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IDENTIFICATION OF 'HOT SPOTS' IN THE LIFE CYCLE OF SOFT DRINKS PRODUCED IN INDIA

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ABSTRACT

Climate change is widely recognised as being one of the major threats facing the world at this time; its consequences go far beyond its impact on the environment alone. The question is no longer whether the focus must be placed on moving into a low-carbon future but, rather, how that will be achieved. Natural resources have to be harvested faster as the world population increases. This study was focused on the soft drink industry. Using CCaLC2 tool, the environmental impacts of different types of packaging used was determined and identified the various environmental hot spots. Polyethylene Terephthalate (PET) bottle of 600 ml and aluminium can of 330 ml was considered for the study. The functional unit of this study was packaging system required to deliver 1000 litres of soft drinks. From the study it was cleared that PET bottles are more sustainable than aluminium cans.

Keywords: Carbon Footprint, Environmental Impacts, Soft Drink Industry, Sustainability, Water Footprint

I. INTRODUCTION

The natural environment encompasses all the living and non living things occurring naturally. The term is most often applied to the Earth or some part of Earth. This environment encompasses the interaction of all living species, climate, weather, and natural resources that affect human survival and economic activity. Natural resources are resources that exist without the actions of humankind. The exploitation of natural resources is the use of natural resources for economic growth, sometimes with a negative connotation of accompanying environmental degradation.

A soft drink is a drink that typically contains carbonated water, a sweetener, and a natural or artificial flavouring. The sweetener may be sugar, high-fructose corn syrup, fruit juice, sugar substitutes (in the case of diet drinks), or some combination of these. Soft drinks may also contain caffeine, colouring agents, preservatives, and other ingredients. Soft drinks are called "soft" in contrast to "hard drinks" (alcoholic beverages). Small amounts of alcohol may be present in a soft drink, but the alcohol content must be less than 0.5% of the total volume if the drink is to be considered non-alcoholic. Fruit punch, tea, and other such non-alcoholic beverages are technically soft drinks by this definition but are not generally referred to as such. According to the industry analysis, internationally the soft drink industry is dominated by two major brands, namely, Coca-Cola (with a global market share of around 50%), followed by PepsiCo (at about 21%). Human impact on the environment or anthropogenic impact on the environment includes impacts on biophysical

IJARSE
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environments, biodiversity, and other resources. Global warming is the result of increasing atmospheric carbon dioxide concentrations.

The hard truth is that our economic system is partially blind. The economy focuses more on the value added items, such as food, clothing, manufacturing goods, work and money whereby the environmental systems are not included in the value added item. The fresh and clean air, the life of animals and our planet are some of the real value items and the economy are ignoring. This blindness is the driving force for the irrational decisions that as humans and the economic system are making today. Because of the change in the life style people are depending on soft drinks. This is increased the production of soft drinks. Large scale productions of soft drinks are directly or indirectly affecting the carbon dioxide emission and the freshwater usage

The primary function of packaging is to protect the product, maintaining its safety and quality, and ensuring it reaches the consumer in the same condition as when it was first produced and throughout its shelf life. The soft drinks sector uses a variety of different packaging formats. The main types are glass, Polyethylene Terephthalate (PET), aluminium and steel cans. It’s harder to recycle plastic bottles than you think. Of the mass numbers of plastic bottles consumed throughout the world, most of them are not recycled because only certain types of plastic bottles can be recycled by certain municipalities. They either end up lying stagnant in landfills, leaching dangerous chemicals into the ground, or they infiltrate our streets as litter. They are found on sidewalks, in parks, front yards and rivers, and even if you chop them into tiny pieces they still take more than a human lifetime to decompose.

Previous studies were conducted on the carbon footprint of industries, food etc. A study was conducted on the life cycle environmental impacts of carbonated soft drinks in UK using GaBi 4.3 software.

This study was focused on the environmental impacts due to the manufacturing of soft drinks in India. CCaLC2 software was used for the study. Polyethylene Terephthalate (PET) bottle of 600 ml and aluminium can of 330 ml was studied. Our main purpose of study was identifying the most sustainable option and to identify the contribution of soft drinks packaging in climate change.

II. METHODOLOGY

The LCA study follows the ISO 14044: 2006 and PAS 2050: 2008 methodologies as far as possible. The functional unit of this study was defined as the packaging system required for delivering 1000 litres of soft drinks. Cradle to grave approach was used for this study. A cradle-to-grave analysis involves a 'holistic' approach, bringing the environmental impacts into one consistent framework, wherever and whenever these impacts have occurred, or will occur. One fundamental reason for choosing such an approach is related to the fact that the final consumption of products happens to be the driving force of the economy. Therefore, this final consumption offers core opportunities for indirect environmental management along the whole chain or network of unit processes related to a product. Another fundamental reason is that a cradle-to-grave approach avoids ‘problem shifting’. It is important in eco-design not to solve one environmental problem merely by shifting it to another stage in the product’s life cycle. For instance, making a car out of aluminium instead of steel means that its gasoline consumption is reduced, but the production of aluminium requires more energy than that of steel. Only when all these facts are taken into account can it be judged whether a car made of aluminium is truly more environmentally friendly than one made of steel.

IJARSE
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The following life cycle stages are considered:

- Raw materials extraction and production;
- Packaging production and transport to filling site;
- Tops and labels production and transport to filling site;
- Filling of the packaging;
- Distribution of the filled packaging to consumers;
- Transport of post-consumer waste to waste management;
- Landfill, incineration and recycling of the waste packaging.

The following is excluded from the system boundary:

- Energy used for storage at the retail stage;
- Energy use at the consumption stage;
- Carbon footprint of the beverage; and
- Secondary and tertiary packaging.

All transport distances in the life cycle stages are assumed to be 100 km using 22 t trucks. The transport stages include:

- Transport of raw materials to the manufacturing site;
- Transport of packaging, tops/ends and labels from the manufacturing site to the filling stage;
- Transport of the filled packaging from the filling site to storage at consumer, which includes transport to warehouse and retail centres;
- Transport to landfill, incineration and recycling sites.

PET bottle of 600 ml and aluminium can of 330 ml of 3 different types of soft drinks was purchased from local market and weighed. Manufacturing data was collected from authorised documents and experts.

III. RESULTS AND DISCUSSION

Various environmental impacts like carbon footprint, water footprint, acidification potential, Eutrophication potential, ozone layer depletion potential, photochemical smog potential, and human toxicity potential were discussed below. All the impacts were estimated for delivering 1000 litres of soft drinks.

3.1 Carbon Footprint

Carbon footprint of PET bottles and aluminium cans were discussed below. Fig 1 was representing the overall carbon footprint of PET bottles (600 ml) used to deliver 1000 litres of soft drinks. From the graph it cleared that the raw materials used for the manufacturing of PET bottles were contributing 82.78% of overall carbon footprint. PET granulates, PP granulates and LDPE films were used for Bottle Manufacturing, Top Manufacturing and Label Manufacturing respectively. The overall carbon footprint of PET bottle (600 ml) was 152.11 kg CO_2 eq. / functional unit

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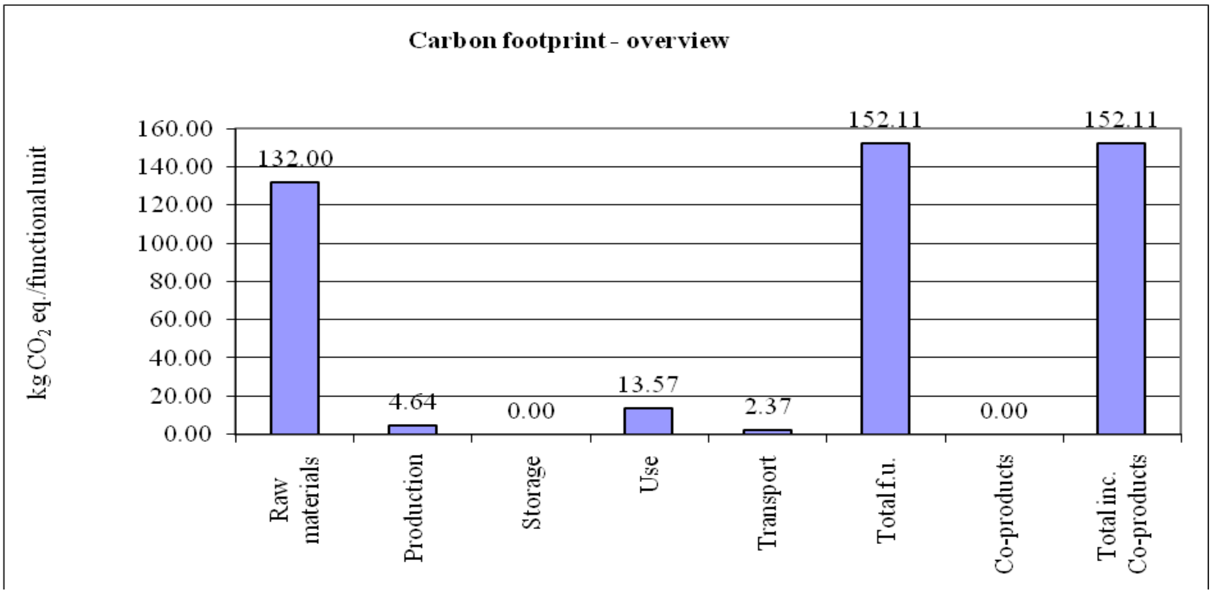

Fig 1: Overall carbon footprint of PET Bottles (600ml)

Fig 2 was representing the overall carbon footprint of aluminium cans (330 ml) for soft drinks. From the graph it cleared that raw materials are the major contributors. And also the overall carbon footprint of aluminium cans was very much higher than that of PET bottles. Aluminium ingots were the major raw materials used for the manufacturing of the cans. The overall carbon footprint of aluminium can was 776.16 kg CO_2 eq. / functional unit

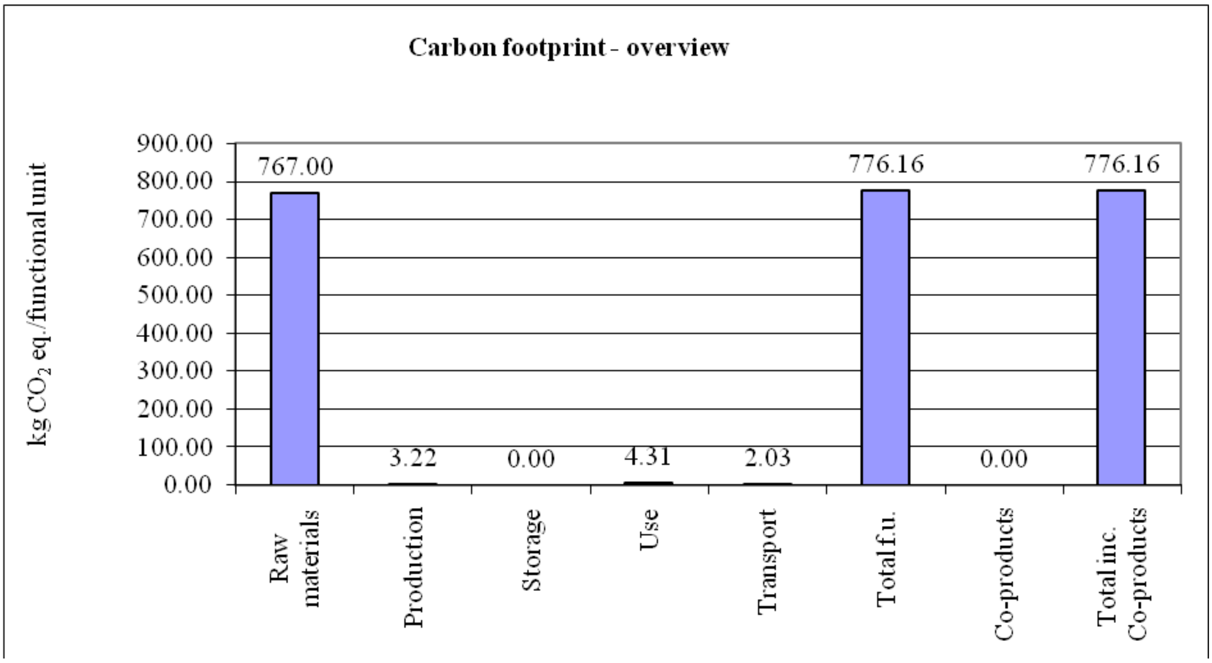

Fig 2: Overall carbon footprint of aluminium cans (330 ml)

Fig 3 was representing the carbon contribution in production stage of PET bottles. 54.74% was contributing by filling stage and 29.74% was contributing by bottle manufacturing using PET granulates. This variation was due to the fact that in the filling stage electricity and Steam (Natural gas) were using as energy sources.

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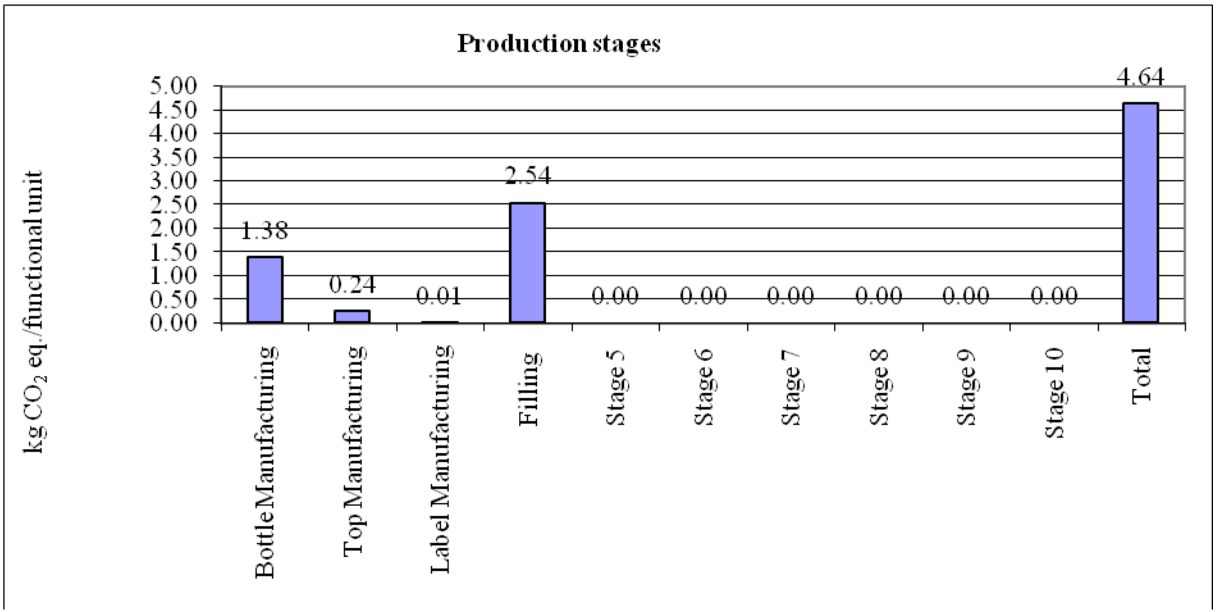

Fig 3: Carbon footprint in the production stage of PET bottle (600 ml)

But in the case of production of aluminium cans, can manufacturing was contributing about 63.66% of total carbon footprint in production stage as per Fig 4.

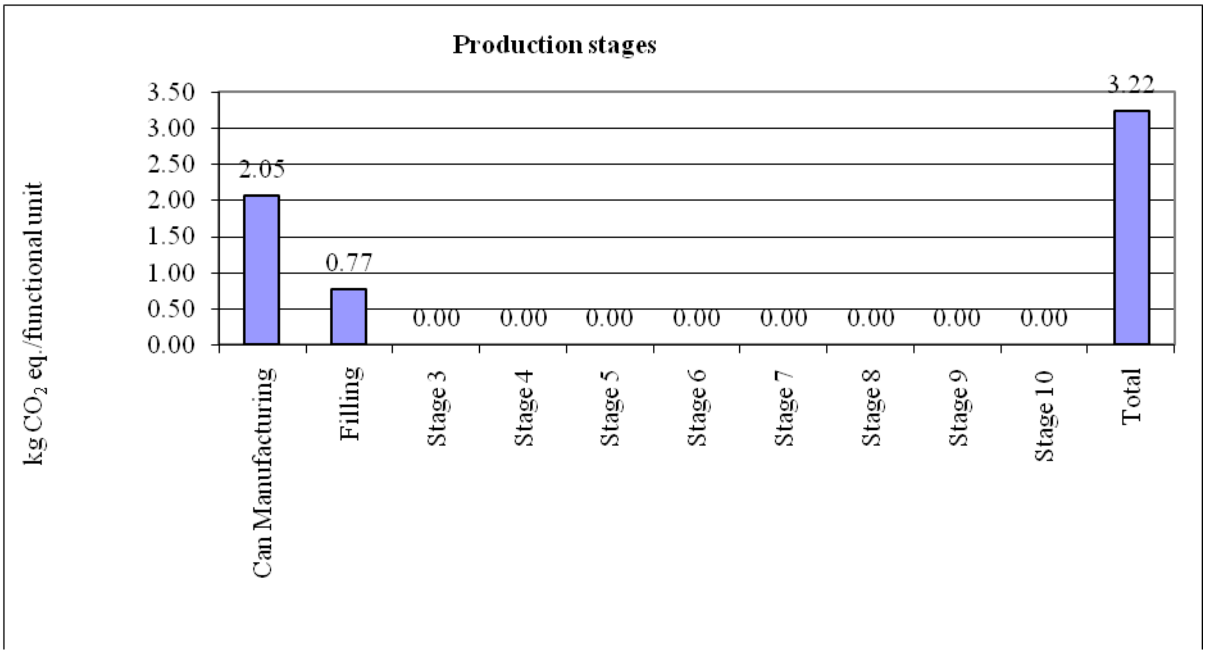

Fig 4: Carbon footprint in the production stage of Aluminium can (330 ml)

3.2 Water Footprint

This study was focusing on the processing water used in different stages and not considering the water used to produce soft drinks. From Fig 5 it was noted that about 90 litres of water was using as process water in the case of PET bottles for 1000 litres of soft drinks. It was not a big contribution towards water footprint but at the same time the study was not considering the water usage for making soft drinks.

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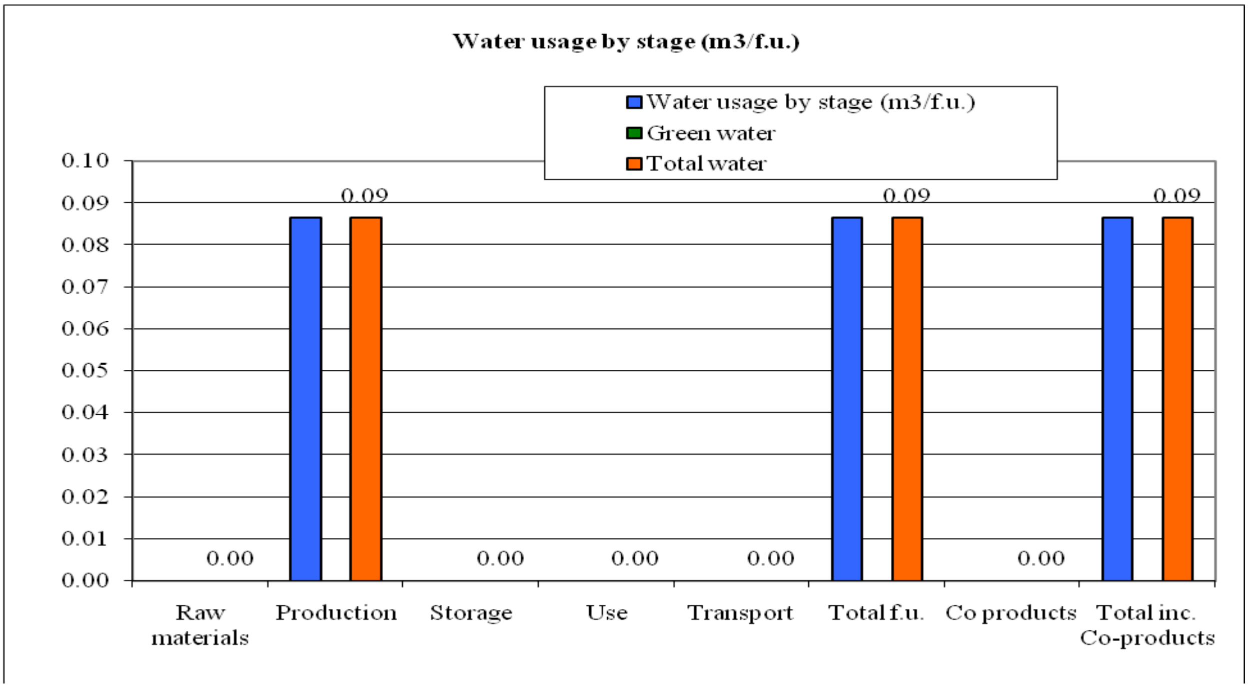

Fig 5: Water usage in each stage of the manufacturing of PET Bottles (600 ml)

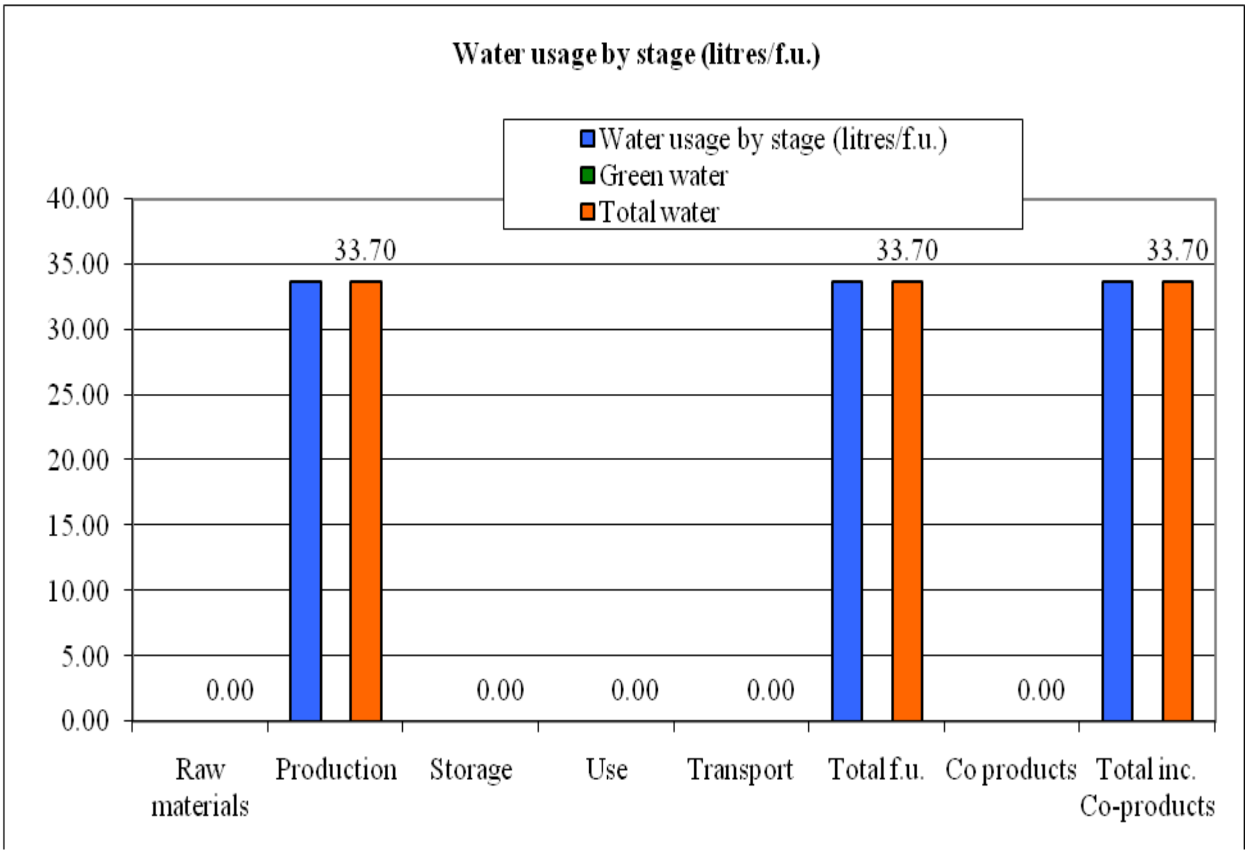

Fig 6: Water usage in each stage of the manufacturing of Aluminium cans (330 ml)

In the case of aluminium cans, 33.70 litres of water was using to manufacturing aluminium cans of 330 ml for delivering 1000 litres of soft drinks.

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3.3 Other Environmental Impacts

Acidification potential, Eutrophication potential, ozone layer depletion potential, photochemical smog potential and human toxicity potential were studied and was tabulated below.

Table 1: Other Environmental Impacts of PET Bottles (600ml) used to deliver 1000 litres of soft drinks

	Raw Materials	Production	Storage	Use	Transport	Total
Acidification potential (g SO_2 eq. / functional unit)	477.82	21.79	0.00	11.54	0.00	520.54
Eutrophication potential (g PO_4 eq. / functional unit)	163.36	0.88	0.00	4.71	0.00	170.58
Ozone layer depletion potential (g R11 eq. / functional unit)	0.01	0.00	0.00	0.00	0.00	0.01
Photochemical smog potential (g C_2H_4 eq. / functional unit)	28.77	1.22	0.00	1.38	0.00	32.19
Human toxicity potential (kg DCB eq. / functional unit)	78.71	0.74	0.00	0.11	0.00	79.61

TABLE 1 was representing other environmental impacts by PET bottles of 600 ml to deliver 1000 litres of soft drinks. From the table it was noted that the values were very much lower than carbon dioxide emission. Raw materials used for PET bottles manufacturing were the major contributor towards other environmental impacts. Human toxicity potential of PET bottles was very high. This was due to the non degradable nature of plastics, if we chop the bottles into pieces and put them into soil, it may take 50 years to degrade. But for the aluminium cans, the values were very much less than that of PET bottles. For aluminium cans production stage is the major contributor since it was directly emitting the hydrocarbons to the environment.

Table 2: Other Environmental Impacts of Aluminium cans (330ml) used to deliver 1000 litres of soft drinks

	Raw Materials	Production	Storage	Use	Transport	Total
Acidification potential (g SO_2 eq. / functional unit)	0.00	1.13	0.00	1.67	0.00	10.85
Eutrophication potential (g PO_4 eq. / functional unit)	0.00	0.16	0.00	11.58	0.00	13.15
Ozone layer depletion potential (g R11 eq. / functional unit)	0.00	0.00	0.00	0.00	0.00	0.00

Photochemical smog potential (g C_2H_4 eq. / functional unit)	0.00	0.11	0.00	0.20	0.00	0.99
Human toxicity potential (kg DCB eq. / functional unit)	0.00	11.52	0.00	31.83	0.00	86.43

Briefly, carbon dioxide emission was the most threatening problem created by packaging to the environment. About 930 kg of carbon dioxide equivalent was emitting from both types for delivering 1000 litres of soft drinks. Million litres of soft drinks was producing by each company in a year. Hence it should be noted the soft drink packaging was a major contributor towards this issue. In the case of water footprint, about 120 litres of water was using as process water in the various stages like bottle manufacturing, top manufacturing, label manufacturing and filling. For aluminium cans both footprints were higher than PET bottles.

For other environmental impacts even though the values were relatively lower it should have a combine effect on the environment. In the case of carbon footprints raw materials used for the packaging production were the “hot spots”. If the company will replace the raw materials with more sustainable materials, it can reduce a major part of carbon dioxide emissions. In the case of water footprint of both materials and other environmental impacts by aluminium cans, the production stage was the “hot spots”. If the company will find out more sustainable energy sources instead of non renewable energy sources it can make a big change.

In the case of other environmental impacts of PET bottles, Raw materials were the “hot spots”. PET granulates, PP granulates and LDPE films were the raw materials. The major problem with the PET bottles was nothing but its raw materials. If the company will recycle the materials it can make a big difference.

From the above discussion it was noted that PET bottles were the sustainable option than aluminium cans. Aluminium cans were the major contributor of carbon footprint. Also the recycling of PET bottles will reduce other environmental impacts.

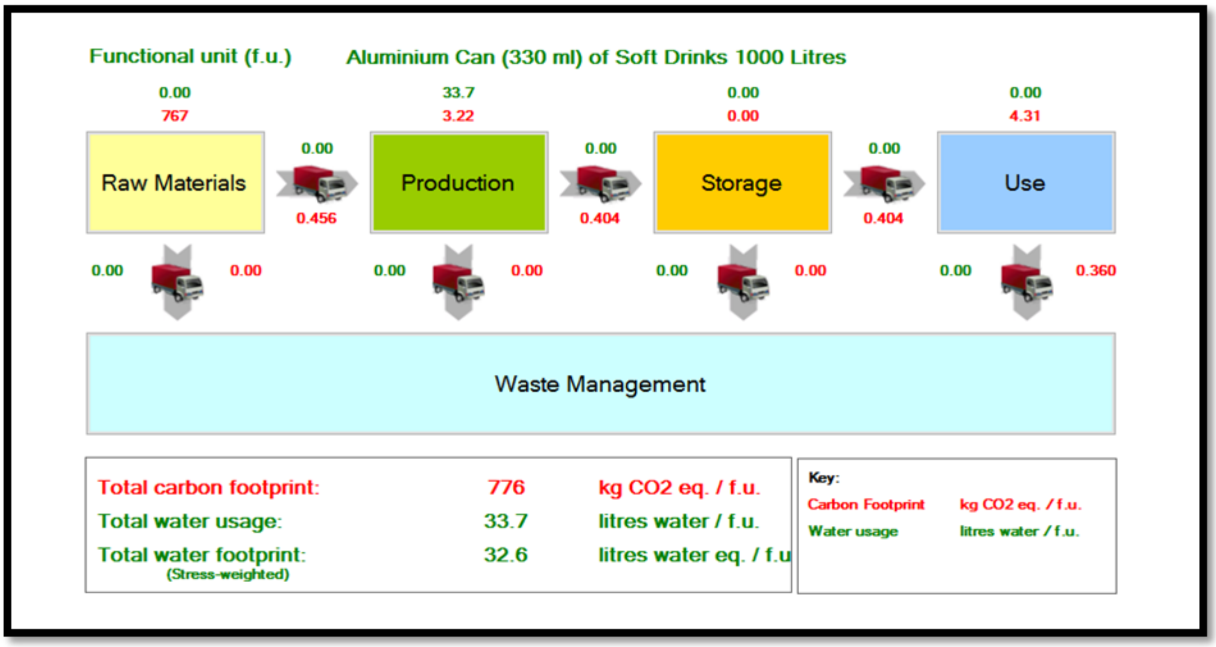

Fig 7: Screenshot of CCaLC2 tool for Aluminium can (330 ml)

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Fig 7 and Fig 8 was showing the screen shot of the software. It was showing the supply chain of soft drinks. The basic four levels of a supply chain were raw materials, production, storage and use. Waste management also specified in each stage. Red vehicle denoted the transportation. Red colour was denoting carbon footprint and green colour was showing water usage. 91% of the PET bottles were managed by land fill and 9% was incinerating. But for aluminium cans 48% was recycling and 52% was managed by land fill. Other environmental impacts of PET bottles were high compared to that of aluminium cans. Hence instead of incineration and landfill, recycling will be the best method for PET bottles management.

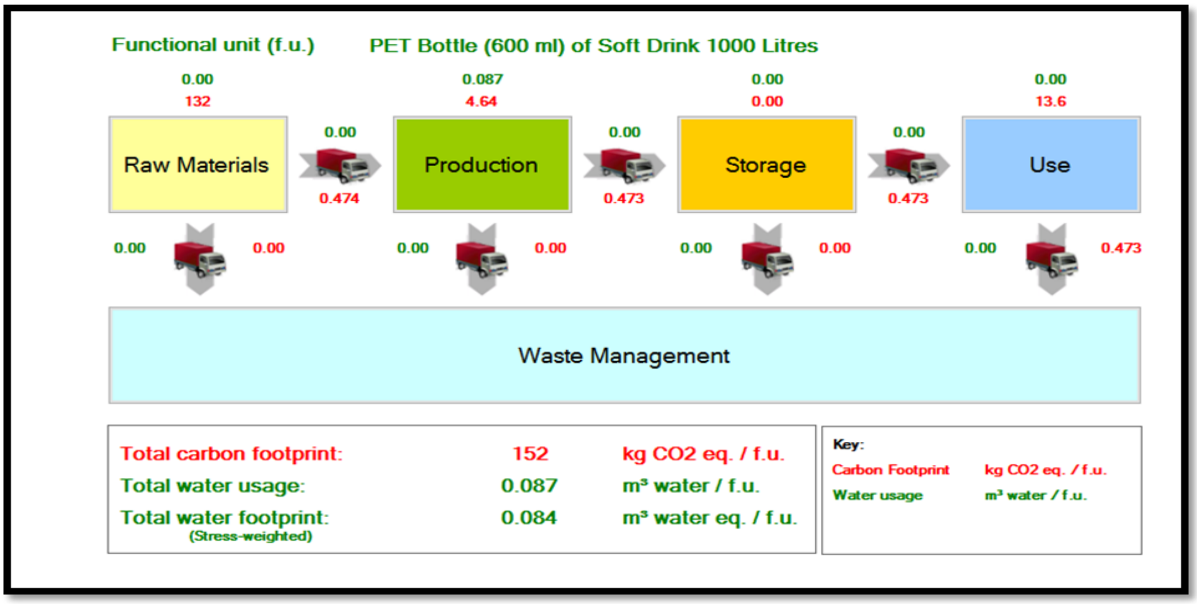

Fig 8: Screenshot of CCaLC2 tool for PET Bottle (600 ml)

IV. CONCLUSIONS

The life cycle environmental impacts of soft drinks have been determined by considering two major packaging options in India and also the most preferred by consumers: PET bottles 600 ml and Aluminium can 330 ml. It has been found that, under the assumptions made in this study PET bottles are more sustainable than Aluminium cans.

In the study system boundary was fixed with cradle to grave approach. Functional unit was defined as the packaging system used to deliver 1000 litre of soft drinks. Life cycle of soft drinks was divided as raw materials, production, storage and use. Waste management was also considered for the study. Second generation of Carbon Calculations over the Life Cycle of industrial activities (CCaLC2) was the tool used for the study. The results confirmed that aluminium cans were contributing 80 – 85% of the combined carbon dioxide emission of both type. Aluminium cans have carbon footprint of 776.16 kg CO_2 eq. per functional unit and PET bottles have 152.11 kg CO_2 eq. per functional unit. In this above 80 to 85% was contributing by the raw materials used for the production. So the replacement or recycling of the raw materials can cause a major reduction. More sustainable materials should be preferred as raw materials. In the production stage filling stage is the “hot spots”

IJARSE
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since it uses non renewable energy sources. Water footprint was 120 litres per 1000 litres of soft drink production. Here process water was considered.

Even though PET bottles were better than aluminium cans it was the major contributor in other environmental impacts like acidification potential, Eutrophication potential, ozone layer depletion potential, photo chemical smog potential and human toxicity potential. The results also show that recycling 40–60 % of PET bottles could reduce environmental impact of the drink by 32–48 %. Refrigerated storage was adding around 33 % and 24.5 % to GHG emissions for the cans and PET bottles, respectively, and should be avoided particularly as soft drinks are not perishable goods.

This paper mainly focused on the environmental impacts of drinks packaging in India. This can be used in the field of zero carbon challenge. In the study the transportation distance was kept constant at 100 km and was not considered the secondary and tertiary packaging of the soft drinks. Further studies can be conducted by changing the assumptions.

V. ACKNOWLEDGEMENT

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REFERENCES

[1] R. U. Ayres, *Life Cycle Analysis: A Critique*, Resources, Conservation and Recycling, *14*, 1995, 199-203.

[2] P. Divya, M. Agarwal, and S. P. Jai, *Carbon Footprint: Current Methods of Estimation*, Environmental Monitoring and Assessment, *178*, 2011, 135-160.

[3] A. Y. Hoekstra, A. K. Capagain, M. M. Aldaya, and M. M. Mekonnen, *The Water Footprint Assessment Manual*, Earthscan, 2011, 1-228

[4] D. Aminyo, H. Gujba, H. Stichnothe, and A. Azapagic, *Life Cycle Environmental Impacts of Carbonated Soft Drinks*, International Journal of Life Cycle Assessment, *18*, 2013, 77-92

[5] O. Ayalon, Y. Avnimelech, and M. Shechter, *Application of a comparative multidimensional life cycle analysis in solid waste management policy: The case of soft drink containers*, Environmental Science and policy, *3*, 2000, 135-144

[6] A. Benhammou, E. Ait Hsine, and M. N. Pons, *Water resources management in soft drink industry: water use and wastewater generation*, Environmental technology, *26*, 2010, 1309-1316

[7] Binnie, *Water and wastewater management in the soft drink industry*, Water research commission project, 1987, 1-30.