Plastic Bags – Greener Than Alternatives!

PLASTIC CARRYOUT BAGS ARE A LITTER NUISANCE BUT OTHERWISE THE BEST SOLUTION FOR THE ENVIRONMENT

By Anthony van Leeuwen, 16 January 2014

Executive Summary*. The main reason policy makers give for banning plastic carryout bags is because of the litter impact of these bags upon the environment.* (Villarreal & Feigenbaum, 2012) *Yet, plastic bags comprise at most a miniscule 0.6% of roadside litter;* (Stein, 2012) *Whereas, Fast Food litter comprises 29.1% of roadside litter.* (Mid Atlantic Solid Waste Consultants, 2009) *Despite the litter impact of plastic carryout bags, plastic bags produce fewer greenhouse gases than paper or cotton bags. Plastic bags require 70% less energy to manufacture than paper bags. Plastic bags take less than 4% of the water needed to manufacture paper bags. Plastic bags generate up to 80% less waste than paper bags. It takes 7 trucks to deliver paper bags and only 1 truck for the same number of plastic bags.* (Frank, 2013) *Furthermore, it takes 91% less energy to recycle a pound of plastic than a pound of paper.* (The ULS Report, 2008)

Introduction

The claims that Plastic Carryout Bags are an environmental villain are simply not true. In fact, comparing the environmental metrics during the production, transportation, use, and disposal of carryout bags shows that Plastic Carryout Bags are better for the environment than paper or reusable bags made from Polypropylene or Cotton.

The main issue with the thin-film Plastic Carryout Bags is the problem of windblown litter. Although only a small number of plastic carryout bags end up in the environment as litter, their lightweight and large surface area easily catch wind currents to become windblown litter. These bags get caught on fences, shrubs, trees, or in some cases end up in creeks and rivers and get caught on rocks and shrubs and debris or find their way to the ocean. In some cases, the plastic bags find their way into a storm drain and are caught by a rubbish trap if one is installed or at the next rain will be carried with storm water into local creeks and rivers and make their way to the ocean. In addition, the thin film plastic bags large surface area also results in an obvious aesthetics issue.

The question is will switching from plastic carryout bags to paper and reusable bags guarantee the elimination of unfavorable environmental conditions? All carryout bags have an environmental impact through production, transportation, use, and disposal. This is because raw materials and energy are used during the production process resulting in the emission of air pollutants, water effluents, and solid wastes. (Chaffee & Yaros, p. 3)

In more scientific terms, environmental impacts are measured using the following Impact Categories: Global Warming Potential, Abiotic Depletion, Acidification, Eutrophication, Human Toxicity, Fresh Water aquatic Eco toxicity, Marine aquatic Eco toxicity, Terrestrial eco toxicity, and Photochemical oxidation.

You might ask yourself, what do these all mean. We will define what these terms mean later on in this paper.

In addition to the above environmental impact categories the following "utility" impacts are looked at consisting of Energy Consumption, Fresh Water Use, Material Consumption, Solid Waste Generation, and Recyclability. (O'Farrell, 2009)

Common Shopping Bag Types

The most common bag types are listed in the Table 1 below. Both the average weight, volume, the average number of items per bag, and usability are listed. The standard plastic grocery bag or T-Shirt Bag is listed as a Standard High Density Polyethylene (HDPE) bag. The paper bag is listed as the Kraft Paper Bag. The Low Density Polyethylene (LDPE) Bag is a thick plastic bag and the Non-Woven Polypropylene (PP) Bag and the Calico Cotton Bags are all reusable bags.

Table 1. Average Characteristics of Different Bag Types

Bag Type	Weight (grams)	Volume (Liters)	Items Per Bag	Use
Standard High Density Polyethylene (HDPE) Bag	6	19.1	6	Single Use
Kraft Paper Bag	55.20	20.1	8	Single Use
Low Density Polyethylene (LDPE) Bag	34.94	21.52	8	Reusable
Non-Woven Polypropylene (PP) Bag	115.83	19.75	8	Reusable
Calico Cotton Bag	183.11	26.65	11	Reusable
Data Source: (Edwards & Fry, 2011, p. 18)				

Environmental Impact Categories

In the following sections we will examine each of the environmental impact categories normally examined in Environmental Impact Reports related to bag bans, identify the category, how it impacts the environment, and how it is measured. In addition we show a table, identifying the actual values for each of the different types of bags listed in Table 1. The table also includes a normalized column where the plastic carryout bag has a value of 1.00 to show the relative value for each of the other types of bags. This allows you to quickly see how much better a plastic bag is compared to the other bags listed for a particular impact category.

Global Warming Potential

Global Warming Potential is a measure of how much greenhouse gas, carbon dioxide (CO_2) and Methane (CH_4), is released into the atmosphere which contributes to global warming. (Edwards & Fry, 2011) This indicator is measured in terms of Carbon Dioxide (CO_2) equivalents. (Verghese, Lewis, Fitzpatrick, Hayes, & Hedditch, 2009)

Table 2. Global Warming Potential

BAG	Unit	Value	Normalized
High Density Polyethylene (HDPE)	Kg CO_2 equivalents	1.578	1.00
Paper Bag	Kg CO_2 equivalents	5.523	3.50
Low Density Polyethylene (LDPE)	Kg CO_2 equivalents	6.924	4.39
Non-Woven Polypropylene (PP)	Kg CO_2 equivalents	21.510	13.63
Cotton Bag	Kg CO_2 equivalents	271.533	172.07
Data Source: (Edwards & Fry, 2011)			

Abiotic Depletion

Abiotic Depletion refers to the depletion of non-living (abiotic) or non-renewable resources such as fossil fuels, minerals, clay and peat. (Edwards & Fry, 2011)

Table 3. Abiotic Depletion

BAG	Unit	Value	Normalized
High Density Polyethylene (HDPE)	g Sb equivalents	16.227	1.000
Paper Bag	g Sb equivalents	26.697	1.645
Low Density Polyethylene (LDPE)	g Sb equivalents	82.711	5.097
Non-Woven Polypropylene (PP)	g Sb equivalents	274.764	16.932
Cotton Bag	g Sb equivalents	1519.838	93.661
Data Source: (Edwards & Fry, 2011)			

Acidification

Acidification refers to the deposit of acids in the soil by pollutants such as sulfur dioxide (SO_2), Nitrous Oxides (NO_x), Hydrochloric Acid (HCL), and Ammonia (NH_3). Acidification leads to a decrease in the pH, a decrease in mineral content, and increased concentrations of potentially toxic elements in the soil. Acidification is measured in terms of sulfur dioxide (SO_2) equivalents. (Edwards & Fry, 2011)

Table 4. Acidification

BAG	Unit	Value	Normalized
High Density Polyethylene (HDPE)	g SO_2 equivalents	11.399	1.000
Paper Bag	g SO_2 equivalents	37.470	3.287
Low Density Polyethylene (LDPE)	g SO_2 equivalents	29.340	2.573
Non-Woven Polypropylene (PP)	g SO_2 equivalents	101.314	8.887
Cotton Bag	g SO_2 equivalents	2787.681	244.554
Data Source: (Edwards & Fry, 2011)			

Eutrophication

Eutrophication refers to the addition of nutrients, such as nitrogen or phosphorus, to soil or water which results in an increase in biomass including algal growth and potentially damage other life forms by oxygen depletion and impacting water quality. (Edwards & Fry, 2011) (edge environment)

Eutrophication is measured in phosphate (PO_4^{-3}) equivalents. (Verghese, Lewis, Fitzpatrick, Hayes, & Hedditch, 2009, p. 24)

Table 5. Eutrophication

BAG	Unit	Value	Normalized
High Density Polyethylene (HDPE)	g PO_4^{-3} equivalents	0.775	1.000
Paper Bag	g PO_4^{-3} equivalents	5.039	6.502
Low Density Polyethylene (LDPE)	g PO_4^{-3} equivalents	2.576	3.323
Non-Woven Polypropylene (PP)	g PO_4^{-3} equivalents	14.579	18.811
Cotton Bag	g PO_4^{-3} equivalents	304.486	392.885
Data Source: (Edwards & Fry, 2011)			

Human Toxicity

Human Toxicity refers to the impact on human health of toxic substances released into the environment. (edge environment) Human Toxicity is measured in terms of Dichlorobenzene equivalents. (Edwards & Fry, 2011, p. 104)

Table 6. Human Toxicity

BAG	Unit	Value	Normalized
High Density Polyethylene (HDPE)	kg 1,4-DB equivalents	0.211	1.000
Paper Bag	kg 1,4-DB equivalents	3.247	15.389
Low Density Polyethylene (LDPE)	kg 1,4-DB equivalents	0.701	3.322
Non-Woven Polypropylene (PP)	kg 1,4-DB equivalents	3.046	14.436
Cotton Bag	kg 1,4-DB equivalents	66.254	314.000
Data Source: (Edwards & Fry, 2011)			

Fresh Water Aquatic Ecotoxicity

Freshwater Aquatic Ecotoxicity refers to the impacts of toxic substances on freshwater ecosystems, such as lakes and rivers. Freshwater Aquatic Ecotoxicity is measured in terms of Dichlorobenzene equivalents. (Edwards & Fry, 2011, pp. 103-104)

Table 7. Fresh Water Aquatic Ecotoxicity

BAG	Unit	Value	Normalized
High Density Polyethylene (HDPE)	g 1,4-DB equivalents	66.880	1.000
Paper Bag	g 1,4-DB equivalents	150.204	2.245
Low Density Polyethylene (LDPE)	g 1,4-DB equivalents	186.726	2.792
Non-Woven Polypropylene (PP)	g 1,4-DB equivalents	467.717	6.993
Cotton Bag	g 1,4-DB equivalents	23477.073	351.032
Data Source: (Edwards & Fry, 2011)			

Marine Aquatic Ecotoxicity

Marine Aquatic Ecotoxicity refers to the impacts of toxic substances on marine ecosystems, such as seashores, open ocean, and estuaries. Marine Aquatic Ecotoxicity is measured in terms of Dichlorobenzene equivalents. (Edwards & Fry, 2011, pp. 103-104)

Table 8. Marine Aquatic Ecotoxicity

BAG	Unit	Value	Normalized
High Density Polyethylene (HDPE)	kg 1,4-DB equivalents	126.475	1.000
Paper Bag	kg 1,4-DB equivalents	244.657	1.934
Low Density Polyethylene (LDPE)	kg 1,4-DB equivalents	311.810	2.465
Non-Woven Polypropylene (PP)	kg 1,4-DB equivalents	1411.312	11.159
Cotton Bag	kg 1,4-DB equivalents	44716.601	353.560
Data Source: (Edwards & Fry, 2011)			

Terrestrial Ecotoxicity

Terrestrial Ecotoxicity refers to impacts of toxic substances on terrestrial ecosystems, such as forests and wetlands. Terrestrial Ecotoxicity is measured in terms of Dichlorobenzene equivalents. (Edwards & Fry, 2011, pp. 103-104)

Table 9. Terrestrial Ecotoxicity

BAG	Unit	Value	Normalized
High Density Polyethylene (HDPE)	g 1,4-DB equivalents	1.690	1.000
Paper Bag	g 1,4-DB equivalents	24.719	14.626
Low Density Polyethylene (LDPE)	g 1,4-DB equivalents	7.323	4.333
Non-Woven Polypropylene (PP)	g 1,4-DB equivalents	50.812	30.066
Cotton Bag	g 1,4-DB equivalents	3208.855	1898.731
Data Source: (Edwards & Fry, 2011)			

Photochemical Oxidation

Photochemical Oxidation refers to the formation of smog as a result of the interaction of sunlight and nitrogen oxides (NO_x), Volatile Organic Compounds (VOC's), peroxyacyl nitrates (PANs), aldehydes, and ozone in the atmosphere. (Verghese, Lewis, Fitzpatrick, Hayes, & Hedditch, 2009) Smog is known to cause respiratory health problems and damage vegetation. (edge environment)

Table 10. Photochemical Oxidation

BAG	Unit	Value	Normalized
High Density Polyethylene (HDPE)	g C2H4	0.531	1.000
Paper Bag	g C2H4	1.955	3.681
Low Density Polyethylene (LDPE)	g C2H4	1.391	2.619
Non-Woven Polypropylene (PP)	g C2H4	5.247	9.881
Cotton Bag	g C2H4	95.114	179.122
Data Source: (Edwards & Fry, 2011)			

Utility Impacts

This section discusses impacts on various utility systems such as energy use, fresh water use, material consumption, solid waste, and recyclability.

Energy Use

Energy use or consumption occurs in all lifecycle phases. Most energy is used in material manufacture, not in bag production or transport. (The ULS Report, 2008) Energy use is measured in Mega Joules.

Table 11. Energy Use

BAG	Unit	Value	Normalized
High Density Polyethylene (HDPE)	Mega Joules	210	1.000
Paper Bag	Mega Joules	721	3.433
Low Density Polyethylene (LDPE)	Mega Joules	78	0.371
Non-Woven Polypropylene (PP)	Mega Joules	46.3	0.220
Cotton Bag	Mega Joules	160	0.762
Data Source: (NOLAN-ITU Pty Ltd, 2001)			

Fresh Water Use

Fresh Water Use is primarily driven by water consumption during material production. (Verghese, Lewis, Fitzpatrick, Hayes, & Hedditch, 2009) Water use is measured in liters.

Table 12. Fresh Water Use

BAG	Unit	Value	Normalized
High Density Polyethylene (HDPE)	Liters H_2O	4.22	1.000
Paper Bag	Liters H_2O	349.97	82.931
Low Density Polyethylene (LDPE)	Liters H_2O	15.33	3.633
Non-Woven Polypropylene (PP)	Liters H_2O	20.71	4.908
Cotton Bag	Liters H_2O	7600.36	1801.033
Data Source: (O'Farrell, 2009)			

Material Consumption

The material consumption in Table 13 for the different type of shopping bags is derived based upon a functional unit of study consisting of carrying approximately 70 grocery items home from a supermarket each week for approximately 52 weeks. In terms of plastic carryout bags (HDPE) that means 10 bags per week for 52 weeks or 520 bags per year. The average weight, relative capacity, and expected life were taken into account for each different bag type to determine the Material Consumption. As can be seen from Table 13, the Non-Woven Polypropylene bag had the lowest material consumption and the paper bag had the highest material consumption. (NOLAN-ITU Pty Ltd, 2001)

Table 13. Material Consumption

BAG	Weight (grams)	Relative Capacity	Expected Life	Material Consumption (Kg)
High Density Polyethylene (HDPE)	6.0	1.0	1	3.12
Paper Bag	42.6	1.0	1	22.15
Low Density Polyethylene (LDPE)	35.8	1.5	12	0.96
Non-Woven Polypropylene (PP)	65.6	1.2	104	0.48
Cotton Bag	125.4	1.1	52	1.14
Data Source: (NOLAN-ITU Pty Ltd, 2001, pp. 69-70)				

Note that the weights of the bags in Table 13 differ from the weights used in Table 1 since the data came from different studies. It should also be noted that there are slight variations in the bag sizes and weights from different manufacturers and in different countries. For purposes of this analysis, these differences are not important.

Solid Waste

The amount of solid waste generated is an important indicator. Solid waste can be generated during bag production and at end of life. Carryout bags are either disposed of in the landfill or are recycled via an appropriate recycling service and largely depends on the kind of material a bag is made up of and availability of an appropriate recycling service. Solid Waste is measured in kilograms. Because of a lack of good data, we used the material consumption figures from Table 13 which represents a fixed volume of groceries and used that as a solid waste value. The normalized number represents the amount of solid waste relative to plastic bags. Obviously some of the reusable bags result in lower solid waste per year than plastic bags. Normally, a mixture of plastic, paper, and different types of reusable bags are used by shoppers in an area, and total solid waste generated depends upon assumptions regarding the exact mix of carryout bags used.

Table 14. Solid Waste

BAG	Unit	Value	Normalized
High Density Polyethylene (HDPE)	kg	3.12	1.000
Paper Bag	kg	22.15	7.099
Low Density Polyethylene (LDPE)	kg	0.96	0.308
Non-Woven Polypropylene (PP)	kg	0.48	0.154
Cotton Bag	kg	1.14	0.365
Data Source: (NOLAN-ITU Pty Ltd, 2001)			

Recyclability

Recyclability is an important characteristic of carryout bags. Not all carryout bags can be recycled meaning that at end of life, the carryout bags must be disposed of in the landfill vice be recycled and manufactured into new products.

Table 15. Recyclability

BAG	Recyclability	Comment
High Density Polyethylene (HDPE)	Yes	In-Store Recycling Bin
Paper Bag	Yes	Curbside Recycling Bin
Low Density Polyethylene (LDPE)	Yes	In-Store Recycling Bin
Non-Woven Polypropylene (PP)	No	Disposal in Landfill
Cotton Bag	No	Disposal in Landfill

Discussion

In virtually all environmental categories, the plastic grocery bag or conventional HDPE bag has the lowest impact on the environment in most environmental impact categories.

To justify banning plastic grocery bags in favor of paper or reusable bags with their higher environmental footprints, bag ban proponents rely on reusing a bag multiple times in order for its overall environmental impact to be less than a plastic carryout bag on a per use basis. Even though reusable bags have a higher environmental footprint, the concept expressed in the Environmental Impact Reports (EIRs) is that because there would be fewer reusable bags in circulation and that each bag would be used multiple times that an environmental advantage is achieved over the use of plastic carryout bags. While this concept is widely accepted it is flawed for the following reasons:

- It is dependent upon the shopper using each reusable bag the requisite number of times for its environmental impact to be less than a plastic carryout bag on a per use basis.
- It is dependent upon the shopper not collecting more reusable bags than they can actually use. Each bag that is unused or not used the requisite number of times is a burden on the environment.
- It is dependent on a grocery store not to sell more reusable bags to shoppers than shoppers can really use. (This goes against the fundamental nature of a retail store to sell more and more reusable bags to increase their profit!)
- It is also dependent on manufacturers not to produce more reusable bags per shopper than shoppers can use. Of course, manufacturers want to increase their profit and to do so have to sell more and more bags. One of the strategies is to sell poor quality bags that do not hold up well so they have to be replaced often. This is called planned obsolescence. In other words, bags will not be able to be used the requisite number of times in order to yield their environmental advantage.
- Human nature being what it is – shoppers will accept free reusable bags in giveaways, because they are free. Even though they have more than they can possible use at home.
- Because reusable bags are plentiful, shoppers will dispose of a bag that is dirty than take the trouble of washing it. Many bags must be hand washed which is inconvenient.

- Every reusable bag once manufactured has an environmental impact, regardless of whether it sits on the retail shelf or stocked in a warehouse waiting to be sold to a shopper, or sits in a closet at home and unused.

In Australia, the reusable bag has been dubbed the "green monster" because people ended up with so many reusable bags, that they ended up being discarded in the landfill. (Munro, 2010)

The paper bag has to be used four or more times to reduce its global warming potential to less than a plastic grocery bag or standard conventional HDPE bag on a per use basis. However, paper bags are seldom reused, meaning that the use of paper bags will be detrimental to the environment compared to the use of plastic carryout bags. In addition, the paper bag is significantly worse in Eutrophication, Human Toxicity, and Terrestrial Ecotoxicity due to the production of paper. (Edwards & Fry, 2011) The paper bag is heavier than lightweight plastic carryout bag, and as such, require more transport and associated costs. They would also take up more room in a landfill if they are not recycled. (Cadman, Evans, Holland, & Boyd, 2005)

The LDPE reusable bag has to be used at least five times in order to reduce its global warming potential to be less than a conventional HDPE or plastic carryout bag. When used five times, its impacts were lower in eight of nine of the impact categories with the exception of Abiotic Depletion. The impact was also substantially lower than the HDPE bag in terms of Acidification, Aquatic Ecotoxicity, and Photochemical Oxidation. (Edwards & Fry, 2011)

The Non-Woven Polypropylene (PP) bag has to be used fourteen times to reduce its global warming potential to below that of the conventional HDPE or plastic carryout bag. With this level of reuse it was also superior to the conventional HDPE or plastic carryout bag in five of the nine impact categories. However, the PP bag was significantly worse than the baseline in terms of terrestrial Ecotoxicity. (Edwards & Fry, 2011)

The cotton bag has to be used 173 times in order to reduce its global warming potential to below that of the conventional HDPE or plastic carryout bag on a per use basis. The cotton bag has a greater impact than the conventional HDPE bag in seven of the nine impact categories. The impact was considerably larger in categories such as Acidification and Aquatic & Terrestrial Ecotoxicity due to the energy used to produce cotton yarn and the fertilizers used during the growth of the cotton. (Edwards & Fry, 2011)

The paper, LDPE. non-woven PP and cotton bags should be reused at least four (4), five (5), fourteen (14) and 173 times respectively to ensure that they have lower global warming potential than conventional HDPE carryout bags. (Edwards & Fry, 2011) There is simply no guarantee that reusable bags will be used these requisite number of times.

Conclusions From Life Cycle Analysis Reports

A number of Life Cycle Analysis (LCA) reports generally conclude that banning plastic bags is worse for the environment or dubious at best. You can read this for yourself as follows:

The ULS report concludes (at page 5): "*Legislation designed to reduce environmental impacts and litter by outlawing grocery bags based on the material from which they are produced will not deliver the intended results. While some litter reduction might take place, it would be outweighed by the disadvantages that would subsequently occur (increased solid waste and greenhouse gas emissions). Ironically, reducing the use of traditional plastic bags would not even reduce the reliance on fossil fuels, as paper and biodegradable plastic bags consume at least as much non-renewable energy during their full lifecycle."* (The ULS Report, 2008)

The "*Life Cycle Assessment for Three Types of Grocery Bags - Recyclable Plastic; Compostable, Biodegradable Plastic; and Recycled, Recyclable Paper*" concludes: "*The study results support the conclusion that any decision to ban traditional polyethylene plastic grocery bags in favor of bags made from alternative materials (compostable plastic or recycled paper) will be counter-productive and result in a significant increase in environmental impacts across a number of categories from global warning effects to the use of precious potable water resources*." (Chaffee & Yaros)

As can be seen from the conclusions reached by two Life Cycle Analysis studies showing that banning plastic carryout bags will not necessarily result is lower environmental impacts and more likely result in higher environmental impacts.

Plastic bags are superior for the environment:

- *"Plastic carryout bags generate 60% less greenhouse gas emission than paper bags*." (Chaffee & Yaros)
- *"Plastic carryout bags consume 4% of the water needed to manufacture paper bags*." (Chaffee & Yaros)
- *"Plastic carryout bags consume 40% less energy during production than paper bags*." (Chaffee & Yaros)
- *"Plastic carryout bags generate 80% less waste than paper bags*." (Chaffee & Yaros)
- *"Recycling a pound of plastic carryout bags takes 91% less energy than a pound of paper bags*." (Chaffee & Yaros)

While reusable bags may be the preferred alternative, there is no guarantee that the majority of customers will use reusable bags, or that every reusable bag are used the requisite number of times in order to achieve a lower environmental impact on a per use basis. In fact the opposite may become a reality as people collect more reusable bags than they can reasonably use. The profit motive on the part of retailers and manufacturers is a perverse incentive that threatens to undo the lower environmental impact of using reusable bags!

About The Author

Anthony van Leeuwen *is the founder of the* ***Fight The Plastic Bag Ban*** *website and writes extensively on the subject. He holds a bachelors and Master's degree in Electronics Engineering and has over 40 years of experience working in the federal government.*

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