Source Reduction of Laboratory Waste

Changing practices and processes to prevent pollution at its source is referred to as source reduction. Source reduction methods include: Process Modification, Operational Improvements, Material Substitution, and Administrative Steps.

Modify Laboratory Processes to Prevent Pollution

- Micro-scale your laboratory processes
  - Reduces the amounts of materials used
  - Other benefits include: reduced cost, quicker run, reduced risk and severity of accidents
- Include a detoxification or waste neutralization step in your experiments
- Avoid the use of reagents containing heavy metals such as arsenic, barium, cadmium, chromium, lead, mercury, selenium, and silver
- Purchase equipment that produces less waste or the least hazardous waste
- Check if equipment modification is possible to reduce waste
- Use spent solvent for initial cleaning and fresh solvent for final cleaning, when applicable
- Substitute wet laboratory experiments with computer simulations and modeling to eliminate environmental impacts
- Change your experimental operating conditions (temperature, pressure)

Improve Laboratory Operations to Prevent Pollution

- Review proper disposal procedures for all your chemicals
- Keep volatile chemicals capped and sealed
- Take care when weighing or transferring chemicals between containers to minimize spills
- Segregate your waste
- Do not store excess chemicals to help increase valuable lab space and decrease spill and fire risks
- Label all laboratory reagents to eliminate unknown substances
- Regularly review your laboratory chemical stocks and dispose of surplus, or donate to other labs
- Pay special attention to chemicals which can become reactive or explosive with age

Substitute with Safer Chemicals

- One of the most successful ways to reduce pollution is by substituting hazardous materials with safer chemicals

Take Administrative Steps

- Control your laboratory chemical inventory
- Improve purchasing techniques by ordering the absolute minimum required to complete the experiment with in a short time period
- Include pollution prevention and waste minimization as part of student/employee training
- Develop incentive programs

Once all source reduction options are reviewed and implemented, assess and implement appropriate reuse and recycle measures.

Reduce Your Solvent Waste Stream

Solvents represent a very large proportion of the volatile organic compounds (VOCs) released into the atmosphere. Organic solvents can be poisonous, carcinogenic, ozone-depleting and/or smog-forming*****. To minimize these health and environmental impacts avoid or reduce use of solvents in the first place. If this is not possible substitute hazardous solvents with ones that show better environmental, health and safety properties.

Ideal solvents:

- Present minimal health and safety hazard (low toxicity and flammability, low peroxide formation, lower vapour pressure)
- Have minimal environmental impact (increased biodegradability, reduced ozone depletion potential, reduced toxicity, less air emission)
- Have the reactivity that fits the reaction
- Allow for control of phase (easy precipitation/separation of product)
- Safely degrade/evaporate after use

"Green" solvents:

- Solvents produced from renewable resources (not derived from petrochemicals) such as ethanol (produced by fermentation of sugar, starch, or cellulosic based materials) or ethyl lactate (derived from corn)
- Ionic liquids which are non-volatile, non-flammable, and have high thermal stability, low vapour pressure/high boiling point and thus less emissions to air
- Solvent-less reactions in which the reagents serve as the solvent as well, or conduct reactions in the solid state
- Water-based solvents; water is the environmentally benign solvent
    - Note that some water-soluble substances are very hazardous
    - Product separation and by-product formation may render effluent more hazardous than conventional solvents

Use commercially available "green" solvents:

- InTech Environmental Canada Corp. (a local supplier) and Sigma-Aldrich offer green solvent products.
- Review the article "*What is a green solvent? A comprehensive framework for the environmental assessment of solvents*", Royal Society of Chemistry, Green Chemistry, Issue 9, 927-934, 2007).

Substitute with less hazardous solvents*

- Substitute benzene with xylene or hexane (many solvent uses)
- Substitute carbon tetrachloride with cyclohexane (qualitative test for halides)
- Substitute halogenated solvents with non-halogenated solvents (extractions and other uses)

***Solvents - Health and Environmental Hazards**
Many organic solvents are poisonous if swallowed or inhaled in sufficient quantity. High concentrations of most solvents can cause narcosis (dizziness, nausea, fatigue, loss of coordination, and coma). Some organic solvents are carcinogens (e.g., benzene, carbon tetrachloride, trichloroethylene), reproductive hazards (e.g., 2-ethoxyethanol, 2-methoxyethanol, methyl chloride), and neurotoxic (e.g., n-hexane, tetrachloroethylene, toluene).

Many Chlorofluorocarbons (CFC’s) are ozone depleting chemicals (e.g., trichlorofluoromethane) causing degradation of the earth's stratospheric ozone layer and its ability to shield ultraviolet radiation from the earth’s surface. The more reactive Volatile Organic Compounds (VOCs) combine with nitrogen oxides to form smog, a toxic inhalant.

Reduce Your Chemical Waste Stream

- Segregate hazardous from non-hazardous waste
- Reduce the scale of your experiment
- Add a neutralization/detoxification stage to your experiments (implement in-lab chemical waste treatment)

Inventory Control

- Keep an up-to-date inventory of your lab chemicals, including where the chemicals are located (mandatory WHMIS / WorkSafeBC requirement)
- Rotate stock; follow the principle of first-in, first-out
- Keep track of expiration dates and storage times, especially for peroxide-forming and other degradable chemicals
- Purchase only the chemicals and amounts you need in the immediate future
- Borrow small amounts from other labs
- Purchase smaller containers that are easier to handle; large containers often become waste when half full
- Accept only gifts or samples you plan to use in the immediate future, do not accept more than you need
- Keep Safety Data Sheets (SDS) and disposal procedures for chemicals used and produced in your laboratory

Materials Substitution

Substitute hazardous with less hazardous chemicals

- MIT Green Chemical Alternatives Wizard (ehs.mit.edu/greenchem)
- EPA Green Chemistry (epa.gov/greenchemistry)
- Sigma Aldrich “Greener Alternatives” (sigmaaldrich.com/chemistry/greener-alternatives.html)

Use alternatives to mercury

Mercury is a toxic metal that is difficult and costly to dispose of safely. Mercury waste from broken thermometers and manometers (e.g. blood pressure monitors) is commonly generated in UBC labs.

- Use alternatives to mercury thermometers: alcohol (red liquid) thermometers, thermocouples and other electronic temperature devices
- Use only Teflon coated thermometers that will contain the mercury if the capillary is broken

Avoid using chromic acid solution for glass cleaning

Chromic acid solutions (mixtures of sulfuric acid and dichromates) are used to clean laboratory glassware. Chromic acid is a strong corrosive and strong oxidizer that reacts violently when combined with oxidizable materials. It contains chromium (VI), which is a known human carcinogen, it is very toxic to humans and the environment. Try the alternatives to chromic acid solutions listed below (in order of increasing hazard). Note that some of these mixtures are very hazardous.

- Non-hazardous cleaning solutions (e.g. ultrasonic baths; Alconox or similar detergents; Pierce RBS-35 or similar detergents; biodegradable surfactants)
- Strong corrosive solutions (e.g. potassium hydroxide/ethanol solutions; dilute hydrochloric acid)
- Strong oxidizing acid solutions not containing chromium or other toxic metals (e.g. potassium persulfate and sulfuric acid; aqua regia, NOCHROMIX®)

Lecture Bottles of Hazardous Gases
Lecture bottles are small compressed gas cylinders, typically 2-3 inches in diameter and 12-18 inches in height. While many gas suppliers offer lecture bottles for purchase, most will not accept the empty or partly full cylinders back for disposal. Before purchasing new lecture bottles try to share the ones available in your department. In order to avoid costly disposal fees, purchase only returnable lecture bottles or small size cylinders.

These local vendors offer returnable lecture bottles/small size cylinders:

- Air Liquide Canada
- Praxair Canada
- Messer Industrial Gases (formerly Linde Gas)

Potentially Explosive Materials
Most chemicals that are used in research and teaching laboratories are stable and non-explosive at the time of purchase. Over time, some chemicals can oxidize, become contaminated, dry out, or otherwise destabilize to become Potentially Explosive Chemicals (PEC) (e.g. isopropyl ether, sodium amide and picric acid).

PECs are particularly dangerous as they may explode if subjected to heat, light, friction, or mechanical shock. The special care and procedures required for these chemicals result in high disposal costs (more than four hundred dollars for each container).

Before ordering new chemicals, review the chemical's SDS. If the material you are about to purchase is a potentially explosive material follow these guidelines:

- Consider substituting with a less hazardous materials
- Purchase the smallest amount possible
- Limit storage duration
- Share with others
- Check expiration dates - certain chemicals deteriorate to a dangerous condition with age
- Routinely test peroxide forming chemicals for peroxide levels
- Inspect containers regularly- certain chemicals may explode due to over-pressurized container
- Dispose before expiration date and before chemicals become unsafe
    - Contact UBC's Environmental Services Facility (ESF) at 604-822-6306 to arrange for special disposal

Minimize Biohazardous and Biomedical Waste Streams

You can reduce the volume of bio-hazardous, biomedical, and pathological waste and hence reduce environmental impact and disposal costs by implementing the following practices for the waste categories below:

Biohazardous waste - laboratory cultures, stocks of micro-organisms, vaccines, cell cultures, and solid waste contaminated with the above:

- Segregate non-hazardous solid waste from hazardous waste
- Treat by properly autoclaving RG1 And RG2 hazards to facilitate disposal as solid waste
- Use products with less environmental impact
  - Use Petri dishes with 35% less plastic
  - Use shorter serological pipettes with less plastic
  - Use reusable, recyclable products- pipette tips reloadable systems. These systems contain less packaging. Reusable/recyclable boxes reduce package waste by 50-80%

Biomedical waste - human anatomical, blood and body fluids:

- Segregate uncontaminated solid waste from hazardous waste
  - Uncontaminated gloves used to handle containers of blood or body fluids;
  - Paper towels and bench paper on which containers of blood or body fluids have been placed but did not spill
  - Empty specimen containers and tubing (no visible blood contamination)

Pathological waste - animal carcasses, tissue, fungi, insects, parasites:

- Segregate any non-hazardous solid waste from pathological waste
- Dispose non-hazardous solid waste through the trash
- Pack all pathological materials for incineration according to approved protocols
- Contact ESF at 604-827-5389 if you have fresh uncontaminated carcasses, this waste may be diverted to animal feed processing

Solid waste contaminated cytotoxics (e.g. ethidium bromide):

- Segregate non-hazardous solid waste from toxic waste
- Replace ethidium bromide with non-mutagenic non-cytotoxic dyes: SYBR® Safe, GelRed™, GelGreen™, EvaGreen®, EZ Vision®.

Radioactive Waste Reduction

Segregate uncontaminated solid waste from radioactive waste (i.e. uncontaminated: gloves, paper towels, bench paper, empty containers and tubing). Minimize mixing of chemical-radioactive waste:

- Substitute the chemical or the radioactive source contributing to the mixed waste
- Use 2.5 mL scintillation vials ("minivials") rather than 10 mL vials.
- Eliminate the use of acetic acid/methanol mix for electrophoresis gel fixing when not required
- Line lead containers with disposable plastic, or use alternative shielding materials, to prevent lead contamination by radioactivity
- Use the minimum activity necessary and select the radionuclide with the most appropriate decay characteristics
- Substitute with shorter-half-life radionuclides such as 32P (t1/2 = 14 days) for 33P (t1/2 = 25 days) in orthophosphate studies, and 33P or 32P for 35S (t1/2 = 87 days) in nucleotides and deoxynucleotides. In many uses, 131I (t1/2 = 8 days) can be substituted for 125I (t1/2 = 60 days)
- Use nonignitable scintillation fluid (e.g., phenylxylylethane, linear alkylbenzenes, and diisopropylnaphthalene) instead of flammable scintillation fluid (e.g., toluene, xylene, and pseudocumene)
- Use nonradioactive substitutes such as:
  - Scintillation proximity assays for 32P or 35S sequencing studies or 3H cation assays
  - Enhanced chemiluminescence (ECL) for 32P and 35S DNA probe labeling and southern blot analysis