutions remove biomass from their infrastructure systems.
The Operations Subcommittee has sought to determine the mercury content in the most commonly used chemicals and reagents. With the cooperation of the MWRA, manufacturers and suppliers, the Subcommittee has compiled an electronic database of more than 5,000 products. Using this information, the Subcommittee is urging mercury source reduction by the substitution of products wherever possible as well as stressing education, awareness and training for both suppliers and users within the hospitals. Training aids presented in the final report can assist hospitals in developinh their own source reduction programs.

Conclusions

The End of Pipe Alternatives Subcommittee has concluded that not one of the technologies investigated is individually or collectively capable of reducing the concentration of mercury in a facility's discharge to below 1.0 part per billion on a consistent or sustainable basis. Some of the technologies have demonstrated abilities in removing 99.7% of the total mercury from the wastestream prior to discharge but the treated effluent still has a mercury content at the 3 to 5 ppb level. Most of the technologies should be viewed as polishing systems only and, as a result, initial pretreatment is required before these advanced techniques can be applied; all of which requires a significant amount of space and money to be installed.
In an attempt to place some perspective on these costs as a function of our membership's relative size according to flow rate, the Subcommittee developed the following "Order of Magnitude" table of costs for an End of Pipe solution which, according to our research, cannot meet a stipulated effluent discharge standard of 1.0 ppb:

Rank	Flowrate gpd	Capital Cost, $	Operating Cost, Expressed as a % of Capital/yr
Large	>20,000	1 to 2 Million	50%
Medium	5,000 to 10,000	Hundreds of Thousands	100%
Small	<1,000	Tens of Thousands	200%

The findings of the Infrastructure Subcommittee clearly indicate that there are things an institution can do to help reduce the residual presence of mercury in the wastewater conveyance system. The Subcommittee's guidelines for maintaining and cleaning systems provide practical and specific information on how to address the residual mercury problem, once it has been detected. Bear in mind, however, that the introduction of new sources that contain even trace amounts of mercury can quickly erase all progress made on this front.
Consequently, source reduction, through product identification and employee/user education and training, has been identified as the best means of effectively reducing the overall amount of mercury being discharged from our wastewater systems. Product manufacturers and distributors have also assisted us in this effort by supplying mercury content information on specific products and, in some cases, by helping us to identify mercury free alternatives. The database of products used by hospitals that has been developed by the Operations Subcommittee is the centerpiece of the Work Group's efforts to identify products containing mercury and the continued testing of products contained in that database will make it easier for all of us to practice effective source control.
Recommendations
The Hospital Mercury Work Group has developed the following recommendations:
Recommendation Number 1:
Read and use the information contained in the Operations and Infrastructure Subcommittee Reports to help reduce the level of mercury contained in an institution's discharge. The MWRA

should publicize and make available the Hospital Mercury Work Group Reports. For their part, institutions should:

- Practice source reduction through education and training of hospital personnel when purchasing and using products containing mercury
- Use the products database as an aid to identifying potential sources of mercury
- Work with vendors, doctors, lab personnel and others to explore the use of mercury free substitutes wherever possible
- If a problem develops and cleaning is indicated, follow the procedures (clean traps, powerwash pipes, inspect/clean tanks) recommended in the Infrastructure Maintenance Guidebook.
- Review the efficacy of limestone chip neutralization tanks and replace with active neutralization systems when and where appropriate
- Develop accurate flow information at points of discharge. If this includes the installation of flow meters, work to ensure their compatibility with MWRA sampling equipment
- Install MWRA approved sampling taps following "Special Waste" collection and neutralization systems. Ensure that no inappropriate (sanitary, NCCW, etc) waste sources enter the "special waste" piping systems.
- Prevent the discharge of identified mercury bearing stains, reagents, chemicals, etc. to the "Special waste" system and dispose off-site as regulated waste.

Recommendation Number 2:
Procedures governing the issuance of Notices of Violation (NOV) for mercury should be revised to reflect the following principles:

- Compliance schedules should be established to allow an institution to demonstrate a good faith effort of implementing the recommendations contained in the Subcommittees' Reports
- Sample testing during the compliance period should only be used to monitor the effectiveness of remedial actions taken and not serve as the trigger for additional enforcement action
- The Memorandum of Understanding (MOU) developed by the MWRA regarding the issuance of fines arising from mercury violations should remain in effect for the duration of the compliance schedule

Recommendation Number 3:
Representatives from the Hospital Mercury Work Group should continue to work with the MWRA on the establishment of a more appropriate discharge limit (both interim as well as long term) for mercury.

Recommendation Number 4:
Continue this MWRA/Hospital Mercury Work Group partnership by establishing an exchange program that would include visits to each other's facilities for more than compliance purposes.

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