United States Environmental Protection Agency

Office of Pollution Prevention and Toxics, Washington, DC 20460

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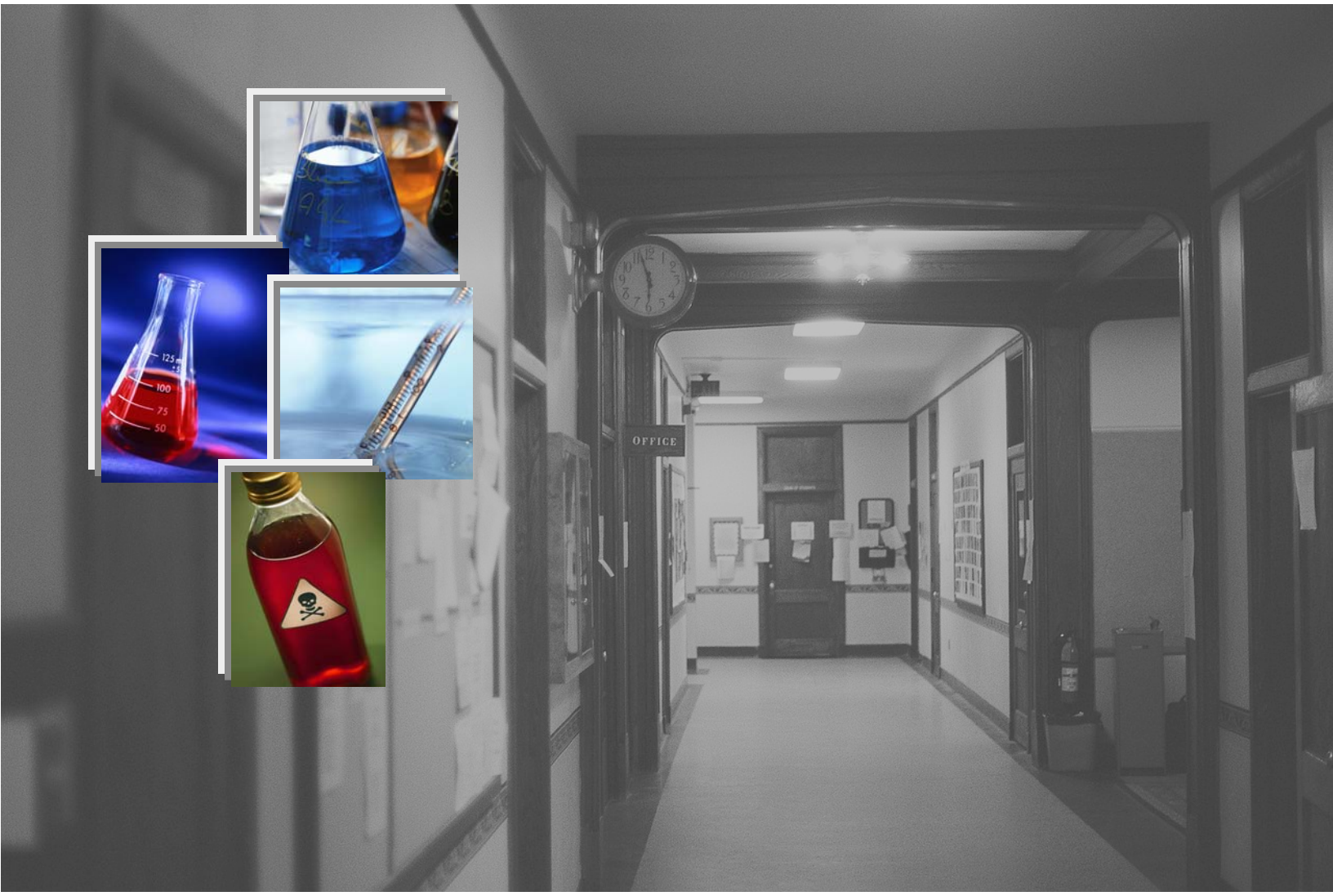
Mercury and Hazardous Chemicals in Schools:

A Manual for Students in Southeast Asia



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Acknowledgements and Disclaimer

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Disclaimer

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Why is Chemical Safety Important?

1.1 Children and Adolescents are Particularly Susceptible to Hazardous Chemicals

Children and adolescents, up to approximately age 20, are more susceptible than adults to potential health risks from chemicals and environmental hazards. Hazardous chemicals can interrupt or alter the normal development of a child's body, leading to lasting damage. Since children are smaller than adults, similar levels of exposure to toxic chemicals will have a greater effect on children compared to adults. In addition, the prevalence of chemicals in the modern era means that children today are exposed to dangerous chemicals throughout their lives, beginning in the womb.

Exposure to even common chemicals such as gasoline, cleaning products, and paints can result in health problems, including memory loss, decreased problem-solving ability, decreased attention span, impaired dexterity and hand-eye coordination, altered reaction time, and altered personality or mood.[1] Exposure to mercury, which can occur at school when a thermometer breaks or at home from eating contaminated fish, can cause severe nausea, vomiting, abdominal pain, kidney damage, inflammation of mouth and gums, excessive salivation, loosening of teeth, muscle tremors, spasms, personality changes, depression, irritability, and nervousness. Students should note that risks associated with exposure to a specific chemical are dependent on many factors, including the chemical's hazard level (for example, how toxic it is), the route of exposure (for example, contact with skin, inhalation, ingestion), and the duration of exposure (for example, minutes, days, years).

A hazardous materials (hazmat) unit responding to a chemical spill.

Children generally rely on adults to protect them from the risks associated with exposure to dangerous environmental agents. Through education and training, however, children and adolescents can empower themselves about the risks associated with hazardous chemicals. Once young people are aware of the threats in their everyday lives, they can take action with the adults in their schools and communities to create safer conditions. This manual will inform you about health risks associated with exposure to chemicals and environmental hazards, especially mercury, and explain what you as a student can do to promote chemical safety in your school and community.

[1]Amber E. Barnato, MD, MPH, Children's Health Environmental Network, Children and Solvents, http://www.cehn.org/cehn/trainingmanual/manual-solvents.html, Accessed February 25, 2008.

1.2 Case Studies: It Could Happen in Your School!

School is one of the most common places where children and adolescents encounter hazardous chemicals. Schools routinely use a variety of potentially dangerous chemicals and equipment for laboratory experiments, cleaning, and grounds-keeping. In schools where administrators and teachers fail to manage chemicals properly, an accident is just waiting to happen. Chemical spills and explosions in schools usually have a big impact on children and adolescents because they are the largest population of a school, and they spend a lot of time there.

Elemental mercury being poured into a beaker.

Do you think a chemical accident cannot happen in your school? The following case studies show that chemical accidents can happen at any time in any school where chemicals are not being handled and stored safely.

1.2.1 A Mercury Spill at a School in the Philippines

During the evening of 16 February 2006, the University of the Philippines, Manila National Poison Management and Control Center (UP/NPMCC) received a call from a young person complaining of numbness, redness, and pain in the extremities. The UP/NPMCC recognized these symptoms as characteristic of acute mercury poisoning. They traced the mercury exposure to an elemental mercury spill that had occurred earlier that day in a classroom at St. Andrew's School in Paranaque City, Republic of the Philippines (RP). Elemental mercury is a toxic metallic liquid. Local and national public health personnel closed the school in order to prevent the spread of mercury and poisoning of more students. 203 students and faculty were evaluated for acute mercury exposure as a result of the spill, and 10 students were admitted to the Philippines General Hospital. The spill was so widespread in the school that local contractors hired to clean it up were unable to fully remove all traces of the mercury. The RP Secretary of Health asked for international assistance from the U.S. Environmental Protection Agency (USEPA) in order to remediate the mercury spill.[2]

1.2.2 A Mercury Spill at a School in Washington, DC, USA

On 2 October 2003, a Hazardous Materials ("Hazmat") unit responded to an emergency call at Ballou High School in Washington, DC, where a mercury spill had occurred. A student had taken 250 milliliters of elemental mercury from a school science laboratory and sold some of it to other students, which caused the spillage. When spilled, liquid elemental mercury breaks apart into drops that cling to shoes, clothes, and other surfaces. By the time the Hazmat unit and local public health officials arrived at the high school, it was too late to contain the extent of the mercury spill. Emergency workers found mercury contamination in classrooms, the gymnasium, and the cafeteria of the school. Students were sent home in an

[2] Final Report, Republic of the Philippines and U.S. Environmental Protection Agency, Collaborative Mercury Spill Response, St. Andrews School Mercury Spill Assessment and Removal La Huerta, Paranaque City, Philippines, 20-25 May 2006.

effort to keep them safe from the spill, but contaminated students unknowingly spread mercury from the school into their homes. As a result, 16 families were displaced from their homes for a month, and Ballou High School was closed for 35 days. The total cost for cleanup resulting from the spill was US$1,500,000.[3]

Drops of elemental mercury.

1.2.3 An Accident with Chemicals in a Science Class near New York City, USA

On the morning of 16 January 2008, fire and emergency workers responded to a chemical accident at Somers High School, located in Westchester County, near New York City. During a science class, a student had dropped a bottle containing bromine, a corrosive liquid chemical that can harm the respiratory system if it is inhaled. The bottle broke and released approximately 90 milliliters of bromine onto the floor of the classroom. Bromine is very volatile, and fumes quickly spread into nearby hallways and classrooms, causing firefighters to evacuate the school as a safety precaution. The school was closed for one day due to the spill, and 11 students were treated at a local hospital for exposure to bromine.[4]

Bromine liquid and vapor in a round-bottom flask.

1.2.4 An Accident with Cleaning Chemicals at a School in Chicago, USA

On the morning of 18 January, 2008, the Chicago Fire Department responded to an emergency call at Southwood Junior High School. A janitor had spilled a container of bleach while he was cleaning a bathroom, and the bleach mixed with other cleaning chemicals, releasing toxic, pungent-smelling fumes that spread throughout the school. Students and teachers complained of headaches, nausea, vomiting, and trouble breathing. Fire officials evacuated the school and sent students home for the rest of the day as a safety precaution. 24 students and 2 teachers were treated at a local hospital for exposure to the chemical fumes.[5]

1.2.5 An Accident with Chemical Pesticides at a School near New York City, USA

On a Monday morning in October 1992, students and teachers arrived at Eastchester High School, near New York City, to find a layer of liquid covering the floors and desks of the school and noxious fumes throughout

[3] For additional information, see EPA's Superfund Featured News Article, http://www.epa.gov/superfund/news/mercury.htm

[4] Corcoran, Terence and Chris Serico, "Somers High expected to open today after chemical spill caused evacuation," The Journal News, 17 January 2008, http://www.lohud.com/apps/pbcs.dll/article?AID=/20080117/NEWS01/801170397/1027/NEWS11.

[5] Hood, Joel, "Cleaning chemicals sicken 26 at school," The Chicago Tribune, 18 January 2008 http://www.chicagotribune.com/news/local/chi-chemspill_webjan19,0,779779.story.

the building. The school had been sprayed with pesticides the day before to kill cockroaches, but the chemicals had been applied too liberally, causing chemical residue to pool on surfaces inside the building. Students complained of headaches, nausea, dizziness, skin rashes, and respiratory problems. One student was admitted to the hospital, and the school was closed for three weeks in order to completely cleanup the pesticide residue.[6, 7] The pesticides used in the school included chlorpyrifos, diazinon, and resmethrin. Since 1992, some restrictions have been placed on the use of these pesticides in the U.S., although they are still used today in many countries.

Student from Southwood Junior High School being treated for inhalation of chemical fumes.[4]

[6] Lombardi, Kate Stone, "Schools weigh risks of pesticides," The New York Times, 10 January 1993, http://query.nytimes.com/gst/fullpage.html?res=9F0CEED8143FF933A25752C0A965958260&sec=&spon=&pagewanted=all&st=cse&sq=school+pesticide+poisoning&scp=5.

[7] Ikramuddin, Aisha, "School Days, Sick Days: Lessons in Pesticides and Classrooms," National Geographic Magazine Green Guide, http://www.thegreenguide.com/doc/44/schools, Accessed January 31, 2008.

Chapter

2

Hazardous Chemicals and Equipment in Schools

Chemicals are everywhere in today's modern world. We use chemicals to clean our houses and get to and from work or school. Chemicals are in the air we breathe and the clothes we wear. Most of us use chemicals everyday without incident. If they are used incorrectly or in the wrong amounts, however, all chemicals can be hazardous, even seemingly innocuous chemicals like table salt (sodium chloride) and water. Some chemicals are inherently dangerous under any conditions, such as elemental mercury. Since students spend a majority of their time in school, they should be aware of the most common potentially hazardous chemicals and equipment in their schools.

2.1 Common Hazardous Chemicals and Equipment in Schools

Many different types of chemicals are found throughout schools in science laboratories, vocational shops, art studios, custodial areas, kitchens, nurses' offices, and athletic fields. When used and stored correctly, chemicals can provide benefits to students, teachers, and administrators. Chemicals help students learn scientific principles and create artistic masterpieces. Chemicals also keep schools clean and free from insects and rodents. Table 1 lists some examples of potentially hazardous chemicals and equipment commonly found in schools.

Universities and high schools offer advanced science, art, and vocational classes, so they tend to have larger inventories of potentially hazardous chemicals and equipment than middle and elementary schools. While most chemicals found in schools have been purchased by school administrators, sometimes employees and students bring chemicals into the school for their own personal use.

2.2 Chemical Categories: Not all Chemicals are Equally Hazardous

Some chemicals are more hazardous than others. In order to help safeguard users of potentially hazardous chemicals, chemicals are typically organized into categories based on what type of danger they pose. To help communicate the possible risks associated with different chemicals, the United Nations has developed an internationally accepted set of symbols called the Globally Harmonized System of Classification and Labeling of Chemicals.[8] Table 2 lists the symbols, their general definitions, examples of chemicals in each category, and some appropriate safety measures. Look for these symbols on the containers of chemicals you use in school.

[8] United Nations Economic Commission for Europe, Globally Harmonized System of Classification and Labeling of Chemicals, 2005, http://www.unece.org/trans/danger/publi/ghs/ghs_rev01/01files_e.html.

Table 1. Examples of Hazardous Chemicals and Equipment Commonly Found in Schools

Location in School	Type of Product	Examples of Hazardous Components
Science Laboratories	Concentrated Acids	Hydrochloric Acid Nitric Acid
	Concentrated Bases	Sodium Hydroxide
	Solvents	Methanol Methylene Chloride
	Oxidizers	Lead Nitrate
	Compressed Gases	Oxygen Nitrogen
	Toxins	Cyanide Salts Chromate (VI) Salts Lead Salts Mercury Salts
	Mercury Thermometers, Barometers, Molecular Motion Devices	Elemental Mercury
Vocational and Trade Shops	Paints, Paint Thinners, Adhesives, Lacquers, Primers	Petroleum Naphtha Turpentine
	Cleaning Supplies and Detergents	Phosphoric Acid Sodium Silicate
	Compressed Gases	Acetylene Oxygen Nitrogen
	Automobile Fluids	Gasoline Benzene Ethylene Glycol
Art Studios	Paints, Inks, Paint Thinners, Adhesives, Lacquers, Primers	Toluene Turpentine Mineral Spirits
	Pottery Glaze	Lead
	Pigments	Cadmium Manganese Chromium
Custodial Areas	Cleaning Supplies and Detergents	2-Butoxyethanol Trisodium Phosphate Ammonia Sodium Hypochlorite
	Drain Cleaners	Potassium hydroxide
	Pesticides	Permethrin
	Swimming Pool Disinfectant	Chlorine Gas or Tablets
Kitchens and Cafeterias	Pesticides	Permethrin
	Refrigerants	Freon Ammonia
	Cleaning Supplies	Ammonium Hydroxide Sodium Hypochlorite
Nurses' Offices	Medical Equipment	Mercury (in thermometers and blood pressure manometers)
Grounds and Athletic Fields	Pesticides	Chlorpyrifos Diazinon Resmethrin
	De-Icer (for sidewalks)	Sodium Chloride
	Fertilizers	Ammonium Nitrate

Table 2. Chemical Categories, Symbols, and Safety Measures

Chemical Type	Description and Examples	Examples of Safety Measures
 **Flammable**	Chemicals that have the potential to catch fire rapidly and burn in the air. Liquids, gases, and solids (in the form of dusts) can be flammable and/or explosive. *Examples: paint thinner; laboratory solvents (acetone, alcohols, acetic acid, hexane); some adhesives*	• Do not use near an open flame • Store in "flammables only" storage cabinet
 **Explosive**	Solid or liquid substance (or mixture of substances) which is in itself capable by chemical reaction of producing gas at such a temperature and pressure and at such a speed as to cause damage to the surroundings. *Examples: hydrazine, nitroglycerine, ammonium nitrate*	• Do not use near sparks or static electricity • Wear face shield or use glove box • Transport with no sudden movements or jostling
 **Corrosive**	Chemicals that can burn, irritate, or destroy living tissue or corrode metal through direct chemical action. This category includes strong acids and bases (alkalines), as well as dehydrating agents and oxidants. *Examples: sulfuric, nitric, and hydrochloric acids; potassium, ammonium, and sodium hydroxides (bases); hydrogen peroxide or chlorine (oxidants)*	• Wear safety glasses • Wear a long-sleeved shirt • Wear long pants • Wear closed-toe shoes • Wear gloves
 **Oxidizer**	Chemicals that cause or contribute to the combustion of other materials by yielding oxygen. *Examples: nitrates; chlorates; nitrites; peroxides; picric acid (crystallized); ethyl ether (crystallized); water reactive metals (e.g., sodium)*	• Do not use near an open flame • Wear safety glasses • Wear a long-sleeved shirt • Wear long pants • Wear closed-toe shoes • Wear gloves
 **Poison**	Chemicals that, even in small amounts, can injure living tissue when ingested, inhaled, or absorbed into the skin. *Examples: mercury, arsenic, lead, asbestos, cyanide*	• No eating or drinking! • Use a respirator • Wear safety glasses • Wear a long-sleeved shirt • Wear long pants • Wear closed-toe shoes • Wear gloves
 **Low Level Hazard**	Chemicals that are harmful if swallowed, inhaled, or in contact with the skin. This category also includes substances that cause eye, skin, or respiratory irritation. *Examples: ammonium nitrate, ferrous sulfate*	• No eating or drinking! • Wear safety glasses • Wear a long-sleeved shirt • Wear long pants • Wear closed-toe shoes • Wear gloves

Chemical Type	Description and Examples	Examples of Safety Measures
 **Severe Chronic Hazard**	Chemicals that are known or suspected carcinogens, mutagens, reproductive toxins, or systemic target organ toxins. This category also includes any substances that are aspiration hazards, meaning they may cause allergic/asthma symptoms or breathing difficulties when inhaled. *Examples: benzene, carbon tetrachloride (carcinogens); acrylamide (mutagen); lead compounds, mercury compounds (reproductive toxins)*	• No eating or drinking! • Use a respirator or face mask • Wear safety glasses • Wear a long-sleeved shirt • Wear long pants • Wear closed-toe shoes • Wear gloves
 **Environmental Hazard**	Chemicals that have acute or chronic toxicity toward aquatic life. *Examples: dioxin, DDT*	• Do not pour excess down drain or sink! • Do not dump of waste in storm drain or sewer!

Students should familiarize themselves with the categories in Table 2 so they can identify potentially hazardous chemicals found in their schools and communities. Whenever you encounter a new chemical, particularly in school, you should ask yourself, "What type of chemical is this? What category does it belong to?" Knowing the category of a chemical dictates the measures that should be taken to safely use the chemical. For example, you would never use a flammable chemical near an open flame, and you would be sure to wear gloves, safety glasses, a long-sleeved shirt, long-sleeved pants, and closed-toe shoes to protect your skin when using a corrosive chemical. The type of gloves (e.g., latex, nitrile) will vary depending on the particular chemical.

Check It Out

Students should completely avoid using chemicals that are poisonous or severe chronic hazards. If you find yourself in a situation where you are asked to use a poisonous or toxic chemical, particularly at school, you should talk to your teacher or school principal. Explain the risks associated with using the particular chemical, and ask if an alternative, safer option is available. In most cases, less toxic chemicals can be substituted in experiments that call for poisonous reagents.

2.3 What You Can Do to Prevent Chemical Accidents at Your School

As the case studies in Section 1.2 illustrate, accidents can happen anytime teachers and administrators are not following safe chemical management practices. As students, you can take action to help reduce your exposure to hazardous chemicals. This section outlines some steps you can take to help prevent chemical accidents at your school. Even the best practices cannot prevent all accidents, however, so make sure your school administrators have an emergency response and spill cleanup plan in place, in the event that you have a spill at your school.

2.3.1 Chemical Management

In order to prevent accidents, school chemicals must be managed safely and effectively. Successful chemical management practices involve thoughtful purchase decisions, careful inventory supervision, safe storage, and proper disposal.

Examples of old chemicals stored in unsafe containers.

All schools should have a chemical hygiene officer who supervises the chemical management process. Effective chemical management begins with a well-organized purchasing plan. Over-purchasing of chemicals is a common mistake schools make, and the extra, unused chemicals represent a safety hazard. Encourage your chemical hygiene officer to purchase the least number and least toxic versions of chemicals possible that will meet the needs of teachers and staff. The chemical hygiene officer should also monitor the inventories of chemicals to help prevent the accumulation of old or expired chemicals. Most chemicals must be used in a certain time period, or they will begin to break down, sometimes into dangerous by-products. In conjunction with careful inventory supervision, the chemical hygiene officer should establish safe storage practices for all chemicals in the school. Many chemicals are incompatible, such as acids and bases, and should not be stored next to each other. Poor chemical storage can lead to accidents that could harm you and your classmates. Take action with your administrators and chemical hygiene officer to make sure your school is following safe chemical storage procedures.

The final step in a good chemical management program is disposal. Many of the chemicals used in schools are considered hazardous waste, and need to be disposed of safely in order to prevent contamination of local water tables, soil, and sediments. Improper disposal of hazardous chemicals can result in fires, explosions, and contamination, with subsequent toxic exposure to students and teachers. In most cases, chemicals should NOT be rinsed down the drain! Encourage your school administrators to consult with the local hazardous waste disposal agency for the proper ways to safely dispose of chemical waste from your school.

Example of incompatible chemical storage: when bleach and ammonia are mixed together, toxic fumes of chlorine gas are released.

2.3.2 Pollution Prevention and Green Chemistry

Pollution prevention programs reduce or eliminate the amount of hazardous waste created through the routine use of chemicals. Less waste generated means less waste to dispose of, which increases the safety of students, teachers, and administrators. An example of pollution prevention is

substituting non-toxic natural cleaning products for bleach and ammonia. Encourage administrators to establish a pollution prevention program in your school to explore less hazardous alternatives for chemicals used for cleaning, pest control, grounds-keeping, and science education.

Green chemistry is a type of pollution prevention that uses fewer and less toxic chemicals in experiments, compared to traditional chemistry curricula. Microscale chemistry and small-scale chemistry are similar concepts that involve scaling down the quantities of chemicals required for science experiments, resulting in improved laboratory safety. In situations where green or small-scale alternatives are not feasible, encourage your instructor to conduct a demonstration experiment so you and your classmates are not required to work with hazardous or toxic chemicals. Each of these options requires a smaller amount of chemicals than traditional experiments, which decreases the risk of student exposure to hazardous chemicals.

Chapter

3

Be Smart About Mercury

In recent years, the global community has become more aware of the hazardous consequences of mercury exposure. Many countries and regions are phasing out the use of mercury, mercury-containing chemicals, and mercury-containing equipment and replacing them with non-toxic alternatives. Nevertheless, mercury, mercury-containing chemicals and mercury-containing equipment continue to be used in schools, sometimes with dire consequences, as the case studies in Section 1.2 demonstrate. This chapter describes common mercury sources, uses, and alternatives, so students can educate and protect themselves and their families from accidental mercury poisoning.

Mercury is a dense, silver-colored metal. It the only element that is liquid at room temperature.

3.1 What is Mercury and Why is it Dangerous?

Mercury (Hg) is element number 80 on the periodic table; it has a molecular weight of 200.59 grams per mole. It is also called quicksilver or liquid silver due to its silver color. Mercury is unique because it is the only elemental metal that is liquid at room temperature. It is also very dense: mercury is more than 13.5 times more dense than water at room temperature.[9] Due to its unusually high density for a liquid, mercury has traditionally been used in thermometers to measure temperature and in barometers to measure atmospheric pressure. Other common applications of elemental mercury include some types of light switches, batteries, and tooth fillings. Mercury is also used in the chlor-alkali industrial process, which produces hydrogen, sodium, chlorine, and potassium hydroxides. In addition, some people use mercury in various religious and cultural practices.[10] Figure 1 illustrates the most common worldwide uses of mercury compounds in 2000, which include batteries, gold and silver mining, and dental amalgams.

[9] O'Neil, M.J., P.E. Heckelman, C.B. Koch, K.J. Roman, (eds.) 2006. The Merck Index: An Encyclopedia of Chemicals, Drugs, and Biologicals, Fourteenth Edition. Merck & Co., Inc., Whitehouse Station, NJ, USA.
[10] Riley, Donna M., C. Alison Newby, Tomas O. Leal-Almeraz, Valerie M. Thomas. 2001. Assessing Elemental Mercury Vapor Exposure from Cultural and Religious Practices. *Environmental Health Perspectives*, 109(8): 779-784.

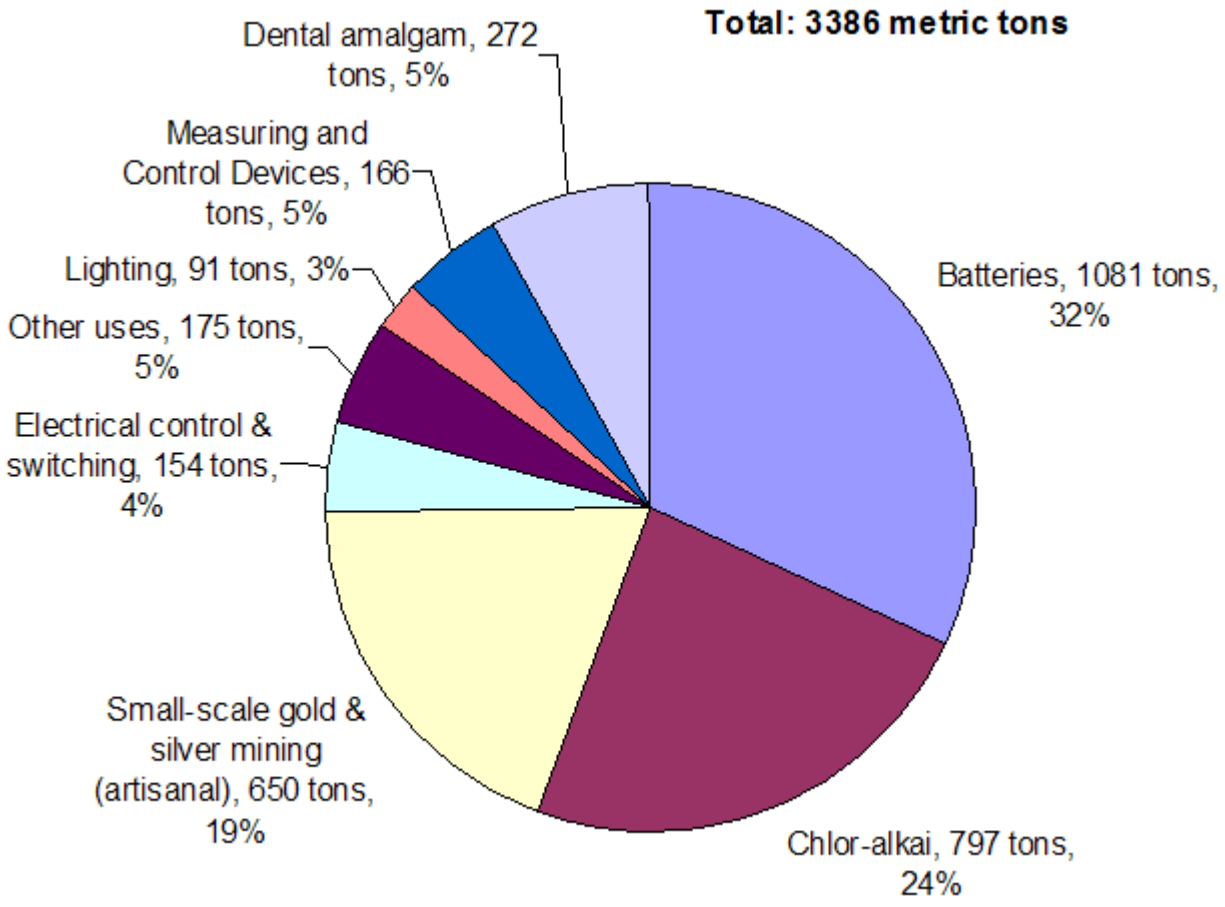

Figure 1. Worldwide uses of mercury in 2000.[11]

[11] Data from U.S. Environmental Protection Agency, Roadmap for Mercury: Figure 6, Chapter V (Addressing International Mercury Sources), 2006, http://www.epa.gov/mercury/roadmap.htm, Accessed March 31, 2008.

Despite its many uses, mercury is a dangerous acute (immediate) and chronic (long-term) poison for humans. The human body quickly absorbs mercury via contact with the skin, ingestion (eating), or inhalation (breathing) of mercury vapor. Symptoms of acute mercury poisoning include severe nausea, vomiting, abdominal pain, bloody diarrhea, and kidney damage. Chronic effects include inflammation of mouth and gums, excessive salivation, loosening of teeth, muscle tremors, spasms, personality changes, depression, irritability, and nervousness. Mercury is also a reproductive toxin, which makes mercury exposure especially dangerous for women who are pregnant or could become pregnant.

Although all forms of elemental mercury are dangerous, elemental mercury vapor is especially toxic. Mercury vapor is a colorless and odorless gas, so you do not know when you are inhaling it. In an enclosed space like a bedroom or classroom, very high levels of mercury vapor can be released from elemental mercury left open to indoor air.

In the event that elemental mercury is spilled in schools, homes, or in other enclosed areas, it is extremely dangerous.

Elemental mercury and compounds containing mercury exist naturally at relatively low levels in air, water, rocks, and soil. Mercury has three different forms: elemental, inorganic, and organic. Table 3 lists some examples of products that contain each of these forms of mercury and the ways humans can be exposed to them.

Inorganic mercury compounds are powders or crystals formed via reaction of elemental mercury with other elements, such as chlorine, sulfur, or oxygen. Inorganic mercury compounds are also called mercury salts. They are used in some skin-lightening creams, antiseptic creams, and ointments. School science classes sometimes use mercury salts in chemistry experiments. Inorganic mercury does not readily evaporate so it is not easily inhaled, but it can be absorbed by contact with skin and by ingestion. An example of the inorganic mineral mercury sulfide (HgS), also called cinnabar, is shown in Figure 2.

Table 3. Examples of Common Products that Contain Mercury.

Form of Mercury	Common Products that Contain Mercury	Routes of Toxic Exposure
Elemental Mercury	*Some types of:* • Thermometers • Manometers • Light switches • Batteries • Tooth fillings	• Inhalation of vapor (very dangerous!!!) • Contact with skin • Ingestion
Inorganic Mercury ("Mercury Salts")	*Some types of:* • Cosmetics • Skin-lightening creams • Antiseptic creams • Ointments • School chemistry experiment reagents	• Contact with skin • Ingestion
Organic Mercury (such as methyl mercury)	• Contaminated fish • Contaminated shellfish	• Ingestion

Figure 2. Crystals of mercury sulfide (HgS).

Organic mercury compounds are formed when mercury combines with carbon in living systems. Microorganisms and bacteria in water, soil, and sediment produce one of the most common forms of organic mercury, called methyl mercury. Many living organisms bioaccumulate methyl mercury, which means the level of the chemical builds up in their tissues because they ingest it faster than their bodies can excrete it. Figure 3 shows how methyl mercury can bioaccumulate in the food chain. Animals in the aquatic ecosystem, such as fish and birds, are particularly susceptible to methyl mercury

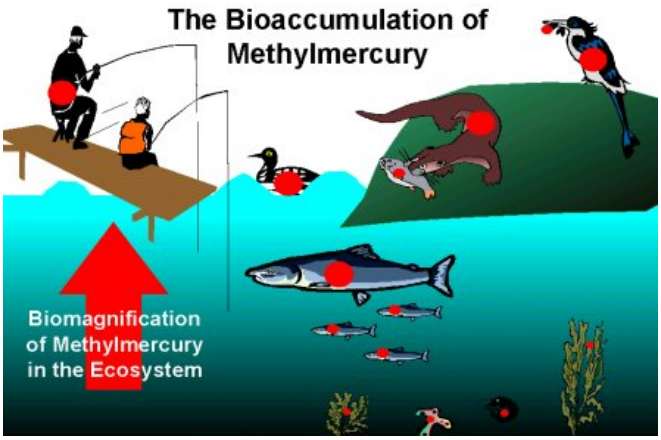

Figure 3. Bioaccumulation of methyl mercury in an aquatic ecosystem.

Red dots indicate the presence of methyl mercury in plants and animals. The size of the red dot corresponds to the amount of bioaccumulation; large dots represent higher concentrations of methyl mercury.

bioaccumulation. For example, when a bigger fish, like a tuna, eats a smaller fish, like a herring, the methyl mercury in the small fish bioaccumulates in the big fish. Bioaccumulation can be a problem for people who eat a significant amount of fish and shellfish in their diet. When people eat seafood contaminated with methyl mercury on a regular basis, the chemical builds up in their bodies and poisons them over time. Fetuses, babies, and young children are particularly susceptible to the chronic effects of methyl mercury poisoning because the chemical can have devastating, irreparable effects on the developing central nervous system.

3.2 The Global Mercury Cycle

Since mercury is a naturally-occurring element that is also used industrially and commercially, both natural processes and human activities release mercury into the environment. Mercury has a global cycle, shown in Figure 4. Weathering of rocks and volcano eruptions are examples of natural processes that introduce mercury into air, water, and soil. Burning of fossil fuels, especially coal, is a significant source of mercury emissions. In addition, municipal waste incinerators, landfills, and trash dumps release elemental mercury from products, such as thermometers, into the environment. Mercury in landfills and trash dumps can also reach lakes, rivers, and oceans by seeping into the surrounding soils and groundwater. In this way, mercury switches between its three forms in the environment and travels around the world in air, water, sediment, soil, rocks, and animals.

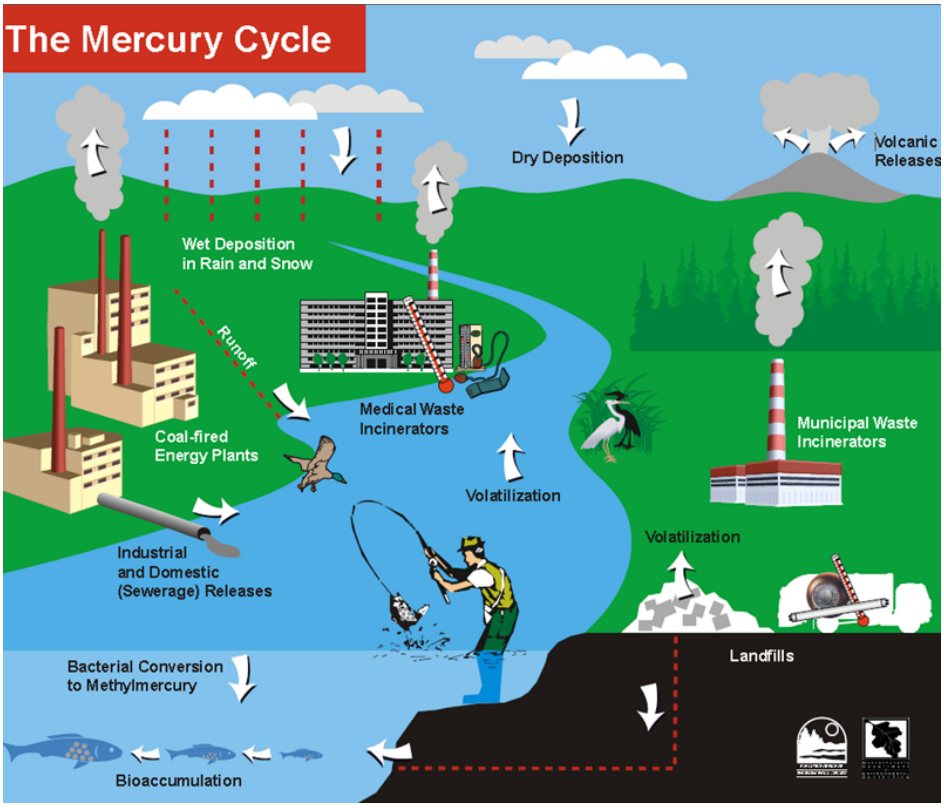

Figure 4. The global mercury cycle.[12]

[12] Northeast Waste Management Officials Association, The Mercury Cycle, http://www.newmoa.org/prevention/topichub/22/mercury_cycle.pdf, Accessed March 31, 2008.

3.2.1 Mercury in Thailand Industries

There are several industries in Thailand that use mercury or release it as a by-product. In 2003, Thailand imported approximately 14 metric tons of mercury, primarily for application in fluorescent lamp production, dentistry, and lab analysis. A Ministry of Industry "green label" program has reduced the amount of mercury in paint, but up to 25% of paint factories still use mercury in their manufacturing process. At least four major thermal power plants in Thailand currently burn coal to produce electricity; since all coal contains mercury, burning coal releases mercury into the air. Oil and gas operations have taken steps to reduce mercury emissions, but many plants still discharge waste into the Gulf of Thailand that contains trace amounts of mercury.

3.3 Mercury in Schools

Schools use a variety of elemental and inorganic mercury products, many of which may come into direct contact with students. Chemistry students may use mercury salts as reagents in laboratory reactions. Science teachers often use equipment that contains elemental mercury, such as thermometers and barometers, to illustrate scientific principles. Occasionally, teachers keep vials or beakers of elemental mercury in the classroom to demonstrate mercury's unique characteristics to students studying the periodic table of elements. School nurses may use mercury fever thermometers and mercury sphygmomanometers (blood pressure-measuring devices) to treat sick students. All of these uses of mercury are very dangerous, because they could result in spills and subsequent acute poisoning of students.

Example of a mercury fluorescent lamp on the ceiling of a classroom.

Mercury can also be found in building equipment, such as fluorescent lamps, thermostats, electrical switches, flow meters, and boiler controls. Some latex paints and pesticides also contain mercury. In most cases, mercury in existing building equipment does not pose an immediate risk to students and teachers because the mercury is not easily accessible. As mercury-containing building materials degrade and break, however, they should be replaced with mercury-free equipment. The exception is mercury fluorescent lamps. Currently, there are no general indoor lamps that are more energy efficient than mercury-containing fluorescent lamps. As a result, schools should continue to use mercury fluorescent lamps for their general indoor lighting needs.

Example of a mercury electrical switch. Notice the pool of silver-colored elemental mercury on the left side of the switch.

3.4 What Can You Do About Mercury in Your School and Community?

Exposure to mercury causes immediate and long-term health effects that are especially severe for young people. There is no reason for you as a student and resident of your community to permit yourself to be exposed to the hazardous effects of mercury. In most cases where mercury and mercury-containing equipment are used, safe and effective non-

mercury products can be substituted. Inform your teachers and parents about the toxic effects of mercury, and encourage them to eliminate mercury from your school and home. In the event that you encounter a mercury spill, make sure you know how to clean it up safely. This section will provide you with tips on how to eliminate mercury in your world, and how to deal with mercury safely if you encounter an accident.

3.4.1 Eliminate Mercury in Your School

There are no safe uses of mercury or mercury-containing products in school classrooms and nurses' offices. Mercury thermometers, manometers, and sphygmomanometers can break and spill elemental mercury onto counters, desks, and floors. The case studies in Section 1.2 describe what can happen when an elemental mercury spill occurs: acute poisoning of students and widespread contamination of schools and homes. Schools should work towards removing all mercury chemicals and mercury-containing devices by replacing them with non-mercury alternatives. For example, a mercury-filled thermometer can be replaced with an alcohol thermometer.

Encourage your school to phase out the use of all mercury-containing equipment in classrooms and the building. Offer to be part of a "Mercury Task Force" with teachers, administrators, janitors, school nurses, grounds-keepers, and parents that leads the effort toward removing all mercury sources from the school. As mercury products are identified and removed from the school, make sure they are disposed of properly! Encourage your administrators to contact the local hazardous waste disposal agency to safely remove mercury sources from school property. Do NOT throw mercury-containing items or chemicals in the trash, down the sink, or down the drain!

Examples of a mercury thermometer (a) and an alcohol thermometer (b).

3.4.2 Eliminate Mercury in Your Home

Just as there are no safe uses of mercury and mercury-containing equipment in schools, there are no safe uses for these products in homes, either. Tell your parents about the toxic effects of mercury, and encourage them to remove all mercury products from your home. Common mercury-containing products found in homes include mercury thermometers, some cosmetics and face-lightening creams, some types of batteries, and mercury electrical switches. If your family members use elemental mercury for religious or cultural ceremonies, explain how dangerous it is, and encourage them to find alternative practices that do not involve mercury.

Be sure to safely dispose of mercury products – do not throw anything containing elemental mercury, such as a thermometer or battery, in the trash! Check with your local hazardous waste disposal agency about the correct way to safely remove mercury products from your home.

Another way you can reduce your risk of mercury exposure at home is by avoiding seafood with high levels of methyl mercury. Almost all fish and shellfish contain methyl mercury, but some fish have higher levels of methyl mercury than others, as shown in Table 4. Adults and children should avoid shark, swordfish, king mackerel, and tilefish, because these fish have high levels of methyl mercury. Instead, choose shrimp, canned light tuna, salmon, pollock, and catfish, because they have low levels of methyl mercury. The U.S. Environmental Protection Agency (EPA) recommends that adults eat no more than approximately 340 grams of these fish and shellfish each week. Children should eat smaller amounts so they limit their overall exposure to methyl mercury.[13]

3.4.3 Learn How to Clean Up Mercury Spills Safely

In the event you encounter a mercury spill, you should know how to clean it up safely. One of the most common causes of mercury spills is a broken mercury thermometer. All mercury spills, regardless of size, are hazardous because elemental mercury emits toxic vapors into the air. Mercury vapor is colorless and odorless so you do not know when you are inhaling it. Cleanup of a mercury spill can be difficult because elemental mercury is a liquid that easily separates into tiny beads that can accumulate in very small spaces, such as on carpet fibers or between floor tiles.

Until all the mercury products have been removed from your school and home, encourage your parents and teachers to have a plan in place in the event of a mercury spill. Whenever possible, a qualified and experienced professional cleanup contractor should be engaged to cleanup mercury spills. Professional cleanup contractors have access to specialized equipment that permits safe removal of mercury from most non-porous surfaces such as smooth concrete, tile floors, and counters. In the event a professional contractor is not available, follow the "Mercury Spill Cleanup" procedure in Appendix A when a mercury spill occurs. Treat this procedure like a "fire drill" by practicing it several times per year so you, your parents, and your teachers become familiar with their roles. Assemble a "Spill Cleanup Kit," also listed in Appendix A, and store it in a secure location so it is readily available in the event of an accident. Note that all items involved in cleanup of a mercury spill will become contaminated and will have to be discarded as hazardous waste, so plan accordingly.

Table 4. Guidelines for Eating Fish and Shellfish.

Fish and Shellfish with *High* Levels of Methyl Mercury (DO NOT EAT)	Fish and Shellfish with *Low* Levels of Methyl Mercury (EAT NO MORE THAN 340 g PER WEEK)
• Shark • Swordfish • King Mackerel • Tilefish	• Shrimp • Canned Light Tuna • Salmon • Pollock • Catfish

[13] U.S. Environmental Protection Agency, "What you need to know about mercury in fish and shellfish," http://www.epa.gov/waterscience/fishadvice/advice.html, Accessed January 31, 2008.

There are also several things that you should NOT do in the event of a mercury spill. Make sure you and the adults cleaning up the spill do not make the following mistakes.

What NOT to Do in the Event of a Mercury Spill

- ***Children and adolescents should not clean up a mercury spill!*** Young people are more susceptible to mercury poisoning than adults, so they should immediately leave the area of the spill and go outside or into a well-ventilated area.
- ***Never use a vacuum cleaner to clean up a mercury spill!*** The vacuum cleaner will volatilize liquid mercury and increase exposure to toxic mercury vapors. In addition, the vacuum cleaner will become contaminated with mercury and will have to be discarded.
- ***Never use a broom to sweep up a mercury spill!*** The broom will break the liquid mercury into tiny beads and spread them into small spaces, such as between floor tiles or floor boards. Once mercury beads are out of sight in small spaces, they are very difficult to remove. They will remain in the room to volatilize and poison adults, children, and pets. In addition, the broom will become contaminated with mercury and will have to be discarded.
- ***Never pour mercury down the sink!*** Mercury will contaminate lakes or streams where waste water is *discharged*. And because mercury is very dense, it can lodge in the drain and cause plumbing problems.
- ***Never wash mercury contaminated clothes or shoes in a washing machine!*** Mercury will contaminate lakes or streams where waste water is discharged. In addition, the washing machine will become contaminated with mercury and will have to be discarded.
- ***Never burn clothes and shoes contaminated with mercury!*** Burning items contaminated with mercury will vaporize the mercury into its most toxic form.
- ***Never throw items contaminated with mercury into the local trash!*** Items contaminated with mercury are hazardous wastes, and they must be disposed of properly. Most local trash is either transferred to a landfill or burned, both of which will release mercury into the environment, where it can harm humans and wildlife.
- ***Never use household cleaning products to clean items contaminated with mercury!*** Cleaners containing ammonia or chlorine will react with mercury to release toxic gases.

3.5 Educate Other Students about the Hazards of Mercury and Chemicals in Schools

It is important to remember that chemicals are essential for the effective functioning of schools. When managed safely, chemicals provide a wide variety of benefits to students, teachers, and administrators. However, chemicals can be dangerous to students and staff when stored and handled improperly. Chemicals that are persistent in the environment and bio-accumulate through the food chain are especially hazardous for children and adolescents. Mercury, in particular, has long-lasting effects on human health and the environment. As a result, mercury-containing thermometers, equipment, and products should be properly disposed of and replaced with safer alternatives when possible.

Now that you understand the potential health risks associated with exposure to chemicals, especially mercury, you can educate other students. Share the information you have learned in this workshop with your friends and classmates. By working together with teachers, school administrators, and your parents, you can make your schools and communities safer.

Police responding to a chemical spill at a school in the USA.

Appendix

A.

Procedure for Cleaning Up a Mercury Spill Safely

Use the following procedure to clean up elemental mercury spills safely. Assemble the "Mercury Spill Cleanup Kit" ahead of time and keep it in a secure location so it is ready in the event of a mercury accident.

Mercury Spill Cleanup Kit[14]

- 5 1-L plastic bags, self-sealing if possible
- 2 large thick plastic trash bags
- Rubber or latex gloves, at least 1 mm thick - enough for all members of the Cleanup Team; make sure gloves fit snugly on the hand
- 1 roll of paper towels
- 1 eyedropper or small plastic pipette
- 1 small plastic bowl
- 1 roll of duct tape
- 1 flashlight
- 1 pair of scissors
- Extra clean clothing for students or residents, in case clothes become contaminated and must be discarded.

Procedure for Safe Cleanup of a Mercury Spill in Homes and Schools[15]

1. Designate two to three adults to clean up the mercury spill. These individuals will be the "Cleanup Team."
2. The Cleanup Team should determine if anyone involved in the spill has become contaminated with mercury on their clothes, shoes, or skin. Contaminated individuals should remain where they are to avoid spreading mercury to other areas. They will be decontaminated by the Cleanup Team.
3. Everyone who is not contaminated or helping with the cleanup, including children and pets, should leave the area immediately. Be careful when evacuating – make sure no one walks through the mercury spill!
4. Open all windows and doors to the outside and allow fresh air to ventilate the area of the spill. Close doors to other parts of the building.

[14] Adapted from U.S. Environmental Protection Agency, Mercury Spill Page, http://www.epa.gov/mercury/spills/index.htm, Accessed February 1, 2008.
[15] Adapted from U.S. Environmental Protection Agency, Mercury Spill Page, http://www.epa.gov/mercury/spills/index.htm, Accessed February 1, 2008.

5. Retrieve the Mercury Spill Cleanup Kit from its storage location.
6. All Cleanup Team members should put on rubber or latex gloves.
7. If any individual has been contaminated with mercury on their clothes, shoes, or skin, the Cleanup Team must decontaminate them. Help the contaminated individuals remove contaminated clothing and/or shoes very carefully so as to avoid dislodging and spreading attached mercury. Place the contaminated clothing and/or shoes into one of the large plastic trash bags. Use the sticky side of a piece of duct tape to carefully remove any mercury that may be clinging to exposed skin. Use a new piece of duct tape for each area of exposed skin. Place the pieces of duct tape with adhered mercury into a 1 L plastic bag, fold the top of the bag over on itself, tape it shut, and place it in the large trash bag with the contaminated clothes. Individuals should use the clean clothes and shoes in the Mercury Spill Cleanup Kit to replace their contaminated items. As soon as individuals are de-contaminated, they should evacuate the area, being careful not to walk through the mercury spill.
8. Cleanup Team members should now turn their attention to the mercury spill. Carefully pick up any pieces of broken glass or other items mixed in with the mercury spill and place them on a paper towel. Be sure not to dislodge any mercury that may be clinging to these broken items. Carefully fold the paper towel and place it in one of the 1 L plastic bags. Fold the top of the bag over on itself and tape it shut. Place the sealed 1 L plastic bag in one of the large trash bags.
9. Mercury is very difficult to remove from fabric items such as carpet, furniture, and draperies. If mercury has spilled on these items, it is preferable to remove the entire item from the building, being carful not to dislodge and distribute the adhering mercury. When removing the entire fabric item is not possible, such as in the case of wall-to-wall carpeting, cut out the contaminated area, being careful not to dislodge and spread adhering mercury. Place the contaminated items in a large trash bag.
10. If mercury has spilled on a hard surface, such as wood, tile, or linoleum, locate the visible mercury beads. Line the bottom of the plastic bowl with a damp paper towel. Use the eyedropper or small plastic pipette to carefully suck up visible mercury beads and drop them on the damp paper towel in the plastic bowl. Mercury is fairly viscous, so it can flow quickly over hard surfaces, thus it is important to carefully collect mercury beads without dislodging them. Use the flashlight to illuminate the floor at an angle in order to locate all mercury beads. Be sure to scan the entire area since mercury can travel long distances on hard surfaces. When you have removed all of the visible mercury beads, carefully place the plastic bowl containing the mercury into a 1 L plastic bag, fold the top of the bag over on itself and tape it shut. Place the eyedropper or small plastic pipette into a separate 1 L plastic bag, fold the top of the bag over on itself and tape it shut. Place the sealed 1 L plastic bags in one of the large trash bags.
11. After you have removed all the visible beads, carefully press the sticky side of a piece of duct tape on the surface of the spill to remove any small, less visible beads. Use a new piece of duct tape for each area of the spill. Carefully place the pieces of duct tape with adhered mercury into a 1 L plastic bag, fold the top of the bag over on itself and tape it shut. Place the sealed 1 L plastic bag in one of the large trash bags.
12. After the Cleanup Team has completely cleaned up the spill, all Team members should remove their gloves and place them in one of the large trash bags. If any clothes or shoes have become contaminated with mercury, they should also be placed in one of the large trash bags. Then the tops of the large trash bags should be carefully folded over and completely sealed with duct tape.

Label the trash bags: "HAZARDOUS! CONTAINS ELEMENTAL MERCURY!" in large, clearly visible letters.

13. Remove the bags containing the contaminated items to a safe holding place outside of the school or house. Consult your local municipal waste authority or hazardous wasted disposal agency for guidance on how to safely dispose of the bags containing the contaminated items.
14. Keep the windows open to the outside for at least 24 hours to allow any traces of mercury vapor to dissipate from the building. Continue to keep children and pets out of the spill area for at least 24 hours. If anyone present during the spill begins to feel ill, seek medical attention immediately.