Assessment of Environmental Impact of Textile Industry and a Roadmap to Life Cycle Thinking

Madhuri Nigam[1] and Bhawana Chanana[2]

[1,2]Lady Irwin College, Department of Fabric and Apparel Science, University of Delhi, India
E-mail: [1]madhurinigam@gmail.com, [2]bhawanachanana@gmail.com

Abstract—*Rapid industrialisation and other forms of development in human lifestyle and activities are responsible for warming of the atmosphere and other climatic changes we are witnessing today. The atmospheric composition has greatly altered due to continuously rising emissions of Green House Gases which are caused by the production and consumption of fuels, manufacture of goods, materials, roads, and services. As greenhouse gases produced by human activities accumulate in the atmosphere, their concentration results in global warming. Having realised the emergence of the situation, a vast amount of research and action is ongoing in this direction and efforts are underway to address the current situation.*

Textile industry is one among the largest contributors to greenhouse gas emissions, water pollution and human health hazard. Thousands of chemicals are used to convert raw materials to textiles, and a quarter of the global pesticides are used to growing up conventional cotton. This results in irreversible damage to people and the environment, and still two-thirds of a garment's carbon footprint will occur during use phase.

Textile industry in India has a long way to go as far as assessment of environmental impact is concerned. Large Industrial Estates, like SIDCUL (State Infrastructure Development Corporation of Uttarakhand Limited) in Rudrapur, Uttarakhand (India), can impact the environment largely, if preventive measures are not practiced.

This is an action oriented research, focusing on, creating awareness, and identifying the hotspots in the selected textile units. Another aim is to quantify the GHG emissions using Life Cycle Assessment following ISO14040 guidelines and report to the respective units. The research aims to initialise life cycle thinking among manufacturers of textiles, with interactive workshops, forming an integral part of the study.

Outcomes of the Life Cycle Assessments would be utilised to prepare a set of recommendations and guidelines for various products systems of textile industry, vis a vis Cotton and Polyester spinning, knitting and Polypropylene sheets, Felt carpet manufacturing, PET recycling to Recycled Polyester Staple Fibre. The textile industry is expected to benefit, from the creation of database and technological improvement roadmaps evolving out of this study.

1. INTRODUCTION

A gradual increase in the surface temperature of the earth is known as global warming. It has been increasing unusually in the past few decades. Scientists have evidences to show that these atmospheric changes are due to human activities. Rapid industrialisation and other forms of development are causing the warming of the atmosphere and other climatic changes. The chemical composition of the atmosphere has been altered due to continuously rising emissions of GHGs which are a result of development. Developed countries are responsible for a major portion of emissions, whereas developing countries are heading towards becoming frontrunners in GHG emissions.

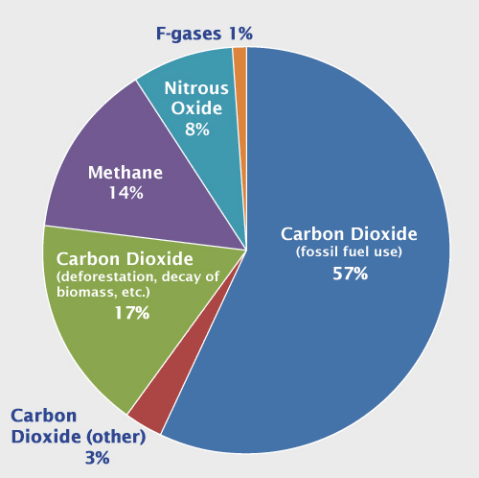

Fig. 1: Source IPCC 2007, based on global emissions from 2004

1.1 GHGs and Climate Change

In recent years the world has witnessed exponential increase in Green House Gas (GHG) emissions causing an increase in the atmospheric temperature. About 6 % rise was reported only in the year 2010 (with a release of about 500 million MT), most of which is contributed by the top three pollutants of the world - China, the USA and India. [1]

Human activities have been responsible for a steep increase in atmospheric concentrations of greenhouse gases, i.e., carbon dioxide (CO_2) methane (CH_4), chlorofluorocarbons (CFCs), nitrous oxide (N2O), and tropospheric ozone (O_3), after industrial revolution [2].

The emission of Green House Gas emission occurs due to the production and consumption of fuels, manufactured goods,

materials, wood, roads, and services. For simplicity of reporting, it is often expressed in terms of the amount of carbon dioxide, or its equivalent of other GHGs, emitted. Burning of fuel leaves CO_2 in the air, which is called a "Carbon Footprint", just as walking on the sand leaves a footprint. Thus the carbon footprint basically indicates the amount of carbon released into the air based on the fuel consumption. [3]

Risks of climate change can be controlled if GHG emission levels of the atmosphere are stabilized between 450-550 ppm.CO_2e. Presently the CO_2e level is at 430 ppm and rising at 2 ppm /yr. To stabilize the emissions at this level we need to bring the emissions at least 25% below current levels by 2050. [4]. It is estimated that the impacts of not acting will be far costlier than taking action to control the emissions. This underlines the urgent need for manufacturers to assess and control the emissions in their process chain.

1.2 Impact of Textile and Fashion industry

Textile and fashion industry have a huge impact on the environment. Globally it provides employment to 9.3% of employees and contributes 4% to the exports. Estimates suggest that an annual global production of 60 billion kg of fabric require about 1,074 billion KWh of electricity (or 132 million metric tons of coal) and between 6 – 9 trillion litres of water. [5].

Natural fibres have smaller carbon footprint, since they can be degraded by microorganisms and thereby improve soil structure, and release the CO_2 fixed in the fibre, thus closing the cycle. Synthetics do not decompose, and are responsible for the release of heavy metals and other additives, in the soil and ground water. [6]

Textile industry is vast and produces a large amount of greenhouse gases. The present textile industry is one of the largest emitters of greenhouse gases on Earth, by virtue of its size. [7] Each step in clothing life cycle creates environmental and occupational hazards. [8]. Fig. 2 illustrates the contribution of various processes in textile manufacturing to the overall emissions of textile industry. [9]

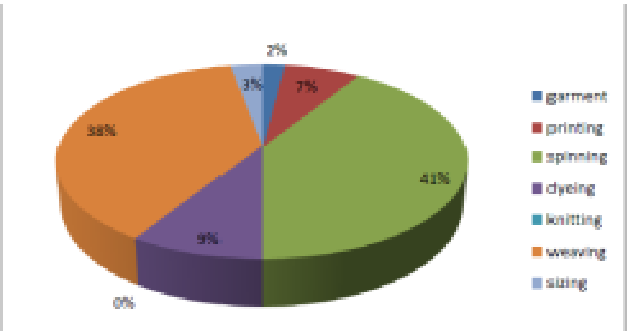

Fig. 2: Carbon footprint of textile industry

About 8000 chemicals are used to convert raw materials into textiles, and about 25% of the world's pesticides are used to in growing non-organic cotton. It results in irreversible damages to people and the environment, and still two-thirds of a garment's carbon footprint is expected to occur in consumer phase. [10]

Manufacturing of all types of textiles impacts the environment. Usage of raw material and other natural resource inputs such like water, electricity etc. has not depletes resources but release of effluents or emissions causes degradation of natural resources. The industry is known to use large quantities of water during its processing. Characterising is complex due to a large variation in the substrates, processes, machinery and components used, and finishing steps involved. [11]

1.3 Importance of Carbon footprint assessment:

Carbon footprint is “A methodology to estimate the total emission of greenhouse gases (GHG) in carbon equivalents from a product across its life cycle from the production of raw material used in its manufacture, to disposal of the finished product (excluding in-use emissions)". [12] Calculating carbon footprint can be a crucial first step towards considerable emissions reductions. This in turn may lead to financial gains in the long-term financial while reducing climate-change impact. [13]

Thus by calculating carbon emissions and publicly disclosing the carbon footprint details of their products, organisations can improve their customer satisfaction and build a positive market image. Developing nations can play an important role in play in reducing GHG concentration, since their participation will help in low cost GNG reductions. Therefore, it is a good business sense to invest in GNG reduction in developing nations. These reduction efforts though cheap will have the same benefits as reductions in developed countries. [14] The Indian govt. has agreed to fully support the carbon footprint reduction during the Copenhagen Meet on climate change held in Dec 09. [15]

Rudrapur is an industrial district in Uttarakhand and comes under one of the most fertile areas of India, i.e. TARAI Region. [16] It has beautiful sightseeing as it is flanked by Kumaon Himalayas and Nepal on either side. Integrated Industrial Estate established by SIIDCUL (State Infrastructure and Industrial Development Corporation of Uttarakhand Limited) of State Government is, about 230 kilometres northeast of Delhi. [17] Further infrastructural development is in the pipeline as the Government is planning widening of the highway to accommodate the increasing transportation. Such expansions will most certainly be accompanied with further demand on the resources, cutting down the trees and depletion of natural resources. This is bound to have negative implications as far as local environment is concerned.

Development of industrial areas like SIDCUL might have put Rudrapur and its surrounding region's environment in a vulnerable position due to infrastructural development, rail, road, expansion, and increased transport for people and goods, increased resultant pollution and so on.

With these issues and concerns in view, the present study aims to create awareness about environmental impacts of textile processes amongst the personnel involved in textile production. It also aims to quantify the carbon footprint generated by the textile manufacturing processes and identify hotspots in the process chain. The results of LCA will be reported to the respective units along with suitable recommendations to help reduce the carbon footprint generation in the units.

2. MATERIALS AND METHODS

This study analyses the carbon footprint of various processes in textile manufacturing chain. A sample of six manufacturing units, were selected based on their willingness to enhance their product sustainability. The selected companies are manufacturing products like, cotton yarn, polyester yarn, Recycled Polyester Staple Fibre, knit garment interlining, nonwoven Poly Propylene bag manufacturing and Felt carpet.

Textile industry being one of the most polluting industries creates a large carbon footprint. Through this study the investigator aims to assess the amount of carbon footprint being generated by the textile industry of Rudrapur, which till recently was a beautiful serene and pollution free location. The study is empirical in nature with exploratory field work forming an integral part of the work.

The study will use LCA (Life Cycle Assessment) approach to quantify the environmental impact. According to ISO 14044 definition, LCA is a technique to address the environmental aspects and potential environmental impacts throughout a product's life cycle from raw material acquisition through production, use, end-of-life treatment, recycling and final disposal (i.e. cradle-to-grave) [18]. LCA is used to assess environmental impacts, such as climate change, stratospheric ozone depletion, eutrophication, acidification, toxicological stress on human health and ecosystems, and the depletion of resources like water use and land use. [19]

LCA is a systematic phased approach consisting of following components-

1. Determine the goals and scope of the LCA;
2. Compile an inventory of energy and material inputs and environmental outputs across all relevant life cycle stages;
3. Evaluate relevant environmental impacts associated with the life-cycle inputs and releases; and
4. Interpret the results to lead to a more informed decision

LCA considers the life Cycle stages as illustrated in Fig. 3.

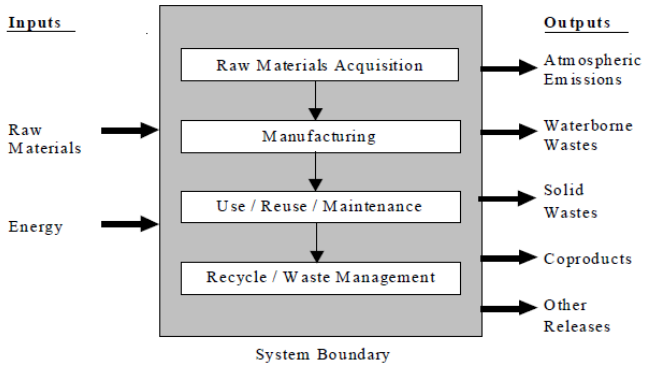

Fig. 3: Life Cycle stages (Source EPA 1993) [20]

In order to fulfill objectives of the study, research work has been designed in the following sequence.

2.1 Awareness workshops

Since global warming and climate changes are global issues, international community has started addressing them, through research development. Buyers are demanding low carbon products. In this scenario, it is imperative that Indian industry should also prepare itself for the upcoming challenge of a Carbon compliant system of Global business. Thus it was also aimed to enhance, the compatibility of the manufacturers by way of introducing impact assessment and sustainable way of manufacturing in the production systems. It is important to sensitise the people working in the textile industry, towards the environmental concerns like global warming and climate change and the relevance of assessing carbon footprint. Awareness workshops were conducted at each of the selected units to create general awareness about the concept of Carbon footprint and its importance for a sustainable business. Through the workshops, an introduction of the concept of Carbon Footprint was done. Various aspects related to Carbon Footprint like energy and resources efficiency, reuse and recycling etc. were discussed.

2.2. Data sources and assumptions

A crucial aspect of LCA is data collection. A life cycle inventory is a process of quantifying energy and raw material requirements, atmospheric emissions, waterborne emissions, solid wastes, and other releases for the entire life cycle of a product, process, or activity [21] Assumptions should be clearly stated to avoid any misinterpretation.

Major portion of data is primary data and has been collected from selected units through interviews observations, company records etc. Inventory was built around consumption of resources like material, fuels, electricity, water, waste generation and status of reuse.

Each manufacturing process was modelled with inputs and output flows at each stage. The data was based on an annual average consumption of material and energy flows.

- Major steps involved in the processing of the textiles
- Electricity and fuel consumption of the machines and various departments
- Fuels consumption in transport of materials and employees commute
- Water consumption involved in the processes
- Waste generated by the processes and effluent treatment practices
- Reuse and recycling options

Data have been acquired from various sources and a lot of data is not available in literature and databases. Data for India is only now being compiled for inclusion in life cycle inventory databases such as Eco invent. Primary data has been supplemented with secondary data obtained from literature, previous studies, reports of environment and audit agencies. As far as possible, primary data has been used instead of generic to facilitate accuracy of results.

2.3 Scope and boundaries

Defining the system boundaries clearly, is crucial to obtaining comparable data and results. This study considers textile production process in its “cradle to gate” boundary. The methodology includes emissions from raw material, transport, production process, packaging, storage and dispatch excludes the consumer use, reuse, and disposal emissions. The study will consider the fuel usage from both direct and indirect sources – Fuel use in transportation, electricity used in operation and other use. The scope 1 and scope 2 of GHG emissions will be considered. The study will include all the contributing factors of GHG emissions and through LCA; hotspots in the process chain would be identified.

2.4 Metrics analysed

Life cycle GHG Emission will be assessed in this study to quantify the environmental impact. Lifecycle analysis of GHG balance is complex, and inclusion or exclusion of co-products processes behind processes, and land use change impacts (direct and indirect) can influence the results considerably. [22] Estimation of life cycle GHG emissions was based on 1 kg of each textile product for yarns and 1sq m for sheets production. This study focuses on all greenhouse gases emissions and related impacts.

2.5 Reporting and recommendations

It should be relevant and complete with all the GHG emission sources and activities within the chosen scope and goal of research. Workshop will be held in each of the unit to educate the unit personnel about the carbon footprint generated in their unit. Based on LCA results, factors contributing to carbon footprint and suitable measures that can be adopted by the unit to bring their carbon footprint to minimum possible will be recommended.

3. RESULTS AND DISCUSSION

Results for the selected textile manufacturing processes aim to highlight comparative life cycle environmental impact in Indian context. The resulting outcomes are expected to be pave way for improvement roadmaps for selected processes through engineering and life cycle design. The results are also expected to help in determining corporate planning and strategy and supporting national policy making. The life cycle inventory is an important contribution of this study.

4. CONCLUSION

The aim of the study was to gain an insight into the sources of the greenhouse gas emission in the selected textile manufacturing units. With an increasing global awareness of environmental impacts of various products and services consumers are increasingly demanding ecofriendly or green products. Assessing the environment Impact of their product will make the manufacturers aware of the emission hotspots in their process chain. This in turn will lead to improved planning, designing and engineering, therefore leading to environmental, economic and social gains. An initiation of Life Cycle thinking among the selected manufacturing units is expected to trigger a positive change in the environment related practices of the surrounding manufacturing units as well.

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