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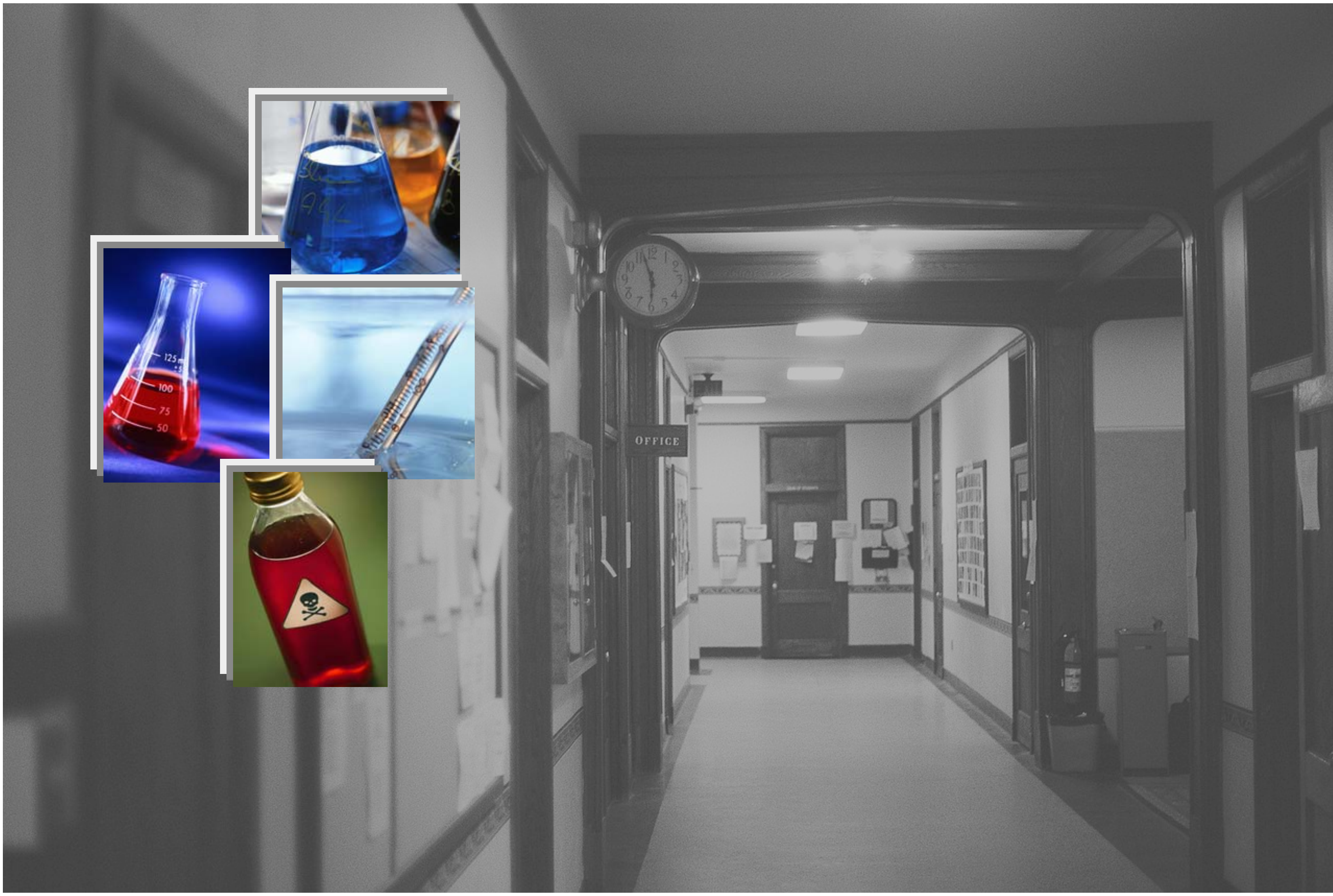
Mercury and Chemical Management in Schools:

Teachers and School Administrators Participant's Manual in Southeast Asia



Acknowledgements and Disclaimer

Acknowledgements

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Disclaimer

Summary

"…No one was sure what chemicals were involved in the fire [in the facilities maintenance warehouse at the school]. Pallets of bleach, ammonia and sulfuric acid based drain cleaner had been stored adjacent to each other, and rupturing of the chemicals during the fire created an acid vapor cloud as well as chlorine and phosgene gases. The total cost of this event was about half a million dollars." – From a case study of a public high school in New England, USA[1]

Are there Mercury-Containing Items or Dangerous Chemicals in Your School?

Many schools have mercury thermometers and potentially even a stock of elemental mercury or mercury salts. The sources of mercury and dangerous chemicals in schools are not always obvious. This guidance applies to any school that purchases, uses, stores, or disposes of chemicals or products containing dangerous materials, including mercury. Some of the most common dangerous chemicals and products in schools include:

- Laboratory chemicals (for example, acids, bases, solvents, metals, salts)
- Industrial arts or "shop" class supplies (for example, inks, degreasers)
- Art supplies (for example, paints, photographic chemicals)
- Pesticides and fertilizers
- Maintenance supplies and equipment (for example, drain cleaners, mercury switches and gauges)
- Measuring equipment (for example, mercury thermometers).

Who Should Read This Guidance?

Designed as a "Participant's Manual" to be used as part of a "Chemical and Mercury Management in Schools Training," this document focuses on the policies and programs needed at the school and district level for safe and sustainable chemical and mercury management practices. This document is designed primarily for school administrators (principals and other policymakers), with a focus on issues of relevance in Thailand and throughout Southeast Asia. This document may also be of value for teachers, maintenance personnel, superintendents, school business officials, insurance industry risk managers, and parents.

What Can Schools Do to Prevent Costly Incidents with Dangerous Chemicals?

- Raise awareness by establishing a leadership team of qualified individuals to oversee chemical management, and confirm the availability of budget and resources (Section 3.1)
- Implement pollution prevention and green chemistry principles, whenever possible, to minimize the use of hazardous chemicals at schools (Section 3.2)
- Establish a chemical management policy and chemical hygiene plan (Section 3.3)
- Establish an environmentally preferable purchasing policy (Section 3.3.1)
- Conduct periodic chemical inventories to identify hazards (Section 3.3.2)
- Implement an appropriate chemical storage and handling policy (Section 3.3.3)
- Create a chemical disposal policy, and train employees, to ensure safe and environmentally friendly disposal in accordance with laws and regulations (Section 3.4)
- Establish a Mercury Task Force, and practice mercury spill response (Section 4.4.1)
- Replace mercury-containing products with alternatives (Section 4.4.1)

[1] EPA. 2006. Case Study – Environmental, Health & Safety Issues in One New England Public High School, Summary 1996. Available at http://www.epa.gov/region1/assistance/schools/health.html [Accessed March 24, 2006].

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Chapter

I

Importance of Mercury and Chemical Management for School Administrators and Teachers

1.1 Overview and Organization of Participant Materials

Schools often contain chemicals and products in classrooms, laboratories, and storage closets that can pose a health hazard to students and teachers. One chemical that is especially toxic for children is mercury, which can be found in some thermometers, batteries, fluorescent lamps, and a variety of other products. Sometimes, pure elemental mercury or mercury compounds can be found in chemistry classrooms, which has resulted in serious contamination and mercury poisoning in some schools. Teachers and students are not always aware of the hazards posed by certain chemicals and products. In other cases, the hazards are known, but there is a lack of suitable alternative chemicals, products, and waste management practices.

Ensuring that these chemicals and products are managed properly will help school administrators to: safeguard the health and safety of students and school employees; avoid disposal expenses and costly school closures associated with spills and emergency incidents; maintain a sense of trust between the school and the surrounding community; and prevent damage to the environment. School districts need solid, useful, specific recommendations and information on responsible chemical and mercury management to facilitate the establishment of sound district-level policies and procedures.

This document is intended to aid school teachers, administrators, and district personnel, particularly at the high school and college levels, in reducing dangerous chemical and mercury hazards in schools. Designed as a "Participant's Manual" to be used as part of a "Chemical and Mercury Management in Schools Training," this document focuses on the policies and programs needed at the school and district level for safe and sustainable chemical and mercury management practices. The goal is to minimize the incidence of chemical spills, exposures, and emergency scenarios in schools. Parents and others in the community who are interested in school health and safety policies also may use this booklet to determine whether their children's schools are effectively minimizing potential exposure to dangerous chemicals and products.

This Participant's Manual is organized as follows:

- **Chapter 1** explains the susceptibility of children to mercury and other chemical hazards, and why school teachers and administrators should be concerned. It also provides examples from Southeast Asia and the United States (U.S.) of mercury and other chemical accidents and their impacts.
- **Chapter 2** provides an overview of the various classes of hazardous chemicals and products of concern found in schools, and

where these chemicals and products of concern might commonly be found.

- **Chapter 3** presents recommendations for school administrators and teachers to take specific actions to raise awareness, promote alternatives, safely manage existing chemicals, and properly dispose of chemicals.
- **Chapter 4** discusses mercury in the environment, health effects, and actions related to mercury in schools.
- **Chapter 5** presents conclusions.
- The **Appendices** provide specific examples that can be used to establish policies and procedures that schools may use to facilitate the implementation of the recommendations in this manual.

By reading this manual and participating in the training activities, participants will be able to:

1. Understand the need for responsible chemical and mercury management in schools.
2. Develop or revise school policies to incorporate basic steps to prevent and minimize the incidence of chemical spills, exposures, and emergency scenarios in schools.
3. Support broader district-level efforts to raise awareness of chemical and mercury safety in schools, promote alternatives, and engage in proper waste management.

1.2 Susceptibility of Children to Mercury and Chemical Hazards

Up until the completion of adolescence (around age 19), children have an increased risk from environmental hazards compared to that of adults. Such environmental hazards include those created by improper chemical and mercury management in the school environment, where many youth spend a large portion of their time. Among other reasons, this is because children often have higher exposures to pollutants in air, water, and food. Because children are growing and developing, they go through specific "critical windows of vulnerability" during which exposure to certain hazards can alter normal body function and structure.[2] Further, children today have a longer life expectancy than earlier generations, and therefore have longer to live with damage from toxic chemicals. Finally, children are "politically powerless," and thus must rely on adults to protect them from toxic environmental agents.[3]

[2] World Health Organization, Training Package for the Health Sector, Children Are Not Little Adults, August 2006.

To add to the particular vulnerability of children, environmental health and chemical safety problems are magnified in developing countries and countries in transition. There are many reasons for this, including:

- Unsafe use of chemicals – due to lack of information on risks and education on their safe and wise use, and prevailing illiteracy in some areas;
- Increasing pollution and uncontrolled use of chemicals – due to lack of appropriate regulatory measures or the impossibility of enforcing them (for example, because of lack of personnel, controls, and surveillance);
- Focus on urgent, immediate health priorities rather than longer-term or broader-scale environmental exposures
- Additional factors such as malnutrition, infectious diseases, and poverty; and
- Discouragement because the environmental problems appear to be too large to solve.[4]

This Participant's Manual on mercury and chemical management in schools focuses on the issues of lack of information on risks, and the need for education on safe chemical use and disposal. This Participant's Manual is a step toward raising awareness on the broader issues of environmental health and chemical safety for children and youth.

1.3 Why You Should Be Concerned

There are five key reasons why school teachers and administrators should be concerned about mercury and chemical management in their schools:

1. The expenses incurred from disposal, spills, and other incidents, including potential liabilities/ lawsuits, can be considerable. The costs of responding to chemical incidents can reach hundreds of thousands of U.S. dollars (or several million Thai Baht) or more at a single school. In addition to response costs, improper chemical waste management can result in fines and increased insurance premiums in some countries.

2. Improper mercury and chemical management poses health and safety risks to students and school employees. Students' bodily systems are still developing; they eat more, drink more, and breathe more in proportion to their body size; and their behavior can expose them more to chemicals than adults.

3. It only takes one chemical incident, such as a spill, explosion, or chemical exposure, to break the trust with the community. School incidents can lead to increased parental and community concern, negative publicity, and embarrassment to the school and school district.

4. Improper chemical management may result in school closures that result in a loss of valuable education time. Schools can be closed for days, weeks, or even months as a result of an improperly cleaned-up chemical incident, such as the breakage of a mercury thermometer, especially when spilled chemicals are accidentally spread throughout the school.

5. Improper chemical management can lead to unintended chemical discharges and spills, which inflict damage upon the environment where students, teachers, staff, and parents live and work. Improper chemical discharges

[3] World Health Organization, Training Package for the Health Sector, Children Are Not Little Adults, August 2006.
[4] World Health Organization, Training Package for the Health Sector, Children and Chemicals, August 2006.

into sanitary sewer lines or on-site waste treatment systems (including septic tanks) can have adverse effects on rivers, streams, and groundwater. Improper waste segregation and management can result in direct exposure of communities to toxic chemicals, whether through fumes from trash burning, direct contact to waste pickers, or contamination of nearby soils and water.

A safe school environment that prevents harm to students and protects school employees from dangerous chemicals must be promoted. Responsible chemical management is likely to lead to improved learning in the classroom and improved overall health of the environment and the community. The following case examples of recent mercury and chemical accidents at schools around the world demonstrate the need for increased attention to proper mercury and chemical management in schools:

School Closes for Months Due to Mercury Spill in Philippines School

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. Recognizing the symptoms of acute mercury poisoning, the UP/NPMCC traced the exposure back to a mercury spill earlier that day in a classroom at St. Andrew's School located in Paranaque City, Republic of the Philippines (RP). After the extent of the spill was recognized, a team of local and national public health personnel took appropriate precautions to protect student health by closing the school and examining other potentially exposed students. Between 20 and 22 February 2006, 203 students and faculty were evaluated for acute mercury exposure, and ten students were admitted to the Philippines General Hospital. After two contractors hired to clean up the spill were not able to fully remove the hazard, the RP Secretary of Health formally invited a U.S. Environmental Protection Agency (U.S. EPA) team to the Philippines to provide technical guidance for the remediation of the mercury spill. The U.S. EPA team assisted the school, contractor, and local and national government officials in determining the extent of mercury contamination and conducting appropriate abatement procedures. Before the school was reopened, the RP/U.S. EPA team monitored mercury vapor levels in the air to ensure that the levels were below recognized safe criteria.[5]

A Mercury Spill at School Spreads Around Washington, D.C., USA

On 2 October 2003, the Washington, D.C. Fire Department Hazardous Materials (Hazmat) Unit responded to a surprising emergency call from Ballou High School. What the Hazmat Unit found that afternoon proved to be the beginning of a long, exhausting search for and clean up of an elemental mercury spill. By the time the Hazmat Unit and public health officials arrived, it was too late to contain all the spills; varying amounts of mercury were found in the classrooms, gymnasium, and cafeteria. In addition, students unknowingly carried mercury through the streets, onto city and school buses, and into their homes, broadening the potential area of mercury contamination. As a result of the spill, Ballou High School was closed for 35 days and more than 200 homes were tested for mercury contamination.[6]

[5] 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.

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

An Accident with Chemicals in a Science Class at a School 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.[7]

Bromine liquid and vapor in a round-bottom flask.

A Broken Jar of Mercury in Boise, Idaho, USA

On 22 February, 2008, the Boise Fire Hazardous Materials Unit (Hazmat) received a call from St. Joseph's Catholic School in Boise, Idaho. A 6 ounce jar that was nearly full of mercury had been dropped and broken. The students were evacuated and sent home. Boise Hazmat located 3 students who had reportedly been in the vicinity when the spill occurred, and had their clothing placed in plastic bags and returned to the school. Boise Hazmat isolated the room, had the heating and air-conditioning system turned off, and cleaned up the visible spilled mercury using a mercury vacuum and mercury amalgam kit. Boise Hazmat coordinated with U.S. EPA to deploy mercury detection equipment to verify that the cleanup had achieved safe levels of mercury prior to re-occupancy. U.S. EPA and Boise Hazmat determined that additional cleanup was necessary involving the removal of 60 floor tiles in the area of the spill and other hot spots. The bags of clothing from the 3 children that were potentially exposed were examined, one of which was found to generate high levels of mercury vapor. U.S. EPA and Boise Hazmat checked the car and house of the child with contaminated clothing, although no further mercury contamination was found. Authorities used a mercury vacuum and mercury amalgam to remove any residual mercury. The classroom was heated to approximately 35°C (95°F) overnight, and then ventilated with a blower and windows open to clear out remaining mercury vapor. Air sampling confirmed that the classroom was then safe for re-occupancy. All mercury-contaminated materials were placed in a large sealed container in a locked area at the school until local authorities could make arrangements for proper hazardous waste disposal.[8]

[7] 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.

[8] United States Environmental Protection Agency, On Scene Coordinator, St. Joseph's Catholic school Mercury Spill, http://www.epaosc.net/site_profile.asp?site_id=3869, Accessed March 25, 2008.

1.4 Activity 1: Interactive Analysis of School Chemical Accident Case Studies

The case studies in the previous section raise many issues about the causes of mercury and other chemical accidents at schools, how quickly contamination can spread, ways to prevent accidents, and proper ways to respond. This activity is designed to generate discussion around these issues for the case studies.

Break into groups of 3 to 5 participants and answer the following questions for each case study:

- What could the school administrators and teachers have done to prevent the accident?
- How would you have handled this situation if you were the teacher in charge?
- Could the emergency responders and government officials have done anything different to help contain the accident?
- Have you ever experienced a similar chemical accident at your school?

The best way to deal with an accident is to prevent it in the first place. However, because accidents do happen, schools need to have established plans and procedures to deal with accidents appropriately. Teachers need to know how to quickly recognize the potential dangers of an accident, remove students from danger, and clean up or coordinate with authorities for appropriate cleanup. (Spill cleanup is further addressed in Section 3.4 of this Participant's Manual.)

Chapter

2

Hazardous Chemicals and Equipment in Schools

2.1 Chemicals and Equipment of Concern

More than 75,000 chemical substances are in commercial use today. Many of these chemical substances are considered toxic or otherwise hazardous to humans and other living beings. Toxic chemicals are associated with a variety of serious health problems, including cancer, brain and nervous system disorders, reproductive disorders, organ damage, as well as asthma. Mercury in particular is associated with damage to the central nervous system, among other effects, as further discussed in Chapter 4. Toxic chemicals that are long-lasting in the environment and become concentrated (or "bioaccumulate") through the food chain can make exposure during childhood and adolescence especially dangerous. Chemicals also can irritate the skin, eyes, nose, and throat. Some chemicals pose significant safety hazards, such as fire or explosion risks.

Many hazardous chemicals can be found in school facilities. Material Safety Data Sheets (MSDS) are comprehensive fact sheets prepared by chemical manufacturers that describe the physical properties, health effects, and other characteristics of chemicals, as well as procedures for handling, storing, and disposing of these substances. An example of an MSDS for mercury sulfide is given in Appendix A. Chemical manufacturers should supply MSDSs along with each shipment of chemicals delivered to your school. MSDSs can also be found on the internet in a variety of languages.

For example, the Merck Thailand chemical company has posted MSDSs in Thai on the internet at http://www.merck.co.th/en/services/chemical_msds.asp. The proper use and management of these substances, as well as the products that contain them, are critical to maintaining a healthy atmosphere for school occupants and the surrounding environment. The term "hazardous chemicals" may include (but is not limited to) the following:

- Laboratory chemicals used or stored in science laboratories and preparation areas;
- Art supplies, including paints, stains, inks, glazes, and photographic processing chemicals, used in (visual and performing) art and shop;
- Cleaning products utilized by custodial, cafeteria, and maintenance staff;
- Pesticides and fertilizers;
- Paints, solvents, fuels, degreasers, and lubricants used in building operation and maintenance;
- Oils, fuels, paints, and other chemicals used to maintain and repair equipment for transportation, school maintenance, and shop classes;
- Inks, solvents, and adhesives used for printing in school offices; and
- Chemicals used to treat water associated with drinking water and swimming pools.

The risks associated with exposure to any chemical are dependent on a variety of factors, including the chemical's hazard level (degree of flammability, toxicity, etc.), the route of exposure (for example, absorbed through skin, inhaled, consumed, injected), and the duration of exposure.

2.2 Chemical Categories

Chemicals can be grouped based on the type of hazard they pose. Understanding the different types of chemicals in a school is important for developing an effective chemical management policy. Hazardous substances in schools may fall into one or more of the following categories: flammables, oxidizers, explosives, low level hazard, corrosives (the majority of which in high school laboratories are acids and bases), severe chronic hazard, poison, and environmental hazard. The United Nations (UN) has developed an internationally accepted set of symbols (Globally Harmonized System of Classification and Labeling of Chemicals[9]). Individual countries may have developed specific definitions for each of these categories; however, the hazards are generally described by the categories in Table 1, along with example safety measures. (Refer to Section 3.3.3 of this manual for further information on how the category of a chemical affects where it should be stored, and what combinations of chemical categories to avoid storing together.)

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

Table 1. 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!

2.3 Where Chemicals and Equipment Are Found in Schools

Chemicals and equipment can be found throughout a school in science laboratories, maintenance areas, vocational shops, art classrooms, and offices. They are used in both the maintenance of schools and the curriculum taught. In the absence of chemicals and equipment, schools would lack certain fundamental tools needed to educate students. Despite their useful purposes, chemicals and equipment (particularly mercury-containing equipment) can be dangerous to students and staff when managed improperly. Universities and high schools usually have larger inventories and more hazardous chemicals and equipment than middle and elementary schools. Chemicals may have been purchased by the school or brought in by employees or students for their personal use.

Table 2 lists some specific locations in which chemicals and products of concern might be found in a typical school. Please keep in mind that this list is by no means all-inclusive, and that chemicals, when used appropriately, can be important to the educational process.

Table 2. List of Common Locations for Chemicals and Equipment in Schools

Location	Product Type	Hazardous Ingredient Examples
Science laboratories	Concentrated Acids (undiluted)	Hydrochloric acid Nitric acid
	Concentrated Bases (undiluted)	Sodium hydroxide
	Solvents	Methanol Methylene chloride
	Oxidizers	Lead nitrate
	Compressed gases	Oxygen
	Toxins	Mercury Cyanides Chromates (VI) Lead salts Mercury salts
	Mercury Thermometers, Barometers, Molecular Motion Demonstration Devices	Mercury
Vocational and trade shops (can also be referred to as Career and Technical Education)	Solvents (used in paints, paint thinners, adhesives, lacquers, primers, and other products)	Petroleum naphtha Turpentine
	Cleaning supplies/detergents	Phosphoric acid Sodium silicate
	Compressed gases	Acetylene Nitrogen
	Fuels, transmission, and brake fluids	Gasoline
Visual and Performing Art Studios	Solvents (used in paints, inks, paint thinners, adhesives, lacquers, primers, and other products)	Toluene Mineral spirits
	Pottery clear coating glaze	Lead Other heavy metals
	Pigments for paints and coatings	Cadmium Manganese Chromium
	Dry clay for ceramics and jewelry	Silica
	Acids for etching	Nitric acid Hydrochloric acid
Custodial/ Maintenance Areas	Cleaning supplies/detergents	2-Butoxyethanol Trisodium phosphate
	Drain cleaners (alkaline) Drain cleaners (acidic)	Potassium hydroxide Sulfuric acid
	Pesticides (including disinfectants/sterilizers)	Permethrin Sodium hypochlorite
	Paint thinners	Toluene
	Solvents (used in paints, paint thinners, adhesives, lacquers, primers, and other products)	Xylene
	Water treatment chemicals for swimming pools	Chlorine tablets
Kitchens/ Cafeterias	Pesticides (including disinfectants/sterilizers)	Permethrin Sodium hypochlorite
	Refrigerants	Freon Ammonia
	Cleaning supplies/detergents	Ammonium hydroxide
Nurses' Offices	Medical equipment	Mercury (thermometers and blood pressure manometers)
Photography Laboratories	Intensifiers/reducers	Potassium dichromate Hydrochloric acid
	Developers	Hydroquinone Lactic acid
	Stop baths and fixer	Acetic acid Chrome alum (potassium chromium sulfate)

Location	Product Type	Hazardous Ingredient Examples
School Grounds/ Athletic Fields	Pesticides	2,4-D
	De-icers	Sodium chloride
	Fertilizers	Ammonium nitrate
Administrative Offices	Correction fluid	Ethylene glycol Trichloroethane
	Solvents (used in paints, inks, paint thinners, adhesives, lacquers, primers, and other products)	Methyl ethyl ketone Petroleum distillates

2.4 Activity 2: Identifying Chemical Hazards

This activity demonstrates that there are many types of mercury and chemical products found throughout schools. Even experienced chemistry teachers may be surprised by potentially hazardous chemicals that are found outside of their classrooms (for example, in janitor maintenance closets). In other cases, students bring items to school that unknowingly contain hazardous ingredients.

The following is a sample list of items that may be found in schools:

- Laboratory chemicals (e.g., acids, bases, solvents, metals, salts)
- Laboratory equipment (e.g., mercury thermometers, mercury barometers)
- Industrial arts or "shop" classes (e.g., inks, degreasers)
- Art supplies (e.g., paints, photographic chemicals)
- Pesticides and fertilizers
- Maintenance supplies and equipment (e.g., drain cleaners, ammonia, bleach, floor stripping products, paints, oils, boiler cleaners, fuels)
- Health care equipment (e.g., mercury thermometers)
- Common household items that students or teachers may bring to school, such as batteries, light-up tennis shoes, and skin whitening creams.

The photographs in Appendix B show various chemicals, some of which may be found in schools. Break into groups of three participants, and do the following:

- Classify each of these chemicals according to the UN Globally Harmonized System of Classification and Labeling of Chemicals categories listed in Table 1 of this manual.
- Suggest appropriate safety measures that you would require of your students (and follow yourself) if they were working with the chemical. Examples of safety measures are listed in Table 1 of this Participant's Manual.

Check It Out

The important points to remember are that:

1. **Chemical hazards are not just found in science laboratories.**
2. **Different chemicals and equipment require different actions for safe management.**

Chapter

3

Policies and Actions for School Administrators and Teachers

School administrators and teachers have an important role to play in reducing the hazards of mercury and chemicals in schools, by taking specific actions and adopting policies that promote chemical safety in schools. This chapter focuses on the actions that school administrators and teachers can take to: (1) raise awareness on chemical hazards, (2) explore safer alternatives, (3) safely manage existing chemicals, and (4) safely dispose of chemicals.

3.1 Raising Awareness

Raising awareness at the national, regional, community, and school levels on mercury and chemical safety is critical to promoting a safer environment for everyone. In this manual we focus on raising awareness at the school and school district level; these actions will be most effective when complemented by broader community, regional, and national efforts to raise awareness on mercury and chemical safety. To institute good chemical management policies, school administrators need to set the tone that chemical management is important by assigning roles and responsibilities for implementing proper safety and chemical hygiene practices. Guidelines are provided below that policymakers at the district level and school administrators should implement in order to initiate responsible chemical management practices in their schools.

- **Establish or confirm that your district has committed budget and staff resources for chemical management.** When schools consider their costs for chemicals, they generally consider only the purchase price. Each stage of chemical and product management, however, has associated costs of labor (e.g., training chemical hygiene officer and other staff), materials, equipment, and disposal, as well as costs of storage space and potential liability when responsible chemical management is not practiced.
- **Design and communicate a chemical management policy.** School district administrators and principals need to establish an overall policy stating a strong commitment to responsible chemical management, including implementation of the policies and actions defined in this document. The policy should be communicated to all by the highest level of management. Strong support from the administration, combined with adequate resources, will enable responsible chemical management.
- **Appoint a chemical hygiene officer.** The chemical hygiene officer is someone who is qualified by training and experience to provide technical guidance and leadership in the development and implementation of the chemical management policy. The position description or job classification of a chemical hygiene officer will vary across school districts; however, in all cases, they should be trained to provide chemical management leadership to the school.
- **Designate a team to oversee the chemical management program at your school.** This team should consist of teachers, janitorial staff, and maintenance

personnel to help oversee the chemical management program at your school described in the sections that follow. Team members should be trained by the chemical hygiene officer (and reinforced at least annually). At a minimum, team members should understand physical/ chemical properties and potential health effects of chemicals, chemical compatibility, applicable environmental regulations and compliance issues, and waste management procedures of the school. You may also consider involving students as part of the process.

- **Develop a chemical management awareness training program for school staff and students.** This training program should address how school employees and students are to be properly trained to handle certain chemicals and products and how to respond to a chemical spill or release, to understand the hazards of these materials, and to understand the types of liability associated with accidents involving chemical usage in schools. Targeted employees should include school management, custodial and maintenance personnel, and appropriate teaching staff. The training program should include a review of the chemical management policy, and approved products listing. The training program may be based on portions of this manual. Training sessions should be documented in a log for each employee and repeated periodically (for example, on an annual basis) to serve as a refresher.
- **Utilize existing community resources.** Contact a local health department, environmental management agency, hazardous waste agency, or chemical supplier to provide a training session with school employees that raises their awareness of using less toxic alternatives to certain chemicals, chemical substitutions, green purchasing, and performing small-scale experiments.

Merck Thailand conducts a "Let's Care Safety Camp" for final-year chemistry and chemical engineering university students.[10]

Check It Out

Chemical Hygiene Plan

To address all aspects of chemical management, schools should develop a written chemical hygiene plan that describes procedures and practices for the protection of students and school employees. Many school districts in the U.S. have developed their own chemical hygiene plans which typically address roles and responsibilities, training, hazard classifications, operating procedures, spills and hazard controls, labeling, disposal, and recordkeeping. The following offer several examples of chemical hygiene plans:

- **Chemical Hygiene Plan, Northshore School District, Washington http://schoolcenter.nsd.org/education/components/scrapbook/**
- **Lake Havasu Unified School District, Arizona District Chemical Hygiene Plan, http://www.havasu.k12.az.us/support/warehouse/chempolicy.html**
- **LAUSD, School Laboratory Chemical Hygiene and Safety Plan, http://www.lausd-oehs.org/docs/CSC/Chemical%20Hygiene%20Plan.pdf**

[10] Merck, Health Safety and Environment, http://www.merck.co.th/en/about/social_HSE.asp, Accessed March 31, 2008.

3.2 Safer Alternatives

Seeking out alternatives to mercury-containing equipment and hazardous chemicals, and identifying ways to minimize chemical use, are key aspects of responsible chemical management in schools. For chemicals, schools should focus on pollution prevention and green chemistry. For mercury-containing products, such as thermometers, schools should focus on obtaining alternative products without mercury. Green chemistry and pollution prevention have many direct environmental, safety, and financial benefits for schools, as demonstrated by the discussion below.

3.2.1 Pollution Prevention

Pollution prevention (sometimes referred to as "P2") is defined as preventing or reducing pollution at the source, whenever feasible, and other practices that replace or eliminate the creation of pollutants. An example of pollution prevention would be using smaller quantities of (or environmentally benign substitutes for) chemical products used for grounds maintenance or cleaning. Because minimizing waste usually results from minimizing input materials, schools will save money up front with pollution prevention. The following are examples of guidelines that can be used to reduce or eliminate the generation of chemical pollutants and wastes (see also Sections 3.2.2 and 3.2.3 for additional pollution prevention guidelines).

- **Establish a pollution prevention program** to help your school minimize the amount of chemical waste generated throughout your school. The program may consist of developing school-wide and departmental annual waste reduction goals. The program may also include pollution prevention education sessions for teachers, maintenance staff, and students emphasizing the importance of substituting hazardous chemicals with chemicals that are less hazardous and scaling down the volume of chemicals used in classroom experiments and maintenance applications. Appendix C contains a Pollution Prevention Checklist that your school may wish to adopt, providing suggestions for material substitution, purchasing/inventory control, process efficiency, recovery/reuse/recycling, and innovation.[11]
- **Contact your government's waste management or pollution prevention department** for assistance in conducting a pollution prevention opportunity assessment to find programs available in your area as well as the issues affecting your part of the country.
- **Minimize the use of pesticides**, a term that refers not only to insecticides but also to herbicides, fungicides, and various other substances used to control pests. Children may be especially sensitive to the health risks posed by pesticides because their bodies are growing and developing; they may also have greater exposure to pesticides because of their increased hand-to-mouth behaviors. A form of pollution prevention, integrated pest management, is an effective and environmentally sensitive approach to pest control that relies on common sense strategies to disrupt the life cycles of pests, such as eliminating standing water where mosquitoes can breed. Contact your local health department for guidance on balancing the benefits and potentially harmful effects of pesticides at schools.
- **Minimize hazards from cleaning products.** Because it is customary in some countries for the students to assist with daily cleaning of the classroom, teachers need to ensure that the cleaning products utilized do not pose chemical risks to the students. There are some very

[11] Ohio EPA, Laboratory Pollution Prevention checklist of lab opportunities, http://www.epa.state.oh.us/ocapp/p2/labp2checklist.pdf, Accessed March 25, 2008.

simple alternative cleaners that you can make yourself, without the need to purchase expensive (and potentially dangerous) cleaning products: [12, 13]

- For general cleaning of countertops, floors, walls, and upholstery, try one of the following:
  - Dissolve 4 tablespoons baking soda in 1 quart warm water; or
  - Use a mixture of 1/2 cup vinegar and 1 cup to 1 quart of warm water; or
  - Mix vinegar and salt together for a good surface cleaner
- For an abrasive cleaner, use baking soda or a nonchlorinated scouring powder.
- For glass cleaner, mix 1 tablespoon of vinegar or lemon juice in 1 quart of water, then spray on and use newspaper to wipe dry.
- For furniture polish, mix 1 teaspoon of lemon juice in 1 pint of mineral or vegetable oil, then wipe onto furniture.

Check It Out

Green Cleaning Pollution Prevention Calculator

One resource that may be useful to school administrators and janitorial/ maintenance staff is U.S. EPA's Green Cleaning Pollution Prevention Calculator (http://www.ofee.gov/janitor/index.asp).

Green Cleaning is a new approach to cleaning that offers better environmental performance and improved health and safety, without sacrificing cleaning results. The online calculator allows the user to enter information about current cleaning products and practices, and then test the benefits of "green changes to implement." For example, your school may decide to adopt improved purchasing controls, make product changes, and make cleaning schedule changes to reduce the numbers or volume of cleaning chemicals used at the school. This calculator forecasts the chemical reduction for various changes and enables users to identify which green cleaning measures will have the greatest impact.

Forecast of Chemical Use Reductions

Name of Building: test
Title of Your Estimate: try
Address: 1233 rere

	Reduction %	Total Product (lbs)	Hazmat Content (lbs)	HazMat %
Amounts Used Before		80	10.4	13
Purchasing Controls				
Buy/Mix According to Shelf Life	2	1.6	0.2	
Buy Non-Aerosols	0	0	0	
Buy or Rent Pre-treated Dust Mops	5	0	0	
Improve Mixing				
Mixing Station or Designated Chef	0	0	0	
Product Changes				
Less Toxic Ingredients	25	0	2.6	
Use Fewer Products	0	0	0	
Work Changes				
Vacuuming Techniques	0	0	0	
Clean By Need Not Schedule	0	0	0	
Training Emphasis / Monitor Use	5	4	0.5	
Microfiber Mops	0	0	0	
Other Changes				
Auto-Flush Valves	0	0	0	

Done

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12 Oregon Department of Environmental Quality, The Hazardless Home Handbook, A Guide to Hazardous Household Products and Effective Alternatives, http://www.metro-region.org/files/living/haz_book.pdf, Accessed March 25, 2008.

13 U.S. Environmental Protection Agency. Consumer's Handbook for Reducing Solid Waste, Source Reduction Alternatives Around the Home, http://www.epa.gov/epaoswer/non-hw/reduce/catbook/alt.htm, Accessed March 25, 2008.

3.2.2 Green Chemistry

One form of pollution prevention is "green chemistry," which seeks to reduce the potentially hazardous effects of chemicals by using fewer and less toxic chemicals in experiments compared to traditional curricula. Microscale chemistry and small-scale chemistry are similar concepts that involve scaling down the quantities of chemicals required for science experiments. In situations where green or small-scale alternatives are not feasible, a demonstration by the instructor may be a feasible substitute for having an entire class conduct individual experiments with hazardous or toxic chemicals. Each of these options requires a smaller amount of chemicals than traditional experiments, thus reducing costs to the school.

The main principles of green chemistry include the following:[14]

- **Prevent waste:** design chemical syntheses so there is little or no waste to treat or clean up.
- **Use safer chemicals and products:** use substances that are effective, yet have little or no toxicity.
- **Perform less hazardous chemical experiments:** perform experiments that use and generate substances with little or no toxicity to humans and the environment. For example, Appendix D contains two examples of green chemistry experiments, dealing with the principles of acid/base chemistry.
- **Use renewable reagents and resources:** renewable reagents and resources are derived from agricultural products or the wastes of other processes; they are preferable to depleting reagents and resources, which are derived from fossil fuels such as petroleum, natural gas, and coal.
- **Focus on catalytic reactions instead of stoichiometric reactions:** one way to minimize waste is by performing catalytic reactions. Because catalysts are not consumed in a chemical reaction, they can be used repeatedly, reducing waste.
- **Avoid chemical derivatives:** when possible, avoid using blocking or protecting groups in organic syntheses; derivatives use additional reagents and generate waste.
- **Increase energy efficiency:** perform chemical reactions that run at ambient temperature and pressure whenever possible.
- **Design chemicals and products to degrade after use:** design chemical products to break down to benign substances after use so that they do not accumulate in the environment.
- **Analyze in real time to prevent pollution:** include in-process, real-time monitoring and control during chemical syntheses to minimize or eliminate the formation of unwanted byproducts.

In some cases, the educational utility of a chemical can be eclipsed by the hazards it poses to human health and the environment. Chemicals that are unsuitable for schools include strong oxidizers, corrosives, toxics, carcinogens, and mutagens. Appendix E lists some examples of chemicals that are more hazardous than educational. Often, common laboratory chemicals have commercial equivalents that are available in safer concentrations than the pure substances sold by chemical manufacturers. Appendix F lists some examples of chemicals that can be found in grocery, drug, and hardware stores. Although commercially available chemicals are generally safer than their concentrated

[14] U.S. Environmental Protection Agency. Green Chemistry: Basic Information http://www.epa.gov/greenchemistry/pubs/whats_gc.html (1/2/08); adapted from Anastas, P. T. and Warner, J. C. 1988. Green Chemistry: Theory and Practice. Oxford University Press: New York, p. 30.

counterparts, remember that all chemicals can be dangerous if they are used without proper safety precautions.

3.2.3 Mercury Product Alternatives

Mercury, sometimes called quicksilver, is a particularly toxic chemical that deserves special attention by school teachers and administrators. Mercury is a very dense, silver liquid element that is commonly found in thermometers and barometers in school laboratories. In addition, mercuric salts are sometimes used in general chemistry and inorganic chemistry experiments. Although mercury has been used extensively in school laboratories in the past, its extremely toxic effects on human health have led some schools to replace mercury thermometers and mercury compounds in experiments with non-toxic alternatives in recent years. Because mercury is so toxic to human health, cleaning up accidental mercury spills from broken thermometers or manometers can be very costly for schools. As a result, the educational benefit of using mercury in the classroom does not warrant the potential risk of exposure to mercury.

Common classroom items that may contain mercury include:

- Laboratory chemicals (*e.g.*, mercury oxide, mercury chloride, mercury sulfate, mercury nitrate, mercury iodide)
- Thermometers
- Barometers
- Manometers
- Sling psychrometers
- Molecular motion demonstration devices that contain elemental mercury.

In most cases, non-toxic equivalents are available for items that traditionally contain elemental mercury. Alcohol and mineral spirit-filled laboratory thermometers provide suitable accuracy for most laboratory temperature-measurement applications. Non-mercury barometer alternatives include electronic digital gauges and aneroid (for example, Bourdon tube, diaphragm, piston or capsule) pressure gauges. For classroom reactions that utilize mercury salts as reagents, it is usually possible to substitute an alternative but comparable experiment that does not include mercury salts. Chapter 4 explains mercury toxicity and alternatives in more detail.

3.3 Safe Management of Chemicals

Even with the practice of pollution prevention and green chemistry, some chemicals will inevitably remain on school grounds. Responsible chemical management is critical to controlling a variety of environmental, health, and safety issues within any school. Knowing what materials are present in your school and how they are used, stored, and discarded will enable you to understand the issues associated with these substances. Properly recognizing and controlling the hazards inherent to these materials, wherever they are found in your schools, will enhance your ability to create a safe school with minimal environmental liabilities and lawsuits. On the other hand, failing to take necessary safety precautions may put your school at increased risk of fire, explosions, and spills that may result in chemical exposure to students and school personnel, harm to the environment, and considerable clean-up costs to the school district.

Safe chemical management begins with smart purchase decisions that reduce unnecessary purchases and give preference to safe, environmentally friendly products. Once products are on school grounds, a designated school official should conduct regular inventories, oversee proper storage, and ensure safe handling and disposal. This section provides guidance on each of these aspects of safe management of chemicals and equipment. Appendix G provides an example of a monthly chemical management checklist your school may wish to adopt.

Check It Out

Thai Pollution Control Department Online Resources

The Thailand Pollution Control Department (PCD) lists information (in Thai) on their website related to hazardous waste handling, chemical use safety, and recycling of fluorescent lamps. See http://www.pcd.go.th/info_serv/en_hazadous.html for these and other resources addressing aspects of safe mercury and chemical management.

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POLLUTION CONTROL DEPARTMENT

3.3.1 Purchasing

Chemicals enter school systems through regular purchases by teachers and facility maintenance personnel, donations from local industries, and chemical suppliers. Chemicals have varying hazard levels; thus, the determination to purchase should factor in need, use, safety, environmental factors, and chemical/product management lifecycle costs. Remember, just because a chemical can be purchased at your local hardware or grocery store does not mean it is safe if improperly used or stored.

Here are some suggestions of best management practices to create a chemically safer school environment:

- **Establish a district-level chemical purchasing policy** that addresses how chemicals and products containing chemicals are entering a school, who is using them, why they are being used, and how they will need to be disposed. Involve all teachers, maintenance and custodial personnel, and other staff to ensure that the chemical purchasing policy meets educational and facility maintenance needs while reducing the quantities and toxicity of chemicals.
- **Establish an environmentally preferable chemical screening process** to ensure that all chemicals and products containing chemicals have been screened for environmental, health, and safety hazards prior to purchase, thus reducing and/or eliminating hazardous chemicals. The Material Safety Data Sheet (MSDS) that should be provided by the chemical supplier may be useful in this process.
- **Establish a district-approved chemicals and products list**, based on less toxic or non-toxic alternatives to make non-toxic implementation and enforcement easier in your school. Only allow procurement of approved chemicals. For example, the Los Angeles Unified School District's Chemical Hygiene Program allows only approved chemicals to be used in school laboratories.[15] Teachers and other staff should be strongly discouraged from bringing in products on their own.
- **Investigate pollution prevention and green chemistry options** (see Section 3.2) to determine whether certain chemicals can be reduced in quantity or eliminated entirely from science and art classes.
- **Limit the quantity of chemicals purchased** to what will be used during the current school year or can be fully consumed under normal conditions within the shelf life of the product. Another concept is "just in time" purchasing in which chemicals are purchased as needed

[15] Los Angeles Unified School District's Chemical Hygiene Program, http://www.lausd-oehs.org/chemical-hygiene.asp, Accessed 28 March 2008

throughout the school year. These purchasing methods reduce the costs and management needs associated with excess and expired chemicals.

- **Consider disposal costs at time of purchase.** Many chemicals deteriorate with time. The disposal cost for expired materials may be 20 to 50 times the original purchase price. The real cost of chemicals should be regarded as the initial purchase price plus any ultimate disposal costs.[16]

Schools should exercise EXTREME CAUTION when accepting chemical donations, product samples, or promotional products (e.g., do not accept chemicals more useful for electroplating than for the teaching of high school chemistry). Schools should not give away chemicals to avoid the costs of disposal.

3.3.2 Inventory

An important part of responsible chemical management is the creation of an accurate chemical inventory that identifies the quantities and physical locations of, as well as the potential hazards associated with, all of the chemicals used and stored in a school. It also serves as a reference for school and emergency personnel (for example, local fire department) in the event of an emergency. Furthermore, a chemical inventory, when used to guide necessary purchases, can reduce the costs and management needs associated with excess chemicals, and can identify inappropriate chemical storage practices.

Examples of unsafe chemical storage practices.[17]
(a) Ammonia and bleach cleaning products are incompatible and should not be stored near each other, especially in maintenance storage areas or in hot boiler rooms where the bottles may bulge or break, because mixing of these two chemicals releases a toxic cloud of chlorine gas.
(b) Old and unlabelled chemicals in leaking containers pose a hazard to students and school personnel.

Guidelines that schools and administrators should follow in order to conduct an inventory at their school are provided below.

[16] Ohio Environmental Protection Agency, Pollution Prevention Lab Sheet, http://www.epa.state.oh.us/opp/Fact16_web.pdf, November 2005.

[17] From "No More Methyl-Something": Improving Management of Curriculum Chemicals in Schools", Maryann Suero, USEPA, presentation at National Teachers Association Regional Conference, November 10, 2005

- **Conduct an inventory** of all of the chemicals and products containing chemicals (e.g., mercury thermometers) stored on-site, covering all sections of the school including maintenance rooms and closets, storage sheds, greenhouses, and all classrooms. Engage all school staff who will either be involved in conducting the inventory, or will be having their chemicals inventoried. Pre-packaged science experiments or demonstration kits should be included in the chemical inventory. Conduct the inventory when students are NOT in school. Refer to Appendix H for instructions on conducting an inventory.
- **Establish a policy that chemical inventories be conducted and updated annually**, unless laws or regulations require a more frequent schedule. Contact your local environmental or health department, industry partner, or chemical supplier, or identify a responsible person within the school who has training in hazardous chemical management to assist with the inventory.
- **Review other documents you may have in schools** in your district, such as a chemical hygiene plan or hazard communication plan, to ensure that chemicals are consistently being managed, stored, handled, and disposed of properly. Review your approved chemicals and products list. Chemicals and products not on this list should be removed and properly disposed of or recycled according to applicable laws.
- **Conduct periodic cleanouts** by identifying and removing unnecessary hazardous materials and expired chemicals through appropriate recycling and/or disposal methods. Existing accumulations of outdated, unknown, poorly labeled, improperly stored, or degraded chemicals, and excessive quantities of hazardous chemicals are present in many schools. Chemical inventories should be conducted prior to cleaning out chemicals from schools. Again, contact your local environmental or health department, industry partner, chemical supplier, or someone with technical qualifications to identify potentially dangerous situations and properly handle the chemicals. School staff should not move very old chemicals because of the extreme hazard they may present.

Check It Out

Schools Chemical Cleanout Campaign

U.S. EPA has established the Schools Chemical Cleanout Campaign (SC3) to improve chemical management in schools in the United States. The SC3 guidelines can help school administrators keep students, faculty, and staff healthy and safe from exposure to dangerous chemicals. For more information, see http://www.epa.gov/sc3/.

School leadership should recognize that cleanout and accident prevention programs are good investments for schools. Cleaning up after a chemical incident is costly (can cost over a million dollars (US$), cause closure of schools, and relocation of students). School cleanout programs are a relative bargain (average cost of US $5,000 per school). For example, compare the following two approaches to mercury in schools:[18]

[18] United States Environmental Protection Agency and Federal Emergency Management Agency, Planning for Environmental Health and Safety Issues in Schools, http://www.epa.gov/epaoswer/osw/conserve/clusters/schools/pdfs/fema.pdf, Accessed March 28, 2008.

Table 3. Two Different Approaches to Mercury in Schools

	Proactive (Schools Cleanout Program)	Reactive (Cleanup After a Chemical Incident)
School's Approach	In a joint "Rehab the Lab" program, *81 schools* collected their liquid mercury and mercury thermometers, and packed and transported them for hazardous waste disposal.	A small amount of mercury was spilled at *one school* on a carpet, causing bad publicity, potential exposure, and extensive clean-up and disposal costs.
Total Cost	US$24,300	US$30,000
Cost/School	US$300	US$30,000

3.3.3 Storage and Handling

In order to reduce the risk of chemical accidents, administrators should familiarize themselves with policies and procedures for safe handling and storage of chemicals in their schools. Products used in schools should have an MSDS, be stored in their original containers in a secure location, and be correctly and clearly labeled. The guidelines below outline some general steps for safe handling and storage of chemicals in schools.

- **Establish a chemical storage policy** that addresses how chemicals should be properly stored, labeled, and secured, as well as who should have access to these chemicals and chemical storage locations. Chemicals should not be stored in areas that are occupied by or accessible to students, such as classrooms or restrooms. Instead, they should be stored in a central, secure location. In addition, many chemicals are incompatible and should not be stored together. Appendix I provides guidelines for safe storage of chemicals.
- **Conduct annual inspections** of classrooms, janitorial closets, and chemical storage areas in your school to ensure the integrity of chemicals and storage structures. Spot inspections may be performed periodically throughout the school year. Engage maintenance staff in these inspections if storage shelving or locks are in need of updates or repair. Create and maintain an up-to-date map of the location and storage pattern of chemical storage rooms and cabinets in your school.
- **Inspect and test emergency equipment** (e.g., eyewash stations and safety showers) as well as fume hoods and ventilation systems/exhaust fans at least on an annual basis. Engage maintenance staff in these inspections if safety equipment is in need of updates or repair. Establish protocols for the upkeep of emergency equipment and the associated maintenance records.
- **Work with a local chemical supplier to ensure that you have MSDS information for all chemicals on site.** Hazardous chemicals in schools should be stored in accordance with MSDS specifications. At a minimum, MSDS information should be located in all chemical storage rooms and cabinets and in a central place within the school (away from the chemicals), as well as a central location for the school district.
- **Follow appropriate safety measures** when working with any chemical. Standard safety measures include wearing safety glasses, long-sleeved shirts, pants, close-toed shoes, and gloves. Not all of these measures may be necessary for every chemical; check with the chemical manufacturer or consult the chemical's MSDS to determine the appropriate safety measures, including the specific type of gloves (e.g., latex, nitrile) to wear.
- **Create a written emergency response plan** for all chemicals and products. This plan should describe what to do and whom to contact in the event of a spill or

release, as well as the location of spill management supplies and equipment (e.g., spill kits, fire extinguishers) within the school. The clean-up and response plan should include a process for communicating with students, parents, teachers, and other staff about the incident, as well as methods for preventing accidents and exposures.

Spill clean-up materials should be available and labeled. Citric acid may be used to neutralize base spills, sodium bicarbonate may be used to neutralize acid spills, and an absorbent material may be used for organic spills.

Check It Out

Poor Chemical Storage Practices

Schools should take special care to AVOID the following examples of poor chemical storage practices:

- **Water reactive chemicals stored near or under a sink.**
- **Heavy containers stored on high shelves.**
- **Corrosive chemicals stored on metal shelves (especially if corroded).**
- **Flammable chemicals stored on wood shelves.**
- **Chemicals stored alphabetically by name.**
- **Unlabeled or "mystery" content chemicals.**
- **Chemicals stored next to food, or in old food containers.**

3.4 Chemical Disposal

Hazardous wastes must be disposed of in accordance with applicable laws and regulations. Such requirements generally prohibit any drain disposal of hazardous chemicals or "treatment" of hazardous wastes beyond pH adjustment, and may be far more stringent than the disposal suggestions provided by chemical suppliers. Proper chemical disposal can reduce the costs and management burdens associated with excess chemicals, including disposal costs of expired chemicals and the time required for inventory and storage of excess and unwanted chemicals, as well as costs of penalties due to enforcement actions that may result from improper chemical management.

Guidelines are provided below that schools and administrators should follow for proper chemical disposal.

- **Establish a policy that makes pollution prevention the preferred form of waste management** and strives to eliminate the purchase and use of most, if not all, hazardous chemicals. If elimination of the particular chemicals is not possible, other options include, in order of preference, reuse or recycling of chemicals and products; treatment of chemicals to reduce toxicity; and disposal of chemicals in an environmentally safe manner.
- **Develop a budget for chemical management and disposal.** Initial costs may involve hiring a chemical expert and disposing of accumulated chemicals and products. A longer-term waste disposal budget should account for the staff time necessary to develop and maintain disposal procedures, the purchase of special equipment and supplies, the upkeep of safety equipment (e.g., fume hoods), and annual hazardous chemical disposal and staff training.

- **Establish a chemical disposal policy** that addresses how unused and outdated chemicals and products containing chemicals should be properly removed from schools (refer to "Chemical Treatment and Disposal Tips" below.

Note that while treatment may be a viable option to reduce or eliminate chemical waste, **treatment of hazardous waste may require a permit** or be subject to regulation. Schools should consider discussing any treatment options with local or regional government regulatory agencies before implementing them in laboratories.

There are a variety of types of treatment techniques for making compounds non- or less hazardous, such as:[19]

- Neutralization
- Separation
- Fixation
- Oxidation
- Precipitation
- Degradation
- Ion exchange.

Neutralization of acids and bases is probably the most commonly used treatment method in educational institutions. Neutralization reduces a material's corrosivity (acid or caustic properties) by raising or lowering the pH to a neutral range, between 6 and 9.

Check It Out

Chemical Treatment and Disposal Tips

Examples of some laboratory wastes amenable to treatment or neutralization are:

- **Phenol – with hydrogen peroxide and iron catalyst**
- **Acid halides and anhydride – by hydrolyzing using sodium hydroxide solution**
- **Hydroperoxide – by addition to acidified ferrous sulfate solution**
- **Metal hydride – through gradual addition of methanol, ethanol, or N-butyl alcohol**
- **Soluble metal fluoride – by treating aqueous metal solutions with calcium chloride solution**
- **Finely divided metal – by oxidation with water**
- **Aqueous solutions containing toxic metal ions, precipitate as insoluble sulfides using sodium sulfide in neutral solution**
- **Oxidizing agents (e.g., hypochlorite or chromate) – by reduction using sodium bisulfite.**

Again, before you implement any treatment methods, you should discuss your plans with state or local regulatory agencies.

[19] Battelle Seattle Research Center, In-Laboratory Treatment of Wastes, http://www.p2pays.org/ref/01/text/00779/ch13.htm, 1996, accessed March 28, 2005.

3.5 Activity 3: Brainstorming on School Polices and Actions

There are many ways to approach mercury and chemical safety; the important thing is to get started on relevant policies and actions at the school and school district levels. In this activity, participants will engage in interactive discussion on the materials in Chapter 3 (Policies and Actions for School Administrators and Teachers) to identify specific policies and actions that their schools can take (or have taken) to improve mercury and chemical safety.

Think through the materials presented in Chapter 3, and participate in the group discussion by developing practical solutions based on your own experience. Here are a few ideas to get you started:

A school could….

- Develop a mercury and chemical safety policy, and award prizes for the classrooms that best demonstrate compliance.
- Join together with other schools and contact a regional hazardous waste management company to deal with disposal of mercury products or other chemicals.
- Have a contest for students to create a cartoon character that will serve as the "mascot" for all school chemical safety materials.

Chapter

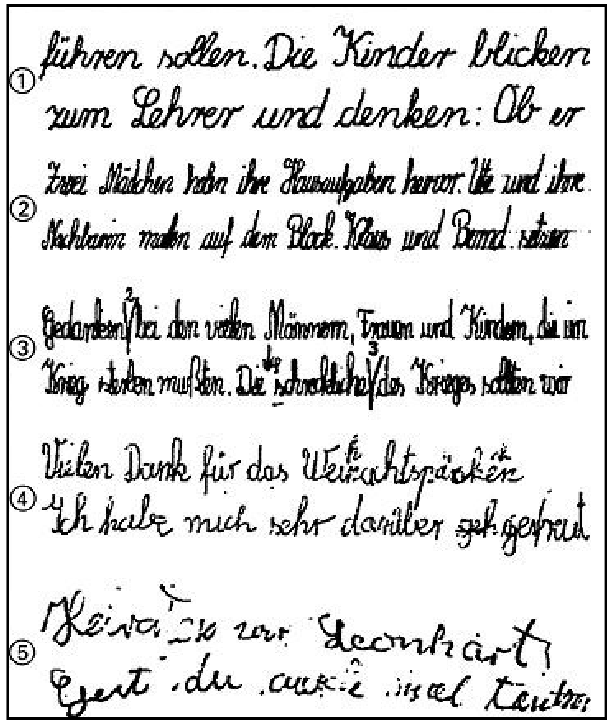
4

Be Smart About Mercury

Mercury exists in various forms, and people are exposed to each in different ways. Mercury deserves special attention because it:

1. Can interfere with the development of children and adolescents,
2. Can be found in some schools, often in science classrooms or elsewhere, and
3. Lasts a long time if a spill is not properly cleaned up.

Exposure to high levels of mercury, as would occur with the direct inhalation of mercury vapor released during a mercury spill, is associated with damage to the brain, heart, kidneys, lungs, and immune system. Concern about mercury has increased recently due to the recognition of its widespread global cycling in the environment and developmental health effects observed at relatively low levels of exposure. It is important to identify potential sources of exposure to mercury in schools and to follow procedures for minimizing or eliminating such exposures. This chapter discusses background information on mercury, global and local mercury sources and cycles, health impacts, and actions that can be taken to reduce mercury impacts in schools.



Hand-writing of a 9 year old girl in monthly intervals after an accidental intake of mercury-containing seed preservatives. This exposure was due to contaminated grain, and demonstrates that exposures well after infancy can also have serious consequences.[20]

[20] World Health Organization, Training Package for the Health Sector, Mercury, August 2006.

4.1 Mercury Basics

Mercury is a naturally occurring element that is found in air, water, and soil. It exists in several forms: elemental, inorganic, and organic.[21]

- **Elemental Mercury:** Elemental mercury, also referred to as metallic mercury or quicksilver, is a shiny, silver-white, odorless liquid that is used in thermometers and other measuring instruments, dental fillings, batteries, electrical switches, and some industrial processes. Elemental mercury is also used in some herbal and religious remedies associated within certain spiritual practices and folk remedies in Asian, Latin American, and Caribbean cultures. Elemental mercury readily evaporates at room temperature forming a colorless, odorless gas. In an enclosed space, even a small amount of mercury can result in the accumulation of very high levels of mercury vapor in indoor air. Therefore, exposure via inhalation of elemental mercury is of particular concern when mercury is spilled in schools, homes, or other enclosed areas.

- **Inorganic Mercury:** Mercury combines with other elements, such as chlorine, sulfur, or oxygen, to form inorganic mercury compounds or "salts" that are usually white powders or crystals. Mercury salts are used in some skin-lightening creams, antiseptic creams, and ointments. Mercury amalgamation (combining mercury with other materials) is the most commonly used method in artisanal and small-scale gold mining, practiced by 10 to 15 million miners (including 1 million children) in more than 55 countries, primarily in Asia, Africa, and South America.[22] Inorganic mercury does not readily evaporate and is not easily inhaled. However, inorganic mercury can be absorbed across the gastrointestinal tract and the skin. Therefore, ingestion and skin contact can result in exposure.

- **Organic Mercury:** Mercury also combines with carbon to form organic mercury compounds. The most common form is methyl mercury produced predominantly by bacteria in water, soil, or sediment. Increasing emissions of mercury into the environment, primarily from coal burning and waste incineration, can increase the levels of methyl mercury that these organisms produce. The most significant source of human exposure to organic mercury is through diet, particularly from fish products. Since organic mercury is easily absorbed across the gastrointestinal tract and through the skin, ingestion and skin contact can result in exposure.

4.2 Mercury Sources and Uses

4.2.1 Global View of Mercury

Mercury is released into the environment (into air, water, and soil) from both natural processes and human activities. Mercury sources can be grouped as follows:

1. Natural processes release mercury from the Earth's crust (for example, volcanic activity and weathering of rocks).
2. Human activities release mercury found in raw materials, such as burning fossil fuels to generate electricity (especially from coal but also from oil and gas), and mining and metals production.
3. Human activities release mercury that is intentionally used in products and

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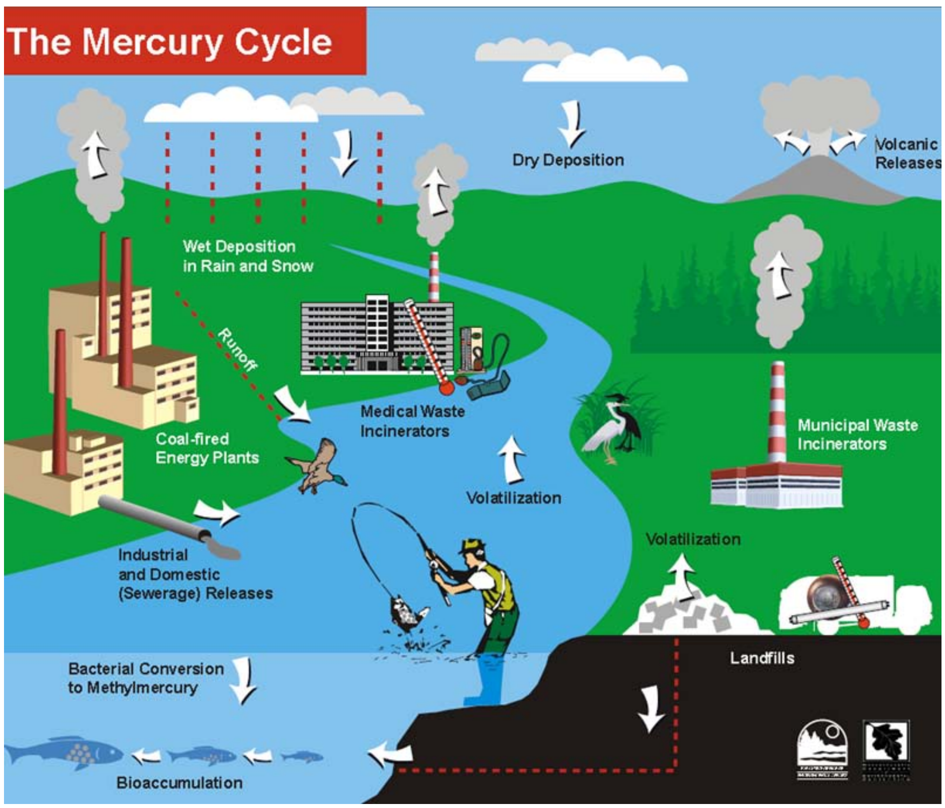
21 Final Report, Republic of the Philippines and U.S. EPA Collaborative Mercury Spill Response, St. Andrews School Mercury Spill Assessment and Removal, La Huerta, Paranaque City, Philippines, 20-25 May 2006.

22 United Nations Industrial Development Organization (UNIDO), Global Mercury Project, Report to the United Nations Environment Program Governing Council Meeting, Global Impacts of Mercury Supply and Demand in Small-scale Gold Mining, October 2006.

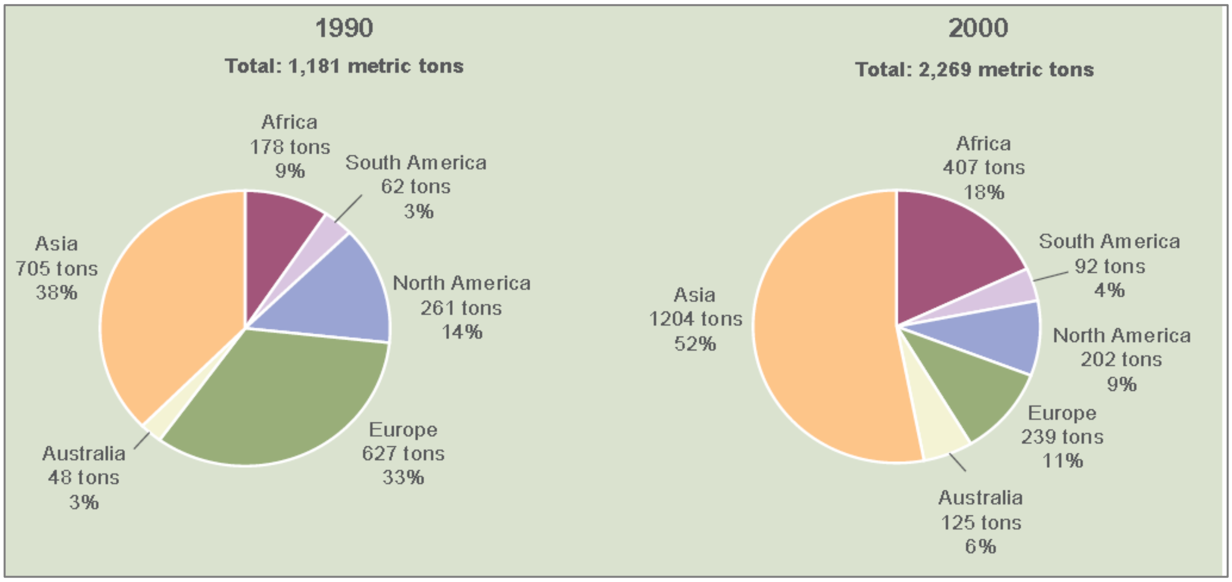
processes (for example, manufacturing, use, and incineration or disposal of some types of batteries, thermometers, and dental amalgams).

The United Nations Environment Program (UNEP) estimates that the total global emissions of mercury (from human activities and natural processes) ranges from 4,400 to 7,500 metric tons per year. The U.S. EPA estimates that 50 to 70 percent of current global anthropogenic atmospheric emissions (from human activities) come from fossil fuel combustion. China, India, and other Asian countries accounted for over 50% of anthropogenic atmospheric mercury emissions in 2000, as highlighted in the following figure. Coal consumption in Asia is expected to grow significantly over the next 20 years.



The Mercury Cycle[23] – Mercury from natural processes and human activities cycles through the environment. Mercury in products such as thermometers is released to the air from municipal waste incinerators, landfills, and trash dumps. Mercury from products in landfills and trash dumps can also reach lakes, rivers, and oceans by seeping into the surrounding soils and groundwater.

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



Distribution of Man-made Emissions of Mercury[24]

Atmospheric mercury can be transported over a range of distances before it is deposited onto land or water, resulting in deposition on local, regional, continental, and global scales. Mercury that remains in the air for prolonged periods of time and travels across continents is said to be in the "global cycle." Mercury in the air eventually settles into water or onto land where it can be washed into water. Once mercury has been deposited, certain microorganisms can change mercury into methylmercury, a highly toxic form that builds up in fish, shellfish, and other animals that eat fish. The process of concentrating mercury as it moves higher up the food chain is called bioaccumulation. The concentrations of methylmercury in large fish can be over a million-fold larger than in the surrounding water.

4.2.2 Local View of Mercury – Thailand

In Thailand, there are several sources of mercury release attributable to human activity, including power plants, oil and gas production, gold mining, hospitals, and industry. At least four major thermal power plants in Thailand burn coal to produce electricity. All coal contains some level of mercury, and burning the coal releases the mercury into the air; mercury also remains in the ash left after combustion. The small-scale application of mercury in gold extraction, which has been a major focus for reduction by UNEP, has been reported to remain in "a few local villages" in Thailand. In the oil and gas industry, treatment technologies have been employed to reduce mercury prior to discharge, but waste discharges in the Gulf of Thailand containing trace amounts of mercury continue from oil and gas operations. Mercury in paint has been reduced by a Ministry of Industry "green label" program, although up to 25% of paint factories still apply mercury in their manufacturing process. The fluorescent lamp industry in Thailand reportedly conducts manufacturing processes in a closed

[24] 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.

system to minimize mercury releases during production. In 2003, Thailand imported approximately 14,000 kg of mercury, primarily for application in fluorescent lamp production, dentistry, and lab analysis.

The Thailand Pollution Control Department (PCD) monitors mercury levels in the environment. Given the elevated awareness of the human health risks associated with the consumption of mercury-polluted seafood, Thailand PCD has sampled marine organisms to assess the extent of such risk. Results of this sampling through 2001 did not find any exceedances of the standard prescribed by the Ministry of Public Health. However, PCD testing in 2007 of imports from China found excessive mercury in some seafood and pickled bean curd, prompting intensified testing by PCD. The PCD also conducts a coastal water sampling program. The results for 2001 to 2003 did not reveal any exceedance of the National Coastal Water Quality Standard of 0.1 ug/L, although values approaching the standard prompted PCD to identify the responsible industrial source to address the problem. Similarly, sampling of 16 major rivers did not reveal any exceedance of the 2 ug/L Thailand Surface Water Quality Standard. PCD has also conducted sampling of sediments (river bottom material) and found isolated cases of mercury concentrations above sediment quality standards established by environmental agencies in Australia, Hong Kong, New Zealand, and Florida.[25]

4.2.3 Mercury in Schools

Science classrooms and storerooms often contain elemental mercury or mercury compounds used as laboratory reagents. Science classes also may use mercury thermometers, or other mercury-containing laboratory instruments such as barometers (pressure gauges for measuring the pressure of the atmosphere). These all create significant risks of mercury spills, particularly if students have access to them. There is no need for science classrooms to use these chemicals or devices; there are safe, non-mercury replacements for all of them. In addition, nurses' offices often contain mercury fever thermometers and sphygmomanometers (blood pressure measuring devices), which also pose spill risks because they are easily breakable. There are non-mercury thermometers and blood pressure devices available as well. All schools are encouraged to prevent spills by removing all elemental mercury, mercury compounds, and mercury measurement devices from classrooms and nurses' offices.

Mercury is also used in many of the types of items that are found in some buildings, such as thermostats, flow meters, boiler controls, and electrical equipment. Generally, such equipment poses little risk of spill because the mercury is not easily accessible and the products are not easily broken. However, such equipment needs to be disposed of properly at the end of its life, and new equipment should be mercury-free. School building maintenance staff should inventory mercury-containing equipment, properly dispose of it when it comes out of service, and implement mercury-free purchasing policies.

Schools may continue to use one category of mercury-containing product – fluorescent lamps. There is currently no alternative to mercury-containing fluorescent lamps that is as energy efficient and that is appropriate for general indoor lighting. The energy efficiency of fluorescent lamps makes them a good environmental choice because of less emissions of mercury and other pollutants from power generation. However, while the amount of mercury in each lamp is small, schools use significant numbers of lamps, and these must be disposed of properly.

25 Thailand Pollution Control Department and Chulalongkorn University, Mercury Situation in Thailand (undated).

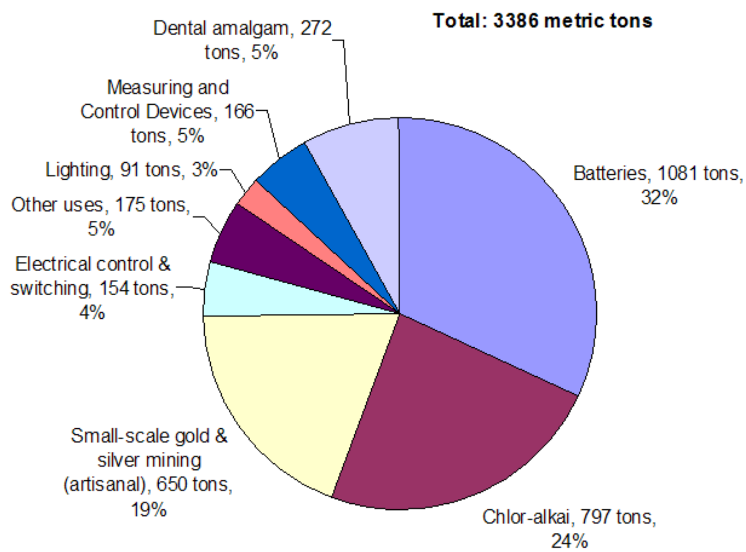
For example, refer to Thailand PCD's website (http://www.pcd.go.th/info_serv/en_hazadous.html) for information (in Thai) on their fluorescent lamp recycling program.

4.2.4 Mercury in Products

Mercury has properties that have led to its use in many different products. Mercury conducts electricity, forms alloys with other metals, and expands in response to changes in temperature and pressure. Mercury is also used in the chlor-alkali industrial process, which produces hydrogen, sodium, chlorine, and potassium hydroxides. Some mercury compounds act as preservatives, and are used in medicines and other products. Because some of these products may be found in schools, or in the homes and communities of students and teachers, they are discussed briefly below.

Products that may contain mercury include certain types of batteries, thermometers, thermostats, skin-whitening creams, dental amalgams (fillings), paints, light-up tennis shoes, and novelty jewelry items. Also, all fluorescent light bulbs contain mercury. These products vary in terms of their risk to human health, as further discussed in Section 4.3. While most skin-whitening creams are considered safe, some of the least expensive (and often black market or illegal) creams contain mercury or other dangerous chemicals. For example, Thailand's Food and Drug Administration has published a list of 70 skin-whitening creams circulating illegally around the country.[26]

While some manufacturers have reduced or eliminated their use of mercury in products, there are still many existing items in the marketplace that contain mercury. However, in most cases, non-mercury alternatives exist for mercury-containing products.



Global Mercury Use in 2000. The largest use of mercury in products in 2000 was in batteries. Source: USEPA Roadmap for Mercury (2006)

[26] Mercury in Cosmetics, Michael Bender, Mercury Policy Project, Serial Mercury Working Group, Workshop to Reduce Use and Release of Mercury in Products for the Asia Pacific, Bangkok, Thailand, 17-19 May 2007, pp. 260-267.

4.3 Mercury Exposure and Health Impacts

Adverse human health effects can result from acute or chronic exposure to mercury. Exposure occurs primarily through inhalation, and to a lesser extent through skin absorption or ingestion. Acute exposures may result from breaking products containing mercury. Acute exposure to high levels of elemental mercury vapor can affect the brain and the central nervous system. Exposure to high levels of mercury vapor can also cause symptoms such as irritation to the lining of the mouth, lungs, and airways; increased blood pressure and heart rate; nausea; vomiting; diarrhea; skin rashes; eye irritation; and a condition known as acrodynia, which is a syndrome characterized by red peeling skin, especially on the hands, feet, and nose. Exposure may also cause symptoms such as weakness, fretfulness, sleeplessness, excessive salivation or sweating, itching, swelling, fever, memory loss, and elevated blood pressure.

Even a small amount of mercury remaining in a room after a spill can continue to evaporate slowly over time, resulting in elevated concentrations of mercury in the air, thus presenting the threat of chronic exposure. Symptoms of chronic exposure to elemental mercury include personality changes (irritability, shyness, nervousness); tremors; vision changes; deafness; lack of muscle coordination; loss of sensation; and memory difficulties.[27]

Fish and shellfish consumption are the main sources of methylmercury exposure to humans, typically representing a chronic exposure. Young children are particularly susceptible to the effects of mercury because it affects the central nervous system, which is still developing in the first few years of life.

[27] U.S. Environmental Protection Agency Emergency Response Team and Region 5, Mercury Response Guidebook (for Emergency Responders) , http://www.epa.gov/mercury/spills/index.htm, July 2004.

Even low levels of mercury exposure have been associated with learning problems in children.

Sources of exposure for children in the developing world may be quite different than exposures to the general public worldwide. For example, children in the developing world may face:

- Occupational exposures from gold/silver mining that are usually high and may be acutely toxic, seen in the context of child labor.
- Regional uses of mercury as seen with traditional rituals and folk remedies, and preparation of cosmetics (skin whiteners, creams, lotions, and soaps) with mercury.
- Eating contaminated fish as a major portion of their diet.

The effects of mercury exposure can be very severe, subtle, or may not occur at all, depending on the person's health, age, exposure, and other factors. Because fetuses, infants, and children are still developing, they are particularly sensitive to the effects of methylmercury on the nervous system.

4.4 What Can We Do About Mercury?

4.4.1 Reduce or Eliminate Mercury in Your School

There are many steps administrators, teachers, and parents can take to reduce or eliminate mercury in schools. For best results, include representatives from all levels of school staff in any efforts to eliminate mercury, as well as parents, students, and concerned citizens. A good way to proceed is to create a "Mercury Task Force" composed of science teachers, janitors, grounds-keepers, school nurses, administrators, parents, and students.

The Mercury Task Force can lead the effort toward removing all mercury from the school by accomplishing the following steps:

- Conduct a thorough inventory of all mercury sources in the school, including those found in classrooms, laboratories, storerooms, and nurse's offices.
- Make sure mercury sources are well labeled.
- Work toward replacing essential mercury sources, such as thermometers, with mercury-free alternatives, as described in Section 3.2.
- Establish a mercury spill response plan (see Section 4.4.2). Ensure that school staff and students know what to do in the event of a mercury spill. A good mercury spill response plan includes steps for spill containment, evacuation, ventilation, decontamination, clean-up, and disposal. The response plan should also include a procedure for notifying the appropriate local authorities and parents.
- Prevent accidental mercury spills by storing non-essential mercury sources properly until they can be removed from school property.
- Contact the local hazardous waste disposal agency or a private hazardous waste disposal company to safely remove mercury sources from school property. Do NOT throw mercury-containing items or chemicals in the trash or down the drain!
- Raise awareness about mercury safety in the community by informing residents about the hazards of mercury compounds.

4.4.2 Follow Safe Handling, Spill Cleanup, and Disposal Practices

Mercury spills can occur at home or in schools. One of the most common causes of mercury spills is a broken mercury thermometer. All mercury spills, regardless

> **Check It Out**
>
> **Secure Temporary Storage of Mercury**
>
> **Until mercury-containing items can be properly removed from the school, they should be stored in a secure location, inside of a larger container with a tight fitting lid packed with oil-absorbent matter (e.g., kitty litter), and clearly labeled with "Mercury - DO NOT OPEN."**

of size, are hazardous. Liquid elemental mercury emits toxic vapors into the air that can poison children, adults, and pets. Mercury vapor is colorless and odorless and thus difficult to detect. Liquid mercury easily separates into tiny beads that can accumulate in very small spaces, such as on carpet fibers or between floor tiles. To avoid dangerous contamination of clothing and belongings, always follow safe cleanup practices when dealing with a mercury spill! This section outlines the equipment you will need to clean up a small mercury spill (about the amount in one thermometer), and tells you what NOT to do in the case of a spill. Appendix J contains detailed step-by-step instructions that you should follow in the event of a mercury spill.

One of the most important things parents and teachers can do to prevent children from being exposed to the toxic effects of mercury is to have a plan in place in the event of a mercury spill. Whenever possible, a qualified professional cleanup contractor should be engaged to clean up mercury spills. Professional cleanup contractors have access to specialized equipment that permits safe removal of mercury from most nonporous surfaces such as smooth concrete, tile floors, and counters. In the event a professional contractor is not available, the procedure below should be followed when a mercury spill occurs. Treat this procedure like a "fire drill" by practicing it several times per year so adults and children become familiar with

Check It Out

Mercury Spill Cleanup Kit

- **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**

their roles. Assemble a "Spill Cleanup Kit" and store it in a safe place so it is readily available in the event of a spill[28]. 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.

What NOT to Do in the Event of a Mercury Spill

- *Never allow children or adolescents to clean up a mercury spill!* Children and adolescents 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. Adults are also more responsible than children and adolescents and can be trusted to follow all the steps for safe cleanup of a mercury spill.
- *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.

[28] Adapted from U.S. Environmental Protection Agency's Mercury Spill Page, http://www.epa.gov/mercury/spills/index.htm, Accessed March 31, 2008.

4.4.3 Support Community-Wide and National Efforts to Reduce Mercury

The UNEP Mercury Program was created in 2003 to reduce the risks of mercury to human health and the environment. The program is supported by 130 nations including the Asian nations of Bangladesh, Cambodia, China, India, Indonesia, Japan, Malaysia, Mongolia, Philippines, Sri Lanka, Thailand, and Vietnam. The program endorses immediate actions to reduce mercury uses and releases, assist developing countries to create mercury emissions inventories, raise awareness, and provide technical assistance.

The role of schools in such efforts can be to educate their students about some broader scale actions that countries can take to control mercury through regulatory measures, such as:

- Control and reduction of Hg release into the environment through actions on:
  - Coal burning power plants
  - Medical uses and waste
  - Municipal and hazardous waste incineration
  - Factory and mining discharges
- Regulation/eradication of child labor in situations where exposure to mercury is likely – in small-scale mining areas and other occupations
- Environmental quality standards – control of mercury levels in drinking water, surface waters, air, soil, and foodstuff, such as fish
- Standards, actions, and programs on mercury exposure – In the workplace, through fish consumption advisories, and consumer safety measures.

The public can contribute to mercury reduction efforts by purchasing mercury-free products and correctly disposing of products that contain mercury, and by reducing demand for products whose production leads to the release of mercury into the environment.

Check It Out

Case Study: Japan Experience With Mercury Recovery from Products

Japan has multiple programs targeted at recovering mercury from used products before it enters the waste stream and ultimately the environment. In 1986, the Ministry of Health and Welfare issued guidance to municipalities on separating batteries in waste collection and recovery of mercury. By 2005 the program had collected 11,300 tons of dry cell batteries, representing 170 kg of mercury recovered. In 1999, the Japan Waste Management Association began a collection and recovery initiative for fluorescent lamps in municipal waste. By 2005, the program had collected 5000 tons of fluorescent lamps, representing 200 kg of mercury recovered.

Source: Eisaku Toda, Environmental Health and Safety Division, Ministry of the Environment, Japan, Workshop to Reduce Use and Release of Mercury in Products for the Asia Pacific, Bangkok, Thailand, 17-19 May 2007, pp. 236-242.

4.5 Activity 4: Mercury Spill Role-Playing

This activity is designed to prepare participants to properly address a mercury spill at a school. The following spill scenario requires specific actions of everyone involved.

Each training participant should pick a role, read through the scenario, and then act out the instructions for clean-up of a mercury spill.

Roles:

1 teacher
1 assistant teacher
1 principal
3 mercury-contaminated students
5 (or more) clean (not mercury-contaminated) students

Scenario:

In a high school chemistry class, mercury thermometers are provided to students as part of the required laboratory equipment for a science experiment. Three of the students are misbehaving, when one accidentally knocks a glass beaker and a thermometer off the laboratory table onto the floor. Both items break.

Following the step-by-step instructions in Appendix J to properly respond to the "spill," act out your role in the spill clean-up. Afterwards, participate in a discussion on ways the clean-up could have been improved, and any lessons learned from practicing the clean-up instructions.

Chapter

5

Conclusions

Chemicals are used daily in both the maintenance of schools and the curriculum taught. Despite their useful purposes, chemicals can be dangerous to students and staff when managed improperly. Some chemicals that are persistent in the environment and bio-accumulate through the food chain can make exposure during childhood and adolescence especially dangerous. In particular, mercury has long-lasting effects on human health and the environment, and mercury-containing thermometers should be properly disposed of and replaced with safer alternatives.

Ensuring that chemicals are properly managed will help school administrators safeguard the health and safety of students and school employees; avoid disposal expenses and school closures associated with spills and emergency incidents; maintain a sense of trust between the district and the surrounding community; and prevent unintended discharges and spills, which inflict damage upon the environment.

As a path forward, schools should:

- Support chemical management efforts with appropriate budget.
- Appoint and train well-qualified, responsible leadership.
- Share your experiences with other districts and administrators.
- Purchase safer alternatives to hazardous substances.
- Adopt policies encouraging proper purchasing, labeling, storage, and disposal of chemicals and products.
- Train faculty and staff (and students, as applicable) on the potential dangers posed by chemicals, and on available alternatives that are less hazardous.
- Disseminate information on reducing the quantity and hazards of hazardous chemicals and products.

When implemented effectively, chemical management promotes awareness about the range of chemicals and products used in schools and creates a healthier and safer atmosphere for school occupants and the surrounding environment.

Appendix A. Example of a Material Safety Data Sheet for Mercury Sulfide[29]

Material Safety Data Sheet
Mercury(II) sulfide, red, 99.5+%

ACC# 94301

Section 1 - Chemical Product and Company Identification

MSDS Name: Mercury(II) sulfide, red, 99.5+%
Catalog Numbers: AC222690000, AC222690500
Synonyms: Vermilion; Chinese Red; C.I. Pigment 106; C.I. 77766
Company Identification:
Acros Organics N.V.
One Reagent Lane
Fair Lawn, NJ 07410
For information in North America, call: 800-ACROS-01
For emergencies in the US, call CHEMTREC: 800-424-9300

Section 2 - Composition, Information on Ingredients

CAS#	Chemical Name	Percent	EINECS/ELINCS
1344-48-5	Mercury(II) sulfide, red	99.5+%	215-696-3

Section 3 - Hazards Identification

EMERGENCY OVERVIEW

Appearance: red powder.
Danger! Very toxic by inhalation, in contact with skin and if swallowed. May be fatal if inhaled, absorbed through the skin or swallowed. May cause eye, skin, and respiratory tract irritation. May cause central nervous system effects. Danger of cumulative effects.
Target Organs: Kidneys, central nervous system.

Potential Health Effects
Eye: May cause eye irritation.
Skin: May cause skin irritation. May be fatal if absorbed through the skin.
Ingestion: May be fatal if swallowed. May cause irritation of the digestive tract. May cause central nervous system effects.
Inhalation: May be fatal if inhaled. May cause respiratory tract irritation.
Chronic: May cause kidney injury. Chronic exposure to mercury may cause permanent central nervous system damage, fatigue, weight loss, tremors, personality changes.

29 Fisher Safety, MSDS Search, http://www.fishersci.com/wps/portal/CMSTATIC?pagename=msds, Accessed March 31, 2008.

Section 4 - First Aid Measures

Eyes: Immediately flush eyes with plenty of water for at least 15 minutes, occasionally lifting the upper and lower eyelids. Get medical aid imme diately.
Skin: Get medical aid immediately. Immediately flush skin with plenty of water for at least 15 minutes while removing contaminated clothing and shoes.
Ingestion: Do not induce vomiting. If victim is conscious and alert, give 2-4 cupfuls of milk or water. Get medical aid immediately.
Inhalation: Remove from exposure and move to fresh air immediately. If breathing is difficult, give oxygen. Get medical aid. Do NOT use mouth-to-mouth resuscitation. If breathing has ceased apply artificial respiration using oxygen and a suitable mechanical device such as a bag and a mask.
Notes to Physician: Treat symptomatically and supportively.
Antidote: The use of Dimercaprol or BAL (British Anti-Lewisite) as a chelating agent should be determined by qualified medical personnel.

Section 5 - Fire Fighting Measures

General Information: As in any fire, wear a self-contained breathing apparatus in pressure-demand, MSHA/NIOSH (approved or equivalent), and full protective gear. During a fire, irritating and highly toxic gases may be generated by thermal decomposition or combustion.
Extinguishing Media: Substance is noncombustible; use agent most appropriate to extinguish surrounding fire.
Flash Point: Not available.
Autoignition Temperature: Not available.
Explosion Limits, Lower: Not available.
Upper: Not available.
NFPA Rating: (estimated) Health: 4; Flammability: 0; Instability: 0

Section 6 - Accidental Release Measures

General Information: Use proper personal protective equipment as indicated in Section 8.
Spills/Leaks: Vacuum or sweep up material and place into a suitable disposal container. Wash area with soap and water. Clean up spills immediately, observing precautions in the Protective Equipment section. Avoid generating dusty conditions.

Section 7 - Handling and Storage

Handling: Wash thoroughly after handling. Minimize dust generation and accumulation. Do not breathe dust, mist, or vapor. Do not get in eyes, on skin, or on clothing. Use only in a chemical fume hood.
Storage: Do not store in direct sunlight. Store in a tightly closed container. Store in a cool, dry, well-ventilated area away from incompatible substances. Poison room locked.

Section 8 - Exposure Controls, Personal Protection

Engineering Controls: Facilities storing or utilizing this material should be equipped with an eyewash facility and a safety shower. Use adequate ventilation to keep airborne concentrations low.
Exposure Limits

Chemical Name	ACGIH	NIOSH	OSHA - Final PELs
Mercury(II) sulfide, red	0.025 mg/m3 TWA (as Hg) (listed under Mercury inorganic compounds).Skin - potential significant contribution to overall exposure by the cutaneous r oute (listed under Mercury inorganic compounds).	0.05 mg/m3 TWA (vapor, except organo alkyls, as Hg) (listed under Mercury compounds).10 mg/m3 IDLH (as Hg, except organo(alkyl) compounds) (listed under Mercury compounds).	none listed

OSHA Vacated PELs: Mercury(II) sulfide, red: No OSHA Vacated PELs are listed for this chemical.
Personal Protective Equipment
Eyes: Wear appropriate protective eyeglasses or chemical safety goggles as described by OSHA's eye and face protection regulations in 29 CFR 1910.133 or European Standard EN166.
Skin: Wear appropriate protective gloves to prevent skin exposure.
Clothing: Wear appropriate protective clothing to prevent skin exposure.
Respirators: Follow the OSHA respirator regulations found in 29 CFR 1910.134 or European Standard EN 149. Use a NIOSH/MSHA or European Standard EN 149 approved respirator if exposure limits are exceeded or if irritation or other symptoms are experienced.

Section 9 - Physical and Chemical Properties

Physical State: Powder
Appearance: bright red - red
Odor: none reported
pH: Not available.
Vapor Pressure: Not available.
Vapor Density: Not available.
Evaporation Rate: Not available.
Viscosity: Not available.
Boiling Point: Not available.
Freezing/Melting Point:583.5 deg C subl
Decomposition Temperature: Not available.
Solubility: Insoluble.
Specific Gravity/Density:8.1000g/cm3
Molecular Formula: HgS
Molecular Weight:232.65

Section 10 - Stability and Reactivity

Chemical Stability: May decompose when exposed to light.
Conditions to Avoid: Light, dust generation, temperatures above 250°C.
Incompatibilities with Other Materials: Strong oxidizing agents, acids.
Hazardous Decomposition Products: Oxides of sulfur, mercury/mercury oxides.
Hazardous Polymerization: Has not been reported

Section 11 - Toxicological Information

RTECS#:
CAS# 1344-48-5: OX0720000
LD50/LC50:
Not available.

Carcinogenicity:
CAS# 1344-48-5: Not listed by ACGIH, IARC, NTP, or CA Prop 65.

Epidemiology: No information found
Teratogenicity: No information found
Reproductive Effects: No information found
Mutagenicity: No information found
Neurotoxicity: No information found
Other Studies:

Section 12 - Ecological Information

No information available.

Section 13 - Disposal Considerations

Chemical waste generators must determine whether a discarded chemical is classified as a hazardous waste. US EPA guidelines for the classification determination are listed in 40 CFR Parts 261.3. Additionally, waste generators must consult state and local hazardous waste regulations to ensure complete and accurate classification.
RCRA P-Series: None listed.
RCRA U-Series: None listed.

Section 14 - Transport Information

	US DOT	Canada TDG
Shipping Name:	MERCURY COMPOUNDS, SOLID, N.O.S.	MERCURY COMPOUND SOLID NOS (MERCURY SULFIDE)
Hazard Class:	6.1	6.1
UN Number:	UN2025	UN2025
Packing Group:	III	III

Section 15 - Regulatory Information

US FEDERAL

TSCA
CAS# 1344-48-5 is listed on the TSCA inventory.
Health & Safety Reporting List
None of the chemicals are on the Health & Safety Reporting List.
Chemical Test Rules
None of the chemicals in this product are under a Chemical Test Rule.
Section 12b
None of the chemicals are listed under TSCA Section 12b.
TSCA Significant New Use Rule
None of the chemicals in this material have a SNUR under TSCA.
CERCLA Hazardous Substances and corresponding RQs
None of the chemicals in this material have an RQ.
SARA Section 302 Extremely Hazardous Substances
None of the chemicals in this product have a TPQ.

Section 313

This material contains Mercury(II) sulfide, red (listed as Mercury compounds), 99.5+ %, (CAS# 1344-48-5) which is subject to the reporting requirements of Section 313 of SARA Title III and 40 CFR Part 373.

Clean Air Act:

CAS# 1344-48-5 (listed as Mercury compounds) is listed as a hazardous air pollutant (HAP).

This material does not contain any Class 1 Ozone depletors.

This material does not contain any Class 2 Ozone depletors.

Clean Water Act:

None of the chemicals in this product are listed as Hazardous Substances under the CWA.

None of the chemicals in this product are listed as Priority Pollutants under the CWA.
CAS# 1344-48-5 is listed as a Toxic Pollutant under the Clean Water Act.

OSHA:

None of the chemicals in this product are considered highly hazardous by OSHA.

STATE

CAS# 1344-48-5 can be found on the following state right to know lists: California, (listed as Mercury compounds), New Jersey, (listed as Mercury compounds), New Jersey, (listed as Mercury inorganic compounds), Pennsylvania, (listed as Mercury compounds).

California Prop 65

WARNING: This product contains Mercury(II) sulfide, red, listed as `Mercury compounds', a chemical known to the state of California to cause developmental reproductive toxicity.
California No Significant Risk Level: None of the chemicals in this product are listed.

European/International Regulations
European Labeling in Accordance with EC Directives
Hazard Symbols:

T+

Risk Phrases:

R 26/27/28 Very toxic by inhalation, in contact with skin and if swallowed.

R 33 Danger of cumulative effects.

Safety Phrases:

S 24/25 Avoid contact with skin and eyes.

S 36/37/39 Wear suitable protective clothing, gloves and eye/face pr otection.

WGK (Water Danger/Protection)

CAS# 1344-48-5: No information available.

Canada - DSL/NDSL

CAS# 1344-48-5 is listed on Canada's DSL List.

Canada - WHMIS

This product has a WHMIS classification of D1A.
This product has been classified in accordance with the hazard criteria of the Controlled

Products Regulations and the MSDS contains all of the information required by those regulations.

Canadian Ingredient Disclosure List

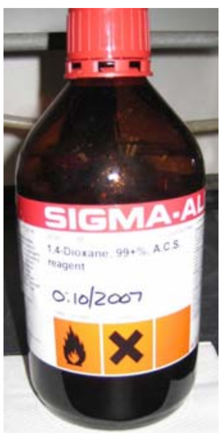
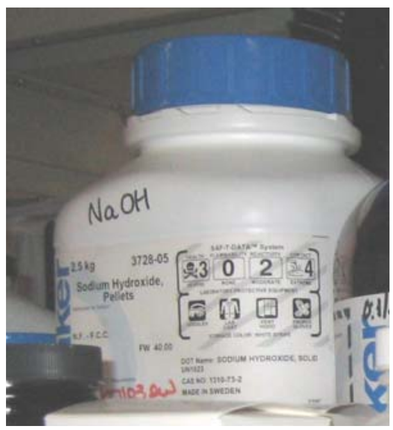
CAS# 1344-48-5 (listed as Mercury compounds) is listed on the Canadian Ingredient Disclosure List.

Section 16 - Additional Information

MSDS Creation Date: 1/27/1998
Revision #4 Date: 3/16/2007

The information above is believed to be accurate and represents the best information currently available to us. However, we make no warranty of merchantability or any other warranty, express or implied, with respect to such information, and we assume no liability resulting from its use. Users should make their own investigations to determine the suitability of the information for their particular purposes. In no event shall Fisher be liable for any claims, losses, or damages of any third party or for lost profits or any special, indirect, incidental, consequential or exemplary damages, howsoever arising, even if Fisher has been advised of the possibility of such damages.

Appendix B: Chemical Pictures

1. Hydrogen Peroxide and Peroxyacetic Acid	2. Ammonium Hydroxide	3. Carbon Dioxide
		
4. 1,4-Dioxane	**5. Sodium Hydroxide**	**6. Unidentified compressed gas**
		

7. Ammonium Nitrate	8. Carbon Tetrachloride	9. Hydrochloric Acid
		
10. Mercury thermometer	**11. Alcohol thermometer**	**12. Fluorescent lamps**
		

Appendix C: Pollution Prevention Checklist[30]

Laboratory Pollution Prevention Checklist

Material Substitution:

- ☐ Substitute less hazardous chemicals for more hazardous ones.
- ☐ Use laboratory detergents rather than hazardous cleaning baths.
- ☐ Use less toxic/hazardous solvents rather than more toxic/hazardous solvents.
- ☐ Avoid the use of reagents containing: barium arsenic, cadmium, chromium, lead, mercury, selenium, and silver.

Purchasing/Inventory Control:

- ☐ Develop a purchasing strategy for chemicals and other hazardous materials.
- ☐ Purchase chemicals in smaller sizes.
- ☐ Standardize chemical purchases across laboratories and establish an area for central storage of chemicals.
- ☐ Designate a single person to be responsible for purchasing chemicals and monitoring inventories.
- ☐ Link purchasing requests into an inventory system so that excess chemicals in stock can be used before buying more.
- ☐ Find a supplier who will accept unopened/expired chemicals that are returned, or will otherwise support waste minimization efforts.
- ☐ Use tags, bar codes, or some other system to establish a computer tracking of chemicals.
- ☐ If trying out a new procedure, try to obtain the chemicals needed from another lab or purchase a small amount initially. After you know you will be using more of this chemical, purchase in larger quantities.

Process Efficiency:

- ☐ Write a waste management/reduction policy.
- ☐ Include waste reduction as part of employee/student training.
- ☐ Set up specific reduction goals. (e.g. 50% reduction in amount of waste generated per year)
- ☐ Create an incentive program for waste reduction.
- ☐ Evaluate laboratory procedures to see if less hazardous or nonhazardous reagents could be used.
- ☐ Consider the quantity and type of waste produced when purchasing new equipment. Purchase equipment that enables the use of procedures that produce less waste.
- ☐ Review your procedures regularly to see if quantities of chemicals and/or chemical waste could be reduced.
- ☐ When preparing a new protocol, consider the kinds and amounts of waste products and see how they can be reduced or eliminated.
- ☐ Scale down experiments producing hazardous waste wherever possible.
- ☐ Use pre-weighed or pre-measured reagent packets for introductory teaching labs where waste is high.

Recovery/Reuse/Recycling:

- ☐ Set up an internal surplus chemical exchange or participate in an outside chemical/waste exchange program.
- ☐ Filter/Distill spent solvent for reuse onsite or via a solvent recycling service.
- ☐ Reclaim metal-bearing waste
- ☐ Segregate Individual Waste Streams. Keep hazardous waste separate from nonhazardous waste and organic waste separate from inorganic waste.

Innovation:

- ☐ Move to microscale chemistry.
- ☐ Substitute computer simulations, videos, etc. for actual experiments.
- ☐ Use alternatives to solvent-based extraction (e.g., Solid Phase Microextraction or Supercritical Fluid Extraction).
- ☐ Use instruments in place of wet chemistry (e.g., chromatography, spectrophotometry, atomic absorption, nuclear magnetic resonance, X-ray diffraction).
- ☐ Adopt green chemistry principles as a standard laboratory management strategy.

[30] Ohio EPA, Laboratory Pollution Prevention checklist of lab opportunities, http://www.epa.state.oh.us/ocapp/p2/labp2checklist.pdf, Accessed March 25, 2008

Appendix D: Green Chemistry Experiments[31]

The following two green chemistry exercises deal with the principles of acid/base chemistry. They can be performed independently or consecutively, depending on time constraints.

Exercise 1. Cabbage Juice Acid/Base Indicator

Introduction

Often, chemists need to know whether a substance is acidic or basic. One way to measure the relative acidity of a solution is to use an *indicator*. Acid/base indicators change color in the presence of acids and bases and thus indicate the relative acidity of a solution. Litmus paper is a common indicator: litmus paper is red in the presence of an acid, blue in the presence of a base, and white in a neutral solution. Sometimes chemists need to know how acidic or basic a solution is in a very narrow range of pH values. In these cases, chemists will use an appropriate chemical indicator that changes color around the pH value of interest. For example, bromthymol blue is an indicator that changes color from yellow to blue in the range of pH 5-8.

Many useful indicators can be derived from natural products, such as red cabbage, blackberries, cherries, apple skins, and radish skins. In this exercise, you will make an acid/base indicator from the juice of red cabbage. Subsequently, you will use your cabbage juice indicator to determine the approximate pH of 10 common household products.

Materials

- 500-750 mL distilled water
- Hot plate
- ¼ head of red cabbage
- Knife and cutting board OR food processor
- 1 1000 mL beaker
- 2 heat-resistant gloves or oven mitts
- 1 500 mL beaker
- 10 50 mL beakers
- Sieve or collander
- 100-200 mL isopropyl alcohol
- 500 mL plastic squeeze bottle
- 1 piece of white paper, cut into approximately 1 cm × 4 cm strips
- 10 common household products to test for pH (suggestions: soda pop, fresh milk, sour milk, orange juice, vinegar, coffee, tea, tap water, bottled mineral water, bathroom cleaner, window cleaner, baking soda, baking powder, antacids, aspirin, dish soap, laundry soap, plant fertilizer)

[31] Adapted from The Science House, http://www.science-house.org/learn/CountertopChem/index.html, Accessed March 31, 2008.

Procedure

1. Using the knife and cutting board OR the food processor, cut the red cabbage into fine pieces.
2. Fill the 1000 mL beaker approximately ¾ full with finely cut red cabbage. Add enough distilled water to the beaker up to completely submerge the cut cabbage.
3. Carefully place the 1000 mL beaker containing the water and cabbage it in onto the hot plate. Turn the hot plate on a high setting until the mixture boils. After the mixture begins to boil, turn down the hot plate until you have a gentle rolling boil, and let the mixture boil for 10 minutes.
4. After the mixture has boiled for 10 minutes, remove it from the heat; be sure to protect your hands with the heat-resistant gloves or oven mitts. Let the beaker stand for 30 minutes, or until it has completely cooled.
5. Carefully strain the cool mixture into the 500 mL beaker using the sieve or collander. Discard the used cabbage. The cabbage juice liquid should be a dark purple-red color.
6. Add isopropyl alcohol to your cabbage juice in a 1:5 ratio of alcohol to juice; isopropyl alcohol acts as a preservative and will prevent your cabbage juice from spoiling. This final liquid is your cabbage juice acid/base indicator.
7. Store your cabbage juice indicator in a squeeze bottle. To make litmus paper-like indicator strips, soak the cut paper strips in the cabbage juice until completely saturated, and then allow the paper strips to dry.
8. Select 10 common household products for pH testing. Place a small sample of each of the 10 household products in 10 50 mL beakers, one product in each beaker. If the product of interest is not a liquid, such as baking soda for example, then add enough distilled water to the product to make a solution. In the case of a solid sample, such as solid antacids, crush the sample into a powder before adding the distilled water so that the solid sample dissolves quickly. Once you have added water to the powdered solid, gently swirl the beaker to help dissolve the sample.
9. To test the acidity of each sample, place either 2-3 drops of the liquid indicator into each beaker containing the household products, OR dip one of the indicator strips into the solution in each beaker. [Note that you will need to use the indicator strips for dark-colored solutions, such as coffee, tea, or brown-colored soda pop.] Observe the color change of the solution or the indictor strip. Determine the approximate pH of each household product using Figure 1. Makes some general observations about the smells, tastes (when safe – don't taste bathroom cleaners or drain cleaners, for example!), and uses of the products. Record your observations and results on your Data Sheet.

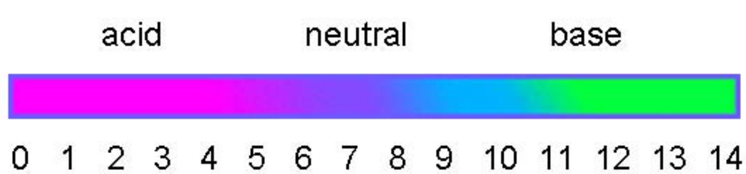


Figure 1. Colors of Red Cabbage Juice Indicator at Different pH Values

10. When you are finished with the exercise, clean up your equipment. Clean, rinse, and dry all of the beakers you used. Throw excess solid cabbage into the garbage.

Discussion Questions

1. Which household products were acids? What do the acids you tested have in common (*e.g.*, uses, smells/tastes, origins)? Based on your observations, make some general statements about acidic household products.
2. Which household products were bases? What do the bases you tested have in common (e.g., uses, smells/tastes, origins)? Based on your observations, make some general statements about basic household products.
3. Which household products were neutral? What do the neutral products you tested have in common (e.g., uses, smells/tastes, origins)? Based on your observations, make some general statements about neutral household products.

Data Sheet

Household Product	Indicator Color	Approximate pH	Acid/Base/Neutral

Observations about acidic products:

Observations about basic products:

Observations about neutral products:

Teacher's Guide

1. Soda pop, orange juice, vinegar, sour milk, and aspirin are acidic. Acids generally taste sour.
2. Bathroom cleaner, window cleaner, baking soda, baking powder, antacids, dish soap, laundry soap, plant fertilizer should all be basic. Bases taste bitter and have a "slippery" feel.
3. Fresh milk, tap water, and bottled mineral water should be neutral. Neutral household products are typically water or water-based, like fresh milk.

Exercise 2. Acid/Base Chemistry

Introduction

Acid-base chemistry has a wide range of important applications across many disciplines. In biology, for example, fish typically are sensitive to the pH of their environment, and they cannot survive in water that is very acidic or basic. Humans are another example: we have complex systems in our bodies that keep our blood in a very narrow range of pH values, otherwise serious illness and even death can result.

The acidity of a solution is given by its pH value, which is defined as:

$$pH = -\log_{10}\left[H^{+}\right] \qquad (1)$$

where [H+] is the hydrogen ion concentration of the solution in molarity, M (mole L-1). Common pH values range from 0 to 14: pH 0 is very acidic, pH 14 is very basic, and pH 7 is chemically neutral. Examples of common acids and bases include soda pop (pH ≈ 3.0), pure water (pH = 7), and drain cleaner (pH ≈ 13.5). Because pH is a log scale based on 10, a change in 1 pH unit represents a factor of 10 change in hydrogen ion concentration. Thus a pH 4 solution has 10 times more hydrogen ions than a pH 5 solution. Strong acids have high concentrations of hydrogen ions, while strong bases have low concentrations of hydrogen ions.

In this exercise, you will measure the pH of vinegar, a common acid, and baking soda, a common base. Vinegar is a solution of 5% acetic acid (CH_3COOH) in water, and baking soda is sodium bicarbonate ($NaHCO_3$). Subsequently, you observe the reaction between vinegar and baking soda and measure the pH of the resulting solution.

Materials

- Red cabbage juice liquid indicator OR indicator strips
- 50 mL vinegar (5% acetic acid, CH3COOH)
- 1 g baking soda (sodium bicarbonate, NaHCO3)
- 50 mL distilled water
- 2 50 mL beakers
- 1 150 mL beaker

Procedure

1. Pour approximately 50 mL vinegar into a 50 mL beaker. Add 2-3 drops of the liquid red cabbage juice indicator to the vinegar OR dip one of the indicator strips into the beaker. Use Figure 1 to determine the approximate pH of the vinegar. Record the approximate pH and any observations about the vinegar (color, smell) on your Data Sheet.

2. Measure approximately 1 g of baking soda. Place the baking soda in a 50 mL beaker, and add approximately 50 mL of distilled water. Gently swirl the beaker to dissolve the baking soda and water. Once the baking soda has completely dissolved, add 2-3 drops of the liquid red cabbage juice indicator to the baking soda solution OR dip one of the indicator strips into the beaker. Use Figure 1 to determine the approximate pH of the baking soda. Record the approximate pH and any observations about the baking soda (color, smell) on your Data Sheet.

3. Pour the vinegar from the 50 mL beaker into the 150 mL beaker. Then carefully pour the baking soda solution into the 150 mL beaker with the vinegar. Record your observations of the reaction between vinegar and baking soda on your Data Sheet. Gently swirl the 150 mL beaker to facilitate the complete reaction between vinegar and baking soda. After approximately 5 minutes, add 2-3 drops of the liquid red cabbage juice indicator to the solution OR dip one of the indicator strips into the beaker. Use Figure 1 to determine the approximate pH of the solution. Record the approximate pH and any observations about the solution (color, smell) on your Data Sheet.
4. When you are finished with the exercise, clean up your equipment. Clean, rinse, and dry all of the beakers you used.

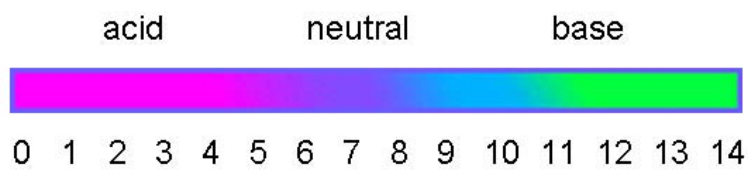


Figure 1. Colors of Red Cabbage Juice Indicator at Different pH Values

Discussion Questions

1. What was the approximate pH of the vinegar? Does this pH value make sense, considering what you know about acids?
2. What was the approximate pH of the baking soda solution? Does this pH value make sense, considering what you know about bases?
3. Describe what happened when you added the baking soda solution to the vinegar.
4. The reaction between vinegar and baking soda is an example of an acid-base neutralization reaction. Explain why that name makes sense, given the pH values of the vinegar and baking soda solution before the reaction compared to the pH of the combined solution after the reaction.
5. Write out the overall chemical reaction between vinegar (acetic acid) and baking soda (sodium bicarbonate) that occurred in the neutralization reaction.

Data Sheet

	Indicator Color	Approximate pH	Acid/Base/Neutral
Vinegar			
Baking Soda Solution			
Combined Solution (after reaction)			

Observations about vinegar:

Observations about baking soda solution:

Observations about reaction between vinegar and baking soda solution:

Observations about combined solution (after reaction):

Teacher's Guide

1. The pH of the vinegar should be around 3, which makes sense because vinegar is an acid, and pH values < 7 correspond to acids.
2. The pH of the baking soda solution should be around 8, which makes sense because baking soda is a base, and pH values > 7 correspond to bases.
3. When the students added the baking soda solution to the vinegar, the solution should have bubbled vigorously. The bubbles are carbon dioxide gas evaporating from solution.
4. The pH of the combined solution, after the neutralization reaction, should be somewhere between pH 3-8. This is an example of a neutralization reaction because the carbonate ions in the baking soda solution reacted with the hydrogen ions in the vinegar, thereby reducing the number of hydrogen ions in solution and *neutralizing* the vinegar. The pH of the combined solution is higher than the vinegar and lower than the baking soda.

5. The reaction steps between vinegar and baking soda are as follows:

$CH_3COOH_{(aq)} \leftrightarrow H^+_{(aq)} + CH_3COO^-_{(aq)}$	dissociation of acetic acid
$NaHCO_{3(s)} \rightarrow Na^+_{(aq)} + HCO_3^-{}_{(aq)}$	dissolution of sodium bicarbonate
$HCO_3^-{}_{(aq)} + H^+_{(aq)} \leftrightarrow H_2CO_{3(aq)}$	production of carbonic acid
$H_2CO_{3(aq)} \rightarrow H_2O_{(l)} + CO_{2(g)}$	production of carbon dioxide* and water
$CH_3COO^-_{(aq)} + Na^+_{(aq)} \rightarrow Na(CH_3COO)_{(s)}$	production of sodium acetate

$CH_3COOH_{(aq)} + NaHCO_{3(s)} \rightarrow Na(CH_3COO)_{(s)} + H_2O_{(l)} + CO_{2(g)}$ **OVERALL REACTION**

* Carbon dioxide has a low solubility in water (0.03 mol L^{-1}), so once it forms in solution, it quickly evaporates, which causes the bubbling students observe during the neutralization reaction.

Appendix E: Chemicals that are More Hazardous than Educational

In some cases, the educational utility of a chemical can be eclipsed by the hazards it poses to human health and the environment. Chemicals that are unsuitable for schools include strong oxidizers, corrosives, toxics, carcinogens, and mutagens. This Appendix lists some examples of chemicals that are more hazardous than educational, and therefore should be avoided in the classroom.[32]

Chemical	CAS Number	Hazard
Acrylonitrile	107–13–1	Flammable; likely human carcinogen
Ammonium chromate	7788–98–9	Oxidizer; known human carcinogen
Aniline	62–53–3	Combustible; may be fatal if inhaled, ingested, or absorbed through the skin
Aniline hydrochloride	142–04–1	May be fatal if inhaled, ingested, or absorbed through the skin
Anthracene	102–12–7	Irritant; may cause an allergic skin reaction
Antimony trichloride	10025–91–9	Corrosive
Arsenic and its compounds	various	Known human carcinogens
Asbestos	1332–21–4	Known human carcinogen
Benzene	71–43–2	Flammable; known human carcinogen and mutagen
Benzoyl peroxide	94–36–0	Flammable; explosive; oxidizer
Calcium cyanide	592–01–8	May be fatal if inhaled or ingested
Carbon disulfide	75–15–0	Flammable); acute central nervous system toxicity and peripheral neurotoxicity
Carbon tetrachloride	56–23–5	May be fatal if inhaled or ingested; likely human carcinogen
Chlorine	7782–50–5	Oxidizer; corrosive; may be fatal if inhaled
Chloroform	67–66–3	Likely human carcinogen
Chromium hexavalent compounds	various	Known human carcinogens
Chromium trioxide	1333–82–0	Oxidizer; corrosive; known human carcinogen
Colchicine	64–86–8	May be fatal if ingested; mutagen
Dimethylaniline	121–69–7	May be fatal if inhaled, ingested, or absorbed through the skin
p-Dioxane	123–91–1	Flammable; likely human carcinogen
Ethylene dichloride (1,2-Dichloroethane)	107–06–2	Flammable; likely human carcinogen and mutagen
Ethylene oxide	75–21–8	Flammable; explosive; may be fatal if inhaled or absorbed through the skin; known human carcinogen

32 [Modified from U.S. Consumer Product Safety Commission (CPSC). 2006. School Chemistry Laboratory Safety Guide. DHHS (NIOSH) Publication No. 2007–107. http://www.cpsc.gov/CPSCPUB/PUBS/NIOSH2007107.pdf]

Chemical	CAS Number	Hazard
Hexachlorophene	70–30–4	May be fatal if inhaled, ingested, or absorbed through the skin; possible teratogen
Hydrobromic acid	10035–10–6	Corrosive; may be fatal if inhaled or ingested
Hydrofluoric acid	7664–39–3	Corrosive; may be fatal if inhaled or ingested (liquid and vapor can cause severe burns that are not always immediately painful or visible but possibly fatal)
Hydrogen	1333–74–0	Flammable
Hydroiodic acid	10034–85–2	Corrosive; may be fatal if inhaled or ingested
Lead arsenate	7784–40–9	Known human carcinogen and teratogen
Lead carbonate	1319–46–6	May be fatal if inhaled or ingested; neurotoxic
Lead(VI) chromate	7758–97–6	May be fatal if inhaled or ingested; known human carcinogen
Lithium, metal	7439–93–2	Combustible; water reactive
Lithium nitrate	7790–69–4	Oxidizer
Magnesium, metal (powder)	7439–95–4	May ignite spontaneously on contact with water or damp materials
Mercury	7439–97–6	Corrosive; may be fatal if inhaled or ingested
Mercuric chloride	7487–94–7	May be fatal if inhaled; teratogen
Methyl iodide (iodomethane)	74–88–4	May be fatal if inhaled, ingested or absorbed through the skin; potential carcinogen
Methyl methacrylate	80–62–6	Flammable; explosive vapors
Methyl orange	547–58–0	Possible mutagen
Methyl red	493–52–7	Possible mutagen
Nickel, metal	7440–02–0	Likely human carcinogen and mutagen
Nickel oxide	1314–06–3	Likely human carcinogen and mutagen
Nicotine	45–11–5	May be fatal if inhaled, ingested, or absorbed through the skin
Osmium tetroxide	20816–12–0	May be fatal if inhaled or ingested
Paris green	12002–03–8	May be fatal if inhaled, ingested, or absorbed through the skin; known human carcinogen
Phenol	108–95–2	Combustible liquid and vapor; corrosive; may be fatal if inhaled, ingested, or absorbed through the skin
Phosphorus pentoxide	1314–56–3	Water reactive; corrosive
Phosphorous, red, white	7723–14–0	May ignite spontaneously in air
Phthalic anhydride	85–44–9	Combustible; finely dispersed particles form explosive mixtures in air; corrosive
Potassium, metal	7440–09–7	Flammable; water reactive
Potassium oxalate	583–52–8	Corrosive; may be fatal if ingested
Potassium sulfide	1312–73–8	Spontaneously combustible; explosive in dust or powder form; corrosive
Pyridine	110–86–1	Flammable; possible mutagen
Selenium	7782–49–2	Severe irritant
Silver cyanide	506–64–9	May be fatal if inhaled, ingested, or absorbed through the skin

Chemical	CAS Number	Hazard
Silver nitrate	7761–88–8	Oxidizer; corrosive; may be fatal if ingested
Silver oxide	20667–12–3	Oxidizer
Sodium arsenate	7778–43–0	May be fatal if inhaled or ingested; known human carcinogen
Sodium arsenite	7784–46–5	Known human carcinogen; teratogen
Sodium azide	26628–22–8	Explosive; may be fatal if ingested or absorbed through the skin
Sodium chromate	7775–11–3	Oxidizer; corrosive; known human carcinogen
Sodium cyanide	143–33–9	May be fatal if inhaled, ingested or absorbed through the skin
Sodium dichromate	10588–01–9	Oxidizer; corrosive; may be fatal if ingested; known human carcinogen
Sodium nitrite	7632–00–0	Oxidizer
Sodium sulfide	1313–82–2	Corrosive; may be fatal if inhaled or ingested
Sodium thiocyanide	540–72–7	Contact with acid liberates toxic gas
Stannic chloride (anhydrous)	7646–78–8	Corrosive; hydrochloric acid liberated upon contact with moisture and heat
Stearic acid	57–11–4	May form combustible dust concentration in the air
Strontium	7440–24–6	Water reactive
Strontium nitrate	10042–76–9	Oxidizer
Sulfuric acid, fuming	8014–95–7	Corrosive; may be fatal if ingested
Tannic acid	1401–55–4	Irritant
Tetrabromoethane	79–27–6	May be fatal if inhaled, ingested, or absorbed through the skin
Thioacetamide	62–55–5	Likely human carcinogen
Thiourea	62–56–6	Likely human carcinogen
Titanium trichloride	7705–07–9	Water reactive; corrosive
Titanium tetrachloride	7550–45–0	Water reactive, corrosive, may be fatal if inhaled
ortho-Toluidine	95–53–4	Likely carcinogen and mutagen
Uranium	7440–61–1	Radioactive material
Uranyl acetate	541–09–3	Radioactive material
Urethane	51–79–6	Combustible; likely human carcinogen

Appendix F: Commercial Equivalents of Common Laboratory Chemicals

Often, common laboratory chemicals have commercial equivalents that are available in safer concentrations than the pure substances sold by chemical manufacturers. This Appendix lists some examples of chemicals that can be found in grocery, drug, and hardware stores.[33] Although commercially available chemicals are generally safer than their concentrated counterparts, all chemicals can be dangerous if they are used without proper safety precautions. Safety measures should be taken when working with any chemical, including wearing safety glasses, long-sleeved shirts, pants, and gloves when appropriate.

Chemical	Formula	Commercial Equivalent	Local Source
acetic acid	CH_3COOH	vinegar (5% solution)	grocery store
acetone	CH_3COCH_3	nail polish remover	grocery or drug store
acetylsalicylic acid	$C_9H_8O_4$	aspirin	drug store
aluminum	Al	foil or wire	grocery or hardware store
aluminum sulfate	$Al_2(SO_4)_2$	flocculating powder	pool supply store
ammonia	$NH_3(aq)$	ammonia cleaner (10%)	grocery store
ammonium carbonate	$(NH_4)2CO_3$	smelling salt	drug store
ammonium chloride	NH_4Cl	sal ammoniac	drug store
ammonium nitrate	NH_4NO_3	nitrate of ammonia	garden supply store
ascorbic acid	$C_6H_8O_6$	vitamin C	drug store
boric acid	H_3BO_3	eyewash solution	drug store
		roach killer (solid)	hardware store
butane	C_4H_{10}	disposable lighter fluid	grocery store
caffeine	$C_8H_{10}N_4O_2$	No-Doz™ tablets	drug store
calcium carbonate	$CaCO_3$	school/sidewalk chalk	drug or grocery store
calcium chloride	$CaCl_2$	sidewalk "de-icer"	hardware store
calcium hydroxide	$Ca(OH)_2$	slaked lime	hardware store
		select antacids	grocery store
calcium oxide	CaO	quicklime	hardware store
calcium phosphate	$Ca(H_2PO_4)_2$	superphosphate	garden supply store
calcium sulfate	$CaSO_4$	plaster of Paris	art/hobby shop
		gypsum	building supply store
carbon	C	charcoal, graphite	hardware store
carbon dioxide (solid)	$CO_{2(s)}$	dry ice	dairy, refrigeration supply
carbonic acid	H_2CO_3	seltzer water	grocery store
citric acid	$C_6H_8O_7$	lemons, limes, oranges	grocery store
copper	Cu	sheet, pipe, or wire	hardware store
copper sulfate pentahydrate	$CuSO_4{\cdot}5H_2O$	Bluestone™ algaecide	pool supply store
		Root Eater™	hardware store
ethanol (95% pure)	CH_3CH_2OH	190 proof Everclear™	liquor store
ethanol (denatured)	CH_3CH_2OH	denatured alcohol	hardware or paint shop
		ethyl rubbing alcohol	drug store
ethylene glycol	CH_2OHCH_2OH	antifreeze	auto supply store
fructose	$C_6H_{12}O_6$	fruit sugar	grocery store
glucose	$C_6H_{12}O_6$	dextrose	drug store

33 [Modified from Katz, David A. and Thomas O'Brien. 2002. Common Chemicals and Supplies in and around Your Home. http://www.chymist.com/Common%20chemicals.pdf]

Chemical	Formula	Commercial Equivalent	Local Source
glycerol	$C_3H_8O_3$	glycerin	drug store
helium	He	helium	party shop
hydrochloric acid	HCl (aq)	muriatic acid, masonry cleaner	hardware store or lawn and garden center
hydrogen peroxide	H_2O_2	3% antiseptic peroxide	drug stores
		Clairoxide (6%)	beauty supply store
hypochlorous acid	HClO	laundry bleach	grocery store
iodine	I_2	iodine	drugstore
isopropyl alcohol	$CH_3CH(OH)CH_3$	rubbing alcohol	drug store
iron	Fe	uncoated nails, steel wool	hardware store
iron(III) chloride	$FeCl_3$	ferric chloride	drug store
iron(III) oxide	FeO_3	ferric oxide, rust	ceramic shop
lactic acid	$C_3H_6O_3$	"sour" milk products such as yogurt	grocery store
lead	Pb	fishing line sinker	sporting goods store
magnesium hydroxide	$Mg(OH)_2$	Milk of Magnesia	drug store
magnesium sulfate heptahydrate	$MgSO_4{\cdot}7H_2O$	Epsom salts	drug store
methanol	CH_3OH	methyl or wood alcohol	paint store, camping store
		duplicator fluid	office supply store
methylene blue	$C_{16}H_{18}CN_3S$	Methidote antiseptic	tropical fish store
methyl salicylate	$C_6H_4(OH)COOCH_3$	oil of wintergreen	drug or grocery store
naphthalene	$C_{10}H_8$	moth balls	hardware store
oxalic acid	HO_2CCO_2H	rust remover	drug store
		radiator cleaner	hardware store
para-dichlorobenzene	$C_6H_4Cl_2$	moth flakes	hardware store
paraffin	Solid hydrocarbon (formula varies)	paraffin wax, candles	grocery store
phenol red indicator	$C_{19}\ H_{19}SO_5$	swimming pool indicator	swimming pool supply
phosphoric acid	H_3PO_4	pH Down (30% solution)	tropical fish store
potassium aluminum sulfate	$KAl(SO_4)_2 \cdot 12H_2O$	potassium alum	photo supply store
potassium bitartrate	$KHC_4H_4O_6$	cream of tartar	grocery store
potassium bromide	KBr	potassium bromide	photo store
potassium carbonate	K_2CO_3	potash	agricultural supply store
potassium chloride	KCl	salt substitute	grocery store
potassium dichromate	$K_2Cr_2O_7$		photo supply store
potassium hydroxide	KOH	lye, caustic potash	hardware store or ceramic shop
potassium nitrate	KNO_3	saltpeter	drug store
potassium permanganate	$KMnO_4$	Clearwater^{TM} aquarium cleaner (53% solution)	tropical fish store
sodium bicarbonate	$NaHCO_3$	baking soda	grocery store
sodium borate	$Na_2B_4O_7$	borax	grocery store
sodium carbonate	Na_2CO_3	washing soda	grocery store
sodium chloride	NaCl	uniodized table salt	grocery store
sodium hydroxide	NaOH	drain cleaner	hardware or grocery store
sodium hypochlorite	NaClO	bleach (5% solution)	grocery store
sodium nitrate	$NaNO_3$	nitrate of soda	garden supply store
sodium phosphate	Na_3PO_4	trisodium phosphate	paint store or garden supply store
sodium silicate	Na_2SiO_3	water glass	hardware store
sodium thiosulfate	$Na_2S_2O_3$	hypo	photo store

Chemical	Formula	Commercial Equivalent	Local Source
stearic acid	$C_{17}H_{35}CO_2H$	candle hardener	hobby shop
sucrose	$C_{12}H_{22}O_{11}$	table sugar	grocery store
sulfur	S	flowers of sulfur	lawn & garden shops
tin	Sn	metal sheets	hardware or builders' supply store
zinc	Zn	galvanized nails	hardware store

Appendix G: Sample Monthly Chemical Management Checklist

Checklists are often used to clearly identify chemical management actions and to verify that they have been completed (see basic example below, an excerpt adapted from the Los Angeles Unified School District "School Laboratory Chemical Hygiene & Safety Plan").[34]

LOS ANGELES UNIFIED SCHOOL DISTRICT

MONTHLY CHECKLIST FOR SAFE HANDLING AND STORAGE OF CHEMICALS

To be completed by C.S.C.

ACTIVITY	Yes	No
1. All chemicals are correctly and clearly labeled.		
2. Unlabeled containers and chemical wastes have been inventories and a disposal request submitted to OEHS.		
3. Only chemicals that are being used are continually being stored.		
4. Only the amount of chemicals which can be consumed within a year are being stored.		
5. CSC is aware of and has trained others on hazards and precautions for protection prior to using any chemical, and has reviewed the precautionary labels and contents before using any chemical product.		
6. All chemicals are stored by compatibility (see CHSP Appendix IV, Table 1: Chemical Shelf Storage Identification Chart and Table 2: Storage for Compatibility Categories).		
7. Chemicals are stored on shelves below eye level.		
8. Chemicals are being stored on the floor.		
9. Chemicals are being stored in approved storage cabinets.		
10. Neutralizing chemicals, absorbent and other spill control materials are readily available.		
11. Compressed gas cylinders are upright and secured to the wall with caps in place.		
12. Storage cabinets for corrosive chemicals (separated for acids and for bases) are appropriately labeled.		
13. Flammable materials are stored in approved storage cabinets.		
14. Shelving is equipped with lips to prevent products from rolling off shelves and secured to walls/floor to prevent tipping of entire sections.		
15. Storage areas/cabinets are labeled to identify the hazardous nature of the products stored within.		
16. Class ABC fire extinguishers are available in chemical storage areas and are in working order.		
17. There are no sources of ignition in the chemical storage area.		
18. Chemical storage area has two exits and egress (exiting) area is clear.		
19. Used and contaminated reagents are stored and labeled properly.		
20. Current and dated inventory lists are posted clearly in each storage room throughout the science department.		
21. Chemical storage cabinets are locked when laboratory classes are not in session.		

Certification: I hereby certify that I have completed all of the above activities in fulfillment of my responsibilities as the Chemical Safety Coordinator (CSC) for my school.	
Date	School
CSC Signature	CSC Name (print)

CSC = Chemical Safety Coordinator, OEHS= Office of Environmental Health and Safety

[34] Los Angeles Unified School District's Chemical Hygiene Program, http://www.lausd-oehs.org/chemical-hygiene.asp, Accessed 28 March 2008

Appendix H. Conducting a School Chemical Inventory[35]

Guidelines for Conducting a Chemical Inventory

Introduction

The first step in developing a comprehensive chemical health and safety plan is to inventory existing chemicals. This may pose significant risks to the individuals taking the inventory and ample time should be allowed to properly conduct the inventory. In some cases an inventory may take two people 100 hours to complete, therefore it is important not to underestimate the amount of time required to complete the inventory. Administrators may not be aware of the time commitment and the importance of an accurate inventory, therefore it is very important to educate them to the extent of the problem. Many schools have provided stipends to inventory chemicals. If you are new to the school and/or a recent inventory has not been conducted you need to be especially cautious. Serious injury can result from touching or moving chemicals that have become shock sensitive or pressurized. The following procedure is suggested.

In most cases, the inventory will need to be used to generate a disposal list and to determine the quality of the chemicals to be retained. Hazardous waste removal companies require very specific information. Therefore, it is important to include as much information about the chemical to avoid unexpected price changes. For example, anhydrous aluminum chloride is much more expensive to dispose of than is hydrated aluminum chloride. In developing a disposal list it is important to list the proper chemical name, the size of the container and the approximate amount present.

Suggested Procedure

1. Allow ample time to conduct the inventory.
2. Have a plan to deal with potential explosives if they are found. Will the local or state bomb squad remove the potential explosives? What agencies need to be alerted? What is the procedure for removal of potential explosives? Will the school have to close until the chemical is removed?
3. Work in pairs and never work alone. It is best if one team does the entire inventory.
4. Be sure the areas in which you are working have adequate lighting.
5. Wear appropriate personal protective equipment. This should include gloves, chemical splash goggles, a lab apron and closed toed shoes.
6. Provide access to a phone, eyewash and a safety shower.
7. Develop a written response plan in case of a spill or accident.
8. One person should act as the recorder and the other person should list the chemicals. Be sure to pronounce the chemical correctly; the recorder should read the chemical name after it is recorded to confirm it is correct.

[35] Reproduced from ChemInfoNet, http://cheminfonet.org/invent.htm, Accessed March 31, 2008.

9. Enter the storage area and develop a general feel for the area. Is this a room in which no one has been in five years? Are there obvious vapors; are broken containers present? Are the shelving units secured to the walls? How is the lighting? If above eye level storage is present use a safety step stool or a small stepladder to reach the top shelf.

10. Record the room number and the date on your record sheet. Also indicate where in the room the inventory begins. Starting on the top shelf record the name of each chemical, the size of the container, the type of container, the approximate amount of chemical present, the condition of the container (i.e. rust, cracks, degraded top, bulging, liquid above a solid, crystals in a liquid), the presence of spills, defects in the shelving or its supports, corroded wires or gas lines or any other indicator of a hazard present. Do not touch or move chemicals if they are listed as potential explosives or the container appears distorted in any manner. **Serious injury can occur from merely touching the top of a container of picric acid or expired ethyl ether. Use extreme caution not to knock a container to the floor.**

11. Be sure you record all containers and record as much information as possible. For example, if ethyl ether is present record its lot number, expiration date and the manufacturer. **Do not touch the container.** You only want to conduct the inventory once and you want to gather as much information as possible. If the inventory is conducted over several days be sure you mark where you stopped at the end of the day.

12. If kits are present be sure to inventory all chemicals in each kit. Many older kits may contain unlabeled chemicals with only manufacturer's numbers on them. Although kits are particularly time consuming to inventory, each container must be identified. Record the manufacturer, the chemical number, and the size of the container and any information concerning the manufacturer such as phone number and address as well as the kit identification number. Do not ignore the kits; many contain carcinogens such as cadmium powder or toxic chemicals such as sodium azide.

13. If preserved specimens are present, record the preservative used. Contact the supplier to determine if the specimens are capable of outgassing formaldehyde. Most specimens contain some formaldehyde.

14. Be sure to examine all areas in each room including desks. For example, a Maine school was shut down for three days after students stole a pound of mercury from a teacher's desk.

15. Once the inventory is developed, the next step is to decide if any immediate response is required. Does any chemical present pose a significant risk if not addressed immediately? This is a difficult question to answer particularly if potentially explosive chemicals are present. If you have a chemical health and safety committee or a chemical hygiene/safety officer they should discuss the situation with the principal and the local fire chief. If the situation does not warrant immediate action review the procedure outlined in chemical management.

Appendix I. Guidelines for Safe Storage of Chemicals

School laboratories generally use a variety of corrosive, oxidizing, and flammable chemicals. Many chemicals are incompatible and should not be stored together. Table 1 gives an example of what types of chemicals to store separately in a small stockroom to ensure maximum safety.

Table 1. Example of Chemical Storage System for a Small Stockroom

Inorganic Shelves	sulfur, phosphorus, arsenic, metals, hydrides *(store all away from water!)**
	halides, sulfates, sulfites, thiosulfates, phosphates, halogens
	sulfides, selenides, phosphides, carbides, nitrides, arsenates, cyanides
	dry hydroxides, oxides, silicates, carbonates
	nitrates, nitrites, borates, chromates, manganates, permanganates, chlorates, chlorites, inorganic peroxides
Organic Shelves	dry and dilute organic acids, anhydrides, peracids
	organic peroxides, azides
	epoxy compounds, isocyanates, sulfides, sulfoxides, nitriles
Flammable Storage Cabinet	hydrocarbons, ethers, ketones, amines, halogenated hydrocarbons, aldehydes, alcohols, glycols, phenol, cresol, combustible organic acids, combustible anhydrides
Corrosive Acid Cabinet	inorganic acids
Corrosive Base Cabinet	concentrated inorganic hydroxides

* Keep water reactive metals away from aqueous solutions and alcohols. Use secondary containers to separate yellow and white phosphorus, which are stored under water, from water-reactive metals.

The following outlines what to do and NOT to do to ensure safe storage of school chemicals.[36]

What to Do to Ensure Safe Storage of Chemicals

- Maintain an inventory of all chemicals in the school.
- Store all chemicals in a designated storage cabinet.
- Store incompatible chemicals separately.
- Anchor flammable storage cabinets to the wall.
- Keep a Class ABC fire extinguisher (capable or extinguishing fires of solid materials, flammable liquids, and electrical/wiring fires) in the room where chemicals are stored.
- Keep chemical containers closed when not in use to avoid accidental spills.
- Clearly label all containers with the name and concentration of the chemical; chemical formulas are not sufficient.
- Regularly check the expiration date of chemicals and dispose of any outdated chemicals.

What NOT to Do

- Do not store chemicals in hoods, under sinks, or on bench tops!
- Do not store flammable liquids in refrigerators or freezers!
- Do not store chemicals that must be refrigerated in coolers that contain food! Use separate coolers for chemicals only, and label them "no food."
- Do not use chemicals in containers that are unlabeled! If you find an unlabeled chemical container, notify an appropriate school official, and treat the container as hazardous!

[36] Adapted from The King County Laboratory Waste Management Guide (http://www.govlink.org/hazwaste/publications/LabGuidelinesRevAugust06.pdf)

Appendix J. Procedure for Safe Cleanup of a Mercury Spill in Homes and Schools[37]

The following procedure should be followed for the clean-up of a small mercury spill (about the amount of mercury in one thermometer). For larger spills, work with your local hazardous waste agency or a qualified mercury cleanup contractor to evaluate the need for their assistance.

> **Check It Out**
>
> **Mercury Spill Cleanup Kit**
>
> - **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**

1. Designate 2 to 3 adults (who have undergone training on mercury spill clean-up) 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.
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 individuals have 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 decontaminated, 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.

[37] Adapted from EPA's Mercury Spill Page: http://www.epa.gov/mercury/spills/index.htm

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 waste disposal agency or a private hazardous waste disposal company for guidance on how to safely dispose of the bags containing the contaminated items.

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.