MERCURY POLLUTION PREVENTION IN MINNESOTA

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ABSTRACT

Mercury has been used for many years in a wide variety of products that end up in the municipal solid waste stream. Programs to prevent mercury pollution are essential to successful integrated waste management systems. These programs, in turn, rely heavily on education of businesses, waste management professionals, and the general public, showing why mercury is a problem and how people can prevent mercury pollution.

This presentation will describe Minnesota mercury reduction programs and illustrate several approaches to outreach and education about mercury pollution prevention. The materials are designed for many different types of audiences, including healthcare professionals; electrical, heating, and building contractors; office building maintenance personnel; and waste management services providers, as well as the general public. They make people aware of the need to manage mercury-containing products responsibly and purchase mercury-free whenever feasible.

INTRODUCTION: WHY POLLUTION PREVENTION FOR MERCURY?

Mercury has been used for many years in all kinds of products, because it has the properties of both a metal and a liquid, making it useful for a wide variety of applications. Mercury is mined as various ores, then processed, shipped, manufactured, used, and discarded in products. Some discarded mercury products are chemically or thermally processed to recover mercury for reuse. Mercury can enter the environment through manufacturing or recycling emissions, dissipative use (paints and pesticides), or disposal in wastewater, municipal solid waste, medical and infectious waste, industrial waste, or hazardous waste. Mercury wastes may also be discarded directly to the environment or be released through associated activities, such as scrap metal recycling of automobiles and major appliances that contain mercury components. Since mercury is volatile and subject to chemical reactions, it can be emitted from facilities such as landfills and incinerators, and from such practices as sewage sludge application and solid waste composting.

Mercury is an element, and therefore it is persistent in the environment, being destroyed neither by combustion nor biological degradation. It evaporates readily and travels long distances in the atmosphere, causing local, regional, and global pollution.

Mercury vapor's residence time in the atmosphere is on the order of three months to two years (Lindqvist and Rodhe, 1985). The atmospheric pool of elemental mercury is slowly deposited to the earth's surface, as shown in Figure 1. Much of the deposited mercury is eventually re-emitted to the atmosphere (the "ping-pong" effect as described by Mason, et al, 1994) to be deposited again elsewhere.

Researchers have documented significant increases in the atmospheric deposition of mercury, largely a result of human use of mercury. Some of the most reliable information on the magnitude of the increase in mercury deposition is from the upper midwest. A study of seven Minnesota and Wisconsin lakes (Swain, et al, 1992) found that the annual deposition of mercury increased 3.4-fold from 1850 to 1990--from 3.7 to 12.5 micrograms per square meter. The seven lakes are in remote regions, distant from any concentrated emission source such as an incinerator or coal-fired power plant. There is evidence that the increased mercury deposition has resulted in significantly higher mercury concentrations in fish from lakes in Minnesota, because virtually all of the mercury in most lakes comes from the atmosphere (Swain and Helwig, 1989).

Currently, about a gram of mercury enters a twenty-acre lake from the atmosphere each year. By comparison, a teaspoonful of mercury weighs about 70 grams. A thermostat contains about three grams of mercury, and a mercury switch 3.5 grams. One hundred fluorescent lights contain from two to four grams of mercury.

The trace amounts of mercury cycling in the environment would not be a problem except that natural bacterial activity in wetlands and lakes converts a small proportion of it into an organic compound, methyl mercury. Unlike metallic mercury, methyl mercury is passed up the food chain to fish. Fish-eating animals, including loons, otter, osprey, mink, and humans, are at risk of being exposed to toxic levels of mercury. Mercury contamination of fish has resulted in health advisories to limit fish consumption in 35 states (RTI 1990).

Figure 1: Transport of Mercury in the Environment

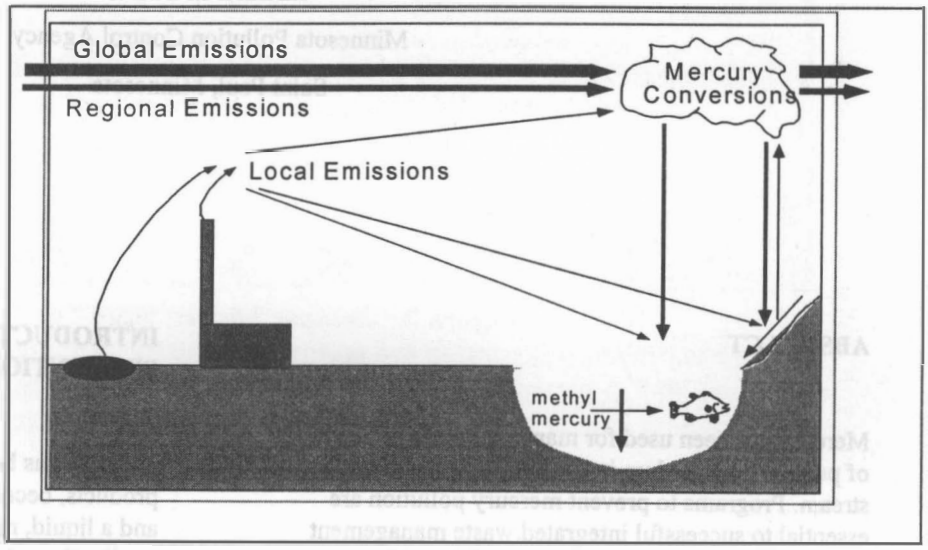
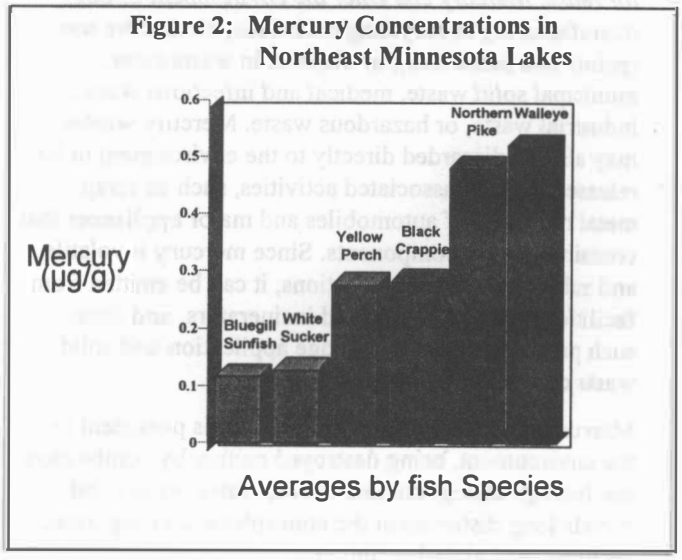


Figure 2: Mercury Concentrations in Northeast Minnesota Lakes

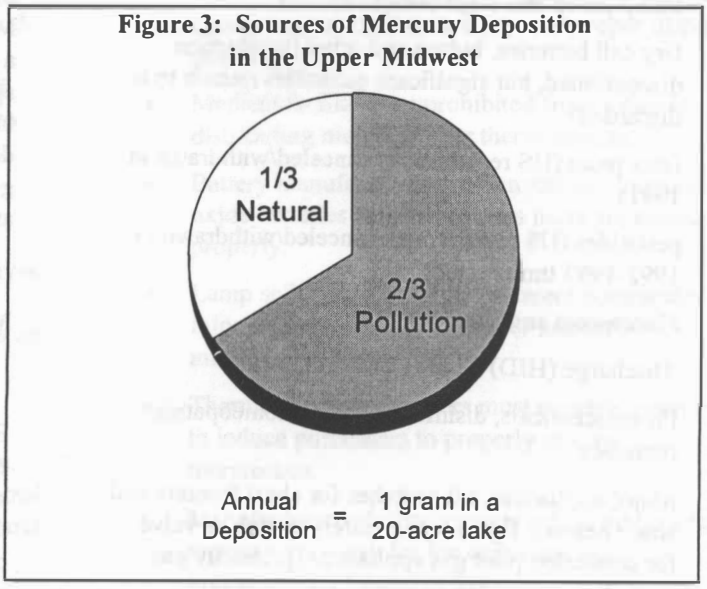


Even small releases of mercury can have a significant negative effect, both locally and, in aggregate, globally. Small amounts of mercury can be significant because the concentration of mercury increases to a high degree as it is passed along the aquatic food chain. For instance, the average concentration of mercury in a northeastern Minnesota lake is about 2 nanograms per liter (ng/L; a nanogram is one thousandth of a microgram), and Sorensen et al found the average concentration in a 22-inch northern pike to be about 450 nanograms per gram (0.45 parts per million), a bioaccumulation factor of 225,000. Figure 2 shows mercury concentrations in different fish, showing elevated levels in many fish species. This is especially true in lakes that are acidic or high in dissolved organic matter. Fish at the top of the

food chain, such as northern pike and walleyes, accumulate the most mercury (Helwig).

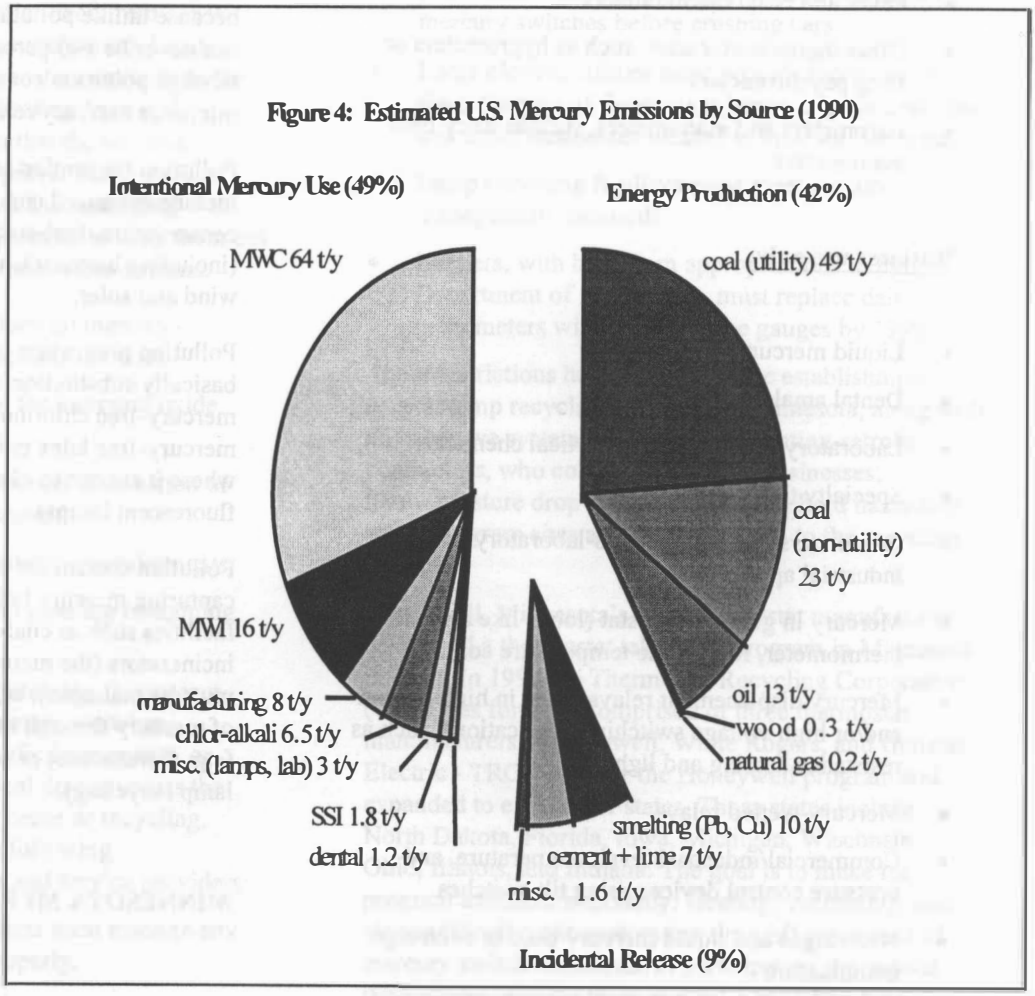
The bioaccumulation of mercury leads to situations that some may find surprising. For instance, it may be safe to drink a lake's water where it would be unhealthy to eat the fish that grow in the water. The U.S. Environmental Protection Agency (EPA) drinking water standard for mercury of 2,000 ng/L (CFR 40) is far above the EPA ambient water standard of 12 ng/L (EPA 1985) that is designed to protect humans from the consumption of contaminated fish. Most lakes tested in Minnesota yield fish that exceed 150 ng/g (0.15 ppm), the level that results in the Minnesota Department of Health advising people to restrict consumption to one meal per week or month. There is evidence that loons, mink and otter in some lakes have elevated mercury levels that are negatively affecting their health (Barr, 1986).

Figure 3: Sources of Mercury Deposition in the Upper Midwest



About a third of the mercury that enters the atmosphere comes from natural sources, such as volcanoes and forest fires, as shown by Figure 3. The remaining two-thirds comes from pollution caused by human activity. In 1990 estimated mercury emissions from anthropogenic sources were roughly half from energy production and the other half from the intentional use of mercury in products (Figure 4).

Figure 4: Estimated U.S. Mercury Emissions by Source (1990)



PRODUCT USE

Major household and business uses of mercury of concern to solid waste, hazardous waste, and wastewater managers are as follows:

- Liquid mercury collected and stored over the years
- Heating/cooling thermostats
- Silent wall switches (look for "top" or "up" mark on switch, production discontinued in 1991)

- Sump pump and bilge pump switches
- Dry cell batteries, button and other (production discontinued, but significant quantities remain to be discarded)
- latex paint (US registrations canceled/withdrawn in 1991)
- pesticides (US registrations canceled/withdrawn in 1992-1993 time period)
- Fluorescent and High Intensity
- Discharge (HID) lamps
- Pharmaceuticals, disinfectants, and homeopathic remedies
- Major appliances: tilt switches for chest freezers and space heaters; flame sensor/safety switch or valve for concealed pilot gas appliances (primarily gas ovens)
- Fever and basal thermometers
- Other thermometer uses, such as hygrometers or sling psychrometers
- Barometers and manometers, such as dairy barn manometers

Business use only:

- Liquid mercury
- Dental amalgam waste
- Laboratory reagents and analytical chemicals
- Specialty thermometers
- Barometers and manometers-laboratory and industrial applications
- Mercury in glass thermostat (looks like a small thermometer, for precise temperature control)
- Mercury displacement relays (used in high current and/or high voltage switching applications, such as resistance heating and lighting)
- Mercury-wetted relays
- Commercial/industrial level, temperature, and pressure control devices using tilt switches
- Neon signs and liquid mercury used in neon sign manufacture

This is only a partial list of the diverse types of mercury-containing products that may be in use or need to be discarded by a household or business. The author and the Minnesota Office of Environmental Assistance maintain a detailed list of products (and brand names, where applicable) that is continually updated as new information is received. This information has been developed in part as a result of Minnesota statutes that govern the sale, use, labeling and disposal of mercury and mercury.

MERCURY REDUCTION OPTIONS

Efforts to reduce mercury emissions need to address both energy production and use of mercury in manufacturing and products. Reduction options are quite different for these two economic sectors, but both cases include the categories of pollution prevention (front end) and pollution control (back end). Pollution control options are generally not as satisfactory as pollution prevention, because unlike pollution prevention, pollution control can never be 100 percent effective and mercury captured through pollution control must still be managed to minimize mercury releases.

Pollution prevention options for the energy sector include enhanced energy efficiency, energy conservation, fuel-switching to low-mercury fuels (including biomass), alternative energy sources, such as wind and solar.

Pollution prevention in manufacturing and products is basically substitution of non-mercury processes (e.g. mercury-free chlorine production) and products (e.g. mercury-free latex paint), or minimizing mercury use where it cannot be eliminated (e.g. lower-mercury fluorescent lamps).

Pollution control for both sectors can consist of capturing mercury before it can exit a smoke stack at facilities such as coal-burning power plants and incinerators (the mercury is added to the fly ash, which must be managed), or, in the case of products, recycling of mercury through manufacturer take-back programs (e.g. thermostats) or user-paid mandates (e.g. fluorescent lamp recycling).

MINNESOTA MERCURY REDUCTION EFFORTS

Because Minnesota greatly values its lake and river resources, mercury contamination of fish is an

environmental problem that is unsatisfactory and has received regulatory attention since the early 1970s, with most of the initiatives implemented since 1990. Minnesota has implemented a comprehensive suite of pollution prevention and pollution control mandates to reduce the mercury content in products and waste streams released to the environment.

Minnesota programs to reduce mercury include conventional regulations, pollution prevention initiatives, and mercury collection and recycling initiatives. Conventional approaches to pollution control, such as air quality standards, have not been viewed as adequate because there is no control technology available for some sources (such as coal) and where technology is available, it does not catch 100 percent of the mercury. Furthermore, mercury that is caught by pollution control equipment may end up in the water or on the land — and eventually back into the air. Mercury that is sent to MSW landfills, similarly, may volatilize to the air in transit, at the working face, or through gas collection systems (some of the mercury volatilized from MSW landfills is methylated, which is even worse). Land application of landfill leachate transfers mercury to the atmosphere through slow volatilization from soil. Minnesota has taken the position that the ultimate solution to mercury pollution is prevention — purchasing mercury-free products and managing mercury-containing products separately to keep them out of the municipal, medical, and water waste streams.

Minnesota statutes place restrictions on mercury-containing products. These restrictions include:

- A disposal ban and sales ban for mercuric oxide batteries.
- Mandatory reduction and eventual elimination of mercury content in other batteries.
- Shelf, battery, and product-labeling requirements.
- Sales ban on games, toys, and clothing containing elemental mercury.
- Disposal ban for mercury-containing fluorescent lamps, thermostats, thermometers, switches, appliances, medical or scientific instruments, or electric relay or other electrical device unless the mercury is first removed for reuse or recycling.

The Minnesota statutes place the following responsibilities on manufacturers and service providers:

- Servicers of household products must manage any mercury-containing items properly.
- Retailers must notify users or handlers of mercury-containing items of its toxicity and proper disposal practices.
- Medical facilities are prohibited from routinely distributing mercury fever thermometers.
- Battery manufacturers must ensure that mercuric-oxide batteries sold to business users are managed properly.
- Lamp sellers and lamp-replacement contractors must inform the buyer/user of proper mercury-management requirements.
- Thermostat manufacturers must provide incentives to induce purchasers to properly manage thermostats.
- Manufacturers of displacement relays that contain mercury must pay for the collection and management of those relays.
- Automobile salvage-yard operators must remove mercury switches before crushing cars.
- Large electric utilities must provide incentives for the collection of fluorescent lamps from households and small businesses located in their service areas.
- Lamp recycling facilities must meet certain management standards.
- Farmers, with help from appropriations to the Department of Agriculture, must replace dairy manometers with mercury-free gauges by 1999.

These restrictions have resulted in the establishment of several lamp recycling facilities in Minnesota, along with an extensive system of haulers and lighting-retrofit contractors, who collect lamps from businesses, hardware store drop-off sites, and household hazardous waste program sites and transport them to the recycling facilities.

Honeywell, Minnesota's only thermostat manufacturer, developed a thermostat take-back program in Minnesota in 1994. In 1997 the Thermostat Recycling Corporation (TRC) was formed. Comprised of three thermostat manufacturers - Honeywell, White Rogers, and General Electric - TRC took over the Honeywell program and expanded to eight other states. Those states include North Dakota, Florida, Iowa, Michigan, Wisconsin, Ohio, Illinois, and Indiana. The goal is to make the program available nationally. Heating, ventilating, and air conditioning contractors can drop off any brand of mercury switch thermostat at participating thermostat wholesalers, placing them in plastic recycling bins provided by TRC. The thermostats are shipped to TRC

facilities, where the mercury switches are removed and prepared for shipment to a mercury reclamation facility. Since the program began in 1994, more than 38,800 thermostats have been collected, preventing 463 pounds of mercury from entering the environment. For more information about the Thermostat Recycling Corporation's collection program, contact Ric Erdheim at the National Electrical Manufacturers Association at (703) 841-3249.

Drop-box programs for mercury-containing batteries have been instituted at selected retail stores. AT Systems, a department of Alexander Batteries in Mason City, Iowa, has established a battery-collection program for mercuric oxide batteries. AT Systems will provide to businesses a battery collection plan and will coordinate packaging and transportation to their facility. For more information about this program, contact AT Systems at 1-888-527-2539.

OUTREACH AND EDUCATION PROJECTS

Minnesota Office of Environmental Assistance staff have implemented two education and outreach projects for mercury pollution prevention, in partnership with the U.S. EPA Region 5, the states of Michigan and Wisconsin, and selected organizations, trade associations, and facility personnel. The processes for developing outreach and education materials differed, depending on the targeted audience for the materials. The following paragraphs describe each set of materials.

First Project

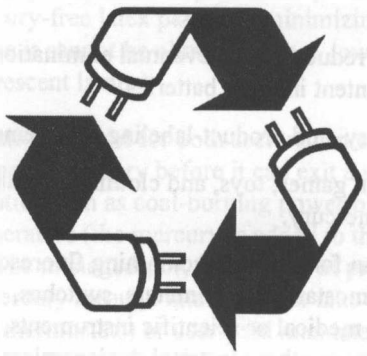
The audiences for the first outreach project were:

- electrical contractors
- heating, ventilating, and air conditioning (HVAC) contractors
- building owners and managers
- construction and demolition contractors
- appliance processors
- dairy farm owners and operators
- utilities
- waste collection service providers
- recycling and disposal facility operators

We worked with the Minnesota Pollution Control Agency and the states of Wisconsin and Michigan to develop a brochure *Mercury in the Environment: the Waste Connection,* which is designed for use by a wide variety of service technicians, contractors, and building owners and managers, but it can also be used by homeowners. The folder for the set explains the environmental and health-related effects of mercury in the environment, and six inserts inform people about how to manage mercury-containing switches, thermostats, thermostat probes, gauges, thermometers, and fluorescent lights. As part of this project, we also purchased copies of the brochure *Mercury: Get Mad Now, Not Later* from the Western Lake Superior Sanitary District in Duluth, Minnesota. This brochure is directed at homeowners. It informs them about what products contain mercury and about mercury's effect on their health and the environment. It encourages consumers to buy mercury-free alternatives when appropriate and to manage mercury-containing products properly during use and when ready to discard them.

We also developed a slide show *Mercury in the Environment: the Waste Connection* and a mercury display *Who Me? Do I contribute mercury to the environment?* for use at conferences and meetings. In addition, we purchased the copyright for a logo used to identify fluorescent lamp recycling drop-off sites, as shown in Figure 5. For more information about these materials contact the Minnesota Office of Environmental Assistance Education Clearinghouse at 1-800-877-6300.

Figure 3: Fluorescent Lamp Recycling Logo

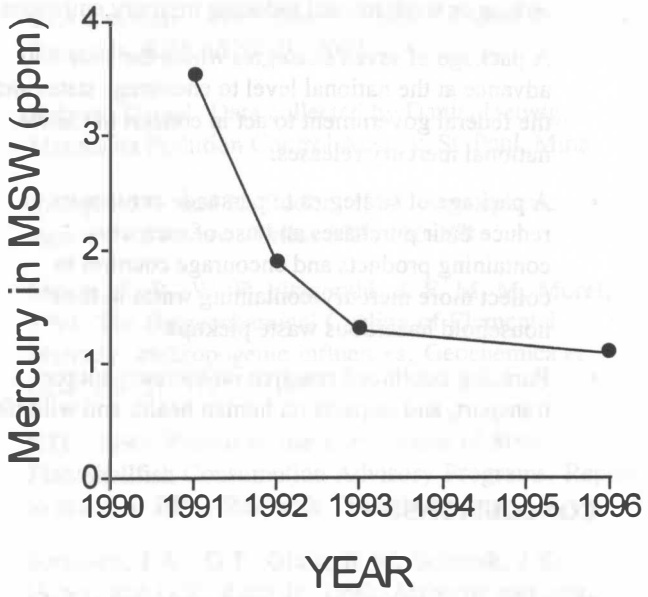


Second Project

The second outreach and education project was to promote mercury pollution prevention within the healthcare industry. The Terrene Institute had worked

with the U.S. EPA Region 5 Water Quality Division before we began our project and had developed a small manual and a poster titled *The Case Against Mercury: Rx for Pollution Prevention.* Our task was to build on these materials and make them specific to Minnesota. We established a steering committee made up of representatives from Minnesota healthcare facilities to determine the types of materials that would be useful within hospitals and clinics. The steering committee recommended a video for use in hospital and clinic staff training sessions. The resulting video, *Mercury and the Healthcare Professional,* is a seventeen-minute video for general audiences within the healthcare industry. The video raises awareness of mercury's impact on the environment and shows its presence in healthcare

Figure 4: Mercury concentration in municipal solid waste in Hennepin County, Minnesota.



settings. It features opportunities for preventing mercury pollution within medical, dental, and veterinary facilities.

In addition, the steering committee recommended a companion print piece which would provide more detail about where mercury is used in healthcare facilities, as well as offering information about available alternatives to mercury-containing instruments and equipment and actions a facility could take to prevent mercury pollution. This handout is titled *Mercury Use in Hospitals and Clinics.*

During this project we also developed a display, *Who Me? Do I contribute mercury to the environment?* for use in hospital cafeterias and at workshops and conferences. It consists of three 20" x 40" panels of pictures and text mounted on gatorboard, showing visually the message conveyed in the other pieces.

Distribution of Materials

Distribution of the educational materials has been an important component of both projects. In both cases, we have used the same network for distribution that we used for developing the materials. The steering committee for the healthcare project plans to stay together and work on the dissemination of the materials and on other environmental issues of importance to the healthcare industry.

In an effort to get the materials to as wide an audience as possible, we have tried to get on the agenda and into the exhibit halls of conferences and meetings of appropriate trade associations, waste management professionals, and healthcare professionals. Local environmental association and county environmental office staff have presented the information at city and county meetings, at county fairs, and at other public gatherings.

RESULTS OF OUTREACH AND COLLECTION PROGRAMS

The state efforts, described above, have worked successfully in tandem with county programs to decrease the mercury content of mercury in the municipal solid waste streams. The mercury content of municipal solid waste is difficult to measure directly, because of its heterogeneous nature. The best measure of mercury in solid waste is through a mass-balance calculation at a mass-burn facility, where no sorting takes place (in contrast to a refuse-derived fuel facility). The mercury concentration in solid waste can be calculated from the sum of mercury emissions to the air, plus the mercury content of the ash sent to landfills.

Hennepin County, which includes the City of Minneapolis, has been able to achieve dramatic reductions in the mercury content of their municipal solid waste (MSW) from an extensive problem materials collection program, which includes fluorescent lamps, batteries, switches, liquid mercury, and consumer electronics (Figure 6). In addition to the source separation programs, the county installed carbon injection pollution control equipment in 1994, an action which together with the source separation programs

helped to achieve 97 percent removal, up from 80 percent without carbon. Emissions dropped an additional 140 pounds from what otherwise would have been emitted (22 pounds emitted out of a total 800 pounds in the MSW). Pollution prevention activities had reduced the mercury in 365,000 tons of MSW processed each year in the Hennepin County incinerator from 2,560 pounds in 1991 to 800 pounds in 1996, a 70 percent reduction.

Decreases in the mercury content of MSW are also evident in the emission data from incinerators without activated carbon control in Minnesota. Figure 7 shows the mercury emissions from incinerators in Red Wing, Minnesota, and Olmsted County's incinerator in Rochester, Minnesota from 1987 - 1996. The mercury emissions decreased from 700 micrograms per cubic meter for Red Wing's incinerator and 550 micrograms per cubic meter for Olmsted County's incinerator to 100 micrograms per cubic meter for each incinerator by 1996, an apparent 85 percent mercury reduction in solid waste.

In addition to the successes in mercury abatement at solid waste management facilities, there is evidence that reductions in mercury use since the 1970s have reduced mercury deposition in the upper midwest of the U.S., even while global pollution increased unabated (Engstrom and Swain, 1997). Minnesota's programs have shown that the whole world doesn't have to work together simultaneously; local reductions will have benefits, both locally and globally.

Other evidence that mercury pollution prevention efforts have had an effect on mercury emissions from solid waste management facilities is shown in The Best Point Estimates of 1994-1995 National Mercury Emission Rates in the EPA Mercury Report to Congress (EPA 1997). The estimates listed in that table show that overall emissions fell from 185 tons per year estimated for1990 to 158 tons/year estimated for 1994-1995. That decrease is due almost entirely to emissions from municipal waste combustors, which fell from 64 tons/year (Figure 4) to 30 tons/year in 1994-1995. Most of the reduction in emission is due to a reduction in the mercury content of the solid waste, in contrast to enhanced pollution control equipment.

THE FUTURE OF MERCURY REDUCTION ACTIVITIES IN MINNESOTA

The Minnesota Pollution Control Agency (MPCA) began work in 1997 on a project called the Mercury Contamination Reduction Initiative, which aims to identify and implement strategies that the state can use to further reduce mercury contamination. The initiative involves all significant mercury sources, including energy production. The Initiative has established an Advisory Council, made up of representatives of industry, environmental groups, and government. The Council's chartered goal was to devise a package of recommendations to reduce mercury contamination in the environment. In December 1998 the Council agreed to adopt a goal of reducing mercury releases to Minnesota's air and water by 70 percent (compared to 1990 levels) by the year 2005.

The recommendations which the council voted to forward to the MPCA include:

- Encouraging voluntary commitments on the part of sources of mercury emissions (e.g. power plants, taconite facilities, sewage sludge incinerators) to reduce or work toward reducing mercury emissions.
- A package of seven strategies which the state will advance at the national level to encourage states and the federal government to act in concert to reduce national mercury releases.
- A package of strategies to persuade consumers to reduce their purchases and use of mercury-containing products and encourage counties to collect more mercury-containing waste in their household hazardous waste pickups.
- Pursuing continued research on mercury sources, transport, and impacts on human health and wildlife.

CONCLUSIONS

The mercury reduction successes described above show what is possible when governments establish mercury pollution prevention initiatives. With good information about mercury's uses, homeowners, businesses, government agencies, and waste managers can identify and source separate mercury-containing wastes for proper management. As the text for the mercury display says, "It takes all of us working together to keep mercury out of the environment." Through such activities, releases to the environment can be reduced and the potential for human and wildlife health risks can be minimized, for current and future generations.

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