Conducting a Waste Audit in the Second Year Introductory Biochemistry Laboratory at Dalhousie University to Determine Waste Diversion Strategies

---

Client: Dalhousie Student Union Sustainability Office (DSUSO)

Kelly Biagi: Department of Environmental Science
Angelica Ciurlia: Department of International Development Studies
Megan McCarthy: Department of Management
Mitchel Penwarden: Department of Marine Biology
Danielle St. Louis: Department of Environmental Science

ENVS/SUST 3502

April 13, 2011

Executive Summary

This report analyzed the amount of waste produced in the Introductory Biochemistry Laboratory 2610 at Dalhousie University to determine the portion of waste that could be diverted from the landfills and also what materials are currently improperly disposed of. The majority of the waste that is produced within the laboratory contributes to environmental issues such as water contamination, greenhouse gases and increasing landfill sites.

Waste audits were conducted four times at the Introductory Biochemistry Laboratory 2610. The quantity and weight of the preparation and student generated waste within the laboratory was determined based on the total of each material collected in the waste bins. Interviews were also conducted in order to gain further quantitative and qualitative data. Microsoft excel spreadsheets spreadsheets were used to construct graphs to compare the amount and variety of materials used in the laboratory, what materials would be best for waste diversion, and also the portion of waste that could be diverted from the landfills.

Results of the data show that the proportion of materials changed for each waste audit but the majority of the waste produced in each laboratory was discovered to go to the landfills. A small portion of the waste is reused and almost none is recycled.

Recommendations discussed include: a sustainable lab program, an effective recycling and refuse program, educating students on proper laboratory waste disposal, hiring student volunteers to clean re-usable materials, autoclave equipment and to ensure proper recycling/disposal of laboratory waste, re-usable apron program, broken glass recycling, and switch to environmentally preferable purchasing.

Incorporating these recommendations to this laboratory could reduce the amount of waste diverted to the landfills and increase the amount of reused and recycled materials.

Table of Contents

1.0 Introduction

1.1 Background

An ecological footprint is essentially a measure of the demands humans place on nature. The ecological footprint measures what we consume from nature for individuals, institutions, cities, nations, or humanity as a whole. It not only demonstrates how much biologically productive land and water we occupy to produce all the resources that we use, but also to absorb our waste (Wilson and Anielski, 2005). Remarkably, Canada currently has the ninth largest ecological footprint of 141 countries ranked globally (Nationmaster.com, 2011), which means that Canadians are consuming nature at a rate that is globally unsustainable. Ecological footprints for regions are based on the population density, average household size, consumerism, energy use and urban land use (Peel Data Centre, 2004). A high rate of consumption leads to large amounts of waste production and disposal. Therefore, a region, such as Canada, with a high rate of consumption will produce more waste, which is disposed of in landfills. In 2000, Canadians produced approximately 640 kilograms of waste per person per year, which is the fifth largest statistic globally (Nationmaster.com, 2011). With this large amount of waste being produced, the importance of waste diversion within regions becomes critical. Major adverse environmental effects associated with landfills include water contamination and atmospheric emissions (The Landfill Site, 2011). Halifax currently has the seventh largest ecological footprint of 20 ranked Canadian cities (Peel Data Centre, 2004). However, it is important to note that Dalhousie University is continuously moving towards becoming a leading university in providing students and faculty with a sustainable campus (Sustainability Office, 2010).

Sustainability, as defined in Dalhousie University's Sustainability plan, "is a pathway of continual improvement where actions protect and enhance human and natural resources needed by future generation to enjoy a quality of life equal or greater than our own" (Office of Sustainability, 2010). For the past twenty years, Dalhousie University has been actively involved with numerous sustainability issues. The university has agreed to and signed three international sustainable and environmental declarations, which include the Halifax Declaration, the Talloires Declaration, and the UNEP International Declaration on Cleaner Production. The president has also recently signed the University and College's Climate Change Statement of Canada, which aids the school in becoming more sustainable. Dalhousie University offers many courses, programs, research placements and publications based on environmental protection and sustainability. Over 100 faculty members at Dalhousie University both teach and perform research in an environmental or sustainable field. In 2008, a new program was developed at Dalhousie University, The College of Sustainability, which allows students to graduate with a degree focusing on the environment, sustainability and society while incorporating knowledge from many different faculties (Office of Sustainability, 2010).

According to the Office of Sustainability (2010) Dalhousie University has seven sustainable goals which include;

1) Values, knowledge, skills and social structures that support sustainability are endorsed 2) Support of organizational behaviours and physical systems that promote sustainability 3) Decrease natural resource energy and outputs 4) Increase renewable energy on campus 5) Enhance health and social attributes of the campus ecosystem 6) Increase sustainable transportation options and 7) Drawing people to Dalhousie University as a result of sustainable activity.

Some of these goals have already been achieved through initiatives at Dalhousie University such as the university's own Sustainability policy, its six-stream recycling program, encouraging reusable bags and also residence food services have been focusing on increasing the amount of local and fair-trade food served to students. The importance of our project in respect to the Greening the Campus movement is that it can ultimately help reduce Dalhousie University's overall ecological footprint. If this project reveals that Dalhousie University is producing a considerable amount of waste from the Biochemistry and Molecular Biology laboratory department, recommendations and solutions may be taken into consideration. This will not only aid Dalhousie University in reducing its ecological footprint, but also move the school towards a more sustainable direction and hopefully spark additional sustainable initiatives in laboratories. Furthermore, this project may also allow other departments to consider supplementary materials that can be used more efficiently and effectively in regards to increasing campus sustainability.

In past years, students have examined the waste disposal in the chemistry department at Dalhousie University; our project however gives the university the chance to see how much waste is generated in another laboratory setting other than chemistry (Daigle et al, 2007). Currently the specific section that will be focused on, Introductory Biochemistry Laboratory 2610, has approximately 111 students enrolled within the class.

1.2 Research Problem

This report will discuss the issues surrounding waste disposal in the Introductory Biochemistry Laboratory at Dalhousie University. The research will attempt to create solutions to minimize waste production and increase waste diversion. There are 111 students enrolled in this class and there are two laboratory sections for the class, each containing 55 and 56 students.

A waste audit was performed to determine quantity and weight of each waste material produced within the laboratory. Interviews with the laboratory instructor and the teaching assistant as well as a facilities management staff member were also conducted. The study will not only examine the amount of waste produced by a biochemistry laboratory, but will also look at what materials could be reused or recycled that are currently treated as garbage.

1.3 Research Question and Objectives

The research question that has been outlined for the project is: what portion of the second year Introductory Biochemistry Laboratory waste at Dalhousie University can be diverted from landfills and what portion of these laboratory materials are currently properly disposed of? Four objectives were identified and are listed below:

1. To determine which materials used within the laboratory are improperly disposed of.
2. To determine what materials found in the refuse are suitable for diversion into recyclable or reusable categories.
3. To determine what instructions are given to students in terms of waste disposal of laboratory materials before they begin their laboratory.
4. To find various solutions to will contribute to minimizing waste produced within the Introductory Biochemistry Laboratory class.

1.4 Research Importance

The majority of waste that is produced within the laboratory contributes to environmental issues such as water contamination and the expanding of landfill sites with materials such as plastic and glass. If harmful chemicals and toxins are improperly disposed of, these toxins may end up in water systems within the environment. A large portion of laboratory waste that is generated in undergraduate laboratories is made of plastic, or has associated plastic packaging. In

2006, Nova Scotia alone discarded approximately 71,407 tonnes of plastic. Only 13.8 percent of plastics generated in Nova Scotia are estimated to have been recovered in 2006; plus, all markets for recovered plastics are outside of Nova Scotia. Significant quantities of these plastics end up in landfills, and/or are processed elsewhere in Canada and the United States which all results in increased costs and negative environmental impacts such as emission of greenhouse gases (PHA Consulting Associates, 2008).

Some of the main environmental issues within landfills include emissions to the atmosphere and emissions to surrounding bodies of water from decomposing materials. Eventually, the earth will not be able to store the amount of waste humans are currently producing. Without reusing and recycling laboratory materials, the waste produced within these laboratories contributes to long-standing environmental problems as well as contributes to increasing Dalhousie University's ecological footprint (The Landfill Site, 2011). Dalhousie University strives to achieve their goal of reaching 75 percent of refuse diversion to recycling. Currently, Dalhousie University is at 50 percent waste diversion, with many sorting bins for recyclables, paper, organics, hazardous waste, chemicals and refuse located in various locations around campus (Facilities Management, 2011). Incorporating sustainable laboratory practices will help Dalhousie University achieve their diversion goals.

Optimistically, this project will discover materials that could be reused or recycled instead of throwing them away, therefore increasing waste diversion within the Biochemistry and Molecular Biology department. Therefore this project is important because it will help in reducing Dalhousie University's negative effect on the environment.

1.5 Relation of Project to the Greening the Campus Initiative

Waste disposal is one of the most important environmental issues occurring in the world today. With Dalhousie University's participation in this biochemistry waste project, they are showing their awareness about this issue as well as their willingness to reduce their overall impact on the environment. Through proper waste management and waste diversion, Dalhousie University's Biochemistry and Molecular Biology Department could greatly reduce the amount of waste they produce and send to landfills, thus reducing their ecological footprint. Not only can laboratories produce large amount of waste, but they also produce a large variety of waste such as plastics, glass, hazardous materials as well as paper towel, which all have devastating effects on the environment if they are improperly disposed of. It is crucial for waste diversion and proper sorting of waste to be implemented within laboratories to ensure that all these varieties of materials get disposed of properly to ensure there will be minimal effects on the environment (Labnews, n.d.). Proper waste management and diversion of materials produced within the laboratory would not only reduce the Biochemistry and Molecular Biology Department's ecological footprint, but would also contribute to Dalhousie University's overall reduction of their ecological footprint.

1.6 Literature Review

Nine past studies have been taken into consideration and analyzed in comparison to the current project relating to an increase of waste diversion within the second year biochemistry laboratory (BIOC2610). Comparisons to existing research within the area of biological waste within laboratories will aid the project with defining objectives, methods and discussions. After extensive research, it is clear that there have been few studies conducted within the subject area.

The majority of studies found relating to the current project were done by other universities trying to increase sustainability within their laboratories. These universities include:

the University of Waterloo, Yale University, McGill University, Shandong University and the University of Melbourne. A group of students at the University of Waterloo analyzed the waste management system within one of the campus buildings and concluded with suggestions to better the system. The group performed surveys on the staff that worked within the building, conducted audits of the waste and held interviews for selected staff members. They discovered that there was cross contamination of recyclable s, inconsistent labeling, location and emptying of the waste bins. The group of students also discovered that 80 percent of the waste in the refuse bins was recyclable (Lockwood et al, 2004). Yale University developed a "Green Laboratory Certification Program" for all laboratories within the University. The goals of this are to create awareness about proper waste disposal and the lower the university's ecological footprint. There are four levels within this program (Y-A-L-E), and each group must gain points by being green within their laboratory and successfully adopting sustainable laboratory practices which allows the group to pass each of the levels. Once a group has successfully achieved all four levels, they are awarded with a certificate. However, this certificate needs to be renewed every year to ensure proper laboratory practices (Yale Environment Health and Safety, n.d.). A "Laboratory Waste Reduction Program" was started at McGill University by a group of students who were concerned about the amount of waste being produced in the biochemistry and immunology and microbiology research laboratories. The students developed this project in order to minimize the university's ecological footprint and to promote more sustainable ways to conduct research within a laboratory. The program conducted numerous surveys within various research laboratories to determine their how they were conducting their research in terms of sustainability and if laboratories would be willing to adopt sustainable practices. They have also posted a website which lists their objectives, suggestions as well as a list of provider companies who offer

eco-friendly materials for purchase or who will recycle old laboratory materials (Laboratory Waste Reduction McGill, n.d). Shandong University conducted a study within their laboratories because they believe that the increased amount of laboratory waste causes risk to the environment and human health. They included a number of suggestions in order to help reduce waste within the laboratory: avoid over production of preparation materials by calculated the exact amount depending on number of students within the laboratory, replace certain student experiments with professor demonstrations to reduce the use of highly toxic chemicals, decrease the use of animals and animal materials, introduce environmental protection education and evaluate student's waste reduction as part of their grade (Zheng et al, n.d). Lastly, the University of Melbourne has a "Sustainable Laboratory" program which provides laboratories across campus to reduce their environmental impact. This program provides a checklist for each laboratory which they are encouraged to follow as well as a list of Laboratory Awareness Principles which goes through various aspects within a laboratory and how a particular laboratory can adopt more sustainable practices (University of Melbourne, 2011).

Other studies were found that were performed by non-university groups such as the Indian Journal of Medical Microbiology, Statistics Canada, NEMS and Canadian Council of Ministers of the Environment. The Indian Journal of Medical Microbiology found that medical laboratories like the Introductory Biochemistry laboratory produce a significant amount of refuse. They discovered that much of the waste was being cleaned before being recycled or being shredded before being recycled. The researchers suggested that more hazardous materials be autoclaved in order for the materials to be safe for recycling (Chitnis et al, 2005). Statistics Canada looked at waste and management among various industries. They looked at waste from local and provincial companies. They analyzed many aspect of waste management such as total

waste, disposal, rate of disposal, sources of waste for disposal, diversion, waste management industry financial characteristics and employment for local government and business sectors. They also had a large statistical table sections where they display the topics mentioned above in various tables and figures. One statistic that stood out within the paper was that each person in Canada was responsible for 1031 kilograms of waste in 2008 (Statistics Canada, 2008). NEMS, which is a sustainable laboratory practice-working group studied and explained how to green general laboratory practices. The study provides guidance, management, tools and new opportunities to be green within the laboratory for research groups. The study also covers laboratory issues such as decreasing the overall amount of waste produced, how to minimize the use of toxic materials and how to lower the energy used within a laboratory (NEMS, 2010). Lastly, the Canadian Council of Ministers of the Environment (CCME) suggests that a laboratory purchase materials with the "EcoLogo" symbol on them because it helps consumers identify materials that are energy efficient, recyclable , made for recyclable materials and minimize the use of hazardous materials (Canadian Council of Ministers of the Environment, 1992).

1.7 Report Outline

This report will describe the methods used in order to answer the research question addressed and achieve the research objectives. These methods are described in full detail and are justified as to why these methods were most appropriate for reaching the project's goals. The results of the data collected are clearly displayed in a series of tables, charts and graphs to fully display and explain the data collected throughout the duration of the project. The discussion portion of the report explains and discusses the significance of the results and their relation to the research question and objectives, a comparison of the project's finding to existing reports and research as well as the implications for theory and practice. Finally, solutions are suggested to

improve the Introductory to Biochemistry Laboratory class's contribution to Dalhousie University's sustainability as well as recommendations for further research on the subject area.

2.0 Research Methods

2.1 Study Design

As nothing was known prior to the audit regarding the contents of the waste bins, or waste habits of individuals in the Introductory to Biochemistry laboratory an inductive approach was required to go from observation to theory to determine what portion of materials used during the laboratory could be diverted from the landfill, and also what materials were being disposed of properly (Palys and Atchinson, 2008). Data collection involved direct measurement, interviews and document analysis. A quantitative approach was used to collect data on the contents of the waste bins through a waste audit, and also through an interview with the Introductory to Biochemistry laboratory coordinator and teaching assistant. While a qualitative approach was used to gather information on what factors play a role in laboratory decisions for both students and instructors and also the feasibility laboratory solutions through an interview with the Waste Management Projects Officer for the Sustainability Office and also the laboratory coordinator and teaching assistant. An ethics proposal was approved to ensure the confidentiality and safety of the individuals involved in the interview (Appendix A).

2.2 Interviews

Purpose

The laboratory coordinator, teaching assistant and the waste management project officer were chosen to be interviewed because each individual had specific information that contributed

to our study on the Introductory Biochemistry Laboratory (BIOC 2610). The interviews with the laboratory personnel were helpful first in determining what waste disposal procedures is given to students at the beginning of each laboratory. This was essential in order to address the final objective of our research project, and to assess whether further instruction can be given to students in order to increase the diversion rate. Furthermore, the laboratory personnel provided information on what companies the materials are ordered from, which factors contribute to purchasing materials, what wastes are associated with packaging, and also what solutions would be feasible for the Introductory Biochemistry laboratory. This was important in answering the research question as it provided the group with which environmental impacts were associated with each material.

The interview with the waste management project officer provided information on solutions to improve waste diversion in the Introductory to Biochemistry laboratory. Furthermore, information was gathered on materials that were found in the garbage but did not have a description of what type of material they were made of. This information helped to determine what materials are available for diversion, and also what solutions are available for the Introductory to Biochemistry laboratory.

Justification of Instrument

The biggest disadvantages of completing face-to-face interviews are their cost and the time required from researchers (Palys et al., 2008 and Olsen et al., n.d.). However, for gathering data from three interviewees, there are several reasons why conducting semi-structured, open-ended, face-to-face interviews were appropriate and worthwhile. The information that the researchers were seeking from the experts were not single response questions that could be

fulfilled through a questionnaire or survey. If respondents gave a verbally stingy answer, researchers could encourage a more elaborate and detailed response in order to achieve a desired response. Additionally, interviews, as opposed to surveys or questionnaires, have a much greater success rate in the number of questions respondents will answer. In a questionnaire, it is easy for a participant to skip a question either accidentally or purposefully. However, in a face-to-face interview, the interviewer can ensure that the questions are in fact answered. Moreover, the ability to hear from respondents directly is helpful in that the interviewer is able to hear the explanations for the respondent's viewpoints, and allows the interviewee to expand on his/her thoughts. There is also great versatility in interviews in terms of their structure. An interviewee may open up new questions that the interviewer had not thought of, or may give the researcher more information than they were expecting. Respondents may be more willing to share information with a person face-to-face rather than a piece of paper, as is the case in a questionnaire (Palys et al., 2008 and Olsen et al., n.d.). Lastly, face-to-face interviews ensure that the information gathered has increased reliability and validity because the researcher can monitor whether the questions are being taken seriously by facial expressions, ensure that all questions are being answered, and also they are able to clarify any misunderstandings (Palys et al., 2008 and Olsen et al., n.d.).

Procedure

The laboratory coordinator agreed to participate in an interview with the researchers with initial contact at the beginning of the study. One researcher emailed the laboratory coordinator one week in advance to schedule the interview. The face-to-face interview with the laboratory coordinator and teaching assistant took place on the eighth floor of the Tupper Building,

Carleton Campus, Dalhousie University, on Friday, March 25th at 10:00 am. The interview was conducted in the laboratory coordinators office in order to provide a safe, comfortable, and private atmosphere. Two researchers attended the interview which allowed for one researcher to ask questions, while the other wrote down the major points, and also summarized the response from the interviewees.

The interview with the Projects Manager took place in the Central Services Building on Monday, March 21st in the interviewee's office. One researcher attended the interview in order to ask straightforward questions to the Project Manager. The researcher recorded the main points of the answers for later analysis. See Appendix B for interview questions.

Analysis

All questions were open ended, and therefore, coding was conducted after the data was collected. The analysis of the results included looking for key themes and patterns in subject responses to the questions such as key words, and the overall main ideas that were presented in the interview. Information that was not intentionally sought was also recorded due to its usefulness in providing recommendations for the research team.

2.3 Waste Audit

Purpose

The waste audit provided the researchers with highly accurate measurements of the quantity and weight of each material used in the laboratory. The data gathered from conducting a waste audit was essential to determining the portion of materials from the Introductory to

Biochemistry laboratory that are available for diversion from the landfill, and also what portions of materials are improperly disposed of.

Justification of Instrument

A waste audit is a traditional method of assessing waste generation and it is considered an important first step towards a comprehensive waste reduction program for any organization, institution, or business. According to the Resource Recovery Fund Board (RRFB), the goal of a waste audit is to produce fairly accurate estimates of the amount of materials available for source reduction, reuse and recycling (2010). A waste audit helped the researchers determine how many materials, in terms of weight and quantity, the Introductory to Biochemistry laboratory is sending to the landfill and also where reduction and recycling efforts will have the greatest impact.

Procedure

Waste audits were conducted on two laboratories titled "Electrophoresis of Amino Acids" and "Effects of Anions on Amylase Activity" which were held during the first two weeks of March. A list of expected materials and quantities was provided by the teaching assistant in advance, which allowed researchers to create an accountability chart to record data collected in the laboratory (Appendix D). In order to achieve a full representation of the waste generated in each laboratory by the students, waste audits were conducted on both days that the laboratory was held (Monday and Wednesday). The audits were conducted on the 7th, 9th, 14th, and 16th of March, 2011 on the 8th floor of the Tupper Building on Carleton Campus. Two group members were assigned to arrive at the laboratory at 2:00 pm before the students arrived to ensure all preparatory materials were placed in the waste bins to be included in the audit. At 5:30 pm all group members arrived at the laboratory to participate in the waste audit. The audits were carried

out in an open area of the laboratory, which allowed researchers access to all reused materials that needed to remain on the laboratory benches. Group members wore appropriate attire such as old clothing, and gloves, to ensure safe handling of the waste. Each member was assigned a task such as collecting, sorting, counting, and weighing in order to conduct the audits efficiently and effectively. First, the waste generated from the teaching assistant to prepare the laboratory was collected during each waste audit, and then sorted on a garbage bag taped to the floor. Each material was separated and the quantity and weight of each material was recorded using the accountability chart. If materials were present that were not expected, they were recorded in the extra rows and columns previously created. Due to the large weight of the gloves, and glass test tubes, they were weighed using a mechanical column scale while all other materials were weighed using a Mettler P3: 3000 g capacity. The same procedure followed for bins collected in the student laboratory area, however, the researchers emptied approximately five garbage bins at a time to sort through to ensure no materials were misplaced. Photographs were also taken of various materials, and their associated packaging, which helped to provide information such as the manufacturer. Plastic waste that did not have a resin identification code was collected, and kept in a bag in order to confirm with experts and document analysis, which polymer they composed of.

Analysis

All data recorded in the accountability charts was placed into Microsoft Excel spreadsheets for further analysis. The spreadsheets were used to construct graphs for visual representation of the amount and variety of materials used in the laboratory, what materials would be best for waste diversion, and also the portion of waste that can be diverted following

the recommendations devised from interviews, and document analysis. Histograms were conducted to demonstrate the frequency of each material found in the four waste audits of the laboratory. In addition, pie charts were created to visually show the quantity and weight of each material in proportion to others which highlighted areas that needed improvement.

2.4 Document Analysis

Purpose

Document analysis was undertaken in order to verify the type of polymer the plastic waste was composed of, what packaging was associated with the materials, and ultimately what alternatives are available for current materials used such as durable, non-disposable, recyclable , and/or reusable items and also cleaning options. In order to assess what portion of laboratory materials can be diverted from the landfill, and also what portion were improperly disposed of – the researchers needed to confirm what each material composed of, and if it was possible to be diverted from the landfill.

Justification of Instrument

Collection of documents is less expensive than many other research methods and can be easier to obtain in some circumstances due to wide availability from the Internet as well as electronic library databases. Furthermore, documents may contain information that experts in their own field have collected through their own research methods. Such experts may not be available for interviews; however, a literature review of their work may be extremely beneficial.

Procedure and Analysis

The analyzed documents came from a variety of sources which included company and manufacturing websites, universities, and organizations. The analysis of these documents gave valuable information on the types of polymers used in laboratory plastics (e.g. polystyrene, polypropylene, and polyethylene) and whether these materials can be recycled, reused, or replaced by a more sustainable alternative within the Halifax Regional Municipality (HRM) and Dalhousie University. Review of documents also allowed a clarification of the environmental concerns related to the amount of waste generation from common laboratory materials such as pipettes, clear tips, test tubes, and gloves.

2.5 Limitations and Delimitations

Limitations in the research or study are factors that the researcher has no control over, while delimitations are measures that a research would intentionally impose on your project or study (Palys et al., 2008 and University of Lethbridge, n.d.). The first limitation of the study is time. In order to fully determine the portion of waste that can be diverted in the Introductory Biochemistry laboratory, waste audits would have to be conducted throughout one semester. As students with a heavy course load, and one month to collect and analyze the results, the study was limited to conducting four waste audits over two weeks which represented 50% of the laboratories conducted during the month of March. In addition, the original study design included an interview with a Facilities Management specialist in order to triangulate the objectives. Unfortunately, due to no response from the individual, the researchers were unable to conduct the interview. Another limitation included, is the way that the laboratory personnel were interviewed. The original study design involved interviewing only the laboratory coordinator however; the teaching assistant was also present due to unforeseen circumstances. It would have

been beneficial to have interviewed each individual separately which would have ensured that both of the instructors were able to properly represent themselves. In spite of the limitations, the data gathered is a first step towards understanding the potential for waste diversion in the Biochemistry and Molecular Biology department at Dalhousie University.

With respect to the goals of the study, several delimitations were deliberately placed on the study design. First, it would have been beneficial to collect data from multiple biology laboratories at an undergraduate level; however, the research study was limited to the Introductory Biochemistry Laboratory due to time restraints for collecting and analyzing data and also willingness from other laboratories. Consequently, it was decided that it would be best to begin in the introductory laboratories where students are introduced to disposal practices that they will carry with them for the rest of their academic career. Second, an analysis of chemical disposal was not included in the waste audits that were conducted. Chemical waste was not addressed because the group is not adequately trained in this subject, and it also posed an unreasonable risk to the researcher. However, it is recommended that further study into disposal of chemical waste in undergraduate laboratories is carried out.

2.6 Reliability and Validity

Reliability can often be referred to “consistency”, as it describes that the same phenomenon occurs over time or that the same judgment occurs from different observers (Palys and Atchinson, 2008). The study strived to ensure reliability of the research project by providing descriptive steps of the research methods such as how the interviews, waste audits, and document analysis was conducted, who were the participants, and how the data was analyzed. As a result, future research groups can replicate the study. Reliability was also ensured while the researchers

weighed the materials in the laboratory, since the same scale was used for the materials each laboratory. However, reliability and validity could have been compromised since two researchers' alternated turns for weighing the materials.

Although waste audits were conducted on the same laboratory twice, there was a large difference in the quantity of materials use. The consistency of the quantity of materials gathered in largely dependent upon the number and behaviour of students. The materials provided for students also plays a large role on presence of materials, for example, students were given individually wrapped 5 ml serological pipettes on Wednesday's laboratory which generated more plastic waste than pipettes that came in bulk (used on Monday). The validity of the data analysis was ensured through re-recording the data collected on the accountability charts in excel spreadsheets by two researchers to ensure that the data was reliable and valid.

Furthermore, the reliability of conducting the interview with the laboratory personnel may have been compromised because they were conducted simultaneously. Coupling individuals for face-to-face interviews may give different results, than separate interviews, because one of the interviewees may dominate the conversation, while potentially valuable information from the other may not be covered.

3.0 Results

The following are the results of the waste audit that was conducted on four separate laboratories occurring over a two-week period during the winter semester of 2011. The graphs depict the materials found in the audit both in terms of count and weight in order to obtain a more complete picture of the true amount of waste being produced with our data. The laboratories from week one entitled "Electrophoresis of Amino Acids", both dealt with the same

materials. The comparative data of the expected waste is therefore the same for both of these laboratories. The same is true of week two's laboratories that are both entitled "Effect of Anions on Amylase Activity". It should be noted, however, that while the laboratories in each week were identical in nature, the waste produced in quantity was quite different.

Week One Waste Audits: "Electrophoresis of Amino Acids" – March 7 and 9

Prior to the start of the waste audits, the laboratory teaching assistant provided a list of expected waste for each laboratory which provided data to compare actual findings against. Figure 1 depicts the combination of both the waste produced during the actual laboratory and the waste produced preparing the laboratory for the students by the teaching assistant on March 7, 2011:

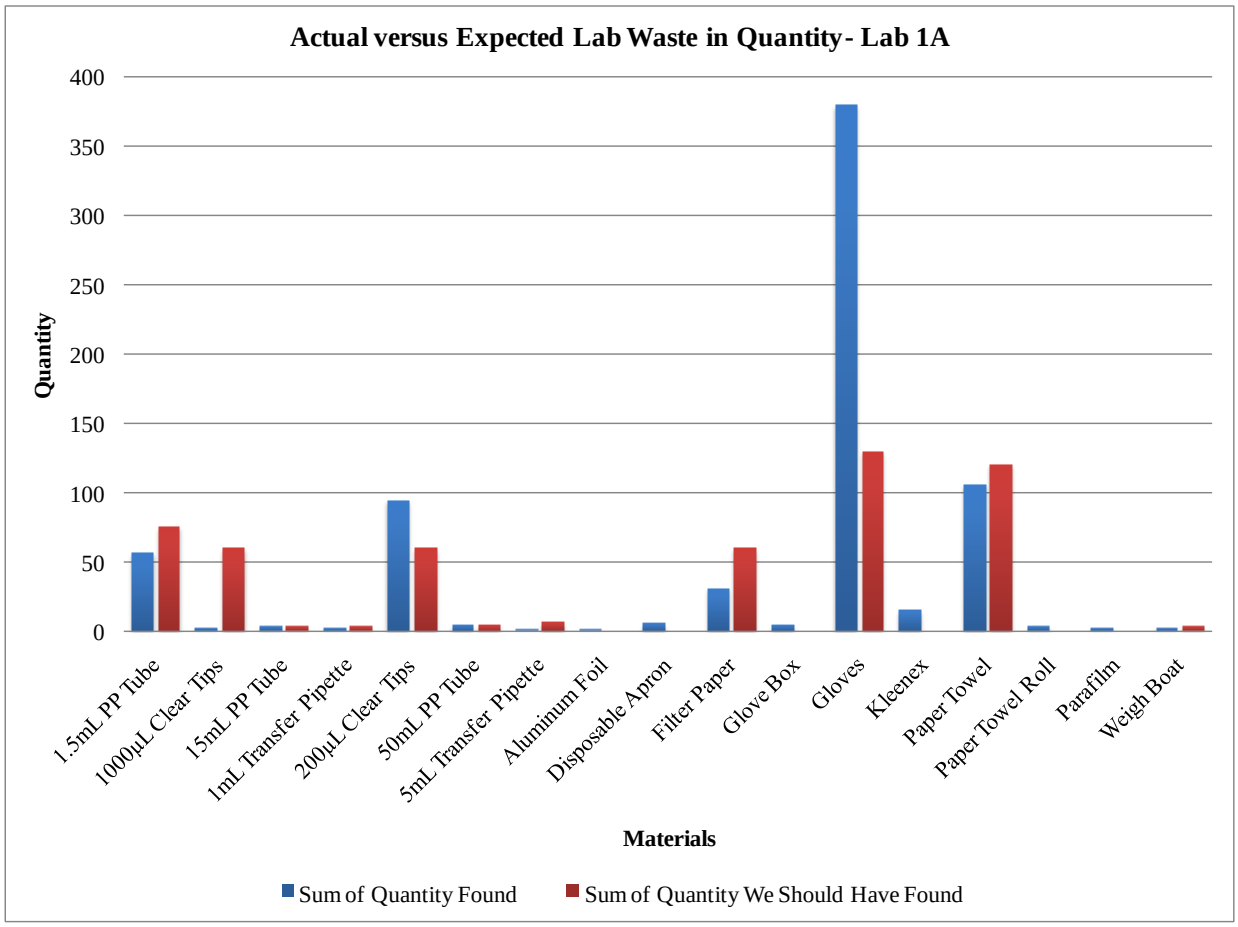


Figure 1. Actual waste versus expected waste from the first laboratory from Monday's group (1A). Quantity of actual and expected waste is plotted against the waste materials found.

It is important to note that the above graph is in quantity of expected waste versus actual waste. This graph shows that the majority of the waste that was produced was latex gloves, whose numbers exceeded the teaching assistant's predicted count. When conducting interviews with the laboratory personnel, they stated that the reasoning for this is safety. Students must feel that they have access to rubber gloves to protect themselves if they feel they need them. Rationing out gloves, to reduce waste produced, could potentially lead to accidents, or exposure to hazardous materials (personal communication, March 25, 2011). The graph shows that 200µL

Clear Tips were also hard to estimate as students used more of these than predicted. Again, there is an issue trying to limit these, due to contamination issues that could alter student's results.

The pie charts below (Figure 2 and Figure 3) further elaborate on the waste found during our audit on March 7, 2011:

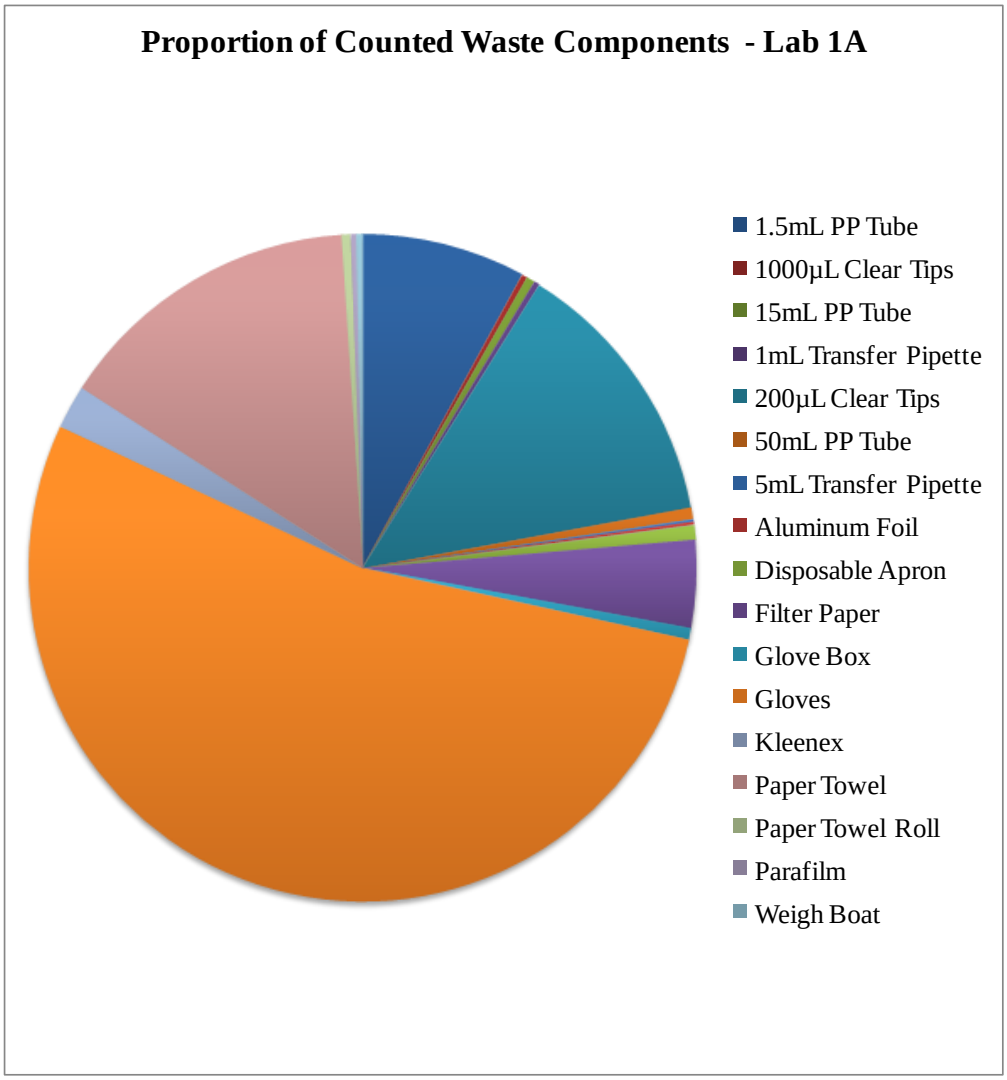


Figure 2. Proportion of quantity of materials found in the waste from the first laboratory from Monday's group (1A).

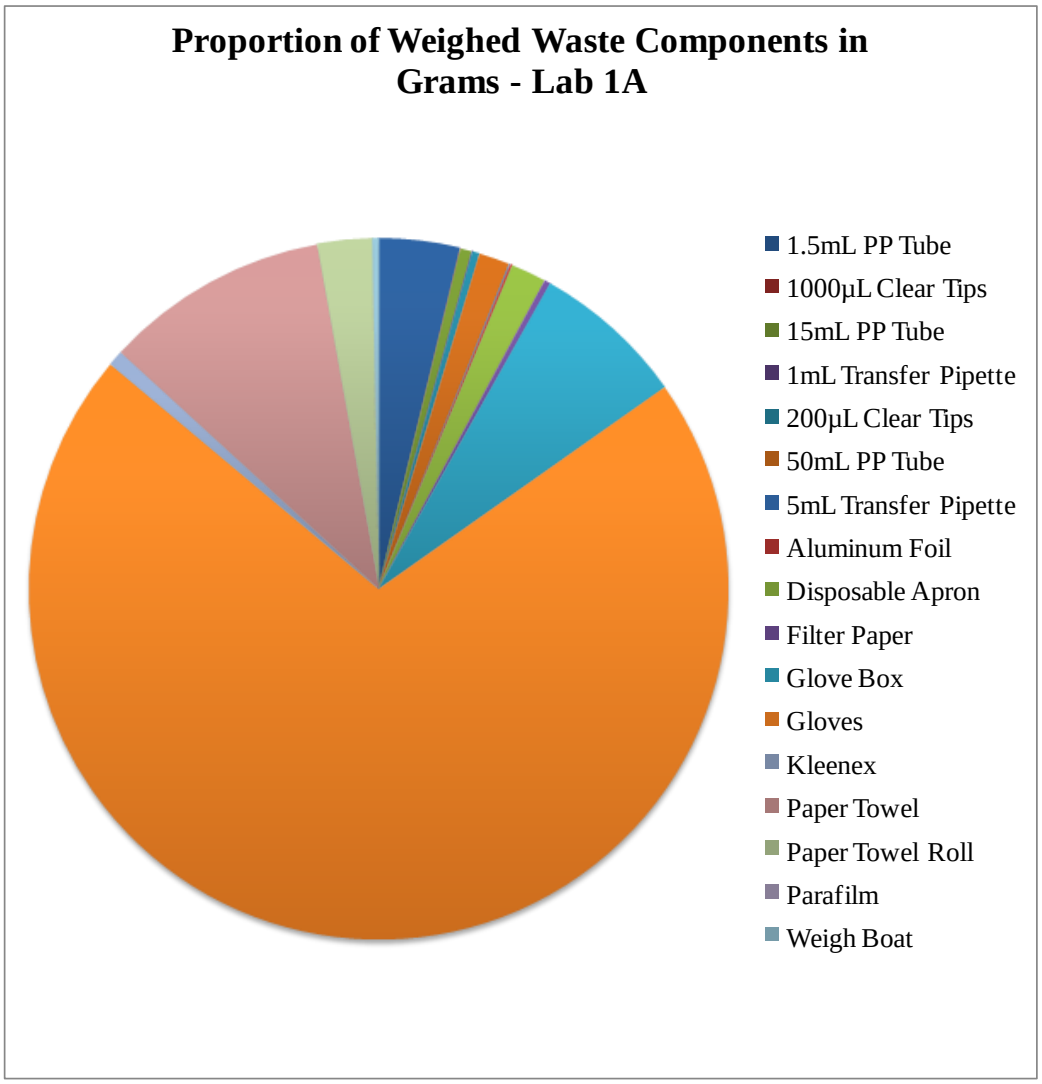


Figure 3. Proportion of wasted weighed in grams from the first laboratory from Monday's group (1B).

In Figures 2 and 3, it is important to note the difference between the weight proportions from the count proportions. It was decided to both weight and count all of the waste materials because it would be more of an accurate representation of what was being found. For example refer to Figures 5 and 6 with glass tubes vs. Parafilm; even if these materials had similar quantities, their weight is significantly different. The pie charts also display that there is a

significant amount of waste from paper towels as well. When speaking with the laboratory personnel, it was determined that the majority substances on the paper towels are harmless to humans, however the paper towel is classified as contaminated because it is generated with a laboratory and is therefore needs to be disposed of in the waste bin (personal communication, March 25, 2011). It was suggested that paper towel be recycled at the discretion of the laboratory instructor, however, this is not within Dalhousie University's policy for waste management (Dalhousie University, 2009).

As for the other main contributor to the waste, the pipette tips, it was discovered that Corning pipette tips are made of polypropylene #5 plastic, which is not recyclable in Halifax, but found to be autoclavable up to 275°F or 135°C and can withstand several cycles through the autoclave machine (Corning, 2011). This has therefore been added to the recommendations as a suggestion to decrease waste produced in this laboratory. For further information on plastics found in the waste audit, their properties and ability to be autoclaved, refer to Appendix E.

Figure 4 depicts the combination of both the expected waste and actual waste produced during the laboratory and in preparation of the laboratory by the teaching assistant on March 9, 2011:

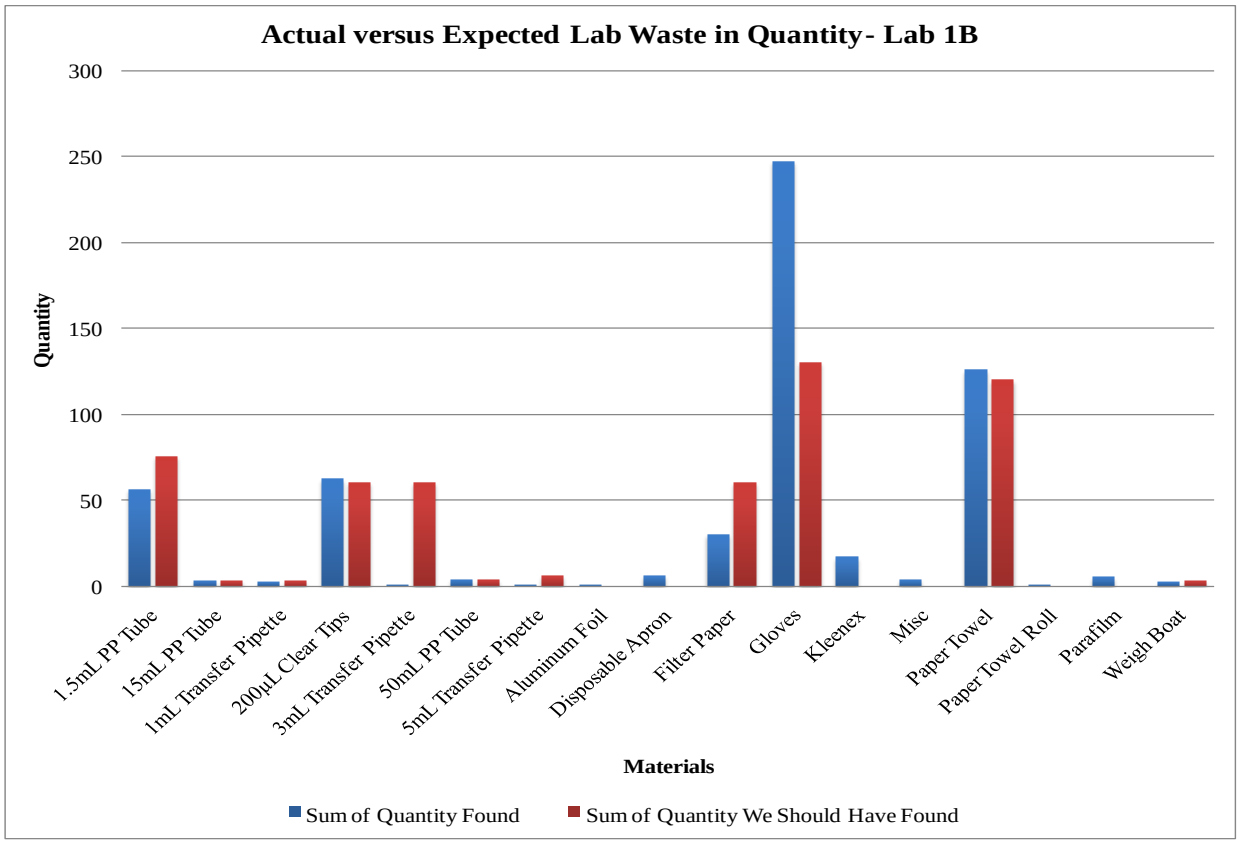


Figure 4. Actual waste versus expected waste from the first laboratory from Wednesday's group. Quantity of actual and expected waste is plotted against the waste materials found.

Again, there are similar trends to what was observed on March 7, 2011. The gloves again produced the most waste, followed by paper towels, 200µL pipette tips and finally 1.5mL PP tubes. Since the observations are similar between the two laboratories, similar recommendations are suggested. The glass tubes are placed in a labelled box to be collected by Facilities Management and are thought to be brought to a recycling depot. However, through the interviews it has been determined that the glass is most likely sent to a landfill and not recycled. **Facilities Management** implied that the majority of glass produced at Dalhousie University is sent to a landfill, therefore it can be assumed that the glass produced within this laboratory is sent

to a landfill as well (personal communication, March 21 and 25, 2011). This will be elaborated on more in our recommendations section.

Below are Figures 5 and 6 that explore the waste found after the laboratory conducted on March 9, 2011:

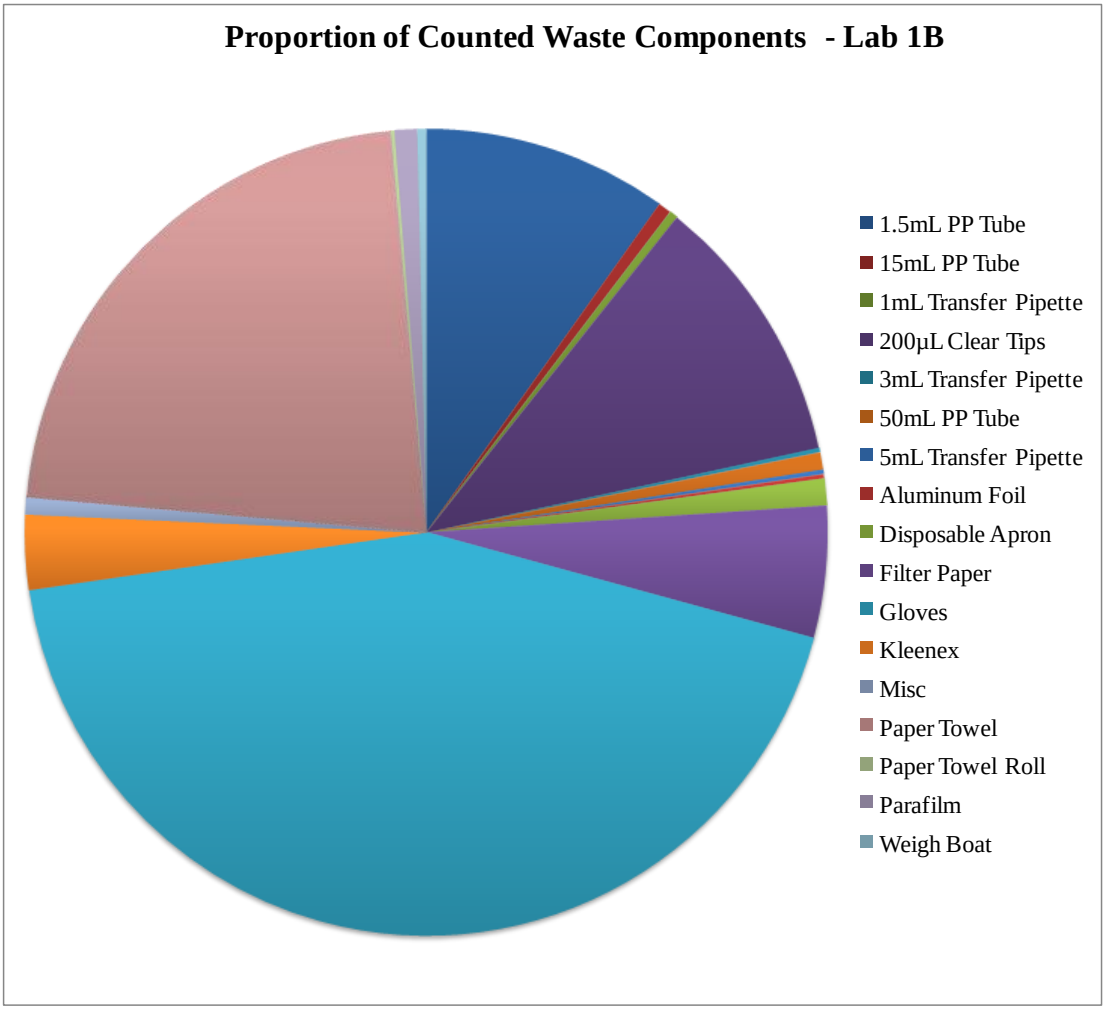


Figure 5. Proportion of quantity of materials found in the waste from the first laboratory from Wednesday's group (1B).

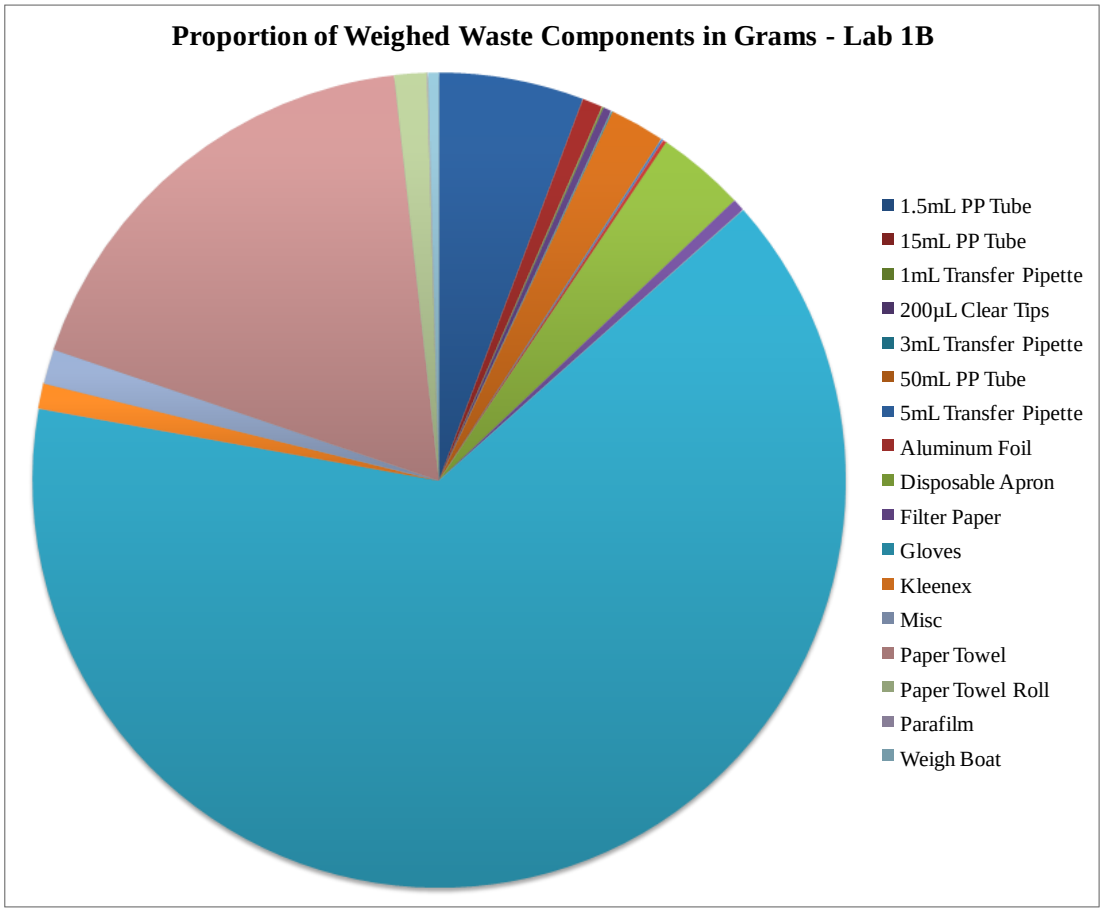


Figure 6. Proportion of wasted weighed in grams from the first laboratory from Wednesday's group (1B).

The pie charts show variations in the proportions of waste produced from Wednesday is similar to Monday, therefore the results are similar enough to suggest the same recommendations applicable. Again, these will be further elaborated on later in this report within the recommendations section. A lot of the waste found was not listed on the expected waste list provided by the teaching assistant. Waste that was also put on the expected waste list was not found in the garbage collected. This displays that predicting quantities and type of waste that will be produced is difficult. Due to prediction uncertainties, certain approximations were made for

example filter paper was mentioned on the expected waste list, however none was found in the waste collection. The laboratory coordinator stated that the students used 30 sheets of filter paper and took them home with them for their data analysis.

Week Two Waste Audits: "Effect of Anions on Amylase Activity" – March 14 and 16

The second set of laboratories produced different waste from week one because it involved different procedures for the students to carry out. This provided a broader scope = of the types of waste produced in the Introductory Biochemistry Laboratory class. As shown in Figure 7, the laboratory from week two produced significantly more waste than week one:

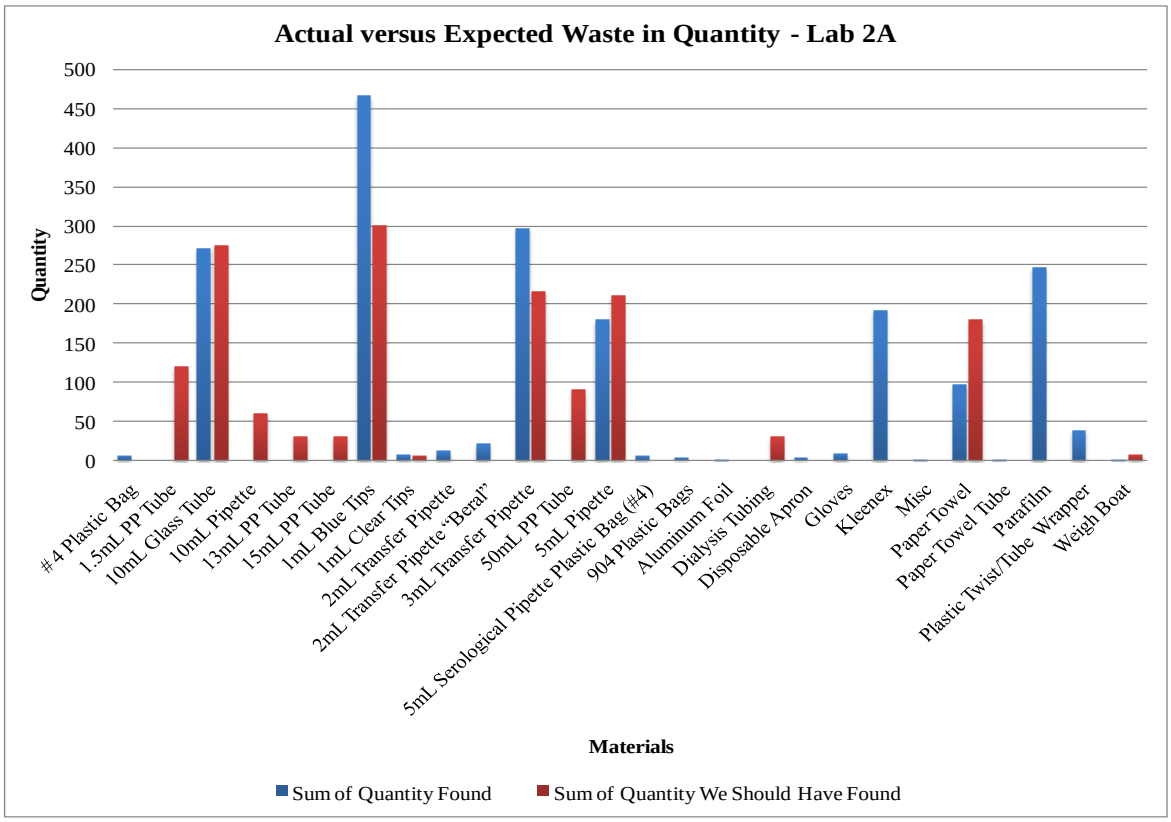


Figure 7. Actual waste versus expected waste from the second laboratory from Monday's group (2A). Quantity of actual and expected waste is plotted against the waste materials found.

Similar to the laboratories completed in week one, there were certain waste components that the majority of the garbage contained. The 1mL Blue Tips had the largest quantity and exceeded the laboratory teaching assistant's predictions of their expected waste. During the interview with the laboratory personnel, it was noted that disposal of the 1mL Blue Tips was one of the few instructions given to students in terms of waste disposal (personal communication, March 25, 2011). Other materials found to have large quantities of waste were 100mL glass tubes, 3mL transfer pipettes, 5mL pipettes, Kleenex and Parafilm. Three of these five listed materials exceeded the laboratory teaching assistant's predicted quantities and the Kleenex and Parafilm were not expected to produce as much waste as they did.

Figures 8 and 9 displays the proportions of these waste components since in quantity and weight:

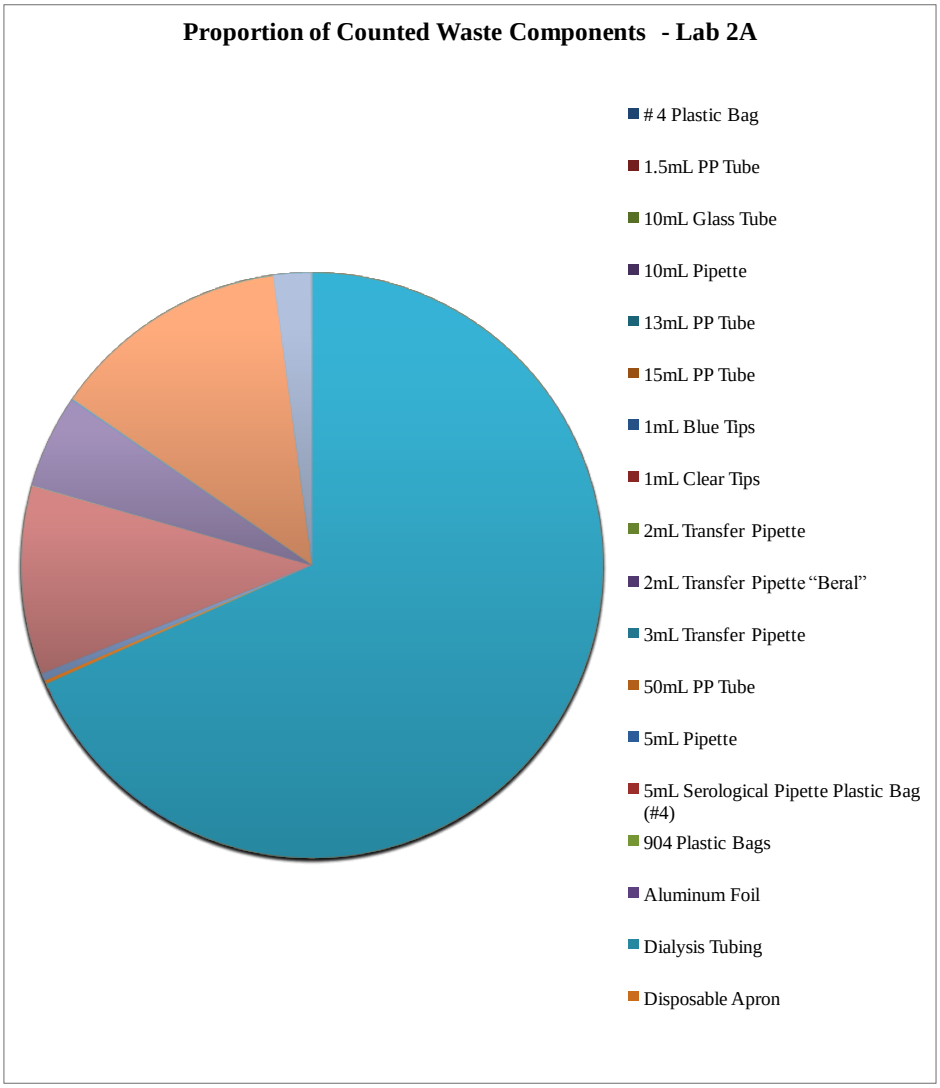


Figure 8. Proportion of quantity of materials found in the waste from the second laboratory from Monday's group (2A).

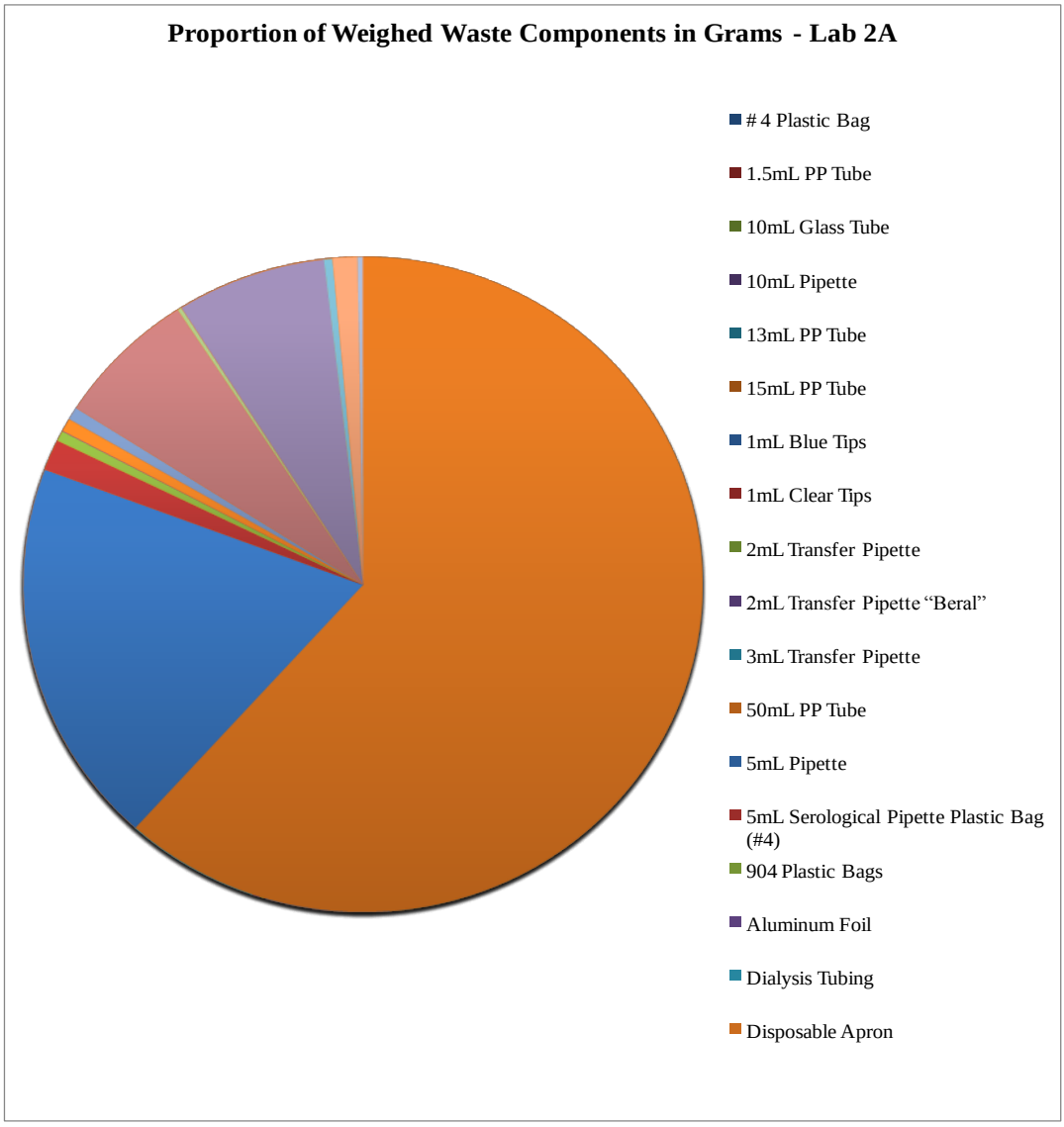


Figure 9. Proportion of weighted laboratory waste components in grams from the second laboratory from Monday's group (2A).

When analyzing Figures 8 and 9, the difference between quantity and weight can easily be seen. While the graph depicting quantity portrays that the waste is relatively evenly distributed, the graph depicting weight shows that 10mL glass tubes make up roughly half of the waste. As previously mentioned, the interviews discovered that this glass could be recycled, it is

most likely not (personal communication, March 11 and 25). Other items that could potentially be diverted from the landfill are 3mL and 5mL pipettes, also constituting largely to the waste. Through research a reusable product called Eco-pipette was discovered which could potentially replace the plastic pipettes. This is further explained in the recommendations section. Kleenex and paper towels weighed more than expected because they were wetted with various liquids. Again these materials are considered contaminated and cannot be composted. Several materials present in the waste were discovered to be recyclable such as well such as #4 plastic bags, paper towel rolls, disposable aprons and Kleenex boxes.

Unlike in week one where the types of waste were similar, the waste produced during week two had a much higher level of variation. Figure 10 depicts the combination of both the expected waste and actual waste produced during the laboratory and in preparation of the laboratory by the teaching assistant on March 16, 2011:

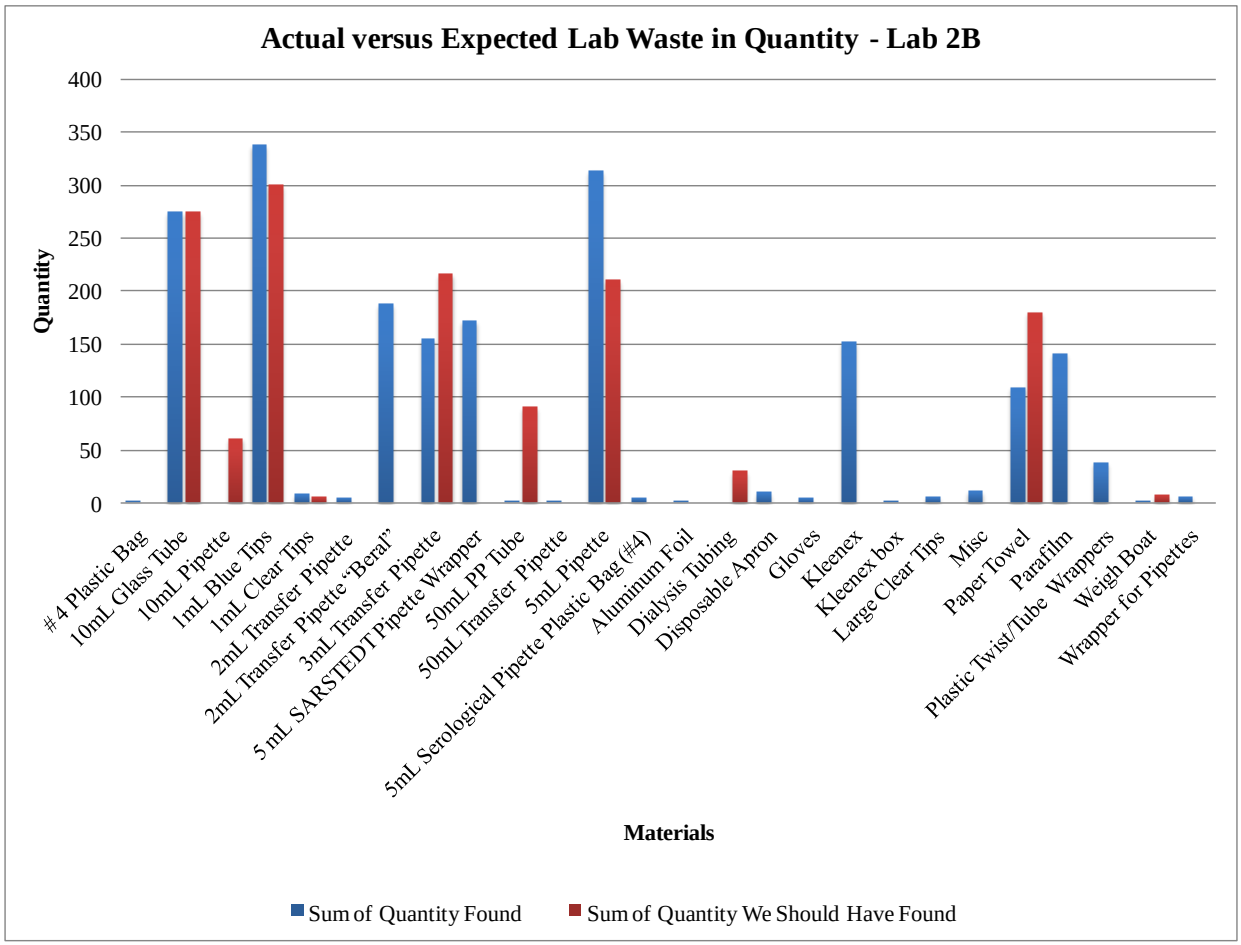


Figure 10. Actual waste versus expected waste from the second laboratory from Wednesday's group (2B). Quantity of actual and expected waste is plotted against the waste materials found.

Below are the pie charts depicting the quantity and weight distributions for the laboratory completed during week two on Wednesday.

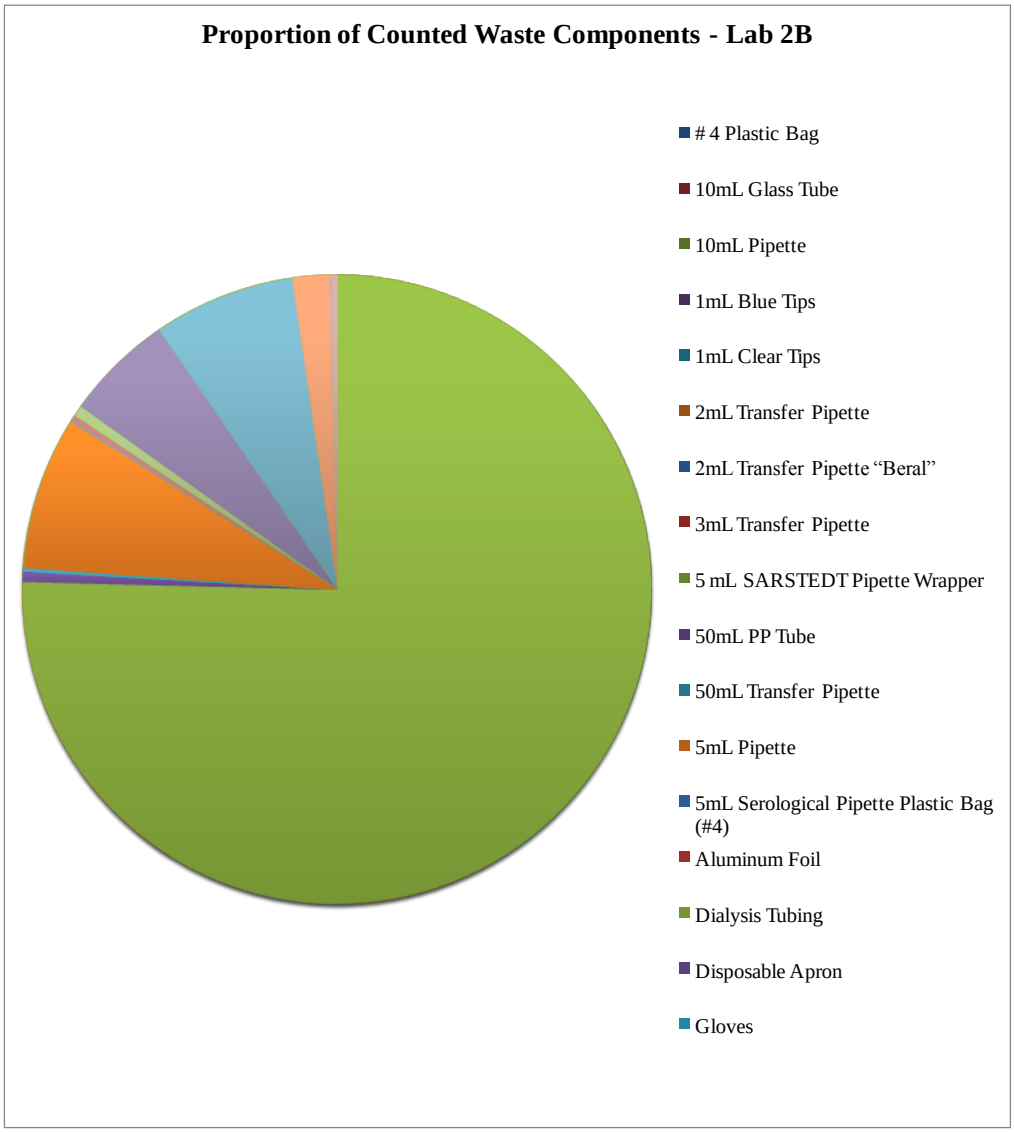


Figure 11. Proportion of quantity of materials found in the waste from the second laboratory from Wednesday's group (2B).

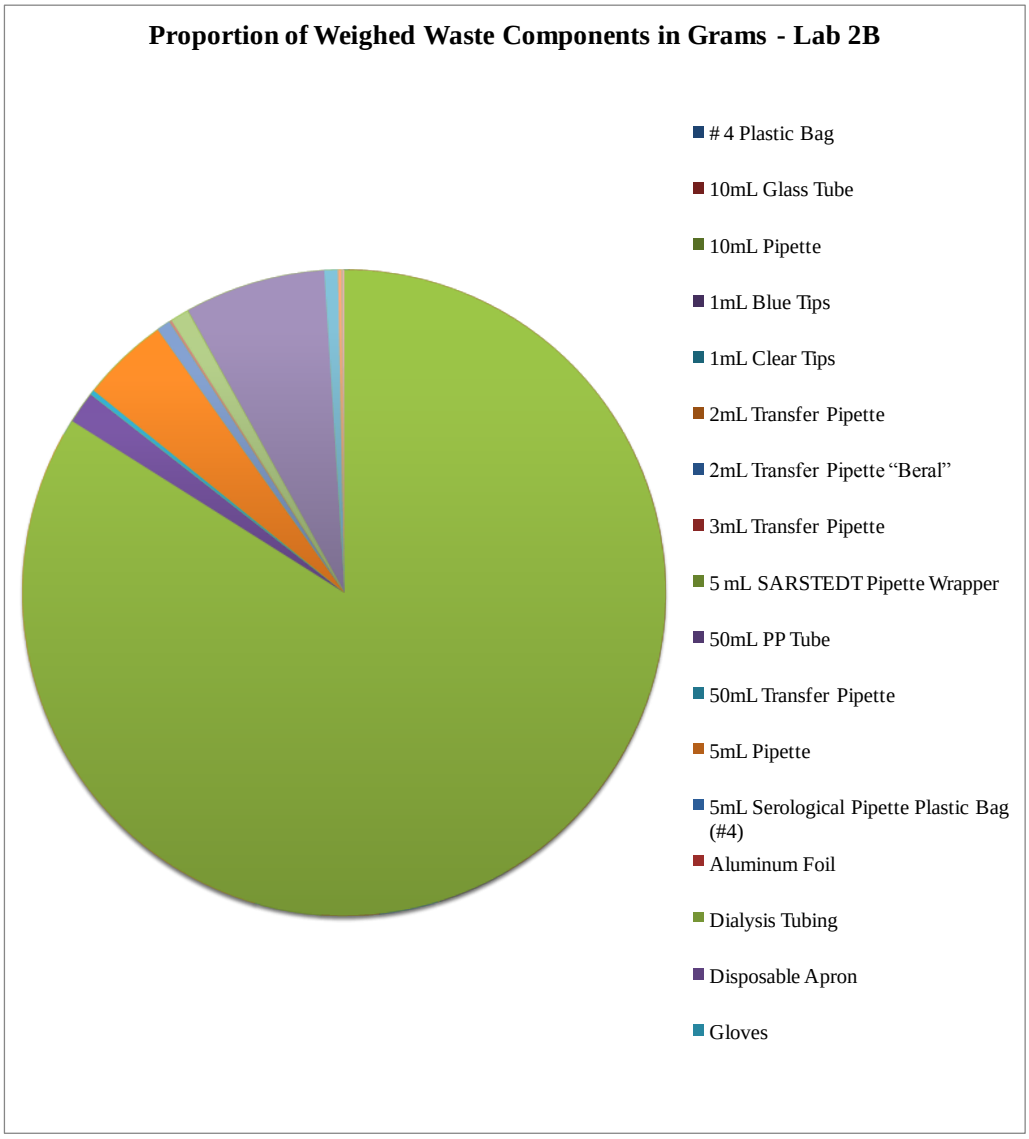


Figure 12. Proportion of weighted laboratory waste components in grams from the second laboratory from Wednesday's group (2B).

The findings show that the majority of the waste comes from the one-time use pipettes that are disposed of after use. According to the laboratory personnel during the interview, the pipettes are one-time use because they are not autoclavable (see Appendix E) and the risk of contaminating the next experiment is almost certain if not washed thoroughly (personal

communication, March 25, 2011).

4.0 Discussion

4.1 Summary of Research Question

The research question for this project is: what portion of the second year Introductory Biochemistry Laboratory waste at Dalhousie University can be diverted from landfills and what portion of these laboratory materials are currently properly disposed of? The objectives for this research project are as follows: 1) to determine which materials used within the laboratory are improperly disposed of 2) to determine what materials are available for waste diversion 3) what instructions were given to students in terms of waste disposal procedures and 3) to determine alternatives and solutions that could be used for this laboratory.

4.2 Overview of Significant Findings

The project has shown high potential for catalytic validity within the Biochemistry and Molecular Biology Department and for various other laboratories at Dalhousie University. The data and results have revealed for the first time at Dalhousie University that there is an opportunity for improvement in terms of waste diversion in laboratories, as this field of study has not been conducted at Dalhousie University before. If Dalhousie University follows the suggested recommendations, sustainable laboratory practices can begin to be adopted throughout campus. For long term recommendations, it is suggested that a laboratory program similar to the ones found at Yale University and the University of Melbourne be adopted at Dalhousie University to promote sustainable laboratories on a campus wide level. The following graphs depict how waste can be diverted if the suggested recommendations are implemented at

Dalhousie University to contribute to the mitigation of student laboratory waste.

The following are the corresponding graphs to the recommendations as seen in Appendix C and E:

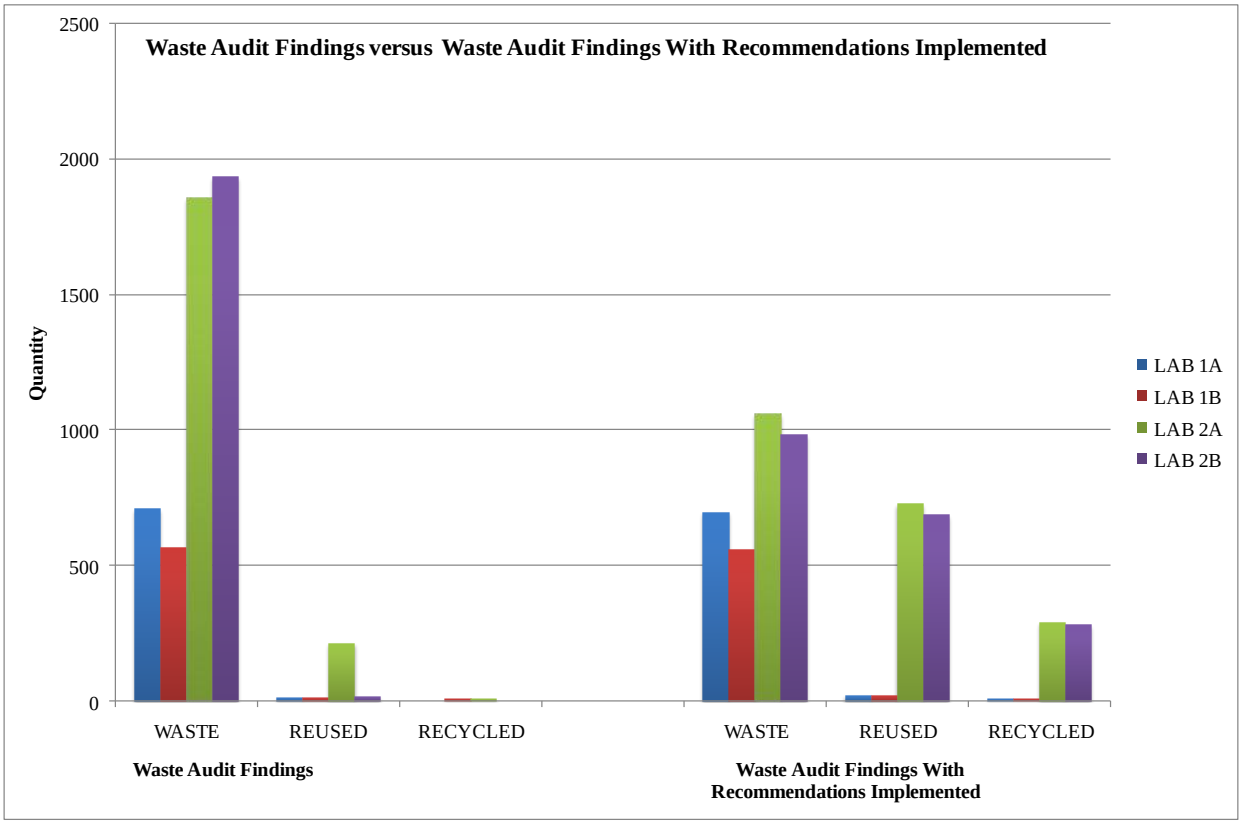


Figure 14. Waste audit findings in quantity versus potential waste audit findings if recommendations stated in this report are taking into account.

With the recommendations implemented, the waste in all of the laboratories is reduced and the recycled and reusable materials will in turn increases. However, when attempting to quantify the amount of waste that could be diverted within an academic year, time limitations and difference of waste materials produced between the different laboratories, makes quantifying unfeasible, inaccurate and unreliable. Therefore, instead of attempting to quantify a yearly

amount of laboratory waste that could be diverted, what was instead observed was the percentage of waste produced within the two specific laboratories and how it could be diverted to recyclable or reusable materials. While this does not serve as comprehensive yearly reduction estimation, it is felt that understanding what areas and components can be reduced holds more catalytic validity in future studies. In some cases, such as pipettes and glass tubes, the amount of waste that is diverted depends on the particular purchasing practices of the Biochemistry and Molecular Biology Department which is based on appropriate funds provided.

The following graphs depict the overall percentage of waste produced in the four laboratories as well as summary of the primary findings from the waste audits. The pie chart on the left depicts the overall combined results from the waste audit and the right pie chart depicts what the waste audit summary would look like with the adoption of the potential recommendations.

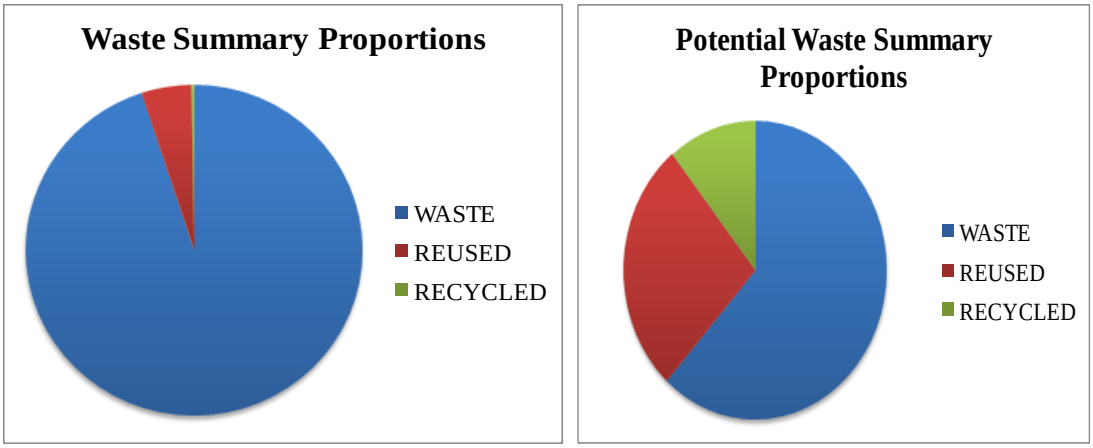


Figure 15. Combination of all waste, reused and recycled materials found within the laboratory (right) and potential combination of waste, reused and recycled materials that would be found

within the laboratory if the suggested recommendations states in this report are taken into account.

4.3 Research in Light of Existing Studies

This study has confirmed many general observations associated with amount of laboratory waste accumulated and waste diversion. Some of these general observations include a large amount of waste, a large variety in types of waste produced, difficulty in predicting the amount of waste that will be produced, the amount of reused and recyclable materials is small and limited, and that there is limited effort to increase waste diversion and environmental stewardship in the laboratory. Studies from other universities that were examined such as Yale University, University of Melbourne, and McGill University all showed similar findings to the second year Introductory Biochemistry Laboratory waste results in that there is a high amount and variety of waste produced and that few materials are recycled or are unable to be recycled. The Indian Journal of Medical Microbiology study also supported this report's results by stating there is a high amount of waste within medical research laboratories (Chitnis, et al 2005). The various literature reviews explained some of the reasons for these high amounts of waste. Several studies stated that refuse is primarily produced by researchers who require sterile materials. Materials are contaminated after one use and the types of materials used are non-recyclable. The type of plastic used needs to be able to withstand many laboratory procedures and therefore cannot be recycled or autoclaved (Chitnis et al, 2005).

This study revealed results that were not evident in past research. Materials for the laboratory were purchased based on cost, convenience and availability. Suggestions from some of the studies that were examined were used as recommendations for this study such as Yale

University and the University of Melbourne. There have also been new recommendations that this study suggests for Dalhousie University to adopt.

This particular topic of research, waste diversion strategies within biochemistry laboratories has had limited research and little evaluation relating to this subject matter. By performing a study in this area, this research has contributed to literature within the subject matter. Further research within this area of study is needed before large changes can be made to sustainability within laboratories. Other universities and future studies at Dalhousie University should be encouraged to perform similar studies as their respective schools in order to lower their ecological footprint and contribute to literature in this subject area.

4.4 Implications of the research

There are numerous implications that this study can have on theory and practice. As there is limited research being conducted on ways to increase waste diversion in undergraduate laboratories, the results found in this report can be applicable to other universities, as well as Dalhousie University, with regards to their procurement, and waste management policies and/or programs. Following the recommendations mentioned in this report, Dalhousie University could create a similar program to Yale University or University of Melbourne that focuses on sustainable laboratory procurement and waste management in order to achieve a sustainable campus. Both these programs give laboratories motivation and incentive to practice sustainable laboratory procedures. As large institutions, Universities have the power to influence the market, and therefore, can create demand for more sustainable laboratory ware such as bulk, reusable, and recyclable materials. Not only are these practices beneficial for the environment, they are

also economically viable – with most reusable items having a pay off period of two to three years.

The research conducted in this report also expected to raise awareness about sustainable laboratory and waste management practices to laboratory personnel and students. Student education on proper disposal procedures, and how to use materials more sustainable, should be required in all laboratories. Following the recommendations, it is anticipated that there will be more information given to students about the consequences of improper disposal, and also where each material should be placed. If such procedures are enforced, students will demonstrate sustainable habits through their participation in laboratories at Dalhousie University, and other institutions.

5.0 Conclusion

The completion of four waste audits in the Introductory to Biochemistry laboratories, were successful in determining several potential improvements which could likely divert waste from landfills and aid Dalhousie University in achieving its goal of 75 percent waste diversion. However, it should also be understood that further studies are required to determine specifically which materials are recyclable and what materials can be re-used within laboratories across campus.

5.1 Recommendations for Action

One way to improve waste management within the Biochemistry and Molecular Biology Department is for Dalhousie University to adopt a sustainable laboratories program. Dalhousie University could develop a sustainable laboratories program, which would help in reaching their 75 percent waste diversion goal, as well as the Office of Sustainability's goal, which strives for

the continual improvement and support of ongoing measurements and improvements of sustainability efforts on campus (Office of Sustainability, 2010). Yale's green laboratory program provides motivation and incentives for laboratories (Yale Environment Health and Safety, n.d). Without some kind of incentive, many laboratories would not change their practices to become more sustainable because it is inconvenient and more costly. A sustainable laboratory program could focus on various waste reduction strategies within the laboratory which would include improved recycling, environmentally conscious purchasing of laboratory supplies, the reduction of harmful chemical solvents, the reduction of overused materials such as gloves and pipette tips, and other suggestions by instructors or students that are deemed appropriate for that given laboratory. A sustainable laboratory program could also be incorporated into Dalhousie University's Rethink initiative which currently focuses on friendly, educational and participatory challenges centered around improving and promoting sustainability on campus (Office of Sustainability, 2010). The Rethink program also offers awards and recognition for outstanding efforts of sustainability throughout the year, which could be included in a green laboratories program by providing prizes, certificates and competition to the laboratory practicing the most sustainable practices in the Biochemistry and Molecular Biology Department or among all laboratories on campus.

In addition to a green laboratory program, an effective recycling and refuse program could also be incorporated and specific to the Biochemistry and Molecular Biology Department. Currently in the Introductory to Biochemistry Laboratory approximately 18 garbage cans are made available for students to dispose of laboratory waste and two paper recycling bins are available, but are occasionally placed out of sight**.** If all waste within the Biochemistry and Molecular Biology Department that was not examined in this study could be characterized as

recyclable, autoclavable, reusable, or refuse, an accurate waste diversion system similar to the Killam Libraries Paper, Recycling, Organic, and Garbage (PROG) system could be incorporated to reduce refuse produced in laboratories. Furthermore displaying signage, specific to the materials used in the Biochemistry and Molecular Biology Department, above waste and recycling receptacles in the laboratory would aid and encourage staff and students to dispose of laboratory waste correctly and would reduce the likelihood of having cross contaminants in each bin.

Other suggestions for improving waste diversion within the Biochemistry and Molecular Biology Department is educating students within the first couple classes and/or laboratories, on proper laboratory waste disposal relating to specific materials and maybe even chemical waste disposal within their laboratory. This would be also be useful during the Introductory Biochemistry laboratory as it is a preliminary course targeted at second year students who would most likely benefit the most from waste management education. This would not only contribute to waste diversion within the department, but would additionally encourage students to practice more environmentally sustainable methods within the laboratory, which they could carry with them throughout their university careers and life. Moreover, student volunteers who want to gain laboratory experience could be hired to clean re-usable materials, autoclave appropriate equipment and to ensure that materials both hazardous and non-hazardous are recycled or disposed of accordingly. Not only would this benefit Dalhousie University by helping reach its goal of 75 percent refuse diversion, but would supply student volunteers with valuable laboratory experience and potentially reduce annual costs associated with purchasing materials by reusing materials that otherwise would have been discarded.

Besides these initiatives, the Biochemistry and Molecular Biology Department immediately needs to commit to change specific practices within its laboratories in order to begin to adhere to Dalhousie's current goals and commitments towards Campus Sustainability. Currently during the Introductory to Biochemistry laboratories 25 disposable aprons were used, which creates 318.3 grams of excess garbage. Dalhousie University's science laboratories could develop a re-usable apron program whereby previous students or instructors could donate laboratory coats that could be re-used by students and then washed - given that there are no dangerous chemicals. This would be in contrast to the ordering and discarding of disposable aprons, which is the Biochemistry and Molecular Biology Departments current practice.

The disposal of 10mL test tubes and subsequent broken glass found in the Introductory to Biochemistry waste audits was also identified as a waste diversion problem that should be strongly considered by the University and the Biochemistry and Molecular Biology Department as a prosperous opportunity for waste diversion. During the two weeks of waste audits 6920 grams (15.26 pounds) of broken and discarded glass were collected and weighed. According to the semi-structured interviews provided by the instructor and laboratory assistant of the Introductory to Biochemistry class and Facilities Management, laboratory glass is to be disposed of in a separate bin, where it is later boxed up and either sent to the dump or incinerated (personal communications, March 21 and 25, 2011). Although it was quite difficult to determine the exact location and disposal of this glass, it was determined that currently this glass cannot be adequately accounted for by custodians, facilities management or laboratory instructors and therefore it is unlikely that it is being adequately recycled. According to a representative at Facilities Management the disposal of laboratory glass or broken laboratory glass in any way other than boxing and incineration poses a danger to custodial staff that may cut themselves on

glass which could additionally be contaminated by hazardous chemicals (Personal Communications, March 21, 2011). As stated by the Halifax Regional Garbage collection, all broken glass should be wrapped in cardboard or a sealed container and marked "broken glass" then discarded of in the garbage, however glass such as bottles or jars can be placed in blue bag recycling (Halifax Regional Municipality, 2010). The Dalhousie Biochemistry and Molecular Biology Department could develop a bin system, in addition to a specific Biochemistry and Molecular Biology Department recycling system that could incorporate the disposal of both broken glass and non-broken glass, ensuring that some portion of glass waste is diverted to recycling and not sent to the dump or to incineration. However in order for this to be accomplished, additional research needs to be completed regarding the waste streams of glass in the Dalhousie Biochemistry and Molecular Biology Department in order to ensure that contaminated glass is not placed in recycling receptacles.

The Biochemistry and Molecular Biology Department could also switch to Environmentally Preferable Purchasing (EPP) which according to Yale University involves purchasing products that have lowered adverse effects on human health and/or the environment when compared to similar products and service (n.d). By being environmentally conscious when purchasing laboratory materials, including choosing products that; are autoclavable, contain less packaging, or are recyclable in Halifax would contribute to Dalhousie University's commitments to greening the campus initiatives and would reduce waste transferred from the Biochemistry and Molecular Biology Department to landfills. Specific equipment such as the Eco pipette, which is an environmentally friendly pipette produced by CAPP, is made from durable materials to ensure a prolonged life, packaged in recyclable or biodegradable paper, fully autoclavable with no necessary disassembly. This is an example of the variety of green equipment available to

institutional laboratories. According to Landmark the Eco pipette distributor, customers can return any brand of old pipettes and receive a discount on the Eco pipette. CAPP will ensure environmentally safe waste disposal of old pipettes (Labmark, 2011). Although at first the purchase of numerous Eco pipettes does not seem cost efficient, despite the environmental benefit associated, a closer look at the feasibility of Eco pipettes showed that in fact purchasing the item was more cost efficient annually for Dalhousie University than current disposable pipettes.

5.2 Recommendations for Further Research

From the completion of waste audits in the Introductory to Biochemistry laboratories, several potential improvements were determined to aid in the diversion of wastes from the Biochemistry and Molecular Biology Department in contribution to Dalhousie University's goals of 75 percent waste diversion. However regardless of the suggestions further research is still required within the department to determine specifically what can be done to divert waste from refuse to other more environmental available streams. Future studies could audit all of the Introductory to Biochemistry laboratories throughout the semester or sample various laboratories within the Biochemistry and Molecular Biology Department to determine the majority of waste produced in the department and to begin to determine more specific solutions the department could include, which would improve waste diversion. Following the broken and used glass streams more closely would also provide stronger evidence of improper disposal of glass and recyclable s within the department. Additionally a future study could be completed on the research laboratories that are also located in the research tower of the Tupper Building. According to a representative of Facilities Management, a substantial proportion of waste is produced in research laboratories, a large majority that is speculated to be recyclable, however a lack of

appropriate policy on chemical and laboratory waste disposal, deficient inventory and the lack of attention given to waste procurement in the laboratories has prevented an adequate disposal or recycling program from being incorporated.

6.0 References

Canadian Council of Ministers of the Environment. (1992). Guidelines for the Management of Biomedical Waste in Canada. Retrieved April 7, 2011 from http://www.ccme.ca/assets/pdf/pn_1060_e.pdf

Chitnis, V., Vaidya, K., and Chitnis DS. (2005). Biomedical Waste in Laboratory Medicine: Audit and Management. Indian Journal of Medical Microbiology, 23(1), pp.6-13.

Corning. (2011). *Corning® 0.1-2.0µL Filtered IsoTip™ Universal Fit Racked Pipet Tips (Fits Gilson® Pipettors or Other Popular Ultra-Micropipettors), Natural, Sterile, 10 Racks/Case, 960 Tips/Case (Product #4801).* Retrieved from http://catalog2.corning.com/Lifesciences/en-US/Shopping/ProductDetails.aspx?productid=4801%28Lifesciences%29&categoryname=

Daigle, C., David, A., Frenette , G., Heggelin, A., Kendall, C., and Walsh, F. (2007). An Analysis of Chemical Waste Disposal in the Dalhousie Undergraduate Chemistry Laboratories. Greening the Campus Term Project Proposal, ENVS 3502. Retrieved from http://environmental.science.dal.ca/Files/Environmental%20Programs/Chemistry_Group.pdf

Dalhousie University. (2009). *The Dalhousie Guide to Waste Management on Campus.* Retrieved from http://office.sustainability.dal.ca/Files/Dalhousie_Guide_to_Waste_Management_-_Version_Oct_2009.pdf

Dalhousie University. (2011). *Rethink! Sustainability on Campus.* Retrieved from http://office.sustainability.dal.ca/rethink

Facilities Management – Dalhousie University. (2011). The Dalhousie Guide to Waste

Management on Campus. Retrieved February 11, 2011 from http://fm.dal.ca/documents/pdf/Dalhousie_Guide_to_Waste_Management_-_Version_Oct__2009.pdf

Halifax Regional Municipality. (2010). *Residential Garbage Collection.* Retrieved from http://www.halifax.ca/recycle/garbage.html

Labmark. (2011). *Ecopipette (CAPP).* Retrieved from www.labmark.eu/pipettes/ecopipette

Labnews. (No date). Consumables Don't Cost the Earth. Retrieved February 11, 2011 from http://www.laboratorynews.co.uk/feature_archive.php/566/5/consumables-dontcost-the-earth/

Laboratory Waste Reduction McGill. (No Date). Laboratory Waste Reduction Program. Retrieved April 7, 2011 from http://sites.google.com/site/laboratorywastereductionmcgill/Home

Lockwood, S., Mirsky, S., and Titaro, B. (2004). Waste Management. Retrieved February 11, 2011 from http://www.adm.uwaterloo.ca/infowast/watgreen/projects/library/f04wastemgmt.pdf

Muise, J. & Olsen, K. (n.d.). Face to Face Interviews. Received from http://web.viu.ca/rtri/Face%20to%20Face.pdf

Nationmaster.com. (2011). Canadian Environment Stats. Retrieved April 7, 2011 from http://www.nationmaster.com/country/ca-canada/env-environment

NEMS. (2010). Sustainable Laboratory Practices Working Group. Retrieved February 11, 2011 from http://www.nems.nih.gov/teams/team_laboratory.cfm

Office of Sustainability. (2010). Dalhousie University Sustainability Plan. Retrieved February 17, 2011 from office.sustainability.dal.ca/

Palys and Atchinson (2008). Sampling in Research Decisions 4th Edition (pp.107-135). Toronto: Thomson Nelson.

Palys and Atchinson (2008). Interactive Methods: Surveys, Interviews and Oral History Techniques in Research Decisions 4th Edition (pp.153-198). Toronto: Thomson Nelson.

Palys and Atchinson (2008). Constructing a Research Proposal in Research Decisions 4th Edition (pp.136-152). Toronto: Thomson Nelson.

Peels Data Centre. (2004). Ecological Footprint. Retrieved April 7, 2011 from http://www.peelregion.ca/planning/bulletins/ecological.pdf

PHA Consulting Associates. (2008). Plastics Studies. Resource Recovery Fund Board. Received from http://www.rrfb.com/pdfs/Plastics_study-2008.pdf

Resource Recovery Fund Board. (2010). Waste Audit Guide. Retrieved from http://www.rrfb.com/pdfs/RRFB_Waste_Audit_Guide.pdf

Statistics Canada. (2008). Waste Management Industry Survey: Business and Government Sectors. Retrieved February 11, 2011 from http://www.statcan.gc.ca/pub/16f0023x/16f0023x2010001-eng.pdf

The Landfill Site. (2011). Landfills: Environmental Problems. Retrieved February 17/2011 from http://www.landfill-site.com/html/landfills__environmental_probl.php

University of Lethbridge. (n.d.). Preferred Format of a Research Project. Received from http://people.uleth.ca/~g.shan/Format%20of%20Lab%20Reports.htm

University of Melbourne. (2011). Achieving a Sustainable Campus: Sustainable Laboratory. Retrieved April 7, 2011 from http://sustainablecampus.unimelb.edu.au/difference/laboratory/

Wilson, J & Anielski, M. (2005). *Ecological Footprints of Canadian Municipalities and Regions.* The Canadian Federation of Canadian Municipalities. Retrieved from http://www.anielski.com/Documents/EFA%20Report%20FINAL%20Feb%202.pdf

Yale Environment Health and Safety. (No Date). The Yale Green Laboratories Certification Program. Retrieved February 11, 2011 from http://www.yale.edu/ehs/sustainability/greenlaboratories.htm

Zheng, F. & Zhang, X. (No Date). The Practices of Laboratory Waste Reduction in Cell Biology Teaching Laboratory. Retrieved April 7, 2011 from http://www.bmtfi.com/upload/product/201006/2010jyhy04a22.pdf

7.0 Acknowledgements

We would like to thank the following individuals for their contribution to the Introductory to Biochemistry waste audits; Paul Briggs, Heidi Berry, Gary Davidson, Emily Rideout, Owain Meyer-Macaulay, Tarah Wright and Rochelle Owen.

Appendix A: Ethics Proposal

GENERAL INFORMATION

1. **Title of Project:** Waste Audit of the Introductory Biochemistry laboratory (BIOC2610)

2. **Faculty Supervisor(s)** | **Department** | **Ext:** | **e-mail:**
   Tarah Wright, Rochelle Owen | Environmental Science | | tarah.wright@dal.ca

3. **Student Investigator(s)** | **Department** | **e-mail:** | **Local Telephone Number:**
   Danielle St.Louis | Environmental Science | danielle.stlouis@dal.ca | 902-220-6718
   Kelly Biagi | Environmental Science | kelly.Biagi@dal.ca
   Angelica Ciurlia | Sustainability | angelica.ciurliae@gmail.com
   Megan McCarthy | Management/Sustainability | Megan.McCarthy@dal.ca
   Mitchel Penwarden | Marine Biology | mt702578@dal.ca

4. **Level of Project:**
   Non-thesis Course Project [X]
   Undergraduate [ ]
   Graduate [ ]

   Specify course and number: ENVS 3502

5. a. **Indicate the anticipated commencement date for this project:** January 25, 2011

   b. **Indicate the anticipated completion date for this project:** April 13, 2011

Briefly describe the purpose (objectives) and rationale of the proposed project and include any hypothesis(es)/research questions to be investigated.

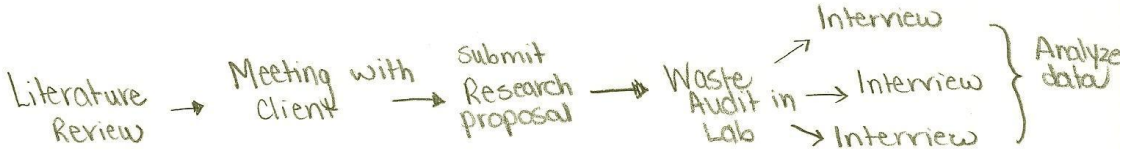
Our research question is what proportion of materials used in the Introductory Biochemistry laboratory are reused, recycled or garbage? We plan to investigate which materials are improperly discarded & are also available for waste diversion.
Many pre-medical laboratories generate a lot of waste that ultimately ends up in landfills & incinerators. We want to see how much of these materials are waste & what solutions are available.

2. Methodology/Procedures

a. ***Which of the following procedures will be used? Provide a copy of all materials to be used in this study.***.

[ ] Survey(s) or questionnaire(s) (mail-back)
[ ] Survey(s) or questionnaire(s) (in person)
[ ] Computer-administered task(s) or survey(s)]
[X] Interview(s) (in person)
[ ] Interview(s) (by telephone)
[ ] Focus group(s)
[ ] Audio taping
[ ] Videotaping
[ ] Analysis of secondary data (no involvement with human participants)
[ ] Unobtrusive observations
[ ] Other, specify _____

b. ***Provide a brief, sequential description of the procedures to be used in this study. For studies involving multiple procedures or sessions, the use of a flow chart is recommended.***



3. Participants Involved in the Study

a. ***Indicate who will be recruited as potential participants in this study.***

Dalhousie Participants:
- [ ] Undergraduate students
- [ ] Graduate students
- [X] Faculty and/or staff

Non-Dal Participants:
- [ ] Adolescents
- [ ] Adults
- [ ] Seniors
- [ ] Vulnerable population* (e.g. Nursing Homes, Correctional Facilities)

** Applicant will be required to submit ethics application to appropriate Dalhousie Research Ethics Board*

b. ***Describe the potential participants in this study including group affiliation, gender, age range and any other special characteristics. If only one gender is to be recruited, provide a justification for this.***

All interviews will be conducted with staff and/or faculty members at Dalhousie University. These individuals all have valuable information in regards to laboratory waste. Coincidently, all individuals are male and between the ages of 25-50.

c. ***How many participants are expected to be involved in this study?*** 3

4. Recruitment Process and Study Location

a. ***From what source(s) will the potential participants be recruited?***

- [ ] Dalhousie University undergraduate and/or graduate classes
- [X] Other Dalhousie sources (specify) faculty/staff directory / Information by Rochelle owen
- [ ] Local School Boards*
- [ ] Halifax Community
- [ ] Agencies
- [ ] Businesses, Industries, Professions
- [ ] Health care settings*
- [ ] Other, specify (e.g. mailing lists) _____

** Applicant may also require ethics approval from relevant authority, e.g. school board, hospital administration, etc.*

b. ***Identify who will recruit potential participants and describe the recruitment process.***
Provide a copy of any materials to be used for recruitment (e.g. posters(s), flyers, advertisement(s), letter(s), telephone and other verbal scripts).

- All group members have been in contact with the individuals who will be interviewed.
- Group members sent out emails describing our project & goals and interviewees agreed to participate in our study.

5. Compensation of Participants

Will participants receive compensation (financial or otherwise) for participation? Yes [ ] No [X]
If **Yes**, provide details:

6. Feedback to Participants

Briefly describe the plans for provision of feedback and attach a copy of the feedback letter to be used. Wherever possible, written feedback should be provided to study participants including a statement of appreciation, details about the purpose and predictions of the study, contact information for the researchers, and the ethics review and clearance statement.

Note: When available, a copy of an executive summary of the study outcomes also should be provided to participants.

- We plan to send a thank-you letter to the three individuals who are interviewed.
- We also plan to let them know the outcome of our study & where they can access our information

POTENTIAL BENEFITS FROM THE STUDY

1. **Identify and describe any known or anticipated direct benefits to the participants from their involvement in the project.**
   - learn whether they are doing a good job with waste management in laboratories
   - Learn solutions for waste diversion (& possibly save money)
   - satisfaction by contributing to research

2. **Identify and describe any known or anticipated benefits to society from this study.**
   - Ultimately we would like our results to provide solutions to miminizing the amount of waste generated in a undergraduate laboratory which would ultimaly lower the amount of waste in landfills & incinerators & provide a start for being more environmentally aware.

POTENTIAL RISKS TO PARTICIPANTS FROM THE STUDY

1. **For each procedure used in this study, provide a description of any known or anticipated risks/stressors to the participants. Consider physiological, psychological, emotional, social, economic, legal, etc. risks/stressors and burdens**

   [ ] No known or anticipated risks
   Explain why no risks are anticipated:

   [X] Minimal risk *
   Description of risks: Risks associated with our study include stress from researchers taking up their time, perhaps the waste audit may reveal bad management of waste.

   [ ] Greater than minimal risk**
   Description of risks:

* *This is the level of risk associated with everyday life*
** *This level of risk will require ethics review by appropriate Dalhousie Research Ethics Board*

2. **Describe the procedures or safeguards in place to protect the physical and psychological health of the**

INFORMED CONSENT PROCESS

Refer to: http://pre.ethics.gc.ca/english/policystatement/section2.cfm

1. **What process will be used to inform the potential participants about the study details and to obtain their consent for participation?**

   [ ] Information letter with written consent form; provide a copy
   [ ] Information letter with verbal consent; provide a copy
   [ ] Information/cover letter; provide a copy
   [X] Other (specify) Information in a email, written consent in email

2. **If written consent cannot be obtained from the potential participants, provide a justification.**

ANONYMITY OF PARTICIPANTS AND CONFIDENTIALITY OF DATA

1. **Explain the procedures to be used to ensure anonymity of participants and confidentiality of data both during the research and in the release of the findings.**

   * Answers given for interviews will not be provided in final report posted on website
   * Interviews will be conducted in private areas

2. **Describe the procedures for securing written records, questionnaires, video/audio tapes and electronic data, etc.**

   * Data will be recorded on excel sheets or microsoft word & will be saved on a flash drive of student researchers

3. **Indicate how long the data will be securely stored as well as the storage location over the duration of the study. Also indicate the method to be used for final disposition of the data.**

   [X] Paper Records
   [ ] Confidential shredding after _____
   [X] Data will be retained until completion of specific course.

   [ ] ~~A~~udio/Video Recordings
   [ ] Erasing of audio/video tapes after _____
   [ ] Data will be retained until completion of specific course.

   [X] Electronic Data
   [X] Erasing of electronic data after _____
   [X] Data will be retained until completion of specific course.

   [ ] Other _____
   (Provide details on type, retention period and final disposition, if applicable)

   Specify storage location: on computers or binders of researchers

ATTACHMENTS

Please **check** below all appendices that are attached as part of your application package:

[ ] **Recruitment Materials**: A copy of any poster(s), flyer(s), advertisement(s), letter(s), telephone or other verbal script(s) used to recruit/gain access to participants.
[ ] **Information Letter and Consent Form(s)**. Used in studies involving interaction with participants (e.g. interviews, testing, etc.)
[ ] **Information/Cover Letter(s)**. Used in studies involving surveys or questionnaires.
[X] **Materials**: A copy of all survey(s), questionnaire(s), interview questions, interview themes/sample questions for open-ended interviews, focus group questions, or any standardized tests used to collect data. (proposal)

SIGNATURES OF RESEARCHERS

Danielle St. Louis Signature of Student Investigator(s)	Feb. 24 / 2011 Date
Signature of Student Investigator(s)	Date
Signature of Student Investigator(s)	Date
Signature of Student Investigator(s)	Date
Signature of Student Investigator(s)	Date
Signature of Student Investigator(s)	Date
Signature of Student Investigator(s)	Date

FOR ENVIRONMENTAL SCIENCE PROGRAM USE ONLY:

Ethics proposal been checked for eligibility according to the Tri-Council Policy Statement: Ethical Conduct for Research Involving Humans

Signature Date

Signature Date

Appendix B: Interview questions with Biochemistry Laboratory Coordinator and Teaching Assistant, Interview questions with Facilities Management, Waste Management Project Officer

Interview questions

Biochemistry Laboratory Coordinator and Teaching Assistant

(1) What waste disposal procedures are given to students during the Introductory Biochemistry laboratory (BIOC2610)?

(2) In one semester, how many materials are ordered for the Introductory Biochemistry laboratory? (Do you have a list of order materials?)

(3) Where do your materials come from (company, province)?

(4) How much packaging is associated with the materials you order (do they come in bulk, individually wrapped, boxes?)

(5) In your opinion, in terms of environmental sustainability, what are the positive and negative aspects of waste management in the Introductory Biochemistry laboratory?

(6) What are the three major factors when purchasing supplies for BIOC2610?

(7) Are you aware of any autoclave machines in the Tupper Building/Biochemistry department that are available for use?

(8) How much does one order of test tubes cost?

(9) In previous years, was the disposal of waste any different (washing method)?

(10) Is it feasible for the Biochemistry Department to adopt a sustainable method of waste disposal such as autoclaving materials, limiting 2 pairs of gloves to students?

(11) Do you know if materials such as transfer pipettes are recyclable?

Interview questions

Facilities Management, Waste Management Project Officer

(1) What did you determine from your investigation, in the research laboratories, in the Tupper Building.

(2) What are the current waste diversion procedures or strategies within the Dalhousie Universities laboratories on the Carleton Campus?

(3) What are the current challenges facing waste diversion in laboratories on the Carleton Campus?

(4) Can paper towel and tissue be recycled subsequent to use in a laboratory?

(5) To your knowledge, what happens to broken glass and test tubes subsequent to use?

(6) How do you perform a waste audit?

Appendix C: Recommended Changes Per Lab - As reflected in Potential Waste Audit graph on p.#)

Lab 1A Changes

- Glove Boxes * 4 Waste → Recyclin
- Disposable Aprons * 5 Waste → Reusable
- Paper Towel Roll * 1 Waste → Recycling
- Pipettes *4 Waste → Reusable

Lab 1B Changes

- Disposable Aprons * 6 Waste → Reusable
- Paper Towel Roll * 1 Waste → Recycling
- Pipettes * 4 Waste → Reusable

Lab 2A Changes

- Disposable Aprons * 4 Waste → Reusable
- Paper Towel Roll * 1 Waste → Recycling
- Glass Tubes * 270 Waste → Recycling
- Pipettes * 509 Waste → Recycling
- Plastic Bags #4 * 11 Waste → Recycling

Lab 2B Changes

- Disposable Aprons * 10 Waste → Reusable
- Kleenex Boxes * 2 Waste → Recycling
- Glass Tubes * 275 Waste → Recycling
- Pipettes * 660 Waste → Reusable
- Plastic Bags #4 * 5 Waste → Recycling

Appendix D: Expected Waste Spreadsheet Provided by the Laboratory Teaching Assistant

Date	Lab	Prep Waste	Prep Reused Materials	Student Expected Waste	Student Reused Materials
##########	Electrophoresis of Amino Acids	4 x 50mL PP tubes	2 x 100mL glass bottles	60 x 1µL clear tips	2 x 9" glass trays
		3 x 15mL PP tubes	3 x 6L glass flasks	120 paper towel	
		75 x 1.5mL PP tubes	1 x 4L PP cylinder	65 pairs gloves	
		3 weigh boats	3 x 1L glass cylinders	60 x 17cm filter paper	
		6 x 5mL pipettes			
		3 x 1mL transfer pipettes			
##########	Effect of Anions on Amylase Activity	7 weigh boats	3 stir bars	30 x dialysis tubing	30 x 1L glass beakers
		6 x 5mL pipettes	4 x 150mL PP centrifuge tubes	210 x 5mL pipettes	30 stir bars
		90 x 50mL PP tubes	2 x 1L glass cylinders	60 x 10mL pipettes	180 spot plates
		30 x 15mL PP tubes	1 x 500mL glass cylinder	300 x 1mL blue tips	
		120 x 1.5mL PP tubes	4 x 100mL glass cylinders	270 x 10mL glass tubes	
		5 x 10mL glass tubes	2 x 1L glass flasks	210 x 3mL transfer pipettes	
		6 x 1mL clear tips	2 x 500mL glass flasks	180 paper towel	
		6 x 3mL transfer pipettes	1 x 250mL glass flask		
		30 x 13mL PP tubes	1 spot plate		

			4 x 100mL glass bottles		
##########	Experiments with Lactic Acid Dehydrogenase	2 weigh boats	2 x 1L glass flasks	150 PS cuvettes	
		3 x 1mL transfer pipettes	4 x 1L glass cylinders	150 x 5mL pipettes	
		33 x 50mL PP tubes	1 x 100mL glass cylinder	660 x 200µL yellow tips	
		4 x 200µL yellow tips	2 stir bars	30 x 1mL blue tips	
		8 x 1mL blue tips	4 x 1L glass bottles		
		1 x 5mL PP tube			
		2 x 5mL pipette			
		1 x 15mL PP tube			
		240 x 1.5mL PP tubes			
##########	Properties of an Aminotransferase	1 x 10mL pipette	1 x 500mL glass cylinder	120 x 1.5mL PP tubes	30 x 250mL glass beakers
		2 x 5mL pipette	9 x 100mL glass cylinders	60 x 1mL blue tips	30 x 1L glass beakers
		7 weigh boats	1 x 500mL glass bottle	240 x 200µL yellow tips	
		2 x 1mL transfer pipettes	2 stir bars	30 TLC plates	
		1 x 1mL blue tips	39 x 100mL glass bottles	210 x 1µL clear tips	
		1 x 200µL yellow tips	1 x 1L glass cylinder	30 x 6" square alum. foil	
		1 x 50mL PP tube		30 paper towel	
		300 x 1.5mL PP tubes		30 x 10mL glass tubes	

		30 x 5mL PP tubes	60 PS cuvettes	
		30 x 50mL PP tubes	30 x 5mL pipettes	
			30 x 2" square parafilm	

Prep stock. Try to reuse for 1-2 years.
Student. Try to reuse for 1-2 years.
Glass - indicated
Plastic - PP, PS, transfer pipettes, tips, weigh boats, pipettes (in glass container)

Appendix E: Worksheet to Determine Plastics that could be Autoclaved

PLASTIC TYPE AND DESCRIPTION	PLASTICS FOUND IN WASTE AUDIT	REUSABILITY (YES/NO)
Polystyrene (#6 - not recyclable in Quebec) melts in autoclave heat distortion point = 147 - 175°F, 64-80°C	5mL Transfer Pipette 13mL PP Tubes Weigh Boat	NO
Polyethylene (High Density; #2) may distort in autoclave heat distortion point = 250°F, 121°C		NO
Polypropylene (#5) withstands several cycles in autoclave heat distortion point = 275°F, 135°C	Corning Pipette Tips	YES
Polycarbonate (some but not all #7) withstands one cycle in autoclave heat distortion point = 280-290°F, 138-143°C		YES
Polypropylene (#4) withstands several cycles in autoclave extra processing time may be needed in the autoclave due to PP's low specific heat capacity	1.5mL PP Tube 15mL PP Tube 50mL PP Tube	YES
Nylon OK to autoclave heat distortion point = 300-356°F, 150-180°C		YES
P.T.F.E. (Teflon¨*) OK to autoclave heat distortion point = 250°F, 121°C		YES
Polyethylene (Low Density; #4) melts in autoclave	Disposable Aprons 2mL SARSEDT Pipettes 3mL SARSEDT Pipettes 13mL PP Tube Caps	NO
Polyethylene Terephthalate (PET; #1) melts in autoclave heat distortion point = 158°F, 70°C		NO

Appendix F: DSUSO Biochemistry 2610 Waste Diversion Preliminary Proposal

DSUSO Biochemistry 2610 Waste Diversion

Preliminary Proposal

By: Megan McCarthy, Danielle St. Louis,
Kelly Biagi, Mitchell Penwarden
& Angelica Ciurlia
ENVS/SUST 3502
Due: February, 28, 2011

Table of Contents

Page #

Project Definition

The alarming rate of worldwide over-consumption of resources has led to the creation of an entire branch of sustainability initiatives devoted solely to the diversion of waste from landfills. The aim of this movement is to reduce, reuse or recycle the materials that have previously been categorized as waste. Several universities, such as Dalhousie, are doing their part to tackle these contemporary issues through projects like the Greening the Campus Movement. As SUST/ENVS 3502 students, we would like to contribute to this movement through the conduction of a waste audit of Paul Briggs' Introductory to Biochemistry laboratory (BIOC2610). The aim of this audit is to determine the type of waste being created by students in this lab and, if possible, how to attain waste reduction.

With the aim of furthering Campus Sustainability, we have developed the following research question: In the Introductory Biochemistry laboratory, what proportion of laboratory materials are disposed of, recycled or reused? We hypothesize that there will be components, which are being disposed of improperly, or that the components themselves have not been placed in the correct bins, and have the potential for reuse. One of our objectives for testing under this hypothesis will be to fully detail and analyze all of the components we find in the trash immediately following four individual labs that have been conducted - each time documenting the observatory evidence of different categories: quality and quantity of the waste production. The objectives of our research include first determining which materials are improperly disposed of, for example placing rubbish in the incorrect waste stream, secondly determining what materials are available for waste diversion, and finally what instructions are given to students in terms of waste disposal procedures After analysis of the data, detecting patterns and reaching conclusions as to the most common objects contributing to the garbage and the function these objects perform, our final objective will be to find a possible replacement object that replicates the task yet without committing the same level of waste.

We are proposing to go about our waste audits by first arranging days with the Introductory to Biochemistry laboratory (BIOC2610). The professor who runs the lab has arranged access to the lab and to remove the waste from the lab before and immediately after this class. By doing this multiple times, we will have a well-rounded understanding of the type of waste coming from this one class. While this seems like a rather small study, we have decided to go about it in this fashion so that we have a very specific, narrowly scoped project where we might be able to effect real change at the student level in the classroom. By doing the background research and completing this project, we have the potential to educate and hence empower students and facilitators to be able to make more sustainable choices, especially if we discover reusable alternatives or proper methods of disposal.

One important note is that while our audits will remain almost exclusively as quantitative sampling due to the physical audits themselves, we will also conduct qualitative, oral interviews with Paul Briggs, Gary Davidson and Michael Murphy. We anticipate these interviews will garner their expert opinions on issues such as; what waste is hazardous and cannot be reused, what types of materials they typically see go to waste and what, if anything could be reused that is being thrown out. Using this qualitative method, we have already conducted an interview and short oral survey with Gary Davidson who is a full-time, Office of Sustainability employee at Dalhousie who is conducting a similar waste audit on research labs in the Tupper Building on Carleton campus (personal communication, 2011).

One last important point that Gary Davidson mentioned is the fact that the decisions made regarding the types of materials used in student labs versus research labs almost always come down to the cost being the greatest incentive (personal communication, 2011). We feel that this is one of the big potentials for our study as well; the ability for students to have the power to reduce their school costs while greening the campus. While the project Gary is working on is larger and of a broader scope, our narrow scope will allow us to thoroughly study waste streams, complete hands on waste audits and complete some qualitative surveys. Gary's study may have a larger impact one day however; our narrow scope has a much better chance of implementation and positively effecting change at the student level, which is of utmost importance to creating a green campus.

Background and Rational

Background

Sustainability, as defined in Dalhousie University's Sustainability plan, "is a pathway of continual improvement where actions protect and enhance human and natural resources needed by future generation to enjoy a quality of life equal or greater than our own" (Office of Sustainability, 2010). For the past twenty years, Dalhousie University has been actively involved with numerous sustainability issues. The university has agreed to and signed three international sustainable and environmental declarations, which include the Halifax Declaration, the Talloires Declaration, and the UNEP International Declaration on Cleaner Production. The president has also recently signed the University and College's Climate Change Statement of Canada, which aids the school in becoming more sustainable. Dalhousie University offers many courses, programs, research placements and publications based on environmental protection and sustainability. Over 100 faculty members at Dalhousie University both teach and perform research in an environmental or sustainable field. In 2008, a new program was developed at Dalhousie University, The College of Sustainability, which allows students to graduate with a degree focusing on the environment, sustainability and society while incorporating knowledge from

many different faculties (Office of Sustainability, 2010).

According to the Office of Sustainability (2010) Dalhousie has seven sustainable goals which include;

1) That values, knowledge, skills and social structures that support sustainability are endorsed 2) To support of organizational behaviors and physical systems that promote sustainability 3) To decrease natural resource energy and outputs 4) Increase renewable energy on campus 5) To enhance health and social attributes of the campus ecosystem 6) To increase sustainable transportation options and 7) To draw people to Dalhousie University as a result of sustainable activity.

Some of these goals have already been achieved through initiates at Dalhousie University such as the university's own Sustainability policy, it's six-stream recycling program, encouraging reusable bags and the fact that residence food services have been focusing on increasing the amount of local and fair-trade food served to students. The importance of our project in respect with the Greening the Campus Initiative is that it can help reduce Dalhousie University's overall ecological footprint. If it is discovered through this project that Dalhousie University is producing a considerable amount of waste from the biochemistry and molecular biology laboratory department, recommendations and solutions can be proposed as a result. This will not only aid Dalhousie University in reducing its ecological footprint, but also move the school towards a more sustainable direction and hopefully spark additional sustainable initiatives. Furthermore, this project may also allow other departments to consider supplementary materials that can be used more efficiently and effectively in regards to increasing campus sustainability.

In past years, students have examined the waste disposal in the chemistry department at Dalhousie University, our project however gives the university the chance to see how much waste is generated in another laboratory setting other than chemistry (Daigle et al, 2007). Currently the specific section that will be focused on, Biochemistry Laboratory 2610, has approximately 100 students enrolled within the class. Our study will not only examine the amount of waste produced by a biochemistry laboratory, but will also look at what materials could be reused or recycled that are currently treated as garbage. Optimistically, this project will discover materials that could be reused or recycled instead of throwing them away, therefore increasing waste diversion within the biochemistry and molecular biology department. It can thus be said that this is an important project because it will reduce Dalhousie University's negative effect on the environment.

Much waste that is produced within the lab contributes to environmental issues such as water contamination and increasing landfill sites. If harmful chemicals and toxins are improperly disposed of, these toxins may end up in water systems within the environment. Municipal sewage systems are not efficient enough to remove certain toxins, which is why such toxins need to be disposed of through other methods and not down the sink. Some of the main environmental issues within landfills include emissions

to the atmosphere and emissions to surrounding bodies of water. Eventually, the earth will not be able to store the amount of waste humans are producing. Without reusing and recycling laboratory materials, the waste produced within these laboratories contributes to long-standing environmental problems and thus Dalhousie University's ecological footprint (The Landfill Site, 2011). Dalhousie University strives to achieve their goal of reaching 75 percent of refuse diversion to recycling. Currently, Dalhousie University is at 50 percent waste diversion, with many sorting bins for recyclables, paper, organics, hazardous waste, chemicals and refuse located in various locations around campus (Facilities Management, 2011).

Literature Review/Past Projects

So far, five past studies have been taken into consideration and analyzed in comparison to the project relating to waste within the biochemistry and molecular biology laboratories. Comparisons to existing research within the area of biological waste within laboratories will aid the project with defining objectives, methods and discussions. The first study examined took place at Waterloo University where a group of students analyzed the waste management system within one of the campus buildings and concluded with suggestions to better the system. The group performed surveys on the staff that worked within the building, conducted audits of the waste and held interviews for selected staff members. They discovered that there was cross contamination of recyclables, inconsistent labeling, location and emptying of the waste bins. The group of students also discovered that 80 percent of the waste in the refuse bins was recyclable (Lockwood et al, 2004).

A second study found in the Indian Journal of Medical Microbiology found that medical labs like the Introductory Biochemistry laboratory produce a significant amount of refuse. They discovered that much of the waste was being cleaned before being recycled or being shredded before being recycled. The researchers suggested that more hazardous materials be autoclaved in order for the materials to be safe for recycling (Chitnis et al, 2005).

The third study that was analyzed for this project was done by Statistics Canada who looked at waste and management among various industries. They looked at waste from local and provincial companies. They analyzed many aspect of waste management such as total waste, disposal, rate of disposal, sources of waste for disposal, diversion, waste management industry financial characteristics and employment for local government and business sectors. They also had a large statistical table sections where they display the topics mentioned above in various tables and figures. One statistic that stood out within the paper was that each person in Canada was responsible for 1031 kilograms of waste in 2008 (Statistics Canada, 2008).

A fourth study that was looked at was performed by NEMS, which is a sustainable laboratory practice-working group. Their study explains how to green general laboratory practices. The study provides guidance, management, tools and new opportunities to be green within the laboratory for research groups. The study also covers laboratory issues such as decreasing the overall amount of waste produced, how to minimize the use of toxic materials and how to lower the energy used within a laboratory (NEMS, 2010).

Finally, the last case examined thus far was completed by Yale University. The university developed a "Green Laboratory Certification Program" for all laboratories within the University. The goals of this are to create awareness about proper waste disposal and the lower the university's ecological footprint. There are four levels within this program (Y-A-L-E), and each group must gain points by being green within their laboratory and successfully adopting sustainable laboratory practices which allows the group to pass each of the levels. Once a group has successfully achieved all four levels, they are awarded with a certificate. However, this certificate needs to be renewed every year to ensure proper laboratory practices (Yale Environment Health and Safety, n.d.).

Conclusion

Disposal of waste is one of the most important environmental issues occurring in the world today. With Dalhousie University's participation in this biochemistry waste project, they are actively showing their awareness for the problem and helping to reduce their overall impact on the environment. Through proper waste management and waste diversion, Dalhousie University's Biochemistry and Molecular Biology Department could greatly reduce the amount of waste they produce and send to landfills. Not only can laboratories produce large amount of waste, but they also produce a large variety of waste such as plastics, glass, hazardous as well as refuse which all has devastating effects on the environment if they are disposed of improperly. It is crucial for waste diversion and proper sorting of waste to be implemented within laboratories to ensure that all these varieties of materials get disposed of properly in order for them to have minimal effects on the environment (Labnews, n.d.).

Research Methods

The following section will outline in detail the necessary steps that will be taken to adequately address our research question and objectives in regards to the Introductory Biochemistry laboratory (BIOC 2610) on Studley Campus, Dalhousie University. In order to assess what proportion of materials used during the laboratories are waste, recycled or reused we will use the quantitative methods of a waste audit and interview with the laboratory coordinator, Paul Briggs. In order to achieve our objectives, qualitative measures such as interviews with Gary Davidson (Waste

Management Projects Officer for the Sustainability Office), Michael Murphy (Facilities Management), and Paul Briggs will provide us with information on possible solutions for waste diversion in the Introductory Biochemistry laboratory and also what type of instruction on disposal is given to students before beginning each laboratory.

Limitations in research or a study are factors that you have no control over, while delimitations are measures that you intentionally impose on your project or study (Palys and Atchinson, 2008). The first limitation of our study is access to laboratory time. The Introductory Biochemistry laboratory has two scheduled laboratory times during the week, Monday and Wednesday at 2:30 – 5:30 pm; these time restraints may make it difficult to conduct a waste audit because of conflicting schedules. In addition, our original plan was to conduct a waste audit in the Cell Biology (BIOL 2020) laboratory; however, due to the laboratory coordinator being away on education leave, we had to redirect our focus on her suggestion of the Introductory Biochemistry laboratory. Also, time is a limiting factor because we have only one semester (approximately 3 months) to plan, design, implement, and analyze our research. Furthermore, cooperation and truthfulness of participants in the interviews may also be a limitation in our study.

There are also several delimitations that we have set due to time restraints and our research goals, which include focusing on the Introductory Biochemistry laboratory because we felt that conducting a waste audit of the whole biochemistry and molecular biology department would be too large of a task. Also, our client suggested that laboratories such as Cell Biology are known to generate a substantial amount of waste due to the need of materials being sterilized; therefore it would be beneficial to conduct a study on this laboratory (or a similar one). In our waste audit, we will not be including chemical waste as we feel it would be timely for our group to adequately address this issue, however, we do recommend further study into disposal of chemical waste in laboratories. In addition, we will be conducting only three interviews due to time constraints. Paul Briggs, Gary Davidson, and Michael Murphy will be interviewed because each individual has specific information that contributes to our study on the Introductory Biochemistry (BIOC 2610) laboratory. Therefore, we are not aiming for representativeness of faculty and staff members, as we have chosen a non-probabilistic purposive sampling method. This method of intentionally seeking out individuals is beneficial when they meet criterion for inclusion in the study (Palys and Atchinson, 2008). In our interview with Paul Briggs we hope to gain information on how much waste is generated during an entire semester, such as numbers on how many materials are ordered, and also other wastes that may not be visible in the laboratory such as plastic wrapping, boxes, Styrofoam and other packaging materials. In addition, we hope to gain information about whether waste disposal procedures are given at the beginning of laboratories to students. In our interview with Gary Davidson, we hope to determine possible solutions to increase waste diversion in the Introductory Biochemistry laboratory. Rochelle Owen, the director of the Sustainability Office, suggested contacting Gary as he has been investigating the amount of waste produced in research laboratories and potential solutions on the Carleton Campus at Dalhousie University. Also, in our interview with Michael Murphy we hope to learn about the waste management solutions offered at Dalhousie University in regards to laboratory waste. We also hope to gain information about specific materials used in laboratories (please see appendix A for three sets of draft interview questions).

The interviews will be conducted as in-person individual interviews. One benefit of conducting face-to-face interviews is higher response rates from participants. Also, the resulting qualitative and quantitative data that we receive from our interviews will ultimately be more valid and reliable than other interview methods because we can monitor whether the questions are being taken seriously, ensure that all questions are completely answered, and clarify any misunderstandings (Palys and Atchinson, 2008). In order to deal with the data collected from our interviews, we have decided to write down the major points or summaries from the responses therefore we will not disrupt the flow of the interview by writing down every word that is said, as Palys and Atchinson suggest (2008). In order to prevent distortion of responses, we will ask fairly straightforward questions that can be answered in one or two sentences.

A waste audit is a traditional method of assessing waste generation within any organization, institution, or business. According to the Resource Recovery Fund Board (RRFB), the goal of a waste audit is to produce fairly accurate estimates of the amount of materials available for source reduction, reuse and recycling (2010). A waste audit will be an efficient way to address what proportion of materials are thrown away, recycled or reused in the laboratory and ultimately single out items that are improperly discarded, or are available for waste diversion.

The Introductory Biochemistry laboratory (BIOC 2610) laboratory is offered two times per week, and there are ten labs throughout the semester. For the month of March there are four laboratories offered. Due to availability of group members, and access to the lab, we are aiming to conduct four waste audits in total. This will be done by determining from Paul Briggs which weeks we are able to access the laboratory, and conduct a waste audit on the Monday and Wednesday in order to get a genuine representation of the proportion of waste generated in one week from the Introductory Biochemistry laboratory. The purpose of conducting another waste audit for a different week is to gain a better representation of materials used, as each laboratory will likely use some different types of materials.

To ensure our measurements are not tampered with, students will not know which days we will be conducting the waste audits on. The first waste audit is scheduled to take place on Monday, March 7th. One group member will arrive at the laboratory while it is being set up for the students (around 2:00 pm) in order to ensure that all waste from packaging is placed in the appropriate waste stream in the laboratory so we can include them in our study. At the end of the laboratory a researcher will return to the lab and collect all necessary bins, and will then go to a designated location for the waste audit. The researcher will then put on the appropriate safety attire such as old clothing and gloves. An assumption that we are making is that reusable materials will more than likely need to remain in the laboratory, and therefore the researcher will conduct the tally of materials, and also the total weight of these materials in the laboratory. Each
bin will be sorted one at a time, and will be emptied on top of a black garbage bag on the floor in order to get a clear view of all the materials.

The total weight of each stream (garbage, recyclable, reused) will be measured in order to access how much of the materials are going into, and also being diverted from landfills or incinerators. Each waste stream will be sorted individually according to the Dalhousie Waste Management Guide and also the Resource Recovery Fund Board (RRFB) waste audit guide (see appendix B). However, all laboratory materials may not have appropriate labels, or fall under one of these categories therefore the material will be photographed, and if possible, collected in a labeled bag where we can get expert opinions on proper disposal by Paul Briggs, Gary Davidson or Michael Murphy. In each bin, we will keep a tally of the number of materials used such as the number of rubber gloves, pipettes, and Kimwipes. We believe that many of materials used
in a laboratory are small, and therefore, we will receive a better judgment on the amount of individual materials used by conducting a tally, and not recording weights of individual material types. Our data will be recorded using an accountability chart that is created using Microsoft Excel. In order to create our accountability chart a list of all materials used in the laboratory will be collected from Paul Briggs during the week of March 1st-7th. The following waste audits that are scheduled to take part on March 9th, 14th, and 16th will follow the same procedures as described above.

The total weight of each stream will be turned into a percentage, which will clearly highlight what proportion of laboratory materials are recycled, reused, or garbage. The individual separation of materials in waste streams will be tallied and then put into a histogram using Microsoft Excel which will demonstrate the frequency of these materials in each bin, and from the garbage bin which materials are most abundant and would benefit from solutions towards waste diversion. In addition to our interviews, a literature review will help with solutions for waste diversion of laboratory materials.

Project Deliverables

For our project we will produce and deliver a research report and a Pecha Kucha presentation. Our report will include: the title, author information, executive summary,
introduction, methods, results, discussion, conclusion, and our results. Our report will be submitted to the ENVS/SUST 3502 class instructors on April 13, 2011. Our report will serve as a final product for our campus clients (Emily Rideout and Owain Meyer-Macaulay). A copy of the report will also be posted as a public document on the ENVS/ SUST 3502 website.

The second product we will deliver from our project is a Pecha Kucha presentation. The presentation will take place on April 5th, 2011 at 6 pm until 9 pm at the
Company House at 2202 Gottingen Street, Halifax. Our presentation will be presented

to our ENVS/SUST 3502 instructors and classmates. Our presentation will consist of 20 PowerPoint slides that will be on an automatic sequence where each slide is shown for only 20 seconds. Each slide will only consist of ten words. Pictures and images will be the main source of information on each slide. Time will be permitted during the evening for informal discussions and question.

Communication Plan

We plan to communicate with our campus clients Emily Rideout and Owain Meyer-Macaulay throughout the duration of the project through email and meetings to update them with information and to receive input on our project. Once our project is completed, we will submit our research report as stated in the project deliverables to our clients.

We will communicate with our project mentor Rebecca McNeil through emails and meetings during class times throughout the projects duration. This will allow us to receive guidance and advice on the process of our research project.

We will communicate with lab instructors/coordinators through meetings. This will allow us to gain access to the labs we plan to audit and receive information on the items used in the lab, which ends up as waste.

A Pecha Prucha presentation will be presented to our ENVS/SUST 3502 classmates and instructors as described in the project deliverables. Our final research report will be submitted to our ENVS/SUST 3502 instructors. The guidelines of the report are presented in the project deliverables. A copy of the report will be posted as a public document on the ENVS/SUST 3502 website. This will allow us to share our findings with the public and other students.

Schedule

What?	When?	Who?
Preliminary research: • Operationalizing definitions • Determining objectives	Feb 1 - 14	Entire group
• Meet with clients Owain Meyer-Macaulay and Emily Rideout • Interview with Gary Davidson	Feb 7	Kelly & Danielle
• Email professors and instructors for potentially auditable labs	Feb 11	Angelica, Megan & Mitchell
• Divide and complete proposal	Feb 1 - 26	Entire group
	Feb 8 - March 1	Entire group
Field Research: • Second meeting with the clients • Interview Paul Briggs	March 1 – 8	Mitchell & Kelly
• Conduct interviews with Michael Murphy	March 2	Angelica, Megan & Kelly
• Enter labs and complete audits	March 2 - 18	Danielle & Mitchell
• Analyze information	March 2 - 18	Entire group
	March 19 - 26	Entire group
Conclusive Preparation: • Divide and write final report • Pecha Presentation • Peer Assessment • Report Due	March 28 - April 10 April 5 April 12 April 13	Entire group Entire group Entire group Entire group

Detailed Budget

SUST/ENVS 3502 FUNDING PROPOSAL FORM

PROJECT TITLE: DSUSO Biochemistry Waste

GOAL: As SUST/ENVS 3502 students, we would like to contribute to the Greening the Campus Movement through the conduction of a waste audit of Paul Briggs' Bio-Chem Laboratory. The aim of this audit is to determine the type of waste being created by students in this lab and, if possible, how to attain waste reduction.

DESCRIPTION: In order to conduct our waste audit, we will need several supplies to aid us. This includes both black garbage bags and clear blue recycling bags so that we might sort and separate the garbage from the recyclables. We will also require labels to place on these bags so that we can keep track of what we have sorted. We have requested money for a sharpie marker so that we may mark these labels as well. Finally, we have asked for money towards a package of latex gloves so that our group members remain free from contamination, especially in case we happen to come into contact with hazardous lab materials while conducting our audit. We would also like to inquire about borrowing the scale from DSUSO as well so that we might weigh out the different components of trash to obtain some of our raw data.

Quantity	Description	Price
1	Box of Regular Black Garbage bags (15 pack)	$4.99
1	Box of Blue Recycling Bags (15 pack)	$2.47
1	Box of Latex Gloves (10 pack)	$1.98
1	Box of Labels (Roll of 100)	$3.99
1	Sharpie	$2.69
1	Scale	Free
	Total Projected Costs:	$16.12

	Total Projected Costs Including HST***	$18.34

*It is important to note that we plan on obtaining our funding through DSUSO and that any unused materials will be turned over to them to use as they see fit.

***All prices are based on Canadian Tire's online prices as at February 25, 2011.

CONTACT INFORMATION:

Megan McCarthy - ENVS 3502 - DSUSO Biochemistry Waste Group Member

megan.mccarthy@dal.ca, (902) 412-2507

*The above name is also to be used as the recipient in the event that our request is granted.

References

Chitnis, V., Vaidya, K., and Chitnis DS. (2005). Biomedical Waste in Laboritory Medicine: Audit and Management. Indian Journal of Medical Microbiology, 23(1), pp.6-13.

Daigle, C., David, A., Frenette, G., Heggelin, A., Kendall, C., and Walsh, F. (2007). An Analysis of Chemical Waste Disposal in the Dalhousie Undergraduate Chemistry Laboratories. Greening the Campus Term Project Proposal, ENVS 3502. Retrieved from http://environmental.science.dal.ca/Files/Environmental%20Programs/Chemistry_Group.pdf

Facilities Management – Dalhousie University. (2011). The Dalhousie Guide to Waste Management on Campus. Retrieved February 11, 2011 from http://fm.dal.ca/documents/ pdf/Dalhousie_Guide_to_Waste_Management_-_Version_Oct__2009.pdf

Labnews. (No date). Consumables Don't Cost the Earth. Retrieved February 11,2011 from http://www.labnews.co.uk/feature_archive.php/566/5/consumables-dont-cost-the-earth/

Lockwood, S., Mirsky, S., and Titaro, B. (2004). Waste Management. Retrieved February 11, 2011 from http://www.adm.uwaterloo.ca/infowast/watgreen/projects/library/f04wastemgmt.pdf

NEMS. (2010). Sustainable Lab Practices Working Group. Retrieved February 11, 2011 from http://www.nems.nih.gov/teams/team_lab.cfm

Office of Sustainability. (2010). Dalhousie University Sustainability Plan. Retrieved February 17, 2011 from office.sustainability.dal.ca/

Palys and Atchinson (2008). Sampling in Research Decisions 4th Edition (pp.107-135). Toronto: Thomson Nelson.

Palys and Atchinson (2008). Interactive Methods: Surveys, Interviews and Oral History Techniques in Research Decisions 4th Edition (pp.153-198). Toronto: Thomson Nelson.

Palys and Atchinson (2008). Constructing a Research Proposal in Research Decisions 4th Edition (pp.136-152). Toronto: Thomson Nelson.

Resource Recovery Fund Board. (2010). Waste Audit Guide. Retrieved from http://www.rrfb.com/pdfs/RRFB_Waste_Audit_Guide.pdf

Statistics Canada. (2008). Waste Management Industry Survey: Business and Government Sectors. Retrieved February 11,2011 from http://www.statcan.gc.ca/pub/16f0023x/16f0023x2010001-eng.pdf

The Landfill Site. (2011). Landfills: Environmental Problems. Retrieved February 17/2011 from http://www.landfill-site.com/html/landfills__environmental_probl.php

Yale Environment Health and Safety. (No Date). The Yale Green Laboratories Certification Program. Retrieved February 11, 2011 from http://www.yale.edu/ehs/sustainability/greenlabs.htm

Appendix A

Draft interview questions

Paul Briggs (Biochemistry Laboratory Coordinator)

(1) What waste disposal procedures are given to students during the Introductory Biochemistry laboratory (BIOC2610)?

(2) In one semester, how many materials are ordered for the Introductory Biochemistry laboratory?

(3) Where do your materials come from (company, province)?

(4) How much packaging is associated with the materials you order (do they come in bulk, individually wrapped?)

(5) In your opinion, what are the problems areas in terms of waste management in the Introductory Biochemistry laboratory?

Gary Davidson (Waste Management Projects Officer for the Sustainability Office)

(1) What are some economically feasible companies that offer alternative packaging methods (for test tubes, pipettes, etc)?

(2) In your opinion, what is the biggest area of concern in terms of waste management in undergraduate laboratories?

(3) What are solutions for waste diversion that you have determined for your study on Carleton campus at Dalhousie University?

(4) What tips do you have for improving purchasing habits?

(5) What solutions do you have to make students, staff and faculty more aware of waste management issues in undergraduate laboratories?

Michael Murphy (Facilities Waste Management)

***** Questions for Michael Murphy will mostly be based on information that we receive from Gary and Paul. It will also be based on specific questions that we need answered, such as how to sort specific materials.

(1) What are the current regulations towards waste disposal in undergraduate laboratories?

(2)

(3)

Appendix B

Compostable Materials (CM)

Food Waste (cooked or raw)
Fruit & vegetable peelings
Table scraps
Meat, chicken, fish and bones
Shellfish, including shells
Dairy products
Cooking oil, grease & fat
Bread, rice, pasta
Eggshells
Coffee grounds & filters
Tea leaves & bags
Yard Waste
Grass, leaves & brush
House & garden plant waste
Soil & old sod
Boxboard (remove foil & plastic liners, metal fasteners, serrated edges, etc.)
Cereal, shoe, tissue, detergent, cracker, & cookie boxes
Pizza boxes (all other corrugated cardboard should be recycled)
Toilet paper rolls & paper towel rolls
Non-Recyclable Paper
Soiled napkins, paper towels & fast food wrappers
Waxed paper & cardboard (please continue to recycle milk cartons)
File folders
Yellow (manila) envelopes
Wrapping paper (no foil paper please)
Paper plates & cuts (not Styrofoam)
Damp & soiled newspapers & flyers
Sugar & Flour bags
Tissue/Kleenex
Other
Sawdust & wood shavings
Popsicle sticks, toothpicks, cotton balls, wooden Q-tips
Kitty litter

Recyclable (Blue Bag) Materials (BB)

Steel & aluminum cans
Glass bottles & jars
#4 LDPE plastic bags

#2 HDPE narrow neck plastic bottles (e.g., shampoo bottles, liquid dish soap bottles, etc.)
#1 PETE plastic containers (e.g., salad dressing bottles, etc.)
Milk cartons

Beverage Containers (BC)
All redeemable beverage containers
Recyclable Fibres (RF)
Corrugated cardboard
Newspapers, flyers, magazines, catalogues, paper egg cartons, paperbacks, phone books
Bond paper
Envelopes (with & without windows), "junk mail", coupons, etc.
(NO manila envelopes, photographs, carbon paper, travel/overnight envelopes, or overheads)
Scrap Tires (ST)
Recyclable Plastics (excluding Blue Bag containers) (RP)
Shrink wrap
Plastic wrap for pink insulation bats
Waste Paint (WP)
Textiles (TX)
Wood (WD)
Pallets
Wood packaging (crates)
Wooden spools
Drums and pails (DP)
Scrap Metals (SM)

<u>Garbage/Non-recyclables</u>

Worn out textiles
Rubber other than scrap tires
Composite materials such as chip bags
#2 HDPE wide mouthed plastic containers (e.g., margarine & ice cream tubs)
#2 HDPE "crinkly" plastic bags
#3, 5, 6 & 7 plastics (except beverage containers) - PVC, polypropylene, & polystyrene
Disposable diapers
Personal hygiene products
Paper products and fabrics contaminated with motor oils or solvents
Wood with preservatives, coatings or adhesives
Non-container glass (e.g., windshields, crystal, Pyrex, etc.)

(Resource Recovery Fund Board, 2010)