CHBE 484: Pollution Prevention
Term Report

Waste Audit of the Chemical Engineering Building

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Executive Summary

The objective of this report was to perform a chemical and hazardous waste inventory audit of the chemical engineering (CHML) building and to make recommendations regarding the current hazardous material management policies. The findings of this report are limited to only research laboratories inside CHML building. A standard walkthrough of the building was first performed to identify the research laboratories and to gauge the state of the laboratories. Simultaneously, chemical and waste inventory forms were emailed to principle investigators (PIs) for them to complete regarding their respective laboratories. Afterwards, interviews were conducted with PIs to determine their hazardous waste management practices and with Mr. Horace Lam and Dr. Madjid Mohseni to understand the current chemical engineering department's (CHBE's) waste management policies. Lastly, laboratories were inspected to verify the findings from the interviews.

All PIs, except Dr. Oloman, that operates a research laboratory in CHML were interviewed. Following the interview, two laboratories were inspected: room 26 had hazardous waste and unlabelled chemicals and room 316C had no hazardous waste on hand. Policy comparison between UBC and CHBE's safety policy and exit protocol revealed the two are very similar.

Through talking to researchers, the CHML store supervisor, and the CHBE safety committee member, six recommendations are made to improve the current CHBE hazardous waste management policies. These recommendations include: (1) developing a colour dot system for quick chemical identification, (2) establishing an intradepartmental chemical exchange program to share unwanted chemicals, (3) allocating space in each laboratory for waste and recyclable chemicals to help distinguish what is not needed, (4) creating a departmental waste disposal procedure for new researchers to read and reference, (5) performing laboratory inspection together between the PI and the CHBE safety committee member for leaving researchers to ensure proper cleanup, and (6) creating incentives for PIs and researchers to follow good waste management techniques.

The continuation of this project should include: performing chemical and hazardous waste audit of other buildings used by CHBE PIs, identifying which PI/researcher is not following good laboratory practice (i.e. proper labeling), and assessing the effectiveness of CHBE safety video given to new researchers whom have missed the health, safety and environment department's orientation.

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1.0 Introduction

All over the world, there is an increased public awareness of environmental impacts and public concerns regarding health and safety issues when dealing with chemicals. In response to these demands, new legislations are being made to protect both the sustainability of the environment and the security of public health. At the regional level, the "Department of Health, Safety & Environment" (HSE) was established to address these demands and to ensure a safe and sustainable community at the University of British Columbia (UBC). In the future, HSE will perform regular regularly performs waste audits of different departments to assess the health and environmental risks associated with hazardous substances, and to determine their location and usage.

Since 1961, the Chemical and Biological Engineering (CHBE) department has occupied the Chemical Engineering Building (CHML). Over time, chemical and process wastes have been accumulating in the building from research and teaching laboratories and from general use. Samples leftover from previous researchers are still stored in laboratories and in storage rooms while unidentifiable substances take up shelf space. In the fall of 2005, the department will move into a new building and the current building will be subsequently torn down. To help facilitate this relocation, a combined project between HSE and the CHBE department was established. A group of CHBE students enrolled in the Pollution Prevention course volunteered to identify the waste and the superfluous chemicals that remain inside the current CHML.

The objectives of this report are to perform a chemical waste audit of CHML and to make recommendations regarding the current waste management policies. The scope of this report is limited to only waste generated from research laboratories inside CHML; interviews will only be conducted with principle investigators (PIs) who operate a research laboratory inside CHML.

2.0 Walk Through

The purpose of the walk through was to identify and assess the state of all the research laboratories, and to develop an overview of the type of storage rooms inside CHML. During the walkthrough, all rooms (except offices) were visited and observations were made for each research laboratory and chemical storage area; observations included the types of research conducted in each laboratory along with chemicals used and labeling practices. The results from the walkthrough are summarized below.

Research Laboratories:

- Room 316C is Dr. Hatzikiriakos' rheology and Dr. Englezos' hydrating lab.
  - Waste generator tags on hazardous waste containers are overlabelled (i.e. more then one tag per container)
- Room 332 is Dr. Watkinson's analytical lab.
- Room 229 is Dr. Bi, Dr. Grace and Dr. Lim's the instrument room.
  - There is some solid particles storage but no chemicals involved.
- Room 222 is Dr. Watkinson's fouling test lab.
  - Red hazardous wastes containers stored in the flammable storage cabinet do not have tags properly filled out.
  - Lots of unlabelled hazardous waste
  - There were a lot of sharp and black broken solids, mostly glasses.
- Room 214 is Dr. Bi, Dr. Grace, Dr. Lim and Dr. Watkinson's processing lab.
  - No chemicals involved in most parts of the lab except for Dr. Watkinson's section.
  - Unlabelled solvent waste containers
- Room 102 is Dr. Oloman and Dr. Elod for their fuel cell experiments.
  - Thiourea waste was stored in glass and white containers.
- Room 26 is Dr. Hatzikiriakos' polymer rheology lab.

- There are some unlabelled containers that appear to hold chemicals and/or sampels.

Undergraduate Teaching Laboratories:

- Room 319 is the 2nd/3rd/4th year lab supervised by Dr. Kannangara.
  - Chemicals were all properly stored in the flammable storage cabinet.
- Room 316 is the 3rd/4th year supervised by Dr. Petrell and Dr. Kannangara.
  - Tags on the hazardous waste containers were not labeled properly.
  - There are some flammable chemicals.
  - Unknown chemicals or wastes were found under the fumehood.
- Room 218 is the 2nd year lab supervised by Dr. Kannangara and Dr. Ellis.
  - There are hazardous waste containers with tags not completed.

Storage Rooms:

- Room 127 has a large amount of chemicals.
- Room 121A has acetone stored in glass bottles with blue tags provided by Mr. Dange.
- Room MR-28 is a compressor room with analytical instrument.
- Room 17 stores radioactive material.
- In receiving bay, there were a few unknown flammable containers.
- In the left outdoor storage room (next to loading bay), there are a lot of gas cylinders and hazardous waste containers without any tags.
- In the right outdoor storage room (next to loading bay), there are containers cleaned out from workshop and lots of leftover samples.
  - Some of the samples should be disposed of.

3.0 Interviews

Interviews were conducted to obtain the "insider's" point-of-view of how waste are managed in CHML. The walkthrough identified seven research laboratories: 26, 112, 214, 222, 316C and 332. Faculty members responsible for each laboratory were interviewed with the aim of gaining a general understanding of laboratory practices and waste management in the research labs and to assess the PIs' knowledge of university safety policies and sustainability programs. Interviews were also conducted with Mr. Horace Lam (CHML Store Supervisor), Dr. Madjid Mohseni (Chair of the CHML Health & Safety Committee). The aim of these two interviews was to gain an understanding of the CHML policies regarding waste disposal and accumulation.

Prior to interviewing the PIs, chemical and waste inventory forms were sent to all PIs for them to complete. The PIs were given two weeks to complete the forms, and the responses are attached in Appendix 10.1.

During the interview, each faculty member was asked a fixed set of questions, which was modeled after HSE questionnaires. These questions addressed issues ranging from labeling procedures to waste disposal and unlabelled left-over chemicals. A sample of the questionnaire is shown in Appendix 10.2. Interviews with the CHML Store Supervisor and the CHML Safety Committee chair were conducted by asking a different set of questions. These questions addressed issues such as improper waste disposal, unlabelled and unused chemicals, exiting protocols and waste accumulation prevention strategies for the new CHML building.

These interviews found that all research laboratories maintained updated material safety data sheets (MSDS) and had the appropriate safety policies relevant to their research. With the exception of one research laboratory, all other laboratories maintained updated chemical inventory forms and were posted on the laboratory door. MSDS's were also kept up-to-date. According to the interview results, all research assistants maintained the chemical inventories and had been properly trained by either the HSE training sessions or CHML safety videos. All of the laboratories listed dealt with hazardous materials and all but one PI had a hazardous waste

generator ID. The most common hazardous materials identified in these interviews were compressed gases, toxic materials, lubricants, flammable solvents and glassware. In terms of waste management, wastes were not brought into CHML from other locations. One laboratory conducted its own waste treatment (Bi, Grace, and Lim , 2005) while other laboratories send waste to waste treatment facilities which held permits to do so. In terms of safety, all rooms supplied personal protective equipment (i.e. safety goggles and breathing masks) relevant to the experiments conducted in the laboratory. The completed questionnaires from the interviews are shown in Appendix 10.3.

The interview with Dr. Mohseni provided an in-depth understanding of the role of the Safety Committee and the content of the CHML safety policies. The role of the Safety Committee is to firstly maintain a safe environment for students and staff and secondly to monitor experiments before, during and after they are conducted. The Safety Committee conducts annual laboratory inspections; when a hazard is identified, the laboratory personnel are advised appropriately. If the laboratory continues to breach safety policies, the experiment is shut-down. The safety policies are compiled in the CHML Safety Program Manual and its contents are further discussed in Section 5.0. While these policies apply to current researchers, exiting researchers must follow an exiting protocol and complete a clearance form before departure. The supervisor of the researcher must sign off on these clearance forms to guarantee that the laboratory has been properly cleaned.

The interview with Mr. Lam provided in-sight into the safety policy weaknesses. Two problems that were identified during the course of this interview were unknown chemicals that were missing proper labeling and old chemicals that researchers left behind. These problems escalate as a result of the lack of enforcement of these policies and they stem from inaccurate completion of clearance forms. In order to eliminate this weakness, the supervisors must be made keenly aware of the costs and dangers of unlabelled chemicals.

4.0 Laboratory Inspections

Following the interviews, PI's laboratories were inspected to ensure the accuracy of the information on the Chemical and Waste Inventory form completed by each PI. The inspections provided an incentive for the PI's to make a thorough examination of their laboratories to make certain all chemical substances were identified and registered; the inspections also allowed the opportunity to discuss waste management procedures with the researchers who have daily contact with the chemicals.

During the inspection procedure, the laboratory was thoroughly inspected; this included examining each cabinet and sifting through shelf spaces to identify any chemical substances. Once the chemical was identified, the substance and its quantity were compared to the information completed on the Chemical and Waste Inventory form. If the chemical was not listed, it was added onto the appropriate form. If the chemical was a waste, it was organized into three separate categories: known waste, unknown waste, and recyclable waste. The waste are kept at the laboratory in separate labeled containers instead of immediate disposal because the CHML Stores, where all waste are processed, was not available at the time and could only handle the waste at the conclusion of the academic term.

Two laboratories were inspected and the results are shown in Appendix 10.4. Observations made during the laboratory inspection are described below. While ideally all the PI's laboratories should have been inspected, there were scheduling conflicts. Dr. Oloman did not respond to the frequent emails sent to him nor was he found during the many visits to his office and laboratory. The laboratories shared by Dr. Bi, Dr. Grace, and Dr. Lim were scheduled for cleanup the week after the interview was conducted. Given the limited time frame for this report, the shared laboratories were not inspected. Dr. Watkinson's researcher did not show up for the arranged laboratory inspection time and was not available afterwards for another meeting; therefore, this laboratory was not inspected.

4.1. Dr. Hatzikiriakos – Room 26

Five researchers occupy this room, both as an office and as a Polymer Rheology research laboratory. During the inspection, unidentified bottles were discovered on the shelf, in the cabinets, and on the windowsill. There were also experimental samples left around the room with inadequate labeling; labeling that did not indicate who was responsible for the sample, what was in the sample or the proper disposal procedure.

The researchers revealed that most, if not all, of the unidentified chemicals were left behind by previous researchers. As a result, this laboratory practiced improper waste disposal techniques and the PI did not enforce good laboratory procedure.

4.2. Dr. Hatzikiriakos – Room 316C

Only a small portion of this laboratory belonged to Dr. Hatzikiriakos and the primary research for this portion was polymer material characteristic research. Most of the chemicals found were experimental samples and waste was not generated in this portion of Lab 316C.

4.3. Dr. Englezos – Room 316C

The other portion of Lab 316C was occupied by Dr. Englezos' researchers. This hydrating laboratory used very few chemicals (mostly compressed gas), and the only waste generated (mostly small amounts of carbon dioxide) was directly vented to the environment. As such, this portion of Lab 316C contained no hazardous waste.

5.0 Hazardous Waste Management Policies

Good waste management practice needs a well-defined and comprehensive set of waste management policies. A good policy must satisfy all the legal requirements while remaining practical for the end user. To determine whether the policies practiced in the CHBE department were proper and effective, it was compared to the UBC safety and hazardous material management policy. A sample of the CHBE Safety Manual, the laboratory checklist and clearance form is shown in Appendix 10.5 - 10.7; the campus wide safety policy can be found on the university website < http://www.universitycounsel.ubc.ca/policies/policies.html>.

The CHBE safety policy was modeled after the campus safety policy; as a result, the two policies were very similar. The only omission in the general CHBE safety policy that was included in the campus guideline was the policies regarding disaster and biohazard management. The CHBE clearance form for retiring researchers also fulfilled the requirements under the university exit protocol.

Since the CHBE policies matched the campus wide policies and the CHBE safety policy required all researchers to read the Safety Manual and attend the safety orientation offered by HSE (or read the CHBE Safety Manual), the only cause for improper laboratory practice shown by unlabeled chemicals and accumulated waste was in the implementation of the waste management policies. While conversing with the CHBE office, it was revealed that PI's did not necessarily perform a thorough inspection of their laboratories before signing off their researcher's clearance form. When the department head, secretaries, and workshop managers signed off on the clearance form, they trusted the PIs to inspect their own laboratories, which in turn, resulted in chemicals that might not be properly stored or disposed. While it is understandable that the department head is busy and may not have time to personally inspect the leaving researcher's work area, it is inexcusable for the PI to not inspect their laboratory.

6.0 Conclusion

A chemical waste audit was conducted at the Chemical Engineering building. The waste audit procedure included: completing a preliminary walkthrough of the building to identify research laboratories, interviewing the principal investigators to understand the waste management practices in their laboratories, and inspecting the laboratories to verify the interview results. The walkthrough of the building identified six research laboratories, which were the focus of this report. The interviews and laboratory inspections identified weaknesses in the CHBE Safety Manual. The weaknesses result from the lack of a comprehensive waste disposal protocol and the lack of emphasis and encouragement by the PIs and researchers, on the importance of proper waste procedures.

7.0 Recommendations

Using the results from both the laboratory inspection and the interviews with Mr. Horace Lam and Dr. Madjid Mohseni, the following recommendations are made for improvements to the current waste management policy. These recommendations are made based on thorough inspection of only two laboratories; as such, it may not be reflective of the trend practiced by the entire Chemical Engineering department.

1) **Colour identification system for fast distinction of different chemicals**

   While all long-term storage chemicals should be properly labelled as defined by BC Occupational Health and Safety Regulations, some temporary chemicals can be categorized by this system for the convenience of the researcher. This colour system is practised in other departments with varying success. The colour dot system uses a green dot that may represent non-toxic chemicals to humans that can be disposed easily either down the drain or in the garbage. The CHBE department should define their own strict definition for what can and cannot be classified as a "green dot" chemicals and the entire department should use the same weighting criteria to maintain consistency. A detailed definition of the green dot also be displayed along with the chemical inventory on the laboratory entrance.

2) **Inter-department chemical exchange program**

   Chemicals not in-use or not expected to be used in the near future should be properly disposed or recycled. An intradepartmental chemical exchange program, similar to the campus wide chemical exchange, could help the professors share unused or unwanted chemicals and reduce chemical accumulation. The identified unwanted chemical would stay in the professor's laboratory while he/she posted the chemical on the departmental chemical exchange website. Other professors could visit the department website before buying new chemicals. The purpose of this program would be to help the professors realize they have unwanted chemicals and to breakdown the mentality of keeping all their chemicals because they "might" use it in the future. This program is not meant to replace the existing UBC chemical exchange program; rather, it is to compliment it. If the

chemical on the department website is not claimed in one year, the professor should then donate the chemical to the UBC chemical exchange program.

3) **Allocate a specific area in the laboratory to waste and/or recyclable chemical**

In a working laboratory with researchers performing various experiments, waste might be hidden among the useful chemicals in cabinets and on shelf spaces. To easily distinguish between various substances, a section in the laboratory should be designated to store waste and recyclable chemicals before they are disposed. This recommendation would help researchers organize the room and ensure wastes are not buried or scattered throughout the laboratory.

4) **Make a central hazardous laboratory waste disposal manual.**

Similar to requiring the researchers to read the CHBE Safety Manual, the department should make an in-depth hazardous disposal waste manual and require new researchers to read it as well. The departmental waste disposal manual would be very similar, if not the same, as the waste disposal manual provided by HSE. This would hopefully re-enforce the seriousness of proper waste disposal taught in the HSE orientation and convey the department's definitive attitude towards this subject. A written quiz might also be necessary to verify researchers' understanding of the waste disposal manual.

5) **Greater cooperation between CHML Safety Committee and PIs**

Both the PI and a safety committee chair must signoff on the clearance form for departing researchers. The significance of the PI's signature is to inform the department that the researcher had cleaned out their work area while the significance of the safety committee's signature is to reassure that this is the case.

However, it is suspected that most PIs currently do not make a detailed inspection of their laboratory before signing the form, and the safety committee member trust the PIs to do their job. As such, wastes are left behind and the clearance form becomes meaningless.

To rectify this situation, both the PI and the safety committee member should inspect the laboratory together. By working together, the inspection will take less time and both members will be assured chemicals and wastes are handled properly.

6) Incentives for researchers to follow proper waste management

Researchers may not be aware of the importance in following the procedures for disposing hazardous wastes. Most of the researchers may find the policies to be too complicated and cumbersome to follow. At the same time, they are not pressured enough by their PI to follow the procedures closely; thus, proper waste disposal procedures are not followed. To stress the importance of waste management, motivation should be given to the PI to ensure that their researchers are following the correct procedures, for example, if there are unknown chemicals, the PI may pay the department to identify these chemicals. Another incentive for PIs relates to benefits of a clean workspace and an uncluttered new building.

8.0 Future Work

The following lists three important tasks that should be considered for the continuation of this project:

1) **The audit of other sites occupied by the CHBE department**

   The CHBE department occupies approximately 8 different sites around campus. Most of these sites will be moving into the new building so it is essential that these other CHBE sites be audited. It would be important to determine how many unlabelled bottles and leftover chemicals are stored at the other sites so that it will not be transferred to the new building.

2) **Identifying researchers who are violating labeling procedures**

   During future audits of other CHBE sites, the auditor may take note of the number of unlabelled bottles in the laboratory. If these unlabelled bottles are the responsibility of the current researcher, the future report may identify this researcher and suggest a re-training.

3) **Evaluating the CHBE Safety Video**

   Currently, all researchers are required to partake in a safety training session offered three to four times a year, by the HSE. If a researcher joins CHBE between these training sessions, they are asked to watch a safety training video. This video should be evaluated and compared with the HSE training session. The evaluators should determine whether or not the safety training video could act as a substitution to the HSE training sessions.

9.0 References

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10.0 Appendices

10.1. Chemical and Waste Inventory Form

10.2. Interview Questionnaire

10.3. Principle Investigator Interview Results

10.4. Laboratory Inspection Results

10.5. Chemical Engineering Department Safety Manual

10.6. Chemical Engineering Department Laboratory Checklist

10.7. Chemical Engineering Department Clearance Form