An Investigation into the Life Cycle Analysis of Bags Used for Food Scraps Collection

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AN INVESTIGATION INTO THE LIFE CYCLE ANALYSIS OF BAGS USED FOR FOOD SCRAPS COLLECTION

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ABSTRACT

As a university dedicated to sustainability through initiatives such as “Zero Waste Campus,” UBC is continually looking for ways to improve its sustainability throughout its daily operations. One such area of concern for UBC Operations is the use of plastic bags in the collection of food scraps across campus. Partnering with the UBC SEEDS program through SEEDS sponsor Mr. Bud Fraser, an investigation was conducted pertaining to the “Life Cycle Analysis of Bags Used for Food Scraps Collection” at UBC.

Research was conducted using both primary and secondary sources with an emphasis on analysis through the Triple Bottom Line (TBL) approach. Primary sources included a Q&A workshop with Mr. Fraser in addition to a tour of the composting facility, and secondary sources included a wide variety of peer-reviewed and popular sources. A number of environmental, economic, and social indicators were used to help conduct this TBL analysis. The indicators focused on within this report include the GHG (greenhouse gas) emissions per bag at every stage during their lifespan, the amount of water required to make a bag, the economic cost of different bag types, the cost of maintaining compost bins, and the effects that the type of bag has on the daily routines of UBC Operations staff.

After assessing and comparing three alternatives to standard plastic bags (paper, compostable plastic, and no bags) using the Triple Bottom Line approach, it was concluded the best course of action would be to discontinue the use of plastic bags and begin to use paper bags as the primary liners for small compost bins. In addition to switching to paper bags, it was concluded that utilizing plastic bags as a security liner and using binder clips to keep the paper bag in place would ultimately result in a system which is ecologically friendly while not a burden on operations staff.

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1.0 INTRODUCTION

Since its compost facility opened in 2004, UBC's emphasis on developing solutions to manage and process compost has made the university into a nationwide leader in sustainability. UBC's innovative in-vessel composting system, the first of its kind at any Canadian university, has allowed the university to truly influence how compost is managed after it is collected while simultaneously acting as an educational model for waste management ("Composting at UBC", 2016). In an attempt to further push the limits of how we view waste production on campus, UBC has set ambitious goals through its Waste Action Plan – aiming to increase the diversion rates of waste away from landfills to 80% by 2020 (Waste Action Plan, 2014). In order to achieve this goal UBC has placed a large amount of emphasis on reducing inefficiencies present within our on-campus waste management systems. The focus of this report is to examine one of these issues, mainly the use of plastic bags within UBC's compost collection bins, and to provide suggestions as to how to mitigate the problem presented.

To collect waste, compost, and other recyclables, UBC relies on the public to personally sort their waste at strategically placed bins across campus. While there are a wide variety of bin types used, compost is commonly collected through two different types of bins, as follows:

"Sort it Out" bins (Figure 1) are used in areas with high foot traffic and/or with a higher than normal waste/compost production rate (such as cafeterias). These permanently installed bins

Figure 1 - Sort it Out Bin
Source: http://blog.students.ubc.ca/ubcfyi/files/2014/08/sort-it-out.jpg

house unlined 35-gallon green carts to store compost alongside similarly-sized bins to store waste and other recyclables. Rather than being emptied when they have filled up, these full 35-gallon green carts are swapped with empty ones by custodial staff and are transported to UBC's composting facility as-is. These bins are then emptied, washed, and placed back into circulation.

"Waste Watcher" sorting bins, as seen in Figure 2, act similar to traditional office-style trash bins. Waste Watcher bins hold the same types of waste as Sort it Out bins and are used in areas where the size or movability of the Sort it Out bins would be restrictive (such as hallways and medium-sized presentation rooms). Instead of transporting each individual Waste Watcher bin segment to the composting facility, these bins are lined with plastic bags which allow for the removal of compost without physically moving the Waste Watcher segment. Upon collection, these bags are emptied into the larger 35 gallon green carts (the same type as the ones found in the Sort it Out bins) and the plastic bags which contained the compost are separated and placed into the trash.

Figure 2 - Waste Watcher Bins
Source: Personally Captured

1.1 ISSUES WITH THE CURRENT COMPOSTING SYSTEM

While the Waste Watcher line of sorting stations have no doubt been successful in making composting more accessible for students and faculty across UBC, the use of plastic liners within their composting compartments presents a large ecological burden. There are approximately 500

Waste Watcher bins currently in use across campus, and each of these bins is emptied once every one to two days (excluding weekends) (Fraser, 2016). Assuming that there are 250 weekdays in a year we find that approximately 62,500-125,000 bags are used by UBC over the course of a year just to line the compost portions of the Waste Watchers.

Beyond the ecological impact of throwing away tens of thousands of bags each year, the use of plastic bags causes additional problems during compost processing at the on-campus facility. While the plastic bags are meant to be separated from the compost before the compost is processed, in actuality operations staff have found that these bags regularly find their way into the compost stream. These bags often enter the in-vessel composter due to a lack of pre-screening at the facility, and resultantly get stuck within the chains of the machinery. Beyond posing a risk to the composter, these stuck bags require composting staff to regularly shut down the plant and climb into the composter to cut them away – a large social and economic burden.

1.2 OUR INVESTIGATION'S FOCUS

After discussing the project with our SEEDs advisor Mr. Bud Fraser, we opted to break down our investigation into two interconnected parts with an emphasis on the Triple Bottom Line:

- Investigating and proposing several different compost collection solutions specific to the needs and challenges faced by the composting system at UBC (with an emphasis on Waste Watcher bin liners)
- Investigating the environmental and economic impacts of each proposed compost collection solution based on pre-existing research in this field

To outline our results of these two investigations, in this report's body we will detail each of our proposed solutions in depth with a Triple Bottom Line Approach. We will also discuss information we gathered during our primary investigation (including details regarding our site visit) and provide conclusions based on all of the data we have acquired.

2.0 PLASTIC BAG ALTERNATIVES

After an initial discussion with our peers, tutorial instructor, and project coordinators, our group brainstormed several solutions to the issue of plastic bag consumption in Waste Watcher compost bins, as outlined in this section. Throughout this section we will take the Triple Bottom Line approach, allowing us to evaluate the performance of solutions based on their environmental, economic and social impacts.

2.1 SOLUTION INTRODUCTIONS

2.1.1 Compostable Plastic Bags

The first bag replacement type we investigated are compostable plastic bags, sometimes referred to as biodegradable bags. These bags are made of renewable resources (such as starch and other plant-based products (Manchanda, Tougas, & Fisher, 2010)) which can biodegrade in traditional composting settings. This solution is immediately notable for the lack of change required to UBC custodial operations protocol if implemented: a transition to compostable plastic bags would require little to no changes to bin structure or custodial staff training. Examining this bag type further, however, we find that the on-campus compost facility found at UBC is not immediately compatible with these bags. While these bags do degrade slowly over time, their degradation rate is not fast enough to properly decompose in the in-vessel composter at UBC (causing similar problems as compared to traditional plastic bags).

2.1.2 Paper Bags

The second bag alternative we investigated are compostable paper bags. These semi-rigid bags are completely degradable and compatible with the current UBC composting system, however they tend to be more expensive than the other bag alternatives (as discussed in the next section). Due to their rigidity we also find that issues arise in the fit of the paper bags in the Waste Watcher bins – a problem compounded by the fact that the Waste Watcher bins are in an unusual size which don’t fit a large amount of paper bags on the market. Without corrections, these sizing issues might result in compost falling between the bag and the bin, resulting in unwanted odours.

2.1.3 No Bags

The third bag alternative we investigated was to use no bags in the Waste Watcher bins and instead regularly empty and clean them manually. While this results in no plastic waste as a result of throwing away garbage bags, this solution is significantly more labour intensive than the other proposed bag types (operations staff would have to regularly lift the Waste Watcher bins and clean them out to prevent odours).

2.1.4 Transitioning to Different Bins

Upon suggestion by our tutorial instructor, we additionally investigated a transition to smaller bins which would replace the current Waste Watcher bins utilized on campus. These smaller bins, potentially similar to the small compost pails commonly used in residences, would require no awkward lifting by operations staff and would be significantly easier to clean. Upon further conversations with waste management staff however, we found that smaller compost pails would have to be emptied at an unfeasible rate and might cause a mess if they are tipped over. It is also important to recognize that UBC has made a significant investment in purchasing the Waste Watcher bins, and suggestions to transition away from them are highly unlikely to be implemented. As a result, we did not investigate this solution any further.

2.2 ENVIRONMENTAL IMPACTS

In this section, we examine data presented by Chet Chaffee and Bernard R. Yaros. While the study in which this data is presented documents the use of biodegradable plastic and paper grocery bags, we can easily extrapolate data from this set to examine the differences in environmental impacts which would result from implementing each solution type (paper, compostable plastic, or no bags) in the Waste Watcher bins.

2.2.1 Greenhouse Gas Emissions

In examining the greenhouse gas emissions stemming from the entire lifespan of paper and compostable plastic bags (Figure 3), Chaffee and Yaros find that compostable plastic bags emit significantly less greenhouse gases than paper bags over their lifespan. While this can be partly attributed to the chemical makeup of compostable plastic bags in comparison to that of paper bags, this also serves as a reminder that while a paper bag and a compostable bag might hold the same amount of compost, the paper bags will be significantly heavier and thus have a higher amount of mass to degrade (potentially increasing the amount of lifetime emissions). In examining the emissions for the no bags solution, we note that while there is no quantitative data available we can assume that the cleaning supplies required to maintain the bins would roughly produce the same amount of emissions as these bag types.

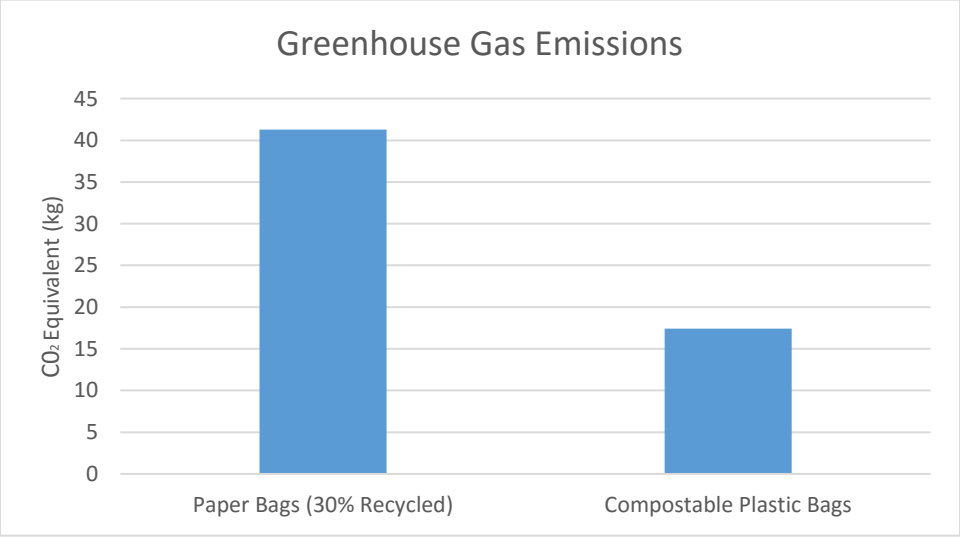

Figure 3 - Greenhouse Gas Emissions Produced by 1000 Bags over Their Lifespans
Adapted from Yaros and Chaffee (2012)

2.2.2 Water usage

Comparing the consumption of water throughout the lifespan of compostable plastic and paper bags (Figure 4), we find that paper bags require significantly more fresh water to produce than compostable plastic bags. This can mainly be attributed to the sheer amount of water required to create paper, with 324 litres of water required to make just 1 kilogram of paper ("Paper Waste Facts", 2016). Examining the water usage of the no bags solution, we find that the water consumption wildly depends on the cleaning schedules and supplies used by individual custodians (i.e. paper towel, hoses, sponges, etc.) and hence we can make no definitive conclusions as to their water consumption.

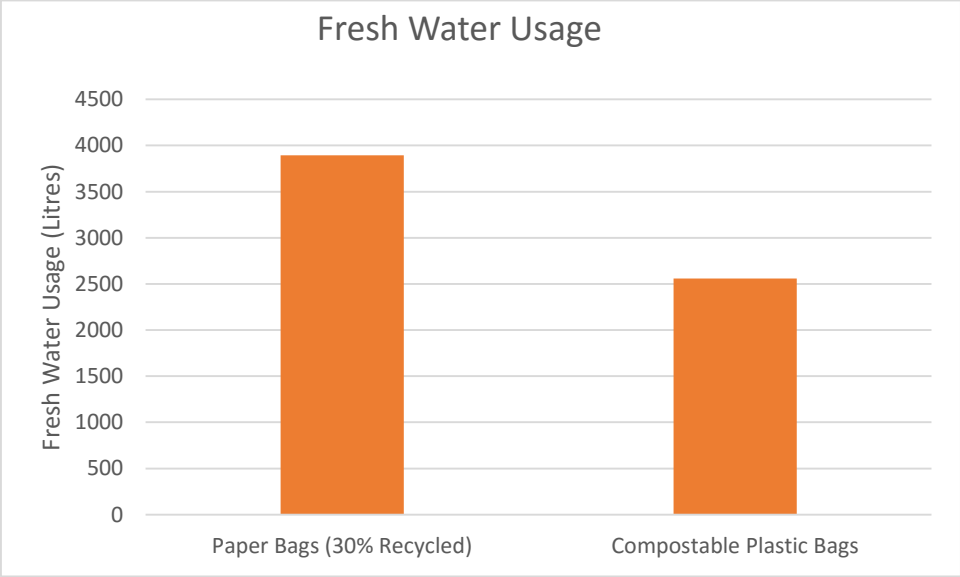

Figure 4- Fresh Water Consumed By 1000 Bags Over Their Lifespans
Adapted from Yaros and Chaffee (2012)

2.2.3 Energy and Fuel Consumption

The consumption of fossil fuels and total energy over a bag's lifespan are important indicators of the larger potential environmental impacts caused through using these bags. The consumption of fossil fuel tends to be greater for compostable bags while paper bags require a larger amount of total energy over their lifespan, as seen in Figures 5 and 6. These results are to be expected, as while the compostable plastic bags are made of fossil fuels (and hence consume

more as a result), we have previously seen that the process of creating paper is very resource heavy and thus these bags take more energy to produce. For the no bag option, the consumption of fossil fuel and energy is considered to be zero as the bins have already been purchased and the cleaning supplies will likely hold a negligible effect on energy/fuel consumption.

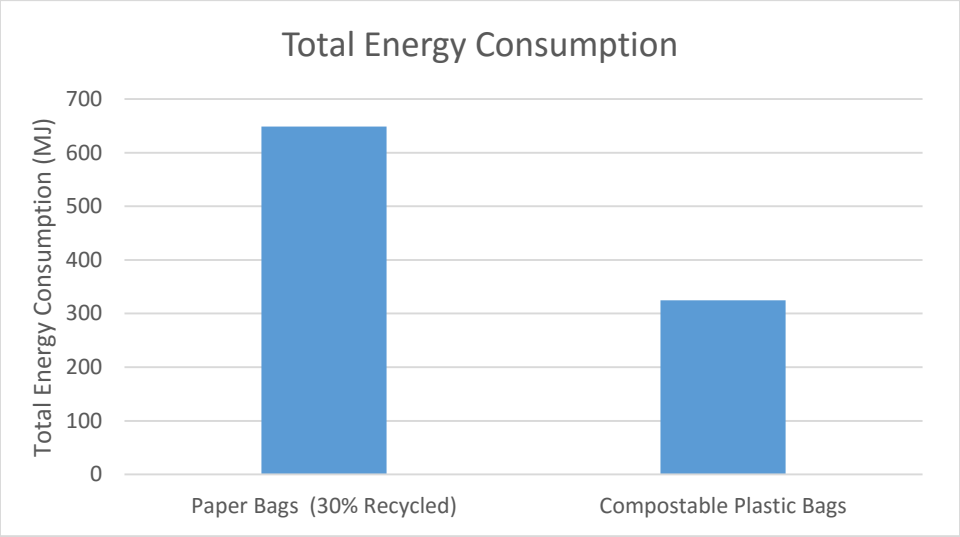

Figure 5 - Total Energy Consumed By 1000 Bags Over Their Lifespans
Adapted from Yaros and Chaffee (2012)

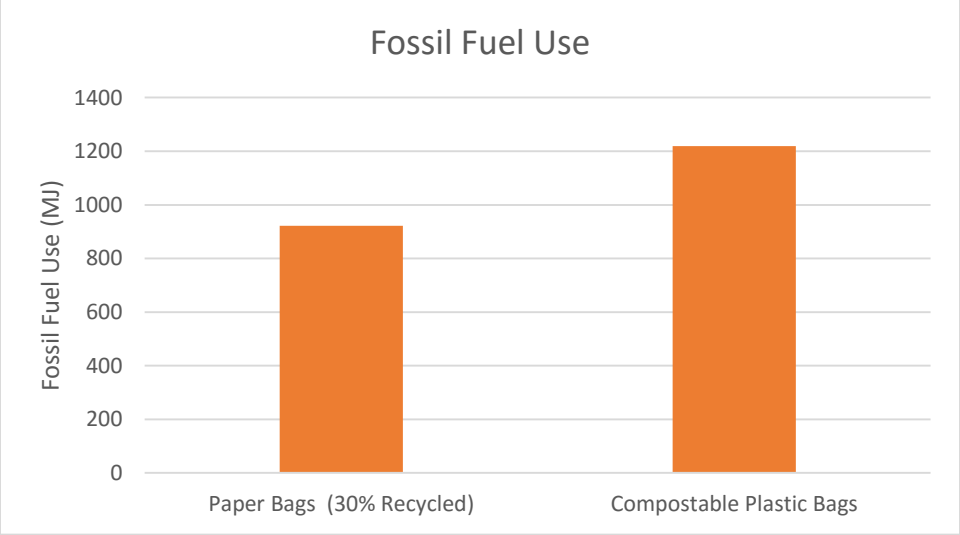

Figure 6 - Total Fossil Fuel Consumed By 1000 Bags Over Their Lifespans
Adapted from Yaros and Chaffee (2012)

2.3 ECONOMIC IMPACTS

2.3.1 Basic Costs

We first must note that the price of compostable and paper bags are dynamic and vary significantly based on exchange rates, available manufacturers, and current market outlooks. As a result, the costs of each bag type are presented in a range and not as a fixed number.

Based on a recent price list found online, the price of regular size compostable plastic bag varies between 15 to 30 cents (York Region, 2011). As described in Section 1.1, we find that there are approximately 500 bins which are approximately emptied every second day. Resultantly, we find that the price range for the use of compostable plastic bags for a year is

$$\$0.15\sim0.30*500 \text{ bins}*125 \text{ days} = \$9,735\sim\$18,750$$

From the same price list we additionally find that the price of a regular sized paper bag lies between 50 and 80 cents. Performing the calculation once more yields

$$\$0.5\sim0.8*500 \text{ bins}*125 \text{ days} = \$31,250\sim\$62,500$$

Once again, we find that since there exists a wide variety of cleaning methods which could be used to clean the bins, determining a price range for this solution is very difficult. Let us examine one scenario wherein we clean the bin with a moist wipe which costs $0.10. Performing the calculation yields

$$\$0.10*500 \text{ bins}*125 \text{ days} = \$6,250$$

It is important to note, however, that it takes significantly longer to clean a bin than it does to simply remove a bag. Assuming that emptying and cleaning takes 3 minutes per bin and the custodial staff is paid $12/hr, we find that

$$0.05\text{hr} * \$12/\text{hr} * 500 \text{ bins} * 250 \text{ days} = \$37,500$$

Hence, the total cost for a no bag solution would likely be $43,750 per year

These cost calculations can be summarized as follows:

Type	Annual Cost
Compostable plastic bags	$9,735~$18,750
Paper bags	$31,250~$62,500
No bags	$43,750

Table 1. Estimated Annual Costs of Three Traditional Bag Alternatives

2.3.2 Other economic factors

Although we have found that the cost of using compostable bags is theoretically the cheapest among the three solutions considered, recall that UBC's in-vessel composter is not compatible with compostable plastic bags and thus they would have to be separated and processed separately as a result (a solution unfeasible due to staffing, land, and equipment constraints). In addition, as the manufacture of compostable plastic bags is a fairly niche market, the market price might swing dramatically based on stock levels and raw material pricing (Manchanda, Tougas, & Fisher, 2010).

2.4 SOCIAL IMPACTS

During our discussions with on-site personnel during our site-visit to the composting facility (see Section 3) we found that the site operators were very enthusiastic about transitioning to paper bags due to their 100% compatibility with the current system. This transition would significantly cut down on the number of bags which inadvertently enter the composter and thus reduce the amount of potentially unsafe maintenance work that the site operators must perform.

Due to the absorptive properties of paper, if compost is left within the paper bags for an extended amount of time custodial staff might find that the bags might lose structural integrity and fail, dropping all of the compost contained within them as a result. Any subsequent cleanup would no doubt burden the custodial staff and might result in unpleasant odours and liquids being released into the area in which the bin is in.

3.0 SITE VISIT SUMMARY

To further investigate the impact of plastic bag contamination and examine additional potential bag replacement options, we visited UBC's on-campus composting facility on March 18th, 2016. Key observations that we noted (and took photos of) are as follows:

Figure 7 – Bags Caught in In-Vessel Composter

While the plastic liners currently used are supposed to be separated from the compost before processing, operations staff found that they are often inadvertently mixed into the compost and get caught in the in-vessel composter (as seen in Figure 7). Removing the bags tangled in the system requires shutting down the entire composter for hours at a time, resulting in a large drop in efficiency.

A majority of the compost facility's land is used for compost processing and storage (as seen in Figure 8), leaving little space for future expansion. Solutions which would require a large amount of unused area, such as a separate compost pile for compostable plastic bags, are thus unfeasible.

Figure 8 – Compost Storage Piles

Figure 9 – Compost Processor

Upon arriving at the composting facility, compost bins from across UBC are lifted and emptied into the compost processor (as seen in Figure 9). It is important to note that the compost is not sorted before being emptied into this processor due to a lack of space and general resources. This limitation prevents us from separating compostable plastic bags before they enter the composter and processing these bags separately (either on-site or at an external facility).

4.0 RECOMMENDATIONS AND CONCLUSION

After conversations with UBC Operations staff and carefully examining the research presented within the previous sections, we arrived at a two part conclusion. The underlying solution section provides our overall conclusion and its rationale. The overlying adaptations section suggests further actions which could supplement our conclusion by mitigating the remaining issues with our given solution.

4.1 UNDERLYING SOLUTION

We came to the conclusion that the underlying solution to this issue would be converting to the use of paper bags in the "Waste Watcher" sorting bins. Below is our rationale of our choice, presented with a triple bottom line approach.

Environmental

While paper bags emit more greenhouse gases than compostable plastic bags, the environmental difference between the two is not overly prohibitive. It can be concluded that the use of paper bags will significantly decrease the amount of waste that UBC generates from plastic bags while simultaneously contributing to the quality of the compost produced.

Economic

Economically, paper bags are more expensive than plastics and thus would require the university to spend more on sustainable operations on an annual basis. Paper bags are, however, compatible with the current composting system and would not require any (very costly) system modifications to be performed. Their use would additionally reduce the amount of maintenance required at the composting facility (workers would no longer need to cut loose the plastic bags that get caught in the composter's machinery), and could potentially save the facility from repair and replacement costs.

Social

Socially, using paper bags would bolster UBC's reputation as a sustainable campus as it would prove that we are making serious efforts towards becoming a zero waste campus. Moreover, using paper bags would not require the bins to be cleaned frequently and would not drastically

reduce the efficiency of the custodial staff (an issue experienced when using no bags). In addition we found that the workers at the composting facility would no longer have to go into the composter to cut loose the plastic bags, allowing them to avoid potentially dangerous working conditions.

4.2 OVERLYING ADAPTIONS

We came to the conclusion that there are two overlaying adaptations to this issue that can be implemented in order to strengthen the effectiveness of the underlying solution (converting to paper bags). The two overlying adaptations are as follows:

Adding Binder Clips to Secure Paper Bags

We came up with the solution that binder clips can be utilized to secure the paper bags within the Waste Watcher bins. At least two clips on each side of the bin would ensure that the paper bag remains open and properly aligned so that it will effectively receive all of the organic waste that is deposited within the bin. This would counteract the concern that paper bags are unable to effectively line bins (as they tend to naturally fold onto themselves), allow for paper bags that would not normally fit the bin, and ensure that the liners are always effective in receiving organic waste.

Figure 10 - Binder Clip
Source:http://ecx.imagesamazon.com/images/I/611VIqwdcqL._SL1038_.jpg

Repurposing Plastic Bags as Lining

We additionally came up with the solution to repurpose the plastic bags which currently hold compost to instead line the Waste Watcher bins underneath the paper bag. This will ensure that if the deposited food waste is not received by the paper bag it will not dirty the bin. This plastic lining would have to be changed at a less frequent rate (e.g. once every ten collection cycles) and would still drastically reduce the plastic consumption from current levels.

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