Mercury Use Reduction & Waste Prevention in Medical Facilities

United States Environmental Protection Agency

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Thanks to Hollie Shaner and Fletcher Allen Health Care, and the Mayo Clinic for their contributions.

Developed in the Agricultural and Biological Engineering Department, Purdue University, 1996, 2003.

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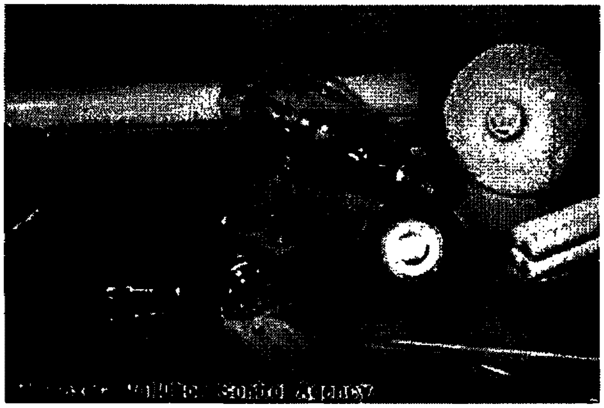
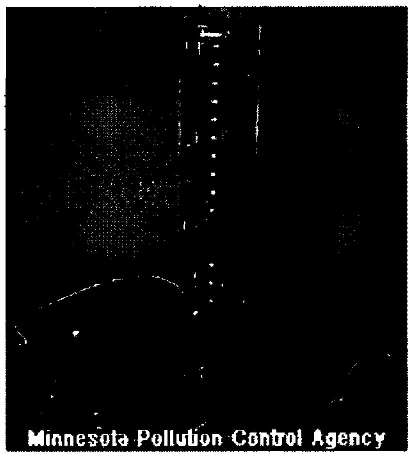
General Introductions

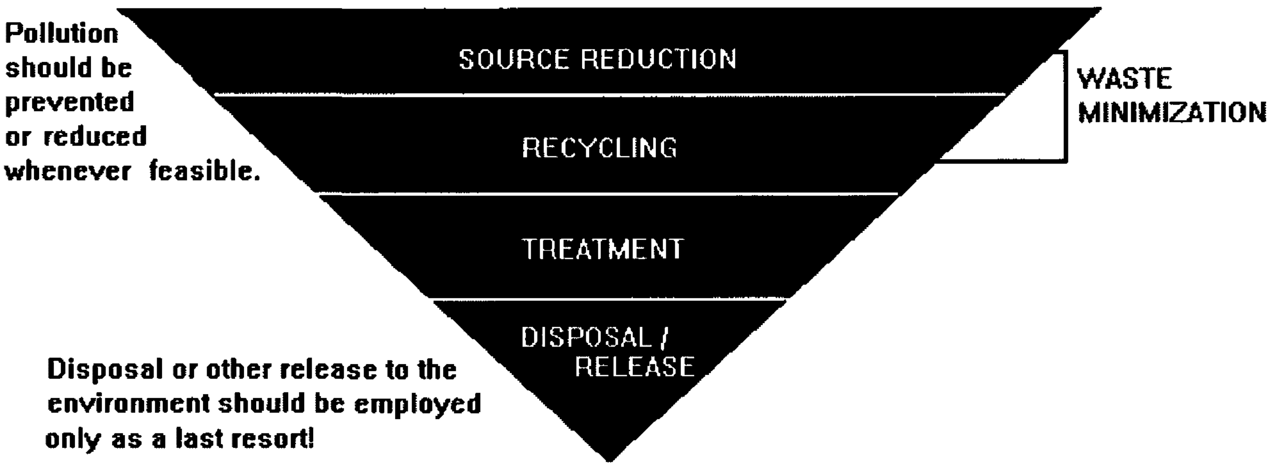
This is an interactive environmental education software program developed jointly by Purdue University and the United States Environmental Protection Agency (EPA) to provide information on the proper handling and disposal of mercury wastes produced by medical facilities.





Minnesota Pollution Control Agency

EPA recognizes the need to develop, or support the development of incentives to move pollutant generators to policies and practices that rely more heavily on pollution prevention, rather than on management practices of pollution of disposal and release. This is especially true for persistent toxic pollutants which are sometimes managed in ways that essentially shift the pollutant from one media to another.



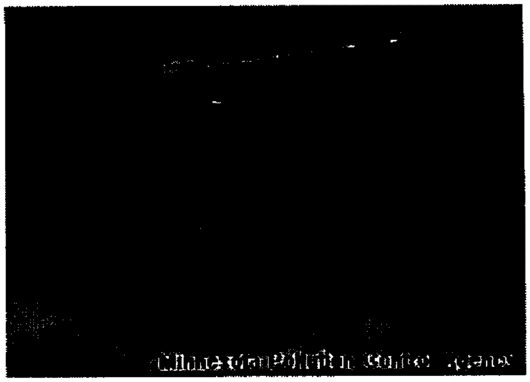
Keeping mercury out of water and the atmosphere is critical to our health and safety.

The purpose of this program is:

1. to introduce you to the dangers of mercury in the environment, and
2. to identify preventive measures against environmental

pollution by mercury from medical facilities.

Alternatives to mercury use in health care settings are identified, and proper management techniques for handling used mercury and mercury spills are described.



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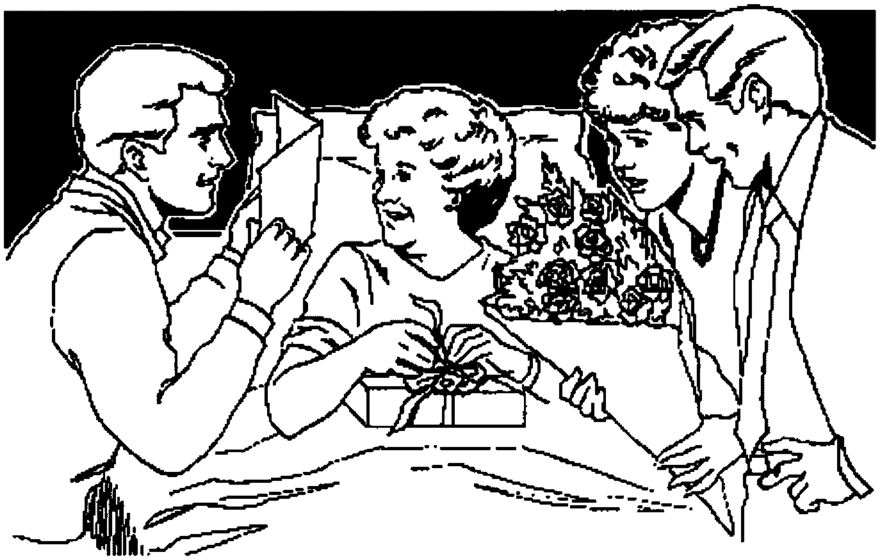
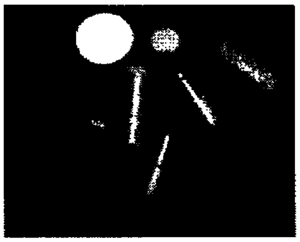
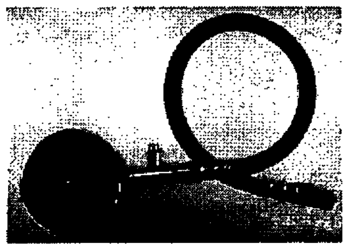
Mercury in Medical Care Settings



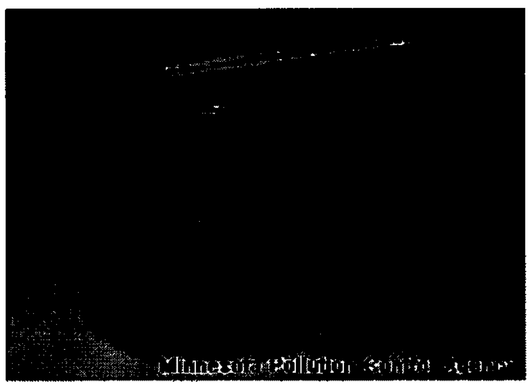


Mercury or mercury compounds are found in many instruments regularly used in medical institutions such as blood pressure monitors, dental amalgam, thermometers and thermostats. Mercury and mercury-containing products are used in patient areas and pathology labs, in clinical procedures (such as x-rays), and in medicines.



At least 20 different medical products contain mercury, and many mercury-containing solvents and degreasers are found in labs, housekeeping departments, kitchens, and maintenance areas.

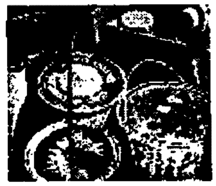
Storage rooms may also be filled with used, damaged, or outdated equipment or supplies that contain mercury. Mercury is an ingredient in some proprietary formulas used to manufacture medical and industrial supplies.



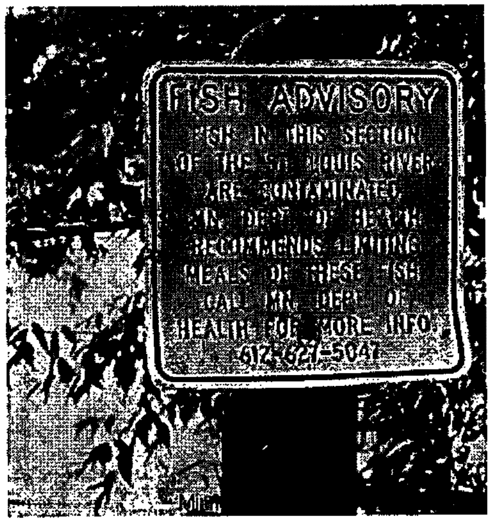
Breakage, waste disposal, and spills from these products release mercury to the atmosphere or to drains, where it can persist for many years.

Some products that formerly contained mercury are no longer manufactured. However, older products are still part of the environment. In fact, broken or obsolete equipment is often the primary source of mercury waste at many hospitals and clinics.

Industrial and chemical uses of mercury are manifold in the medical community: mercury is present in fluorescent and high-intensity lamps, thermostats and switches, and a variety of generators, manometers, and batteries.



Non-medical uses of mercury are also present in a variety of products: cleaning solutions, preservatives, paints, and antifouling agents for wood and other surfaces. Some uses of mercury are purely frivolous or unnecessary, such as singing greeting cards, talking refrigerator magnets, lighted athletic shoes, and toys. Patients, visitors, and employees bring these products into the facility.



According to the EPA's proposed rule for medical waste incinerators, incinerators are a significant source of mercury emissions to the atmosphere. Medical care facilities may also emit mercury through accidental spills and releases, that is, through discharges to wastewater and landfills. The amount of mercury in such releases may be quite small. Still, any release is costly and may add to mercury's buildup in the environment. Mercury spills may result in additional fish advisories, and in some circumstances, mercury spill cleanups can be expensive. The guidelines recommended in this program will help minimize or eliminate mercury releases from medical facilities.

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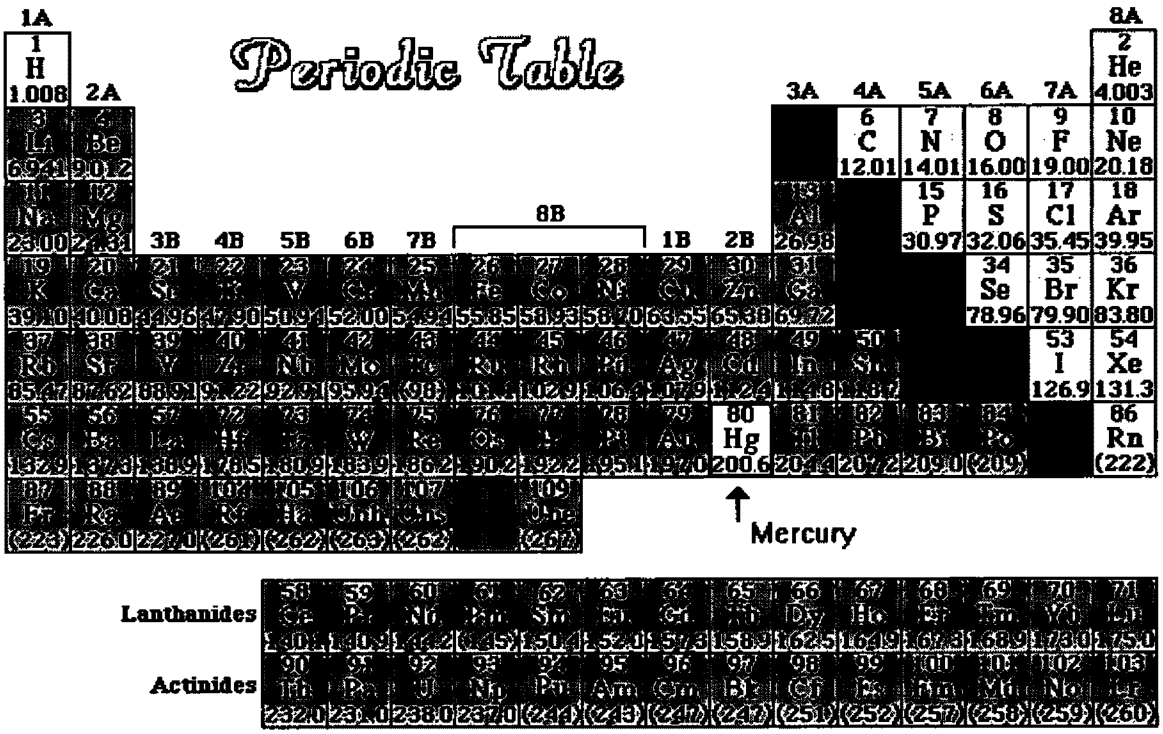
What is Mercury?

Mercury (or "quicksilver"), is a naturally occuring element of remarkable qualities, a volatile liquid metal (at normal temperatures) that easily becomes a gas. Mercury (chemical symbol Hg, atomic number 80) conducts electricity, and can be used to directly measure temperature and pressure. Its applications can be found everywhere in human society:

- as a catalyst in industrial processes
- in solvents, and pesticides;
- in temperature and pressure measurement instumentation
- in electrical switches, lamps, and batteries
- in paints and preservatives
- in cosmetics, and pharmaceuticals
- in dental amalgams (fillings)

Mercury is one of the group of elements known as heavy metals. Many of these (including lead, cadmium, and selenium) are toxic to living things. Mercury can also kill living things, ranging from bacteria to human beings. In particular, it can be converted into an organic form, methylmercury, which is especially dangerous because it is easily absorbed into living tissues and it bioaccumulates.



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Presence of Mercury in the Environment

Mercury is a naturally occurring mineral that can be found throughout the environment. Mercury forms can be found as the elemental metal or in a wide variety of organic and inorganic compounds.

There is a constant biogeochemical cycle of mercury. This cycle includes:

- release of elemental mercury as a gas from the rocks and waters (degassing);
- long-range transport of the gases in the atmosphere;
- wet and dry deposition upon land and surface water;
- absorption onto sediment particles;
- bioaccumulation in terrestrial and aquatic food chains.

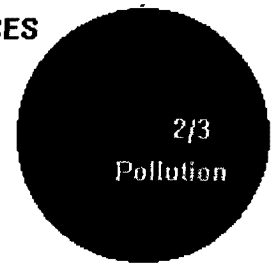
To Mercury in the Environment Main Menu

Natural and Manmade Emissions of Mercury

Mercury is released to environmental media (air, water, soil) by a wide variety of natural processes and human interventions. Worldwide, natural emissions of mercury from physical and biological processes may equal or exceed manmade emissions.

MERCURY SOURCES IN THE MIDWEST

Annual deposition = 1 gram in a 20 acre lake



The global anthropogenic emission rate for mercury is estimated to be 650 metric tons (650,000 Kg) annually, while natural emissions could be as much as 1020 metric tons (1,020,000 Kg). While the totals are quite uncertain, natural emissions may comprise about 50 percent of them.

Even if all manmade emissions of mercury were eliminated, a significant natural discharge to the environment --through both biological and physical processes-- would persist.

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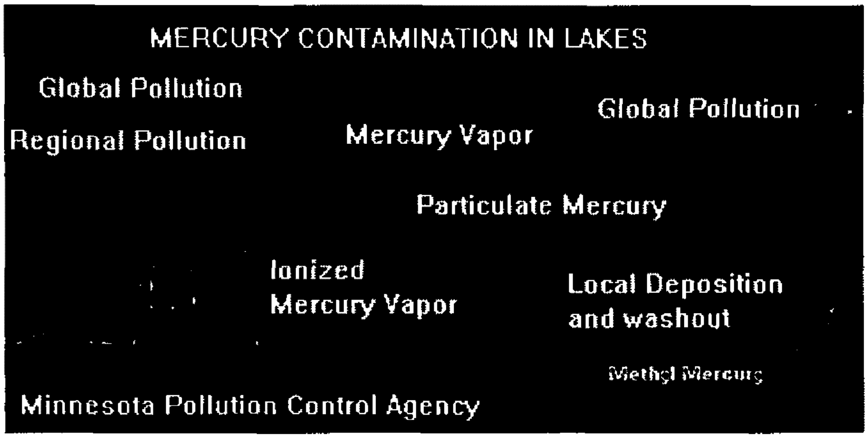
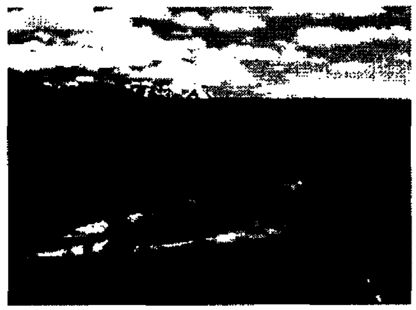
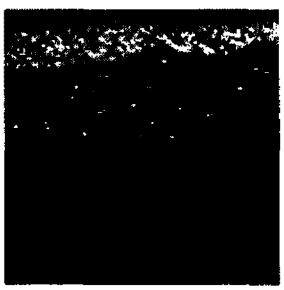
Mercury in Nature: Chemistry and Biology





Significant amounts of mercury are directly released from the earth's crust by the process of degassing. Both natural and manmade emissions are modified by biological processes into forms more directly harmful to human beings. All forms of mercury are toxic, but the various forms are more or less available for absorption by animals and humans. Methylmercury, the organic form of mercury that is often found in fish, is easily absorbed by the body and is highly toxic. Elemental mercury is highly volatile, and inhaling elemental mercury vapor can present a serious health riisk, as often occurs when mercury metal is spilled indoors. Mercury also occurs in an ionic form as a salt.



Common bacteria of the soil and water have adapted to the presence of mercury. They have developed methods to detoxify its organic compounds and salts to the elemental form of mercury. Elemental mercury can be transported long distances via the atmosphere. Once it reaches inland aquatic environments however, elemental mercury can again accumulate and be transformed into methylmercury, the toxic form that bioaccumulates in fish, animals, and humans. This toxic transformation can occur from any of three causes:

- the photochemical (abiotic) action of sunlight
- the methylcobalamin (a hydrocarbon compound), excreted by bacteria
- the plants of aquatic ecosystems.

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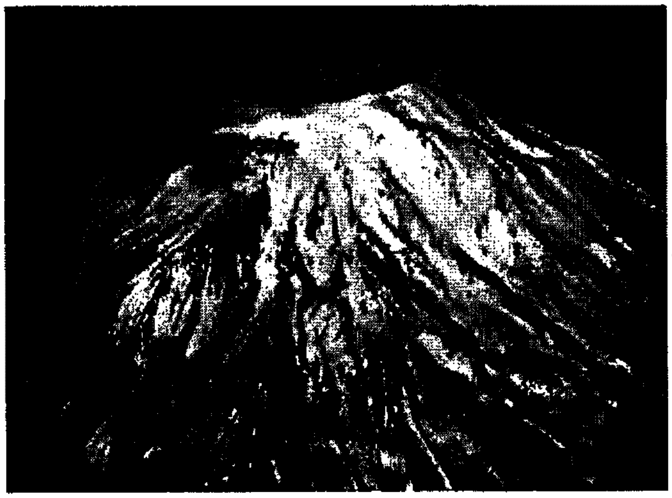
Mercury in the Atmosphere

At least 99 percent of all mercury in the atmosphere exists in the elemental gaseous form of mercury-zero. Much of the remainder is mercury-two, which is water soluble and the form most often deposited by rainfall.



Most of the mercury in the atmosphere comes from natural degassing from water and rocks. Major manmade discharges to the atmosphere come from:

mining and smelting of mercury ores
industrial processes using mercury
combustion of fossil fuels, primary coal.

Less common manmade sources of atmospheric mercury include:

paint application
waste oil combustion
geothermal energy plants
municipal and waste incineration.
diffuse emissions from dental procedures

One important local source of atmospheric mercury is the incineration of medical wastes.

To Mercury in the Environment Main Menu

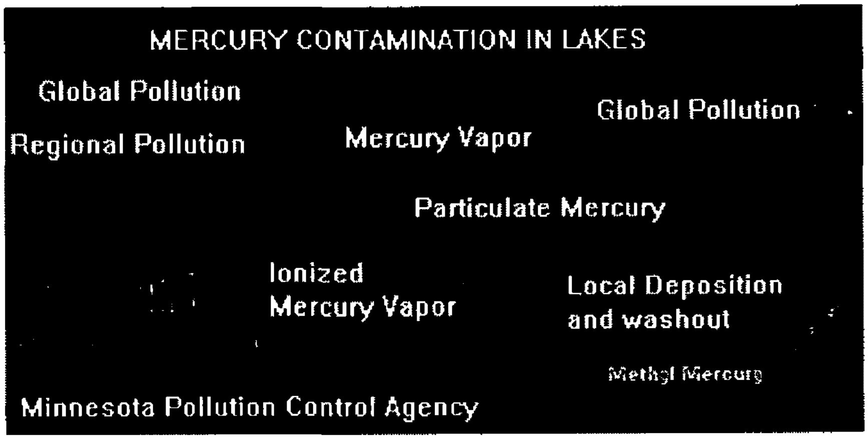
Mercury in Water and Soil

Mercury can enter water by many different routes and processes:

- wet and dry atmospheric depositions
- particle flux to sediments
- dissolved species exchange at sediment/water interfaces
- gas exchange at air/water/surface interfaces
- moving dissolved species exchange and particle flux via stream and rivers
- dissolved species exchange via runoff from groundwater to lakes
- direct discharge of dissolved species via groundwater to lakes
- gas exchange at soil-air ion interfaces

Manmade discharges may result from industrial processes, such as:

- chlorine-alkali production
- mining operations
- paper mills
- leather tanning
- pharmaceutical production
- textile manufacture



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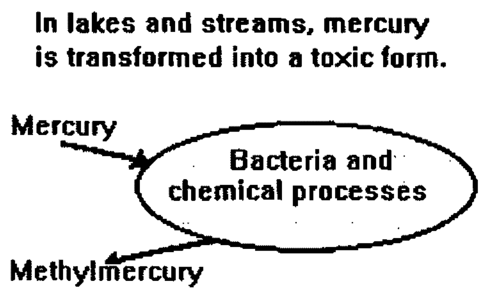
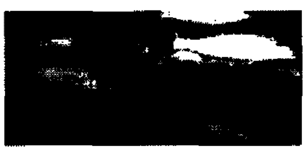
Trouble in the Waters: Methylmercury



In the aquatic environment, mercury can be:

- dissolved or suspended in the water
- trapped in the sediments
- ingested by living things (biota)



Methylmercury is the form of mercury most available and most toxic to biota (including zooplankton, insects, fish, and humans). This form of mercury is easily taken up by biota and bioaccumulates in their tissues. Unlike many other fish contaminants, such as PCBs, dioxin, and DDT, mercury does not concentrate in the fat, but in the muscle tissue. Thus, there is no simple way to remove mercury-contaminated portions from fish that is to be eaten.

The local aquatic environment largely determines how much available mercury takes the accessible toxic for of methylmercury. Research suggests that sulfur-using bacteria are a major source. The extent of biomethylation may depend upon such factors such as pH, (i.e. alkalinity), available sulfur sources, and dissolved organic materials.

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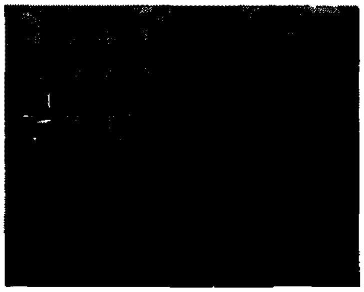
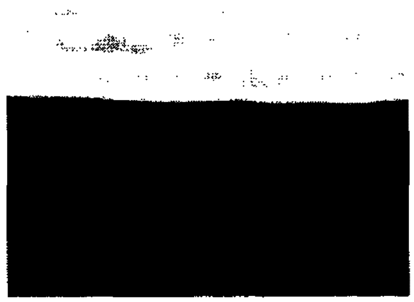
Mercury in the Soil



Human agricultural activities may release mercury to the soil through direct applications, such as:

- organic and inorganic fertilizers (especially sewage sludge and compost)
- lime
- fungicides



Once in the soil, mercury compounds may undergo the same chemical and biological transformations found in aquatic systems. Elemental mercury will form various compounds with the chloride and hydroxide ions of soils. The exact result will depend upon the pH, salt content, and other characteristics of the soil.

For soil, like water, both inorganic chemistry and the actions of living things will affect the formation and degradation of organic mercuric compounds. For example, elevated levels of chloride ions will reduce methylation of mercury in river sediments, streams and soils. In contrast, increased levels of organic carbon and sulfate ions will increase methylation in sediments.

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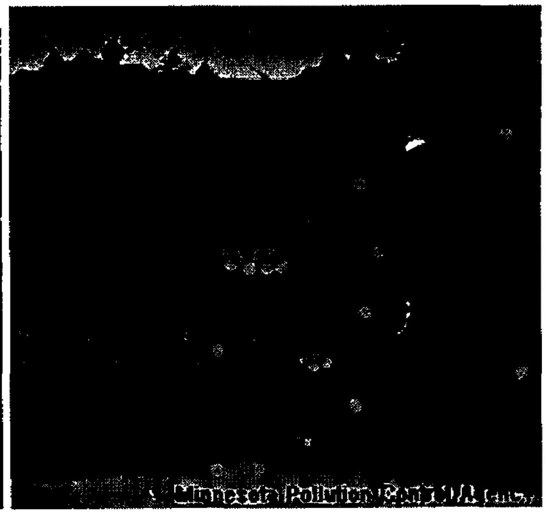
Mercury in the Food Chain



Benthic (bottom-dwelling) invertebrates and certain fish and amphibian species may face exposure to mercury by absorbtion through direct contact with sediments via skin and gills. They may also release mercury bound in the sediment by direct ingestion. Having thus entered the food chain, mercury bioaccumulates as bottom dwellers are consumed by others.

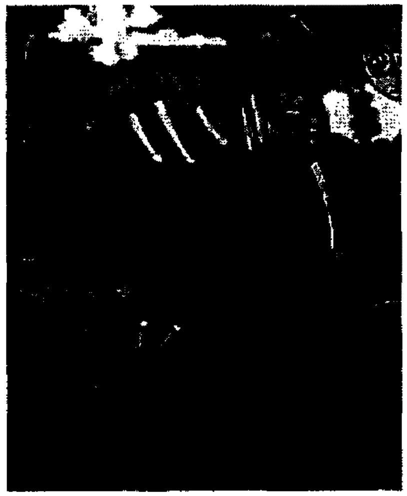
Toxic methylmercury can inflict increasing levels of harm upon species near the top of the aquatic food chain. These likely victims include: predatory fish such as freshwater trout and salmon, ocean swordfish and tuna; turtles; fish-eating birds such as loons, cormorants, pelicans, ospreys, and eagles; and humans.

There is a great deal of uncertainty as to the sensitivity of various organisms to mercury. The exposure levels believed to be safe for humans may protect certain species but not others. The modes of exposure experienced by many species, particularly in the aquatic realm, differ drastically from those of humans. This makes it diifficult to ascertain the methylmercury threshold dose for adverse effects to the many species of wildlife.

To Mercury in the Environment Main Menu

The Worldwide Mercury Cycle

There is a worldwide cycling and recycling of mercury through the environment, called the biogeochemical cycle of mercury. The cycle has six steps, as shown in the adjoining diagram:



1. Degassing of mercury from rock, soils and surface waters.
2. Movement in gaseous form through the atmosphere.
3. Deposition of mercury on land and surface waters.
4. Sorbtion of the element as insoluble mercury sulfide.
5. Precipitation or bioconversion into more volatile or soluble forms.
6. Either:
    a. Reentry of mercury into the atmosphere, or
    b. Bioaccumulation in terrestrial or aquatic foodchains.

Elemental metallic mercury ("elemental mercury"), released to the atmosphere in vapor form, can be transported very long distances. Eventually, wet and dry deposition processes return it to land or water surfaces in the form of compounds.

Wet depositions of mercury by precipitation (rain, snow, etc.) is the primary method of mercury removal from the atmosphere (perhaps 66 percent of the total). Mercury can also be removed from the atmosphere by sorbtion of the vapor onto soil or water surfaces.

The particular form of mercury and its compounds strongly influence the movement and partitioning of mercury among surface waters and soils. Ninety seven percent of all the gaseous mercury dissolved in water is the elemental form -- "mercury zero". Volatile forms of mercury, such as the metallic liquid and dimethyl mercury, will evaporate into the atmosphere. Solid forms particulates in the soil or the water column, and once in the water column are transported downward to the sediments.

To Mercury in the Environment Main Menu

What Makes Mercury Run?

Sorption of nonvolatile forms of mercury onto soil and sediment particulates is the central process that determines the distribution of mercury compounds in the environment. This sorbtion process varies according to the organic matter content of the soil or sediment.

Inorganic mecury sorbed onto particulate material is not easily desorbed. This means that freshwater and marine sediments will be important storehouses for inorganic forms of mercury, and that leaching from soils will play a minor role in mercury transport.

Where the soils are rich in humus, surface runoff will be an important route moving mercury from soil to water.

There are processes that will release the sorbed mercury from particulates:

- Chemical or biological reduction to elemental mercury.
- Bioconversion to volatile organic forms.

To Mercury in the Environment Main Menu

Human Exposure to Mercury

To Risks of Exposure for Humans to Mercury

Ways of Exposure to Mercury

Mercury in its various forms (pure element, inorganic compounds, organic compounds) is found in air, water, soil and fauna and flora. All of these environmental media may be involved in human exposure to elemental mercury and mercury-containing compounds.

Elemental mercury is a liquid and gives off mercury vapor at room temperature. This vapor can be inhaled into the lungs and passed into the blood stream. Elemental mercury can also pass through the skin and into the blood stream. If swallowed, however, this form of mercury is not absorbed out of the stomach, and usually passes out of the body without harm.

Inorganic mercury compounds (ionic mercury) can also be inhaled and absorbed through the lungs, and may pass through the stomach if swallowed. Many inorganic mercury compounds are irritating or corrosive to the skin (see other health effects of mercury), eyes and mucus membranes as well.

Organic mercury compounds, like methylmercury, can enter the body readily through all three routes ; lungs, skin and stomach.

Humans are exposed to mercury primarily through ingestion of fish that contain methylmercury. Inhalation of mercury vapors is a potential occupational risk in industries that process or use mercury. Skin contact with materials containing organic mercury and elemental mercury may also result in mercury exposure. People with dental amalgams that contain mercury have greater exposure.

To Human Exposure to Mercury

Workplace Exposure Limits

Environmental Protection Agency (EPA): EPA estimates that for an adult of average weight, exposure to a very small amount (less than 0.021 milligrams [mg]) of inroganic or organic mercury per day in food or water will probably not result in any harm to health.

Occupational Safety and Health Administration (OSHA): The legal airborne permissible exposure limit (PEL) is 0.1 mg/cubic meter, not to be exceeded at any time.

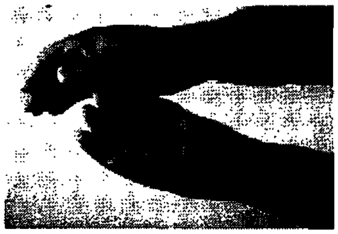
National Institute for Occupational Safety and Health (NIOSH): The recommended airborne exposure limit is 0.05 mg/cubic meter averaged over an 8-hour workshift.

ACGIH: The recommended airborne exposure limit for mercury vapor is 0.05 mg/cubic meter, averaged over an 8-hour workshift.

The above exposure limits are for air levels only. When skin contact also occurs, a worker may be overexposed, even though air levels are less than the limits listed above.

To Human Exposure to Mercury

Ways of Reducing Exposure to Mercury



Where possible, enclose operations and use local exhaust ventilation at the site of chemical release. If local exhaust ventilation or enclosure is not used, respirators should be worn.

Wear protective work clothing.

Workers whose clothing has been contaminated by mercury should change into clean clothing promptly and place contaminated clothing into designated recepticles.

Do not take contaminated work clothes home. Family members could be exposed.

Contaminated work clothes should be laundered by individuals who have been informed of the hazards of exposure to mercury.

Do not eat, smoke, or drink where mercury is handled. Wash hands carefully before eating or smoking.

For clean-up use a specialized charcoal-filtered vacuum or suction pump to avoid generating mercury vapor. Care should be taken not to disturb spilled material.

Wash thoroughly immediately after exposure to mercury and at the end of the workshift.

If there is the possibility of skin exposure, emergency shower facilities should be provided.

Post hazard and warning information in the work area. In addition, as part of an ongoing education and training effort, communicate all information on the health and safety hazards of mercury to potentially exposed workers.

To Human Exposure to Mercury

Tests for Mercury Exposure

There are two tests available to measure mercury in the body:

The mercury blood test measures exposure to all three types of mercury, but because mercury remains in the blood stream for only a few days after exposure, the test must be done soon after exposure. Most non-exposed people have mercury levels of 0 to 2 (all blood measurements are in micrograms of mercury per deciliter of blood, or ug/dl). Levels above 2.8 ug/dl are required to be reported to the Health Department. This test can be influenced by eating fish, because fish may contain high levels of mercury.

The urine mercury test only measures exposure to elemental and inorganic mercury. Organic mercury is not passed out the body in the urine and thus cannot be measured this way. A person with no exposure to mercury would probably have a urine mercury level of 0 to 20 ug/dl. Some Health Departments require reporting levels above 20.

To Human Exposure to Mercury

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To Human Exposure to Mercury

Mercury Monitoring

Medical monitoring is the periodic evaluation of exposed workers to ensure that they are experiencing no adverse effects of potentially hazardous workplace exposures. It serves as a backup for a program of routine air and biological monitoring, which are the primary means for ensuring that exposure levels are below those known to cause adverse health effects. A medical monitoring program should be designed to detect adverse effects of exposure as early as possible, at a stage where there are still reversible, so that exposures can be controlled and serious permanent adverse effects prevented.

An initial medical examination should be performed on all employees exposed to potentially hazardous levels of mercury. The purpose of this examination is to provide a baseline for future health monitoring.

The examination should include a complete medical history and symptom questionnaire, with emphasis on the:

- nervous system (target organ for chronic exposure)
- kidneys (target organ for acute and chronic exposure)
- oral cavity (target organ for chronic exposure)
- lungs (target organ for acute exposure)
- eyes (affected by chronic exposure)
- skin (since mercury is a known skin sensitizer).

Signs and symptoms of the earliest signs of mercury intoxication should be elicited; these include personality changes, weight loss, irritability, fatigue, nervousness, loss of memory, indecision, and intellectual deterioration. Complaints of tremors and loss of coordination should also be sought. Physical examination should focus on the target organs described above. A baseline handwriting sample should be obtained. Laboratory evaluation should include at minimum a complete urinalysis.

This examination should be repeated annually. Results should be compared with the findings on the baseline examination for changes suggestive of mercury toxicity. Handwriting samples should be compared to the baseline sample for evidence of tremor. Interim evaluations should be conducted if symptoms suggestive of mercury intoxication are occuring.

To Monitoring for Workers Exposed to Mercury

Biological Monitoring

To Monitoring for Workers Exposed to Mercury

What is Biological Monitoring?

Biological monitoring is the measurement of chemical substances in the urine, hair or fingernails, or in blood or other body tissues of exposed individuals to determine how much of the chemical has been absorbed into the body. It serves as a back-up to environmental exposure measurements, since air measurements cannot assess skin exposure or the effects of protective equipment and work practices. Since it measures the amount of a substance actually absorbed into the body, it is usually a better estimate of risk for adverse health effect than air monitoring.

There is no ideal monitoring method for evaluating the risks of contamination from elemental mercury. Mercury can be measured in both blood and urine. Individual levels may vary greatly from day to day and even within a given day. While proper interpretation of the results can be difficult, the measurements can nevertheless provide information on potential overexposure. Measurements should be carried out regularly (several times a year) in chronically exposed workers. Individual as well as aggregate results should be evaluated. Where possible, baseline levels should be obtained before exposure begins for comparison purposes.

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Mercury in the Urine

Measurement of mercury in urine is the recommended approach to biological monitoring for workers exposed to metallic and inorganic mercury. Ideally, the collection should be over 24 hours, but this is seldom feasible. Spot urine samples may also be taken, but care must be taken to always collect them at the same time of day near the end of the work week after several months of steady exposure. Overnight samples may also be collected; this collection extends from the time the employee goes to bed through the first urination of the morning.

Samples must be collected in containers provided by the laboratory, since a preservative must be added. At least 25 mililiters of urine must be collected. Great care must be taken to prevent contamination of the sample containers or the urine with mercury from the skin or workplace air.

When results are interpreted, the urine values should be corrected for grams of creatinine in the sample, and should be expressed as ug Hg/gram creatinine. In persons not occupationally exposed to mercury, urine levels rarely exceed 5 ug/g creatinine.

While many laboratories indicate that only levels above 150 ug/L should be considered toxic, there is strong evidence that early signs of mercury toxicity can be seen in workers excreting more than 50 ug Hg/L of urine (standardized for a urinary creatinine of 1 gram/L). This value of 50 ug/g creatinine is proposed by many experts as a biological threshold limit value for chronic exposure to mercury vapor, and in 1980 this was endorsed by a World Health Organization study group. Recent studies have found subclinical effects (changes in urinary enzymes) as low as 35 ug.

Exposed individuals with levels above 50 ug/g creatinine should be placed in a low-exposure job until the reason for their elevated level of mercury has been identified and corrected, and worker urine mercury levels have fallen below the biological threshold limit value.

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Mercury in the Blood

The concentration of mercury in blood reflects exposure to organic mercury as well as metallic and inorganic mercury; thus it can be influenced by the consumption of fish containing methylmercury.

Samples should always be taken at the same time of day near the end of the work week after several months of steady exposure. The blood should be collected in mercury-free heparinized tubes after careful skin cleansing.

In unexposed individuals, the amount of mercury in blood is usually less then 2 ug/100 ml. According to some experts, an average airborne concentration of 50 ug/cubic meter corresponds to a mercury concentration in blood of about 3-3.5 mg/100 ml. Early effects of mercury toxicity have been found when the blood concentration exceeds 3 ug/100 ml. Any workers exceeding this level should be placed in a low-exposure job until dietary and workplace exposures have been evaluated and worker blood mercury levels have returned to baseline.

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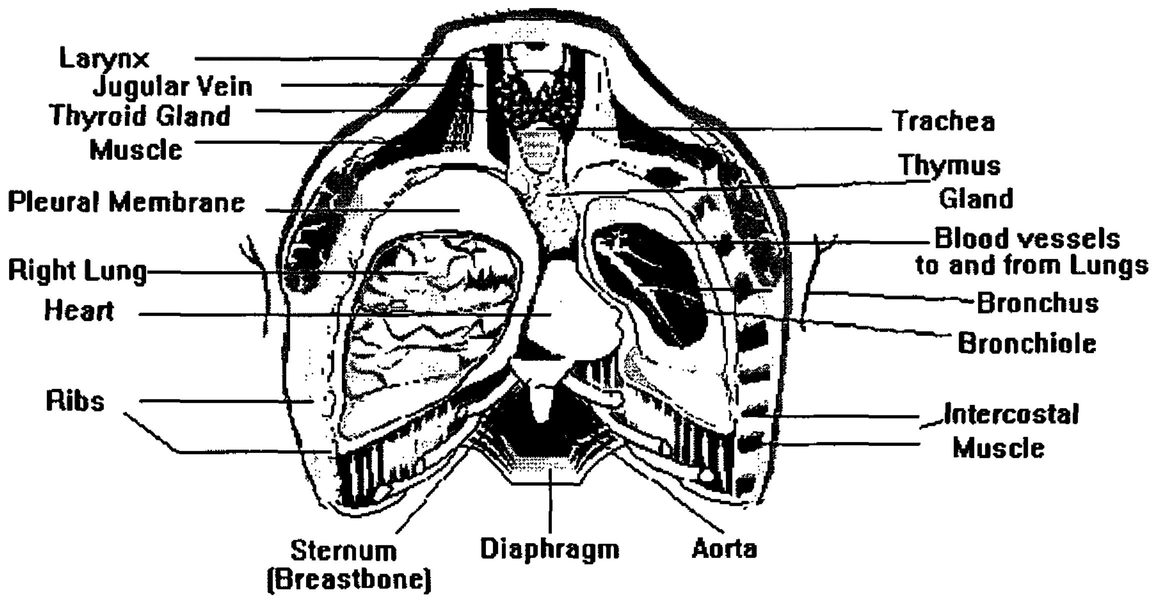
Effects of Mercury Poisoning in Humans



Mercury is both a precious metal and a neurotoxin. The "mad hatters" of the 19th century suffered from mercury poisoning - so did the hat makers in Danbury, Connecticut, who called their disease the Danbury Shakes. In short, mercury can be harmful to fish, waterfowl, wildlife, and humans.

The mercury felting process prevalent in the nineteenth century and many other industrial uses of mercury have been discontinued, and today most people are not exposed to dangerously high levels of mercury in their job settings. However, mercury may still be an occupational hazard for people working in medical care facilities.

Suppose, for example, a thermometer breaks or a mercury-containing solvent spills. If mercury vapor is inhaled, as much as 80 percent of the inhaled mercury may be absorbed into the bloodstream.

The biological half-life of mercury is 60 days. Thus, even though exposure is reduced, the body burden will remain for at least a few months.

The effects of mercury poisoning can be classified as:

- acute,
- chronic, or
- other

The degree of risk varies depending on how much mercury a person is exposed to and how often, and on stage of life. The work environment can be designed to minimize workers' exposure. We can, for example, be as careful about mercury as we are with x-rays. But not all of the mercury that we use remains in the facility. Some of it escapes into the environment, undergoes change, and may eventually be eaten by fish. Mercury-contaminated fish are the most likely source of mercury 's potentially adverse effects on human health. It is recommended that mercury's uses in medical settings be eliminated, not because its presence makes medical facilities dangerous places to be, but to help keep mercury out of the environment.

To Risks of Exposure for Humans to Mercury

Case Studies in Humans

Section Menu:

- A. Minamata Disease
- B. Iraq
- C. Guatemala
- D. New Mexico
- E. Belle-Glade, Florida
- F. Boca Raton, Florida
- G. Illinois

To Risks of Exposure for Humans to Mercury

Minamata Disease

What we now call "Minamata disease" was first observed in communities near Minamata Bay in Southwestern Japan. It was officially "discovered" in 1956, and by 1959 it had been demonstrated that the disease was caused by ingestion of fish contaminated by mercury discharged from a chemical manufacturer plant.

Levels of methylmercury chloride reached 50 ppm in fish and 85 ppm in shellfish obtained from the contaminated areas. One hundred and twenty one persons were poisoned, 46 fatally, from eating the contaminated fish. Dogs, cats, pigs, rats, and birds living around the bay developed classical clinical signs and many died.

In most cases, the patients began to show symptoms without any apparent signs. The onset began with numbness of the limbs and the area around the mouth, sensory disturbance, and difficulty with hand movements (such as grasping things, fastening buttons, holding chopsticks, writing, etc.); also, there was lack of coordination, weakness and tremor, slowed and slurred speech, and ataxic gait, followed by disturbances of vision, and hearing. These symptoms became aggravated and led to general paralysis, deformity of the limbs, difficulty in swallowing, convulsions, and death.

To Case Studies Menu

Iraq

In 1956 in Northern Iraq, over 100 people were poisoned by eating flour mixed with wheat seed treated with a fungicide containing 7.7% ethylmercuri-p-toluene sulfonalide. At least fourteen of the intoxicated people died. They had fed the treated seed to chickens for several days and after observing no ill effects had eaten it themselves. In addition to central nervous system manifestations, a number of other clinical signs were observed including polydypsia, polyuria, weight loss, severe proteinuria, deep musculoskeletal pain refractive to anlagesics, and prurits of the palms, soles, and genitals. Researchers attributed the other clinical signs to the prevalence of a parasitic disease called ancylostomiasis, and to dietary deficiencies of protein and vitamins.

Four years later during the winter and spring of 1961, an additional 100 people were poisoned by flour and wheat seed treated with a fungicide containing 1% mercury as ethylmercury chloride and phenylmercury acetate. Four of 34 patients died; however, the authorities believed others probably died after refusing hospitalization or signing out against medical advice. A combination of clinical signs was observed reflecting insult to the central nervous system by the ethylmercury fraction and to the renal and gastrointestinal organs apparently due to the phenylmercury component.

To Case Studies Menu

Guatemala

During the wheat-planting seasons of 1963-1965, numerous cases of a disease suspected of being a viral encephalitis occurred in and around Panorama, Guatemala. Forty five cases were observed, over 50% of which occurred in children, and 20 of these died. Autopsy and subsequent tissue analyses disclosed high levels of methylmercury in brain, liver, and kidney tissue of one victim. Being too poor to buy enough food to survive, the victim had eaten wheat seed treated with a fungicide containing 1.5% mercury as methylmercury.

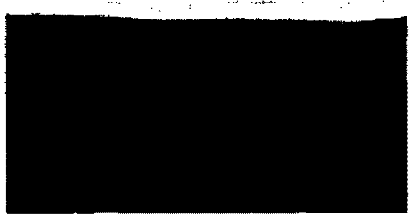
To Case Studies Menu

New Mexico

As a result of human consumption of pigs previously fed organomercurial compounds, mercury poisoning became evident in a farm family in Alamogordo, New Mexico. On December, 1969, an 8-year old farm girl living near Alamogordo, New Mexico, developed ataxia, visual disturbances, and a reduced state of consciousness which progressed to coma within a period of 21 days. Two weeks after the onset of her illness a 13-year old male sibling developed similar clinical signs and, like his sister, became comatose within a 3-week period.

By the end of the same month, a 20-year old sister developed similar clinical signs and became semicomatose. At the time the pork containing the high levels of mercury was eaten by the 10 members of the farm family, the mother was 3 months pregnant. She did not eat any of the meat after her sixth month of pregnancy. Clinical examinations during the last 2 months of her pregnancy disclosed only normal findings; however, her urine contained high levels of mercury. The pregnancy terminated with delivery of a 6.7-lb male infant. At birth he manifested intermittent trembling of the extremities which persisted for several days; however, he was otherwise normal. Electroencephalograms, electromyograms, blood electrolytes, calcium, magnesium, glucose, and bilirrubin remained normal during the first 6 weeks. Marked elevation of urinary mercury was present during the first 6 weeks; however, after that time urinary mercury was no longer detected.

Electroencephalograms became slightly abnormal at 3 months of age; by 6 months of age they were markedly abnormal, and generalized myoclonic jerks had developed. By 6 months of age, the infant had nystagmoid eye movements without evidence of visual fixation, was hypotonic and irritable. All of these clinical signs and other physical examination findings have been observed in Japanese children born to parents who consumed various fish caught from Minamata Bay and surrounding areas. The poisoning of these children presumably resulted from transplacental poisoning with organic mercury.



Six months after the initial appearance of clinical signs among members of the farm family in New Mexico, their condition remained essentially unchanged. The 8-year old girl and 13-year old boy remained comatose; however,, the 20-year old sister continued to improve and was able to speak and walk with difficulty. The neonate's condition remained unchanged.

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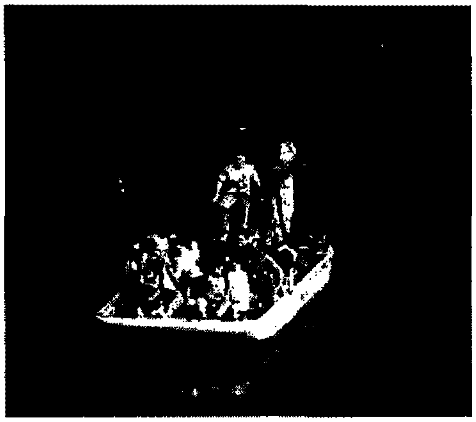
Belle-Glade, Florida



August 1994 - more than 500 students in Belle-Glade Florida were contaminated with liquid mercury after three boys found four jars filled with the silvery metal in an abandoned van. The boys brought the jars of mercury to school and passed it out to their friends. The children were fascinated by the silvery, liquid metal. "You ever seen "Terminator II?" asked a 14-year-old boy, "When the bad guy melts into the ground? That's just what it's like." The students played with the mercury, rubbing it on their teeth, throwing it at each other, dipping their jewelry into it, and pouring it into a local canal. Many children took home samples in paper cups and bags.

Although inhaling mercury vapors is by far a more serious threat than swallowing liquid mercury, local officials were very concerned. "If the children ate small amounts, that is not likely to be toxic," a local pediatrician stated. "The problem is going to come if the mercury is spilled or if its stays in a child's pockets. When it is vaporized and inhaled, it can be very, very toxic." Initial symptoms include a cough, breathing difficulties, and chest pain. Vomiting, diarrhea, fever, and nerve or kidney problems may develop later.

Hundreds of children had to be decontaminated. The local hazardous waste materials team, dressed in yellow safety suits, stood the children in a wading pool, hosed their arms, and scrubbed their skin with brushes. Doctors at area hospitals were on call 24 hours-a-day for several days to examine the children and adults exposed to the mercury and to give free blood tests. More than 20 homes had concentrations high enough to be of concern to the U.S. Environmental Protection Agency (EPA). Families had to be evacuated while EPA decontaminated these homes.

A hospital spokesperson said that he did not think any children had come in contact with enough mercury to cause any serious damage. No permanent damage to the children is expected.

To Case Studies Menu

Boca Raton, Florida

November 1994 - Over the Thanksgiving break, college students at Florida Atlantic University in Boca Raton, Florida removed liquid mercury from one of the school's laboratories. Although the laboratory manager noticed the missing chemical when he returned on Tuesday morning, he did not report it to authorities until the mercury was discovered spilled inside and outside of a university dormitory. Students living in the dormitory were evacuated and housed in a local hotel while the dormitory was decontaminated. Potential short- or long-term damage is unknown.

To Case Studies Menu

Illinois

Spring 1994 - A young boy in Moline, Illinois may suffer severe nerve damage due to mercury poisoning. The child brought home liquid mercury from the school science room and played with it in his basement. He spread the silvery liquid on his arms and legs in an attempt to look like the Tin Man from the *Wizard of Oz*. The home was so contaminated that the family was evacuated for nearly 10 months while the U.S. Environmental Protection Agency (EPA) cleaned up the spilled mercury. Ceiling tiles and the air conditioning and heating systems also were replaced. Although the boy is now recovering, the extent of permanent damage is unknown.

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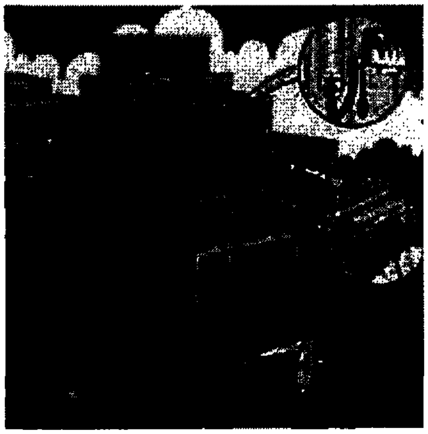
Mercury in Medical Institutions



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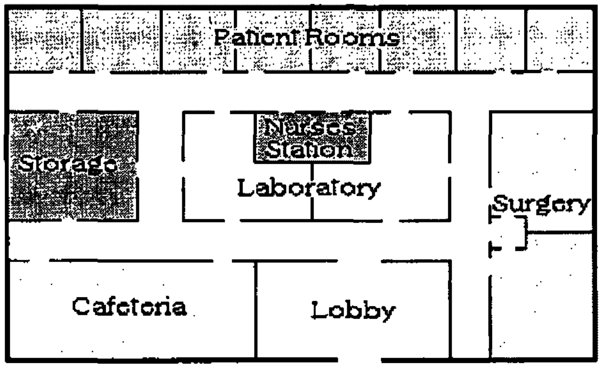
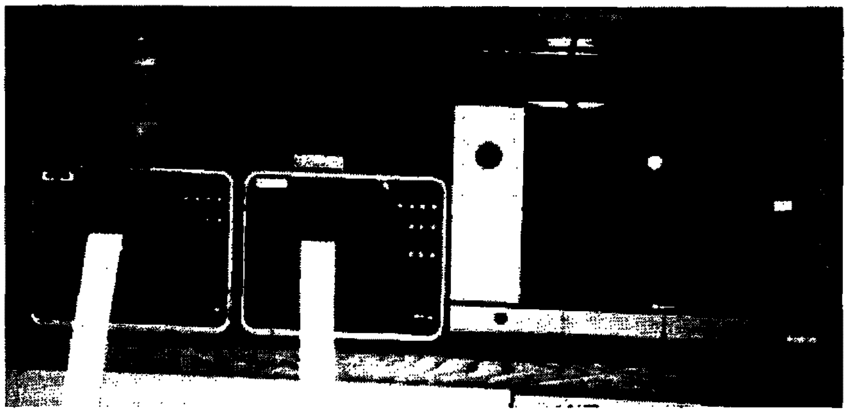
Virtual Hospital

The following image allows you to discover typical sources of mercury contained in specific rooms types of a medical institution. Simply click on the room of interest. Each page contains a panorama image which you can navigate. Either click and drag to rotate the image, or use the cursor keys. Also, you can zoom in by pressing the the 'a' key, and you can zoom out by pressing the 'z' key.



To Mercury in Medical Institutions Menu

Mercury Containing Equipment in Medical Facilities



Equipment	Use
Batteries Mercuric Oxide	Hearing Aids Pacemakers Defibrillators Fetal Monitors Hofler Monitor Pagers Picker Caliber Spirometer Alarm Telemetry Transmitter Temperature Alarm Blood Analyzer
Thermometers	Temperature Measurement
Sphgymomanometers	Blood Pressure
Barometers	Weather Conditions
Esophageal Dilators Cantor Tubes Miller Abbot Tubes Feeding Tubes	Hg is used as weight at the bottom of the tubes.
Electrical Instruments	Laboratory Ovens (including Microwave Ovens) Nursing Incubators Room Temperature Controllers Refrigerators Relays Switches (no noise switch used in patient rooms)
Lamps	Fluorescent Lamps Metal Halide Lamps High Pressure Sodium Lamps Ultraviolet Lamps Cathode Ray tubes

Analytical Instruments using mercury chloride as reagent	Sequential Multiple Analyzer (SMAC) AU 2000
Electron Microscope	Mercury used as vibration dampner.

To Mercury in Medical Institutions Menu

Mercury Products Used in Medical Laboratories

Test Type	Reagent	Mercury
Albumin		Thimerosal
Drugs of Abuse	All	Thimerosal
Antifungal/Anti-Infectious /Bacteriostatic Enzyme /Ammonia	Merthiolate Mercury Nitrate Mercury Iodide	Thimerosal (26% of Hg).
Herpes EIA	Buffer	Thimerosal
Cytology	Mucolex	Thimerosal
Urine Analysis	Stabilur Tablets	Mercuric Oxide
Hepatitis B Core		Thimerosal
Hepatitis B AG & AB		Thimerosal
Hepatitis C		Thimerosal
HIV		Thimerosal
CA 125		Thimerosal
Progesterone		Thimerosal
Blood Bank Saline	Immu-sal	
Identification of White Cells	Camco	
Clostridium difficile		Thimerosal
Group A *Streptococcus*		Thimerosal
Giardia		Thimerosal
Fixatives	B 5 Fixative Zenker's Solution Helly Ohlamacher Carnoy-Lebrun Shardin	Mercuric Chloride
Histology		Mercuric Chloride
Harris Hematoxylin	Mercuric Oxide	
Antibacterial Agent	Mercurochrome	
Mercurial Diuretic (known as mercupurin)	Mercurophyline	
Flame photomoter (obsolete use)	Mercury Sulfate	
Protain Test (contain Hydroxyphenol group)	Millon's Reagent	
BUN Test	Nessler's Solution	

Enzyme Non Protein Nitrogen	Nessler's Solution Nessler's Solution	
Pharmaceutical Preservative	Phenol Mercuric Acetate	
Takata-ara	Takata's Reagent	

To Mercury in Medical Institutions Menu

Mercury Stains Used in Medical Laboratories

Test Type	Stains
Microbiology	Gram Iodine
Histology	Carbol-Fuchin
Histology	Mercury Chloride
Histology	Carbol Gentian Violet
Histology	Gomori's
Ganglion Cells	Cajal's
HBFT	Alum Hematoxylin (Solution A)
Use in delineating nerve cells	Golgi's

To Mercury in Medical Institutions Menu

Mercury Products Used in Dental Clinics

Chemical	Use
Dental Amalgam	Dental filling

Dental amalgams do not pose a health risk. However, their disposal is a potential source of mercury to the environment. Separate collection and recycling are recommended along with predetermined operating procedures and spill cleanup measures.

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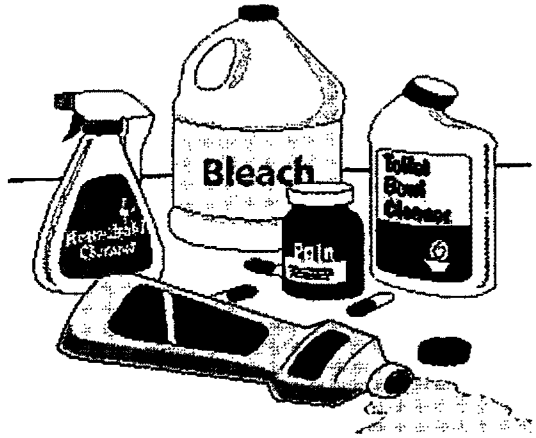
Other Sources of Mercury in Medical Institutions



- Mercury and mercury compound trapped in the sewer traps during spill.
- Incinerators: Mercury is discharged to air while burning or discharged to water through water scrubber.
- Manhole Bottom: Mercury accumulates in the sludge at the bottom of the manhole .
- Cleaning Chemicals.

To Mercury in Medical Institutions Menu

Prevention Measures of Mercury Pollution

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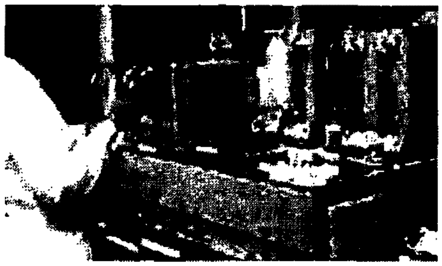
Preventing Mercury Pollution: General Guidelines

EPA regulates mercury disposal in manufacturing and other industries. However, there are currently no regulations restricting the discharge of mercury down the drain at medical institutions and laboratories.



Therefore, it is up to the individual facilities to be responsible and help keep mercury out of their waste streams and thus out of the environment.

Accidental spills and waste from medical facilities contribute in some measure to the fate of mercury in the environment.

Other industrial sources and human activities may be quantitatively more significant, but pollution prevention begins on home ground, and each of us - in even the smallest medical facility - can make a difference.

Remember: any mercury released to the environment can be converted to methylmercury, which can bioaccumulate in the food chain. Therefore, eliminating smaller amounts of mercury will have a beneficial effect on the environment.

This program will help you design a mercury pollution prevention program at your facility. Guidance is also available from state and federal agencies. Some states even have waste reduction requirements for hospitals. Still, your program will differ from others in your state, depending on local conditions and because voluntary efforts are often more flexible than regulatory approaches.

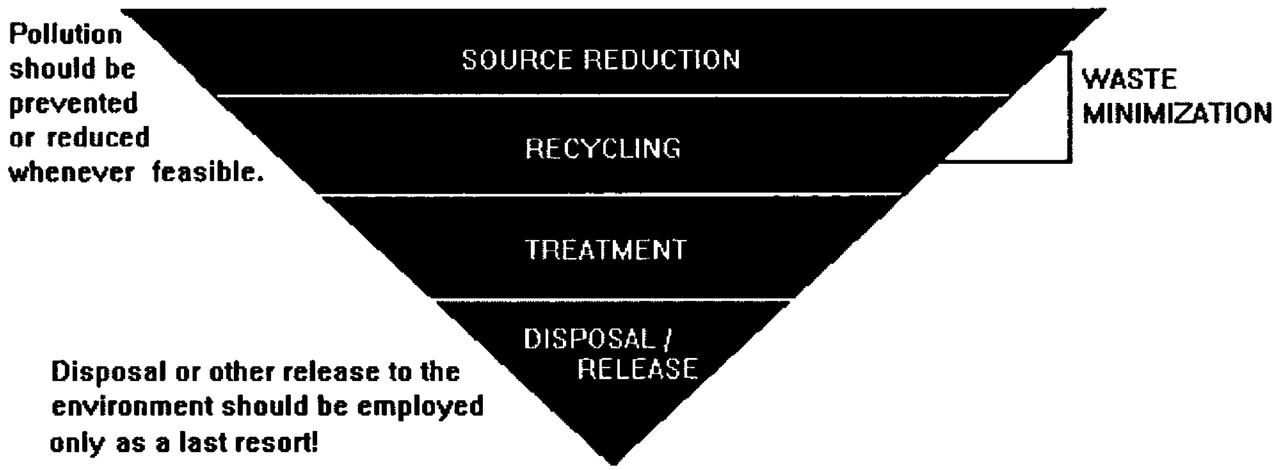
Identify the key players at your facility. Who has access to doctors and nurses, to engineers, safety officers, suppliers, and housekeeping and maintenance personnel? Engage these people as a team to spearhead your program. Their careful planning will ensure that your program is unique - notwithstanding that all programs may have similar strategies and goals. Even if you cannot immediately replace all the mercury-containing equipment that your facility has accumulated over the years, every direct action you take will make a difference!

The objective of this section is to get you started in setting up a mercury pollution prevention program that meets eight sets of guidelines:

GUIDELINES

1. Training and communications
2. Good housekeeping and plant management
3. Auditing your program and facility regularly
4. Setting attainable goals

Whatever you do, make it your goal to eliminate mercury entirely. Look carefully at your facility. How serious is the problem? What are the symptoms? Who else is aware of the problem and will help in remediation efforts? Once you have developed a case history, it will be far easier to determine the cure.



Disposing of mercury, no matter how carefully, should be the last resort. No matter how small the quantity, mercury is always a toxic waste. Engage everyone at your facility in the program because everyone's participation is vital. ***It takes only one person to begin pollution prevention.***

To Preventive Measures Menu

Preventing Mercury Pollution: Case Studies

Section Menu:

Summary of Mercury Pollution Prevention in Selected Michigan Hospitals

	U of M	Alpena	Butter-worth	Genesys	Henry Ford	Bronson	Quest
Administrative Directives - Purchasing, etc. (Formal vs. Informal)	● I	● F	● F	● I	● F	● F	● F
Clean Drain Traps/Catch Basins		●			●		●
Educate Staff	●	●	●	●	●	●	●
Install Energy Efficient Lighting	●				●		
Inventory Mercury Use	●	●	●		●		●
Mercury-free Batteries	●	●	●	●	●	●	●
Purchase New Mercury-free Sphgmomanometers	●	●	●	●	●	●	N/A
Replace Broken Sphgmomanometers w/ Mercury-free Units	●	●	●	●	●	●	N/A
Replace Thermometers	●	●	●	●	●	●	
Separate Wastes	●	●	●	●	●		●
Substitute Pathology Lab Regeants		●					●
Training on Spill Prevention/Management	●	●	●	●	●	●	●

To Preventive Measures Menu

Preventing Mercury Pollution: Case Studies

A. ST. MARY'S MEDICAL CENTER

To Case Studies Menu

1. Build Support

St. Mary's Medical Center is a 326-bed hospital located in Duluth, Minnesota. To begin the mercury reduction project, WLSSD staff met with hospital management to ensure their interest and commitment to the project. Once support was assured, an existing team of hospital employees (who had already implemented an excellent solid waste reduction program) worked with WLSSD staff on the project.

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2. Form team

The team was made up of representatives from different areas of the hospital. This was important because of the wide variety of different activities performed in a hospital. Representatives from maintenance and purchasing were particularly important. The maintenance staff has knowledge of the inner workings of the hospital which is especially helpful when conducting monitoring. Toxics reduction projects often require that changes be made in the use of certain products. For this reason, a representative from the purchasing department is essential to the team.

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3. Perform an Assessment

As a first step in the project, the mercury reduction team completed a survey on mercury use provided by WLSSD. The survey disclosed that St. Mary's had already replaced some mercury containing items, such as thermometers and blood pressure cuffs, with alternative electronic devices. In addition, mercuric chloride, a common reagent used in pathology labs, was being captured and handled as hazardous waste instead of being flushed to the wastewater treatment plant.

A wastewater monitoring plan was then developed to try to pinpoint mercury sources within the hospital. Often several discharge points may enter the sanitary sewer system from an older building like a hospital. Meeting with maintenance staff to review old blueprints is essential before beginning a monitoring program. Particularly in facilities that have undergone expansion, the use of dye tablets may be needed to verify source information.

Monitoring results found mercury concentrations varying from 0.3 ppb to 1.2 ppb. The monitoring also identified the days on which mercury concentrations were high, and where it came from in the hospital. In this case, the monitoring results were valuable in educating the reduction team. The team felt they had already solved their mercury problem, and did'nt anticipate additional discharges. Once they saw the numbers, however, a "can do" attitude quickly developed.

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4. Take Action

At this point, the mercury in the wastewater appears to be coming from the hospital laboratories and from the laundry services. Reagents and bleach are the suspected sources. These products are being investigated and where possible, alternatives will be substituted. Historic sources are also under investigation. In older buildings where there has been high mercury use in the past, items such as broken thermometers may have been disposed of down the drain. The mercury accumulates in waste traps and is discharged in small amounts each time water is used. Traps in nursing stations and in the labs are being cleaned as part of the reduction effort.

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5. Document Share Results

WLSSD staff will continue to work with St. Mary's on future reduction efforts. New information about sources of mercury and additional wastewater monitoring results are shared with the team in regular meetings. Reductions in mercury discharge will continue to be documented and shared.

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Preventing Mercury Pollution: Case Studies

B. UNIVERSITY OF MICHIGAN HEALTH SYSTEM

Contact Person: Trixie Dietrich, (313) 764-4427
The University of Michigan Health System
Safety, Building and Environmental Management
(10/4/96)

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Overview of Pollution Prevention Efforts

Pollution prevention (P2) is an important goal at the University of Michigan and the University of Michigan Health System. We are firmly committed to the waste minimization efforts, energy conservation and the efficient and responsible use of resources. Many departments across campus are involved in these efforts. We believe that by working together, we can enhance the environment in which we live and work.

The University of Michigan Health System initiated a mercury reduction program to systematically remove mercury-containing equipment from this facilities. This has mitigated the potential for mercury to enter the environment by reducing the possibility of mercury escaping during accidental equipment breakage and traditional disposal methods. As of May 1996, 440 pounds of mercury was removed from blood pressure cuffs, thermometers and other equipment. The mercury collected was recycled.

Evaluating mercury containing reagents from laboratories, changing big specifications requiring mercury free equipment and providing mercury training and education for employees among other efforts are being performed. A fluorescent light tube recycling program has been implemented to avoid the potential release of mercury-containing powder inside the bulbs into the environment. Mercury reduction efforts are monitored by several quality control measures. The mercury reduction goals are evaluated periodically to assure continuos improvement and success.

Efforts are being coordinated cooperatively through the Safety Building and Environmental Management Department and the Department of Occupational Safety and Environmental Health. Some of these effort have been performed in settlement of an enforcement action brought by the Michigan Department of Environmental Quality.

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University of Michigan Health System

- 872 beads - adult and pediatric
- Onsite clinics
- 8000 employees
- 37 clinics housed in 25 buildings
- 15 acquired practices
- These numbers are always increasing

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History

1992 Discussions began regarding replacement of Hg sphygmomanometers
- Initiated by incidence of Hg spills
- Concerns for exposure potential
- Environmental concerns for Hg in Great Lakes Program

1995 Hospital Hg reduction efforts became a Supplemental Environmental project (SEP) performed in settlement of an enforcement action by the MDNR.

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Mercury Identification

- Terrace Brochure
- Hg Pollution Prevention in Michigan
- Discussion with other health care facilities
- Surveys
- Targeted sources
- Review material Services inventory for Hg equipment

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Communication

- Written correspondence to specific groups based on identification efforts
- Written correspondence to inform staff about Hg reduction efforts
  - asked for voluntary evaluation of Hg containing equipment & products
- Speaking of Safety Newsletter

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Case Studies

- Sphyg fell off wall at the clinic
- Sphyg fell of wall in the cast room
- Blood bank calibration sphygs
- Pathology fixatives

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Accomplishments

- 660 total Hg sphygmomanometers were replace with aneroid units
- Approximately 440 lbs Hg sent for recycling
- Eliminate B5 reagent from Pathology
- Eliminated Hg thermometers from Material Services inventory
  - Cost effective
  - More convenient
  - Less hazardous
- Eliminated Hg filled esophageal devices
- Using only thimerosol free products
- Pharmacy is not dispensing Hg for Miller-Abbott tubes
- New baby kits do not contain Hg thermometers
- Using only Hg free batteries
- Change language on new equipment acquisitions requiring Hg free if possible
- Eliminated most calibration sphygs
- Recently implemented a fluorescent light tube recycling program
- Some of the project accomplishments were performed in settlement of an enforcement action by the MDNR

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Current Efforts/Quality Assurance Measures

- Training the offsite clinics as part of the Hazard Communication Program
- Collecting dental Hg amalgams and disposing as hazardous waste
- Testing incinerator ash prior to disposal to assure compliant Hg levels
- Sampling selected sink traps
- Hazard Surveillance Rounds
- Waste disposal - monitor billing reports
- Collecting "discovered" left over equipment

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Future Goals

- Use a substitute for Hg amalgams
- Replace barometer with Hg free alternative
- Collect Hg at the newly acquired locations
- Perform additional Hg sampling
- Conduct feasibility study for Hg containing maintenance equipment replacement

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Preventing Mercury Pollution: Case Studies

C. Alpena General Hospital (Michigan, August 1995)

Alpena General began instituting mercury pollution prevention measures approximately eight years ago by adopting a purchasing a policy that eliminated mercury-containing items such as thermometers and sphygmomanometeres. In addition, the institution purchases only mercury-free batteries from suppliers, and items such as thimerosal-free saline solution are being used.

Alpena's laboratory conducted its own study on mercury in solvents to determine where mercury was originating. It was necessary to follow this procedure because manufacturers might not list the solvents' ingredients if the formula is under copyright protection. Material Safety Data Sheets might not list mercury in a solvent if amounts are too small or if the formula is protected. After completing roughly 350 analyses, Alpena contacted their suppliers and requested that mercury-free solvents be supplied. Analyses were completed by examining lab results and testing and cleaning drain traps. This last method is currently used as a spot-check system to isolate any mercury discharges. Wastes generated within the institution are separated, and disposed of according regulations. The institution has a procedure policy on spill prevention and management in case of mercury spills or leakages.

Alpena provides an ongoing educational and advisement program with those departments directly involved in mercury pollution prevention, such as advising the nursing department to check for materials that may contain mercury like thimerosal-containing saline solution. The plant superintendent has the responsibility of seeing that all mercury pollution prevention measures are being instituted, as well as cleaning the drain traps and testing for mercury residues.

To Case Studies Menu

Preventing Mercury Pollution: Case Studies

D. Butterworth Hospital (Grand Rapids Michigan, August 1995)

Hospital: 529 beds
Goal: Eliminate 300 lbs of elemental mercury
Contact: Dan Stickles (616) 391-1801

Butterworth Hospital recently hired a local environmental consultant to devise a disposal plan for mercury that will be safe and economical for the entire hospital. In addition, Stock Environmental will develop a spill response plan that is in accordance with the Occupational Safety and Health Administration and the Joint Commission for the Accreditation of Health care Institutions, as well as offer training on spill response, prevention and management. Educational materials about mercury, specifically the Terrene Institute brochure produced by the Health Care Sector Subgroup, have been distributed to all hospital departments, administrative personnel, and regional facilities.

Butterworth Hospital has made a commitment to reach mercury-free status, and is attempting to reach that goal by instituting a purchasing department policy stating unless there is no suitable, mercury-free alternative, no mercury-containing devices are to be purchased. This list includes thermometers, sphygmomameters, esophageal dilators and batteries. Administrative approval has been given to replace all sphygmomameters currently in use with anaeroid devices, which will speed the transition to mercury-free status. In addition, Butterworth Hospital has made a commitment to discontinue sending mercury-containing devices overseas in their humanitarian products, and is currently in the process of discontinuing sending mercury thermometers home with new mothers in the obstetrics department.

Last year two new buildings that are part of Butterworth Hospital opened. Administrative groups managing these buildings have committed them to be mercury-free. Applying the Butterworth Hospital purchasing policy concerning mercury has been difficult with office space being rented to private doctors. The challenge now lies with making the buildings 100% mercury free, in both public and private doctor facilities. The purchasing policies implemented at Butterworth has allowed the facility to explore options of recycling mercury at mercury refining centers, and look to minimize hazardous waste disposal costs. For example, fluorescent tubes are now being recycled using a mobile collection unit.

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Preventing Mercury Pollution: Case Studies

E. Genesys Health System (Michigan, August 1995)

Group of 4 hospitals, 750 physicians

A formal policy that replaces mercury-containing thermometers and sphygmomameters with electrical devices where medically acceptable and feasible has been instituted by Genesys Health System, as well as a purchasing policy that allows only mercury-free items to be purchased. Also in effect is a goal to eliminate clinical lab procedures that contain mercury. Currently, the health system laboratory removes mercury from the waste stream by precipitating and filtering out the material. The wastes are then separated and mercury waste recycle by reusing the material on site, or sending it to a mercury recovering company.

Genesys Health System has devised programs to train its employees on spill response and spill prevention and management that properly clean up mercury spills in accordance with applicable regulations, as well as to evaluate fluorescent tubing. An Environmental Control Advisory Committee within Genesys has formed an Environmental Control Policy stressing reduction of waste into the environment. The committee has also provided education materials concerning mercury pollution prevention to staff people.

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Preventing Mercury Pollution: Case Studies

F. Henry Ford Hospital (Michigan, August 1995)

Perhaps one of the most important aspects Henry Ford stresses in environmental matters, including mercury pollution prevention, is education. Educational at the clinical, administrative, and emergency planning levels focus on being environmentally responsible while at the same time meeting the community health needs. The alternatives to mercury-containing items must be clinically viable in order to be used, and a product that is not environmentally sound will not be purchased. First-response teams are able to minimize patient discomfort and maximize their care, tuning into the emotional element of pollution prevention.

Thermometers and esophageal dilators containing mercury have been or are being replaced with mercury-free alternatives. Blood pressure cuffs that contain mercury are in the process of being replaced with aneroid devices. While there are still devices that contain mercury located and used at the hospital, the safe storage of these devices is an important consideration for Henry Ford.

Henry Ford's laboratory does not release any chemicals down its drains, thereby minimizing chemical on their laboratory sites, buying only the necessary amounts of chemicals needed for their procedures. Henry Ford has removed their old drains and catch points and replaced them with up-to-date systems. The sediment within the pipes are cleaned systematically, and the sludge is treated as hazardous waste.

To Case Studies Menu

Preventing Mercury Pollution: Case Studies

G. Bronson Methodist Hospital (Michigan, August 1995)

Capacity: 414 beds

Educating the staff at Bronson Methodist Hospital, including the proper use of mercury-containing devices, eliminates breakages, and the proper procedures to follow in case of a breakage, has helped to decrease mercury from its system. In addition, instituting a purchasing policy to ban the purchase of mercury-containing items, if an alternative exists, has been formalized. A company that purchases the mercury-containing devices from the hospital has been located. Batteries that contain mercury are in the process of being phase out and replaced with mercury-free batteries. Sphygmomanometers containing mercury are being replaced with aneroid devices throughout the facility.

Bronson is also working in conjunction with Kalamazoo's waste-water department to remain below their mercury discharge detection limit of 0.5 parts per billion, and to further decrease their concentration to 0.3 parts per billion. The hospital has monitored its systems, located areas to clean up, and has since decreased its emissions significantly.

Bronson's work in mercury was recognized by Kalamazoo with the first annual Industry Excellence Award for having the best mercury minimization results of all the significant industrial users discharging to the Reclamation Plant.

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Preventing Mercury Pollution: Case Studies

Quest Diagnostics, Incorporated (Wyoming Michigan, August 1995)

Contact: Neil Findley, (616) 538-6700

Quest Diagnostics Incorporated has instituted a wide range of mercury pollution prevention measures to meet the city's strict water guidelines of 0.5 ppb. Initially, Quest Diagnostics isolated manufacturer contributions of mercury within its waste water system by testing its list of reagents for mercury content. Reagent manufacturers might not list mercury in their Material Safety Data Sheets because the amount is so small; therefore Quest Diagnostics did not know the sources of mercury until test results were finalized. Once the sources where determined, a formal mercury reduction policy to continually decrease mercury in its effluent, as well as evaluating mercury content of the reagents it purchases, was instituted. If the vendor cannot provide mercury-free reagents, Quest Diagnostics will locate a vendor that does or, where possible, change methodologies to processes that do not involve mercury; if the purchase of mercury-free reagents is not possible, waste is segregated. This policy was submitted by the laboratory to the city, and is updated quarterly with the report sent to Wyoming semiannually.

In addition, Quest Diagnostics separates their wastes and packages them to send to the correct hazardous waste facility. Test spickets are inserted into 100% of all laboratory drains to regularly test the material being released. If the tests are above the limits, the drain traps are replaced, the material is handled as hazardous waste, and investigation begins as to the source of the contamination.

The staff and employees of Quest Diagnostics Incorporated service 3,000 patients per day. Regular updates on mercury reduction are shared with employees at quarterly meetings. This keeps them informed of the actions and policies of the laboratory. Employees are given the required Occupational Safety and Health training, additional training in bloodborne pathogens, and are broken up into ôrisk groups in relation to where they work and the chemicals that are handled. A formal chemical-hygiene plan is also in effect for Quest Diagnostics Incorporated.

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Preventing Mercury Pollution: Case Studies

I. MERCURY MANAGEMENT AT MAYO CLINIC

Contact Person: David H. Senjem
Environmental Safety Coordinator
(2/13/97)

Mayo's management of mercury in the medical environment has evolved over time. Historically, elemental mercury from thermometers, blood pressure units, research apparatus, and other devices was referred to Mayo's Pulmonary Laboratory for cleaning, redistillation, reuse, or sale. Mercury batteries were first collected for referral to a California-based reprocessing center in 1978. A strong emphasis has existed since the mid-1970's on collecting and commercially disposing of mercury-containing laboratory wastes through Mayo's hazardous waste program. Specialized mercury vacuum cleaners were first purchased in the 1970's to ensure than mercury spills were effectively and safely managed.

In more recent years, institutional interest in mercury management has led to even more aggressive actions. Mercury thermometers have been removed from Mayo's 1500 outpatient examination rooms and replaced with electronic devices. Similarly, mercury thermometers and sygnometers were removed and replaced with electronic devices in all hospital areas. Mayo's Pulmonary Function Laboratory discontinued the use of large quantities of mercury associated with their Haldane/VanSlyke devices in favor of electronic instrumentation. Laboratory test procedures have been re-evaluated for mercury use with an emphasis on substitution, whenever possible, and strict attention to disposal management when substitution is not possible. Used mercury-containing fluorescent light bulbs are, of course, collected and disposed of through a commercial vendor who recovers and recycles mercury.

Efforts continue to further investigate and reduce the presence of mercury in the Mayo environment. Examples of such efforts include the incorporation of heavy metal analysis in certain product purchases and similar evaluations in certain large components of Mayo's incinerated waste stream. Additionally, we have strived through continuing educational efforts to sensitize staff on avoidance of the use of mercury or mercury-containing materials, whenever possible, and especially when alternative choices are available.

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Tracking Progress of Mercury Pollution Prevention

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Qualification/Quantification Approaches to Evaluate Mercury Use at Medical Facilities

The U.S. Environmental Protection Agency Region 5 has initiated a Medical Waste Mercury Reduction Project to reduce the amount of mercury discharged into the environment. Mercury continues to be used routinely at medical facilities.

Mercury's usefulness in the medical industry must be weighed against its hazards when released into the environment through incineration or discharges from publicly owned treatment works. For example, significant amounts of mercury in publicly owned treatment works (POTWs) waste streams can be attributed to the disposal of dental amalgam down drains when fillings are removed at dental offices. Mercury is also released into the environment through the incineration of mercury-containing materials from hospital facilities that have been placed in infectious waste containers.

Because there are currently no federal regulations for medical facilities to limit the discharges of mercury down the drain, voluntary programs must be implemented to encourage the medical industry to reduce the use of mercury and its releases into the environment through product substitution, recycling, and proper handling and disposal practices.

In an effort to track reductions in mercury from medical facilities, it is necessary to quantify the mercury that is currently in use. The purpose of this section is to present the elements needed to qualify and quantify the amount of mercury used in a medical facility.

A Use existing data or reporting requirements to estimate mercury use and release
B Develop and implement a survey

To Tracking Progress of Mercury Pollution Prevention

Tracking Progress of Mercury Pollution Prevention

There are several databases that include information on mercury use and/or release. These databases can be accessed to determine the relative amounts of mercury products that have been purchased by a facility. Examples of relevant databases include

To Mercury Use Qualification/Quantitation Approaches

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1. Michigan Critical Materials Register Annual Wastewater Report

Under Michigan's Pollution Control Act, facilities in Michigan are required to report the quantities of mercury they use. The Act requires that commercial facilities file annual reports that list the materials used directly or incidentally to produce a product or service including by-products and waste products. The Act applies to materials on Michigan's Critical Materials Register, which includes metallic mercury as well as several mercury compounds, some of which are used in pharmaceuticals (mercuric acetate, mercuric chloride, mercuric nitrate, mercuric sulfide, and mercurous nitrate). All critical materials used, manufactured, stored, discharged in wastewater, disposed of as waste materials (residuals) or transferred off site must be reported each year. Separate forms and instructions are provided for reporting releases to wastewater outfalls and critical materials used. Questions asked about critical material use cover:

- Amount that was or might have been discharged to wastewater and whether this amount was measured or estimated
- How much was discharged to each outfall
- Amount of critical material that was or might have been contained in residuals (i.e., other waste streams)
- Source of critical material in residuals (production, wastewater treatment, or combination)
- Physical state of critical material-containing residual (liquid, sludge, wet solid, dry solid)
- How critical material-containing residuals are stored before removal (metal drums, fiber drums, above-ground tank, underground tank, stockpiled on ground, holding/pond lagoon, dumpster/roll-off box, other [please specify]
- Disposal method for critical material-containing residuals (sanitary landfill, hazardous waste landfill, own land, shipped out of state, incinerated, recycled, other [please specify]).

Nineteen hospitals reported mercury use or release in the 1991 Critical Materials Registry Annual Wastewater Report. Additional information or retrievals from the Michigan Critical Materials Registry Annual Wastewater Report data base can be requested from Christopher Hull at the Michigan Department of Natural resources in Lansing (517) 335-4199.

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2. RCRA Biennial Report

The RCRA Biennial Report System (BRS) tracks information on hazardous waste generated and managed by large quantity generators and permitted treatment, storage, and disposal facilities. Several of the codes used in the BRS are used to identify the presence of mercury in a waste stream or discarded product. Eighteen health services facilities reported mercury-bearing wastes in the RCRA Biennial Report System in 1991 out of a total of 572 facilities reporting mercury overall in the Great Lakes states. Sixteen of the 18 health care facilities were general medical and surgical hospitals. the other two consisted of one medical clinic and one medical laboratory. No dental clinics reported RCRA waste generation.

Commonly reported sources of mercury in hospital waste streams are laboratory wastes (most common among Great Lakes states health care facilities), discarded out-of-date products or chemicals, filter or battery replacement, and wastewater treatment or pollution control wastewater treatment processes.

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3. Permit Compliance System

The Permit Compliance System (PCS) contains information on wastewater discharges for permitted dischargers. These data are based on monitoring data supplied by the facilities. Few hospitals are represented in the PCS database as having NPDES permit limits for mercury.

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4. Toxic Release Inventory

The Toxic Release Inventory (TRI) is not a good source of information on health care facilities because it only covers the manufacturing facilities (SIC codes 20-39). The reporting thresholds for TRI are so high relative to the amounts that could impact the Great Lakes that they are not useful for tracking mercury releases.

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Develop and Implement a Survey

To Mercury Use Qualification/Quantitation Approaches

Approaches to Developing a Survey

There are two basic approaches: look at what is coming into the healthcare facility with orders of supplies, shipments, patients, etc. ("supply side" approach) or look at what is going out in the waste streams ("waste stream" approach). The advantage of looking at what is coming in is that more detailed records might be available for procurements than for discards of unwanted materials. The supply side to the hospital is also directly linked with the purchasing behavior that healthcare facilities should examine and change. A difficulty with the supply side approach is that hospital personnel might not know which products contain mercury or how much mercury they contain. Some sources might be missed by the supply side approach that would not be missed if the waste stream were analyzed as in the waste stream approach. The waste stream approach, however, might require more "detective work" to trace mercury in waste streams back to the actual source of mercury in the healthcare facility. Use of this later approach requires information on both the concentration of mercury in the waste stream and the quantity of waste generated. A combination of both approaches could be used to fill information gaps.

To Develop and Implement a Survey

Information Needed to Qualify or Quantify Mercury Use

Mercury use primarily centers around the use of products and equipment. A list of products and supplies containing mercury that might be used at hospitals is needed to form the basis of a questionnaire on use patterns and disposal practices. The section Mercury in Medical Facilities provides a list of mercury-containing products and supplies the might be found at a medical facility.

The hospital purchasing manager can be asked to identify products on the list that the hospital uses and how much is normally ordered in a year. Another list of hospital equipment and appliances that contain mercury can be compiled to address issues related to equipment use. Issues to explore might include how unwanted equipment is disposed and whether mercury is removed from equipment prior to disposal by hospital personnel, service contractors or the vendor.

For example, a survey might ask the hospital administrator to check which supplies or equipment are used and in a column at the left of each item checked write in information to calculate how much is used, how items are disposed, and how they are stored before disposal pick-up.

It is important to state up front that the survey is confidential so that their answers will be as honest as possible and the respondents won't be inclined to give the "right" answer. Always include a self-addressed stamped envelope for them to return the survey.

The range of medical facilities surveyed in terms of size and geography should be broad. The larger hospital facilities may have already substituted products that don't contain mercury, while smaller hospitals, nursing homes, and clinics, might not have the resources to upgrade their equipment.

The recipients of the survey should also include a broad range of personnel to determine if the entire facility follows similar procedures. Particularly at smaller facilities, procedures and practices for mercury use may not be standardize.

An EPA survey draft is presented in the next section using the above-mentioned questions to help personnel in the medical industry quantify the amount of mercury in use at their facilities and to determine their current disposal practices.

To Develop and Implement a Survey

EPA's Medical Facility Mercury Use Survey

The United States Environmental Protection Agency, Region 5, would appreciate your participation in this survey to determine the sources and disposal practices of products containing mercury in your medical facility.

We hope through this survey and other efforts, that we can help control the amount of mercury released into the environment. The information you provide is confidential. Thank you for your time.

1. Facility ______________________________
2. City ______________________________
3. Zip Code ____________________________

4. Which of the following best describes your role in the medical industry?

   ___Purchasing manager
   ___Physician
   ___Nurse
   ___Laboratory technician
   ___Custodian
   ___Administration personnel
   Other ______________

5. Does your healthcare facility have any written policies or procedures to control mercury use? If yes, please explain.

   Yes
   No

6. What precautions or other measures are taken when handling mercury or cleaning, servicing, or disposing of mercury-containing equipment or materials?

7. Who is responsible for implementing policies and procedures?

8. Who sees that mercury is removed from unwanted equipment prior to disposal?

9. What are the best ways for you to learn the proper use and disposal of mercury-containing products? (check top three).

   ___printed matter (newsletters, brochures, fact sheets)

___onsite visits
___information hotline
___seminars
___speakers at medical meetings
other ___________

10. What specific factors would help change the current practices towards addressing mercury in medical facilities? (check top three).

___economic benefits
___concern for environment
___ease of disposal
___concern for government enforcement
___concern for public image
___concern for liability
___pick up/drop off services for waste
___concern for human health
___increased awareness
___concise disposal guidelines
other ___________

11. If you would like to receive more information about mercury reduction in medical facilities please complete the following:

Name ______________________________
Organization _________________________
Address ____________________________
____

Products containing mercury	Check here if used at your facility	Quantity used or ordered per year	Average mercury content per unit measure	How disposed ●	How stored while waiting for disposal ❍
Amalgam					
Fluorescent lamps					
High intensity mercury lamps					
Miller Abbott tube					
Pagers					
Sequential multiple analyzers					
Sphygmomanometer					
Thermometers					
Thermostats					

● Choice for how disposed might include: sewer, hazardous waste, municipal solid waste, infectious waste, or recycle.

Choice for how stored while waiting for disposal might include: drum, dumpster, laboratory hood, waste receptacle, etc.

Laboratory materials containing mercury	Check here if used at your facility	Quantity used or ordered per year	Average mercury content per unit measure	How disposed ●	How stored while waiting for disposal
Alum hematoxilin					
Cajal's stain					
Camco					
Carbol-Gentian violet stain					
Formol-Zenker's stain					
Golgi's stain					
Millon's reagent					
Mercuric chloride					
Nessler's solution					
Takata's reagent					

● Choice for how disposed might include: sewer, hazardous waste, municipal solid waste, infectious waste, or recycle.

Choice for how stored while waiting for disposal might include: drum, dumpster, laboratory hood, waste receptacle, etc.

To Develop and Implement a Survey

Mercury Reduction Survey Worksheets

Worksheet 1: Survey Scope
Worksheet 2: List of Survey Team Members
Worksheet 3: Information Sources
Worksheet 4: Raw Material Summary/Equipment Survey
Worksheet 5: Source / Waste Reduction Alternatives

To Develop and Implement a Survey

Worksheet 1: Survey Scope

Hospital Name:

Address:

Area to be included in the survey:

Department(s):

Specific work area:

Specific chemical(s):

Specific waste(s):

Specific instrument(s)/equipment(s):

Report prepared by:

Date:

To Mercury Reduction Survey Worksheets

Worksheet 2: List of Survey Team Members

Hospital Name:

Address:

Occupational health & safety rep.:

Hazardous materials rep.:

Nursing department rep.:

Microbiological lab. rep.:

Pathology lab. rep.:

Purchase manager:

Maintenance engineer:

Power plant (incinerator) engineer:

Rep. from doctors offices:

Others:

Team leader:

To Mercury Reduction Survey Worksheets

Worksheet 3: Information Sources

Information Sources & Reports (Use all that apply)	Exist (Y/N)	Complete (Y/N)	Last Revision	Permanent Storage Location of Information
Facility Layout:				
Area Description:				
List of Waste Sources:				
Waste Description:				
MSDS:				
Operational Manuals:				
Maintenance Records:				
Purchasing Records:				
Inventory Records:				
Process Description:				
Instrument Diagram:				
Equipment Specification:				
SARA III, Section 313 Submittal:				
Waste Manifest:				
Waste Management Contacts:				
Solid/Liquid/Emission Characterization Data:				
Other Information Sources:				

Reported by:

Date:

To Mercury Reduction Survey Worksheets

Worksheet 4: Raw Material Summary/Equipment Survey

HOSPITAL NAME:

ADDRESS:

<u>DEPARTMENT/LAB:</u>

Material Name:

Material Use:

Specifications:

Material Form (Sol/Liq/Gas):

Consumption (Vol/Time):

Purchase Price:

Minimum Inventory required:

Maximum Inventory Required:

Container Type:

End Use (Process):

Delivery Method on Site:

On Site Storage Method:

On Site Distribution Method:

Disposal Form:

Cost of Disposal:

Cost of Replacement:

Requesting Personnel:

Mercury Concentration (% or ug/l):

Leak/Spill Handling Method:

Reported by:

Date:

To Mercury Reduction Survey Worksheets

Worksheet 5: Source/Waste Reduction Alternatives

HOSPITAL NAME:

ADDRESS:

Source/Waste/Process/Analytical Method Type:

Waste Stream:

Description:

SUGGESTED ALTERNATIVES/COMMENTS	SUGGESTED BY:

To Mercury Reduction Survey Worksheets

A Checklist to Help You Verify Your Progress

1. Have you estimated the extent of the mercury uses in your facility? (if yes, record these estimates and proceed to question 2).
2. Have you measured the volume of mercury contained in your equipment and supplies? (if yes, record these figures and proceed to question 3).
3. Have you begun a recycling program? (if yes, briefly describe this program and record the volume of mercury recovered in this process).
4. Have you computed the amount of mercury and money saved each time an alternative product is substituted for a mercury-containing product? (if yes, briefly describe the original product, the alternative, and the process you used to discover the alternative).
5. Have you set up a procedure to report mercury spills? (if yes, document the number of reported mercury spills).
6. Have you displayed your emergency procedures prominently and communicated all facets of your program to all members of your staff? (if yes, prepare a file of your communication pieces to share with other facilities).

To Tracking Progress of Mercury Pollution Prevention

EPA & State Agencies

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EPA's Mission Statement

The U.S. Environmental Protection Agency is charged by Congress to protect the Nation's land, air, and water systems. Under a mandate of national environmental laws, the Agency strives to formulate and implement actions that lead to a compatible balance between human activities and the ability of natural systems to support and nurture life.

The Agency's priorities include emphasizing flexibility and innovation, working in partnerships with private and government groups, and encouraging sound science and engineering. For example, under the "Common Sense Initiative" the Agency looks at pollution industry-by-industry, rather than by using the pollutant-by-pollutant approach of the past. Everyone concerned with a given industry--from manufacturers to community organizations--works together to fashion new strategies to emphasize preventing pollution.

EPA works in partnership with state, county, municipal, and tribal governments to carry out its mission. State and local standards may exceed federal standards, but they cannot be less stringent. EPA works with states and municipalities so they can carry out federal standards consistently but flexibly. The Agency also makes extensive efforts to involve the public in environmental protection. Some laws specifically invite public monitoring; others allow individuals to sue polluters or to notify environmental agencies of violations.

Through research, development, and technical assistance, EPA generates and disseminates sound science and engineering to support its missions. These efforts provide the data that the Agency needs to set and address priorities in identifying, assessing, and managing serious risks to public health and the environment. EPA's research combines the in-house expertise of Agency scientists and engineers with complementary research by universities and nonprofit organizations under a competitive, peer-review extramural program. EPA operates a large website at: http://www.epa.gov

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EPA's Role

EPA administers 11 comprehensive environmental protection laws. These are explained in summary form at the website: http://www.epa.gov/epahome/laws.htm

1. the Clean Air Act
2. the Clean Water Act
3. the Safe Drinking Water Act
4. the Comprehensive Environmental Response, Compensation, and Liability Act ("Superfund")
5. the Resource Conservation and Recovery Act
6. the Federal Insecticide, Fungicide, and Rodenticide Act
7. the Toxic Substances Control Act
8. the Uranium Mill Tailings Radiation Control Act
9. the Lead Contamination Control Act
10. the Ocean Dumping Ban Act
11. the National Environmental Education Act

The text of the laws and the regulations based upon them are accessible at the website: http://www.epa.gov/epahome/rules.html

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EPA's Structure

The Agency is directed by an Administrator and a Deputy Administrator, both appointed by the President with the advice and consent of the Senate. Nine Assistant Administrators, the Agency's General Counsel, and its Inspector General, also are named by the President and are subject to Senate confirmation.

The nine Assistant Administrators manage specific programs, such as those protecting the air, water, and land of Americans, or direct other Agency functions, such as enforcement of environmental laws.

Three Associate Administrators are named by the Administrator to carry out programs for public affairs, congressional and legislative relations, and regional, state, and local relations. Ten Regional Administrators work closely with state and local governments to carry out the Agency mission.

The EPA is divided into twelve offices, most of which offer websites containing large amounts of information and publications in downloadable format:

1. Office of Water: http://www.epa.gov/OW/ This is the entry point to large water submenus for all 10 EPA regions, and a large publications catalog.
2. Office of Air and Radiation: http://www.epa.gov/oar/oarhome.html This contains many air and pollution prevention publications in downloadable formats.
3. Office of Solid Waste and Emergency Response: http://www.epa.gov/epaoswer/ This contains many publications in downloadable format listed under the component programs.
4. Office of Pollution Prevention, Pesticides, and Toxic Substances: http://www.epa.gov/internet/oppts/ This offers large publications catalogs listed under "Consumer Information."
5. Office of Enforcement and Compliance Assurance: http://www.epa.gov/oecaerth/index.html
6. Office of Research and Development: http://www.epa.gov/ORD/
7. Office of Policy, Planning, and Evaluation: http://www.epa.gov/oppe/oppe.html
8. Office of Administration and Resources Management: http://www.epa.gov/epahome/OARM.html This includes the very large "Envirofacts" database of

articles

9. Office of International Activities
10. Office of Communications, Education, and Public Affairs: http://www.epa.gov/docs/OCEPAterms This is not a full website, but contains the large and extremely useful "Terms of Environment" glossary.
11. Office of Congressional and Legislative Affairs
12. Office of Regional Operations and State/Local Relations: http://www.epa.gov/regional/

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Glossary

Either select a word from the Word List or scroll through this file.

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Word List

A

abiotic
acid
acute toxicity
alkalinity
alloy
amalgam
anthropogenic
anthropogenic mercury emissions
antifouling
atmosphere

B

base
benthic
benthos
bioaccumulation
biocide
bioconcentration
bioconversion
biogeochemical cycle
biohazard
biomagnification
biomass
biosphere
biota

C

calorie
carcinogenic
catalyst
chlorophyll
chronic toxicity
combustion
condensation
conductivity
crematory

D

DDT (dichlordiphenyltrichloroethane)
degassing
degradation
degreaser
discharge
ductility

E

ecosystem
effluent
emission
environmental release
erosion
evaporation
excretion

F

fauna
felting process
fermentation
fertilizer
flora
fluorescence
food chain
fossil
fossil fuel
fungi
fungicide

G

gingivitis

H

half life
heavy metal(s)
herbicide
humic
humus
hydrograph
hydrologic cycle
hydrosphere
hydroxide

I

igneous
incinerator
inorganic
insecticide
ion

L

lagoon | landfill | latent heat
lethal dose 50% (LD50) | lethal dose (LD) | lime
lithosphere

M

manometer | mantle | mercury (Hg)
mercury/ionic mercury | mercury/elemental mercury | metabolism
metal | methylmercury

N

natural mercury emissions | neurotoxin | nitrate (NO3)
nitrite (NO2)

O

opacity | ores | organic
oxidation

P

paralysis | pathogen | pathology
PCB (polychlorinated biphenyl) | permeability | pesticide
pH | pharmaceutical | photochemistry
photosynthesis | plankton | poison
point-source pollution (PS) | pollution prevention | pollution reduction
porosity | parts per million (ppm) | precipitation (ppt)
predatory fish | prenatal | preservative

R

reduction | refuse | root zone
runoff

S

salinity | salt | saturated fat
sediment | smelting | sorb/sorption
soil moisture content (mc) | solvent | storage

T

TCDD | teratogenic | textile
threshold | toxic | toxicity
turbidity

U

uptake

V

valence | volatilization

W

wastewater

X

x-rays

Z

zooplankton

abiotic

a system characterized by the absence of life or living organisms.

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acid

a sour substance , typically soluble in water, which neutralizes bases to form salts.. A compound containing hydrogen atoms (H) which are capable of being replaced by a positive element or radical. A substance which gives up H to another substance.

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acute toxicity

any poisonous effect produced within a short time after exposure to the toxic compound, usually within 24 to 96 hours

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alkalinity

the total measurable bases (OH, HCO3, CO3) in a volume of water; a measure of a material's capacity to neutralize acids.

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alloy

a substance composed of two or more metals.

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amalgam

an alloy that consists chiefly of silver mixed with mercury and variable amounts of other metals and is used as dental filling.

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anthropogenic

man-made

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anthropogenic mercury emissions

the atmospheric emission of geologically bound mercury by human activity (e.g. emission of mercury in fossil fuels such as coal)

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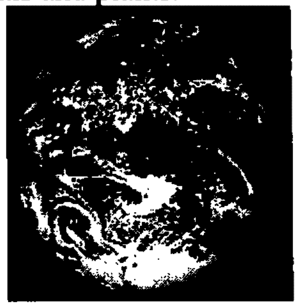
antifouling

a coating process or the like that prevents the accumulation of aquatic animals and plants.



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atmosphere

the gaseous layer that surrounds the earth (air)

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base

a substance which neutralizes an acid. A substance which furnishes hydroxyl (OH) ions and a positive ion, usually a metal. An ion which will combine with hydrogen ions. An alkali.

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benthic

of or pertaining to the benthos

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benthos

the bottom of the sea or of any body of water.

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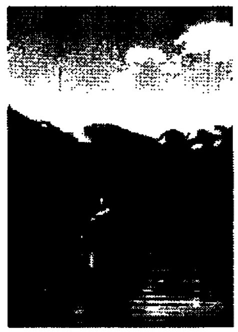
bioaccumulation



the uptake and retention of substances by an organism from its food and its surrounding environment. Chemicals that bioaccumulate become more concentrated at each successively higher level of the food chain.

Bioaccumulative chemicals can be toxic to organisms at the upper end of a food chain, such as predatory fish, loons, eagles, otters, or humans that eat fish

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biocide

any chemical that destroys life by poisoning.

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bioconcentration

a specific bioaccumulation process by which the concentration of a chemical in an organism becomes higher than its concentration in the air or water around the organism. Although the process is the same for both natural and manmade chemicals, the term bioconcentration usually refers to chemicals foreign to the organism.

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bioconversion

the conversion of biomass to usable energy, as by burning solid fuel for heat, by fermenting plant matter to produce fuel, as ethanol, or by bacterial decomposition of organic waste to produce methanol.

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biogeochemical cycle

a cycle dealing with the relationship between the chemical changes of the earth's crust of a given region and its flora and fauna, including the circulation of such elements as carbon, and nitrogen between the environment of the cells of living organisms.

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biohazard

the health risk posed by the possible release of a pathogen into the environment.

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biomagnification

it describes a process that results in the accumulation of a chemical in an organism at higher levels than are found in its food. It occurs when a chemical becomes more and more concentrated as it moves up through a food chain. At the top of the food chain an animal, through its regular diet, may accumulate a much greater concentration of chemical than was present in organism lower in the food chain.

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biomass

the amount of living matter in a given habitat.

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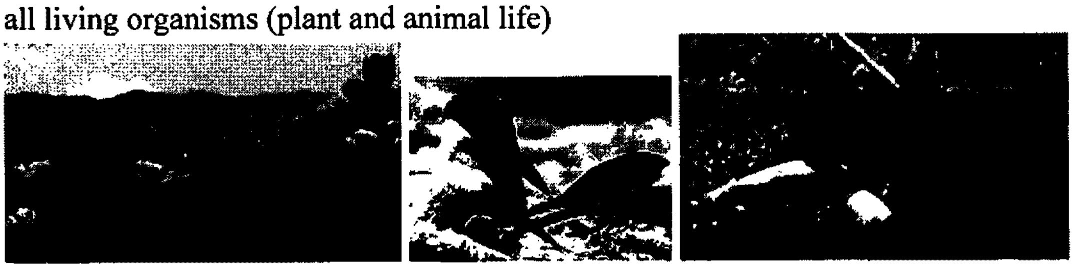
biosphere

all living organisms (plant and animal life)



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biota

living organisms.

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calorie

the amount of heat required to raise the temperature of one gram of water by one degree centigrade

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carcinogenic

event, condition or effect that produces cancer.

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catalyst

a substance or agent which alters the velocity of a chemical reaction but is not itself changed in the process. An enzyme is an example of a catalyst.

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chlorophyll

one of a number of green pigments present in plant cells which are essential in the utilization of light energy in photosynthesis.

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chronic toxicity

any poisonous effect having long duration, usually months or years.

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combustion

the act or process of burning.

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condensation

the process in which water vapor is cooled to the liquid phase. The water film produced is reffered to as condensate.

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conductivity

the property of conducting heat, electricity, or sound.

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crematory
a place where a dead body is reduced to ashes by fire.

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DDT (dichlordiphenyltrichloroethane)
a white, water-insoluble solid used as an insecticide, and whose agriculture use was prohibited in the U.S. in 1973.

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degassing
to free from gases.

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degradation
to wear down, reduce to lower quality, by erosion or reduce the complexity of a chemical compound

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degreaser
solutions that remove grease

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discharge
(1) the flow of surface water in a stream or canal or the outflow of groundwater from a well, ditch, or spring

(2) the release of wastewater through a pipe outlet or similar apparatus to a discharge point such as a ditch or storage lagoon

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ductility
malleable. Able of undergoing change of form without breaking.

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ecosystem
an ecological system, a natural unit of living and nonliving components which interact to form a stable system in which a cyclic interchange of materials takes place between living and nonliving units, as in a balanced aquarium or in a large lake or forest.

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effluent

the discharge of a pollutant in a liquid form from a containing space.

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emission

the act of sending forth, to emanate.

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environmental release

the introduction of a pollutant into the environment through waste-water discharge, air emission, or volatilization or leaching from soil, landfill, or other contaminated site

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erosion

the wearing away of the land surface by running water, wind, ice, or other geological agents, including such processes as gravitational creep. Geological erosion is natural occurring erosion over long periods of time. Accelerated erosion is more rapid than normal erosion and results primarily from man's activities. Erosion is further classified by the amount and pattern of soil removal and transport as gully, interrill, rill, sheet, and splash or raindrop erosion.

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evaporation

the process in which liquid water is transferred into the atmosphere.

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excretion

the elimination or discharge of waste products or substances present in excess from the body.

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fauna

the animal life of a locality or a region

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felting process

process where nonwoven fabrics of wool, fur, or hair are matted together by heat, moisture, and great pressure.

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fermentation

a change which converts grape sugar into ethyl alcohol.

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fertilizer

any substance, like manure, used to enrich the soil.

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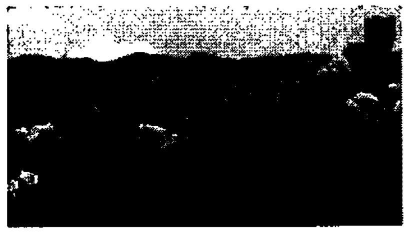
flora

the plant life of an area or locality.



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fluorescence

the property of absorbing light of a particular wave length and then emitting light of a different color and wave length.

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food chain

a group of organisms involved in the transfer of energy from its primary source, plants, as algae, insects, small fishes, larger fishes, fish-eating birds or mammals.

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fossil

any remains, impression, cast, or trace of an animal or plant of a past geological period. The term is generally restricted to parts which have been petrified or converted to stone.

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fossil fuel

any combustible organic material as oil, coal, or natural gas, derived from fossils.

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fungi

any of a large group of simple plants characterized by lack of chlorophyll as the mold, mildews, mushrooms, rusts, and smuts. Most have a filamentous body and subsist on organic matter.

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fungicide

an agent which kills or inhibits the growth of fungi

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gingivitis
swollen of the oral cavity gums.

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half life
the time it takes certain materials, such as mercury, to become chemically altered

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heavy metal(s)
any metal with a density of 5.0 or greater, especially one that is toxic to organisms, as lead, mercury, copper, and cadmium.

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herbicide
chemicals used to kill undesirable vegetation

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humic
of or pertaining to the humus

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humus
dark material in the soil consisting principally of organic matter.

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hydrograph
a graph which illustrates hydrologic measurements over a period of time, such as water level, discharge or velocity

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hydrologic cycle
the circulation of water in and on the earth and through earth's atmosphere through evaporation, condensation, precipitation, runoff, groundwater storage and seepage, and re-evaporation into the atmosphere

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hydrosphere

water held in oceans, rivers, lakes, glaciers, groundwater, plants, animals, soil, and air.

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hydroxide

a compound formed by the union of a metal or a radical with one or more hydroxyl (OH) groups, as sodium hydroxide (NaOH).

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igneous

produced under conditions involving intense heat, as rocks of volcanic origin.

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incinerator

a crematory instrument for the combustion (incineration) of organic material, leaving only ash.

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inorganic

not containing carbon or compounds of carbon. Not of plant or animal origin.

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insecticide

chemicals used to control undesirable insects

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ion

an electrically charged atom or group of atoms formed by the loss of one or more electrons, as a cation (positive ion), which is created by an electron loss, or as an anion (negative ion), which is crated by an electron gain.

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lagoon

water impoundment in which organic wastes are stored or stabilized or both

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landfill

a low area of land that is built up from deposits of solid refuse in layers covered by soil.

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latent heat

the heat (energy) absorbed or released as water changes between the gas (water vapor), the liquid (water droplets), and the solid (ice) states

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lethal dose 50% (LD50)

the dosage of a toxic substance required to kill one half of the organisms under study in a given period of time

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lethal dose (LD)

the amount of a toxic substance required to cause death of an organism under study in a given period of time

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lime

calcium oxide (CaO) or quicklime, prepared by heating calcium carbonate thus driving off carbon dioxide.

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lithosphere

a general term for the outer layer of the earth. A wind blown deposit of silty soil having little or no stratification

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manometer

a device for measuring the pressure exerted by gases or liquids. In its simplest form, it is a U-shaped tube containing a fluid (water or mercury) against which the pressure of an unknown is balanced.

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mantle

a general term for the outer covering of earth material

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mercury (Hg)

a silvery-colored metal, commonly called quicksilver. The term refers to any of the different chemical forms that mercury can take, including elemental mercury, methylmercury, and ionic mercury

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mercury (ionic)

Ionic mercury is water soluble and associates with particulates. Atmospheric deposition of elemental mercury is relatively fast, either as dry deposition or in precipitation. Combustion sources can emit both elemental mercury and ionic mercury. Ionic mercury can be produced in the atmosphere by the oxidation of elemental mercury by ozone or other oxidants

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mercury (elemental mercury)

The elemental form of mercury is familiar as the silvery liquid. Elemental mercury can volatilize to the atmosphere at normal temperatures. Over 90% of mercury in the atmosphere is in the elemental form, although other forms may be considerably higher than 10% near sources. Because elemental mercury does not adsorb to particulates and is not very water soluble, it is removed from the atmosphere very slowly with a half life in the atmosphere of about a year. Ingested elemental mercury is not absorbed, but the vapor is readily absorbed by the lungs

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metabolism

the chemical or energy changes which occur within a living organism or a part of it which are involved in various life activities.

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metal

any of a class of elementary substances, as gold, silver, or copper, all of which are crystalline when solid, and many of which are characterized by opacity, ductility, conductivity, and a unique luster when freshly fractured. An element yielding positively charged ions in aqueous solution of its salts

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methylmercury

any of several extremely toxic compounds formed from metallic mercury by the action of microorganisms and capable of entering the food chain.

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natural mercury emissions

the atmospheric emission of geologically bound mercury through natural processes (e.g. emission of mercury from volcanoes)

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neurotoxin

a poisonous substance which affects nervous system.

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nitrate (NO3)
an important plant nutrient and type of inorganic fertilizer (most highly oxidized phase in the nitrogen cycle). In water, the major sources of nitrates are septic tanks, feed lots and fertilizers.

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nitrite (NO2)
product in the first step of the two-step process of conversion of ammonium (NH4) to nitrate (NO3)

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opacity
the state or quality of being opaque.

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ores
a metal-bearing mineral or rock, or a native metal, that can be mined at profit. A mineral or natural product serving as a source of some nonmetallic substance, as sulfur.

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organic
compounds that contain carbon.

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oxidation
the removal of hydrogen from a compound. The loss of electron with an increase in positive valence of an element.

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paralysis
loss of sensation or loss of muscular function usually due to an injury to a nerve or a lesion within the central nervous system.

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pathogen
any disease-producing agent.

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pathology
the scientific study of disease, including causes, symptoms, signs, and various structural and functional alteration which may occur in its course.

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PCB (polychlorinated biphenyl)
a family of highly toxic chemical compounds known to cause skin diseases and suspected of causing birth defects and cancer.

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permeability
the capacity of a porous rock, sediment or soil to transmit a fluid such as water. The more fluid that can be transferred, the more permeable the material.

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pesticide
a chemical substance used to kill or control pests such as weeds, insects, fungus, mites, algae, rodents, and other undesirable agents

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pH
a numerical measure of acidity, or hydrogen ion activity used to express acidity or alkalinity; neutral is pH 7.0, values below 7.0 are acid, and above 7.0 are alkaline.

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pharmaceutical
a chemical drug or medicine.

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photochemistry
the branch of chemistry that deals with the chemical action of light.

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photosynthesis
The process which occurs in the cells of green plants in which simple sugars are formed from carbon dioxide and water in the presence of light and chlorophyll. The basic reaction by which light or radiant energy is converted to chemical energy and stored in the molecules of carbohydrates.

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plankton

aquatic organisms of fresh, brackish, or sea water which float passively or exhibit limited locomotor activity.

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poison

a substance, which upon contact or being introduced into an organism, impairs or prevents normal metabolic processes from taking place, thus altering the normal functioning of organs or tissues.

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point-source pollution (PS)

pollution of water from one place in a concentrated manner that is easy to identify. Ex. leaking underground storage tank or discharge pipe from a sewage treatment plant.

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pollution prevention (P2)

Altering a process or use of materials to reduce environmental release of mercury. Examples of pollution prevention include nonfossil-fuel energy production (e.g. wind energy), more efficient use of fossil-fuel energy, use of low-mercury coal, and use of alternative products (e.g. digital thermometers instead of mercury thermometers). According to the Federal Pollution Prevention Act of 1990, pollution prevention is "any practice which reduces the amount of any hazardous substance, pollutant, or contaminant entering the waste stream or otherwise released into the environment prior to recycling, treatment, or disposal...". Pollution prevention is also called "source reduction".

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pollution reduction

in this program, pollution reduction is the decrease in the use and environmental release of mercury.

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porosity

the degree to which the total volume of soil, gravel, sediment or rock is permeated with pores or cavities through which fluids (including air) can move

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parts per million (ppm)

a common basis for reporting water analysis. One ppm equals one unit of measurement per million units of the same measurement. One ppm equals one milligram per litre. One ppm is approximately the aspirin concentration formed when one aspirin tablet is dissolved in 100 gallons of water.

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precipitation (ppt)
moisture falling from the atmosphere in the form of rain, snow, sleet or hail.

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predatory fish
a fish living by killing and eating other animals.

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prenatal
before birth.

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preservative
a chemical substance used to preserve food or other organic material from decomposition or fermentation.

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reduction
a chemical reaction in which one or more electrons are gain by the substance reduced. The addition of hydrogen atoms or the loss of oxygen atoms.

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refuse
something that is discarded as worthless or useless; rubbish, trash, garbage.

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root zone
the depth of soil penetrated by crop roots. Also called the vadose zone.

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runoff
the flow of water from the land to oceans or interior basins by overland flow and stream channels.

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salinity
the concentration of dissolved salts in water.

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salt
a substance other than water resulting from the reaction between an acid and a base.

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saturated fat
a type of single-bond animal or vegetable fat, as that found in butter, meat, egg yolks, and coconut or palm oil, that in humans tends to increase cholesterol levels in the blood.

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sediment
that which settles to the bottom, as in a lake or a river.

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smelting
fusion or melting process in order to separate metals.

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sorb/sorption
to take up and hold (to sorb) either by absorption (to absorb) or adsorption (to adsorb).

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soil moisture content (mc)
the portion of water in a soil that can be readily absorbed by plant roots. It is the amount of water released between in situ field capacity (FC) and the permanent wilting point (WP).

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solvent
a liquid in which a substance is dissolved.

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storage
the temporary deposit of a chemical in body tissue or in an organ. Storage is just one facet of chemical bioaccumulation. The term also applies to other natural processes, sucs as the storage of fat in hibernating animals or the storage of starch in seeds.

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TCDD

a by-product of pesticide manufacture; a toxic compound that is carcinogenic and teratogenic in certain animals.

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teratogenic
capable of interfering with the development of a fetus, causing birth defects.

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textile
any cloth or goods produced by weaving, knitting, or felting.

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threshold
the lowest limit at which a certain phenomenon will occur.

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toxic
of, pertaining to, affected with, or caused by a poison.

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toxicity
the quality, relative degree, or specific degree of being toxic or poisonous.

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turbidity
a measure of water cloudiness caused by suspended solids.

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uptake
it describes the entrance of a chemical into an organism -- such as by breathing, swallowing, or absorbing it through the skin -- without regard to its subsequent storage, metabolism, and excretion by that organism.

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valence
the combining power of an atom; its capacity to combine with other atoms to form a molecule, expressed in terms of the number of hydrogen atoms or their equivalent with which any atom may combine.

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volatilization

loss of a substance through evaporation or sublimation. When manure is spread on a field, ammonia-nitrogen in the manure may volatize quickly and be lost as fertilizer unless it is incorporated into the soil.

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wastewater

water that has been used in washing, flushing, manufacturing, etc.; sewage

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x-rays

also know as Roentgen rays. Radiant energy of short wave length produced by high speed electron striking a metal target in a vacuum.

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zooplankton

the animals of plankton

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