An Overview of Mercury and Methods For Its Analysis

What is Mercury?

Mercury is a naturally occurring element that exists in several forms: elemental or metallic mercury; inorganic mercury compounds; and, organic mercury compounds. Elemental or metallic mercury is a shiny, silver-white metal that is liquid at room temperature. Elemental mercury can evaporate to become an invisible, odorless toxic vapor.

Inorganic mercury compounds take the form of mercury salts that are generally a white powder or crystalline, with a notable exception being mercuric sulfide, which is red. Organic mercury compounds, such as methylmercury, are formed when mercury combines with carbon. Microscopic organisms convert inorganic mercury into methylmercury, which is the most common organic mercury compound found in the environment. Mercury is bio-accumulative.

Sources of Mercury

Mercury is a naturally occurring element that can be found throughout the environment. Human activities, such as burning coal and using mercury in products or manufacturing, have increased the amount of mercury in many parts of the environment, including the atmosphere, lakes, and streams. When dropped, elemental mercury breaks into smaller droplets, which can go through small cracks or attach strongly to certain materials. People can be exposed to elemental mercury vapor when products that contain mercury break and expose mercury to the air, particularly in poorly ventilated spaces.

Mercury is used in thermometers, fluorescent light bulbs, and some electrical switches (thermostats). Most Mercury contamination results from power plants, mills, and refineries emitting mercury into the air via stack emissions. The Mercury settles from the atmosphere or is pulled with precipitation and ultimately ends up in water supplies. Mercury that enters the environment may become involved in the food chain and create a cycle of contamination.

Contamination Issues

High levels of mercury in the bloodstream of unborn babies and young children may harm the developing nervous system. As a testament to the widespread presence of mercury, most people have at least a trace amount of mercury in their tissues. Whether an exposure to mercury will harm a person's health depends on a number of factors including:

- the chemical form of mercury - elemental (metallic), inorganic compounds, or organic compounds;
- the dose (quantity);
- the duration of exposure (time);
- the route of exposure (eating, breathing, injecting, touching);

- other chemical exposures; and,
- the specific characteristics of the person (age, health, etc.).

Environmental Regulations

Federal, state and local governments can issue fish consumption advisories about which fish are unsafe to eat or which bodies of water are unsafe to fish. Laws and regulations are used as a major tool to protect the environment of mercury released through emissions from manufacturing, use, or disposal activities.

These regulations, often enforced by agencies such as the Environmental Protection Agency (EPA), provide specific rules and details for how to put the law into practice. Under certain Federal environmental statutes, such as the Clean Air Act (CAA), Clean Water Act (CWA), and Resource Conservation and Recovery Act (RCRA), EPA has the responsibility to develop regulations to control some mercury emissions to air, water, or from wastes and products.

In addition, states also develop regulations to address mercury emissions.

Clean Air Act

The CAA regulates air toxics known as "hazardous air pollutants." Mercury is one of these air toxics. Certain sources that emit these air toxics are required to obtain CAA operating permits and to comply with all applicable emission standards.

On March 15, 2005, EPA issued the Clean Air Mercury Rule, which creates performance standards and establishes permanent, declining caps on mercury emissions. The Clean Air Mercury Rule marks the first time EPA has ever regulated mercury emissions from coal-fired power plants. Additional information on this new rule can be found at: http://www.epa.gov/air/mercuryrule/.

Clean Water Act

Under the CWA, states adopt water quality standards for their rivers, streams, lakes, and wetlands. These standards identify levels for pollutants (including mercury) that must be met in order to protect human health, fish, and wildlife. Under the Act, either EPA or individual States issue permits, which must include limits that ensure the water quality standards are met.

Resource Conversation and Recovery Act

RCRA was created to eliminate the problem of solid and hazardous waste and its potential risks to human health and the environment. It placed controls on the generation, transportation, treatment, storage, and disposal of hazardous waste, as well as establishing a framework for the management of non-hazardous waste. Additionally, it

established statutory authorities and liability for owners and operators of facilities that failed to comply with the statutory and regulatory requirements.

RCRA regulations also address the "Universal Wastes" which include batteries, pesticides, and mercury-containing thermostats and lamps.

Great Lakes Initiative

In l995, EPA and the Great Lakes states agreed to a comprehensive plan to restore the health of the Great Lakes. The Final Water Quality Guidance for the Great Lakes System, also known as the Great Lakes Initiative, includes criteria for states to use when setting water quality standards for 29 pollutants, including bio-accumulative chemicals of concern such as mercury, and prohibits the use of mixing zones for these toxic chemicals.

Acknowledging the potential environmental impacts from the steady increase in the use of rechargeable batteries, as well as their improper disposal, the U.S. Congress passed the Battery Act in 1996 to promote the collection and recycling or proper disposal of used nickel-cadmium (Ni-Cd) and certain other batteries. The Act was also passed to limit the mercury content in some consumer batteries and prohibit the sale in the United States of certain consumer batteries that contain added mercury. The Act targets battery and product manufacturers and battery waste handlers, not consumers.

Analytical Methods

To support regulations such as the CAA, CWA, and RCRA, EPA publishes methods used by industrial and municipal facilities to analyze the components of wastewater, drinking water, sediment, and other environmental samples. The following table includes a select list of the more prominent methods typically utilized by the environmental community:

Method Number	Description	Program
EPA 200.8	Metals in Water using ICP/MS	CWA
EPA 245.1	Mercury in Water using CVAAS	CWA, SDWA
EPA 245.2	Mercury in Water using CVAAS (Automated)	CWA, SDWA
EPA 1631E	Mercury in Water using CVAFS	CWA
EPA 7470A	Mercury in Water using CVAAS (Manual)	RCRA
EPA 7471A	Mercury in Solids using CVAAS (Manual)	RCRA

Most analytical methods for metals analysis require a preliminary acid-digestion. This digestion solubilizes particulate matter in the sample, as well as aids in the removal of potential interferences within the sample matrix. Using Inductively Coupled Plasma / Mass Spectrometry (ICP/MS) solutions are nebulized (made into a fine, aerosol-like spray) and then transferred into a plasma generated by the radio-frequency excitation of argon gas. The ions in the sample are separated on the basis of their mass-to-charge ratio by a mass spectrometer where the ions are detected. Comparison of ion response in the samples relative to that measured in standards of known concentration provide for the quantitation of analyte concentration.

Using Cold Vapor Atomic Absorption Spectroscopy (CVAAS) samples are digested then oxidized to convert the various mercury forms to their ionic state. Mercury is then reduced to its elemental state and aerated from solution in a closed system. The mercury vapor passes through a cell where the absorbance is measured as a function of mercury concentration.

Using Cold Vapor Atomic Fluorescence Spectroscopy (CVAFS), mercury can be detected at very low levels under proper conditions of sample collection. With the CVAFS technique, mercury is oxidized in the original sample container then reduced to convert mercury to its elemental state where it is collected on a gold trap. Desorption of the trap produces mercury vapor that passes through a cell where the absorbance is measured using a fluorescence detector.

Low Level Mercury (EPA Method 1631)

The latter technique has become important lately because of a recent EPA initiative requiring detection of mercury at levels below 1 part per trillion (ppt) in some cases. EPA approves analytical methods used to determine chemical components of wastewater. EPA Method 1631 allows determination of mercury at a level as low as 0.5 ppt (parts-per-trillion).

This method supports the measurement of mercury at the lowest water quality criteria (WQC) levels published in the National Toxics Rule and in the Final Water Quality Guidance for the Great Lakes System.

Method 1631 requires the CVAFS instrumentation and is usually performed in a “clean room” environment to prevent sample contamination, which can be a major problem when analyzing samples in the low ppt range. Even the sampling procedures required by this method involve special cleanliness procedures to avoid sample contamination.

Because of the challenge of determining mercury at such a low level, the EPA has instituted rigorous quality control and analytical requirements for this method. For those who generally perform their own sampling, special sampling kits and training are needed.

If Low Level Mercury analysis is required for your monitoring and permit compliance, Microbac Laboratories, Inc. is fully certified to help you with your monitoring program.

For more information:
Dr. Kim Baughman, Director of Development
Microbac Laboratories, Inc.
kbaughman@microbac.com