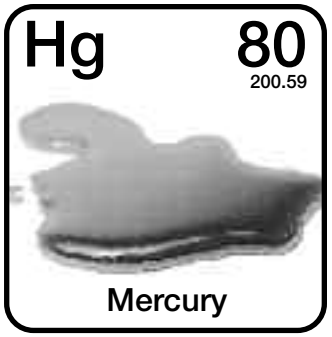
Mercury – Its Toxic Nature and Legacy

by Robert Hennigan



Periodic Table's symbol for mercury is Hg with atomic number 80. The metal is also referred to as liquid silver.

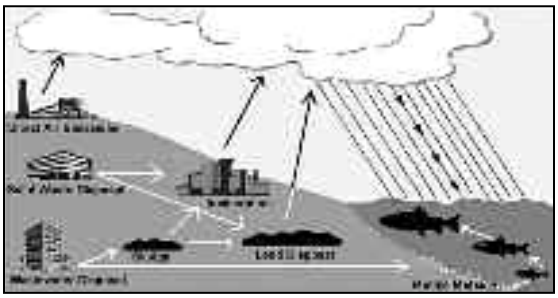
Mercury (Hg), which is a toxic heavy metal, is extremely poisonous, extensively utilized and a major pollutant in air, water and land (surface and subsurface). It is extremely dangerous to people who work in mining and certain industries, and to the general public by way of polluted air and water, contaminated industrial sites, some medical and dental practices, instruments and products containing mercury and mercury contaminated fish and game. This article covers the nature of mercury - its natural occurrence and input into the environment – and its utilization and toxicity.

Mercury Is Everywhere

Mercury is ubiquitous – it is found everywhere in the environment. Sources of mercury are of natural origin (volcanoes, cinnabar ores, hot springs, degassing from natural deposits and soils, and volatilization from the oceans), as well as human origin (coal burning power plants, municipal waste incinerators, medical waste incinerators, municipal and industrial waste landfills, cement plants, industrial effluents, wastewater treatment plant effluents, municipal and industrial solid waste, mercury and gold mining activities, and any activity where mercury or its compounds are utilized).

Major deposits of mercury ore called cinnabar (HgS) are found near volcanic activity. It is also a small component of coal deposits. Mercury is produced by roasting crushed cinnabar ore in rotary furnaces. Pure mercury separates from the sulfur, evaporates and is collected in a condensing column as elemental mercury.

Mercury is a good conductor of heat and electricity with a specific gravity of 13.53 – only the precious metals platinum and gold are heavier. A unique characteristic of mercury is that it is a liquid at room temperature. Its melting point is a minus 37.89° Fahrenheit. It has a high rate of volatilization from the liquid and amalgam state at normal temperatures and pressures. It readily combines with other elements to form mercuric amalgams and other compounds. Some of these compounds are more toxic than the elemental form. An example is methyl mercury, formed by bacterial action when elemental mercury is discharged to waterbodies and settles at the soil-water interface in an anoxic environment. It undergoes methylation, forming methyl mercury. An even more toxic form is dimethyl mercury, sometimes used in scientific research.



How mercury cycles into the environment

Courtesy of NYSDEC

Mercury cycles through the environmental system transported by air and water, and human utilization. The total amount of mercury is fixed, however. It is transformed by the way it is used – whether as a gas, solid, amalgam and as part of different chemical compounds. The input into the environment is a function of how it is utilized and how the resulting waste products are handled and disposed back into the environment.

When mercury undergoes methylation, forming methyl mercury, it is a highly toxic form as described above. This process mobilizes the methyl mercury and it enters the food chain. As it goes up the food chain, from microbiologic organisms to larger living organisms, it undergoes a process known as biomagnification, accumulating in the higher organisms as they continue to eat contaminated animals or fish.

History of Toxicity

The Mad Hatter, depicted by artist John Tenniel, recites a nonsensical poem.

The history of mercury use goes back to early Greek and Roman antiquity. Relatively primitive societies used cinnabar to make a reddish paint, which was applied on different objects and on their bodies. These early societies also used mercuric compounds for medicinal purposes as tonics for a number of ailments whose main effect was probably to shorten their lives. Large deposits of cinnabar were located in Spain and Italy where it was mined by mostly slaves and criminals who suffered shortened lives due to mercury poisoning.

Mercury was used in the felt hat industry as mercuric nitrate which produced a superior felt. Eventually this caused much illness in workers in Danbury, Connecticut who had serious neurological symptoms. The US Public Health Service banned use of mercury in the felt industry across the nation in 1941. The Mad Hatter, originating from the story *Alice's Adventures in Wonderland,* allegedly reflected the disease caused by mercury exposure in the hat (curing felt) industry.

Mercuric compounds were also used as a cure for syphilis because of their germicidal properties – the efficacy of such use was debatable. Fortunately, antibiotics took their place.

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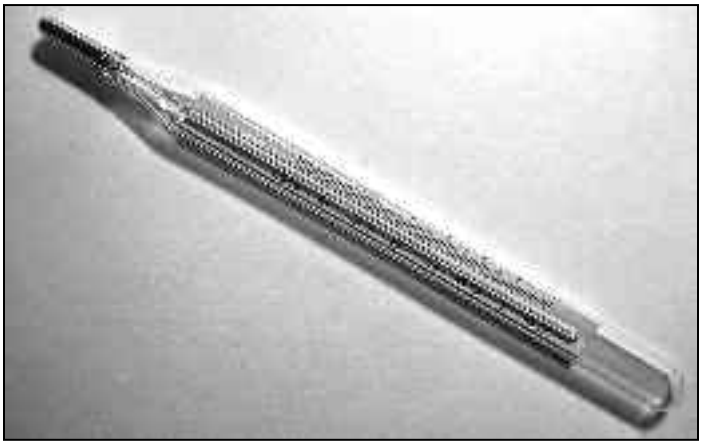
Another use of mercury was in gold mining, both placer and hard rock. The purpose was to simplify the recovery of gold particles since gold has an affinity for mercury and forms a heavy amalgam that settles rapidly in collection basins and sluices. This activity was mainly carried out in California and Nevada. The residuals from past and current mining operations continue to be a problem as reported by the Idaho Conservation League (October 25, 2007 communication), and by the United States Geological Survey ("Mercury Contamination from Historical Gold Mining in California," November 2005).



Wikipedia.com

Mercury is used in thermometers, as well as in many medical and scientific instruments.

Moving into the industrial age, the use of mercury for a number of applications accelerated. The many uses for mercury and mercury compounds are mind boggling. These include the following: alkaline, mercuric oxide and nickel cadmium batteries; adhesives, antiseptic products, cathode tubes, cleaning solvents, coal combustion products, dental amalgams (filling dental cavities), electrical switches, fluorescent light bulbs, fungicides, germicidal lamps, laboratory reagents, methiolate, mercurochrome, mercury cell chlorine production, medical devices and instruments, scientific devices and instruments, thermometers, thimerosal (preservative used in childhood vaccines, flu vaccine, and other vaccines).

Exposure Restrictions

Human exposure to mercury is common and inescapable. Those living near facilities that use and/or process mercury and work in industries and institutions that deal with mercury on a regular basis are at most risk.

The most often cited case of human mercury poisoning was the Minamata disaster in Japan (1952-1967). A vinyl-producing factory in Minamata was using mercury as a catalyst in the preparation of acetaldehyde. Mercury was discharged in wastewater to the adjacent bay which was utilized by the local population for sea food (fish and shellfish) which constituted the principal part of their diet. The fishery was heavily contaminated by methyl mercury and resulted in literally thousands of methyl mercury poisoning cases and hundreds of deaths. The symptoms of methyl mercury poisoning are horrific because as noted it attacks the central nervous system and the brain, causing paralysis, tunnel vision, blindness and a number of other crippling conditions. It took an appreciable amount of time – 15 years – before the Japanese government recognized and responded to this situation. Now the Japanese have the most strict controls over mercury releases.

Another case of interest is the pollution of Onondaga Lake in Onondaga County (Syracuse, NY). Hundreds of pounds of elemental mercury used in the production of chlorine and soda ash by the mercury cell process was lost to the lake over the years from 1950 to 1990. This mercury underwent methylation converting the elemental mercury to methyl mercury. This form entered the food chain and contaminated the entire lake fishery. The taking of fish was banned by health agencies. Mercury was also taken up by certain plant life from the soil substrate and aspirated from the leaves of these plants to the surrounding atmosphere. The cleanup of the site with tons of elemental mercury in deep deposits was severely criticized in a report by the Onondaga Indian Nation, dated November 30, 2005. It called for the state to be much more aggressive in compelling the Honeywell Corporation to clean up the mercury site to a greater extent than planned.

Another contentious issue is the exposure of the public to mercury in medical practice. Two exposure pathways that could harm the general public are the use of mercury amalgam as filling material for dental cavities and the use of thimerosal (half ethyl mercury) as a preservative in vaccines. There is a professional debate over the impact of these two practices. The medical and dental establishments generally take the position that this exposure is minor and presents no problem. There are other scientists and doctors who challenge this position, including Donald W. Miller, Jr., MD. In his article, "Mercury on the Mind," Miller asserts, "… autism and Alzheimers disease share a common cause: mercury."

Agreement is apparently still out on this debate. One thing is evident, human exposure to mercury should be minimized as much as possible. California has banned the use of thimerosal in vaccines.

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Apparently, there are non-mercury substitutes available that can be used instead of thimerosal. There are available safe alternatives for dental use that do not use mercury amalgams. Use of mercury amalgams for dental fillings in the United States became standard practice. Some scientists recommend that all mercury amalgam fillings be replaced. The use of mercury amalgams and mercury compounds for these purposes gradually is being phased out voluntarily. One confusing aspect is the variability in individuals in their response to mercury contamination – some readily remove mercury from the body, others do not. Those who do not have this ability are at highest risk. A number of states have enacted or are actually considering bills to limit or ban use of thimerosal in vaccines. The same can be said for amalgams used for mercury dental fillings.

There is complete agreement on the danger of eating mercury contaminated seafood.

Power Plants and Cement Kilns

There is continued contention over regulatory action needed to limit mercury emissions from coal burning power plants and cement kilns. The mercury output from both these operations results from coal burning. Both the USEPA and the NYSDEC are under some pressure to more effectively limit mercury input from these sources. New York and the New England states have been petitioning the EPA for years to take the lead to control emissions from power plants mainly in the Ohio River Valley since they have a negative impact on the Northeast for mercury fallout and acid rain. New York has proposed strong regulations covering power plants but remains under fire to put like restrictions on cement kilns in the Hudson Valley. Other states have moved more aggressively on this issue than New York. The EPA is also under fire to move aggressively to limit mercury emissions from cement kilns. It remains an ongoing issue raised by environmental advocates.

For example, a news release by the organization Earth Justice dated October 25, 2007, headlines: "New York Cement Kilns Must Reduce Mercury Pollution." Earth Justice, formerly the Sierra Club Legal Defense Fund, is allied with organizations such as the Sierra Club, New York Public Interest Research Group (NYPIRG), and Friends of the Hudson. It cites three cement kilns – Ravena, Glens Falls and Catskill - that should be brought under strict mercury emission standards.

Susan Lawrence, chair of the Sierra Club Atlantic Chapter, said: "The cement industry in New York has for years been given a free ride when it comes to reducing their mercury pollution. It's time Lafarge and other cement kilns start drastically reducing this dangerous pollution and protecting our air and water from mercury contamination."

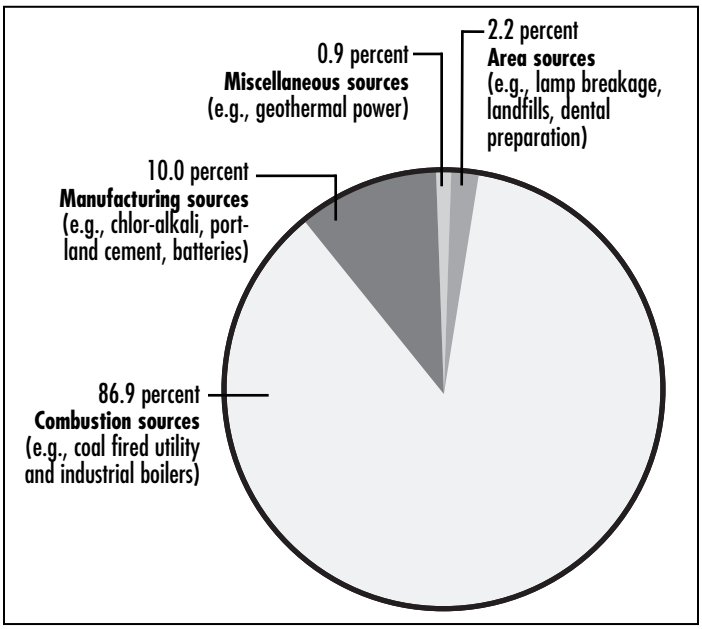
Jason Babbie of NYPIRG commented: "We hope that the Spitzer administration will build on his track record of leadership on this issue by including strict mercury limits for the Lafarge kiln and all other New York cement kilns."

Unique Properties Mean Challenges

Mercury is continuously recycling through the global environment. Part of each major phase and a component of the physical environment, mercury cannot be viewed as simply a water, air or land pollutant. It is one of the most dangerous elements and, at the same time, one of the most useful. It pollutes the air we breathe, the water we use, the land we live on and the food chain, particularly seafood. Yet, it's been utilized for many applications, literally numbering in the hundreds, particularly in electrical gear, for medical and scientific instruments, and as an antiseptic. Mercury is a metal and a liquid at room temperature, it transmits heat and electricity, it evaporates, it is over 13 times heavier that water, it is transformed by bacterial action, it has an affinity for other metals to form amalgams, and it readily reacts with other chemicals to form compounds. Because of these unique properties, mercury is difficult to manage and regulate.

Wikipedia.com

A cement kiln plant where mercury and its compounds can condense on the exhaust gas route due to cooling of the gas and are partially adsorbed by the raw material particles.



US Environmental Protection Agency, 1997

Combustion from coal-fired utilities and industrial boilers accounts for more than 85 percent of the transmission of inorganic mercury to the atmosphere.

However, there is some good news - the use of mercury and its compounds has steadily decreased over the past two decades. Dealing with and removing mercury contamination in the environment is a slow process. Much remains to be done.

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