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Study, design and analysis of sustainable alternatives to plastic takeaway cutlery and crockery

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Abstract

Most of the take away materials used today is made of plastic. This presents a huge challenge in terms of waste management and pollution. It is widely known that plastic takes several hundred to thousand years to decompose, releasing toxic substances in the process. Therefore, the aim of this work was to analyze alternatives to plastic takeaway cutlery, crockery from areca palm and coconut tree by products. This focuses on reviving the methods and knowledge that existed in the southern and central parts of the Indian subcontinent for making sustainable cutlery and crockery products used in everyday life. A market analysis, design, life cycle analysis and deeper research on the fabrication will be briefly presented.

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Keywords: disposable cutlery and crockery; eco friendly products; sustainable cutlery and crockery.

1. Introduction

In the last few decades, the plastic industry has taken us by storm and most things are packed and processed in plastic containers. One of the most important example is that of the take-away industry and of the disposable cutlery/crockery industry.

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Apart from polluting, plastic waste is dangerous to the environment and can cause adverse health issues. It is also clear that the plastic waste patch in the middle of the ocean is posing a big threat to us in terms of ecosystem and micro plastics accumulation [1].

It is estimated that billions of Styrofoam coffee cups are thrown away every year [2]. The huge issue facing us is recyclability. It is estimated that close to 40 billion individual plastic utensils are produced every year. About 64 billion paper and 73 billion Styrofoam & plastic cups and plates were thrown away in 2003 in the USA, single-use food/drink containers disposal is at about 140,000 each second [3]. These end up in the oceans and landfills/dumping sites.

Per a 2009 survey conducted by IPSOS [4], 79% of consumers would rather buy from companies doing their best to reduce their impact on the environment with a competitive price. It is evident that a rising number of consumers judge a business based on how green they feel it is. This presents a huge opportunity for establishing a sustainable solution. This work will focus on using the knowledge of sustainable product design and raw material usage from the Indian subcontinent and other Asian countries.

2. Raw materials and extraction methods

The materials discussed for making sustainable take-away containers are Areca palm (*Areca catechu*) sheaths, Sal (*Shorea robusta* Gaertn. f.), leaves, *Bauhinia vahlii* leaves, coconut (*Cocos nucifera*) fiber/coconut shells and banana fibers (*Musa acuminata)*). Most of the material is extracted manually, hence the energy and the impact involved is minimal. Palm *Areca* sheaths, coconuts and Sal leaves are primarily extracted by hand. Extracting the fibers involves dehusking, followed by natural retting or mechanical drawing. Most energy is spent in transportation materials for processing and people for extraction.

2.1. Areca nut

The *Areca* trees are cultivated extensively for beetle nut production. The sheath that cover the leaves are extracted by hand and used as a base for making several products like bags, plates, cups and wrapping. The sheath is attached to the leaves, once collected they are generally dried in shade to remove excess moisture and sent for processing.

2.2. Sal leaves

Sal forests cover over 11 million ha in India, Nepal and Bangladesh, and these forests are conventionally managed for timber. During the peak season of May to July, leaves are collected by tribal communities (Fig. 1). Only the leaves that are mature are collected by hand by the tribal communities in the forests, hence making the process sustainable. The picked leaves are then sent to nearby homes for being stitched, or undergo pressing in a heated press and sold.

(a) (b) (c)

Fig. 1. (a) Extracted *Areca* palm sheaths; (b) A tribal woman picking Sal leaves; (c) Bundled Sal leaves for plates

2.3. Coconut fibres

Coconuts that fall or picked coconuts can be used to extract fibre, green coconuts that are picked are the best for making fibre coir. The outer layers covering the coconut seed are processed and spun into fibres commonly known as coir (Fig. 2). Ripe coconuts are husked immediately, but unripe coconuts may be seasoned for a month by spreading

them in a single layer on the ground and keeping them dry. To remove the fruit from the seed, the coconut is impaled on a steel-tipped spike to split the husk. The husk is then sent for retting or fibre drawing or pressing [5].

2.4. Coconut shell

Once the nuts are dehusked, water and whites are extracted from the nuts, they can be sent for processing to remove the excess fibre remaining. Very low power battery machines are used for this process or they are operated mechanically.

2.5. Banana Fibres

Bananas (*Musa* family) is one of the most consumed fruits in the world. There are thousands of hectares of plantations in the world. The banana leaf is waterproof and has been used for serving food, packing food, takeaway for several decades in South India because it imparts a subtle sweet flavour. Both fresh and dried banana leaves are used in the making of takeaway containers. The stem (Fig. 2-c) of the banana plant is usually consumed in the states of Tamil Nadu and Kerala (South India), but the outer part is thrown away. Retting of the other part of the stem through chemical or mechanical methods can result in extraction of soft fibres of the banana plants that could be used as an alternative to conventional clothing [6,7].

(a) (b) (c)

Fig. 2. a) Dehusked coconuts for fibre production; b) Discarded coconut shells after the extraction of coconut water and flesh; c) Stems of banana trees extracted for fibre production.

3. Processing

3.1. Areca nut cutlery/crockery

The sheets are soaked in water, dried under a shade and pressed by a hydraulic heated die (5.5 kW) to get the desired shape and size (Fig. 3-a). The excess sheath is cut and further used or powdered to make cattle fodder. The product is then transported to the distribution network.

3.2. Sal /Bauhinia vahlii wraps and plate

The collected leaves are stitched (Fig. 3-c) by manual stitching machines, soaked in water and are mechanically pressed. The plate machines of the Sal leaves consume only manual power. Some companies use heat presses, since we are just considering wraps, the pressing part will be ignored.

3.3. Coconut coir

Extracted coconuts are dehusked using a machine (4 kW). For lower quality fibers, once dehusked the fibers are drawn before retting. The nuts are sent for sale, the husks are then retted in backwaters or tanks. They are beaten using a wooden mallet to extract the fiber. They are drawn out as ropes using a spindle or the fibers are compressed using a hydraulic press (18.5 kW) to form a mattress base/sponges for cleaning, and can be pressed and cut to make sponges.

3.4. Coconut shells

Once the coconut water and copra is extracted, these shells (Fig. 2-b) are then collected and polished using sandpaper, and then used as cups or parts of ladles and cutlery. Most work done here is mechanical. Small battery powered motors can be used for polishing.

(a) (b) (c)

Fig. 3. a) Pressed *Areca* plates; b) Coconut fiber ready for being processed; c) Sal leaves being stitched.

3.5. Banana Fibers

Outer layers of the stem are stripped and the fiber is extracted manually or using low power machines, they are then cut, flattened and sun dried. The fiber is then mixed with a small amount of sodium hydroxide, boiled strained, mixed with water, blended and dried on sheets to make cardboard or paper.

4. Existing business flow model with stakeholders

As discussed previously, the production of crockery and cutlery from renewable materials is not only possible, but also desirable, as it can represent a source of revenue and a labor opportunity for families, while generating environmental friendly products that can replace plastics. The whole chain of value for the process comprises different stakeholders that must be included in the process of expansion the market for these products.

In Fig. 4 it is shown the stakeholder and business models presently implemented. The largest amount of revenues is associated to the stages of production, distribution and commercialization, whereas the raw material is essentially free of cost, as it is generally the waste resulting from other producing other goods.

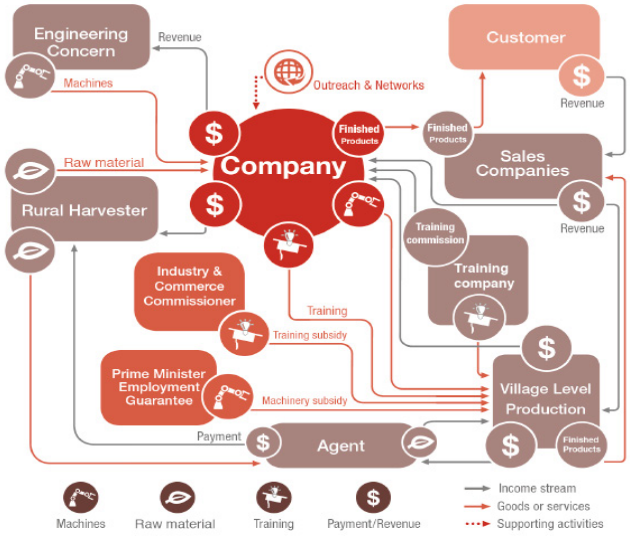

Fig. 4. Existing stakeholder and business models followed [8].

5. Primary impact analysis using LCA

Life Cycle Analysis (LCA) is a tool that can be used to assess the sustainability of a product, and then compare its environmental performance against a possible alternative. The LCA must consider all the phases in the life cycle of the product, from Extraction and Processing, to waste treatment in the End-of-Life, including transportation, distribution, etc. The impacts to assess are not only direct, but also indirect Environmental impacts, as well as Economic and Social impacts. Evaluation of Environmental and Economic impacts is well established. However, the evaluation of the Social impacts is still the object of discussion.

The preliminary impact analysis is shown in Table 1. Shades of green represent how eco-friendly and sustainable the process is, shades of red represent it being unsustainable and having high impacts in the environment. The greener, the more sustainable the process is.

All emissions from sources including transport of people were considered for the tabulations.

Table 1. Primary impact analysis.

Type	Immediate & Direct Environmental Impacts			Indirect & Delayed Environmental impacts			Economic and social impacts		
Phase	Extraction	Processing	End of life	Extraction	Processing	End of life	Extraction	Processing	End of life
Plastic Cutlery and Crockery									
Area Palm Cutlery									
Sal / Bauhinia Wraps & Plates									
Coconut fiber sponges & ropes									
Coconut shells and leaf utensils									
Banana Fibers									

Impact analysis comparisons were obtained through emissions produced from all steps of extraction, production, transportation and disposal.

6. Proposed tweaks in design suited for the takeaway industry

The traditional methods were changed for making newer designs for take away containers and crockery. Spoons, forks knives made from the suggested materials already exist, but some of the designs were custom made for the disposable cutlery, crockery and the fast food industry.

The proposed models are coconut shell cups, Sal leaf bowls, palm *Areca* burger / takeaway boxes and chips cone (Fig. 5). All of them have taken into consideration that the containers must be piled up in such a way as to avoid empty spaces between them for reduced volume for storage and transportation.

(a) (b) (c) (d)

Fig. 5. A few of the proposed designs for take away bowls and boxes

7. Business plan for commercialization

The main plan would be to tap in the huge potential that the takeaway industry possesses. Portugal has a population of 10 million inhabitants, with about 81.9% under the age of 65 [9]. Plastic cutlery and crockery has entered our lives in the form of disposable containers at shops and restaurants. It is estimated that a person uses an average of 500 disposable cups and about 230 disposable paper plates per year [10]. Keeping the same average for Portugal, considering just 50% of the population under 65 use forms of disposable containers, around 2047.5 million disposable plastic/paper cups and 941.85 million paper /plastic plates a year are used and disposed off.

The model that could prove to be successful would be to make the product a disruptive innovation through various models by making simple products accessible to the masses. It would also consider consumer behavior in designing the product to have minimal behavioral changes and maximum product changes to make a product a smash hit. To cross the market chasm Moore's model of identifying a niche and capturing other niches would be used. Models of many renowned economists like Christenson, Barry, Moore and Gourvill can be considered and used [11-14].

8. Conclusion

From the challenges plastics pose, these materials could be a sustainable alternative with minimal impact when the source material is obtained in a sustainable manner. From the life cycle analysis and the comparisons to plastic and mass produced paper alternatives, there is a clear indication that the proposed materials could contribute to solve our current problems in waste management and emissions.

Even though there are emissions involved in the current production methods, they are minimal when compared to plastic or current takeaway materials.

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Note: Most of the work here does not have references because the data was collected from calls made to micro industries in the south of India (T.N.). The designs are influenced from modern and traditional design methods of food containers.