Pollution Prevention for Laboratory Wastes

Research and educational institutions have unique waste management problems because there are often many separate "business" operations within a university or school. Laboratories create a very diverse set of wastes from student experiments and research labs in biology, chemistry, physics, medical, food production, and many other varied studies supported at educational institutions. In addition to wastes created in classes and from research, a school's facility maintenance and upkeep also generate pollutants and wastes of concern. Cooling and heating systems, power house operations, motor pool and vehicle maintenance, and upkeep of grounds are just a few of a school's activities that generate hazardous waste or regulated discharges.

Literally hundreds of types of wastes are generated that must be handled properly and must be figured into a school's operational and management budgets. Under current regulations, all generators are responsible for the safe cradle-to-grave management of any hazardous waste they generate. This fact sheet is dedicated to management of lab wastes through pollution prevention to help schools reduce their compliance and other related waste-handling costs.

Pollution prevention (P2) should be as much a part of doing business as worker safety and product quality. Successful P2 begins with a strong commitment to prevent generation of wastes at their source. Merely having P2 policies in place is not going to create an instant success; everyone in the lab–professors, teaching assistants, researchers, and even students should be educated and involved in the process in order for it to be successful. The following lists contain P2 opportunities that can be used to reduce waste and compliance-related operating costs for college and university operations.

Colleges and universities usually have decentralized materials purchasing, meaning everyone orders their own materials whenever they want to. Each faculty member has distinctive material needs, and in many instances these materials are of the utmost importance to the success of his or her research. This creates, understandably, an environment where each lab orders its own "new" materials, which in time creates an incredibly diverse waste stream of usually small quantities of each waste, which require disposal through the use of lab-packs of hazardous waste. Lab-packing chemical waste is expensive and many times involves disposal of usable chemicals. Long-term liabilities and stricter Land Disposal Restrictions (LDR) associated with the disposal of lab-packs make them a less-than-desirable management option.

Management practices to reduce lab waste

EPA and many states' regulatory agencies have recently focused on environmental compliance in institutes of higher learning. Unfortunately, these efforts have resulted in many schools being assessed penalties for non-compliance. P2 programs can often be used by schools to mitigate these penalties. The following approaches can help prevent excessive use of chemicals and reduce the generation of hazardous wastes, emissions, and water discharges.

Establish a directive and centralize environmental management responsibilities.

This will involve appointing a university-wide safety or waste management officer and a chemist or other qualified individual from each department to work on waste generation and storage issues. This will facilitate proper handling of environmental contaminants and incoming wastes generated at each department. It may be possible to mix compatible wastes in order to reduce the amount of lab-packs necessary, and some chemicals may be evaluated for use in other labs with less critical research operations. Because of the semi-autonomous climate in which most research is conducted, development of an organizational approach is very important. Without this, further efforts to reduce waste may have little or no effect.

Waste management should be a departmental priority and have support at the management level to achieve waste reduction and environmental compliance. Management should meet with all departmental labs and strive to validate the level of importance given to this effort and educate participants; monthly totals of hazardous waste generation and their costs (regulations require monthly totals to determine generator status), and the economic and regulatory impacts (if possible, by each lab activity) on the department should be discussed. A second meeting should address training needs and seek input from all involved on the approach they should take to establish a waste management and compliance program. After an infrastructure of support is established, the departments should institute an initial waste reduction goal so that each lab involved has a finite, well-defined objective.

Establish an inventory control program.

A school-wide purchasing and inventory control program is not practical in larger institutions, although it may be very successful in small colleges or technical schools. Larger institutions should strive to do this at the departmental level. A centralized purchasing program would require all personnel to send their requests for chemicals through one office. Orders for lab supplies may be set up on a scheduled basis, say on the first Monday of every month.

Purchasing agents can combine lists from each lab to spot duplicate materials ordering, track materials use by lab, monitor expired chemicals, and track hazardous waste generation from each lab. This information can also promote sharing of chemicals by common users, identify users of extremely hazardous materials and high-volume users, and delineate points where waste reduction options are needed. Institute procedures to restrict hazardous chemical purchases to those needed only for the current instructional or research programs and in minimal amounts that reflect short-term use. Do not buy extra chemicals in bulk for supposed "savings."

Establish or utilize a waste exchange system.

Waste exchanges can be utilized when the materials to be disposed are still good enough to be reused. In laboratory facilities, a waste exchange is generally limited to unopened containers which have not been contaminated. For this reason, it may be more cost-effective to order supplies in smaller quantities to facilitate use of leftover supplies. A periodic newsletter can be used to alert laboratory personnel to chemicals which are available. If an on-site waste exchange is not a practical option, there are several regional waste exchanges. Contact the Kansas SBEAP program for more information on waste exchanges in your area (800-578-8898).

Conduct routine self-audits.

All laboratories should conduct self audits to assess compliance with environmental regulations, minimize reagent accumulation, and maximize recycling and sharing of surplus materials.

Consider disposal cost at time of purchase.

Many chemicals deteriorate with time. When they must be removed, *the disposal cost 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. Reduced disposal costs can often offset savings from buying in quantity.

Consider handling and disposal requirements.

If the facility does not have adequate storage and safety provisions for a chemical, its purchase should be discouraged. Try to use nonhazardous chemicals or those that are suitable for reuse.

Reduce expired stock.

Negotiate expiration dates of chemicals with suppliers based on their intended use. Order reagents in amounts needed and stock smaller containers of chemicals. This helps prevent waste due to surplus or shelf-life expiration.

Use up old stock.

Rotate chemical stocks to avoid expiration of their shelf life. Note expiration dates. Use a "first in, first out" policy to keep chemicals from becoming outdated.

Avoid donations of chemicals.

Do not accept donated chemicals or "free samples" unless they meet a specific need, as they can become a future waste problem.

Personnel training

Provide employee training.

Each department should have a training program for all those who may generate or handle hazardous materials. If your school generates more than 55 pounds of hazardous waste on a monthly basis, this training is *mandatory*, not optional. Hazardous waste handlers' training should include how to identify hazardous waste, labeling and storage requirements, and emergency preparedness and response to name a few.

Educate all personnel who may generate or handle hazardous materials on the benefits of waste minimization and specific techniques for reducing waste generation. Communicate information through departmental meetings, memos, seminars, presentations, and brochures. Provide special training for procurement staff to obtain and study material safety data sheets (MSDSs) of all incoming chemicals for special handling and/or disposal requirements. The cost of unused or waste chemicals should be included in a separate category to be shared with each lab ordering chemicals.

Laboratory practices

Basic procedural changes can affect the amount of waste generated in a lab. The following approaches should be evaluated for use in laboratories–some of these may even be adopted as a supplemental environmental project, which may be performed in lieu of paying a monetary fine for environmental non-compliance violation penalties.

Use microscale experiments.

These processes are specifically designed to scale down the volume of chemicals used in laboratory experiments and generate less hazardous waste. The scale of starting material can be reduced a hundredfold, leading to a parallel reduction in solvents required for these experiments. Microscale practices decrease the hazard of fire and explosion, and reduce exposure to harmful vapors. For more information, please contact the following center:

National Microscale Chemistry Center
315 Turnpike St.
N. Andover, MA 01845
Phone: (508) 837-5137

Increase use of instrumentation and alternative teaching methods.

Modern instrumentation not only achieves more reliable results but also reduces chemical usage. Alternative teaching methods such as an interactive video chemistry lab offer an alternative to the traditional “wet” chemistry laboratory, reducing use of chemicals and the potential hazards involved.

Substitute less toxic or hazardous compounds in experiments.

For example, substitute sodium hypochlorite for sodium dichromate; use alcohol for benzene; substitute cyclohexane for carbon tetrachloride in the standard quantitative test for halide ions; and replace acetamide with stearic acid in phase-change and freezing-point depression experiments. In most cases, specialty detergents, potassium hydroxide, or sonic baths can be used effectively in place of chromic acid solutions to clean glassware.

Design laboratory experiments to eliminate waste.

During experiments, include certain steps which will eliminate hazardous end products by reusing the material for other reactions. This has the benefit of teaching students to avoid generating hazardous wastes and take responsibility for their own wastes.

Pre-weigh chemicals.

Chemicals used in student labs should be pre-weighed when appropriate. This will reduce the amount of waste generated by spills and other mishandling. Students can participate in pre-weighing and handling exercises.

Reuse or recycle spent solvent.

When cleaning with solvent, reuse the spent solvent for the initial cleaning and use the fresh solvent only for the final rinsing.

Reuse solvents or use on-site distillation.

Recycle solvent for reuse in laboratory processes. Using recycled solvent reduces disposal costs and solvent purchases. Distill and reuse solvent from classroom experiments or use as a cleaning agent where ultra-pure solvent is not required. Small solvent distillers are available in a variety of sizes. Check with fire and worker safety regulations regarding on-site solvent distillation operation.

Segregate waste streams.

A properly labeled container for each waste stream should be provided, thus providing for better waste management at less cost. Do not mix hazardous waste with nonhazardous waste. Avoid dilution of hazardous waste. Include waste segregation as part of the educational process. Segregate recyclable wastes from nonrecyclable wastes. Segregate solvent in a closed-top drum and recycle. Segregate used oil from other wastes.

Segregate precious metal wastes for recovery.

Wastes containing platinum, palladium, and rhodium can be recovered using chemical procedures specific to those metals. Silver-containing solutions from photographic and x-ray facilities can be recycled on site or sent to commercial firms that specialize in recovering valuable silver.

Use waste minimization technologies.

Waste minimization can be applied to the management of metallic wastes and their solutions. Waste mercury can easily be recycled depending on the type or degree of contamination. Contact the SBEAP office for more information about commercial mercury recyclers.

Use a designated safe storage facility.

Wastes should be stored in a secure area, and should be segregated from incompatible materials by a dike, wall, or other means. Wastes stored for treatment should also be stored in a secure location until treated.

Label incoming chemicals.

When stocking new chemicals, label with purchasing date, and add storage code and safety precautions. Include information required by workers' right-to-know regulations.

Maintain labels.

Routinely inspect and clean old containers, tighten lids, and maintain legible labels. Re-label as needed. Unidentified reagents and wastes cannot be legally shipped for disposal without expensive characterization testing, and present a difficult waste management problem.

Develop an "orphan chemical exchange" program.

Maintain an inventory of unused reagent chemicals which can be given or shared with other laboratories. This keeps surplus materials from being unnecessarily discarded. This can be set up as a special stockroom where unused reagents can be returned and offered to others. Alternatively, a material exchange sheet containing "available" and "wanted" listings can be created as part of an inventory control system. Ohio EPA offers case studies on orphan chemical exchange programs in Ohio. In some cases, it may be possible and profitable to coordinate with several different laboratories to have instruction done at one centralized location and/or to share chemicals. This would allow consolidation of laboratory waste generation and its management.

Conclusion

Under current regulations, all generators are responsible for safe cradle-to-grave management of any hazardous waste that they generate. Laboratories are recognizing the need to reassess existing chemical waste management to alleviate the pressure of skyrocketing disposal costs, aggressive enforcement actions, and future liabilities. The best way to manage a waste problem is to prevent waste wherever possible.

Additional resources

American Chemical Society, 1985
Less Is Better, Washington, DC

Michigan State Board of Education, 1992
Pollution Prevention in Schools, Lansing, MI

National Research Council, 1983
Prudent Practices for Disposal of Chemicals from Laboratories

National Academy Press,
North Carolina Department of Environment, Health, and Natural Resources, 1986
Management Strategies and Technologies for the Minimization of Chemical Wastes from Laboratories
Raleigh, NC

Rice, SC, October 24, 1988
Minimizing Wastes from R&D Activities

Chemical Engineering, pgs. 85-88, Sanders, H.J., 1986
Hazardous Waste in Academic Labs

USEPA, 1996
Partners for the Environment – Green Chemistry Challenge
http://www.epa.gov/opptintr/greenchemistry/

The Small Business Environmental Assistance Program's (SBEAP) mission is to help Kansas small businesses comply with environmental regulations and identify pollution prevention opportunities. SBEAP is funded through a contract with the Kansas Department of Health and Environment. SBEAP services are free and confidential. For more information, call 800-578-8898, send an e-mail to SBEAP@ksu.edu, or visit our Web site at http://www.sbeap.org. Kansas State University is an EEO/AA provider.