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A Brief Analysis of Life Cycle Analyses (LCAs) and the Impacts of Plastic Vs. Paper Bags

Reliance on LCAs to determine and compare the impacts of single-use bags can be problematic because of incorrect assumptions. Different LCAs have also provided a wide range of impact level on the same resources. This document outlines these weaknesses, and also shows an adjusted estimated greenhouse gas emission rate in landfills through the use of California-specific information on methane emission, recycling, and carrying capacity.

Impacts Based on LCAs

Many of the existing LCAs for single-use bags have been funded by the plastics industry. They contain inaccurate assumptions about single-use bags that exaggerate the environmental impacts of plastic bags over paper bags. These include:

- Minimizing the carrying capacity of paper bags compared to plastic bags. Studies have reported a wide range of carrying capacities for paper bags compared to plastic bags, from a ratio of 1.5 to 1 up to as much as 3 to 1.
- Underreporting paper bag recycling rates. According to the US EPA, the last reported recycling rate in 2009 was almost 50%, while the Boustead LCA used 2005 EPA numbers at 21% recycling.
- Wrongful assumptions about higher end-of-life greenhouse gas (GHG) emissions for paper bags compared to plastic bags. The LCAs report that paper bags have lower GHG emissions up to the point of disposal. After disposal, erroneous findings about higher GHG emissions are based on incorrect assumptions about low recycling rates and high methane emissions in landfills.
- Omitting the reduced environmental impacts from using recycled content in paper bags, and inaccurate assumptions about the amount of postconsumer content (pcc) in recycled paper bags.
- No consideration of the litter effects of plastic bags.

Estimates from the LCAs are often based on different assumptions due to the varying geographical locations of where they were written, rendering them inapplicable for use by jurisdictions in California. For instance, the Ecobilan LCA assumes a higher incineration rate of solid wastes due to its study location in France, compared to low incineration rates found in the US. Los Angeles County examined several impacts in its Environmental Impact Report using a variety of existing LCAs. These impacts are described in further detail below.

GHG Emissions

Los Angeles County assumed an 85% conversion rate from plastic bags to paper bags with its plastic bag ban, and determined that the subsequent increase in paper bags would increase GHG emissions by 19,700 metric tons a year. However, an examination of existing LCAs found a varying range of estimates for GHG emissions in LA County. Using the same conversion rate for the County, the Boustead LCA estimated an increase of 38,300 metric tons of GHG emissions a year for the entire County, while the ExcelPlas LCA estimated an increase of 73,700 metric tons. The divergent and wide range of estimated GHG emissions indicates a level of uncertainty in the actual impact of GHG emissions from paper bags.

The Boustead LCA calculated its disposal-related GHG emissions with the assumption that 60% of methane would be released in landfills. However, according to the California Air Resources Board (ARB), an average of 75% of landfill gas is captured in gas collection systems, and a small percentage of landfill gas is oxidized as it travels through cover soils. Thus only 22.5% of methane gas generated in landfills is actually released.

Furthermore, the Boustead LCA assumed for paper bags a recycling rate of 21%, with a combustion rate of 13.6% and thus a landfill rate of 65.4%. In comparison, using EPA numbers, paper bags are recycled at 50%, with a combustion rate of 13.6% and a landfill rate of only 36.4%. A lower landfill rate would impact the amount of estimated GHG emissions released.

Water Consumption
Similarly, a varying range of estimates in water consumption were calculated for LA County based on different LCAs. The Ecobilan study determined an increase of 0.03 million gallons a day (MGD) due to the County's bag ban, while use of the Boustead LCA estimated an increase of 0.36 MGD. Again, these estimates used the conservative 85% conversion rate from plastic to paper. None of the LCAs appeared to factor in recycled water usage, a common practice in the paper bag manufacturing process.

Non-Renewable Energy Consumption
LA County also found a varying range of estimates for energy consumption. While the Ecobilan LCA estimated a decrease in energy consumption by 0.01 million kW/hour, the Boustead LCA estimated an increase of 0.19 million kW/hour based on LA County information. Again, these conflicting estimates indicate the specialization and lack of general applicability of the LCAs.

Solid Waste
Some LCAs make erroneous considerations about the end-of-life or disposal options for paper bags and plastic bags. LCA estimates of solid waste impacts also fail to include mining wastes or other solid waste that end in the hazardous waste stream. Most of the LCAs agree that paper bags generate higher amounts of solid waste compared to plastic bags due to their increased weight and volume compared to the lighter HDPE bags. However, paper bags are recycled at higher rates than plastic bags, will eventually biodegrade, and also have a higher carrying capacity. These factors would help decrease the amount of solid waste generated despite an increase in paper bag usage. The Boustead LCA assumed that it took 1.5 plastic bags to carry the same amount of groceries as 1 paper bag although other studies have found higher ratios. For instance, the City of San Jose determined a 2:1 ratio carrying capacity with its study. The Boustead LCA also reported recycling rates of 21% and 5.2% for paper and plastic, respectively, based on EPA numbers in 2005. Updated numbers from the EPA in 2009 showed that the paper bag recycling rate has increased considerably to nearly 50%, while the HDPE plastic bag recycling rate stayed fairly constant at 6.1%.

Adjusting for Incorrect Assumptions of Past LCAs
Some of the false assumptions and overlooked factors by the LCAs can be manually adjusted using the table below. Impacts can be recalculated to adjust for increased carrying capacity rates of paper bags. In the case of GHG emissions, end of life impacts in landfills can be better examined as well.

The first column in the table below lists the various impacts on GHG emissions, fresh water consumption, fossil fuel use, energy consumption and solid waste. GHG emissions have been broken down to show production emissions and disposal emissions under varying assumptions. As previously noted, the Boustead LCA assumed disposal-related GHG emissions with a 60% amount of methane released in landfills, while the ARB estimates a 22.5% methane release rate. The Boustead LCA also assumed a landfill rate of 65.4%, while the EPA estimates a 36.5% recycling rate using the same combustion rate as Boustead. The disposal emissions have been adjusted accordingly in regards to both methane release and recycling rates, and added to the production emissions in the last row related to GHG emissions.

The second column shows the environmental impacts, as listed, of 1000 single-use paper bags.

The third column shows the impacts of 1000 single-use plastic bags. This column assumes a carrying capacity ratio of plastic to paper at 1:1.

The fourth column shows the impacts of 2000 single-use plastic bags. This column assumes a ratio of 2:1 (i.e., it takes 2 plastic bags to carry the same amount as 1 paper bag).

Sizes of plastic and paper bags will likely vary in different geographical locations, and so will the carrying capacity ratio. To adjust for a different carrying capacity in the table below, multiply the "Plastic (per 1000 bags)" column by the new ratio. For instance, to determine the impacts if the paper to plastic ratio was 3:1, multiply the third column numbers by a factor of 3.

As highlighted below, the adjusted levels for a 22.5% emission rate of methane in landfills and 36.4% landfill rate of paper bags show that cradle-to-grave GHG emissions are actually *higher* for plastic bags than paper bags with a 2:1 ratio. Paper bags in this scenario generate less CO2 (0.0374 CO2 equivalent tons) compared to plastic bags (0.0534 CO2 equivalent tons).

Impact	**Paper (per 1000 bags)**	**Plastic (per 1000 bags)**	**Plastic**
	ratio	*1 to 1*	*2 to 1*
GHG Emissions (CO2 Equiv Tons) production & disposal	0.08	0.03	0.05
GHG Emissions (Co2 Equiv Tons) - production	0.0261	0.0212	0.0423
GHG Emissions (Co2 Equiv Tons) - disposal (assuming 60% GHG emissions released, sequestered scenario in landfills)	0.0539	0.0055	0.0111
GHG Emissions (disposal, adjusted for 22.5% emissions released in landfills instead of 60%)	0.0202	--	--
GHG Emissions (disposal, adjusted for 36.4% landfill rate and 22.5% emissions released)	0.0112	--	--
GHG Emissions (production + adjusted disposal)	0.0374	0.0267	0.0534
Fresh Water Consumption (Gallons)	1004	40	80
Fossil Fuel Use (kg) -coal, oil, gas in the extraction/transport of raw materials, manufacturing process, and transport to retail establishments	23.2	10	20
Energy Consumption (MJ) -includes fuel production, fuel use, transport, feedstock	2622	509	1018
Solid Waste (kg)	33.9	4.7	9.4

Conclusion

Closer analysis of reports with incorrect assumptions reveals that paper carryout bags have a reduced impact compared to plastic carryout bags particularly in regards to solid waste impact and, as indicated in the previous table, greenhouse gas emissions.

Sources

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