UBC Social Ecological Economic Development Studies (SEEDS) Student Report

An Investigation into Solid Waste Accounting

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Abstract

The University of British Columbia is devoting its efforts into having a waste free Vancouver campus as a part of its larger Climate Action Plan to combat global climate change. The Alma Mater Society (AMS) will do its best to assist in this goal at the new Student Union Building (SUB). In order to achieve a waste free SUB as a part of a waste free campus, the AMS needs reliable data on the amount of waste generated and its composition. That is where solid waste accounting comes in.

Three different methods of solid waste accounting are investigated and a triple-bottom-line assessment is conducted into each of them. The methods are on-board truck scales, platform scales and hand sorted waste audits. On-board truck scales involves retrofitting UBC Waste Management's garbage trucks with scales using either load cells or air suspension. They allow for metrics to be gathered on waste for other buildings on campus besides the SUB but are relatively expensive, have a larger margin of error than smaller scales and approval would fall under the jurisdiction of UBC and not the AMS. Platform scales are simply scales with a large surface for weighing. They are relatively inexpensive but require more work in weighing and recording the information. Hand sorted waste audits are a full accounting of both composition and weight of waste. They gather useful information of the composition of the solid waste but require the most manpower. Also, waste audits can be used in conjunction with on-board scales or platform scales with little redundancy in the information obtained.

Research into the different methods of solid waste accounting was done by analyzing sustainability programs at other Canadian universities. Social assessments were done by debating the possible effects on students and staff. Economic assessments were done by analyzing the labour, equipment purchase, and maintenance costs. Environmental assessments were done by taking into consideration the environmental impacts of manufacturing, shipping and disposal of equipment used in the researched methods of waste accounting.

From the research, a conclusion was reached that the most effective methodology for gathering metrics on solid waste was a combination of both industrial platform scales and a regular hand sorted waste audit. The effectiveness of the methodology was deemed on both the triple bottom line assessment and the comprehensiveness of the acquired data. The use of on-board truck scales by UBC Waste Management was concluded to be expensive to purchase and install as well as difficult to implement because it would require approval from UBC.

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LIST OF ABBREVIATIONS

- AMS - Alma Mater Society
- CFC - chlorofluorocarbons
- EECE - Electrical, Electronic and Computer Engineering
- SUB - Student Union Building
- UBC - University of British Columbia
- UNBC - University of Northern British Columbia

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GLOSSARY

Biodegradable: (of a substance or object) Capable of being decomposed by bacteria or other living organisms

Microbial: a microorganism

Platform scale: A scale with a platform area that can support large and heavy objects (varies based on model).

1.0 INTRODUCTION

Solid waste at landfills is a major source of greenhouse gas emissions. There are estimates that between 50% to 90% of degradable carbon in landfill waste is converted into carbon dioxide and methane gas, two major contributors to anthropogenic climate change (Pikon, 2010). In order to reduce solid waste, accurate, comprehensive and current data must be acquired. Without accurate, comprehensive and current data on solid waste, the AMS will not know the specific areas in which to target their waste reduction efforts nor whether they are reaching their goals or not (Wilson, 2012).

In this report, the methods of a on-board truck scales, platform scales and hand sorted waste audits will be explored. An assessment of the social, economic and environmental impacts, the triple bottom line will be conducted. The three explored methods of solid waste accounting are not mutually exclusive therefore it could be possible to implement all three of them without a large overlap in data, albeit at a hefty price. Recommendations are given on the most effective methodology based on the usefulness of the data acquired as well as the full cost based on the triple-bottom-line assessments.

2.0 ON-BOARD TRUCK SCALES

2.1 INTRODUCTION

A truck scale is an onboard scale installed in a truck which is designed for the weight measuring of incoming loads. Truck scale allows vehicle to be a mobile scale, saving time and money since there is no need to drive to a calibrated stationary scale. However, truck scales are not immaculately accurate since it has wide weighing range of load capacity with scale division of approximately 10 kg. (MOBA Mobile Automation AG, 2009)

2.2 SOCIAL ASSESSMENT

There are various people involved in the production and installation of the waste truck scale such as factory workers and technicians. The scale lasts about 15 years but requires maintenance so it provides continued job opportunities. Due to the limited number of the number of waste trucks, the social impact is rather minimal. (MOBA Mobile Automation AG, 2009)

2.3 ECONOMIC ASSESSMENT

Image 1.UBC Waste Management Truck. (2009). Retrieved November 18, 2012, from: http://www.buildingoperations.ubc.ca/municipal/waste-management/

The regular operating distance of a garbage truck was estimated at 40,300km per year covering travel distance to Vancouver Transfer Station and daily waste collection (Google Map, 2012).The annual gas consumption of a waste truck to cover such distance was calculated to 31,800L or approximately $40,000 of gas fee at $1.25 per litre(VancouverGasPrices.com, 2012). Labour cost of a worker is considered; $15 of hourly wages will result in around $20,000 per year

(LivingInCanada, 2011). The waste truck scale itself will cost about $1000 but it can be installed into an existing waste truck in UBC (TrachTrucksOnline, 2012). The obvious advantage of an on-board weighing truck is having relatively low maintenance cost once it is installed into a truck. One forestry study that showed transporters routinely leave 5-8% payload on the table to avoid running overweight (Menzies, 2012). The waste truck scale frees the operator from having to use commercial scales saving scale fees and the time and fuel spent travelling to such sites.

2.4 ENVIRONMENTAL ASSESSMENT

Garbage trucks emit greenhouse gas that contributes to climate change and it is forecasted to increase by 35% from 2000 to 2025 (Ali Ergudenler & Derek Jennejohn, 2005).

Pollutant	Fleet	2000	2005	2010	2015	2020	2025
Vehicle CO_2equiv, t/yr	All Municipal Fleets	20,594	21,020	22,354	24,042	25,794	27,523
	TransLink Buses	84,588	71,732	125,956	117,167	117,220	117,220
	BC Transit Buses	3,005	2,631	2,855	3,332	3,148	3,406
	All other HDDV	1,119,436	1,182,424	1,265,807	1,358,843	1,451,277	1,539,598
	Total	1,227,623	1,277,807	1,416,971	1,503,385	1,597,439	1,687,747
Full Cycle GHG, t/yr	All Municipal Fleets	24,392	24,845	26,385	28,479	30,604	32,763
	TransLink Buses	111,364	108,915	144,103	159,184	159,184	159,184
	BC Transit Buses	3,895	4,037	4,619	5,009	5,151	5,167
	All other HDDV	1,324,453	1,432,816	1,546,679	1,661,773	1,774,463	1,882,044
	Total	1,464,103	1,570,613	1,721,786	1,854,445	1,969,401	2,079,157

Table 1.. Greenhouse gas emission forecast for the LFV by fleet. Adapted from "Heavy-Duty Diesel Vehicle Emissions in Greater Vancouver," by A. Ergudenler, D. Jennejohn, and W. Edwards 2005, Reprinted with permission.

The waste truck scale can minimize vehicle emissions by both maximizing the truck's load to the landfill because the operator knows the exact load of the truck and not having to drive to a certified commercial scale. One of the negative environmental impacts of the scale is that the scale puts extra weight onto the truck. The other negative impact is from the construction of scales which are built with heavy metals.

3.0 PLATFORM SCALES

3.1 INTRODUCTION

The use of scales may seem like one of the most basic methods of accounting; in addition to being quite accurate in terms of collecting data. The use of scales allows for keeping track of where in the building the individual bags of solid waste are collected. Knowing the location inside the building where the amounts of solid waste is generated is critical in being able gather data for the SUB's solid waste output. In addition to being able to gather data on the locations of solid waste output, this data gathering can be done daily, providing a continual stream of data to help the waste managers of the SUB move towards their goal of reducing waste output from the building. The following sections will analyze the impacts of the use of a platform scale, one of our candidates to keep account of the solid waste that is output from the SUB.

3.2 SOCIAL ASSESSMENT

The social factors associated with implementing the use of scales are not very extensive. The primary factor regarding the social impact is training the building's janitorial staff and adding this additional task to their daily workload. This additional task may require a minimal addition for the current janitorial staff planned for the new SUB; the necessity of this will be determined by the actual planned waste output by the new SUB as well as the current number of janitorial staff planned to be working in the building. The regular operations of collecting garbage throughout the building may remain the same with the exception on keeping track of where the garbage was collected; this may be done through labeling upon collection or having pre-labeled bags in use for the varying locations in the building.

The University of Northern British Columbia (UNBC) has conducted a study on the solid waste generated on their campus which had required the training of janitorial staff. Their report mentions that there were limitations in the control of the waste and as a result some of the samples had to be excluded from their study (Smyth, 2010). This would imply that the training provided to the janitorial staff as well as having the appropriate number of staff working would determine the accuracy of the use of this method of accounting. Undertrained or an understaffed building may lead to inaccuracies in the data collected. The social aspect regarding non-janitorial staff; there would be no visible difference in the daily operations by the staff thus it would not seem reasonable to conclude that there would no effect on students or other university staff.

3.3 ECONOMIC ASSESSMENT

As compared to our other suggestion, the onboard truck scales, platform scales are much more financially reasonable option. Depending on the capacity and size (area), platform scales can range from a couple hundred dollars to just under a thousand dollars. The weight capacity (which can range up to 5,000kg) of the scale needed can determined by the amount of waste output from the SUB as well as if there will be multiple weighing stations; multiple stations would require more scales but of lesser capacity. Also a determining factor in the scale is the area available for weighing; this would ideally be located near where the garbage is collected for disposal. The accuracy for these types of platform scales is around 1kg which would be sufficient for the purposes of the collecting the mass of the waste output from the entire building. The University of Northern British Columbia (UNBC) when conducting a waste audit throughout their campus had used a fish scale which had an accuracy of 2kg (Smyth, 2008). The UNBC waste audit report was done over a five day period, the plan for the SUB would be daily or however frequent the SUB management would desire. I would not recommend the fish scale as it is much more inconvenient although less costly.

Another financial aspect to consider in addition to the scale is the possibility or requiring additional staff hours to account for the extra task of recording data or the minimal training required to operate and record data correctly. The necessity of additional staff is mentioned in the social aspect portion of this section. In a financial perspective this option would be an ideal method to conduct the solid waste accounting at the new SUB.

3.4 ENVIRONMENTAL ASSESSMENT

The environmental implications of implementing the use of platform scales at the new SUB are quite minimal. The scales themselves are shipped from either within Canada or the United States, thus keeping the environmental impact from shipping a large item very low. The scales use electricity which would have a negligible environmental effect.

However, the environmental impacts from using platform scales to gather data from the solid waste generated at the SUB would be beneficial to the environment. The precision of the scales can provide valuable information as to where in the building the waste is being generated. Since the solid waste throughout the building would be labeled upon collection, the location of where the waste was collected would be included with the mass of the waste. Using this data, it can be determined which particular areas of the SUB have a high waste output and can be targeted to reduce the waste. According to the University of Northern British Columbia's report, a significant amount of solid waste on their campus, 71%, was either recyclable or compostable (Smyth, 2010).

This is waste that went to the landfill but could have been diverted through recycling and composting. It is expected that there would be similar figures from the UBC campus, especially the new SUB, where there will be numerous food outlets as there would be a lot of compostable/ recyclable waste. Through the data that can be collected through the use of scales, the particular locations in the new SUB can be targeted and have waste reduction programs in place in those particular locations. In the environmental standpoint there is very little to no impact from adapting the use of scales, but can potentially be a positive impact based on what action is taken with the data gathered from the scales.

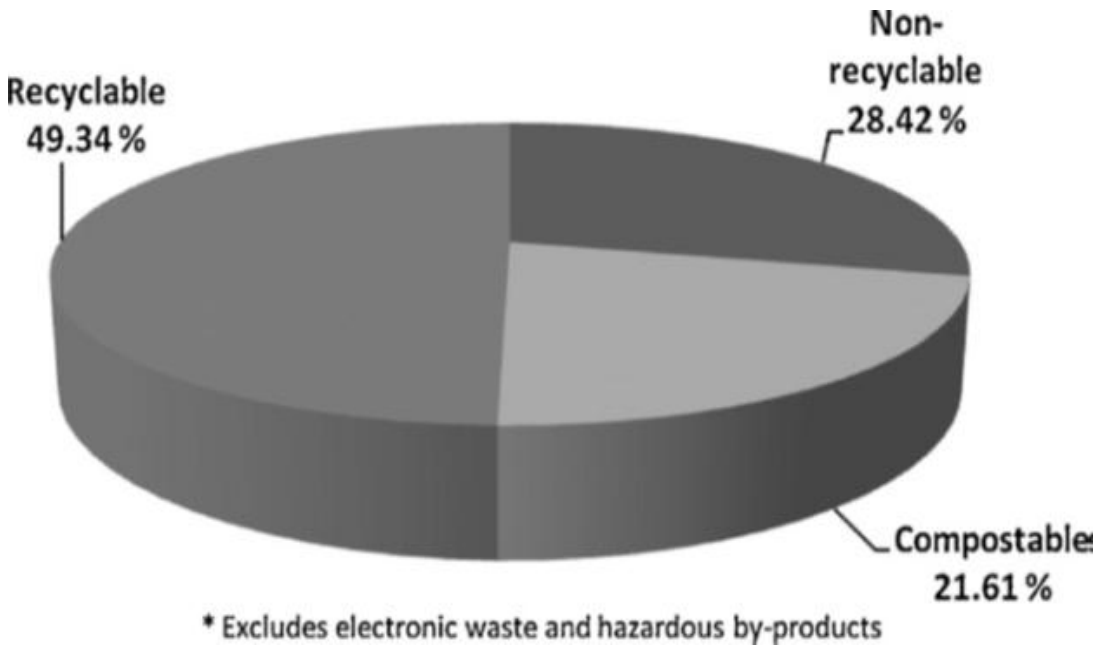


Figure 1. UNBC Solid waste composition percentages. Adapted from "Reducing solid waste in higher education: The first step towards 'greening' a university campus" by D. P. Smyth, 2010, *Resources, Conservation and Recycling, 54*, p. 1012. Copyright 2010 by Elsevier.

4.0 HAND SORTING

4.1 INTRODUCTION

One of the most valuable pieces of research that will help in reducing the overall waste in the New SUB is through a waste audit. Although not the easiest, but the most precise way of performing a waste audit is by hand sorting. Conducting waste audits is useful for determining the waste composition, the quantity of waste generated, and the source of where the waste is being generated. The materials that can be expected from performing a waste audit are shown in figure 2 where a waste audit was conducted at the University of Northern British Columbia in 2008. The data obtained from a waste audit provides a baseline in which measures the effectiveness of the current waste reduction programs. This information can then be used to develop strategies towards improving the waste management system and ultimately reducing the solid waste generated in the New SUB. This section investigates the economic, environmental, and social aspects of conducting a waste audit by hand sorting.

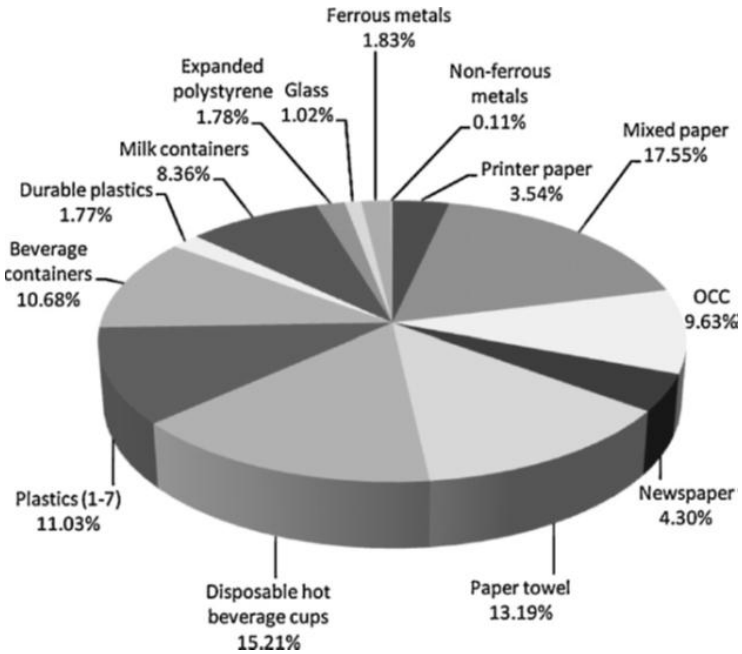


Figure 2. A waste audit conducted at UNBC in 2008. Adapted from "Reducing solid waste in higher education: The first step towards 'greening' a university campus" by D.P. Smyth, A.L. Fredeen, and A.L. Booth, 2008, *Resources, Conservation and Recycling*, 54, 1007-1016. Copyright 2010 by Elsevier B.V. Adapted with permission

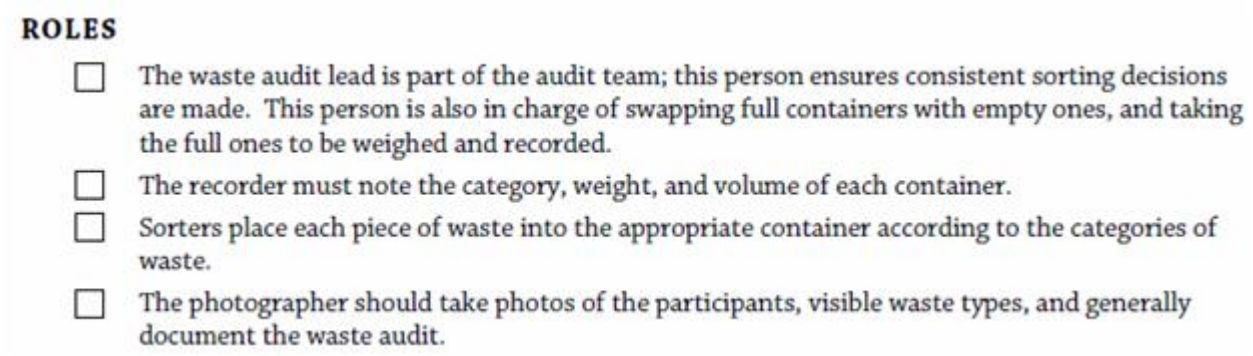
4.2 SOCIAL ASSESSMENT

The social challenges involved with performing a waste audit are safety, time and space, and data collection. Dates must be planned ahead of time to find the optimum time period when most volunteers are not occupied with other obligations. Also, a large area needs to be reserved to

set up tables and equipment for the procedure. One location that would be ideal for the New SUB is Macinnes field because it is relatively close and in an open field where the odor can dissipate into the atmosphere.

To ensure that the waste audit is done correctly with minimum injury it is recommended that volunteers go through a safety training orientation before they begin sorting. It is important to emphasize safety because the content in each garbage bag is unpredictable. They may contain sharp or hazardous objects such as broken glass that can penetrate through thin gloves and lead to serious infections which make it beneficial to have first aid kits available. Not only will hand sorters have to look out for sharp objects, the odor emitted from the waste may be very strong and cause nausea.

To increase efficiency of the procedure and accuracy of the data being recorded it is recommended to have volunteers placed into teams with different roles. By having volunteers responsible for specific tasks it increases the flow of the procedure and decreases the human error in data collection as the recorder can focus on just tallying the data.



ROLES

- ☐ The waste audit lead is part of the audit team; this person ensures consistent sorting decisions are made. This person is also in charge of swapping full containers with empty ones, and taking the full ones to be weighed and recorded.
- ☐ The recorder must note the category, weight, and volume of each container.
- ☐ Sorters place each piece of waste into the appropriate container according to the categories of waste.
- ☐ The photographer should take photos of the participants, visible waste types, and generally document the waste audit.

Figure 3. Hand Sorting Roles implemented in Thurston County, Washington for conducting a waste audit. Adapted from How to Conduct a Waste Audit, in *Thurston County*, n.d, Retrieved November 19, 2012, from http://www.co.thurston.wa.us/solidwaste/business/business-audit.html. Copyright 2012 by Emily Orme. Reprinted with permission.

4.3 ECONOMIC ASSESSMENT

When determining the cost of conducting a waste audit by hand sorting, several key factors must be considered. Depending on who is involved in the physical process of sorting the waste, the price of labor can be very high as many workers may be required. However, at many universities in Canada such as Wilfrid Laurier University, Dalhousie University, Concordia University, and Waterloo University waste audits are done voluntarily by students, some apart of a sustainability course or club. To assess whether UBC students would volunteer to help sort solid waste at the New SUB, we conducted a short survey on Facebook among the undergraduate students in EECE class of 2014/2015. Out of the 205 members, 21 said yes and 8 said no (note the few amount of votes are due to the short period of time the survey was available for). Extrapolating to the whole

campus, with a student body of more than 38,000 undergraduate students and 10, 000 postgraduate students, the number of students that may be willing to volunteer would be more than enough.

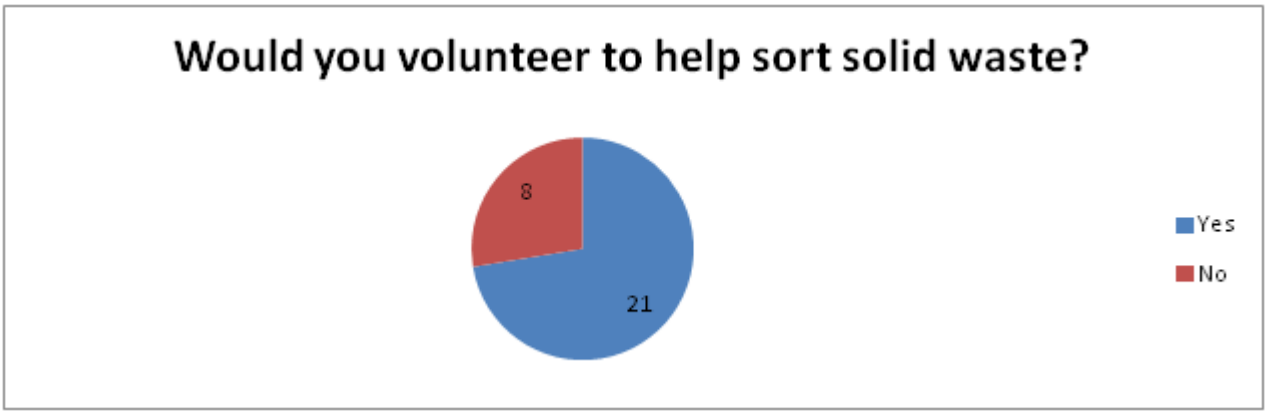


Figure 4. Survey on the number of students willing to volunteer to sort solid waste

Another factor that must be considered is the cost of materials required. The approximate price of each material can be seen in table 1 and varies from store to store (price seen are from amazon.com). As seen from this section with the help of volunteers, the economic costs are purely from the equipment required to sort the solid waste.

Material	Approximate Cost
Hazmat Suit	$10
Goggles	$5
Gloves (50 pack)	$15
Masks (50 pack)	$10
Buckets to categorize different waste	$15
Tape	$5
Large transparent bags for weighing (100 pack)	$20
Scale for weighing bags	$100-$1000
Paper towels to wipe off hands (per 8 rolls)	$10
Soap	$5
Disinfectant Spray	$5
Plastic sheets to cover tables	$10

Table 2. Materials and cost

4.4 ENVIRONMENTAL ASSESSMENT

The environmental impact of a waste audit via hand sorting mainly comes from the materials involved in the procedure. After a waste audit has been conducted the disposable gloves, masks, hazmat suits, paper towels, and plastic table sheets must be thrown out which directly increases the solid waste quantity. However, the tables, scales, and buckets can be reused for future waste audits and will need to be cleaned and washed with water.

The major problems with cleaning products are the chemicals they contain and the packaging they come in. The chemicals may pollute streams and rivers and take a long time to degrade in the environment. The raw materials used to make these chemicals consist mostly of petroleum which is a nonrenewable natural resource . Also, during the process of manufacturing these chemicals large amounts of energy and water are consumed (Ashkin, 2009). Products that come in aerosol cans contain a propellant gas (CFC) which is a chemical that has been proven to damage the ozone layer. Most cleaning products come with a lot of packaging which leads to even more waste. A list of chemicals found in disinfectant sprays (Makandi, n.d.) can be found in the table below.

Although the environmental impact of conducting a waste audit may not seem significant it can be further reduced by limiting the number of disposable materials used such as paper towels and gloves to reduce the extra waste after the audit is complete. For cleaning the equipment, biodegradable cleaning products can be purchased to minimize the damage to the environment caused by the chemicals present.

Disinfectant Spray	Chemicals	Environmental Impact
	Ethanol	Ÿ May cause microbial death (Australian Government,2009)
	Nano Silver Particles	Ÿ May cause improper sperm function and disrupts beneficial microbial activity in ecosystems Ÿ Slows decomposition and decrease nutrient available to plants (Catacchio, 2010)
	Benzalkonium Chloride	Ÿ Toxic to plants, animals, and fish (“Harmful Chemicals,”2007)
	Calcium Hypochlorite	Ÿ Calcium phosphide is very toxic to aquatic organisms (Lenntech, n.d.)

Table 3. Chemicals found in disinfectant sprays and the environmental impacts.

5.0 CONCLUSION

After conducting a triple bottom line assessment of the three methods of solid waste accounting, it was concluded that the most effective methodology for accounting waste at the new SUB would be a combination of both platform scales and hand sorted waste audits. Platform scales are only a fraction of the cost of an on-board truck scale and provide more accurate data due to a smaller margin or error. Also, the data provided from scales could be specific to certain areas in the SUB as opposed to on-board truck scales providing data only from the entire SUB. Hand sorted waste audits provide comprehensive data on the amount of waste that is compostable or recyclable. With a combination of the two, the AMS could collect data on the mass of solid waste generated and the location of where in the sub it is generated from on a daily basis as well as data on the composition of the waste whenever waste audits are conducted. The frequency at which waste audits are conducted could be determined based on the availability of willing volunteers. At least one waste audit per term is recommended to keep the composition data current. Despite the recommendation being for the new SUB, its possible for the AMS to implement the recommended solid waste accounting methodology immediately at the current SUB.

Although the on-board truck scales was deemed to be too expensive for the AMS to fund. It is recommended that the AMS pass on the suggestion to UBC. On-board truck scales would allow for data on weight to be gathered from every building on campus with a dedicated dumpster. With this information, UBC could get specific data on solid waste output building by building allowing them to concentrate their efforts on specific high output buildings.

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