An Investigation into Compostable Plastic Bags

APSC 262 Section 201

Pat Cramond

Johnson Chou

Rahul Garg

April 6, 2010

ABSTRACT

The purpose of this report is to evaluate the current usage and disposal of plastic bags being used at the UBC campus, as well as, to evaluate its alternatives. The two alternatives that are going to be evaluated in this report are Degradable plastic bags and Plastic Bag-Free Garbage Collection System. The report will focus on the resource and energy evaluation, economic feasibility and social implications, such as health and labor for the three options. In another words, this report will focus on the social, environmental, and economic impacts.

Degradable plastic bags are regular plastic bags that have additives in it and which are claimed to degrade with sunlight, water and oxygen. The extent to which these bags are degraded, and whether it these bags are actually worth replacing the regular bags is explored in this report.

Plastic Bag Free Garbage Collection System is another strategy that UBC Waste Management is working on. It involves, as the name suggests, a non-usage of plastic bags, and instead using bins which can be collected by garbage collectors, be cleaned by them, and then returned to the user. The report shall, also focus on the economic and resource feasibility aspects for this option over regular plastic bags and degradable bags.

Table of Contents

LIST OF ILLUSTRATIONS

LIST OF ABBREVIATIONS

HDPE: High Density Polyethylene

LDPE: Low Density Polyethylene

Mn: Mangenese

Cu: Copper

Fe: Iron

Co: Cobalt

Ni: Nickel

UV: Ultra Violet

UBC: University of British Columbia

UN: United Natio

1 INTRODUCTION

The use of plastic bags has been controversial for the past few years, with many supermarkets starting to charge a few cents per plastic bag. Plastic bags are known to be un-degradable and harmful for the environments. Alternative solutions to conventional plastic bags have been thoroughly investigated. Degradable bags are an option, but certain environmental conditions have to be met to be degradable. The extent that the degradable bags break down to is questionable and the benefits of the degradable bags are unclear. Plastic bag free garbage collection is a possibility and the water usage involved has been researched. Currently, there is a global water shortage and the benefits of not using plastic bags have to be weighed against water spending.

2 DEGRADABLE PLASTIC BAGS

2.1 CONCEPT

Degradable plastic is substance created from a polymer called Polyolefin combined with certain additives, in order for it decompose or degrade. Degradability of a material is a property of a material to break down into simpler parts by bacterial (biodegradable), thermal (oxidative) or ultraviolet (photodegradable) action. In order for polyolefin or a degradable polymer to be used as a plastic bag, it needs to comply by the following requirements:

- Be able to be formed into film,
- Have adequate tensile strength and elongation,
- Have adequate puncture resistance,
- Have adequate tear resistance, and
- Usually possess properties that resemble low-density polyethylene (LDPE) or high density polyethylene (HDPE) in overall physical properties and rheological characteristics.

The degradability of the bags needs to comply by the following requirements:

- They must disappear and leave no visible trace,
- This disintegration must occur in a reasonable timeframe (e.g. 3 months or 6 months), and
- They must not leave behind any toxic residues.

2.2 TYPES OF DEGRADABLE PLASTIC BAGS

Degradable polymers are usually classified in two different ways.

i) First is the way degradation method: If the process requires microbial action or whether they require heat, UV light, mechanical stress or water in order to break down.

ii) Second is the way they are manufactured: If they are produced using natural starch polymers, from synthetic polymers or from a mixture of a usual polymer with an additive to aid the degradation.

Polymers can degrade in different ways, such as, biodegradable, oxo-biodegradable, photodegradable or water-soluble. However, for the purpose of this report we will focus on oxo-biodegradable polymers.

The polymers are categorized into three different categories as per their manufacturing,

a) Thermoplastic starch-based polymers: These are made from a minimum of 90% renewable resources such as corn, potato, tapioca or wheat.
b) Polyesters: These are manufactured from hydrocarbons.
c) Starch polyester mixture: These are a mixture of thermoplastic starch-based polymer and hydrocarbon based polyesters.

2.2.1 OXO-BIODEGRADABLE BAGS

2.2.1.1 OVERVIEW

These bags focus on controlled degradation through the incorporation of prodegradant additive masterbatches or concentrates, which allows polymers to oxidize and embrittle in the environment and erode under the influence of weathering, pressure or agitation. Upon discarding to sites that have appropriate requirements for its degradation, oxidative degradation, which is initiated by heat, UV light or mechanical is greatly accelerated by several orders. These oxidized molecular fragments are hydrophilic, have molecular weight values reduced by a factor of ten or more, and are biodegradable.

Prodegradants in the EPI degradable plastics (and analogues by other manufacturers) include additives based on transition metal ions (Mn, Cu, Fe, Co, Ni) and metal complexes (e.g. cobalt stearate, cerium stearate), which render conventional polyethylene susceptible to hydroperoxidation. The critical point is that only trace quantities of Mn, Cu, Fe, Co, and Ni are added to the polymer and these mirror the trace elements present in most soils. Polyolefin pellets which have been compounded with these additives are processed on conventional equipment at normal speeds. An important feature of these additives is that they are activated both by the action of sunlight and by heat. The problem is that as there are quite a few solutions available and testing for efficiency becomes very difficult. Tests have shown that the bags have degraded in most systems.

2.2.1.2 DETAILS OF DEGRADTION PROCESS

The degradation of a degradable plastic bag is ideally supposed to have a mechanism which would convert the polymer into carbon dioxide (if aerobic), methane (if anaerobic) and biomass. Biodegradable polymers require microorganisms to conduct the process. However, degradable polymers require sunlight, or UV light, or mechanical stress, and water to initiate the process and convert the polymer into components that can be decomposed by microorganism's enzymatic actions. This is also defined in the European standard (prEN13432 2000).

Polyolefins are hydrophobic, and therefore, support the growth of micro flora. The oxidation products of polyolefin are proven to be biodegradable. Oxo-degradation derives its name from the low molecular weight by-products that inhibit polar oxygen containing groups like ketones, alcohols and acid. The degradation process for oxo-degradables involves two sequential steps, oxidative degradation which is an abiotic (involving water, sunlight or UV light, mechanical stress) process, followed by biodegradation of the oxidative products.

Oxidative degradation occurs starts by peroxidation, carried on radial formation to create chain scission. Oxygen and heat or mechanical stresses cause the polyethylene to preoxidate. Heat of UV light then leads degradation to free radicals. The figure below shows the chemical reactions during the degradation process.

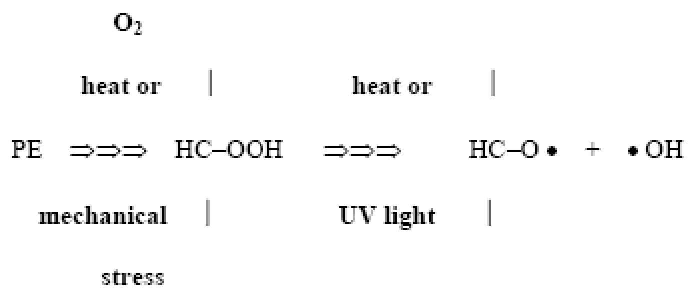

Figure 1: Degradation of peroxidation of polyethylene

To control the lifetime and the degradation the speed of the bags, the use of the pro-oxidants (prodegradants) need to be accompanied with antioxidants. The ratio between the two controls the speed at which the bag degrades. The most popular pro-oxidants are metal ions (Fe, Co, Ni) that act as catalyst in the decomposition process of hydroperoxides. Thus degradation speeds can be tailored by choosing the appropriate antioxidant to meet the requirements of various sites around the world.

Microbial heat generation during decomposition elicits oxidative degradation of polyethylene, and is aggravated due to the presence of prodegradants. Reduction in molecular weight leads to breaking of the polymer, mechanical stresses from windrow turning alleviate the fragmenting of PE film, and increases the surface area of the polymer. The microorganisms in the compost biodegrade the oxidized plastic at molar mass values at least as high as 40,000, more rapidly. Overall, the process leads to the emission of carbon dioxide in the atmosphere, which leads to an increase in the level of green house gases.

2.1.1.3 DEGRADABILITY IN A LANDFILL

Currently, there are no standards in North America of oxo-degradable bags. ASTM-6400 is the main standard for compostable bags, and stands for American Society for Testing and Materials. To meet this standard, a compostable needs be manufactured with non-toxic substances and is required to disintegrate within a short period and mineralize in ninety days (as measured by carbon dioxide evolution in lab composting environments). Earlier polymers failed to meet the ASTM standard as the failed to reach sixty percent mineralization in 180 days.

The benefits of a degradable polymer are uncertain. Degradation is much slower in dry landfill than wet landfill and degradation of organic materials could have undesirable effect on greenhouse gas generation and contamination of groundwater with leachate if they are not well controlled.

2.1.1.4 POTENTIAL IMPACT ON ENVIRONMENT

Degradable plastics have additives have that initiate their process of degradation on exposure to sunlight, UV rays, water, or mechanical stress. However, these additives may also cause a destabilizing threat to recyclable polymers if they were to be mixed with the plastic recycling stream. The consequential effect of this may be premature failure or a reduction of the structural integrity of recycled plastic pipe, plastic bins and crates and film/sheeting products. Such adverse effects can be reduced by chelating additives that prevent them from having the prodegradant effect by forming non-reactive complexes. Also, if the prodegradant products are mixed up with litter stream, they will degrade but not biodegrade, that is a failure of microbial to complete decomposition. This would result in small fragments being left over for a long time. In water, this may increase the possibility of ingestion by fish as the prodegradant additives have the property to alter their buoyancy property, and they fail to neither sink nor float.

The emission of methane instead of carbon dioxide is another concern. This only occurs if the process is anaerobic that is lack of availability of oxygen. This usually occurs in landfills that are covered up and do not have enough exposure to environment. Efforts have been made to capture the methane from such landfills, however leakages have been found. Better, methane capturing mechanisms may improve the situation.

However, recent claims by Department of Environmental Food and Rural Affairs (DEFRA) on 11^{th} March, 2010 claim that should not be sent for recycling as they can make the recyclate more likely to degrade and potentially harm packaging made from it. The study showed the ambiguity on the extent to which the particles actually degraded. The study aimed at discouraging retailers from claiming their products to be more environmentally friendly than conventional plastic.

2.1.1.5 POTENTIAL IMPACT ON PEOPLE

The traditional plastic bags are highly popular around majority of the population and the incorporation of degradable plastic bags should be highly welcomed by people as they wouldn't have to change their habits. People would tend to reuse these bags as bin liners or rubbish bags as these bags wouldn't disintegrate until exposed to the required conditions, which is the exposure to sunlight, oxygen, and micro-organism. Companies like Econogreen, claim to produce bags that last for at least two years until the degradation process can begin.

Feedback from Ritchies Supermarket, which is large supermarket chain in Australia, tells that degradable bags are a highly popular among customers. They are perceived to be environmentally friendly and seem to remove the guilt of using something harmful.

2.1.1.6 ECONOMIC FEASIBILITY

Cost is another important aspect that needs to be focused on and is a concern. Traditional plastic (HDPE/LDPE) is still relatively cheaper than oxo-degradable bags. As, the HDPE/LDPE bags cost about 1.39 cents per bag compared to the oxo-degradable ones which range from 1.71 to 23.54 cents and averages out 12.475 cents. So, traditional plastic bags are usually around ten times cheaper than the oxo-degradable ones.

3 PLASTIC BAG-FREE GARBAGE COLLECTION SYSTEM

3.1 CONCEPT

The plastic bag-free garbage collection system utilizes water to clean the garbage bins after each use. Instead of holding the garbage within a plastic bag, the garbage is dumped directly into the bin without another layer, the plastic bag. This method of choice avoids the use of plastic bags but instead consumes water in the process. The feasibility of such a plastic bag-free garbage collection system and the bin washing system required is investigated. Such a washing system will consume a significant amount of our yearly water supply. Water shortage is a known crisis all over the world. Achieving sustainability by avoiding the use of plastic bags may not be appropriate when involving the use of water. In comparison, plastic bags are also of environmental concern. Not only are they not sustainable, they are also a hazard to animal life and are dangers to children. Children around the world constantly die from plastic bag suffocations. A bin cleaning system that would collect the garbage bins on campus and then have them washed will be required to be implemented. A significant capital will be required to implement such a system. The benefits associated with such a costly system will be required to greatly outweigh the advantages of the alternatives for this method to be chosen. An investigation into the economical, social and environmental impacts of using the plastic bag-free garbage collection system follows.

3.2 WATER

Water covers 71% of Earth surface, however only 1% of that water is drinkable, [4]. Clean and fresh water are essential to all life forms so with the implementation of a system that utilizes water, the potential impacts as a result should be investigated. Even without the implementation of such a water system on campus, water resources are already becoming scarce and present us with a number of crises. Because of the importance of water to humans, the current situation of the water supply should be thoroughly reviewed before making the decision to pursue this path. By abandoning the use of plastics bags and replacing it with huge water spending may not be the smartest choice. The economical, social and environmental impacts of both choices have to be weighed against each other. The following sections investigate into the current water situation and the crisis facing us today.

3.2.1 WATER AVAILABILITY

Although water has always been abundant in Canada, water shortage is a known crisis around the world. Also in recent studies, water has been shown to be scarce in our Western Prairies, [5]. We humans are quickly using up our freshwater supplies and at the same time polluting them as fast if not faster. In many places around the world, waters are too polluted for human to drink. Approximately 80% of China's and 75% of India's waters are too polluted for drinking, fishing, and even bathing, [5]. Similar results can also be found within Africa and Latin America, [5]. By using our new and improved technologies, groundwaters are also being harvest from the ground faster than they can be replaced. Once adequate water is recovered, crops can no longer be grown in the land and another dessert will be created. With increasing human population, also results in increasing demand for water and it carries a significant impact on the environment.

3.2.2 ARGICULTURAL CRISIS

Food has always been scarce and poses a challenge to the human race. Millions of Africans are threatened with starvation, mainly due to the worst droughts in a decade [6]. Water withdrawals for agricultural use also represent 66% of the total water withdrawals enforced [7]. With the water usage increase due to lifestyle and population increasing, means that the water available to produce food and water for drinking is becoming scarce.

3.2.3 ENVIRONMENTAL CRISIS

The increased water usage by humans not only reduces the supply of water but also has a profound effect on wildlife, mainly the aquatic ecosystems and their dependent species [7]. Water pollution does not only cause water borne diseases but is also the one of the main cause, followed by over fishing, in the decline in fish populations. On land, water shortage has a noticeable effect on plant life. Lack of water prevents the growth of plants and dryness has caused a lot of the major forest fires in recent years.

3.2.4 ECONOMIC CRISIS

Water shortages in many countries have led them to construct complicated pipeline networks to move water from other places [5]. Such a pipeline, often over great distances, is very expensive. The money spent on such a system could have been used for other purposes if humans know how to conserve water better. Expensive huge dams are also built around the world to maintain a reservoir of water supplies. "Water scarcity threatens economic and social gains and is a potent fuel for wars and conflict," said UN Secretary General Ban Ki-moon [8]. Humanity had fought many times throughout history for fuel, a non-necessity. So human will definitely fight each other once again when water, a necessity to all life form, runs low.

3.3 UBC AND WATER

UBC's long-term vision is to achieve a net positive water system on campus and will find innovative ways to achieve it [9]. UBC first step to achieve the net positive water system is to conserve water. The campus has already retrofitted over 300 buildings with water efficiencies in mind [9]. With all the efforts put into achieving the net positive water system, upgrading to a plastic bag-free garbage collection system would go against UBC's long-term vision. Even if the plastic bag-free garbage collection system recycles the water, a significant amount of water would be uncollected every year.

3.4 SUMMARY

Water usage has been increasing for the past few years; meanwhile the supply of freshwater has been drastically decreasing. With the shortage of water, we are faced with agricultural, environmental and economical crisis. This is also why UBC's long-term vision is to achieve a net positive water system on campus. In order to achieve the campus' long-term vision and react responsibly to the ongoing water crisis, we highly advice the campus not to pursue the plastic bag-free garbage collection system.

4 CONCLUSIONS

In this paper we investigated two alternatives to traditional plastic bags. The first alternative looked in to was the degradable plastic bags. Even though, in the laboratory the degradable bags completely degrade, their degradability in landfill is still a matter of ambiguity. In terms of social aspects, they were very easily accepted and were in fact quite popular among the customer's in Richies, a store chain in Australia. However, investment in bags which are around ten times more expensive than the traditional ones when their purpose is still not proven may not be smart decision at the moment. It may only transfer the problem from dealing with one bag to multiple bits of a bag. For the second alternative, plastic bag free garbage collection, the problem seems to be transferred from the issue of dealing with plastic bags to water shortage. Water is very valuable, and is limited. Once again, it may not be smart to invest in system that involves a fair amount of infrastructural and habitual changes. It would be wiser, to wait for a more concrete and proven solution to invest in to rather solutions that only transfer the problem to another problem.

5 REFERENCES

[1] “The impacts of degradable plastic bags in Australia,” 2003. [Online]. Available: http://www.environment.gov.au/settlements/publications/waste/degradables/impact/pubs/degradables.pdf [Accessed: Mar. 23, 2010]

[2] Josh Brooks, “Oxo-degradable plastics 'should be incinerated', says government: download report,” 2010 [Online].Available: http://www.packagingnews.co.uk/news/989849/Oxo-degradable-plastics-should-incinerated-says-government-download-report/ [Accessed: Mar. 23, 2010].

[3] “11 common myths about oxodegradable bags,” [Online].Available: http://www.econogreen.com/11-myths.php [Accessed: Mar. 23, 2010].

[4] “Aquatell”, [Online]. Available: http://www.aquatell.com/water-tips/only-1-earths-water-drinkable [Accessed: Apr. 2, 2010].

[5] The Edmonton Journal, “Water shortage Looming Crisis for Earth,” *Canada*.com. CanWest MediaWorks Publications Inc., Mar.26, 2007. [Online]. Available: http://www.canada.com/ edmontonjournal/news/opinion/story.html?id=5fae1bbc-e8db-4edb-8a65-a0604185a9d0 [Accessed: Apr. 2, 2010].

[6] “Food Shortage in Southern Africa,” *Care*. [Online]. Available: http://www.care.org/ newsroom/specialreports/southernafrica/index.asp [Accessed: Apr. 3, 2010].

[7] “Water Crisis,” *World Water Council*. May 27, 2009. [Online]. Available: http://www.worldwatercouncil.org/index.php?id=25 [Accessed: Apr. 3, 2010].

[8] Mata Press Service, “Water Shortage in Asia,” *Asian Pacific Post*. Dec. 20, 2007. [Online]. Available: http://www.asianpacificpost.com/portal2/c1ee8c4416f9b78e0116f9d5229f0012_ Water_shortage_in_Asia.do.html [Accessed: Apr. 2, 2010].

[9] “Water,” *University of British Columbia*. [Online]. Available: http://www.sustain.ubc.ca/ campus-sustainability/campus-themes/water [Accessed: Apr. 3, 2010].