

Cradle to Grave of Materials

A. Vijayalakshmi, Assistant Professor, Department of Chemistry, RMK Engineering College, Kavaraipettai, Thiruvallur

M. Meena, Professor, Department of Chemistry, R. M. K. Engineering College, Kavaraipettai, Thiruvallur

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Abstract:

Each and every product has an environmental impact, such as emission of methane and carbon dioxide (Green House Gases - GHG), use of valuable resources and land usage. Life Cycle Analysis (or) Life Cycle Assessment (LCA) and Carbon Footprint are methods used to analyze the environmental issues of those products and supply chains. These methods give an insight in possible ways to improve the supply chain. To achieve sustainable development and aesthetic green environment this analysis is very essential. The main difference between carbon foot print and LCA is, the first one focuses on environmental impact category like GHG emissions and later one takes much impact categories in to its account such as, changes in the climatic conditions, health of human beings, usage of land, acidification of water and effect on biodiversity by the products in each and every phase of its life cycle. The ultimate aim of LCA is, to compare the impact on environment, related to the flow of materials and products by analyzing the way these affect the entire environment. The information obtained by this analysis is used to enhance processes, policy support and offer a well found informed decision. This paper gives an outline of life cycle assessment of plastic with variety of materials used in our day to day life.

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1. INTRODUCTION

Life cycle assessment (LCA) is a systematic quantitative evaluation method for investigating the effects on our surroundings from the beginning to end of a product's life cycle i.e., from the manufacture to end of its life span (from cradle to grave) [1]. According to the ISO 14040 [2] and 14044 [3] standards, a Life Cycle Analysis is carried out in four different phases *goal and scope*, *inventory analysis*, *impact assessment*, and *interpretation* as shown in Fig.1. The stages are often inter-reliant in that results of one stage will inform how other stages are completed. Based on this information, variety of applications like step up of product, strategic planning, policy making and marketing can be arrived. So, a sound basis of knowledgeable decisions will be available and it informs wide opportunity to tackle various sustainability issues.

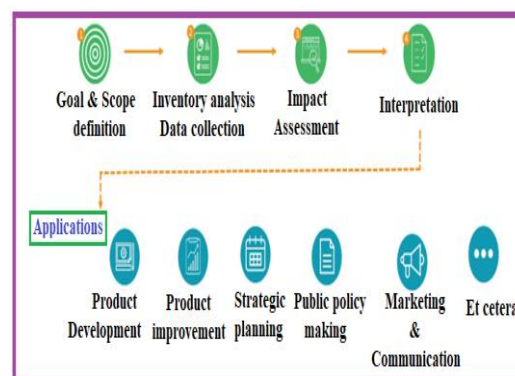


Fig.1. Illustration of LCA phases

2. PLASTIC-AN EXTRAORDINARY MATERIAL

Plastic is an extraordinary material due to its specific characteristics, such as lightweight, durable, elastic, cost efficient, etc. Almost in all the industries, Plastic is an eminent material due to its astounding properties. Although plastics afford

human beings with numerous advantages they play a negative role for the environment. It causes danger and affect both aquatic and terrestrial ecosystem [4].

3. LIFE CYCLE ANALYSIS OF PLASTIC BAGS

Worldwide alternatives are in search, to find a best suitable solution for the usages of plastic bags by doing a systematic analysis. But already many comparative results and report are available between plastics and other materials. A comparative study has been done between paper and plastic bag by the American Chemical Council Plastics Division [5]. This study established that, lesser resources like energy, water are needed for the production of plastic bags when compared to paper and also waste generated.

4. PLASTIC BAG WITH PAPER BAG

For the manufacture of paper, every year cutting of millions of trees is unavoidable. To make paper, highly toxic chemicals and tones of energy are required. So, water pollution and air pollution is a big issue. Paper is a sustainable renewable resource but the chemicals and energy consumption make it, is NOT. Recycling of paper always pollutes water bodies more than making a new paper. 1000 shopping bags can be equated with burning 56.79 liters of petrol. For cleaning the GHG emitted in this process, 6 trees must work for 365 days. Fig.2 shows the analysis of paper shopping bag and plastic on various parameters.

Shopping bag Analysis		Renewable Resource	Energy Required to Make	Water Pollution Created	Air Pollution Created	Chemicals Used	Recycle-ability	Landfill Space (Disposal)	Degrade-ability	Consumer Cost
Paper	Yes	Very High	Very High	High	Very High	Med.	Very High	High	Free	Paper
Plastic	No	Med.	Low	Med.	High	Low	Med.	Very Low	Free	Plastic

Fig.2. Various parameters of paper and plastic bag

The energy consumption during the manufacture of plastic is 40% less than the paper bags (Fig.3).

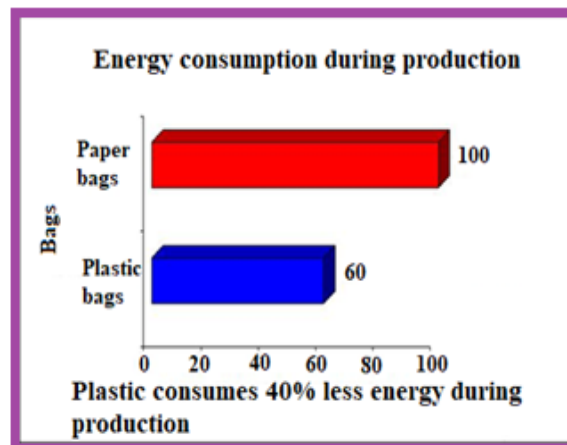


Fig.3. Energy consumption for plastic and paper bags

The solid waste generated in plastic is less by 80% than paper after the usage (Fig.4.) [6].

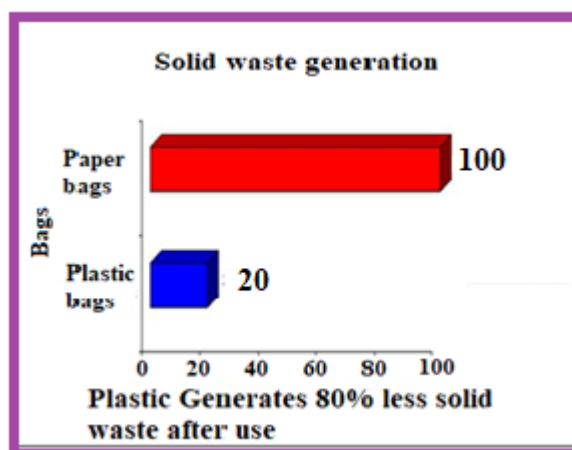


Fig.4.Solid waste generation for plastic and paper bags

Most of the studies from North America and Europe concluded that plastic bags have less impact on the surroundings than paper bags. The scientific research also revealed the same and stated that less impact by plastic bags than the paper on GHG and global warming. Another industry-funded Boustead Associates study showcased the score of 1 for plastic on environmental impact. The reference point above 1 indicates severe problem in environment. When we compare plastic and paper, except the risk of

litter, other indicator of environmental impact is safer [7]. The data in Table 1 supports the same.

Table.1. Comparative Analysis of paper and plastic on environment.

Indicator of Environmental impact	Plastic bag (HDPE light weight)*	Paper bag
Consumption of non-renewable primary energy	1.0	1.1
Consumption of water	1.0	4.0
Climate change (GHG emission)	1.0	3.3
Acid rain	1.0	1.9
Air quality (Ground level ozone formation)	1.0	1.3
Eutrophication of water bodies*	1.0	14.9
Solid waste production	1.0	2.7
Risk of litter	1.0	0.2

*HDPE lightweight refers to a conventional plastic grocery bag

Comparison of need of resources and pollution for plastic bag and paper bag is given by Boustead life cycle assessment [8] is given in the following Fig.5

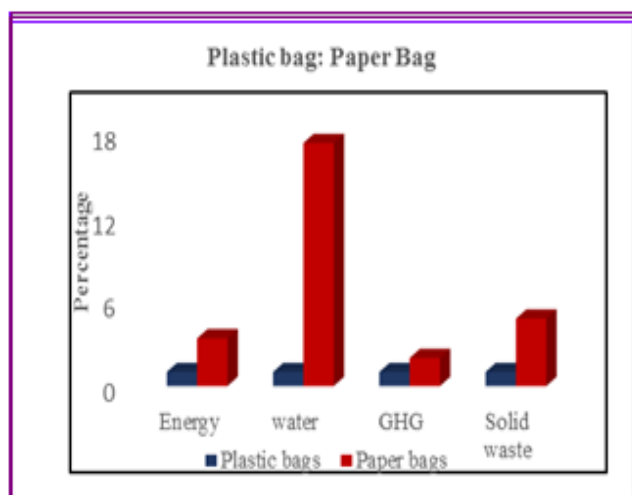


Fig.5. Comparison of resources and pollution for plastic bag and paper bag

Table.2. shows the LCA of 1000 paper bags with plastic and reveals that impact of plastic is less on comparison with paper.

Table.2. LCA of 1000 paper bags with plastic.

Environmental impact based on equalized carrying capacity of 1000 paper bags	Plastic bags	Paper bags with 30% recycled content
Total energy use in MJ	763	2622
Fossil fuel use in Kg	14.9	23.2
Municipal solid waste in Kg	7.0	33.9
Green house gas emissions in CO ₂ in equiv. tonnes	0.04	0.08
Fresh water usage in gallons	58	1004

5. PLASTIC BAG WITH JUTE BAG (GOLDEN FIBRE)

Jute is a naturally available vegetable fibre which is made from the outer layer of stem and skin of a jute plant. Jute requires less space for cultivation, less space for farming and water. So it is eco-friendly choice and can surely sustain for future. At the same time, life span of jute bag is much longer than Plastic Bags. Not only sustainable but, it is also durable, strong, and also available in gorgeous designs and maintain the beauty for longer time. Disposing of Jute bags is so easy when compared to plastics bags. Jute material can be decomposed within a short span of one or two weeks, but plastics take several hundreds of years to disintegrate completely. The main drawback of jute is not possessing water proof capacity. Packing of food items with a jute bag needs a lot of care. These bags are not suitable for food items like sugar or salt which gets dissolved easily. However, we can use plastic laminated jute bags in order to make it waterproof. Jute is losing its market value to artificial fibers like nylon that are much more cost efficient and durable. The natural fiber also has several negative qualities, such as the fact that it greatly loses strength upon getting wet, changes color after too much exposure to sunlight, and does not react well to a humid climate.

As per the report of IIT Delhi [9], pollution produced during the manufacture of jute bags is higher side when compared to plastic bags and the values are mentioned in Table.3.

Table.3. Pollution levels during the production of jute and plastic bags

Environmental burden in Kg	Jute bag	Plastic bag
Air pollution		
CO	54.3	0.6
CO ₂	6610.2*	760*
SO _x	134.8	5.2
NO _x	68.1*	4.8*
CH ₄	39.5	3.2
HCl	5.3	0
Dust	67.6	1.4
Water pollution		
Suspended solids	352.3	0.2
Chlorides	4535.5	0.1

*Values are for packaging of 1 Lakh MT of Atta.

During the transportation of the same also results in more global warming than plastic (Table.4).

Table.4. Pollution levels during the production of jute and plastic bags

Emission	Gm/Km	Excessive Emission for Jute bags	Plastic Bags
CO ₂	781*	11107.3*	Taken as basis
CO	4.5	64.0	Taken as basis
HC	1.1	15.6	Taken as basis
NO _x	8*	113.8*	Taken as basis
Particulates	0.36	5.1	Taken as basis
Total regulated tail pipe emission	13.96	198.5	Taken as basis

*High potential for Global warming

6. FOAM PLASTIC CUP IS BETTER THAN CHINA GLASS AND PAPER

On the comparison of a foamed plastic cup, china glass and paper cup, foamed plastic play a positive impact in the environment (Table.5) [10].

Table.5. Environmental impact analysis on foamed plastic cup, china glass and paper cup.

Environmental Impact	Foam plastic	China glass	Paper
Energy conservation	Very high. Needs relatively little energy to make	Poor: Needs high energy to run kilns and wash for reuse.	Poor: Requires high energy to run mills.
Water conservation	Excellent: Little amount required.	Poor: Needs large quantities to make and wash	Poor: Requires large quantities to make.
Waste to Energy conversion	Excellent	None	Poor
Recyclability	Total	Partial	Partial
Landfill contaminants	None: Inert	None: Inert	Can contribute to methane gas and leachates
Air pollutants when properly incinerated	None	None: Does not burn.	Virtually None
Impact on Ozone layer	Positive: contains no CFCs	Positive: contains no CFCs	Positive: contains no CFCs
Relative pocket book impact (Price)	Low	High	High

6. CONCLUSION

Eventhough Plastic having numerous advantages, the main drawback is its non-biodegradability. Scientific research shows that it takes long span of 500-1000 years to decompose this plastic. Government should ban the production of single use plastic. In the current scenario, we can avoid plastic completely. But we can use in minimum amount without affecting our environment. So that we can be able to maintain ecological balance. Based on the above reports it can be concluded that plastic is advantages in the prodction level, discharge of pollution is also less when compared to other types of material. Though it is advantageous in the above mentioned category, its impact on environment while discarding is highly problematic. Hence a lot of research is going on to develop bio-degradable plastic from plant extracts. There are some varieties of bio-degradable plastic already available in the market. Bio-degradable plastic is a very good alternative potential material but currently they are costlier than synthetic plastic. Recycling plastic is one of the best solutions to prevent releasing plastic garbage in the environment. Currently, the amount of plastic recycled could be as low as 10% of the total plastic disposed annually. New plastic will become costly with the rising price of petrochemicals and hence recycling will play a bigger role in future.

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