Pollution Prevention

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Project Report
on

Life Cycle Assessment of Imported Non-Woven Polypropylene Grocery Bags in the City of St. John's with Landfill Waste Management Facility: A Newfoundland and Labrador Case Study

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Submitted by

Nahidul Kabir Siddiki #202291960

Denise Ming Yan Lee #202294171

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Submitted to

Amir Ali Khan Ph.D. P.Eng

Executive Summary

Newfoundland and Labrador (NL) has implemented the ban on single-use retail plastic bags since October 1, 2020, after 87 percent of respondents opted for the ban in public consultation. Prior to the decision, the province noted that several comparative lifecycle analyses of single-use paper and plastic bags have shown that paper bags have a more significant potential for adverse environmental impact than plastic bags in terms of energy consumption in production, emissions from transportation, and larger volume of material in landfills at disposal. However, paper bags are considered better as they are recyclable in existing curbside programs and less problematic when littered or mismanaged at end-of-life because of their compostable and/or biodegradable capability. The impact of using multiple-use plastic grocery bags in St. John's, NL, with landfill as the only end-of-life waste management option, has been insufficiently documented. This research proposal seeks to conduct a life cycle assessment (LCA) of a reusable polypropylene non-woven bag that is imported from Vietnam and commonly sold by retail stores to shoppers. The findings of this study shows reusable PP bag is a good alternative to single-use plastic bag after implementation of the ban as North American citizens normally use the durable PP bags 14.6 times on average and thus it has less impact to the climate and environment. In addition, a fully landfill waste management strategy in St. John's can take up higher % plastic in the mixed solid waste stream than other areas where incineration is available in terms of overall GHG emissions. However, the governments should regulate distributors, which are grocery and retail chain stores, to provide reusable plastic bag recycling program in the absence of curbside recycling program so that the 3 long-life PP bags disposed by each shopper in St. John's will not occupied the landfill space for over 400 years without degradation. The idea of circular economy where producer responsibility for reuse and recycling should be adopted and applied to PP bags distributors as most of the reusable plastic bags are imported and the producers are located primarily in Asian countries.

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1. Objective

In light of Newfoundland and Labrador's provincial ban on the distribution of single-use retail plastic bags came into effect in October 1st, 2020 (Mooney, 2021), but there is a knowledge gap in research about the impact of imported reusable plastic shopping bag as a major substitute for single-use plastic bag within a specific scenario in St. John's, Newfoundland, Canada. This study aims to fulfill that gap by conducting a Life Cycle Assessment (LCA) of a selected type of multiple-use plastic grocery bag that is commonly sold by major grocery chains and often used by shoppers in St. John's. LCA is an analysis tool that makes objective measurements based on a quantifiable inventory of all inputs and outputs associated with the entire life cycle of a product, which includes extraction of raw-materials, manufacturing, transportation and ultimate end-of-life consumer disposal. The goal of this LCA study was to highlight the contribution of different life cycle stages (production, transportation, use and end-of-life) of long-life polypropylene (PP) grocery bag to the overall environmental burden in St. John's.

2. Life Cycle Assessment

2.1. Literature Review Methodolog

Research papers, studies and surveys conducted by Governments, Universities and Market research firm regarding cradle-to-grave LCA and user behavior of imported reusable PP shopping bags for other cities, provinces and countries were reviewed and applied to evaluate the LCA of imported multiple-use non-woven PP grocery bags in St. John's, NL. Worst-case scenario analysis is applied in this LCA to predict the greatest potential environmental outcomes of the subject PP carrier bag.

2.2. Assumptions & Parameters

a. Selected reusable plastic bag for this study: long-life non-woven PP bag

b. Brand: Compliments, Sobeys

c. Cost: $0.99

d. Size: 42 cm high by 35 cm wide by 18 width

e. Capacity: Up to 22.5 kg or 26 L (Mackenzie, 2009)

f. Functional unit: 1 standard PP bag weighted 100g with a capacity of 22.5 kg or 26L

g. Raw-material/Fabric: 100% virgin PP granulate (worst case scenario)

h. Country of origin: Vietnam (There is no PP bags manufacturing plant in Newfoundland, all PP bags are imported from Asia - primarily from China or Vietnam. Manufacturing plants situated in different parts of China are powered by very diverse resources of electricity grid. To make a more accurate analysis, Vietnam is selected as the country of origin of PP bags as the whole country shares a more standard electricity grid composition.)

i. Location of the selected Sobeys store for PP bags distribution: 8 Merrymeeting Rd, St. John's, NL A1C 2V5

j. End-of-life scenario: 100% Landfill (there is no existing curbside recycling program for plastic bag and no incineration in St. John's. Although the City of St. John's states that some grocery and department stores accept plastic shopping/ grocery bags for recycling which is the best option for residents to dispose their plastic grocery bags (The City of St. John's, n.d.), none of the major grocery chains announced such recycling program available on their official websites or have a recycling collection bin for plastic bags at their stores in St. John's and other parts of Newfoundland. Walmart is the only store mentioned having a plastic bag recycling program on its website *"many of our stores provide recycling bins for plastic bags and other* *plastic films"* (Walmart, n.d.), however the alleged recycling bins are not provided in the three (3) Walmart stores in St. John's. Therefore, this study assumes 0% recycling of PP bags with 100% going to landfill at the end of their life.)

k. Location of landfill facility in St. John's: Robin Hood Bay Waste Management Facility, 340 East White Hills Road, St. John's, NL A1A 5J7

2.3.LCA Scope and system boundaries

The scope of the study is cradle to grave, including all relevant life cycle flows, processes and phases: raw material extraction, transport of materials, manufacturing processes of bags in Vietnam, transportation of bags to Sobeys St. John's Merrymeeting Road, and in the end-of-life of bags as well as the 100% end-of-life disposal scenario by landfill.

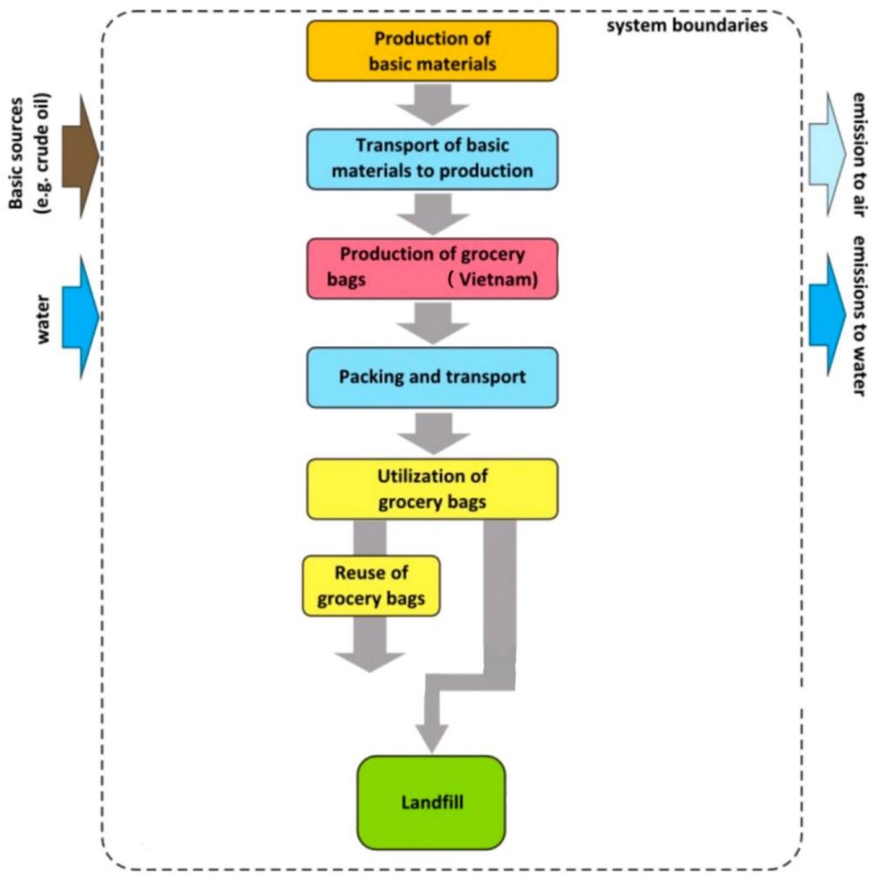

Figure 1 – Basic LCA model for long-life non-woven PP plastic bags, Flow-chart image reproduced from "Life Cycle Assessment of Supermarket Carrier Bags And Opportunity Of Bioplastic" (Mitja, Bostjan, Gasper, & Sekavcnik, 2013)

2.4. Raw materials production

Data of raw materials production (PP granulate) for bad manufacturing for PP bag were taken from generic Gabi 5 database from PE International in the research published by *Mitja, Bostjan, Gasper, & Sekavcnik, 2013*. The cardboard boxes and pallets used in the packing and transportation of PP bags are also included in the study and added to the transport weight. 100% cardboard boxes are recycled and 100% pallets are reused as common industrial practices by grocery stores and logistic companies.

2.5. Manufacturing processes

According to the *Mitja, Bostjan, Gasper, & Sekavcnik, 2013* study, the blown film extrusion process is used to manufacture PP carrier bags. Main inputs taken into account are PP granulate and Vietnam electrical energy mix. It also assumes there is no technical waste generated in the manufacturing processes of PP bags.

2.6. Transport

Transport routes were defined with materials distributors and bags manufacturers. PP bags manufactured in Vietnam are shipped to Port of Halifax, palletized and loaded to Truck which boards a ferry at North Sydney, NS and travels to Channel-Port aux Basques, NL, then the Truck continues its journey to deliver the PP bags to a Sobeys store on Merrymeeting Road. The farther the distance, the higher the transportation costs will be. Other factors that can impact transportation costs include customs fees, regulations, and the volume of bags being transported. Therefore, bulk transport in one scheduled shipment is preferred. In addition, the transportation process can take several weeks, depending on the mode of transport used and the distance between the two countries, transits in Halifax all the way to the destination in St. John’s.

Here is an overview of the transportation routes at different life cycle stages of PP bags:

Transportation of raw materials (PP granulate): Sea freight and road transport are used for delivery of PP granulate from areas such as India, Saudi Arabia, Thailand to the PP bags Manufacturing plant in Ho Chi Minh City, Vietnam.

Transportation of Cardboard boxes: Cardboard boxes are made in a site in proximity within Ho Chi Minh City and delivered by Truck to the PP bags factory for packaging.

Packaging on-site: Once the PP bags are made in the factory, the bags are packed in large cardboard boxes and stored on-site until being loaded to truck and moved to the Port for scheduled shipment. The boxes are usually labeled with details such as the number of bags, weight, and destination.

Transportation to the Port of Vietnam: The boxes of bags are transported from the factory to Saigon Port in Vietnam. This can be done by road or rail transport. Road transport is more common as it is faster and more convenient.

Transportation from Vietnam to the Port of Nova Scotia (NS): The bags are loaded onto a cargo ship that will transport them from Saigon Port, Vietnam across the ocean to the Port of Halifax, Canada. The bags can be transported in containers or in bulk, depending on the volume of bags being shipped. Shipping cargo containers are typically used for larger volumes of bags, while bulk shipping is more common for smaller volumes.

Transportation to Newfoundland (NL): Once the cargo ship arrives in Halifax, Canada, the bags are palletized and reload to the truck for another road transportation to Port of North Sydney, NS where the truck loaded with bags boarded the ferry’s commercial compartment and being shipped to Channel-Port aux Basques, NL.

Distribution to final destination: After the truck disembarked from the ferry, the bags are traveled by road again using the same truck for distribution to different Sobeys stores in NL. The final destination of this study is the Sobeys store on Merrymeeting Road, St. John’s.

The table below provides information about the transportation of PP carrier bags, including the distance traveled for the transport of raw materials to production locations and production locations to supermarkets. The distances mentioned in the table are estimated based on inputs from industry sources. It is assumed that the overall distance for the transportation of bags from the bag manufacturer in Vietnam to the supermarket in St. John’s is 17530 kilometers.

Table 1 – Transport Routes for PP Bag and associated CO2-eq. Emission

From	To	Mode of Transport	Approx. distance (km)	Transportation: CO2 emission (kg CO2-Eq)/ per 1 cargo container (280,000 bags)
Producers of PP granulate, India, Saudi Arabia, Thailand	PP Bag manufacturer, Ho Chi Minh City, Vietnam	Cargo ship, overseas	6000	0.014537 GWP/kgCO2-eq/per 1 bag (Mitja, Bostjan, Gasper, & Sekavcnik, 2013) -> 4070.324 GWP/kgCO2-eq
		22 tons Truck, EURO 1	50	
Cardboard manufacturer, Vietnam		22 tons Truck, EURO 1	20	
PP Bag manufacturer Ho Chi Minh City, Vietnam	Port Ho Chi Minh City, Vietnam	22 tons Truck, EURO 1	50	
Port Ho Chi Minh City, Vietnam	Port of Halifax, NS	Sea Freight	16000	8702.688
Port of Halifax, NS	North Sydney, NS via Ferry	Canadian Heavy-duty Truck (Diesel)	400	368
North Sydney, NS via ferry	Channel-Port aux Basques, NL	Ferry (Diesel)	180	341.9

Channel-Port aux Basques, NL	Supermarkets in St. John	Canadian Heavy-duty Truck (Diesel)	900	828
				Total: 14310.91 kg CO2-eq /280,000 bags -> 0.05111 kg CO2-Eq /1 bag

Calculations:

CO2-eq. for Sea Freight from Saigon Port, Vietnam to Halifax Port, NS:

A cargo ship produces 16.14 g of CO2 per metric ton of goods shipped per kilometer (Kilgore, 2023). For 1 cargo at 3740kg + 280,000 PP bags at 28000kg + cardboard boxes at 1960kg, total weight of a loaded cargo of cardboard boxes packed PP bags is 33,700 kg = 33.7 tons.

Therefore, 1 loaded container 33,700 kg can emit CO2-eq= 8702.688 kgCO2-eq

CO2-eq. for Diesel Truck Road Transportation (Canadian Emissions Standard):

Using the given mileage of 35L of diesel per 100km, we can calculate the amount of diesel fuel required to cover the given distances (Natural Resources Canada, 2019):

To cross 400km, the amount of diesel fuel required is 140 liters (400/100 x 35)

To cross 900km, the amount of diesel fuel required is 315 liters (900/100 x 35)

Now we can calculate the CO2 emissions for each distance by multiplying the amount of diesel fuel required by the emission factor:

To cross 400km, the CO2 emissions would be 368.2 kg (140 x 2.63)

To cross 900km, the CO2 emissions would be 828.45 kg (315 x 2.63)

CO2-eq. for Ferry Transportation (with average 4.5 cargo trucks onboard per trip) (International Emissions Standard):

According to the International Maritime Organization (IMO), the average CO2 emission factor for marine diesel oil (MDO) is around 3.11 kg CO2e per liter of fuel consumed (Krantz, 2016). The fuel consumption rate for the typical ferry is given as 200 liters per 1.852 Kilometer. Therefore, the fuel consumption for a 180 km ferry crossing would be:

Fuel consumed = Fuel consumption rate x Distance traveled Fuel consumed = 200 liters/1.852 km x 180 km Fuel consumed = 19,309 liters

We need to calculate the total CO2 emissions for this amount of fuel consumed. The average CO2 emission factor for MDO is given as 3.11 kg CO2e per liter of fuel consumed.

Therefore, the CO2 emissions for 19,309 liters of MDO would be: CO2 emissions = Fuel consumed x CO2 emission factor CO2 emissions = 19,309 liters x 3.11 kg CO2e/liter CO2 emissions = 60,103 kg CO2e So, the CO2 emissions for a 180 km ferry crossing would be approximately 60,103 kg CO2e. For MV Atlantic Vision that travels between North Sydney Port, NS and Channel-Port aux Basques Port, NL, its Deadweight tonnage (DWT) is 5915 (Vessel Finder, n.d.), in which 4.5 cargos of truck and loaded bags only constitute about 2.56% of the overall DWT, therefore 1 cargo of bags and truck weight in 1 ferry trip only account for 341.9 CO2e.

Table 2 – Raw material consumption and primary packaging

Type	Material-basic	Material	Mass	Primary Packing
PP-life	Polypropylene	PP virgin	100g	Cardboard 1400g / 200 bags or Cardboard 700g / 100 bags, so that the total weight of 1 loaded Cardboard box with PP bags does not exceed 50 lbs. as per Walmart Shipping Guide (Walmart, 2022) 1 cargo / 280,000 bags 14 cardboard boxes (1400g box) / 1 palate

2.7.End of life and recycling

As previously mentioned, 100% recycling of cardboard, 100% reuse of palate and 100% landfill of PP bags at their respective end-of-life scenarios were assumed. In the case of landfill process, landfill gas is not produced by the disposal of PP bags as plastic in general can take more than 400 years to degrade. (Great Britain's Royal Statistical Society & National Geographic Society, 2018) Therefore, we can assume that the GWP impact from landfilling is negligible and tends to zero.

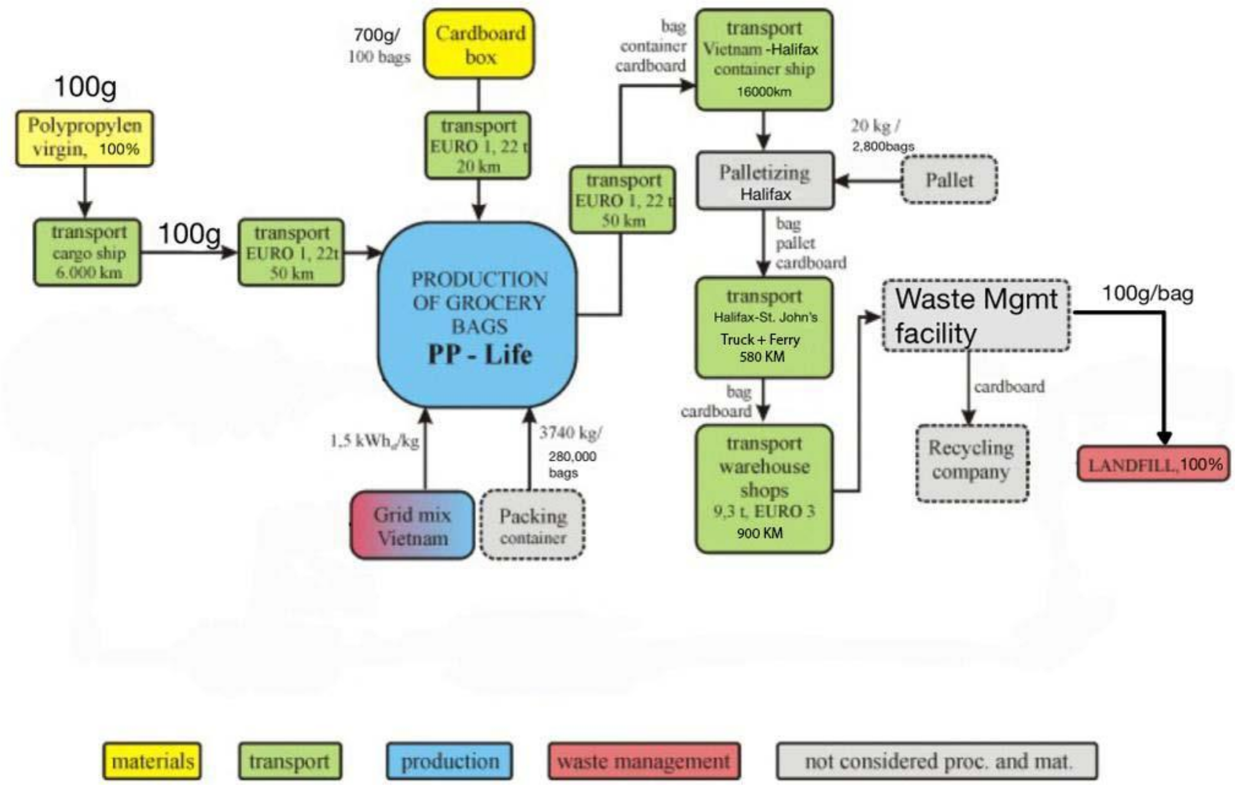

Figure 2 - LCA model of PP bag, Flow-chart image reproduced from "Life Cycle Assessment of Supermarket Carrier Bags And Opportunity Of Bioplastics" (Mitja, Bostjan, Gasper, & Sekavcnik, 2013)

2.8. Impact assessment

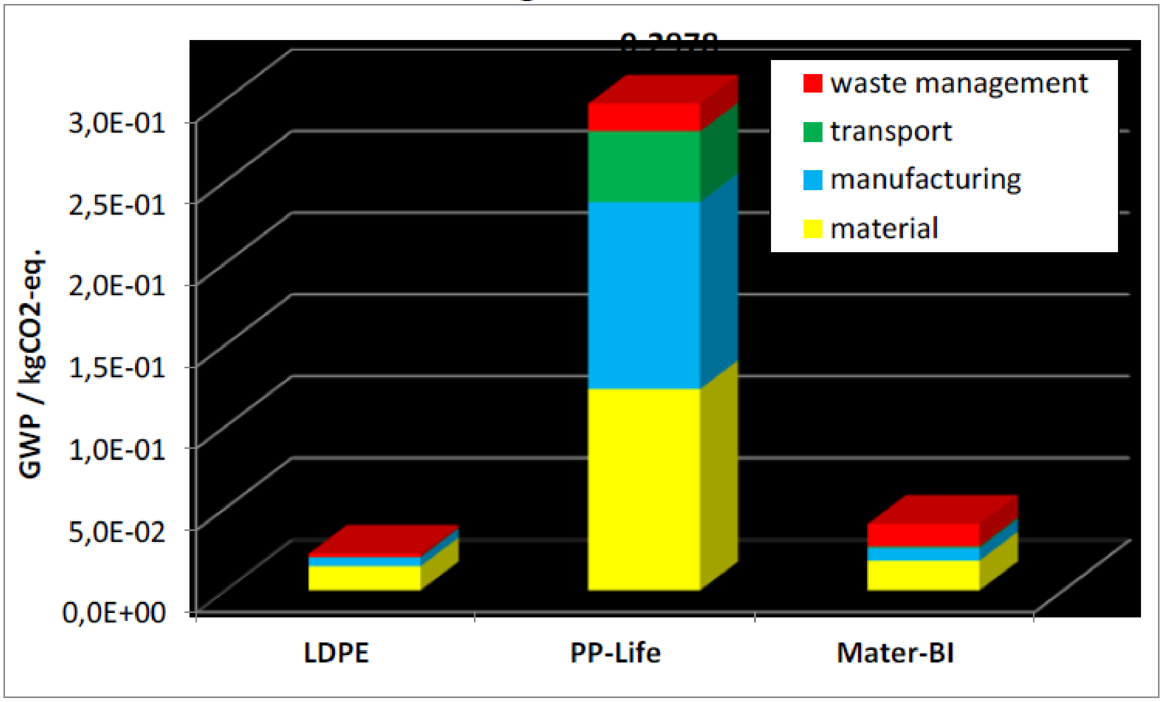

Figure 3 – GWP for 1 Carrying bag (functional unit) from "Life Cycle Assessment of Supermarket Carrier Bags And Opportunity Of Bioplastics" (Mitja, Bostjan, Gasper, & Sekavcnik, 2013)

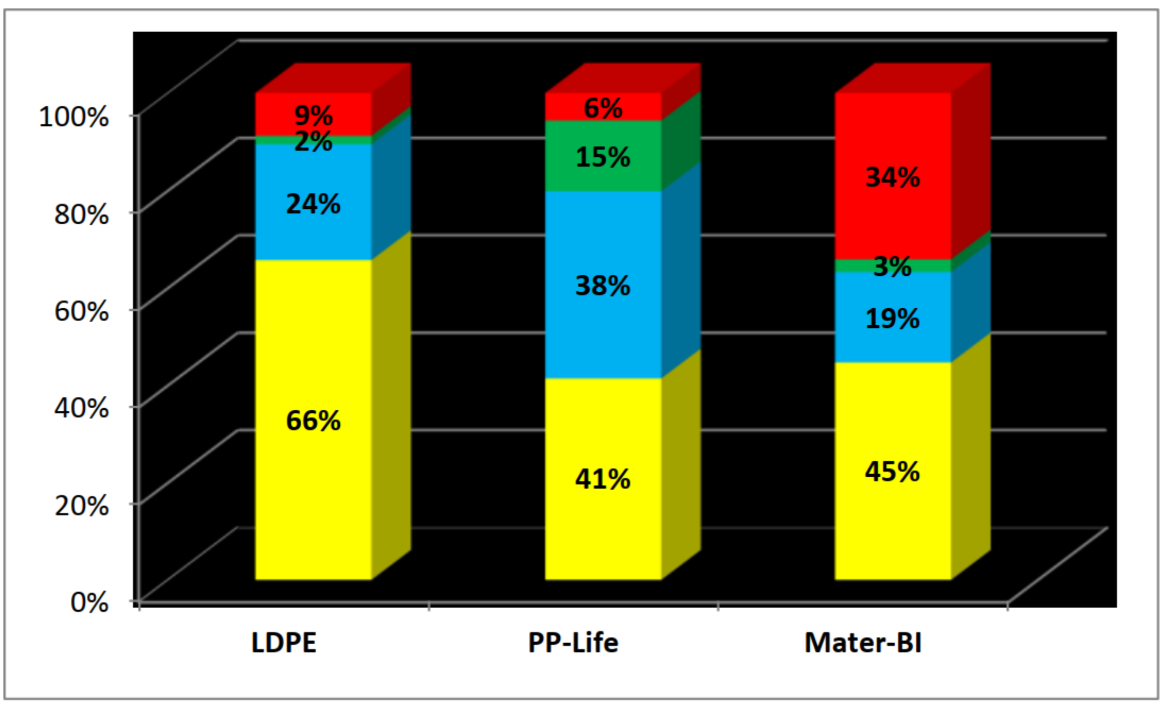

Figure 4 – Relative Contribution to overall environmental impact from "Life Cycle Assessment of Supermarket Carrier Bags And Opportunity Of Bioplastics" (Mitja, Bostjan, Gasper, & Sekavcnik, 2013)

Referring to the study in *“Life Cycle Assessment of Supermarket Carrier Bags And Opportunity Of Bioplastics”*, the GWP in terms of kgCO2-eq of material and manufacturing of PP bag from a factory in Vietnam remains unchanged while the emissions from transportation i.e. the Green Section of the PP-Life Bar as shown above enlarged significantly due to the distance between Vietnam and St. John’s, NL is much farther than that between Vietnam and Ptuj, Slovenia. The overall calculated GWP for transportation of 1 PP bag in St. John’s scenario is 0.05111 CO2-eq vs. 0.04467 CO2-eq of the reference case, resulting in an increase of 14.42% in GWP for transportation. The relative contribution of transportation in the present case i.e. the Green Section in Figure 4 becomes 17.16%.

On the other hand, the Red section representing the waste management becomes zero as there was 14% of the PP bags incinerated at their end-of-life disposal in the study case of the research paper with associated GWP emissions, whereas 100% of PP bags in the present study goes to landfill without degradation or gas emissions generated. Using 100% PP granulate as raw material in this study rather than having 50% recycled content for production in the reference research (Mitja, Bostjan, Gasper, & Sekavcnik, 2013), the Yellow and Blue sections are expected to be doubled in Figure 3 above as the GWP for 50% more virgin material also increases the need for electricity from 0.6kWh/kg of recycled PP to 1.5kWh/kg of virgin PP.

3. Discussion and Conclusion

In 2014, Edelman Berland conducted a nationwide study to determine the reuse rate of reusable bags in the United States, and the results are relevant to the current life cycle analysis of non-woven polypropylene PP bags. The study found that on average, PP bags are reused 14.6 times, with higher rates in markets where legislation is in place. Edelman Berland provided data that shows the percentage of people and the number of times they reused their PP bags based on a sample of 1,002 individuals across the U.S. (Edelman Berland, 2014)

Another U.S. study found that for 14.6 times usage of non-woven PP imported to the U.S from China, indicated as NWPP in Figure 5 below, have lower Global Warming Potential than all other types of single-use plastic retail bags, paper bags but double than that of reusable Low-Density Polyethylene (LDPE) bags (Kimmel, 2014). However, the Edelman Berland's study found that a LDPE bag is only used 3.1 times on average by Americans nationwide despite their place of abode has legislation or regulation affecting the selection and use of grocery bags or not (Edelman Berland, 2014).

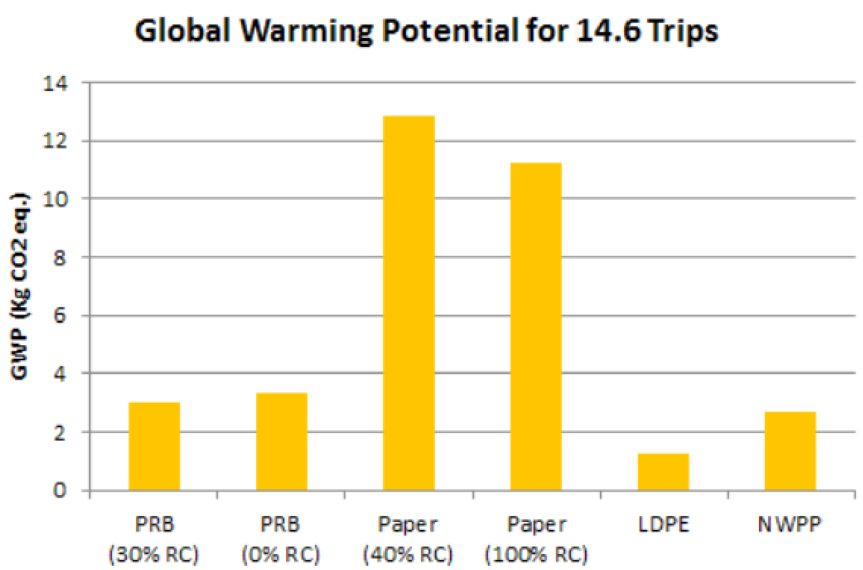

Figure 5 – Comparison of Global Warming Potential for 14.6 Trips among Single-use Plastic Retail Bags (PRB) with 30% Recycled Content (RC), PRB with 0% RC, Paper Bags with 40% RC, Paper Bag with 100%, reusable Low-Density Polyethylene (LDPE) Bags and NWPP (Kimmel, 2014)

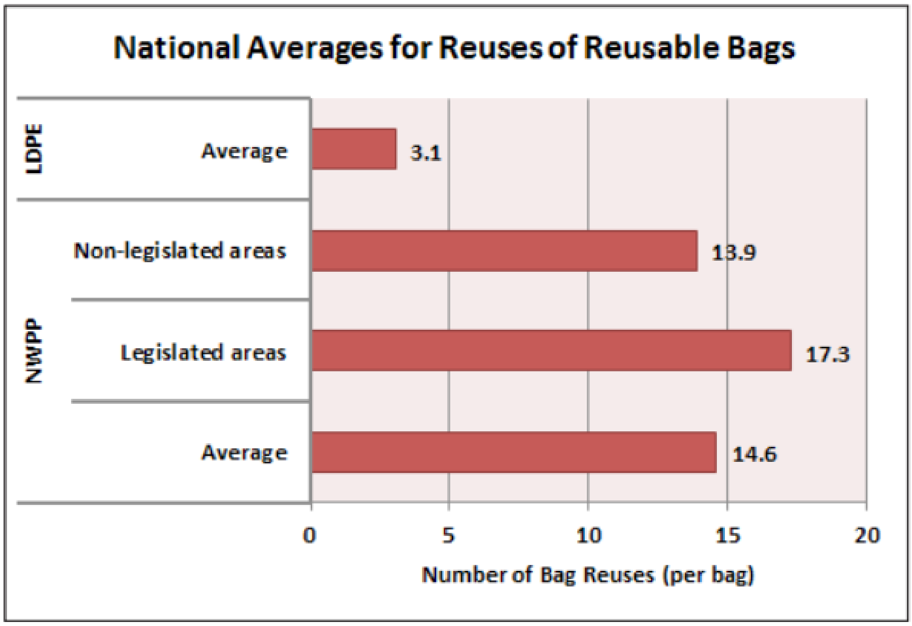

Figure 6 – Keys findings for reuse of reusable LDPE vs. NWPP Bags from the Edelman Berland Study (Kimmel, 2014)

Assuming residents of North America have similar usage pattern of long-life PP bags for grocery shopping, 1 PP bag will be used 14.6 times on average in its lifespan per year by residents of St. John's. If a shopper goes to Sobeys for grocery shopping once a week, a PP bag will be used for 14-15 weeks, which means every shopper will consume 4 PP bags annually (52 weeks tenure). Amongst these 4 PP bags, 3 of them will end up being disposed in landfill every year.

According to another study about GHG emissions footprint for treating mixed municipal solid waste with different waste compositions, by landfilling and mass-burn incineration estimated by Solid Waste Optimization Framework (SWOLF) (spreadsheet version retrieved April 2019), landfilling a waste stream with at least 40% to 54% plastic content resulted in more GHG emissions favor than incineration, when including carbon sequestration, for both landfill gas approaches (aggressive and conservative) minus incineration emissions. The major assumption made in that research resulted in landfill GHG emissions favor was the landfill gas management assumptions, specifically the landfill gas collection efficiency assumption (Malak Anshassi, 2021). For the waste management in the absence of incineration in St. John's, the plastic % can be even higher without having to subtract the incineration emissions.

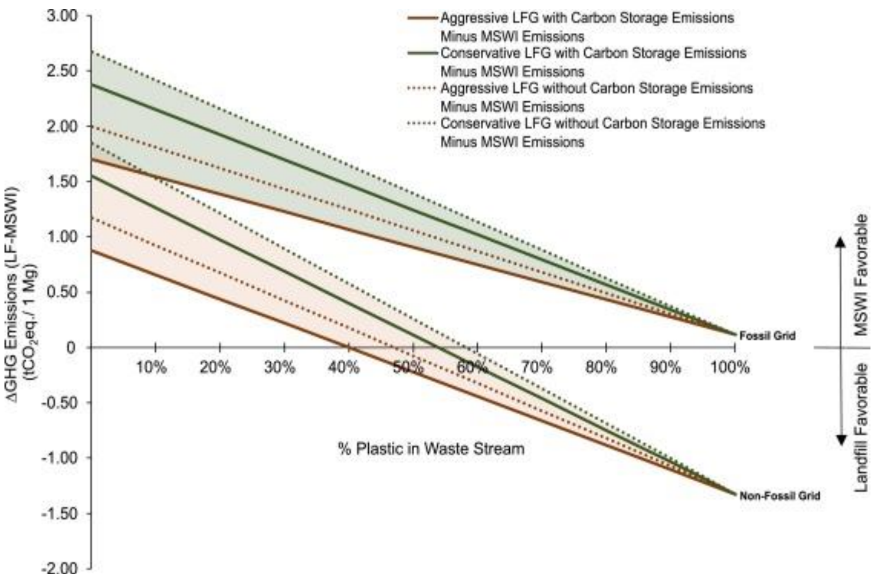

Figure 7 – GHG Emissions Landfill vs. Municipal Solid Waste Incineration against % Plastic in Waste Stream (Malak Anshassi, 2021)

United Nations study "Single-use plastic bags and their alternatives, 2020" indicates that a non-woven PP bag need to be used 10-20 times to have less impact to the climate and become more environmentally friendly than a single-use plastic bag (United Nations, 2020). An average use of 14.5 times of 1 PP bags by residents in North America falls within this range and can be considered as a good alternative to single-use plastic bag after the NL government implemented the ban. Yet, GWP impacts of PP bag noted significant increase due to extra-long travel distance of imported PP bag, especially in the case when it contains 0% RC. Shoppers should be reminded to use the long-life PP bag as many times as possible before disposal to even out or surpass its adverse environmental impacts generated in production, manufacturing, and most importantly transportation processes.

In view of the waste management strategy and technology – landfill used by the City of St. John's, the city should calculate the threshold of % of plastic in the mixed solid waste stream that favours landfilling as there is no incineration available and monitor the increase of plastic waste due to disposed long-life PP bags so the dynamic or optimum equilibrium for landfilling will not be disturbed.

Though LCA of long-life PP bag is better than single-use plastic bag, the disposed PP bags will all end up in landfill without degradation for another 400 more years. Therefore, all levels of governments should regulate the Importer/Seller of reusable PP bags, especially the grocery and retail chain stores, to provide recycling program (in the absence of curbside recycling program provided by municipality) as part of the scheme of circular economy similar to the rationale behind producer responsibility, as the producers of reusable plastic bags are normally located overseas in Asian countries, the distributor of long-life plastic bags should take up this responsibility.

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