Science Education International
Vol. 17, No. 3, September 2006, pp. 205-211

International Council of Associations in Science Education

Safe Science: Be Protected!

KEN ROY, *(Royk@glastonburyus.org)*
K-12, Glastonbury Public Schools, Glastonbury, CT 06033-3099

WASTE NOT! WANT NOT!

I. WHY ALL THE WASTE?

More science laboratories are being built because of larger enrollments in academies and schools. There is an increase in hands-on/process science effected by the renewed interest in and priority of science education. New science curricula like Biotechnology and Advanced college type program courses are being introduced with the use of exotic laboratory chemicals. The cost in dealing with chemicals in the science laboratories has been sky-rocketing. All of these changes are putting pressure on the laboratory waste issue. Nevertheless, what exactly is laboratory waste and how should it be dealt with?

II. WHAT IS HAZARDOUS WASTE AND WHO REGULATES IT?

The definition of "waste" varies with the user. The dictionary defines waste as "refuse from places of human or animal habitation." In the laboratory, many different types of waste can be found, such as biological, chemical, radioactive, bulk, etc. Waste can be solid, liquid, or contained gaseous material no longer used. Waste is recycled, thrown away, or stored until a sufficient quantity exists to be treated or disposed of. Waste is considered hazardous waste and subject to regulatory statute in one of two ways; waste can be specifically listed as hazardous or it can be identified as hazardous through characteristics.

The legal definition of the term "Hazardous Waste" has been clarified by government legislation. For example, in the United States, under the 1976 Federal Resource Conservation and Recovery Act (RCRA) and amendments to the Act – administered by the United States Environmental Protection Agency (USEPA), a "hazardous waste" is generally defined as any waste that exhibits certain hazardous characteristics such as ignitability, corrosivity, reactivity, or toxicity:

A. Ignitability: capable of causing or fostering a fire during handling – flash point less than 60 C or 140 F – EPA Designated Waste Number D001 - Examples include Acetone, Ethanol, Ethyl Ether, Hexane and Methanol.

B. Corrosivity: capable of corroding containers – pH less than 2 or greater than 12.5 – EPA Designated Waste Number D002 - Examples include

strong acids with pH less than 2 or strong bases with pH higher than 12.5.

C. Reactivity: capable of exploding or reacting violently with air or water and other chemicals – EPA Designated Waste Number D003 - Examples include picric acid, dinitro and trinitro compounds, and ethers with peroxides.

D. Toxicity: capable of leaching hazardous concentrations of specific toxic components – EPA Designated Waste Numbers D004-D043 -Examples include carcinogens, mutagens, teratogens, heavy metals.

Three general EPA general categories of hazardous waste include the following:

A. Hazardous Characteristics: The four characteristics that make waste hazardous – Ignitability, Corrosivity, Reactivity and Toxicity;

B. Acutely Hazardous - Waste is fatal to humans in low doses based on EPA toxicity information.

C. Toxic: EPA lists waste as toxic providing it contains certain hazardous constituents. EPA judges this as posing a health or environmental problem based on criteria such as toxicity, environmental problems, amount of waste generated and migration potential. The USEPA waste list for laboratories found in 40 CFR parts 261.31, 261.32 and 261.33, include F-listed hazardous wastes (including processes that generate waste solvents such as cyanides) and P-and U-listed Hazardous Wastes (including pure commercial grade formulations such as U-list hazardous wastes from processes - chemicals like cyclohexane, chloroform, formic acid, acetone, and P-list acutely hazardous waste – chemicals like carbon disulfide, sodium azide, and potassium cyanide.)

In addition to chemical hazardous waste, nuclear waste is regulated. Nuclear waste management is directed by the Nuclear Regulatory Commission under 10 CFR 20 Subpart K. This deals with the disposal of radioactive isotopes.

The Occupational Safety and Health Administration (OSHA) primarily deals with labeling and storage of hazardous waste. The Hazard Communications Standard and Bloodborne Pathogens Standard apply in these cases.

Shipping of hazardous waste is the responsibility of both the Department of Transportation (DOT) and EPA. Standards for labeling, signage, etc. are addressed.

In addition to federal regulations on waste, state and local regulations exist and should be investigated for applications to school science laboratories.

Other countries and the international community as a whole are also addressing the waste problem. This information is available on the Internet at various government website.

With all of these regulations, what is the school's responsibility in taking care of hazardous waste produced in their science laboratories?

III. SO WHAT'S ONE TO DO?

The first thing to do is to determine if and where waste is being generat-

ed. Usually, the chemistry laboratory is a sure bet, though other labs may also be producing waste. More recently, high school or academy biology laboratories have the potential to produce biological or medical waste as the result of biotechnology and microbiology course work. Other area schools include art rooms, automobile shops and maintenance closets.

The second thing to determine is whether the waste being produced is hazardous or nonhazardous. This determination will dictate how to handle the waste. All waste chemical solids, liquids, or containerized gases should be treated as hazardous waste unless they have been confirmed to be a non-hazardous waste. Remember that a laboratory chemical is "waste" when you no longer plan to use it. Also, remember that spilled chemicals and materials used to clean them up are hazardous waste. In addition to stock chemicals, items containing chemicals are also to be considered; e.g., paints solvents, glues, disinfectants, etc. A generator can make the determination based on information supplied by the manufacturer, having the waste tested or having the chemical listed in the Resource, Conservation and Recovery Act (RCRA).

The final thing to determine is how to manage the waste appropriately. Depending on the type of waste will dictate if it is subjected to regulatory statute.

IV. OPTIONS FOR DEALING WITH WASTE!

There are appropriate methods in how to deal with the disposal of high school or academy science department waste. Included in these management methods are:

A. Recycling procedures;

B. Discharge to municipal water treatment facilities (sewage systems). Local regulations will dictate what is allowed for disposal in this method. For example, strong acids might be diluted to a pH of around 3-7 before pouring down the drain at a relatively slow rate.

C. Discharge into the atmosphere;

D. Disposal into local refuse or solid waste collection;

E. Disposal via state recognized waste contractor.

V. WHAT KIND OF WASTE GENERATOR ARE YOU?

National governments and to some degree, local governments, regulate hazardous waste. A little history of waste regulation in the US is provided as an example. As noted before, in 1976, the U.S. Congress enacted the Resource, Conservation and Recovery Act (RCRA) to address a growing waste problem. RCRA directed the U.S. Environmental Protection Agency (EPA) to protect the general public and environment from improper hazardous waste management practices. The RCRA provided a framework for controlling the generation, transport, and disposal of solid and hazardous waste "from cradle to grave." School science laboratories are not totally exempt from federal and state waste regulation! In 1984, the Hazardous and Solid Waste Amendments (HSWA) to RCRA became law.

Congress defined hazardous waste generators by three categories: conditionally exempt small quantity generators (CESQG), small quantity generators (SQG), and large quantity generators (LQG).

CESQG: If a site generates 220 pounds (100 kg) or less of hazardous waste per month, it is considered a CESQG.

SQG: If a site generates more than 220 pounds (100 kg) but less than 2200 pounds (1000 kg) of hazardous waste per month, it is considered an SQG for that year.

LQG: If a site generates 2200 pounds (1000 kg) or more of hazardous waste in per month of the calendar year, it is considered an LQG for that year.

Note that the status could change from one month to another and be subject to the management requirements for that new classification.

To determine the appropriate classification, all quantities of hazardous waste must be inventoried that are generated and collected at the work site prior to treatment or disposal on a monthly basis. In addition, waste packaged and transported offsite per month. Generators are not only defined by the amount they generate, but also the amount they store.

Not all waste must be counted. For example, waste directly discharged to a water treatment plant without being stored or accumulated first. This discharge however is subject to Clean Water Act provisions and other local regulations. Hazardous waste that are to be recycled do not need to be considered, but must be managed as hazardous waste until they are recycled.

It must also be noted that most states have additional hazardous waste regulations that must be followed. It is only prudent to check with state environmental office for additional requirements.

VI. CESQG IS NOT A RELATIVE OF THE SASQUATCH OR BIGFOOT!

CESQC or Conditionally Exempt Small Quantity Generators are exempt from all RCRA notification, reporting, and manifesting requirements. However, they are required to send their wastes to permitted or interim status treatment, storage, or disposal facilities, or to legitimate recycling or to legitimate recycling or reclamation facilities.

All but the largest urban or county school districts are classified as CESQGs. The federal hazardous waste laws however do require CESQGs to:

a. Identify and inventory all hazardous waste it produces;

b. Forward waste to a permitted, licensed, or registered hazardous waste facility or landfill or other locations approved by state regulations (40 CFR 261.5(f)(3)).;

c. If the hazardous waste is treated or disposed of on site, the facility must be able to use, reuse or legitimately recycle the waste.

d. Never store more than 1000kg of hazardous waste on property.

There are no specific federal requirements for record keeping in the case

of CESQG. However, it would be prudent to do so in efforts to determine generator status each calendar month. When hazardous waste is sent to a disposal facility, is must be listed on a Uniform Hazardous Waste Manifest or a State manifest. If the monthly generation for the facility exceeds 220 pounds, EPA must be notified of change in status.

The waste manifest form is a legal document and must be kept for at least three years. In addition, a land disposal restriction form for the disposal facility will probably have to be completed. As a legal document, it must be kept for at least five years.

There is no specific storage requirement. However, prudent practice ensures safe management of hazardous waste. Storage containers should not be leaking, rusting, incompatible with waste stored in them. OSHA requires that labels be placed on all containers under the HazCom Standard.

Storage and time limitations: There is no time limitation, only storage limitation.

Once over 1000kg of hazardous waste is accumulated, the organization is then classified as a small quantity generator. These generators can store no more than 6000Kg of hazardous waste on site for up to 180 days, or for up to 270 days if the waste must be shipped to a treatment, storage or disposal facility, which is, located over 200 mi away. Small quantity generators are allowed to store for as long as 180 or 270 days so that they will have time to accumulate enough hazardous waste to be shipped off-site.

Following RCRA was the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA). This was also known as the Superfund. Congress passed this legislation in order to finance the cleanup of hazardous waste. More importantly, CERCLA created strict reporting obligations for hazardous waste. Additional state and local statutes and regulations have been developed to address the handling of waste. For example, certain states have restricted use of landfills and incinerators. Some landfills allow only specific solid-waste and prevent such items as batteries, oil, etc.

Again, specific regulations on waste management and disposal are relative to national and/or local governments. These should be secured and reviewed prior to developing policies and procedures at a local school or academy.

VII. HOW IS WASTE DEALT WITH?

The cost of dealing with laboratory waste has been increasing dramatically. Ask anyone who has started a waste management program. Planning and setting waste reduction goals can significantly reduce the cost of dealing with waste over the long term. In addition to helping the environment, waste management programs help to reduce or eliminate potential liabilities. The following items represent the basic components of a program to reduce laboratory waste production in academy or high school laboratories:

A. Develop Chemical Practices: Practices need to be established from what

and how much to purchase to inventorying and disposal programs. Use coordinated planning in procurement procedures. For example, many schools purchase numerous bottles of the same chemicals or buy in too large volumes. Also, try substituting less-hazardous chemicals for experiments. For example, in lieu of para-Dichlorobenzene for freezing point depression labs, use lauric acid and benzoic acid as substitutes.

B. Develop Laboratory Practices: Microchemistry is in fashion and for a good reason. Scaled down volumes of chemicals in lab experiments reduce cost of chemical use from cradle to grave, especially in austere budget times, take up less storage space and have less chance of decomposition. Pre-massing chemicals for students use is another strategy. Have waste storage planned in advance of its production. Try to recycle spent solvents. Plan to dispose of hazardous waste via appropriate methods.

CESQG's are allowed to perform waste minimization procedures, such as neutralizations, redox reactions and precipitations. Academy or high school laboratories can use methods to convert waste to innocuous, non-hazardous forms or minimization of waste volume. Disposal procedures can be used on inorganic acids, organic acids, inorganic bases and anhydrides, halogenated hydrocarbons, non-halogenated hydrocarbons, peroxides, oxidizing agent, chromates, dichromates and permanganates, reducing agents, sulfides, inorganic, carbides, halogens, heavy metal salts (soluble) and mercury and mercury compounds. Procedures exist for each of these categories but should only be done with small quantities under a fume hood. Chemical splash goggles, gloves and apron.

VIII. LEADERS OUTSTANDING IN THE FIELD OF WASTE!

Many schools have held "hazardous waste" collection days in efforts to remove 20 plus years old chemicals. In the United States, some states like Vermont and Ohio have developed planned hazardous waste programs for their schools' science laboratories, including training. Connecticut has established programs to coordinate school cleanouts of hazardous chemicals. The state of Kansas through the Bureau of Waste Management has developed an impressive document to assist those responsible for administering or improving waste management programs at local schools throughout Kansas (see Resource below). More states are planning such programs like New Hampshire.

The bottom-line is that laboratory waste must be addressed. If not, it will only grow out of control! Pay now or pay more later.

LIVE LONG AND PROSPER SAFELY!

RESOURCES:

http://www.dot.gov – Department of Transportation

http://www.epa.gov – Environmental Protection Agency (EPA)

http://www.osha.gov – Occupational Safety and Health Administration (OSHA)

http://www.kdhe.state.ks.us/waste/ - Kansas Bureau of Waste Management

http://www.des.state.nh.us – New Hampshire Department of Environmental

Services

http://www.anr.state.vt.us – Vermont Agency of Natural Resources

http://www.dnr.state.oh.us – Ohio Department of Natural Resources

http://www.usyd.edu.au/ohs/ohs_manual/hazwaste.shtml - University of Sydney, Australia

Author's note: A special thanks goes to Tom Metzner, Environmental Analyst, Connecticut Department of Environmental Protection (79 Elm Street, Hartford, CT, USA) for his time and expertise in review of this column.