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Characterization of Products Containing Mercury in Municipal Solid Waste in the United States, 1970 to 2000

Executive Summary

CHARACTERIZATION OF PRODUCTS CONTAINING MERCURY IN MUNICIPAL SOLID WASTE IN THE UNITED STATES, 1970 TO 2000;

EXECUTIVE SUMMARY

April, 1992

U.S. Environmental Protection Agency
Office of Solid Waste
Municipal and Industrial Solid Waste Division

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Executive Summary

THE PURPOSE AND SCOPE OF THIS REPORT

The purpose of this report is to identify the products in municipal solid waste (MSW) that may contain mercury and to quantify, to the extent that data are available, the mercury present in these products. Since the data are presented in a time trend (1970 to 1989), the report helps to identify which products in MSW are making declining contributions of mercury and which are increasing. The information in this report can thus be used to identify opportunities for source reduction and removal of mercury from the municipal solid waste stream.

As in earlier municipal solid waste characterization reports published by EPA*, the characterization of mercury in MSW relies on a material flows methodology. By definition in the referenced reports, municipal solid waste is generated from residential, commercial, and institutional sources. Some wastes from industrial facilities, such as office waste and packaging, are also included. MSW as characterized in the referenced reports does *not* include other Subtitle D wastes such as municipal sludges, municipal waste combustion ash, industrial nonhazardous process wastes, small quantity generator wastes, construction and demolition wastes, agricultural wastes, oil and gas production wastes, and mining wastes. Subtitle C (hazardous) wastes also are not included.

HEALTH AND ENVIRONMENTAL EFFECTS OF MERCURY

Human Health Effects

Mercury is a heavy metal with a high toxicity and strong tendency to bioaccumulate in the food chain. Worldwide, the major route for entry of mercury in humans is ingestion of mercury-contaminated food, especially fish. Long-term exposure, or exposure during developmental stages, to either organic or inorganic mercury can permanently damage the brain, kidneys, and fetuses. Short-term exposure to high levels of inorganic or organic mercury can cause similar health effects, which may be reversible. Pregnant women, fetuses, and children appear to be at highest risk.

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* The most recent of these reports is **Characterization of Municipal Solid Waste in the United States: 1990 Update.** EPA/530-SW-90-042. June 1990.

Environmental Effects

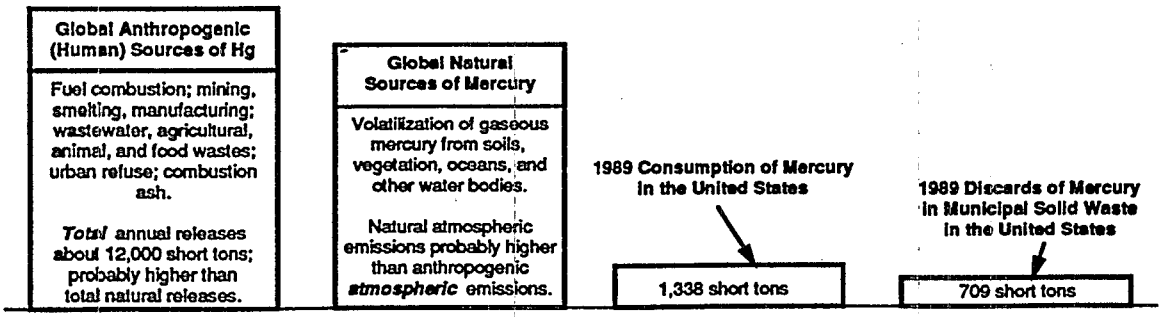
In addition to potential effects on human health, mercury poisoning can also affect other living organisms. Mercury is unique among the metals in that it is consistently biomagnified within the aquatic food chain. Organisms eating mercury-contaminated fish, such as birds, wild mink, and otter, have been found to have mercury poisoning. In addition, several countries have reported poisoning of birds through ingestion of seeds treated with mercury compounds, and of predatory animals through ingestion of contaminated birds.

MERCURY RELEASES IN PERSPECTIVE

While the products containing mercury in municipal solid waste are an important source of mercury releases in the environment, they are far from the only source. Global releases of mercury in the environment are both natural and anthropogenic (caused by human activity). Relative sources of mercury are shown in Figure ES-1.

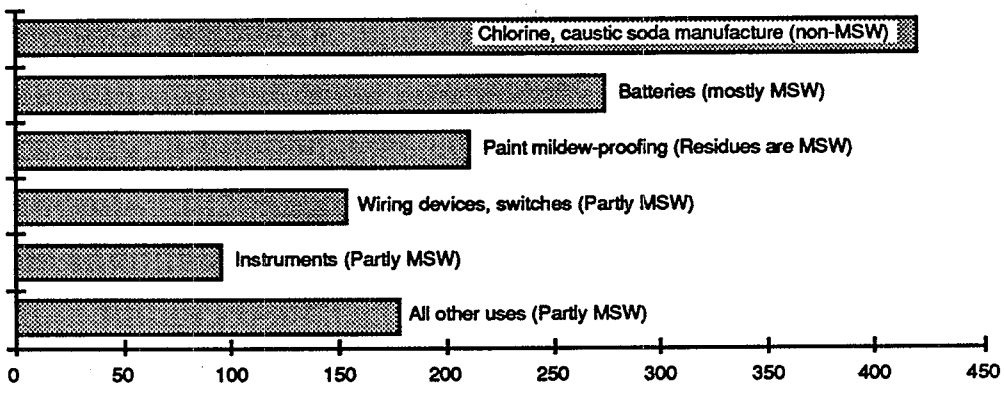
While global releases are not well documented, the best estimate available is that about 12,000 short tons of mercury are released annually to the air, soil, and water through anthropogenic sources. These sources include combustion of various fuels; mining, smelting, and manufacturing activities; wastewater; agricultural, animal, and food wastes; urban refuse; combustion ash, and other human activities. Global natural sources of mercury include volatilization of gaseous mercury from soils, vegetation, oceans, and other water bodies. The natural sources are thought to release less mercury overall than the anthropogenic sources, but natural atmospheric emissions may be higher than anthropogenic atmospheric emissions.

Figure ES-1. Global and United States sources of annual mercury releases.



Note: Heights of columns are for comparative purposes only. Global anthropogenic and natural sources of mercury are not well documented. Due to time lag before products in MSW are discarded, mercury in discards may have been consumed several years previously.

Figure ES-2. U.S. consumption of mercury, 1989 (in short tons)



Discards of mercury in products in municipal solid waste in the United States are derived from consumption of mercury, with appropriate adjustments for manufacturing losses, imports and exports of products containing mercury, and the lifetimes of the relevant products. In 1989, an estimated 709 short tons of mercury were discarded in the U.S. in municipal solid waste compared to the 1,338 short tons reported to be consumed in the U.S. the same year (Figure ES-1). The MSW discards are less than consumption because mercury is used in several products and processes that are not discarded as MSW. (The adjustments listed above also partially account for differences between consumption and discards in any given year.)

There are several uses of mercury in products and processes that are not classified as MSW discards. The largest use of mercury in the U.S. is in chlorine and caustic soda manufacture (Figure ES-2); mercury wastes from these processes are classified as industrial process waste. Another example is mercury-containing paint that has been applied to indoor or outdoor surfaces. If the structure is demolished, the waste would be classified as demolition waste, not MSW. Many batteries, instruments, and electrical devices containing mercury are used in industrial, communications, transportation, or military applications that also are not classified as MSW.

SOURCES OF MERCURY IN MUNICIPAL SOLID WASTE

Research performed in the preparation of this report identified a number of sources of mercury in municipal solid waste, with total discards of mercury in 1989 estimated to be 709 short tons. A summary of the results is shown in Tables ES-1 and ES-2, and Figure ES-3.

Table ES-1

DISCARDS* OF MERCURY IN PRODUCTS IN THE MUNICIPAL SOLID WASTE STREAM, 1970 TO 2000
(In short tons)**

Products	1970	1980	1989	2000
Household Batteries	310.8	429.5	621.2	98.5
Electric Lighting	19.1	24.3	26.7	40.9
Paint Residues	30.2	26.7	18.2	0.5
Fever Thermometers	12.2	25.7	16.3	16.8
Thermostats	5.3	7.0	11.2	10.3
Pigments	32.3	23.0	10.0	1.5
Dental Uses	9.3	7.1	4.0	2.3
Special Paper Coating	0.1	1.2	1.0	0.0
Mercury Light Switches	0.4	0.4	0.4	1.9
Film Pack Batteries	2.1	2.6	0.0	0.0
TOTAL DISCARDS	421.8	547.5	709.0	172.7

* Discards before recovery.
** Weights in this report are converted to short tons of 2000 pounds.
Source: Franklin Associates, Ltd.

The tables show that batteries discarded from households and other sources of MSW are by far the largest current source of mercury. Light bulbs, paint residues, thermometers, thermostats, and pigments are estimated to contribute most of the remainder of mercury in MSW. A few other uses, such as dental mercury and light switches, were also identified, but these totaled less than one percent of mercury in MSW in 1989.

Mercury discards in MSW peaked in 1986, and are declining rapidly (Figure ES-4). In particular, there is projected to be a significant decrease in mercury in alkaline batteries and paint residues over the next few years. The decrease in batteries is due to a long-term commitment to research and development by the battery industry to remove mercury from alkaline batteries. The removal of mercury from paint residues is the result of bans by the Environmental Protection Agency, and voluntary cancellations of registrations by the paint industry, of mercury-based biocides in 1990 and 1991.

The only products identified to be increasing in total tonnage of mercury discarded are electric lighting and mercury light switches. Fever thermometers and thermostats, while formerly increasing in tonnage discarded, are projected to be fairly stable as sources of mercury.

Table ES-2

DISCARDS* OF MERCURY IN PRODUCTS IN THE MUNICIPAL SOLID WASTE STREAM, 1970 TO 2000
(In percent of total discards)

Products	1970	1980	1989	2000
Household Batteries	73.7	78.4	87.6	57.0
Electric Lighting	4.5	4.4	3.8	23.7
Paint Residues	7.2	4.9	2.6	0.3
Fever Thermometers	2.9	4.7	2.3	9.7
Thermostats	1.3	1.3	1.6	6.0
Pigments	7.7	4.2	1.4	0.9
Dental Uses	2.2	1.3	0.6	1.3
Special Paper Coating	0.0	0.2	0.1	0.0
Mercury Light Switches	0.1	0.1	0.1	1.1
Film Pack Batteries	0.5	0.5	0.0	0.0
TOTAL DISCARDS	100.0	100.0	100.0	100.0

* Discards before recovery.

Source: Franklin Associates, Ltd.

Each identified source of mercury in MSW is discussed briefly in this section.

Household Batteries

Batteries containing mercury that are assumed to be discarded into MSW are mostly of two types:

- Alkaline batteries, which are usually the cylinder-shaped batteries used in flashlights, radios and other electronics, and toys.

- Mercury-zinc batteries, which are usually in a "button" form, are used in hearing aids, watches, calculators, cameras, and similar applications. Mercury-zinc cylinder-type batteries are also used in some medical applications that were assumed to be discarded in MSW.

A few other kinds of batteries—carbon zinc, silver oxide, and zinc air—account for relatively small amounts of mercury in MSW.

Alkaline Batteries. Alkaline batteries accounted for about 419 short tons, or over 59 percent, of discards of mercury in MSW in 1989. While the

amount of mercury used in each battery has been quite small, the large numbers of alkaline batteries sold have caused these batteries to become the leading source of mercury in MSW.

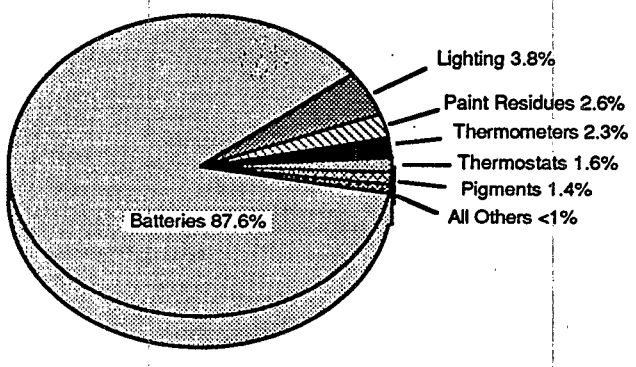
The battery industry has been under intense pressure to reduce the amounts of mercury (and other heavy metals) discarded into MSW. The industry has announced its intention to reduce mercury in alkaline batteries to 0.025 percent by weight by 1992, and to eventually eliminate all mercury from these batteries. Projections made for this report take these goals into account.

Mercury-Zinc Batteries. Mercuric oxide is used as the cathode material in mercury-zinc batteries, so mercury comprises a relatively high percentage of the material in these batteries. They contributed over 196 tons, or nearly 28 percent, of mercury discards in 1989. The amount of mercury discarded in mercury-zinc batteries has declined over the years as other kinds of batteries (silver oxide, zinc air) have taken some of their market share.

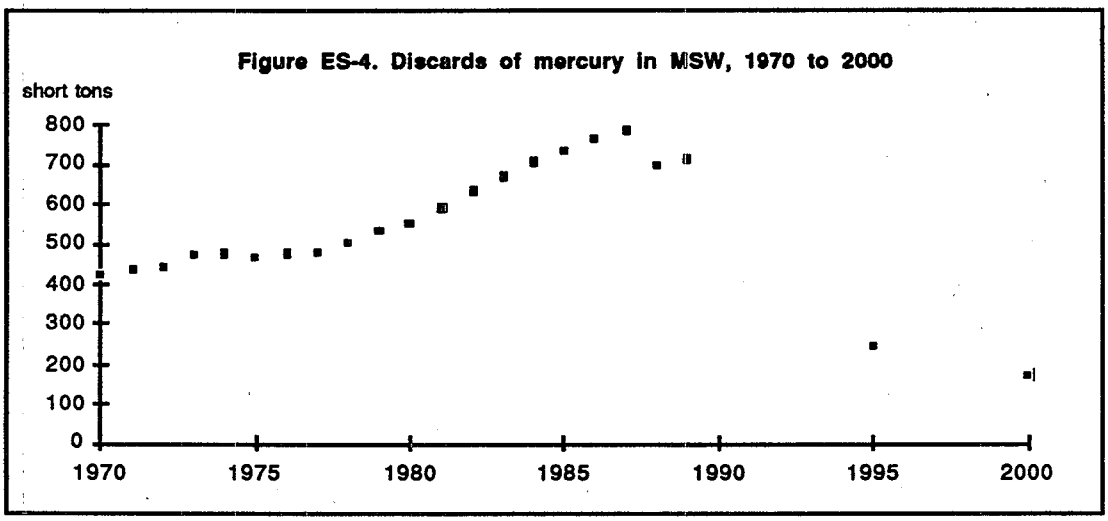
While mercury can be eliminated from alkaline batteries, it is an integral part of mercury-zinc batteries. Discards of mercury from this source were thus projected to decrease but not be eliminated. Based on the projections, only mercury-zinc batteries will be found in MSW in the year 2000.

Other Batteries. Other batteries that contributed about 5 tons, or less than one percent, of mercury discards in MSW in 1989 include carbon-zinc batteries, silver oxide batteries, and zinc air batteries. Production of carbon-zinc batteries is declining, while use of silver oxide and zinc air batteries has

Figure ES-3. Discards of mercury in MSW, 1989



Total mercury discards = 709 short tons



been increasing. It is projected that use of mercury in these batteries will be discontinued.

Recovery for Recycling. While some programs to recover batteries, either for recycling or simply to keep them out of the waste stream, were identified, the quantities recovered were not believed to be significant enough to affect discards in 1989. It was assumed for this report that 5 percent of the mercury in batteries will be recovered in 1995 and that 20 percent will be recovered in the year 2000. These recovery rates are consistent with recovery rates achieved by many other products in MSW, and lower than some.

Electric Lighting

The second largest source of mercury in MSW in 1989 was estimated to be electric lighting. This mercury came from two sources:

- The ordinary fluorescent lamps (bulbs) used in residences, offices, and other commercial and institutional buildings
- Certain high intensity lamps (bulbs) used in lighting streets, parking lots, and similar sites.

Of these two sources, fluorescent lamps are by far the largest, accounting for 26 tons of mercury in MSW in 1989, or 3.7 percent of total discards. All lighting sources were estimated to contribute nearly 27 tons of mercury in 1989, or almost 4 percent of total discards.

The mercury content of these lamps has been reduced over the past 5 years, but increasing sales will cause the amount of mercury from this source to continue to increase. New energy-efficient fluorescent lamps are being promoted as a replacement for incandescent lamps at this time, but it is too early to determine whether sales and discards of these lamps will further increase the amount of mercury discarded.

While a few attempts to recover mercury from fluorescent lamps were identified, no basis for projecting a significant amount of recovery from lamps in MSW in the future was found.

Paint Residues

By 1991, EPA had banned the use of mercury as a biocide in paints for exterior or interior use. Even though mercury is no longer used in paint manufacture, paint cans containing residues including mercury will continue to be discarded. It was estimated that about 18 tons of mercury were discarded in paint residues in 1989, or 2.6 percent of total discards. These discards are projected to decline rapidly as paints made after the ban on mercury took effect begin to be discarded. (Note that these estimates do *not* include mercury in paints applied to interior or exterior surfaces, which are not classified as municipal solid waste.)

Fever Thermometers

The familiar fever thermometer was identified as a source of mercury discarded from homes and medical establishments. In 1989, an estimated 16.3 tons of mercury were discarded in thermometers, or just over 2 percent of total discards.

Mercury fever thermometers are being replaced by digital thermometers, especially in medical applications. It therefore was projected that there will be a gradual decline in discards of mercury from this source.

Thermostats

The typical thermostat used for temperature control in residences and other buildings contains mercury that could enter MSW if the thermostat is discarded. (This mercury could also become demolition waste if the thermostat is in a demolished house.) An estimated 11 tons of mercury entered MSW in thermostats in 1989; this was less than 2 percent of total discards.

Thermostats have a long life—estimated to be 20 years—so there is a long lag time before they are discarded. Thus, even though mercury

thermostats are gradually being replaced by digital thermostats, they are projected to continue to be a source of mercury in MSW through 2000.

Pigments

Published data on the end uses for pigments containing mercury was not found. It appears that most of the mercury in pigments is used in plastics, often in combination with cadmium, but other uses could include paints, printing inks, rubber, textiles, and others. Based on the data available, it was estimated that 10 tons of mercury in pigments were discarded in 1989. This was less than 2 percent of total discards.

Use of mercury in pigments has been declining steadily. Cadmium-mercury pigments are no longer manufactured in the United States, but some imports were identified. Since there is continuing pressure on pigment makers to eliminate metals, it was projected that use of mercury in pigments will continue to decline rapidly.

Other Sources of Mercury in MSW

Other sources of mercury in products discarded in MSW include dental amalgams, a special paper coating used with cathode ray tubes, and mercury electric light switches. Together these uses amounted to less than one percent of mercury in MSW discards in 1989.

Use of mercury in dentistry is declining, and the manufacturers of the special paper have announced plans to discontinue use of mercury by 1995. Of this group, only mercury light switches are a growing source of mercury in MSW. Their discards are projected to total about 2 tons in 2000, or about one percent of total discards in that year.

Mercury was formerly a component of batteries used in instant camera film packs, but this use was discontinued in 1988.

Discontinued Sources of Mercury in MSW

Research for this report identified several products that can be classified as MSW where mercury has been used in the past. These sources were not quantified, but are listed below:

- Mirrors (discontinued about 50 years ago)
- Glass in highly specialized applications
- Felt (discontinued in the 1950s)
- Textiles intended for outdoor use
- Paper (discontinued about 1972).

MERCURY IN NON-MUNICIPAL SOLID WASTE PRODUCTS

While the purpose of this report was to quantify sources of mercury in municipal solid waste, other products containing mercury were identified in the research. Some of these wastes could very likely be managed in a landfill or combustor intended primarily for MSW.

Agricultural Products

Mercury and mercury compounds have been used as fungicides for agricultural purposes. These uses were greatly restricted by FIFRA, and presently only applications for treatment of outdoor textiles, to control brown mold on freshly sawn lumber, to control Dutch elm disease, and to control snow mold are allowed. No use is permitted on food crops.

Paints

In the past mercury compounds were widely used as biocides or preservatives in paint, especially in latex paints. Mercury was also formerly used in antifouling paints for marine use, but this use was banned in 1972. By regulatory action taken in 1990 and 1991, EPA prohibited further use of mercury in indoor or outdoor paints manufactured in the U.S.

Paint containing mercury manufactured before the ban may, however, still be discarded as a residue (see above), and demolition waste including mercury in paint will undoubtedly still be discarded.

Chlorine and Caustic Soda Production

Mercury is used in the manufacturing process for the production of chlorine and caustic soda. In fact, this use was the largest consumer of mercury in the United States in 1989. This use was classified as industrial, not MSW.

Other Non-MSW Sources of Mercury

Other uses for mercury not classified as entering MSW include the catalysis of various plastics, explosives, laboratory uses, residues of pharmaceuticals and cosmetics, and certain electrical apparatus.

Discontinued Uses of Mercury

A number of non-MSW applications for mercury that have been discontinued were identified. These include embalming fluid, photographic development, soap, and wood preservatives.

LIMITATIONS OF THIS REPORT

The purpose of this report was to characterize the sources of mercury in municipal solid waste. The characterization applies to the United States as a whole, and should not be construed to be representative of mercury in MSW in a particular locality. Local variations in waste composition and in waste management practices may cause the mercury content at any particular facility to vary from the United States average.

In many cases, the amounts of historical, current, and projected mercury in products in MSW are not well documented in any available data source. The estimates in this report are, therefore, often based on assumptions, which are documented in the report.

Identification of alternatives and substitutes for mercury in products was not part of the work scope for this report. Information on these topics must come from other sources.