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An Investigation into Methods of Garbage Handling at UBC

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ABSTRACT

Over the past few decades, plastic waste has become an increasingly concerning problem. The plastic bag is one of the most abundant forms of this plastic waste. As plastic is a durable material, it takes an extremely long time to break down, and thus plastic waste accumulates at a much higher rate than it can be disposed of. In order to combat the plastic problem, UBC recently started using degradable plastic garbage bags which can break down into smaller pieces when exposed to sunlight and oxygen. However, it's been argued that these bags cannot work as intended in landfills and that a bag-free method of garbage collection may be the best way to prevent the accumulation of plastic waste. In order to determine the best method of garbage collection, traditional plastic bags, degradable plastic bags and bag-free methods of garbage collections were compared based on triple bottom line (economic, environmental and social) criteria.

Traditional plastic bags were found to have high operating costs at $276,392 yearly to purchase the bags, but had no other economic costs other than that. Environmentally, it was found that traditional plastic bags require a high level of energy to produce, and while they are recyclable, most of the bags are discarded as garbage and often consumed by animals. Socially, it was found that traditional plastic bags can cause health issues in people and can also negatively affect tourism due to being unsightly when discarded. Degradable bags were found to have similar environmental impacts to regular bags but had the economic benefit of lower costs. Bag-free collection was found to have higher capital costs than the first two options; however the operating cost would likely be similar to the first two options. Environmentally, bag-free collection has the advantage of diverting millions of bags from being sent to landfills; however it has the disadvantage of using more electricity and water than the first two options. With regards to the social aspect, bag-free collection would create new jobs on-campus, but at the same time may cause loss of jobs for the garbage bag manufacturers. In addition, there would be less health issues created by plastic bags with this method, and the bins from Busch Systems are known to be made only in Canada and the U.S., so they would be made following the labour laws of those countries.

Comparing these three options, it is decided that although bag-free collection is weaker economically than both of the bagged options, the environmental and social benefits are too great

to ignore. By stopping the use of plastic bags, not only would UBC be preventing the accumulation of plastic waste in landfills, but also potential health issues, but also creating more jobs on-campus. It is recommended that UBC implement bag-free garbage collection after doing further research to confirm the economic figures and determining the power usage of the bin-washer.

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GLOSSARY

Biodegradable – Breakdown of materials by microbial activity

Capital Costs – Cost incurred during purchase of land, building, construction or equipment

Degradable – Materials that do not biodegrade and are not compostable but do break down into smaller pieces.

Embrittlement – Loss of ductility of a material

Greywater – Waste water generated from domestic activities

Hydro power- Electric power generated by using the force of moving water

Oxy-degradable plastics – Plastic to which have been added very little amount of catalyst metal salts

Triple Bottom Line Assessment- Economic, Environmental and Social assessment of product/method

1.0 INTRODUCTION

A significant portion of the world's waste is made up of plastic materials, including plastic bags. In order to reduce the amount of plastic waste, engineers have developed degradable plastics, which have additives that allow them to break down into smaller pieces with the right environmental conditions, and biodegradable plastics, which can be decomposed by microorganisms. UBC currently uses Acklands Grainger 2600 series degradable plastics bags for garbage collection after making the switch from regular plastic bags not long ago. However, it has been unclear if these bags actually provide any advantages over regular plastic bags, as landfills generally do not meet the required conditions for these bags to degrade. It has also been brought up that dropping the use of plastic bags entirely may be a solution to the plastic waste problem. This report aims to provide an in-depth assessment for three options of garbage collection on campus at UBC: regular plastic bags, degradable plastic bags and bag-free garbage collection. The three options will be assessed based on the triple bottom line criteria, which includes economic, environmental, and social aspects. After assessing the three options based on these criteria and determining which option best meets these criteria, we will provide a recommendation to the Design Team for the New SUB as to how UBC should proceed with on-campus garbage collection.

2.0 REGULAR GARBAGE BAGS

UBC has switched from the use of regular plastic bags on campus to degradable bags. This section discusses the economic, environmental, and social impacts of regular plastic bags and assesses whether it is worthwhile to switch back to regular plastic bags.

2.1 Economic Assessment

Based on our research, the total cost of regular plastic bags would be more than the total cost of degradable bags. This section breaks down the costs into subcategories of capital costs, operating costs, labour costs, maintenance costs, and expected lifetime. To make the comparison easier, the differential cost approach is used, which only includes the extra costs and savings incurred if UBC switches to the regular bags option and excludes any duplicate costs.

2.1.1 Capital Costs

The advantage of switching to regular bags is that there is no need to purchase new equipment such as new bins and bin-loading trucks or hire new truck drivers. The garbage bins currently in use for degradable bags are also suitable for regular bags. Therefore, the regular bags option does not incur any extra cost compared to the current degradable bags system.

2.1.2 Operating Costs

Currently UBC spends $120,000 yearly to purchase three different sizes of degradable bags from Acklands Grainger (UBC garbage bag figures). The cheapest regular plastic bags from Acklands all have higher unit costs than the degradable bags of the same three sizes. The details are provided in the following tables.

Table 1: Unit price of degradable bags (UBC garbage bag figures)

W x L	Stock#	Amount	Cases/Year	Bags/Case	Price/Case	Price/Bag
35X50	2665-01	$28,725.72	1,172	250	$24.51	$0.10
30X38	2673-01	$14,755.60	740	200	$19.94	$0.10
26X36	2661-01	$75,557.90	4,610	250	$16.39	$0.07

Table 2: Unit price of regular bags (Acklands Grainger, 2010)

W x L	Stock#	Amount	Cases/Year	Bags/Case	Price/Case	Price/Bag
35X50	2765-01	$66,651.64	1,172	200	$56.87	$0.28
30X38	2763-01	$34,284.20	740	250	$46.33	$0.19
26X36	2761-01	$175,456.60	4,610	250	$38.06	$0.15

The total amount for degradable bags is $119,039, while the total amount for regular bags is $276,392. If UBC decides to switch to regular bags, the disadvantage is that the extra costs incurred would be $157,353.

Other than the extra cost of bags, the regular bags option does not require any other operating costs. For example, the cost of fuel for the current garbage truck is approximately $30,000 a year, but UBC does not need to buy extra trucks and fuel since the garbage collecting process would be the same for both regular and degradable bags.

2.1.3 Labour Costs

Compared with the current degradable bags system, the switch to regular bags would require no extra labour since only the bags are changed. The same garbage collecting process could be used with the same number of garbage collectors and truck drivers hired and equal number of working hours. Therefore, switching to the regular bags option results in no extra labour costs or savings.

2.1.4 Maintenance Costs

Because the regular bags option simply changes the type of bag used and keeps the current collecting process intact, it incurs no new maintenance costs or savings compared to the degradable bags option.

2.1.5 Expected Lifetimes

The lifetime of regular bags during their use on campus is roughly the same as the degradable bags as they are cleaned and replaced daily. The garbage bins and trucks used are also the same. Therefore, there is no change in the expected lifetime of regular plastic bags and no extra costs or savings are incurred.

2.1.6 Net Cost

Because the regular bags do not incur any extra capital, maintenance, and labour costs, its net cost is equal to the extra operating costs of $157,353 spent on buying regular bags.

2.2 Environmental Assessment

Regular plastic bags have many negative impacts on the environment. They are made of polyethylene and require a great deal of energy to produce. One plastic bag requires 735KJ of energy to produce, with 495KJ of natural gas, 120 KJ of petroleum, and 80 KJ of coal (Needearth, 2010). Natural gas, petroleum, and coal are non-renewable energy sources and have limited supplies. Also, for every kilogram of plastic bag produced, 6.25kg of carbon dioxide is produced (Simmons, 2002). Therefore, producing plastic bags is not sustainable for the environment as it depletes natural non-renewable resources and contributes to global warming by releasing greenhouse gases.

Plastic bags are recyclable. However, most of them are discarded after use and end up in landfills or public areas as litter. For example, only 5.2% of all plastics bags used in the U.S. in 2005 were recycled (Thurston, 2010). The discarded bags that end up in landfills can take up to 1000 years to degrade (ReusableBags, 2010). The bags that are discarded in public areas such as streets, rivers, and oceans, pollute the environment and are health threats to wildlife.

Plastic bags discarded on land and in the ocean are often eaten by animals who mistake them for food. Every year, hundreds of thousands of turtles, seal, whales, fish, and other marine animals die from eating discarded plastic bags. Many land animals such as cows and birds also suffer from ingesting plastic bags. The ingested plastic bags are not digested and can choke animals, causing painful deaths (ReusableBags, 2010). After the animals die and their flesh decomposes, the plastic bags return to the environment and get ingested by other animals, leading to a vicious cycle.

2.3 Social Assessment

Regular plastic bags, when discarded in the environment, can pose health threats to humans. They can clog sewage systems and disrupt water recharge and discharge, causing bacteria and disease to spread. This is especially evident in less developed countries where the waste disposal system is not well controlled. For example, plastic bags clogging the sewage systems in Mumbai were widely considered to be cause of the Mumbai flood in 2005 (West Bengal Pollution Control Board, 2010).

Littered plastic bags also pose threats to people's well-being, especially in countries that rely heavily on tourism for income. Pollution caused by plastic bags discourages tourists from coming and reduces the local residents' income. As a result, authorities in many popular tourist locations have banned plastic bags. For instance, the government of the Malaysian state of Sabah has banned the use of plastic bags and forbidden tourists from bringing plastic bags to the area (The Star, 2009).

3.0 DEGRADABLE GARBAGE BAGS

Degradable generally refers to all classes of degradable plastic including biodegradable and compostable. However, plastic that is not biodegradable or compostable use the label degradable plastic. Most of the products using the label degradable plastic degrade as a result of physical and chemical impact. The Acklands Grainger 2600 degradable bags we chose to assess are oxy-degradable and are currently being used on campus (see figure 1).

Figure 1 – Acklands Grainger 2600 series degradable bags

They are regular polyolefin plastic to which catalytic additives have been added to speed up the breakdown of the molecular chain, accelerating the degradation of the plastic. For the Acklands Grainger 2600 series, the catalytic additive Reverte is used. The polymer chain length is first reduced greatly to make the material more vulnerable to microbial attack. The Reverte catalyzes the initial oxy-degradation of the polymer chain and promote the microbial colonies growth, which causes a serial reduction in polymer molecular weight. This starts the embrittlement and fragmentation, which decompose the material. It is hard to quantify the time length of the degradation period as it differs depending on the temperature, daytime length, and the moisture level. The most accurate test shows that it has a dwell time of around 6 to 7 months followed by 4 to 12 months of fragmentation and ebrittlement for 12 hour days at a constant temperature of 20 °C (Scott, 2002). The main reason that oxo biodegradable (OBD) products do not degrade so rapidly is because they are stabilized to control the service lifetime. Due to the fact that the oxidation process takes longer than 180 days, the American Society for Testing and Materials (ASTM) considers it biodegradable but not compostable.

3.1 Economic Analysis

The net cost of using Acklands Graigner 2600 Degradable(oxy-degradable) bags is lower than that of using regular plastics. A detailed economic assessment is shown in section 2.1 i.e. Economic assessment of regular plastic bags in which it is found that the only difference between the costs of regular plastics and degradable plastic is operating costs. The operating cost of degradable plastic is $119,039 whereas regular bags cost about $256,392. Therefore, degradable bags are economically more beneficial than using regular plastic bags.

3.2 Environmental Assessment

The aim of this section is to assess the evidence for the effects (both positive and negative) of oxy-degradable plastics on the environment, across their life cycle. The difference between oxy-degradable plastics and other petroleum-based plastics is the use of additives to give them the accelerated property of degradation; hence the focus of this section is on the environmental effects at disposal or end of life. In particular we have assessed:

- The extent and timeframe of degradation of oxy-degradable plastics
- The effects of degradation of oxy-degradable plastics on the natural environment and landfills

3.1.1 Extent and timeframe of degradation of oxy-degradable plastics

The length of time to degradation of oxy-degradable plastic cannot be predicted accurately because it depends so much on the environmental conditions. Evidence for degradation of oxy-degradable packaging is not difficult to come by and there is no doubt that when exposed to sunlight for an extended period of time, the plastic will become embrittled and fragment. Obviously, the time required depends on the strength of the sunlight and will clearly be much quicker in the Middle East, for example, than in the cold climate of Canada.

It is suggested that oxy-degradable plastics left in the open environment degrade to small fragments within 2 to 5 years (Murphy et al. 2008). The fate of oxy-degradable plastic after it has fragmented to a fine powder is not clear. Therefore, it is recommended that further research should be carried out to determine whether complete degradation to carbon dioxide and water is achieved, and if so, over what time scale. Moreover, if the fine particles are found to persist in the environment for a long period of time, research should be carried out to determine the effect of the particles on the wider environment.

3.1.2 Emissions during production and in use phase

From our research we found that oxy-degradable bags have the same effect on green-house gas emissions and on depletion of resources (i.e. oil depletion) as do conventional single-use polyethylene bags. Hence, in the production and use phases of the life cycle, oxy-degradable bags are not considered to have a significantly better or worse environmental impact than conventional single-use plastic bags. The reason for this is that, during the production and use phases, by far the largest contributing factor to the environmental impact is the energy and oil used in the production of ethylene and its conversion to polyethylene.

Another point to make regarding the LCA of oxy-degradable bags is that because polyethylene is derived from oil, then, when these bags degrade to Carbon-dioxide (CO_2), they are releasing fossil carbon into the atmosphere. Hence they have a more negative environmental impact during this phase of the life cycle compared with disposable bags made from biopolymers, which are derived from renewable biomass sources.

3.1.3 Bio-accumulation of Plastic fragments in the environment

An area of uncertainty is the fate of plastic fragments that remain in the soil. The producers regard these as beneficial because they are claimed to add to the content of humus in the soil (Scott and Gilead). However, there is a lack of evidence about the environmental impact of oxy-degradable plastic fragments in the soil and a number of concerns have been raised. For example, these fragments might act to concentrate pesticide residues in the soil (Koutny, M. et al. 2006). It is possible that earthworms, other insects, birds or animals may ingest them. Alternatively, they may enter watercourses and become ingested by fish or birds. It is also possible that they may find their way into the marine environment and become ingested by marine organisms (Chiellini et al. 2003). There are also concerns that degraded fragments may become cross- linked and hence persist in the environment (Feuilloley et al. 2005).

No evidence was found in this study that oxy-degradable fragments have a harmful bio-accumulative effect but neither was there evidence that they do not. It is therefore concluded that this is a topic requiring more research.

3.1.4 Degradation in Landfills

There is only a limited amount of information about what, if anything happens to oxy-degradable plastics in landfill sites. A landfill study carried out by the University of California has reported that oxy- degradable plastics did not undergo anaerobic biodegradation (biodegradation in the absence of air) during the study period of 43 days (Narayan, 2009). A control sample of paper did biodegrade under the same anaerobic conditions to produce methane gas.

The overall conclusion is that incorporation of additives into petroleum-based plastics that cause those plastics to undergo accelerated degradation does not improve their environmental impact and potentially gives rise to certain negative effects

3.3 Social Assessment

The most important advantage of degradable bags over regular plastic bags is that they do not stay in the environment for long like the traditional plastic bags and break down into smaller pieces. This can tremendously reduce the size of landfills, ocean water pollution, and health problems caused by the plastic's existence in the food chain. Also unlike starch based degradable bags, OBD bags can be made with normal machinery, therefore there is no need to change suppliers, which prevents possible loss of jobs. These bags are also certified to be non-toxic and safe for food-contact, which can reduce the impact on the health problem mostly seen in the developing countries where the wastes are dumped.

One of the problems for OBD bags is that they are not designed to degrade in regular landfills, though they can be safely dumped there. So in order to efficiently utilize the degradation attribute of these bags, new facilities need to be created to accommodate them. Another potential problem is that the precise rate of degradation is impossible to predict due to its reliance on the state of the environment they reside in, which can create problems for waste management as the quantity increases.

4.0 BAG-FREE GARBAGE COLLECTION

While the first two options assessed were different types of garbage bags, the third and final option is one that aims to eliminate the use of bags all together. This option explores the feasibility of using UBC's already installed bin-washing machine to clean garbage bins that collect garbage without bags (see figure 2). As the bins would give off an unpleasant smell over time, they would have to be transported to the bin-washing facilities on a regular basis for cleaning. This section will assess the economic, environmental, and social impacts of switching to bag-free garbage collection.

Figure 2 – Bin Washer System from Industrial Washing Machines

4.1 Economic Assessment

In order to switch to bag-free garbage collection, there would be several economic changes that would have to occur. This section details the capital costs, operating costs, labour costs, maintenance costs, and expected lifetimes of necessary infrastructure.

4.1.1 Capital Costs

The bin-washing machine is specifically designed to wash 35 litre Schaefer bins, but presently only compost and some recyclables are collected in these bins. In order to go bag-free, the bins must be washable, which means UBC would have to purchase new 35 litre Schaefer bins from Busch Systems to replace the garbage bins currently in use on campus (see figure 3). The bins are $89 each plus freight costs, however a Busch Systems sales associate said this was just a rough estimate on what one bin would cost. Generally, the costs are based on the size of the order (Mainprize, 2010).

Figure 3 – 35 litre Schaefer Bin from Busch Systems

UBC goes through around 30000 bags each week and under the assumption that bags are changed 5 days per week (weekdays only) that would translate to about 6000 garbage bins on campus (UBC garbage bag figures). However, the cylindrical bins currently used are roughly half the size of the Schaefer bins and likely would not have to be replaced on a one-to-one basis. Assuming that half as many Schaefer bins would be required to replace the current bins, and using a price of $89 per bin, the initial cost would be around $267,000.

The bins would have to be rolled outdoors by the custodial staff, where a garbage truck would empty their contents. An automated side-loader garbage truck would be required to empty the bins and while UBC does have a few side-loaders, they are currently used in collecting recyclables (UBC Waste Management). A new garbage truck generally costs around $175,000 and a side-loader would likely be around this price (Inform).

4.1.2 Operating Costs

The biggest economical incentive for UBC to switch bag-free garbage collection is the money saved on garbage bags. Presently, UBC spends around $120,000 yearly on Acklands Grainger 2600 Degradable bags (UBC garbage bag figures). One disadvantage is that additional fuel would be required to fuel the bin pickup truck for extra trips. The extra costs would be dependent on the number of extra trips, truck fuel efficiency and the cost of fuel itself. The cost of fuel for a side-loader garbage truck would likely be comparable to the current garbage truck at roughly $30,000 yearly (Wongharichao; 2008). However, the use of the current garbage truck would be greatly reduced so these costs would most likely cancel out. Another operating cost to consider is the cost of running the bin-washing machine. By implementing bag-free garbage collection, the machine will be used more often meaning additional utilities costs (electricity and water) will be incurred. Lastly, the Max Pro Detergent used by the machine costs about $25 per gallon, though the machine uses only a small amount each wash cycle (Beaudrie, Bin washer facilities tour, 2010).

4.1.3 Labour Costs

In order to implement bag-free garbage collection, it is likely that at least two new labourers would need to be hired to collect and wash the bins on a regular basis. Wongharichao suggests an hourly wage of about $19 for an organics driver in her 2008 report. Using this number, the yearly cost of two new labourers would be about $80,000 (Wongharichao, 2008).

4.1.4 Maintenance Costs

Vehicle maintenance costs would likely be unchanged with this system, provided the current garbage truck is used in a minimum capacity when replaced. The estimated costs of maintenance are about $17,500 yearly for the garbage truck. The maintenance costs of the bin collecting truck are estimated at $12,000, though with increased use this number would likely increase as well (Wongharichao, 2008).

4.1.5 Expected Lifetimes

According to a Busch Systems sales associate, the bins have a 7 year warranty, but they are generally very sturdy bins and last a lot longer than the warranty. The associate agreed that 15 years would be a reasonable estimate of a bin's lifetime (Mainprize, 2010). The lifetime of a garbage truck is generally around 12-14 years (Inform).

4.1.6 Net Cost

By switching to the bagless option, UBC can save $120,000 spent on degradable bags, but must spend on new bins and trucks, two new drivers, and maintenance and fuel for the new trucks. According to our calculation, if UBC buys one extra truck, it will have to spend an extra $31,467 (Appendix A). For every extra truck purchased, another $53,667 would have to be spent. However, we estimate that UBC does not have to purchase many new trucks since it already has some side-loading trucks.

4.2 Environmental Assessment

The most positive environmental impact of bag-free collection would be the amount of bags UBC would prevent from going to the landfill each year. Presently, UBC purchases nearly 1.6 million bags each year, the majority of which go to landfills. By implementing bag-free collection, UBC would prevent some of the greenhouse gases created in the manufacturing of these bags. Additionally, the likelihood of plastic materials polluting the ocean and other water bodies is also reduced. Another positive impact is that the Schaefer bins are manufactured using a minimum 35% recycled materials (Busch Systems).

This change would have the negative effect of increasing gas emissions due to increased truck use. Whether this increased truck use would create more emissions than the manufacture of plastics is difficult to assess, however the increased truck use would certainly not contribute to filling up landfills and water pollution to the extent that plastic does. Another impact to consider is the extra use of the bin washing machine. The machine is powered by electricity and uses water and detergent to clean two bins at a time. Most of British Columbia's electricity is generated by hydroelectric dams (Plutonic Power Corporation). Hydro power is proven to produce significantly lower levels of greenhouse gases on a yearly basis compared to other energy sources such as natural gas. In a study by Lenzen, it was found that the intensity of greenhouse gases created by hydro power is 15 g CO_2-e/kWh, with the next closest being wind power at 21 CO_2-e/kWh (Lenzen, 2008 – see table 3).

Table 3 –Greenhouse gas intensity by power source (Lenzen, 2008 pp. 8)

Electricity technology	Energy intensity (kWh_{th}/kWh_{el})	Greenhouse gas intensity (g CO_2-e/kWh_{el})
Light water reactors	0.18 (0.16 – 0.40)	60 (10 – 130)
Heavy water reactors	0.20 (0.18 – 0.35)	65 (10 – 120)
Black coal (new subcritical)	2.85 (2.70 – 3.17)	941 (843 – 1171)
Black coal (supercritical)	2.62 (2.48 – 2.84)	863 (774 – 1046)
Brown coal (new subcritical)	3.46 (3.31 – 4.06)	1175 (1011 – 1506)
Natural gas (open cycle)	3.05 (2.81 – 3.46)	751 (627 – 891)
Natural gas (combined cycle)	2.35 (2.20 – 2.57)	577 (491 – 655)
Wind turbines	0.066 (0.041 – 0.12)	21 (13 – 40)
Photovoltaics	0.33 (0.16 – 0.67)	106 (53 – 217)
Hydroelectricity (run-of-river)	0.046 (0.020 – 0.137)	15 (6.5 – 44)

The operator of the washer estimates that the machine uses about 3 litres of water per wash cycle and that each wash cycle lasts 4 minutes (Beaudrie, Bin washer facilities tour, 2010; Wongharichao, 2008). As several bins would be washed on a daily basis, a significant amount of wastewater would be created. The detergent used is highly basic, with a pH of 13-14, but with further research it may be found that the water can be collected and reused as greywater (MChem).

4.3 Social Assessment

If UBC switches from plastic bags to bin washing, then there would most likely be new jobs created on campus for bin collectors and cleaners. The social downside is that there will be a loss of income and possibly jobs for the companies such as Acklands Grainger that provide the university with garbage bags.

As for the jobs on campus, truck drivers and machine maintenance personnel would have to be hired in order to transport the bins around campus and make sure that the bin-washers are operating at an optimal level. While less usage of environmentally damaging plastic bags will be required if the bin-washing method is implemented, this method is arguably less sanitary for the janitors who have to handle bins that emit foul odours. With some careful assessment, hygiene issues do not appear to be a deterrent for the implementation of the new method as those who apply for the jobs know exactly what to expect.

Additionally, bins from Busch systems are manufactured in Canada and the U.S, which means that no sweatshop labour from third world countries is used in their manufacture. Some plastic bag companies can build factories in other countries to take advantage of cheap labour. Therefore, if plastic bags are not used, then labour laws will not be taken advantage of. There are, of course, health benefits of bag-free garbage collection which ties in with the environment assessment section. By minimizing our use of garbage bags, less plastic would get into our water and food supplies, reducing harmful health effects. Animals will also be less likely to be harmed from consuming.

5.0 CONCLUSION AND RECOMMENDATION

Based on the triple bottom line assessment, regular plastic bags are not a favourable option because they cost $157,353 more yearly than the current degradable bags option. They also pollute the environment and harm the health of wildlife and humans. While the degradable bags are a better option economically, they pose many of the same environmental and social problems of the traditional plastic bags as they often do not break down as intended. There is no evidence that proves 100% degradability of degradable bags in the landfill and the small plastic pieces might be left in the environment.

The bag-free option incurs net yearly costs of $31,467 if one extra truck is purchased, but will sustain the environment by reducing pollution. Reduced pollution means that there will be less people and wildlife suffering from health problems. Due to the harmful impacts of plastic bags, many companies in Canada such as Zellers and Ikea have begun to promote the reduction of plastic bags by charging customers fees to use them. UBC should also help protect the environment by reducing the use of plastic bags. The environmental and social benefits of the bag-free option outweigh the higher economic costs. Till the time we cannot find a plastic that is completely degradable within a short period of time and does leave any harmful effects, we recommend switching to bag free system in UBC.We also recommend that further research be done to obtain more accurate economic figures and the power usage of the bin-washer, and provided these figures hold well, we believe UBC should implement bag-free garbage collection on campus.

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LIST OF APPENDICES

APPENDIX A

	Total Amount	Lifetime (Years)	Amount/Year
1 new truck	$175,000	15	$11,667
Maintenance for 1 new truck	$12,000	1	$12,000
Fuel for 1 new truck	$30,000	1	$30,000
New bins	$267,000	15	$17,800
2 new drivers	$80,000	1	$80,000
Savings on degradable bags	-$120,000	1	-$120,000
			Extra costs: $31,467

Extra costs incurred for bagless option