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Human and Natural Sources of Mercury

Issue Brief

Mercury is a naturally occurring substance. Geological areas enriched with mercury exist throughout the world, releasing mercury to the atmosphere over time. Mercury may also be released during the combustion of coal and waste materials. In addition, other industrial processes, such as production of cement, use or release mercury. Deposits of mercury-containing waste are found at thousands of industrial sites globally, while mercury associated with petroleum formations may be released during oil and gas operations. U.S. mercury emissions make up about 5% of global human emissions, while more than half of these emissions originate in Asia. Data show that global mercury emissions have substantially decreased since the mid-20th century, but may have leveled off in the past 15 years.

Where Does Mercury Originate?

Mercury is a chemical element (atomic number 80 in the periodic table) and thus cannot be created or destroyed through ordinary chemical or physical means. It is a medium-weight metal that, in pure bulk form, is liquid at room temperature. Mercury is found throughout the earth's crust, often occurring in chemical combination with sulfur or other elements in a wide variety of rocks and minerals. These include most forms of coal as well as other economic minerals such as copper and zinc. During recovery, purification, and use of these materials, the mercury may be released into the environment. Waste streams from resource processes may also contain mercury separated during material production.

What are the Primary Forms of Mercury in the Environment?

The various mineral deposits containing mercury in the earth's crust can be divided into two primary forms: elemental mercury and inorganic mercury. The elemental form is the uncombined form, occurring as pure silvery mercury in mineral bodies. The inorganic form can combine with other chemicals to form compounds. During combustion of material containing either form, both elemental and inorganic mercury may be released due to the high temperatures and the presence of other chemicals. Thus, during combustion of municipal waste, which might contain mercury in discarded electrical equipment or paints, both forms of mercury can be released.

Small amounts of mercury may be bound to fine particles emitted from emission sources. This mercury may be either inorganic or elemental but tends to be chemically inactive while bound to the particulate material.

There are many organic compounds of mercury. The primary public health concern is methylmercury, which may be formed by aquatic bacteria acting on inorganic mercury. There is also some evidence of methylmercury traces in the atmosphere of unknown origin.

How Does Mercury Behave in the Atmosphere?

The inorganic form of mercury is much more soluble in water, and thus in precipitation, than the elemental form. Once the two forms are emitted, they will both travel with wind currents to nearby or distant points on the earth's surface. The inorganic form may partially dissolve in precipitation (rain or snow) that descends through emissions plumes containing trace amounts of mercury, and thus may be carried to the ground closer to its source than elemental mercury emitted at the same time. Even so, only about 15 to 20% of the inorganic mercury that is emitted from a source reaches the ground within 30 miles or so of its source. The remainder disperses and only gradually deposits to the surface, regionally (tens to hundreds of miles away) or globally (hundreds to thousands of miles away). Like any substance, the mercury disperses rapidly as it travels downwind, so ground concentrations are hundreds or thousands of

times less at these distant points. Elemental mercury, once emitted, generally remains aloft in the atmosphere for much longer periods and over greater distances and thus tends to travel regional or global distances before depositing to the earth's surface.

Both elemental and inorganic mercury, once emitted to the atmosphere, may deposit to the earth's surface through physical and chemical processes even in the absence of precipitation. This "dry deposition" occurs for any material which is at greater concentrations in the atmosphere than it is on the surface below it. Dry deposition and wet deposition of mercury, nationally, are roughly equivalent in magnitude, although dry deposition is more dominant in areas such as the intermountain west where precipitation is sparse or sporadic.

Like all atmospheric emissions, emissions of mercury disperse over time and distance as winds and turbulence increasingly mix them with air. Thus the greater the distance from a particular mercury source, the less evident and measurable mercury will become. Meanwhile, other major or trace constituents of the atmosphere can combine with the inorganic mercury, or act to change inorganic to elemental mercury (or vice-versa). Over time, the elemental form, once converted chemically to inorganic mercury, will be captured by precipitation and removed from the atmosphere before it can chemically re-convert to the elemental form. As a consequence, the atmospheric mercury left behind tends to be preferentially composed of the elemental form.

Where Do Mercury Deposits in the U.S. Originate?

Global surveys of mercury emissions from industrial and energy activities show that U.S. emissions make up less than 5%, or 1/20th, of the world total. U.S. utilities emit less than 2% of this human, or "anthropogenic," source category of roughly 2,400 (US) tons globally. Emerging findings indicate that at least this same amount of mercury is emitted by the naturally occurring deposits of mercury on land masses and along the ocean floor.

Since 1995, an increasing number of monitoring stations have been measuring mercury in rain and snowfall around the United States and Canada. These stations have not yet shown a trend in the "wet deposition" of inorganic mercury over time, nor any strong trends east to west nor north to south across the U.S. Modeling studies indicate that about 170 tons of mercury deposit into the continental United States each year, both via precipitation and by atmospheric contact at the ground surface.

U.S. utilities emit about 46 tons, and all U.S. anthropogenic sources total 130 tons per year. Since some 2/3 of these emissions are carried outside the U.S., most of the deposited mercury must originate elsewhere. Asia emits roughly half of the 2400 tons emitted globally per year, and makes up the source area for about half of the approximately 100 tons of mercury depositing in the U.S. that originates elsewhere.

How Have Human-Caused Emissions of Mercury Changed Over Time?

Records of mercury deposition over time are created by natural processes. Precipitation will lay down layers of material into lake sediments, glacier ice, and other repositories of past deposition. Thus, these natural archives can all yield time records of mercury reaching back hundreds or thousands of years. These records, along with historic reconstructions of industrial mercury use over more recent times, indicate that mercury emissions began rising at the beginning of the Industrial Revolution in about 1800. The atmospheric emissions of mercury from many more sources than are now in use rose until the mid-20th century, then began dropping. This drop coincided with the decline in use of mercury in everyday products such as house paints, pesticides, and electrical equipment. Such materials would often find their way to waste streams and later result in mercury releases to the atmosphere when burned or when disposed of in unsecured landfills.

More recent reconstructions of mercury emissions, based on measured concentrations of mercury in remote ocean areas over time, indicate that the decline in mercury emissions from the 1960s until the 1990s may have ceased, and emissions may now be increasing globally. This increase appears to result from industrialization in continental Asia, particularly in China and India.

Contact Information

For more information, contact the EPRI Customer Assistance Center at 800.313.3774 (askepri@epri.com).

Media Information

Contact Clay Perry at 202.293-6184 (clperry@epri.com) or Heather Lynch, 650.855.2017 (hlynch@epri.com).

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Electric Power Research Institute
3420 Hillview Avenue, Palo Alto, California 94304 • PO Box 10412, Palo Alto, California 94303 USA
800.313.3774 • 650.855.2121 • askepri@epri.com • www.epri.com