Rehab the Kansas Lab

Pollution Prevention Institute

Chemical stockpiles plague academic laboratories

Science laboratories across the country use and store dangerous chemicals that are potentially hazardous to teachers and students. Many of these chemicals have been unused and stored on shelves and in cabinets for decades. New instructors inherit unfamiliar chemicals stored in original bottles or containers with faded and torn labels. Some containers are corroding and leaking not only due to age, but also due to improper storage practices (i.e., a reaction occurs between incompatible chemicals located next to each other because they were stored alphabetically). Some containers are broken. Some have crystals forming around them. Deteriorating metal clips or dried-out plastic clips that support chemical shelving add to these chemical management problems.

"Spend it or lose it" budgets may have caused some labs to have excessive quantities of chemicals as seen in this photo.

The environmental health issue

These chemical stockpiles often include persistent, bioaccumulative, and toxic (PBT) substances. PBTs are highly toxic, long-lasting substances which can build up in the food chain to levels that are harmful to human health and can cause environmental harm. They are associated with a range of adverse human health effects including damage to the nervous system, reproductive and developmental problems, cancer, and genetic impacts. The pollutants' ability to travel long distances; to transfer rather easily among air, water, and land; and to linger for generations in humans and the environment make them a priority issue. The U.S. Environmental Protection Agency's (EPA's) waste minimization program has drafted a strategy to reduce 31 priority chemicals in regulated hazardous waste through voluntary measures employing pollution prevention. This list of chemicals, considered PBTs, was used to help Kansas college laboratories prioritize chemicals for removal.

Laboratory chemicals can also be radioactive, explosive, and carcinogenic, posing a threat to public and environmental health. No college administration wants this kind of potential liability.

Radioactive waste in a lead box.

Eliminating PBTs and high-risk chemicals

Rehab the Lab Kansas Style is a project funded through an EPA Region 7 grant. This assists Kansas college science laboratories (mainly community colleges) with identification, reduction, and elimination of these high-risk and PBT materials. The Kansas State University Pollution Prevention Institute (PPI) reviews colleges' chemical inventories and helps in identifying PBTs and high-risk chemicals (risk exceeds educational utility).* PPI assists colleges with making plans to reduce or eliminate PBTs (and quantify those reductions) and other dangerous chemicals by substituting less-toxic alternatives, new technologies, and/or different processes. With this project, PPI also provides facilities assistance with multimedia (air, water, waste, etc.) environmental regulatory compliance.

A drawer full of mercury thermometers is a common site at colleges.

Bethany College Green Team Mission Statement

A network of volunteers taking action to achieve environmental compliance and using simple tasks to accomplish realistic goals for the improvement of the Bethany College campus.

* The following PBTs and high-risk chemicals lists were used:

http://www.epa.gov/epaoswer/hazwaste/minimize/chemlist.htm

http://cheminfonet.org/high.htm

http://www.govlink.org/hazwaste/publications/highrisktable.pdf

Case study – Bethany College

Introduction

Bethany College in Lindsborg, Kansas, is a private, four-year liberal arts institution established in 1881. The student population is approximately 500. The science building was dedicated in 1956 and an addition was dedicated in 1983. One of the college's guiding principles is sustainability.

Sustainability encompasses an understanding of our stewardship for the future and recognizes that our actions and policies may often have long-term implications. For Bethany College, this includes the judicious use of resources and operating in such a way that the college is a viable institution in perpetuity.

When Dr. Loranelle Lockyear arrived in fall 2002, she immediately began applying this guiding principle to her work. Bethany's chemistry department was typical of long-established natural sciences departments in its storage of chemicals and waste and with its use of mercury-containing devices. In the interim between her first and second semesters at Bethany, Dr. Lockyear implemented and oversaw the clean out of old laboratory solutions and old, unused stockroom chemicals. In that and subsequent clean outs, a total of 11,410 grams (25 pounds) of mercury, 17,960 grams (40 pounds) of total PBTs, and 29,340 grams (65 pounds) of high-risk chemicals were properly disposed.

In the summer of 2004, Dr. Lockyear attended a laboratory waste management workshop at Kansas State University where she was first introduced to services provided by the Pollution Prevention Institute (PPI). At the time, PPI was developing an environmental compliance and pollution prevention checklist, a tool for colleges (see page 7). After Dr. Lockyear volunteered to be a technical reviewer of the draft checklist, she was interested in applying it at her college.

Site visit

With the support of Bethany's president, academic vice-president, and chief financial officer, PPI was asked to perform a site visit and assist the college with its ongoing environmental compliance and pollution prevention efforts. Bethany had already formed a green team made up of faculty, staff, and student representatives from various departments with the potential need to comply

Case study – Bethany College *(continued)*

with environmental regulations or with significant potential to voluntarily practice pollution prevention. Having such a green team greatly facilitated communication among the various affected departments and was a great way to learn from each other. The team was an asset when coordinating solid and hazardous waste recycling or disposal efforts, and when setting priorities.

A 30-inch barometer is estimated to contain 1850 grams (4 pounds) of mercury.

As a result of Bethany's interest in the Rehab the Lab program, the chemical storeroom underwent a major reorganization and consolidation. A thorough chemical inventory was performed during this reorganization, with 836 containers of chemicals identified. A table was developed listing each item stored, its chemical formula, container size and amount of chemical present, state of matter, hazard code, whether it's on the EPA P- or U-list, storage location, and date of its material safety data sheet (MSDS). The chemical list was evaluated for mercury compounds, PBTs, and high-risk chemicals. In addition to the chemicals, mercury-containing devices were inventoried. Ninety mercury thermometers and two barometers were inventoried in the science building, resulting in approximately 4240 grams (9 pounds) of mercury that will eventually be replaced with mercury-free devices.

Final steps

"There are none! Compliance is a never-ending process," says Dr. Lockyear. Bethany has established a triple-A process when it comes to compliance:

- Awareness
- Action (with assistance)
- Accountability (by documentation)

Bethany College
data summary in grams (pounds)

	Mercury	PBTs	High-risk
Stockroom	660 (1.5)	1840 (4)	25,790 (57)
Devices	4240 (9)		
Past disposal	11,410 (25)	17,960 (40)	29,340 (65)
Total	**16,310 (36)**	**19,800 (44)**	**55,130 (122)**

Common laboratory environmental compliance issues

- *Not knowing the campus' hazardous waste generator category.* Hazardous waste generator categories are assigned to an address, not to departments. The entire campus at the same physical street address needs to identify the total amount of hazardous waste generated each calendar month to know which regulations are applicable to that generator category. In Kansas, the categories are small quantity generator (SQG), Kansas generator, and EPA generator.
- *Improper or no labeling of hazardous waste storage containers.* Containers collecting hazardous waste must be labeled with "Hazardous Waste."
- *Improper storage of hazardous waste containers.* Hazardous wastes should be temporarily stored in a satellite accumulation area or stored together in a "permanent" area where it will be picked up for off-site disposal. Containers must be in good condition and their lids must be closed except when adding or removing waste. Incompatible wastes and raw materials must be separated by a dike, wall, or secondary containment such as plastic tubs or beakers.
- *Improper discharges to the local wastewater treatment system.* Laboratories must scrutinize all discharges down the sink or floor drain and adhere to local municipal sewer-use ordinances. Written documentation should be secured and kept on file for all other questionable discharges. Collect and properly dispose of wastes that cannot be discharged to a drain.

Need assistance with compliance?
Call PPI at 800-578-8898

Why worry about mercury and PBTs?

In the environment, mercury is highly mobile, circulating through land, air, and water while maintaining and, in most cases, increasing in toxicity. Since mercury is a PBT, if released in small amounts, it accumulates and can cause environmental problems. Mercury vapor can be carried over great distances in the atmosphere and be deposited into lakes and streams. Under anaerobic conditions, some mercury is transformed to methylmercury, which gets absorbed by bottom-dwelling organisms that pass mercury up the food chain to fish. Concentrations of methylmercury in the tissues of aquatic organisms may increase at each level of the food chain. As a result, top predators in a food chain, such as largemouth bass or walleye, may have concentrations of bioaccumulative contaminants in their tissues a million times higher than the concentrations found in the lake. This is a nationwide problem—in 2004, of the 3,221 fish advisories issued in 48 states, 76 percent of these, at least in part, were issued because of mercury in 44 of the states (*www.epa.gov/waterscience/fish/*). Nationwide and in Kansas, fish tissue mercury levels are on the rise (KDHE Kansas Environment 2000 Report).

Mercury, particularly in the organic methylmercury form, is a potent neurotoxin capable of impairing neurological development in fetuses and young children, and damaging the central nervous system of adults. People are most likely to be exposed to harmful quantities of mercury through consumption of fish contaminated with methylmercury. Exposure to elemental mercury vapor in indoor air can also cause serious harm. Exposure to inorganic mercury can also occur from drinking contaminated water and touching contaminated water and soil, although harmful exposures are much less likely through these routes. For these reasons, PBTs like mercury are being targeted for reduction and ultimate elimination.

In a college setting, the most likely exposure to elemental mercury is inhalation of mercury vapors after a spill. The high vapor pressure of mercury encourages its evaporation. The central nervous system is probably the most sensitive target organ for mercury vapor exposure. Mercury vapors can affect different areas of the brain, resulting in a variety of symptoms including memory loss, headache, sleeplessness, irritability, and tremors. These symptoms may result from exposure to high levels of mercury vapor or from long-term exposure to low levels. Short-term exposure to high levels can also cause coughing, shortness of breath, chest pain, nausea, vomiting, diarrhea, fever, high blood pressure, and skin rashes.

After entering an area where a mercury spill has occurred, people may not be aware that the indoor air contains mercury or that they are breathing mercury vapor, since it is colorless and odorless. The exposure can last a long time if the spill is not properly cleaned up. Mercury trapped in plumbing may not be discovered until decades later. Just a few drops of mercury

A silvery, odorless toxin, mercury breaks up into tiny beads when released.

can produce harmful vapor levels in enclosed spaces such as rooms or vehicles. Mercury spills of one pound or more (the equivalent of two tablespoons) are required by law to be reported to the EPA National Response Center, 1-800-424-8802. Report all mercury releases to KDHE, 785-296-1679.

Case study – Cardozo High School

Mercury spills in schools are likely to occur from the breakage of thermometers or other mercury-containing instruments. But spills can also occur due to vandalism.

On Feb. 23, 2005, Cardozo High School in Washington, D.C., was evacuated after officials found mercury in three places throughout the building. This prompted testing of more than 600 students for the presence of mercury on their clothing. Of all students tested, seven had mercury on their shoes, clothes, and hands. Cardozo reopened Feb. 28, after a four-day, $125,000 cleanup by the EPA. However, the school closed again March 2 after more mercury was discovered. This time after screening hundreds of people, 88 students and staff had mercury contamination on their clothing and shoes. More mercury was found March 6 while the school was still closed.

A hidden surveillance camera recorded three students working together to spread the mercury throughout the building. According to police sources, when detectives questioned one of the suspects, he said he obtained the mercury from Cardozo's science lab. Administrators at Cardozo originally believed that the student responsible for the mercury was pulling a prank and had brought the mercury to school. According to Cardozo principal Reginald Ballard Jr., all mercury was removed from the science labs in the school after a similar incident occurred at Ballou High School (also in Washington, D.C.) in fall of 2003.

During cleanup, Environmental Protection Agency officials discovered mercury, acids, and other improperly stored chemicals. "We found problems at Cardozo High School that go well beyond the initial mission of identifying mercury and removing it from the building. The mission has been expanded because there are other chemicals that create safety and hazardous conditions," Superintendent Clifford Janey told the *Washington Times*.

Whether by vandalism or accidental mercury spills, schools need to be prepared by having a spill plan in place. However, the best plan is ultimate elimination of mercury sources.

Mercury not only found in chem labs

Instruments containing mercury are found not only in college chemistry laboratories, but also in art rooms, medical and dental departments, gymnasiums, and boiler rooms. Liquid mercury is used in instruments that measure the following:

- temperature (thermometers)
- pressure (barometers or sphygmomanometers)
- humidity (hygrometers)
- vacuum (laboratory manometers)
- flow (water meters)
- air speed (anemometers)

Mercury can also be found in the following devices:

- lights (particularly gymnasium and fluorescent lights)
- thermostats
- heating/ventilation and air-conditioning (HVAC) systems
- plumbing systems
- cafeteria equipment
- medical devices
- regulators
- gauges
- science room equipment

After taking an inventory of mercury sources on campus, ask your suppliers about non-mercury-containing alternatives, or see the resources section of this document for Web sites listing non-mercury-containing devices.

Case study – Emporia State University

The Emporia State University Teachers College is known for educating teachers. As a part of their curriculum, proper management of chemicals and wastes in the science department is not only practiced on campus during the school year, but has been taught the last two summers as part of the CH500 Chemical Safety and Hazardous Waste Management class. Current and soon-to-be middle and high school teachers attended this class. Part of the course content was to perform an on-site visit to an off-campus school laboratory where the class reorganized the chemical stockroom and properly categorized waste generated there. The school was selected from among the class participants based on comments the teachers had provided about their own schools. The lab appearing most in need of help was chosen for the renovation. In addition, any teacher enrolled in the class could receive on-site assistance from the instructor at his or her own school laboratory, if requested.

Emporia State University has adopted a two-pronged approach to reducing persistent, bioaccumulative, and toxic chemicals (PBTs) since May 2003. First, the institution has sought to reduce use of PBTs in its teaching, research, and grounds maintenance activities by the following methods:

- Reduction in the number of experiments that produce a waste stream containing PBTs. As an example, prior to June 2003, five experiments that produced a waste stream containing PBTs were performed as part of freshman chemistry laboratory courses. There is now only one such experiment that produces this waste.
- Reduction in the use of chlorinated solvents for degreasing.
- Reduction in the use of PBT pesticides on facility grounds.
- Adoption of a lead battery storage and recycling program.

Next, the institution sought to reduce the amount of PBTs and high-risk chemicals (risk exceeds educational utility) stockpiled on the campus. Table 1 lists chemicals and amounts that have been eliminated through disposal.

Table 1

Chemical	Disposal amount in kg (lbs)
1,4-dichlorobenzene	5 (11)
Methoxychlor	7 (15)
Phenol	245 (540)
Arsenic	15 (33)
Chromium	30 (66)
Lead	20 (44)
Mercury	40 (88)
Cyanide	13 (29)

Congratulations to ESU for taking proactive steps to change its chemical and waste management practices. Future teachers being trained there should no longer carry the legacy of using and accumulating PBTs and high-risk chemicals.

Emporia State University data summary in grams (pounds)

	Mercury	PBTs	High-risk
Past disposal total	40,000 (90)	67,000 (150)	355,000 (780)

Case study – Friends University

The beautiful, lighted clock tower at Friends University is an icon on the Wichita, Kansas, landscape. Friends University, with a history that dates back to the 1880s, has stayed true to its arts and sciences core—providing "a broad-based education, one that truly expands the horizons and frees the mind."

Today, Friends University hosts nearly 3,000 students and its state-of-the-art science labs house chemistry, biology, and environmental studies students. As a campus, the university supports waste minimization, providing campus recycling for a number of items including paper products, aluminum cans, and silver fixer, and no longer uses oil-based paints in its art classes. Through the Rehab the Lab Kansas Style program, the chemistry program is taking a step-by-step approach to identifying and removing old and highly toxic chemical reagents that are commonly found on the shelves of academic laboratories across the country. This is creating a safer environment for the students and staff, while preparing students for their professions with consideration for environmental health and safety impacts.

It started with compliance

When Friends University contacted PPI, they asked for assistance with compliance issues related to hazardous waste handling. "With several different students and faculty handling different solvents and reagents in our labs, we want to be sure we are handling the wastes properly," stated Dr. J.C. Moore, professor of chemistry.

Training tomorrow's chemists

After walking through the laboratories and reviewing compliance-related issues, the chemistry staff decided to host hazardous waste handlers' training and asked their science students and science faculty to attend. Dr. Kathryn M. Boyle, professor of chemistry, has a long history of addressing the need for proper hazardous waste disposal. When her organic chemistry students are given an experiment assignment, the directions include instruction on how and where to properly dispose of the chemical waste. "We take safety very seriously and all of our students are given lab safety guidelines and rules they must read and sign. I then require the students to take a written safety examination that includes waste disposal questions," Dr. Boyle said. The department now plans to use the Small Business Environmental Assistance Program (SBEAP) on-line, hazardous waste handlers' training (*www.sbeap.org*) for its students, in addition to this safety training.

Taking inventory

After completing the training and reviewing some of their compliance concerns as a departmental team, the staff enlisted Dr. Gary Branum to assist them with an inventory of the chemistry labs and storage areas. Friends University had completed a laboratory clean out of unwanted chemicals in the 1990s, but determined the stock could be trimmed even further, especially when it came to toxic substances that now have acceptable, less hazardous alternatives.

Dr. Branum's inventory had 1137 chemical entries, which were broken down by location and included both usable stock and storage. As a team, the professors reviewed the inventory for the following:

- Old chemicals targeted for removal
- Chemicals whose risk outweighed their educational utility
- Persistent, bioaccumulative, and toxic substances

In addition to the 1137 chemicals identified in their inventory, another 84 mercury-containing devices have been identified, some of which will be replaced with non-mercury-containing devices.

When chemistry labs have been in place for decades, changes need to be made incrementally. By setting achievable educational and financial goals, and by identifying training needs and inventorying current stock, the university is taking the first steps to rehabilitate the Friends University labs.

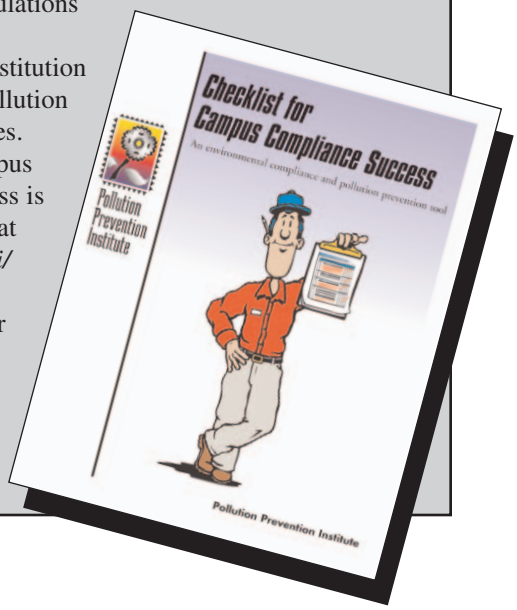
Friends University
data summary in grams (pounds)

	Mercury	PBTs	High-risk
Stockroom	15,050 (33)	56,660 (124)	335,410 (739)
Devices	11,025 (24)		
Past disposal	4080 (9)	28,120 (62)	28,120 (62)
Total	**30,160 (66)**	**84,780 (186)**	**363,530 (801)**

Friends staff identify and inventory priority chemicals for removal.

Campus compliance checklist

The structure and independent operations of various departments is a barrier to getting a handle on all of the environmental regulations applicable to an entire campus. Often cost-saving pollution prevention opportunities go unrealized. In recent years, the Environmental Protection Agency has focused on bringing colleges and universities into compliance with environmental regulations. In an effort to help colleges and universities with these issues, PPI has developed a self-inspection checklist for campuses to assess their degree of compliance with the numerous environmental regulations that could apply. Additionally, an institution can evaluate its pollution prevention activities. Checklist for Campus Compliance Success is found on the Web at *www.sbeap.org/ppi/publications.asp*. Choose the link for Colleges and Universities.



Green and micro-scale chemistry

To eliminate PBTs and high-risk chemicals (chemicals whose risk exceeds their educational utility), use alternative experiments or lesson plans that incorporate green or micro-scale methods. Green chemistry in academia focuses on reducing, recycling, or eliminating use of toxic chemicals with classroom chemical experiments. This will minimize the human and environmental impact without compromising scientific learning. Reducing hazard and waste has been the goal of many academic labs across the country. Recently, the trend has been toward "micro-scale" methods, using smaller quantities of reactants. Green chemistry, however, focuses on using less-toxic reactants, reducing the need to use micro-scale methods. Students trained in green chemistry will be ready to meet the demands of many industries that have adopted these principles.

The following Web sites offer alternative teaching methods, chemicals, or devices for the chemistry lab:

- University of Oregon's Green Chemistry Web site: *www.uoregon.edu/~hutchlab/greenchem/* and *http://greenchem.uoregon.edu/*
- EPA document for small laboratories: *www.epa.gov/sbo/pdfs/smalllabguide_500.pdf*
- University of Scranton's Green Chemistry Web site: *http://academic.scranton.edu/faculty/CANNM1/greenchemistry.html*
- Fact sheet on mercury in science labs and classrooms; gives non-mercury alternatives: *http://www.newmoa.org/prevention/mercury/schools/Science.pdf*
- Ohio lab waste-reduction fact sheet: *www.epa.state.oh.us/opp/Fact16_web.pdf*
- Micro-scale chemistry resource links: *http://campus.umr.edu/ehs/Hazardous_Waste_Mgmt/Waste_Minimization_Program/wmmicro.html*
- Bemidju State University case study: *www.mntap.umn.edu/intern/projects/BSU.htm*
- American Chemical Society's Green Chemistry Institute: *www.chemistry.org/portal/a/c/s/1/home.html* (go to "quick find" and select "Green Chemistry Inst.")
- Mainly for high schools. High-risk chemicals list and green lesson plans: *www.govlink.org/hazwaste/schoolyouth/rehab/*

Case study – Labette Community College

After attending a green chemistry conference, Dr. Doug Ecoff realized there was no need for most of the chemicals stored in his department. Labette Community College spent about $14,000 and disposed of a ton (literally) of chemicals and wastes. Dr. Ecoff now substitutes safer chemicals in familiar experiments or has replaced experiments by incorporating green and micro-scale chemistry techniques.

How you can participate in Rehab the Kansas Lab

Science laboratories are critical to student learning and research that can facilitate new technologies and efficiencies in the 21st century. At the same time, it is important to minimize risks in laboratories. Consider the following action items that can help your lab improve safety and minimize environmental impacts:

- Complete a chemical inventory.
- Reduce or eliminate mercury-containing devices and reagents.
- Reduce or eliminate high-risk chemicals (chemicals whose risk exceeds the educational utility).
- Adopt green and micro-scale chemistry technologies where applicable.
- Work with purchasing staff to minimize new inventory purchases that cannot be used up in two years.
- Identify compliance gaps (use compliance checklist as a guide).
- Contact PPI for assistance (800-578-8898).

Helpful links and resources

Kansas Small Business Environmental Assistance Program College and University Web site:

www.sbeap.org/ppi/industry/colleges.htm

EMS for colleges and universities:

http://campusems.org/

Virtual campus:

www.c2e2.org/evc/home.html

Mercury in schools resources:

www.newmoa.org/prevention/mercury/schools

www.epa.gov/mercury/schools.htm

www.mercuryinschools.unex.edu/home.htm

General mercury resources

Mercury overview:
http://clu-in.org/contaminantfocus/default.focus/sec
Fish advisories:
http://epa.gov/waterscience/fish/basic.htm

Response to spills:
www.epa.gov/mercury/disposal.htm

www.kdhe.state.ks.us/mercury/what_to_do.html

http://cheminfonet.org/mercury.htm

Non-mercury equipment:
www.newmoa.org/prevention/mercury/schools/Science.pdf

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Kansas State University

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