Chapter 1

A GUIDE TO THE DISPOSAL OF TOXIC CHEMICALS IN UC BERKELEY LABORATORIES

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Introduction

The absence of a comprehensive procedure for the disposal of toxic chemical waste in laboratories on the UC Berkeley campus can lead to problems because the wastes may be disposed of in hazardous ways. Lab technicians and students must be informed of potential dangers and proper disposal procedures to avoid accidents and illegal disposal practices.

The purpose of this paper is (1) to determine which chemicals are most commonly used in the laboratories; (2) to find out which laws and regulations apply; (3) to evaluate the current disposal methods; and (4) to write a simple manual that can be used by laboratory technicians on the campus.

Past Work

A recent study of chemical discharge from UCB laboratories (Jolly, 1983, Ujihara, 1983) has shown that there is a potential problem with dangerous chemicals being disposed of down the drain to the sewage system. This is due to the fact that lab technicians have varying degrees of knowledge of chemical disposal techniques and procedures. The current management of chemical waste on campus was found to be inadequate. Lab facilities and education of new students and employees also need improvement.

One department on campus that does try to educate employees and graduate students concerning lab safety is the College of Chemistry. New lab technicians are given a copy of a pamphlet called "Who Does It and Where to Find it." This is a guide to services within the College of Chemistry, which includes guidelines for disposal of chemical wastes, emergency procedures should an accident occur, where to get supplies and whom to contact regarding a question or problem. Although the pamphlet is a helpful guide, it is not circulated to other departments because most of the information applies only to the College of Chemistry.

Chemicals Used in the Laboratories

The most commonly used groups of chemicals include inorganic acids, chlorinated and aromatic hydrocarbons, ketones, esters and ethers (Figure 1). High-use chemicals include all the inorganic acids, chloroform, ethanol, methanol, propanol, phenol, pentane, hexane and all the aromatic

hydrocarbons (Jolly, 1983). Of the chemicals listed in Figure 1, approximately 55% are considered hazardous by the Environmental Protection Agency (EPA). Corrosive chemicals include all the inorganic and organic acids. Aniline and phenol are considered poisons. Pyridine, methanol, acetone, pentane, amyl acetate, propylene oxide, tetrahydrofuran, and all the aromatic hydrocarbons are flammable liquids (U.S., 1983). Many of these chemicals are also known carcinogens. Because of the toxicity of these chemicals they must be disposed of according to law.

Laws and Regulations

The regulation of hazardous waste is confusing because federal, state, and local regulations all differ. Federal regulations are usually general, whereas the state regulations define specifics of the law. An example is the definition of a hazardous waste. The federal government defines a hazardous waste as:

> any waste material or mixture of wastes which is toxic, corrosive, flammable, an irritant or a strong sensitizer which may cause personal injury, serious illness or harm to wildlife during or as an approximate result of any disposal of such wastes or mixture of wastes (U.S., 1982).

The definition in the California Administrative Code (CAC) is more specific. A "toxic" substance is one that can cause injury to humans and wildlife. An "irritant" can induce a localized inflammatory reaction after prolonged or repeated exposure. A "corrosive" substance can cause destruction of living tissue by chemical action. A "flammable liquid" is defined as a substance with a flash point at or below 37.8°C (100°F). A "strong sensitizer" can cause hypersensitivity through an allergic or photodynamic process (CAC, 1982).

The Resources Conservation and Recovery Act (RCRA) of 1976 was enacted by the federal government to improve solid and hazardous waste management. RCRA sets standards for the production, storage, transfer, management, and disposal of hazardous waste. Waste generators must obtain a permit for on-site treatment or disposal. They may get a manifest allowing for off-site disposal. Only sites that meet EPA regulations and have state or federal permits may handle these wastes. The EPA determines which substances are hazardous and has established a manifest system with California's Department of Health Services (DOHS) to track wastes from generator to disposer (Conservation Foundation, 1982). In California the DOHS is:

> responsible for regulating transportation of hazardous materials. This includes requirements for the preparation for transportation, construction of containers, packaging, weight of volume marking, and other related factors. The DOHS regulates the following hazard classes: flammable and non-flammable solids, oxidizable materials, organic materials, poison materials, etiologic agents, radioactive materials, corrosives, and explosives (CAC, 1982).

CHEMICAL	UCB Department: CHEMISTRY	BOTANY	MICROBIOLOGY/ IMMUNOLOGY	PHYSIOLOGY/ ANATOMY	ZOOLOGY
Inorganic Acids:					
*Hydrochloric acid	□	□	■	■	□
*Nitric acid	□	□	■	■	□
*Hydrofluroic acid	□	□	■		□
*Phosphoric acid	□	□	■		□
*Sulfuric acid	□	□	■		□
Organic Acids:					
*Acetic acid		□			■
*Formic acid		□			□
*Propionic acid		□			□
Amines & Alkamolamines:					
*Aniline		□			□
*Pyridine					□
Halogenated Compounds:					
Carbon Tet(CCl_4)	□	□			
Chloroform	■	■	■		□
Dichloromethane	■	□			
Alcohols, Glycols & Glycol Ethers:					
Butanol		■			□
Ethanol	■	■	■		■
*Methanol	■	■			■
Propanol	■	■	■		
Ethylene glycol					■
Ethylene glycol monoethyl ether		□			
Glycerine		□			□
Ketones:					
*Acetone	■	□			■
MEK	■				
Saturated Hydrocarbons:					
Hexane	■				
Paraffin wax		□			□
*Pentane	■				
Petroleum ether		□			
Aromatic Hydrocarbons:					
*Benzene	■	□			□
*Toluene	■	□			■
*Xylene		□			■
Petroleum Oils:					
Mineral spirits		□			
Lubrication oil		□			
Mineral oil					
Penetrating oil		□			
Esters:					
*Amyl acetate		□			
Ethyl acetate	■	□			□
Phenols:					
*Phenol		□	■		□
Alkylene Oxides:					
*Propylene oxide					□
Ethers:					
Ethyl ether	■				
*Tetrahydrofuran	■				

Figure 1. Liquid Chemicals Commonly Used in Laboratory Research at UC Berkeley.

Source: Jolly, 1983, p. 292.

Key: blank = not mentioned ■ = high-use chemical

□ = used regularly * = considered hazardous by the EPA

The CAC guidelines for the disposal of laboratory waste are not very specific. Lab waste may be placed in the landfills if it is put in sturdy, nondegradable, tightly-sealed containers (CAC, *1982).* Section 66535 (CAC, 1982) describes specific labelling instructions for transportation of waste. Each label must include:

1) composition and physical state of waste
2) special safety recommendations and precautions for handling waste
3) statement(s) which call attention to the particular hazardous properties of the waste
4) amount of waste and name and address of persons producing the waste

There are also some local ordinances that regulate hazardous substances in Berkeley. The City of Berkeley is not responsible for regulating UCB's hazardous waste. However, it does regulate the campus' sewer effluent that passes through the City's system before it reaches East Bay Municipal Utility District's (EBMUD) sewers. Waste gas, petroleum products and flammable substances are illegal to discharge, according to the City's Municipal Code. Under Ordinance 270, EBMUD establishes its own limitations on effluent. Suspended solids, biological oxygen demand, pH, phenolic compounds, heavy metals and total identifiable hydrocarbons are monitored by EBMUD (Ujihara, 1983).

Current Disposal Methods

The campus office of Environmental Health and Safety (EH&S) has a hazardous waste disposal program for the campus, directed by Dave Belk. Toxic waste generated in the labs is picked up by an EH&S employee and transported to the "Acid House," a temporary storage area near the Botanical Gardens. Here the waste is consolidated in 55-gallon, 5-gallon, and 2½-gallon drums. A contract hauler picks up the waste approximately every two weeks and takes it to treatment, storage and disposal facility in Casmalia. This is done in compliance with DOHS regulations, including proper labelling of drums and manifest (Belk, pers. comm., 1983).

The major problem with the current disposal system is that waste commonly is not packaged correctly for pick-up by EH&S, nor is it properly labelled. Bottles that are not wrapped in soft material and boxed correctly can break, causing injury to the EH&S hauler. Last fall a chemical-laden refrigerator broke down. As the temperature inside the refrigerator rose, the chemicals begin emitting noxious odors and vapors. None of the bottles were labelled, making it impossible to determine the seriousness of the problem or how it should be resolved (Belk, pers. comm., 1983).

Another concern is that many hazardous chemical wastes are disposed of through the sewer drain regularly (Figure 2). EBMUD does not consider this a problem; they assume that the chemicals evaporate or are diluted before reaching the Bay. However, a study of UCB's effluent discharges

UCB Departments

CHEMICAL	CHEMISTRY	BOTANY	MICROBIOLOGY/ IMMUNOLOGY	PHYSIOLOGY/ ANATOMY	ZOOLOGY
Acids (inorganic)	■	■	■		■
Acetone	■				■
Acrylamide (unpolymerized)					
Alcohols	■	■	■	■	■
Dinitrophenol			□		
Ethylene bromide			□		
Formaldehyde					■
Glutaraldehyde					■
Picric acid					■
Propylene oxide					■
Toluene	■				
Neutralized salt solutions				■	

Figure 2. Drain Disposal Patterns in the UC Berkeley Campus.
Source: Jolly, 1983, p. 296.
Key: blank = not disposed of through the drain
□ = disposed of through the drain only in very small amounts and/or infrequently
■ = disposed of through the drain regularly

shows that there is a potential problem (Jolly, 1983). One of two samples taken by Jolly contained total chlorinated hydrocarbons (TICH) above EBMUD limits. Because the other sample showed TICH levels below EBMUD limits, it is not known whether the results from the second test are a chronic problem or just a one-time occurrence.

Conclusion

Problems with UCB's current disposal system of hazardous wastes are apparent and must be changed. The major problem appears to be lack of education. Lab technicians must be informed of proper disposal methods and procedures as well as the dangers involved in handling toxic chemicals. For this reason I have written a manual (Appendix A) for the safe disposal of toxic chemical waste in UC Berkeley laboratories. Although this manual is an important component in the improvement of the current disposal system, it is not all that is needed. New employees and students should undergo a mandatory orientation and training session to ensure that proper disposal procedures are understood.

Because it is easy to forget that certain chemicals are hazardous, signs should be put up to remind people of the dangers and proper disposal methods. If these steps are taken, toxic chemical wastes generated in UCB labs will be disposed of in a safer and more responsible manner.

REFERENCES CITED

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APPENDIX A

MANUAL FOR THE SAFE DISPOSAL OF HAZARDOUS CHEMICAL WASTE

Procedures to Follow before Disposing of Any Chemicals

A. Safety First! - Always wear goggles, gloves, long pants, long-sleeved shirts and closed shoes whenever handling any toxic chemicals and/or hazardous wastes. Be sure to use the fume hood when noxious fumes are emitted.

B. Labelling - All chemicals and their wastes must be clearly labelled:

1. Label each bottle with the name of the chemical(s), concentration(s) and amount(s).

2. Use the following list of characteristics to describe waste chemicals:

a. explosive - a substance which reacts violently under normal conditions

b. poison - a substance known to be so toxic that it is a health hazard

c. flammable liquid - a substance that has a flash point at or below 37.8°C

d. flammable gas - a mixture of 13% or less by volume which is easily ignitable at atmospheric pressure

e. flammable solid - a substance which is likely to cause fire due to friction, or can be ignited under normal temperatures

f. non-flammable gas - a gas that is not easily ignited

g. poison gas - a gas that is hazardous to human health

h. corrosive - a substance which in contact with living tissue will cause destruction of tissue by chemical action

i. irritant - a substance that induces a localized inflammatory reaction after repeated exposure

j. biomedical material - a viable microorganism or its toxin, which may cause human diseases

k. radioactive - plutonium-238, plutonium-239, plutonium-241, uranium-233, uranium-235, or any material containing any of these substances

l. empty

m. unknown

3. List any observations you think may be important for proper handling or in an emergency:

a. age

b. odd characteristics
--unusual odor
--unusual color

Procedures for the Disposal of Chemical Wastes

A. Substances Which May Be Disposed of Down the Drain with Large Quantities of Water:

1. spent acid solutions

2. ordinary salts

3. small quantities of diluted solvents

4. hydrofluoric acid - small amounts only

5. acetic acid and acrylic acid - must be neutralized with soda ash or sodium bicarbonate first

B. Disposal of Hazardous Chemicals

Toxics, irritants, and highly flammable or corrosive chemicals must be picked up by EH&S. Waste chemicals must be packaged in the following manner or EH&S will not accept them for pick-up:

1. DO NOT put incompatible chemicals in the same bottle or box! This can lead to heat generation, violent reaction, fire, explosion or generation of noxious gases. Check the table of incompatible substances (Table A) to make sure that the chemicals you package together will not react!

TABLE A

DO NOT MIX THE FOLLOWING GROUPS OF CHEMICALS!!

1A with 1B or 6B (violent reaction!)

2A with 2B (explodes releasing toxic fumes!)

3A with 1A or 1B or 3B or 6B (ignites, violent reaction!)

4A with 1A or 1B or 4B or 6B (generates toxic fumes!)

5A with 1A or 1B or 3A or 5B or 6B (violent reaction!)

6A with 1B or 6B (generates toxic fumes!)

7A with 2B or 3A or 4A or 7B (violent reaction!)

GROUP 1A - acetylene sludge, alkaline caustic liquids, alkaline cleaner, alkaline corrosive liquids, alkaline corrosive battery liquid, caustic waste water, lime sludge, other corrosive alkalies, lime waste water, spent caustic

GROUP 2A - asbestos waste, unrinsed pesticide containers, beryllium wastes, waste pesticides

GROUP 3A - aluminum, beryllium, calcium, lithium, potassium, sodium, zinc powder, other reactive metals and hydrides

GROUP 4A - alcohols, water

GROUP 5A - alcohols, aldehydes, halogenated hydrocarbons, unsaturated hydrocarbons, other reactive organic compounds & solvents, nitrated hydrocompounds

GROUP 6A - spent cyanide & sulfur solutions

GROUP 7A - chlorates & other strong oxidizers, chlorites, chromic acid, hypochlorites, nitrates, nitric acid, perchlorates, permanganates, chlorine

GROUP 1B - acid sludge, acid & water, battery acid, chemical cleaners, etching acid liquid or solvent, other corrosive acids, spent acid, spent mixed acids, spent sulfuric acid

GROUP 2B - cleaning solvents, data processing liquids, petroleum wastes, obsolete explosives, refinery waste, retrograde explosives, oil & other flammable & explosive wastes

GROUP 3B - any 1A or 1B waste

GROUP 4B - any concentrated 1A or 1B waste, calcium, lithium, metal hydrides, potassium SO_2Cl_2, PCl_2, CH_3SiCl_3, $SiCl_3$, other reactive wastes

GROUP 5B - concentrated 1A or 1B wastes, 3A wastes

GROUP 6B - 1B wastes

GROUP 7B - acetic acid & other organic acids, 2B wastes, 3A wastes, other flammable and combustible wastes

2. Proper Packaging Procedures

   a. All bottles containing toxic chemicals must be put in boxes with lids. Each bottle must be labelled. If the bottles are glass, they must be packed with styrofoam, bubble packing, or other soft materials. All bottles must have screw tops, stoppers run the risk of leaking. Make sure the tops on all the bottles are screwed on securely.

   b. Dry chemicals must be placed in a plastic bag or bottle, labelled and sealed in a box.

   c. After each box is filled and sealed, it should be labelled, using the same procedure for labelling the bottles.

   d. Unlabelled boxes, broken, or leaking bottles and packages will not be accepted for pick-up by EH&S.

3. To make arrangements for pick-up or if you have any questions, call EH&S at 642-3073.

4. Emergency Phone Numbers:

Accident-Fire-Police	9-911
EH&S	2-3073
Herrick Memorial Hospital . . .	845-0130
Alta Bates Hospital	845-7110