An Investigation into Plastic Bag Alternatives and Plastic Bag Disposal on Campus

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Abstract

This investigation attempts to address the problem of plastic bag contamination in the compost bins on UBC campus. It has been noted that a significant number of plastic bags are ending up in these bins, and the reasons for this are not clearly understood. There are other harmful items that also end up in these compost bins, this investigation is restricted to contamination by plastic bags.

One large constraint is that research was only performed within UBC campus, and no data was collected from elsewhere in Vancouver. Additionally, access to residential areas was limited. The composting and garbage disposal areas were, understandably, not publicly available, and as such, little data was collected from residences. Method- The primary investigation consisted of two components, one being actual field work, in which several dozen compost bins, standalone or otherwise, were searched in their entirety in an attempt to locate any plastic bags inside. The second part of the primary research was strictly observational. People that utilized the bins were observed, and certain recurring behavioural patterns were noted and later analyzed.

In searching through compost bins, it was discovered that many of the bags that end up in the compost bins are from the UBC Village area, where many students go to retrieve take-out food. It has also been noted that in compost bins not coupled with a garbage bin, the plastic bag count was significantly higher. Through the observational portion of the investigation, it has been discovered that much of the aforementioned contamination is caused by effects that are primarily psychological in nature. It appears that many people that are somewhat new or unfamiliar with UBC's composting system tend to be influenced by the signage that appears on the bins themselves. Also contributing to the ambiguity is the lack of clear labeling of compostable items. Through these observations, it is clear that most of the contamination occurs without malicious intent on the part of the student. On the most part, students are willing to participate, but seem to get frustrated or otherwise confused by the visual cues on the bin displays and on the disposable items.

It appears that the visual displays above waste bins at UBC are far more important that one may realize. The exact message that the symbols are designed to deliver is not in question, and it is only the interpretation that is suspect. Students are unsure as to what really is compostable. The distinction between food and food containers must be made clear. The signs above the bins must

change and perhaps have a more descriptive list as to what cannot be composted. The red “STOP” signs above the garbage bins should either be removed, or analogous signs could be placed atop the compost bins, to draw more attention to the issue of potential contamination. Not only should the bin displays be improved, but also the disposable items themselves should be labeled. Many of the compostable containers designed to be composted right here at UBC are not labeled as such and get thrown in the garbage bin. As elaborate as the designs are already on these containers, a small note letting the user know whether or not the item is compostable would be a welcome addition. The financial costs of implementing these changes would be small, and in light of the evidence discovered in this investigation, they could significantly reduce the problem of plastic bag contamination in compost bins.

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1 Introduction

The use of plastic bags has been a topic of controversy in recent years, often criticized as creating an unnecessary excess of landfill waste. The chemical properties of plastic bags also make them an exceptionally severe contaminant of compost and composting facilities. Many solutions have been proposed in the form of alternatives to plastic bags, though these come with problems of their own, often involving much higher production costs and negligible improvement in biodegradability. It is possible that with upcoming technologies a more viable alternative may be found. The impacts of each potential alternative must be closely evaluated in terms of social, economic and enviromental effects, in order to be adequately compared to currently used plastic bags. It is also possible that the presence of plastic bags as a compost contaminant can be mitigated through other means, and as such it is important to explore methods of improving waste management infrastructure in order to discourage contamination.

2 Plastic Bag Alternatives

2.1 Polyhydroxyalkanoate (PHA) based bioplastics

Polyhydroxyalkanoates (PHAs) are one of the most well known biodegradable alternatives to petroleum-based plastics. PHAs are susceptible to a wide variety of degradation methods, including exposure to soil, compost, and a wide variety of microorganisms (Reddy, C. S. K., Ghai, R., Rashmi, & Kalia, V. C. , 2003, p. 143), making them a suitable replacement for the more commonly used petroleum-based plastics. However, limitations with the use of PHAs do exist, primarily regarding cost and production waste.

Environmental Assessment

The most significant reason why PHAs are considered to be one of the more suitable replacements for petroleum-based plastics is the flexibility in degradation. PHAs have been seen to reach levels of up to 85% degradation within a period as short as seven weeks (Reddy et al., 2003, p. 143). However, LCA reports of PHA compared to those of polyethylene (PE) production show an increase of up to 69% in production impact (Khoo, H., Tan, R., & Chng, K. , 2010, p. 292). Similarly, CO2 landfill emissions of PHAs have also been found to be significantly higher than that of PE emissions (Khoo et al., 2010, pp. 341-342), which raises questions of whether or not the benefits of PHAs in proper composting situations outweighs the environmental impacts created throughout the life cycle of PHAs.

Economic Assessment

In comparison to common petroleum-based plastics such as polyethylene, the use of PHAs present another problem. The cost of PHA is significantly higher than that of PE and other common petroleum-based plastics. Current production costs lie at around 3-5USD/kg (Reddy et al., 2003, p. 143), compared to production of polyethylene at around 1.5USD/kg (Naylor, L., 2013, p. 50). Having a

cost of around 2-3 times as much as polyethylene provides quite a challenge in the adoption of PHAs as a replacement to common petroleum-based plastics such as polyethylene. Along with this, PHAs show a much lower extension to break at around 5% compared to polypropylene at 400%, creating a much more brittle plastic less suitable for plastic bag use (Sudesh, K., Abe, H., & Doi, Y. , 2000, p. 1524).

Social Assessment

The need for a replacement of petroleum-based plastics has been growing within the last decade, and as public awareness of our current issues with waste grows, the social attitude towards biodegradable plastics will become increasingly positive. With PHAs being one of the most popular biodegradable options available, and with an increase in awareness, use of PHAs may find their way as a replacement to common petroleum-based plastics.

2.2 Polylactic acid (PLA) based bioplastics

Polylactic acid (PLA) is another biodegradable plastic commercially available as an alternative to the petroleum-based plastics used today. PLA can be produced from a variety of natural processes including during fermentation of sugars and other starches, and are found naturally in the body of mammals (Sin, L. T., Rahmat, A. R., Rahman, W. A. W. A., & Knovel Plastics & Rubber Library - Academic Collection. 2012. p. 72). PLAs are regarded as a possible alternative due to the wide variety of processes that can induce degradation of PLAs. However, similar to PHAs, PLAs suffer from similar problems including cost and reliability.

Environmental Assessment

PLAs are susceptible to a wide variety of degradation processes, which makes it suitable for disposal in either landfills or compost. These processes include thermal activation, hydrolysis, biological activity, oxidation, photolysis, and radiolysis (Madhavan Nampoothiri, K., Nair, N. R., & John,

R. P., 2010, p. 8497). However, LCA reports of PLAs show promising results. Emissions through the production of PLAs using sugarcane have been found to be far lower than the petroleum-based plastics (Groot, W. J., & Borén, T., 2010, p. 978).

Economic Assessment

The cost of producing PLAs is one of the challenges holding back widescale use of PLAs. Currently, the price for producing PLAs lie at around 2.2USD/kg though this is expected to decrease as manufacturing gets more widespread (Madhavan Nampoothiri et al. 2010, p. 8499). Compared to the cost of polyethylene at around 1.5USD/kg, use of PLA is significantly more expensive. Along with this, PLAs face problems with being brittle, similar to PHAs in comparison with PE.

Social Assessment

Due to the properties of PLAs and the need for biodegradable alternatives to our current petroleum-based plastics, PLAs are showing promise in the market for biodegradable plastics. Growth of the PLA plastics market is seen to be around 20-30%, and is expected to increase as PLA prices go down (Madhavan Nampoothiri et al. 2010, p. 8494). Application of PLAs are limited by the thermal resistance and moisture barrier, which may cause failure during use (Madhavan Nampoothiri et al. 2010, pp. 8499-8500).

2.3 Polyhydroxybutyrate (PHB)

Comparing to PHA and other biodegradable materials, “poly(3-hydroxybutyrate) (PHB) has been studied most extensively and has triggered commercial interest in this class of polymers.” (Ju¨rgen Scheller, 2005, p191) Also, one of the noticeable property differs it from PHA is, since PHA is categorized as short-chained monomers, the material is more stiff than PHB which is a long-chained monomers. (Ju¨rgen Scheller, 2005, p192) However, in contrast of the petroleum polymers, PHB do have its flaws during its production process, cost, and most importantly, the impact to nature after the

material is degraded.

Environmental Assessment

Even though, comparing to petroleum polymers, PHBs are biodegradable which seems to be more eco-friendly, its residue issue generated during the degrading process is still yet to be solved in the future research. Researches have shown that PHB accumulation is found in plant growth which could possibly leads to chlorosis, male sterility and growth retardation. The PHB production in transgenic plants aimed at higher accumulation without side-effects needs to be further improved in the future studies. (Ju¨rgen Scheller, 2005, p194)

Economic Assessment

“It is a fact, at the present state of technological development, that the bioprocess used for PHB production requires more energy than do those for most petrochemical plastic resins.” (Nonato, 2001, p5) In comparison to the petroleum polymers, PHB still presents a problem. According to , the current production cost of PHB lies around US$5.85 per kg (Nonato, 2001, p4) whereas the petrochemical is below US$1 per kg which is almost 5-6 times more than the petroleum polymers.(Ju¨rgen Scheller, 2005, p194)

Social Assessment

Also, according to Ju¨rgen, PHB also weight 15% more than petroleum plastic bags. Tore is also easier to generate comparing to the regular plastic bags.(Ju¨rgen Scheller, 2005, p194) At present, it is not clear whether stable high-level polymer production can be obtained without severe side-effects, such as growth retardation and improving these shortcomings with further researches.

3 Plastic Bags in Compost

The misplacement of plastic bags in compost bins has been identified as a significant problem at UBC, and results in a failure of the composting program to operate at maximal effectiveness. If they are to efficiently manage compost in the volumes produced by UBC, it is not feasible for composting facilities to separate plastic bags and other contaminants from compost before processing. Consequently, compost bins that are found to be overly contaminated are emptied into garbages, ultimately wasting the effort required to set up the composting programs and producing unnecessary waste in landfills. Given that the problem cannot feasibly be addressed by increasing labour and capital costs of composting facilities (as would be required for separation of contaminants from compost), it is important that we investigate the causes of improper disposal of plastic bags in compost, in order to suggest viable ways to minimize the problem.

Firstly, let us acknowledge that the problem here is primarily a behavioural one, and could in theory be remedied by increasing awareness of composting and somehow discouraging the lack of consideration for composting implied by the existence of these behaviours. However, an attempt to mitigate the problem using social initiative could be difficult and could take a very long time to take effect. It is possible that the problem could be reduced significantly by relatively simple changes to the organization and infrastructure of campus waste programs, and we hope in this investigation to identify some of these potential changes and to make valuable recommendations for solutions.

In an effort to better understand the degree to which plastic bags contaminate compost bins at UBC, we conducted an investigation of compost bins in and around academic buildings and at residence halls on campus, in addition to examining nearby garbage bins for comparison. We kept record of the number of plastic bags, and the presence of other contaminants, in compost bins at different locations, and looked for patterns and relations to help identify causes of misuse.

A clear observation is that the extreme cases of contamination occur almost exclusively in

compost bins that are not in close proximity to garbage bins. The converse is also true, to a lesser extent: the presence of food and compostables in garbage cans is more evident in the absence of a nearby compost bin. The reasons for this are understandable: a person looking to dispose of an item will often, depending on their level of awareness and concern for waste management, dispose of it in any nearby waste container he/she can access conveniently. Also, where compost bins and garbage containers are grouped together, there is often a clearer indication of where to dispose of different types of waste. In response, we recommend that compost bins be placed so as to coincide with garbage bins, reducing incentive for incorrect disposal.

Another likely cause of compost contamination, specifically by plastic bags and plastic containers, is the failure of the displays above many compost bins to emphasize that plastics should not be disposed in them. Though most compost bins have a “No Plastics” indicator above them, it is subtle and does not stand out against the rest of the display. A person without a thorough understanding of composting might believe that a plastic bag containing food scraps should rightly be placed in the compost, and we have seen that a significant proportion of plastic bags in compost bins do contain food waste, relative to the proportion of plastic bags in garbages. The likelihood of this is increased by the “STOP” sign graphic that is displayed above garbages, which could discourage people from properly disposing of waste that really does belong in the garbage, including plastic bags. In fact, while the other waste containers (compost, recycling) usually have indicators of what types of waste fall into their respective categories, the garbage is an exception and assumes that people know already what is to be placed there. This often creates ambiguity about where to dispose of specific items, even from the perspective of our group members and others who are knowledgeable about correct waste disposal. We have seen, while conducting our research, people that after attempting to sort their waste into the correct containers simply throw everything into one bin. Usually this is the garbage bin, which indicates that most people are mindful of avoiding contamination, but sometimes the entire pile ends up in the compost bin. It can be thought that for many people, especially when a language barrier or cultural barrier is present, the display above compost bins is much more friendly than the aforementioned “STOP” signs above garbage bins, and as such people are inclined to drop their handfuls of waste into the compost bins, which offer much less resistance.

The ambiguity about waste categorization is created not only by the displays above waste bins, but also by the lack of consistent labelling on compostable or non-compostable bags and containers. Many meals coming from UBC Food Services are served in compostable containers, but on some of these containers it is not indicated clearly that the container is indeed compostable. The same can be said about plastic bags: compostable and biodegradable bags are used, albeit perhaps uncommonly, in today's society, and many people are aware of their existence. However, the majority of plastic bags that are not compostable do not have a label indicating this. Given UBC's focus on sustainability, many people might be inclined to assume that plastic bags distributed at UBC are of the biodegradable variety, in the same way that we (correctly) assume food containers to be compostable, and this could also be a source of plastic bag contamination in compost bins. This ambiguity due to lack of labelling is another cause of the observed frustration that many people experience in attempting to sort their waste, and this frustration may cause people, on average, to take proper waste disposal less seriously than they might otherwise.

4 Conclusion and Recommendations

Based on our observations of compost bins and their users, we can make some simple recommendations to address the contamination problem. One recommendation would be to modify the displays above waste bins to target plastic bag contamination in compost. This could be as simple as adding emphasis to the “No Plastics” indicator above compost bins, similar to what has been done with the “STOP” signs described above, which would be easy to implement and would not require a thorough redesign of the displays. It is also worth evaluating the effects of the “STOP” sign on how each type of waste is disposed of. Certainly it works to encourage proper composting and recycling of food and recyclables, but it also contributes to contamination, and it is possible that the negative effects outweigh the positive. The other recommendation would be for UBC to impose a set of guidelines for the containers and bags that they distribute, requiring that plastic bags that are not compostable be labelled as such, and of course that compostable bags also be labelled accordingly. The relevance of this policy would remain to be seen, however, because a large proportion of plastic bags that end up being disposed of at UBC come from off-campus distributors, and it would be difficult to impose these guidelines on firms operating from, for example, University Village (many plastic bags that we found were identified as having come from there).

Of the more commonly used alternatives to polyethylene plastic bags, bags made from polylactic acid bioplastics appear to be the most viable due to their relatively low cost and their lower life cycle emissions. As we see more widespread use of these plastics, production costs could decrease further, closer to the costs of polyethylene bags, and these may present a practical alternative for everyday use.

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