Pollution Prevention Measures for Safer School Laboratories

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This tool kit is designed for teachers and students of the science laboratory. School administrators, science department personnel, janitorial staff, and others who have an interest and involvement in the laboratory would also benefit from the information contained within this tool kit.

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For More Information

www.epa.gov/schools/

School Science Laboratories

Hands-on activities are an essential part of school science. Activities conducted in school laboratories are important if students are to learn the processes of science and have direct experiences that capture their interest and maintain their motivation. A school's lab environment, however, can be unsafe to students and school personnel due to the presence of unknown and toxic chemicals, or excessive stocks of these materials. Poor management and use of chemicals may also result in risks to human health and the environment.

Young people are at particular risk to the hazards of chemicals because

- They may be affected by lower levels of exposure than adults
- Their immune systems are not as well developed as those of adults
- Their health risks can be greater because some toxic chemicals accumulate in the body over long periods of time
- They may be more easily distracted and may not pay careful attention to safety precautions or instructions, and
- They are less experienced than adults and more likely to behave unpredictably.

This tool kit provides guidelines and tips for preventing and controlling risks, avoiding future build-up of undesirable chemicals, reducing waste generation, and maintaining a safe school laboratory environment.

The following sections address issues that need to be considered in the management of materials used in science teaching.

Maintaining Your Chemical Inventory

You should establish and implement a plan for purchasing and managing laboratory chemicals to prevent accumulating excess and undesirable ones. Inventories enable you to determine the existence of a specific chemical, its location, and approximate shelf age, thus helping to control the hazards in your laboratory.

- Maintain a complete, and current inventory of all chemicals, including location, chemical names, amounts, and dates of entrance to your school;

- Update the inventory when chemicals are purchased or used up, and inventory your entire stock at least once a year;
- If possible, centralize purchasing of your chemicals through one person;
- Develop purchase guidelines, which include buying chemicals in the smallest quantities needed, or only a one to two-year supply;
- Establish a policy for restricting the acceptance of donated chemicals unless they meet a specific need during a defined period of time (preferably within a year);
- If your regulatory authority has a list of prohibited and or restricted chemicals, ensure that these materials are not purchased;
- Consider obtaining needed chemicals from another laboratory that may not need them or has them in excess;
- Ensure your chemical supplier provides you an MSDS for every chemical that is purchased, and that it is maintained in the laboratory files.

Chemical Purchasing

Careful consideration should be given to purchasing chemicals for your laboratory to avoid common problem chemicals and excess stocks.

- Create an authorized use list of those chemicals that can be purchased in the school. Be conscious of avoiding shock sensitive and explosive materials, and be aware of the top 40 chemicals found to be a problem in many schools (see links to chemical lists on left).
- Select a chemical supplier who can deliver small amounts of chemicals and accept unopened chemicals that are returned, thereby supporting waste minimization efforts;
- Remember that a chemical's true cost includes the purchase price plus the cost of proper disposal.

Storing Chemicals

By understanding and following these guidelines and precautions, you can ensure that your laboratory's chemical storage area is safe for use in science and chemistry instruction.

- Designate a safe and secure area for chemical storage. This will provide an area that reduces the risks of breakage and spills. It is recommended that the storage area be

Common Problem Chemicals in Schools
(www.cdphe.state.co.us/cp)
Click on "Guidance on Chemical Management in Schools," then "List of common hazards..."

Excessive Risk Chemicals (King County, Washington)
(www.govlink.org/hazwaste/publications/highrisktable.pdf)

ventilated, locked, and fire-resistant.

- Limit access to your chemical storage areas to authorized personnel only;
- Keep chemicals in the storage area except when in use;
- Keep chemical storage areas clean and orderly at all times;
- Post signs for hazardous chemical storage;
- Store chemicals in containers designed for chemical storage and appropriate for each type of chemical; ensure that lids are tight;
- Store chemicals at or below eye level;
- Do not store chemicals alphabetically. Store them by chemical group (chemical class/reactive group) to keep incompatible chemicals away from each other. Make sure your organization ensures vertical and horizontal compatibility, as well as compliance with the local fire code. Appropriate measures may include separation by shelving, and or the use of secondary containment such as clean tubs, buckets, and trays. The following provides some general guidelines for storage:

  √ Keep <u>acids</u> separate from <u>bases</u>
  √ Keep <u>organic acids</u> separate from <u>inorganic acids</u> (nitric acid from formic acid, acetic acid, and anhydrides)
  √ Keep <u>ignitables</u> separate from <u>oxidizers</u> or sources of ignition, especially solvents
  √ Keep <u>flammable liquids</u> separate from <u>corrosives</u> (except acetic acid – store with flammables)
  √ Keep <u>pyrophorics</u> separate from <u>flammables</u> and <u>corrosives</u>
  √ Keep <u>oxidizing agents</u> separate from <u>reducing agents</u>
  √ Keep <u>halogenated solvents</u> separate from <u>non-halogenated solvents</u>
  √ Keep <u>water reactives</u> separate from <u>aqueous</u> sources. Do not store them under the sink.

- Check chemical containers for the formation of peroxides. In glass bottles, peroxides may be visible as distinct crystals; in metal cans, particularly deteriorating ones, peroxidation should be presumed. These materials are highly explosive, and should be handled with extreme caution by qualified individuals, such as fire department personnel. Peroxide-forming chemicals should be stored in sealed, airtight containers with tight-fitting caps, and checked periodically for peroxide formation.
- Do not use standard refrigerators to store flammable chemicals; only refrigerators of explosion-proof or explosion-safe design should be used.
- Do not store food in chemical-containing refrigerators; label these refrigerators with signs that say “no food allowed.”
- Keep current material safety data sheets (MSDSs) for every chemical that is being stored in order to understand storage

Safe Handling, Identification of Peroxide Formers
(www.ehs.pitt.edu/waste/Peroxide%20Forming%20Chemicals.pdf)

Peroxide-Forming Chemicals
(http://ehs.missouri.edu/chem/peroxide.html)

Flinn MSDS Sheets for Science Instructors:
(www.flinnsci.com/search_MSDS.asp)

A Guide to MSDS Sheets
(www.hazardouswaste.utah.gov/ADOBE/p2factsheets/MSDS.pdf)

Mercury in Schools
(www.epa.gov/mercury/schools.htm)

requirements, hazardous characteristics, and health and safety information. Flinn Scientific is a resource for over 1300 updated MSDSs written specifically for science instructors teaching at a middle school, high school or community college.

- Follow instructions for recommended shelf-lives of chemicals, since chemicals can become more hazardous with age;

- Eliminate from storage all chemicals that are beyond their shelf life, that are unusable, unneeded, deteriorated, and or excess. Also, take steps to eliminate chemicals that are shock-sensitive, explosive, and highly toxic. Use caution since old chemicals may be unstable. For example, the self-life for potassium metal is three (3) months because it forms peroxides and becomes unstable.

- Check chemical containers periodically for rust, corrosion, and leakage.

Mercury and its compounds, both organic and inorganic, are health hazards. The most harmful exposure occurs through inhalation, but it is also harmful by absorbance through the skin. Production of mercury vapor is heightened by heating mercury or by subdividing which occurs during a spill. Laboratory sources of mercury include, among others, thermometers, manometers (barometers), lamps, and batteries.

- EPA encourages schools to discontinue use of and remove all mercury compounds and mercury-containing equipment.

Labeling

Proper labeling is a simple and effective way to reduce many of the environmental hazards and costs associated with chemicals used in the laboratory. Proper labeling also decreases the risk of accidents and injuries.

- Label all chemicals to ensure proper identification. Use labels that are colorfast and permanent, and re-label as necessary.

- When organizing your storage area(s), check for and label mislabeled and unlabeled chemicals only if you are sure of their identity. For substances that are unknown, plan to eliminate them by following appropriate waste management procedures (refer to the “Hazardous Waste Management for School Laboratories” tool kit).

- Label all chemicals with the date they are <u>received</u> so that older ones will be used first (first in, first out);

- Label all peroxide-forming chemicals with the date they are <u>opened</u> and the date they will <u>expire</u>;

- Routinely inspect your chemicals and maintain legible labels.

Laboratory Waste Minimization and Pollution Prevention: A Guide for Teachers (Chapter 8)
(www.p2pays.org/ref/01/text/00779/index2.htm)

National Microscale Chemistry Center at Merrimack College
(www.microscale.org)
(978)837-5137
315 Turnpike St.
N. Andover, MA 01845

National Small Scale Chemistry Center at Colorado State University
(www.smallscalechemistry.colostate.edu)

Microscale Lab - Journal of Chemical Education
(http://jchemed.chem.wisc.edu/aboutjce/features/ML)

Free Reference Manual, Ideas, and Information for Science Teachers
(www.flinnsci.com/Sections/Freebies/flinnFreebies.asp)

Least Toxic Chemistry Labs: Topical Units for Instruction
(www.govlink.org/hazwaste/schoolyouth/rehab/labs.htm)

Rehab the Bio Lab
(www.govlink.org/hazwaste/publications/rehabbio.pdf)

Green Chemistry – Greener Education Materials
(http://greenchem.uoregon.edu/gems.html)

Waste Minimization and Pollution Prevention

To reduce potential hazards in your laboratory and the costs and potential liability incurred for waste management, minimize the generation of wastes and implement pollution prevention measures. While students are increasingly sensitive to the environment, they often do not realize how their concerns translate into specific practices that cumulatively can make a big difference.

- Consider the use of microscale techniques, which use less chemicals than traditional experiments. Microscale chemistry, also known as small scale chemistry, is a method of performing chemical processes using small quantities of chemicals without compromising the quality and standard of chemical applications in education and industry. Microscale procedures and equipment result in smaller quantities of waste, are safer, and teach careful laboratory techniques. They decrease the risk of fire and explosion, reduce the exposure to harmful vapors, are more economical, and less bulky to store.
- Include waste management and waste reduction/pollution prevention as part of the students' laboratory experience and training. One idea is to have your students research waste minimization techniques as part of an experiment's curriculum to identify ways to minimize use of hazardous chemicals or generation of hazardous byproducts.
- Waste minimization begins when planning an experiment. Consider the kind and quantity of waste that will be generated and adjust the experimental design to minimize it.
- Consider preparing pre-measured amounts of chemical for an experiment into vials for each student to minimize waste and save time during the class period;
- Consider using classroom demonstrations for some of the most hazardous experiments instead of individual-based experiments;
- Consider the application of green chemistry principles. Green chemistry is the redesign of chemical transformations and processes to reduce or eliminate the use of materials that are hazardous to human health and the environment.
- Monitor experimental reactions closely and add additional chemicals only as necessary;
- Use solvents and other hazardous chemicals sparingly;
- Consider cyclic experiments where the product of one reaction becomes the starting material for the next experiment;
- Look into the possibility of including detoxification and/or neutralization steps in laboratory experiments;

Laboratory Waste Minimization and Pollution Prevention: A Guide for Teachers (Chapter 9) **(www.p2pays.org/ref/01/text/00779/index2.htm)**

Current literature contains numerous references to these types of substitutions.

Materials & Waste Exchanges **(www.epa.gov/jtr/comm/exchange.htm)**

Lab Hood Safe Practices **(www.uwm.edu/Dept/EHSRM/LAB/fume.html)**

Guides to Perform a Hood Evaluation:

ANSI/AIHA Z9.5-2003 American National Standard Laboratory Ventilation **(www.aiha.org/webapps/commerce/product.aspx?id=LVEA03-437&cat=Features&subcat=)**

ANSI/ASHRAE 110-1995 Method of Testing Performance of Laboratory Fume Hoods **(webstore.ansi.org/ansidocstore/product.asp?sku=ANSI/ASHRAE+110-1995)**

- When cleaning with solvent, reuse the spent solvent for the initial cleaning, and use the fresh solvent only for the final cleaning;
- Consider substituting less hazardous chemicals for the more hazardous ones, for example:
    - Use detergents and hot water, enzymatic cleaners, or aqueous solvents for cleaning glassware instead of bases, ethanol, or acids
    - Use vinegar and ammonia instead of hazardous acids and bases, respectively, for acid and base experiments;
- Recover metals for recycling or reuse by precipitation;
- Teach and practice resource efficiency:
    - Conserve water by reducing rinse times where possible
    - Save electricity by turning off equipment when it is not being used;
- Examine your excess chemicals and waste to determine if there are chemical and or waste exchange networks, or uses within other laboratories within your school system;
- For substances from laboratory experiments that must be disposed of, please refer to the "Hazardous Waste Management for School Laboratories and Classrooms" (EPA 908-F-06-001) tool kit that compliments this document for guidelines on proper waste management.

Laboratory Ventilation

Laboratory ventilation or engineering controls reduce airborne concentrations of hazardous chemicals. In a science laboratory, this is typically accomplished with a bench-top laboratory hood. The use of engineering controls is extremely effective in minimizing exposures to hazardous materials and is the preferred method for reducing exposures. Work with hazardous chemicals should always be conducted in a laboratory hood that has been evaluated for satisfactory performance in the past year, while using proper hood use practices.

- Know the toxicity and hazardous properties of chemicals and handle them accordingly;
- Look for an evaluation certificate that has been completed within the past twelve (12) months that shows 80 to 120 fpm (feet per minute) face velocity;
- Work at least six (6) inches inside of the hood;
- Lower the hood sash as much as possible;
- Keep the hood clear of clutter;

OSHA's Personal Protective Equipment Fact Sheet **(www.osha.gov/OshDoc/data_General_Facts/ppe-factsheet.pdf)**

Best Manufacturing Company's Comprehensive Guide to Chemical Resistant Best Gloves **(www.chemrest.com)**

Ansell Chemical Resistance Guide **(www.ansell-edmont.com)** Scroll down and click "View the 7th Edition Chemical Resistance Guide"

Oklahoma State University Laboratory PPE **(www.pp.okstate.edu/ehs/modules/ppe/index.htm)**

Harvard University PPE **(www.uos.harvard.edu/ehs/lp_ppe.shtml)**

- Elevate large equipment at least two (2) inches above the base of the hood to allow for proper air flow;
- Avoid rapid movements in front of the hood;
- Do not adjust the baffles.
- Do not use the hood for chemical storage or chemical disposal (through evaporation).

Personal Protective Equipment (PPE)

Personal protective equipment (PPE) can be defined as equipment worn to minimize exposure to physical and health hazards. PPE doesn't replace engineering controls like functioning fume hoods or good work practices. Instead, PPE must be used in combination with engineering controls and good work practices by anyone who is conducting school laboratory experiments.

- Common PPE in the laboratory includes eye (safety glasses with side shields), hand (gloves), and body protection (laboratory coat).
- Wear closed toed shoes in areas where chemicals are used or stored.

Prevention and Clean Up of Spills

Spills are inevitable in the school laboratory. Proper prevention planning can help minimize their incidence and decrease exposures that are hazardous to teachers and students.

- Develop a plan with procedures to prevent and clean up spills so that administrators, teachers, and students know what to do if an incident occurs;
- Ensure all persons who handle chemicals are familiar with spill plans;
- Use proper containers for dispensing solids and liquids. Solids should be contained in wide-mouthed bottles and liquids in containers that have drip-proof lids.
- Maintain spill kits (absorbents, neutralizers) and procedures for major hazardous chemical classes, such as acids, bases, and organics. Some general guidelines include the following:

  a. Acids – use powdered sodium bicarbonate
  b. Organic acids, halides, nonmetallic compounds, inorganic acids – use slaked lime and soda ash
  c. General spills – use commercial absorbents, spill kits, or

Mercury in Schools
(www.epa.gov/mercury/schools.htm)

Environmental Management Systems
(www.epa.gov/ems/index.html)

School Pilot EMS Projects
(www.epa.gov/NE/ems/projects.html#k)

Evaluation of EPA New England's EMS Pilot Efforts for K-12 Schools
(www.epa.gov/evaluate/K-12_report_Oct2004c.pdf)

Healthy School Environments Assessment Tool
(www.epa.gov/schools/healthyseat)

small particles of clay absorbents (kitty litter)

d. Mercury (if mercury-containing equipment is used) – use a specialized, commercially available spill kit. Never use a broom or commercial vacuum cleaner, and do not pour mercury down the drain. See EPA's website on mercury for spill clean-up instructions and precautions.

- If possible, contain areas where spills are likely to occur to help limit the affected area. For example, use trays for secondary containment of liquids that are being stored. Other examples of secondary containment are clear heavyweight bags and clean, empty paint cans for containers of very hazardous and toxic chemicals.

Other Tools and Resources

Other tools that may be useful resources for your school include Environmental Management Systems (EMS) and the Healthy School Environments Assessment Tool (HealthySEAT).

An Environmental Management System (EMS) is a continual cycle of planning, implementing, reviewing and improving the processes and actions that an organization undertakes to meet its business and environmental goals. Most EMSs are built on the "Plan, Do, Check, Act" model. An EMS can result in many benefits, including enhancing compliance and improving environmental performance, reducing risks, increasing efficiency and reducing costs, among many others.

- The elements of an EMS are flexible by design to accommodate a wide range of organizational types and sizes, such as your school.
- An EMS provides a structured approach to evaluating activities of your school that impact the environment, and then planning and taking action to reduce those impacts. It is a continual cycle of planning, implementing, reviewing, and improving practices to meet established goals.
- Much of what you have in place now can be incorporated into an EMS.

The Healthy School Environments Assessment Tool (HealthySEAT) was developed by the EPA to help school districts evaluate and manage their school facilities for key environmental, safety, and health issues. This free downloadable software tool is designed to be customized and used by district-level staff to conduct voluntary self-assessments of their school facilities, and to track and manage information on environmental conditions school by school.

- HealthySEAT contains a fully integrated environmental health and safety checklist that is designed to be easily customized to reflect state and local requirements and policies.
- EPA has included critical elements of all of its regulatory and voluntary programs for schools, as well as web links to more detailed information.

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U.S. Environmental Protection Agency. www.epa.gov/

Utah Department of Environmental Quality. Laboratories Pollution Prevention Fact Sheet.

Please Note: The inclusion of non-EPA links and their content does not necessarily reflect the views and policies of the EPA, nor does the mention of trade names or commercial products constitute endorsement or recommendation for use. These links are included to maximize the utility the Internet provides and to better fulfill our role as information provider and disseminator.

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