American Scientific Research Journal for Engineering, Technology, and Sciences (ASRJETS)
ISSN (Print) 2313-4410, ISSN (Online) 2313-4402

http://asrjetsjournal.org/

Life Cycle Analysis (LCA) of a Lungi

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Abstract

The sustainability of textile materials has gained much attention due to the resource consumption and pollutant emissions at present time. So it is very essential and core requirement to evaluate the environmental effect of textiles from a life cycle perspective to develop the sustainability of textiles. Environmental issues have becoming important over the last few years because of increasing pollutions, waste materials, global warming etc. The consumers have also started to demand green products. As a result of these events, more strategic and systematic approaches are necessary for changing environmental issues. Life Cycle Analysis or Assessment (LCA) is one of the tools to meet this necessity. In this paper, we are analyzing the LCA of a 'Lungi', also known as a 'sarong' and scientifically evaluating the environmental impacts as well as resource utilization to produce, from raw materials to the disposal of the product at the end of life.

Keywords: Lungi; Environmental Impact; Life Cycle Analysis.

1. Introduction

The Life Cycle Analysis (LCA, also known as life-cycle assessment, ecobalance, and cradle-to-grave analysis) is a technique to assess environmental impacts associated with all the stages of a product's life from raw material extraction through materials processing, manufacture, distribution, use, repair and maintenance, and disposal or recycling. Underlying the LCA is the Life Cycle Inventory or LCI, a quantification of energy and material inputs and environmental release or emissions data associated with production and use [1].

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Life cycle analysis (LCA) is a comprehensive and systemic tool that helps to identify environmental hotspots and can show improvements throughout product life cycles, during product innovation and development [2]. With the growing interest in minimizing environmental impact, companies are turning to LCAs to fully understand the risks and liabilities across their supply chain. Major textile brands such as Levi Strauss have performed product-level LCAs and are changing business practices as a result of those assessments [10]. LCA of T-shirt was analyzed the impacts of different configurations of antibacterial T-shirts to select an environmental friendly configuration and make improvements in the product design, especially at the yarn level. In addition, a comparison is made between conventional finishing agents and nanoparticle synthesis techniques [7]. Lungi is a traditional garment worn around the waist in India, Indonesia, Bangladesh, Pakistan, Cambodia, Sri Lanka, Burma, Brunei, Malaysia, Nepal, Singapore, Thailand, the Horn of Africa and the southern Arabian Peninsula [9]. The basic raw materials to produce lungi are 100% cotton yarns.

2. Methodology

We choose 100 % cotton lungi to conduct a cradle-to-grave life cycle assessment because 100 % cotton fabrics are the fundamental materials for apparels in Bangladesh's market. Our research focused on the environmental impacts of the product. This study is conducted according to primary and secondary data collection, the declared unit is a piece of 100 % cotton lungi. The production data was mainly collected from field investigations of Ashuganj, Brahmmanbaria and Sirajganj areas in Bangladesh. The use-phase data are mainly from questionnaires of mills representative. The secondary data from internet, literatures and authoritative statistical data are supplemented in case primary data are not available. We determine hotspots throughout the life cycle of the lungi considering the impact categories of water use and toxicity. The LCA consists of primary and secondary data collected in the following categories: raw material collection, manufacturing, transportation, final product, use and end-of-life. ISO 14040 and 14044 specify how to conduct an LCA study. There are four phases of an LCA :

a) Definition of the goal for and scope of the LCA;
b) Compiling an inventory of relevant inputs and outputs of the product system - inventory analysis;
c) Evaluation of the potential environmental impacts - impact analysis;
d) Interpretation, i.e. improvement analysis considering the results of b and c [3].

2.1. Goal and Scope definition

The specific objective of this study is to assess the environmental impacts, to identify the environmental hotspots, and to seek for improvement opportunities during the life cycle of 100 % cotton lungi in Bangladesh. We consider two main impact categories to determine hotspots throughout the life cycle of the cotton lungi. The first category is total water consumption the second impact category is energy consumption of full life time of a cotton lungi.

2.2. Primary Data

We have collected data from two factories. One is "Bondhu Lungi & Gamsa" at Ashuganj, Bangladesh and

another one is 'Perfect Lungi" at Sirajganj, Bangladesh. We collected data about the manufacturing process of lungi from the representative of the factory. We prepared some questionnaires and tried to collect data from the factory personnel. It was very difficult for us to get the exact information or data, because lack of the technical knowledge of factory personnel.

They do not keep any written data either. Normally they collect raw materials, basically yarn from local market which is mostly dyed. If the yarn is not dyed, then they dye it. The vat dye is mostly used for dyeing and they don't follow any specific recipe for dyeing. Most of the time, the recipe is set by themselves.

They mix ingredients of dyeing until they get perfect shade. After dyeing they throw the water into to ground or nearby pond or canal. The rest of the materials (thread, dyes) are bought by the other small entrepreneur. They are used in handicraft like floor mat.

The water they used for manufacturing lungi, is fresh water. But they throw this water after dyeing process in to pond, river and cannel. First they take plenty of water from ground and waste it by chemical dye and drain this waste water in to the fresh water. In two ways the water is polluted and moreover lots of emission and effluent are the result of chemical dye also polluted environment. The mill representative said that they import dyed thread or buy thread from local market, they dye it. The interesting fact is they don't have any educational background or any idea of pollution from their wastage or effluent.

Only with experience and practical knowledge they continue the business years after years. They dyed the thread as per color gradation and mix the color as requirement. Even they use their hand for dyeing without any protection. After dyeing they throw the water in to a drain, which is connected to a river. The dye amount is more than 10%-50%, which remain unused in fabric, rinsed away.

This water also polluted the fresh water as well as. If this situation running in this way, this will result in an additional water demand of over 3,400 billion liters by 2030 which is equivalent to the annual water needs of a population of approximately 75 million people [10].

Technical information of the studied textile product:

- Type of Product : Plain Weave Check Outerwear
- Fiber Content : 100% Cotton (Card Yarn)
- Construction : 110 X 90/40 X 40,Width – 48" (Approx.)
- Weight : 200 Grams (approximately)
- Estimated Life Span : 1 Year

2.3. Process for the cotton lungi

2.4. Secondary Data

We collected some important data from websites, journal which was not found from field investigation.

2.5. Impact assessment

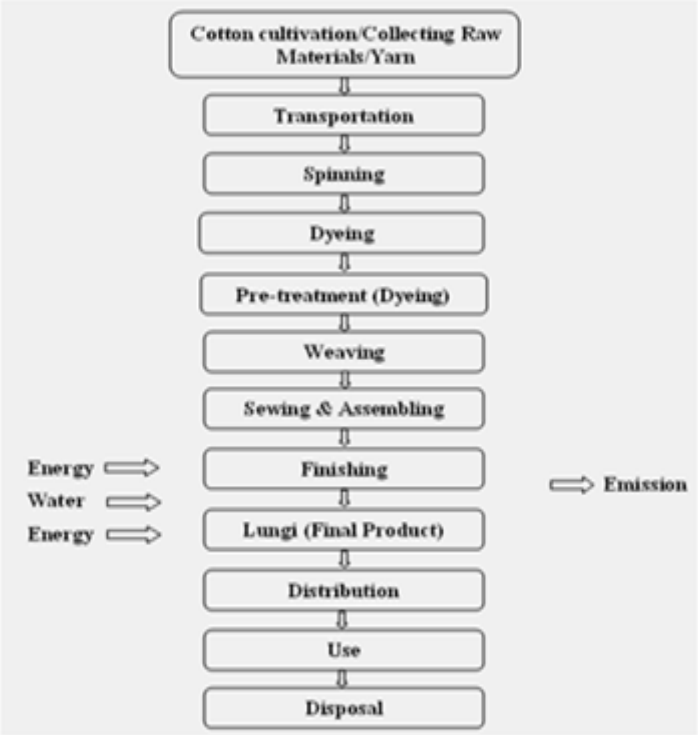

Figure 2

Table 1

Life cycle stage	Data type	Source
Cotton cultivation	Cradle-to-gate cotton fibers ginned at firm	Websites
Transportation and distribution	Transportation distance of cotton fibers and distribution distance of lungi	Websites
Spinning, warping, sizing, weaving, Finishing.	energy and Water used	Websites
Dyeing	On-site energy, water consumption data to100 % cotton fabrics dyed with Vat dyes	On-field investigation & also websites
Use	Consumer behaviors of lungi: life time, use frequency, and habits of washing such as the Hand wash or machine wash. Energy, water use per washing	Questioner & websites
Disposal	Through landfill	

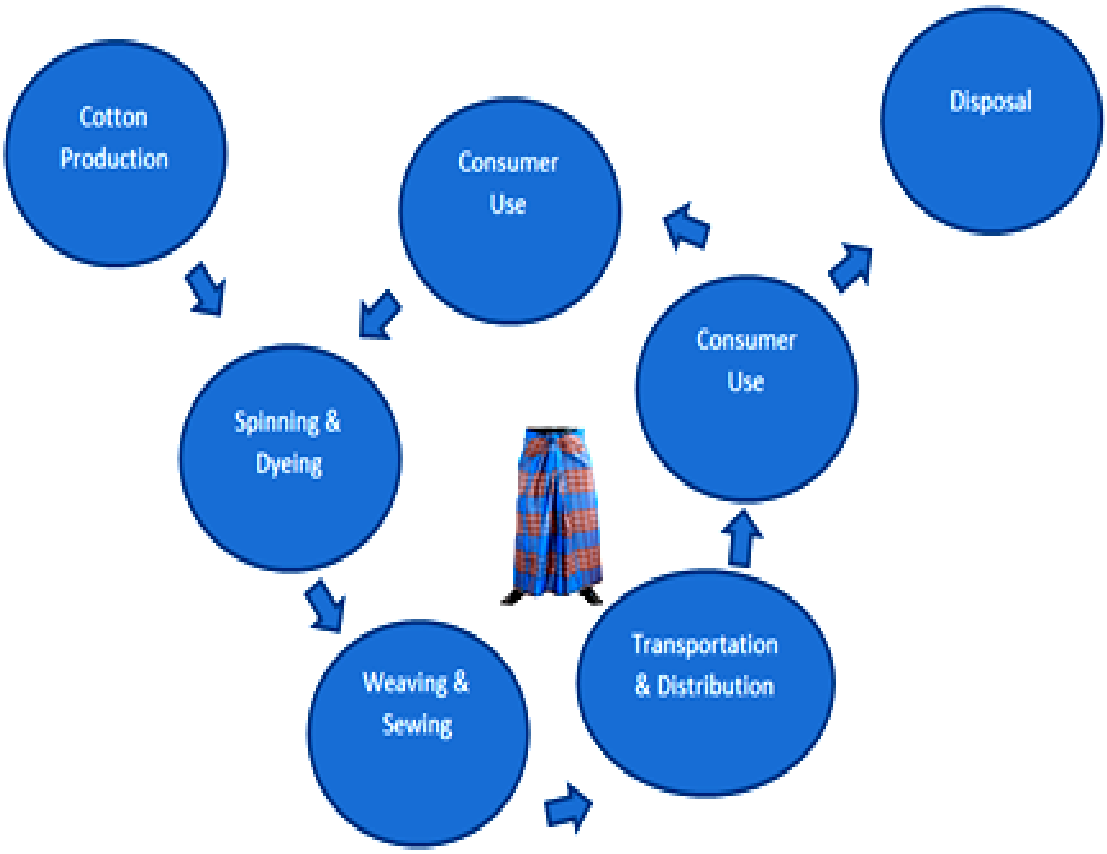

Figure 1: The Life Cycle of a Lungi

3. Result

The life cycle assessment of a cotton lungi:

3.1. Raw Material

Table 2

3.1.1 Water	The cotton plant requires about 180 – 200 days from planting to maturity & ready for harvest [4]. Average production of seed cotton in India is average 5,544,380 (ton/year), consumptive water used at field level for cotton production in India is 810 mm, effective rainfall 405 mm, irrigated share of area 33 percent, total water requirement 538mm, where Bangladesh need total 687 (Mm3/year) water [5]. But From our primary research we came to know that the manufacturer bought dyed thread from local market or they bought thread, which is dyed by them.
3.1.2 Energy	Total production 65.243 kg woven fabric, electric energy consumption of production is 71.328 kWh, electric energy consumption of non production unit 28.862 kWh, estimated energy consumption 100.190 kWh, Actual energy consumption 129.110 kWh [6].

3.2. Transportation & distribution

Table 3

3.2.1 Water	Not Applicable
3.2.2 Energy	Not Applicable
3.2.3 Cost	Export cotton from port to textile mill distance 480 miles, Truck with special equipment handling 0.39 USD/ton, total shipping cost 88.24 USD/ton, unit shipping price 0.18/USD/ ton/mile [7].

3.3. Spinning

Table 3

3.3.1 Water	Not Applicable
3.3.2 Energy	3.30 kW/h [6]

3.4. Dyeing

Table 4

3.4.1 Water	1.5 liter/piece, dye requirement 10gm/piece, yarn requirement 250-300 gm [Field investigation]
3.4.2 Energy	0.164KW/h [6]

3.5. Warping & sizing

Table 5

3.5.1 Water	
3.5.2 Energy	0.0073 kWh/kg [6]

3.6. Weaving

Table 6

3.6.1 Water	Not Applicable
3.6.2 Energy	1.78KWh/kg [6]

3.7. Finishing

Finishing materials (Caustic, Hydroze, Sodium) as required (Depends on shade).

Table 7

3.7.1 Water	136 L
3.7.2 Energy	Not found

3.8. Wet processing

Table 8

3.8.1 Water	In wet processing total wasted water volume 360 m3/ton. Bleaching 30 L, dyeing 142 L, finishing 136 L, total 496 L. [5]
3.8.2 Energy	1.05 KWh/kg [6]s

3.9. Use

Table 9

3.9.1 Water	Total use of cotton is 7 64 Mm3 per year [5] Machine wash 303 kg tap water, manual wash 136 kg whole use phase(one year) [5].
3.9.2 Energy	The average extracted energy consumed transporting 1 tone material to the customer is 77.5 kWh. For the 14 892 tones dispatched to the customer this is equivalent to 1,154,000 kWh [8].

3.10. Disposal

In Bangladesh no up cycling is happen from lungi. Only the lungi is used for baby wrapper or cleaner towel .However, the average American household does nearly 400 loads of laundry per year, using about 40 gallons of water per full load with a conventional washer. The final stage of life, which is disposal, involves incineration. This is another process that releases harmful emissions, or involves a landfill where cotton takes years to break down. Current U.S. records show that an estimated 15% of clothes and shoes are recycled, which means that consumers send a shocking 85% of these materials to landfills [8].

4. Limitation

We cannot trace all inputs and outputs to product systems and that has to define boundaries around the system.

- Raw material processing
- Land uses
- Transportation
- Air emissions calculation
- Water emissions

5. Conclusion

Waste waters with high chemical contents in wet processes, pesticides and synthetic fertilizer problems in natural fiber productions, energy consumption during manufacturing processes and toxic materials are the main environmental problems in textile industry [8]. LCA methodology has started to use for the assessment of environmental impacts during manufacturing. We cannot abolish it by 100% but can reduce it. In particular, water, auxiliaries and electricity used in making-up of a lungi based on the life cycle impact assessment (LCA) results. The manufacturer are not concern about the impact of the process in environment even the workers health. Those who work as a weaver must have aware about the energy consumption and environmental effects during manufacturing process were investigated in this study. Environmental footprint of a product from raw material acquisition through consumer use and disposal are water, energy, chemicals, air emissions, solid wastes, co-products, lungi disposal. After an average of two years, the lungi is used to make other household articles like- rags etc, donated to poor people or disposed of in a landfill. The overall related contribute to global warming & environmental changes during the total life cycle. In conclusion, improvements in sustainability should be in research, application and communication. Energy consumption and environmental effects during manufacturing process were noticed in this study. The main contribution almost all impact categories have come from manufacturing process. These results are due to higher water consumption in dying. Vat dye was responsible for high rate of water & solid emission. Necessary initiative should be taken by government and environmental organization for potential improvements of sustainability.

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