Carbon Footprint in Textile Processing

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"Global warming" and "carbon footprint" are a buzz word now. Its importance and the consequential long term devastating effects of "Climate Change" on the environment, habitat and even the existence of our mother Earth are widely discussed. This warming of atmospheric temperature is attributed to the emission of Green House Gases (GHG)–Carbon Dioxide, Methane, Nitrous Oxide and Fluorocarbons are the major contributors.

The recent years have witnessed exponential increase in the emission of Green House Gases (GHG) raising the atmospheric temperature. It is reported that there is about 6 % rise only in the year 2010 (releasing about 500 mn MT) majority of which is attributed to the top three pollutants of the world - China, the USA and India.

The Green House Gas emission is caused by 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. Just as walking on the sand leaves a footprint, burning fuel leaves carbon dioxide in the air, which is called a "Carbon Footprint". Thus the carbon footprint basically relates to the amount of carbon released into the air based on the fuel consumption.

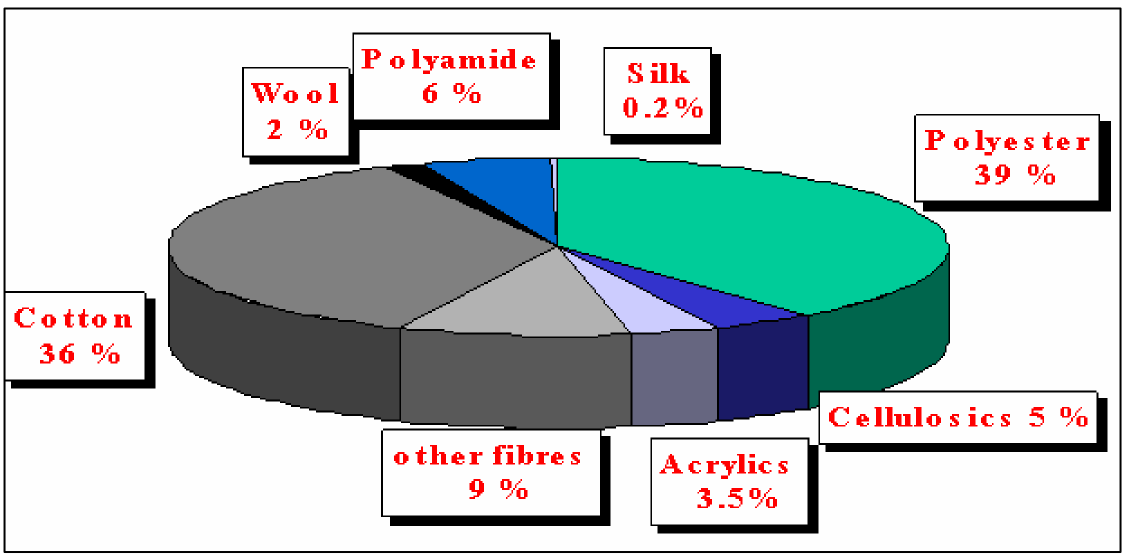
The Carbon Footprint is assessed in 2 layers;

1. Primary footprint - monitors carbon emission directly through energy consumption - burning fossil fuels for electricity, heating and transportation, etc.
2. Secondary footprint- relates to indirect carbon emissions (Life cycle of products and Sustainability).

Thus, the most effective way to decrease a carbon footprint is to either decrease the amount of energy needed for production or to decrease the dependence on carbon emitting fuels.

The textile industry is one of the major consumer of water and fuel (energy required for electric power, steam and transportation). The per capita consumption of textiles is about 20 kg/year and increasing day by day. The world population has reached 7 bn out of which almost 18 % is from India. Thus the energy requirement and consequently the Carbon footprint of the Textile industry in India is considerably high and at the same time the Textile Industry in India is expected to grow from an estimated size of US$ 70 bn today to US$ 220 bn by 2020 which would proportionately increase impact on our Carbon Footprint.

Thus, it is imperative for us to take immediate steps and develop innovative technologies and sustainable solutions that can help reduce the environmental impact. The Government is also demanding industries to comply with stricter conditions for environmental protection.



The estimated Global consumption and processing of textile substrates is shown above. In India also, Polyester and Cotton constitute more than 80 % of textile processing.

The textile industry, according to the U.S. Energy Information Administration, is the 5th largest contributor to CO_2 emissions. Thus the textile industry is huge and is one of the largest sources of greenhouse gasses on Earth. In 2008, annual global textile production was estimated at 60 bn kg of fabric. The estimated energy and water needed to produce such quantity of fabric is considered to be:

- 1,074 bn kWh of electricity or 132 mn MT of coal and
- About 6-9 tn liters of water

Thus, the thermal energy required per meter of cloth is 4,500-5,500 Kcal and the electrical energy required per meter of cloth is 0.45-0.55 kwh

The carbon footprint of the textiles is estimated based on the "embodied energy' in the fabric, comprising all of the energy used at each step of the process needed to create that fabric. To estimate the embodied energy in any fabric it's necessary to add all the process steps from fiber to finished goods. Based on the fiber used the carbon footprint of various fibers varies a lot.

Further, based on the study done by the Stockholm Environment Institute on behalf of the Bio Regional Development Group, the energy used (and therefore the CO2 emitted) to create 1 ton of spun fiber is much higher for synthetics than for cotton:

Fiber	**Kg CO2 /Ton of fiber**
Polyester	9.52
Cotton- conventional	5.89
Cotton - Organic	3.75

For natural fibers, the energy consumption starts at planting and field operations - mechanized irrigation, weed control, pest control and fertilizers (manure vs. synthetic chemicals), harvesting and yields. Synthetic fertilizer use is a major component of conventional agriculture: making one ton of nitrogen fertilizer emits nearly 7 tons of CO2 equivalent greenhouse gases. In case of synthetics, the fibers are made from fossil fuels, where very high amount of energy is consumed in extracting the oil from the ground as well as in the production of the polymers.

The Embodied Energy used in production of various fibers

Fiber	**Energy in MJ / Kg of fiber**
Cotton	55

Wool	63
Viscose	100
Polypropylene	115
Polyester	125
Acrylic	175
Nylon	250

Natural fibers, in addition to having a smaller carbon footprint have many additional benefits: being able to be degraded by micro-organisms and composted (improving soil structure); in this way the fixed CO2 in the fiber will be released and the cycle closed. On the other hand, Synthetic fibers do not decompose: in landfills they release heavy metals and other additives into soil and groundwater. Recycling requires costly separation, while incineration produces pollutants – in the case of high density polyethylene, 3 tons of CO2 emissions are produced for every 1 ton of material burnt.

Substituting Organic fibers for conventionally grown fibers considerably helps reduce carbon footprint based on

- Elimination of synthetic fertilizers, pesticides and genetically modified organisms (GMOs) which is an improvement in human health and agro-biodiversity
- Conserves water - making the soil more friable so rainwater is absorbed better – lessening irrigation requirements and erosion

An additional dimension to consider during processing: environmental pollution. Conventional textile processing is highly polluting:

- Up to 2000 chemicals are used in textile processing, many of them known to be harmful to human (and animal) health. Some of these chemicals evaporate while some are dissolved in treatment water which is discharged to our environment.
- The application of these chemicals uses copious amounts of water. In fact, the textile industry is the largest industrial polluter of fresh water on the planet.

Various ways and methods for reducing the carbon footprint during textile processing have been reported and widely published. Commercially viable products are available in market and being supplied by many organizations. Some of the major areas of work are :

A. Machinery/ Equipment related

- Use of low and ultra low liquor ratio machines – to reduce consumption of water during pretreatment, dyeing and post dyeing wash off sequence. Simultaneously reducing the energy required for water heating at various processing steps and effective load on the effluent treatment.

- Preheating of process water by Solar panels to reduce consumption of other non renewable energy sources (fossil fuels, wood, husk, etc.)
- Adequate insulation of dyeing, drying and stenter machines and appropriate heat recovery systems to avoid undesired energy loss
- Recycle and reuse of process water and alkali by installing adequate filtration process

B. Process related

- Combined scour and bleach process, combined peroxide neutralizing and bio softening process, one bath one step dyeing of P/C blends, etc. so as to reduce number of textile processing stages and thereby reduce consumption of water & energy

- Cold Pad Batch (CPB) preparation and dyeing for energy conservation
- Continuous processing of knits
- Pad/dry vs. pad/dry/pad/steam, minimizing steam and water consumption during washing processes and minimizing number of drying processes
- Foam dyeing, finishing and coating
- Improving Right First Time (RFT) and Right Every Time (RET) dyeing performance

C. Chemicals and Dyes

- Use of Enzymes – biodegradable & non corroding for desizing, scouring, bleach neutralizing, bio-softening and post dyeing wash off. Suppliers and formulators of enzymes are offering specialized products for combined processes to reduce no of processing steps.

- Cationization of Cotton for salt-free dyeing with Reactive and Direct dyes
- High fixation Reactive dyeing with reduced salt for exhaustion
- Digital Ink Jet Printing.
- Low temp curing pigment printing

D. Waste Water Treatment

- Use of physical, biological and activated carbon systems
- Waste water treatment sludge used/sold for fuel

Atul Ltd, pioneer in manufacturing of Dyestuffs in India and a major producer of Dyes, Pigments and Textile chemicals of International repute is a member of ETAD and supplies products conforming to various global safety and Eco Conformance standards like GOTS, REACh, Blue Sign, etc. Atul has already initiated and developed products and processes to reduce Carbon Footprint not only during manufacturing of Dyestuffs but also during the Textile Processing.

Use of renewable energy source based on Hydroelectric Power of 45 MW, control of gaseous emissions by use of sophisticated containment devices and a modern ETP and water treatment plant for recycling and reusing of water during dyestuff manufacturing. Atul has reduced greenhouse gas emission by approx. 150000 MT/year through innovative technologies and received host country approval for three projects under Clean Development Mechanism (CDM).

Being the largest manufacturer of Vat, Sulphur and Reactive dyes in India, the focus is on Cotton processing and products for reducing water and energy during coloration and subsequent processes. Given below are few initiatives and achievements in this direction.

Tulacon C process – These are specialty formulated Vat dyes in liquid form, developed for application by a simple and efficient process of Pad-Dry-Cure on woven cotton fabric and its blends in open width form for a wide gamut of pastel shades. The advantage of this process over conventional Vat dyeing by exhaust or PDPS continuous method is mainly in terms of substantial water and energy saving.

The conventional Vat dyeing on Jigger consumes about 15-20 L/kg (considering MLR of 3 and light shade) consisting minimum steps of - dyeing, rinsing, Oxidation, Soaping and neutralization wash. This process requires temp of about 50-60 deg C depending on class of Vat dyes for 1-2 hrs depending on the fabric length during dyeing and further during oxidation and soaping. Additionally, energy is consumed during fabric drying and thermo-chemical finishing. In case of conventional PDPS process, it involves dye padding-drying, chemical padding and steaming followed by a wash off sequence on continuous washing range, drying and finishing. This too consumes substantial amount of water during washing off and energy for intermittent drying, steaming and finishing process.

In comparison to this, the specific advantage of Tulacon C range and process is in terms of

- Ready to use and easy to handle liquid form
- Simple application process
- No intermittent washing and NO post dyeing wash off sequence
- A combined dyeing and finishing process. As the dye bath chemicals confer desired soft feel minimizing post dyeing thermo-chemical finishing step
- Considerable saving in water, time and energy.
- Excellent lab to bulk reproducibility
- No wash off – no effluent generation– Environment friendly

Tulacon C - X g/l (up to 7 g/l)
Tulachem ATB - 10-20 g/l
Tulachem ATS - 5-10 g/l
Glauber's salt - 5-10 g/l (optional)

Adjust pH between 5-6 with Tulachem Demin C (non volatile, organic acid having buffering capacity). Pad (60-70% expression) – Dry at 110-130°C – Cure at 170°C for 30-45 sec (Cotton) /

190°C for 30 sec (Polyester / cellulosic blends). Infra-red drying can be introduced prior to hot flue drying.

A general and indicative carbon footprint in terms of water and energy saving based on estimations of usage during dyeing, post dyeing wash off and effluent treatment is considered to be:

Vat dyeing Method	**Water in Ltr**	**Energy**	**Effluent in Ltr**
Exhaust - Jigger	15-20	5-6 KW/h	15-20
PDPS– continuous	10	2-3 Kw/h	10
Tulacon C	Almost Nil	0.5-1 Kw/h	Almost nil

Tularevs XL dyes – A high tinctorial, high fixative, low wash off, long lasting, sustainable Reactive dyeing system.

Compared to the conventional reactive dyes, which exhibit comparatively low dye exhaustion and fixation levels and proportionately high wash off of un-reacted hydrolyzed dyestuffs, the molecular reengineered Tularevs XL Reactive dyes exhibit high color yield and less wash off. These warm dyeing dyes have similar dyeing profile which helps achieve uniform level dyeing and right first time (RFT) performance.

Owing to the high fixation levels, this compact range of dyes covering wide shade gamut achieves outstanding wet fastness properties, long lasting color shades. The low wash off and less ensures low effluent generation. Though the exact impact and saving in carbon footprint is not yet ascertained, the overall water and energy saving due to short dyeing and wash off cycle is practically proven. Thus the advantages envisaged are

- **Increase productivity**: based on shorter process cycle, RFT and RET (Right-Every-Time) behavior

- **Cost optimization:** high color strength for optimum shade built-up, easy wash off resulting in reduction in utility cost.
- **Eco- conformance :** meeting international product safety standards and eco norms.
- **Optimum fastness :** satisfies stringent fastness and quality expectations of major brands

Some other products and processes providing considerable reduction in consumption of water and energy include :

Rucoflow CPB – a ready to use, easy to handle liquid buffered alkali recommended for use in CPB Reactive dyeing and print fixation for partial or complete replacement of Sodium Silicate.

Rucoflow CPB confers optimum alkalinity desired for Dye fixation, assists ease of dye penetration inside the fiber, improves color yield, ensures uniformity of dyeing and is easy to wash off. Thus, helps in optimizing the water and energy consuming wash off sequence required during Silicate fixation process. Additionally the free flowing liquid form ensures eous for the auto dosing systems.

The specific advantages of Reactive dyeing with Rucoflow CPB system over the conventional CPB dyeing system are : Sodium Silicate being

- Viscose fluid, available in varying Na_2O : SiO_2 ratios difficult to control desired alkalinity for Reactive dye fixation.
- High viscosity and presence of impurities in commercial grades affect choking/clogging of dosing systems
- Difficult to wash off - requiring large quantity of water
- Tends to impart undesired harsh handle, surface feel – requiring subsequent higher dosage of finishing softeners
- Difficult effluent treatment, especially in case of intended water recycling by RO process – blocking of RO membranes.

Rucogen SOP – a novel washing off agent specifically designed to minimize Reactive dye soaping process and improve wet fastness properties. Generally, in conventional washing off sequence, depending on the depth of shade about 4 to 8 post dyeing wash cycles involving soaping and intermittent hot and cold washes are commercially practiced.

Rucogen SOP (**S**ave **O**ur **P**lanet) is a unique Ter-polymer derivative designed to ensure optimum removal of unfixed, un-reacted or hydrolyzed dye from the fiber without adversely affecting the adequately formed dye-fiber bond and avoids re-deposition or back staining. Thus, lowers the carbon footprint by reducing number of wash off baths and load of colored water effluent.

The specific advantage of Rucogen SOP over the conventional non ionic or anionic washing off agents is in terms of

- Has affinity for the dyestuff, being a mildly cationic polymeric compound
- High emulsifying and dispersing property helps prevent agglomeration of unfixed dye and wash off residues in the bath.
- Forms a stable metal ion complex and avoid adverse effect on dyestuff in case of presence of water hardening agents
- Exhibits dye transfer inhibition property by not allowing the dye re-deposition or back staining
- Improves wet fastness properties

Many such innovative products and processes are being developed by researches and organizations across the globe for minimizing the processing steps, offering alternative sustainable technologies for ultimate reduction, reuse and recycling of water and conservation of energy to reduce Carbon Footprint. The sustainability aspects, like water and energy saving are key concerns of the textile industry and novel technologies, in turn, show the ways to achieve such savings.

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