A Sustainability Comparison Between Biodegradable and Petroleum-based Plastics

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Abstract

Using corn and other more sustainable methods of producing plastic has been around for some time, but the polymer was too expensive for broad commercial applications until 1989.[1] Hughes Hybrid, a seed company in southern Wisconsin and northern Illinois, was handing out pens produced from corn over a decade ago. They were flexible and reliable, but simply a novelty. The next step was to manufacture a product out of a renewable resource that is far from a novelty: a package that has the potential to biodegrade and be mass produced. With the sudden push for environmentally friendly packaging, this has been implemented on a small scale nationwide. Companies like NatureWorks have narrowed their production line to being derived solely from corn and other renewable resources, still being able to contend with other, petroleum-based manufacturers in the plastic packaging industry. Plastic packaging, due to the fact that it is made from crude oil, has been the target of many environmental issues. Are biodegradable plastics a viable option to counter the effects of petroleum-based plastics on the environment?

Introduction

Two years ago San Francisco became the first city in the United States to ban plastic grocery bags. The options proposed in San Francisco included biodegradable plastics

and bags made from recycled paper. Since the bags were so light, they caught wind easily, finding their way into sewers and streams. Action has been taken across the globe to reduce the use of these non-biodegradable plastics. In South Africa plastic bags are referred to as their "national flower" (Cunningham, 2007), and a minimum thickness of the bag was instated, which led to the charging of bags and promoted reuse. Taiwan initiated a rule in 2003 that restaurants and supermarkets must charge customers for plastic bags and utensils. Bangladesh has recognized plastic bags as a cause of flooding and consequently banned them.

Plastic grocery bags are not the only area in manufacturing that is using biodegradable plastics for production. Polylactide (PLA), a plastic designed to biodegrade, is being used for cups and bottles. PLA can be produced from many plant starches, corn and sugarcane being the most prevalent. In 2005, Wal-Mart partnered with NatureWorks, introducing their corn-based plastic (PLA) in produce packaging throughout stores in the United States.

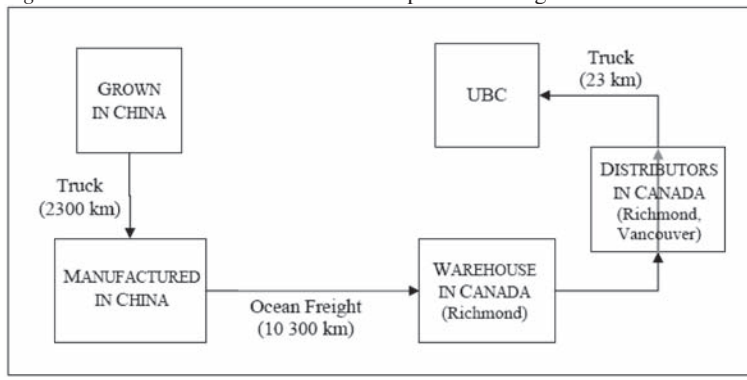
Underlying issues on the environmental friendliness of biodegradable plastics were not unearthed until a few years ago. Shifting attention from a primary energy source—oil used in the production of plastic—to a secondary one—oil used in harvesting of corn—easily confuses consumers. By advertising biodegradability, companies avoid secondary and concentrate on primary energy sources, like oil used in the production of plastic. Previous literature that was reviewed used Life Cycle Assessment (LCA) to determine overall energy use of biodegradable plastics compared to conventional plastics. "The major stages in an LCA study are raw material acquisition, materials manufacture, production, use/reuse/maintenance, and waste management."[2] Examinations of these studies look to verify if biodegradable plastics are a healthy alternative to conventional plastics.

Literature Review

A study performed by Chaffee & Yaros (2007) compared three options for grocery bags. Addressed was the newly formed opinion on the environmental impact of single-use plastic grocery bags. When comparing the typical polyethylene (PE) grocery bag to grocery bags made with compostable plastic resins—traditional plastic grocery bags use less energy in terms of fuels for manufacturing, less oil, and less potable water, and emit fewer global warming gases, less acid rain emissions, and less solid wastes (Chaffee & Yaros, 2007). The findings of Chaffee & Yaros (2007) indicate that biodegradable plastics are neither a clean alternative to petroleum-based, traditional plastics nor to grocery bags made from recycled paper. The debate of the environmental friendliness of single-use grocery bags has risen once again by efforts to ban traditional plastic bags. These efforts question if there are any environmental trade-offs in switching from conventional plastic bags to bags made from biodegradable material.

Lee (2009) broke energy use into agriculture, manufacturing, and transportation of products from two companies: Biodegradable Food Service (BFS) and Biodegradable Solutions International (BSI). It was proved that transportation costs were one of the major secondary energy source.

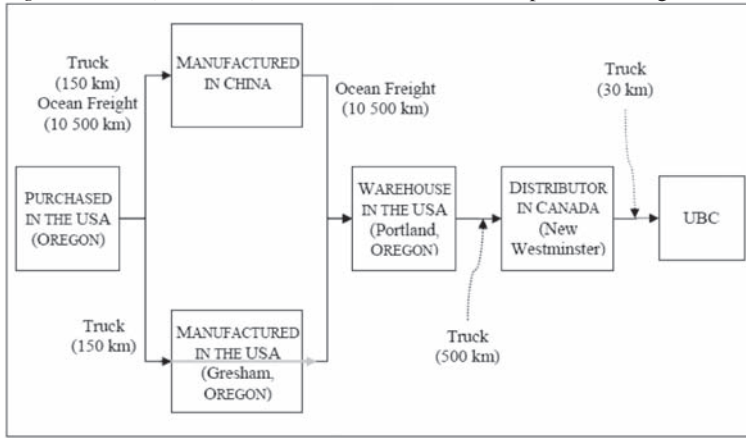
Figure 1: BSI Process Location and Transportation Diagram



Source: Lee, Sin. Nov. 2009

In Figure 1 above, distance was tracked from production of corn, through the manufacturing, and up to the distribution of the biodegradable plastic. At over 10,000 km, ocean freight between manufacturing in China and the warehousing in Canada consumes the most energy.

Figure 2: BFS (Taterware) Process Location and Transportation Diagram



Source: Lee, Sin. Nov. 2009

In Figure 2, potato wash, which is the substitute for corn in biodegradable plastics, is first purchased by

Biodegradable Food Service (BFS) in the United States, and then either freighted for manufacturing in China or driven 150 km for manufacturing in Oregon. Twenty-five percent of this wash is sent to Gresham, Oregon for manufacturing; the remaining 75% is sent to China (Lee, 2009). From Figure 2 above, 21,000 km in ocean freight is required for manufacturing in China.

Franklin Associates (2008) narrowed their research to that of milk containers and the energy, postconsumer solid waste, and greenhouse gas emissions involved in the process. Through this analysis, they evaluated 10,000 half-gallon milk containers consisting of glass, paper, biodegradable plastic, and conventional plastic. Conventional plastics, as milk containers, performed more efficiently than biodegradable plastics. High-density polyethylene (HDPE), a conventional plastic identified by Franklin Associates (2008), is used for traditional milk bottles. The total energy for the HDPE bottle system is considered significantly less than the PLA bottle system (Franklin Associates, 2008). It should be noted that if the energy of material resource for corn were not included in the PLA bottle system, the total energy would be 48.7 million Btu. However, this total is still significantly higher than the total energy of all other systems (Franklin Associates, 2008).

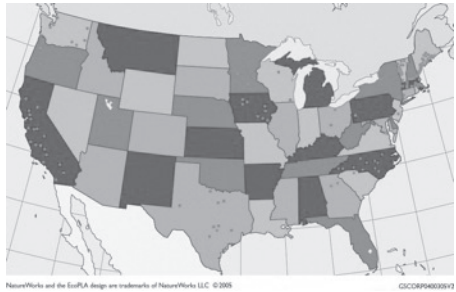
Biodegradable plastics, as a substitute for conventional plastics, have been an important step in an attempt to reduce waste sent to landfills. Kinneman (2006) examined recycling and the associated costs and benefits of reducing waste sent to landfills. A municipal curbside recycling program required households to label garbage bags. Identifying biodegradable plastics for sorting could be implemented through this collection system. By giving the consumer the option to sort biodegradable plastics from other, non-biodegradable plastics, issues with PLA products finding their way into the waste stream could be avoided.

With the verification that conventional plastics

perform more environmentally friendly than biodegradable plastics in both studies of Chaffee & Yaros and Franklin Associates, it is obvious that biodegradable plastics are not the immediate answer to the perceived landfill problem traditional, non-biodegradable plastics started.

The American Society for Testing and Materials (ASTM) has a standard for biodegradable plastics: This specification is intended to establish the requirements for labeling of materials and products, including packaging made from plastics, as compostable in municipal and industrial composting facilities (ASTM, 2009)[3]. Biodegradability, then, does not define a material to have the capacity to break down along with food and yard waste in one's backyard. Even if biodegradable plastics had more efficient means of production than conventional plastics, the cost of sorting and transportation arises with the post-consumer disposal phase.

Figure 3: Industrial Composting Facilities



In Figure 3, industrial composting facility sites are shown across the United States. These facilities are being built as alternatives to landfills to meet the ASTM standard for being compostable. Western United States lacks many facilities. Economic theory suggests that the cost of new innovation is expected to be high; however, as more companies participate in industrial composting, these associated costs will fall drastically.

Adam Kramschuster, a professor at UW-Stout, earned his Ph.D. in the research and development of polymer

composites consisting of biodegradable polymers and natural fibers. After speaking to him about biodegradable plastics as a sustainable option[4], the future does not seem so bleak. "The challenge in using food (corn and soybeans) as a feed stock for plastics pose challenges that will have to be tackled in the future as the population continues to increase," he said. "However, the idea of taking carbon out of the atmosphere to grow plants and putting it back into the atmosphere as the plastic degrades is drastically better than taking 'old carbon' that has been stored in fossil fuels and introducing that into the atmosphere."

Figure 4

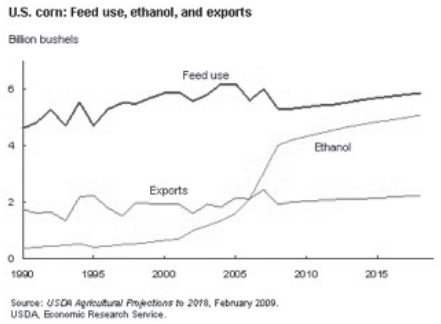


Figure 4 above, estimates corn use in the U.S. for feed use, exports, and ethanol. With the projections of corn use for fuel drastically rising in the next few years, many are skeptical about how much of our food should be going to inedible production. If the biodegradable plastics are not making it to the industrial compost facilities, it's almost as if we are not only throwing away our food but putting mass amounts of energy into it—electricity and potable water to produce carbon dioxide emissions and solid waste.

Conclusion

Currently, biodegradable plastics are unproductive in their manufacturing and recovery processes. Transportation costs can be greatly reduced by simply reusing cloth and

plastic bags. An increase in recycling of non-biodegradable plastics is an unfailing option as well. In Canada, plastic bag recycling is encouraged through the education of municipal curbside recycling. Informing citizens on how to prepare bags to be recycled through flyers and radio advertisements can be found on their website. Companies like Advanced Environmental Recycling Technologies are a part of the push for green advertising. Through the innovation in plastic scrap recycling for wood decking, they are able to advertise their sustainable efforts with plastics by taking a closed loop approach, moving away from the straight-line approach of waste management. HilexPoly, a plastic bag producer based in South Carolina, is another leader in recycling. There, collected plastic bags are washed, ground into pellets, and used to manufacture entirely recycled bags.

Since energy use associated with biodegradable plastics is still more than that of conventional plastics, biodegradable plastics will not serve as an efficient alternative until industrial composting facilities are more widely established across the United States. Even if created from a renewable resource, biodegradable plastics will not solve economic and environmental problems if they find their way into landfills through trash cans or conventional plastic recycling programs through recycling bins. A third sorting system specific to biodegradable plastics must be employed to insure biodegradability in composting facilities. Then, the excess energy in the manufacturing of biodegradable plastics will be outweighed by the transference of carbon dioxide as the plastic biodegrades.

Endnotes

1. http://www.smithsonianmag.com/science-nature/plastic.html?c=y&page=2
2. www.epa.gov/NRML/lcaaccess/pdfs/600r0606.pdf
3. http://www.astm.org/Standards/D64000
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