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Ecological approach to reduce carbon footprint of textile industry

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ABSTRACT

The textile industry is one of the biggest causes of environment pollution. Carbon dioxide and GHG emission during the production and use of textile product reveals its carbon footprint. Toxic dyes and chemicals used in wet processing of textile goods which are coming in contact with the skin and causing a direct damage to the health like skin cancer, allergy etc. The elimination of hazardous solvents is one of the prime concerns of eco-friendly chemistry. Use of enzymes in wet processing, reuse of water, eco-friendly neutralizing agents, single step desizing, scouring and bleaching, elimination of carcinogenic dyes and pigments, use of low impact, fiber reactive and natural dyes, supercritical fluid dyeing using liquid Carbon dioxide, Ultrasonic and Ultraviolet energy for dyeing, recycling system for organic solvent used in textile pigment printing, phthalate free printing, digital textile printing, electrostatic sublimation transfer printing, heat transfer printing, formaldehyde free finishing and biopolishing are some of the modified processes consuming lesser or ecofriendly chemicals thereby providing a safer and sustainable environment.

Key Words : Green chemicals, Recycling, Reduce, Reuse, Standards and labels

INTRODUCTION

The concept and name of carbon footprint originates from the ecological footprint discussion and is based upon life cycle Assessment (LCA). The carbon footprint reveals how much CO_2 in total is emitted along the value chain of a product. It is the total set of greenhouse gas (GHG) emissions caused by an organization, event or product. It is calculated for the time period of a year and expressed in terms of the amount of carbon dioxide, or its equivalent of other GHGs emitted (Nieminen *et al.,* 2007). As greenhouse gases produced by human activities accumulate and their concentration increases in the atmosphere, it causes global warming. The main contributor to global warming is carbon dioxide, which accounts for nearly 80 per cent of emissions from the industrialized countries.

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Carbon footprint of textile industry:

The textile industry is a gigantic industry – and it is gigantically polluting. The textile industry uses copious amounts of two things: water and chemicals. It is the number one industrial polluter of water in the world. Wet treatment of textiles like desizing, prewashing, mercerizing, dyeing, printing etc. includes a lot of chemical applications on the fibers or fabric. Water is used at every stage in fabric manufacturing - to dissolve chemicals to be used in one step, then to wash and rinse out those same chemicals to be ready for the next step. Some fibres need to be bleached with chlorine before dyeing. This causes organo-chlorine compounds to be released, which are very dangerous to the environment (Malik and Biswas, 2013). It takes between 10% and 100% of the weight of the fabric in chemicals to produce that fabric. From dyes to transfer agents, around 2000 different varieties of chemicals are used in textile industries (Table 1).

During the process of wet treatment, huge quantity of fossil fuels is consumed which have carbon content and react with oxygen to form carbon dioxide. This results in acidification, fossil fuel depletion and ultimately global warming. Fabrics take a lot of energy to produce fabrics. In 2008, annual global textile production is estimated at 60 billion kilograms (KG) of fabric. The estimated energy and water needed to produce that amount of fabric boggles the mind: 1,074 billion KWh of electricity (or 132 million metric tons of coal) and between 6 – 9 trillion liters of water. According to estimates, textiles and clothing typically account for around four per cent of the secondary carbon footprint of an individual in the developed world. More than 1 million tones of textile are thrown away each year out of which 50 per cent are recyclable. These wastages need a landfill, and they do not decompose quickly. Woolen garments while decomposing generate gases like methane which results in global warming. Clothing is responsible for approximately one ton of each individual's CO_2 emissions (including washing and drying). Research has shown that over the lifecycle, around 75 per cent of the T-shirt's carbon footprint will be caused by machine washing and drying.

Ignorant Indian Textile Industry:

Indian textile industry has an overwhelming presence in the country's economic life. The industry's size and extensive use of raw materials and chemicals make it mandatory to adopt technologies that are environmentally sustainable. A large number of textile industries and units, particularly those in the processing sector across the country have failed to meet many environmental laws and regulations.

Despite stringent environmental laws and regulations, the compliance level by the textile industry has not been very satisfactory. Although, with 16 per cent of the global population, India's share of carbon dioxide emissions is only 3.11 per cent, yet in one study from the Stockholm Environment Institute it was found that the embodied energy of organic cotton from India was greater than conventionally produced cotton from the USA because the yields are much less in India, requiring more land to grow the same amount, and much of India's energy is generated by coal. Toxic dyes and chemicals used in wet processing of textile goods cause a direct damage to the health like skin cancer, allergy etc. (Deo, 2001). Therefore, eco-friendly textile wet processing should be adopted to eliminate/optimize the use of harmful/ hazardous/ carcinogenic chemicals / auxiliaries/ dyestuffs.

Strategic measures to reduce carbon footprint:

The Indian textile industry will need to cover a lot of ground on crucial environmental issues that will impact both competitiveness and bottom line in a regime driven by environmental and sustainability concerns. A worldwide paradigm shift toward cleaner and greener processes is already underway and it can no longer afford to remain a mute spectator if wants to emerge as a significant player in the global market. Only a systematic approach including a continuous improvement process reduces the carbon footprint of textiles. Companies will realize how they can benefit from increasing energy efficiency and thus cutting costs for fuel and electricity. In fact, it can be a triple wins for the textile retailer, supplier and the

Table 1 : Environmental impact of various processes of textile industry

Process	Emission	Wastewater	Solid wastes	Pollutants
Sizing	VOCs	BOD, COD, metals	Starch, waxes, carboxymethyl cellulose (CMC), unused sizes, polyvinyl alcohol (PVA), wetting agents.	Nitrogen oxides, sulpher oxide, carbon monoxide
Desizing	VOCs from glycol ethers	BOD from sizes lubricants, biocides, antistatic compounds	Starch, CMC, PVA, fats, waxes, pectins	BOD, COD, SS, DS and high pH
Scouring	VOCs from glycol ethers and scouring solvents	Disinfectants, insecticide residues, NaOH, detergents, oils, lubricants and solvents	Little or none	BOD, COD, SS and high pH
Bleaching	Little or none	H_2O_2, stabilizers, high pH, Sodium hypochlorite, Cl_2, NaOH, acids, surfactants, $NaSiO_3$, sodium phosphate	Little or none	Chlorine, chlorine dioxide, High alkalinity, high SS
Dyeing	H_2S, aniline vapours,	surfactants, cationic materials, BOD, COD, sulfides, dyes, chemicals, dyestuffs urea, reducing agents, oxidizing agents, acetic acid, detergents, wetting agents	Metals, salt	Strongly coloured, high BOD, DS, low SS, heavy metals,
Printing	Pigments, Solvents, acetic acid, gases	Pastes, urea, starches, gums, oils, binders, acids, thickeners, cross-linkers, reducing agents, alkali, solvents, colours, heat, BOD, foam, PVC, phthalates	Suspended solids, urea, metals	Strongly coloured, high BOD, SS slightly alkaline, oily appearance, Hydrocarbons, ammonia, heavy metals
Finishing	VOCs, contaminants, formaldehyde vapours, Fluorocarbon	COD, suspended solids, toxic materials and solvents, resins, catalyst, softeners, stiffeners	Fabric scraps and trimmings, packaging waste	Formaldehydes, low weight polymers, lubricating oils

environment.

Environmental sustainability can be achieved by looking at the full life cycle of our clothing, from the design and materials sourcing process onwards. An individual, nation or organization's carbon footprint can be measured by undertaking a GHG emissions assessment. All of the energy used at each step of the process needed to create that fabric is known as embodied energy and it is sum total of the energy required to produce the fiber and yarn/ filament as well as to weave those yarns/ filaments into fabric. Beyond fiber production, the dyeing and finishing sector is the largest energy and water consumer in the whole textile chain and has the highest potential for energy and water savings and efficiency improvements. Once the size of a carbon footprint is known, a strategy can be devised to reduce it, e.g. by technological developments, better process and product management, changed Green Public or Private Procurement (GPP), Carbon capture, consumption strategies, and others. The mitigation of carbon footprints through the development of alternative projects, such as solar or wind energy, or reforestation, represents one way of reducing a carbon footprint and is often known as Carbon Offsetting.

Adoption of 3 R concept :

To create new green paradigm the textile and apparel industry needs to adopt 3R Concept, *i.e.* Reduce, Reuse and Recycle.

Reduce :

Low carbon foot print processes cut costs by reducing waste of raw materials and energy. Water and energy usage reductions by the textile dyeing and finishing sector can help reduce global carbon dioxide emissions. By saving energy and water, the textile industry can not only save a lot of money, but also help to slow down climate change. The textile industry needs to adopt more energy efficient processes; such as innovative textile chemicals and processing technologies that contribute to eco-efficient processes for textile mills can save costs and help reduce the environmental burden. Some Innovative products and processes with smaller carbon footprints have been discussed below.

Use of organic fibers:

Substituting organic fibers for conventionally grown fibers as it uses less energy, no petrochemical-based fertilizers and pesticides for production, emits fewer GHG and supports organic farming (which has myriad environmental, social and health benefits). Other "greener" alternatives include organic wool, linen, bamboo, hemp, abaca, soybean fibre, biopolymers and polyester recycled from used clothing. Natural fibers, in addition to having a smaller carbon footprint in the production of the spun fiber, have the benefit of being able to be degraded by micro-organisms and composted. In this way the fixed CO_2 in the fiber will be released and the cycle closed, whereas, Synthetics do not decompose. In spite of that natural fibers also sequester carbon. Sequestering carbon is the process through which CO_2 from the atmosphere is absorbed by plants through photosynthesis and stored as carbon in biomass (leaves, stems, branches, roots, etc.) and soils. Polymer fiber, made with agricultural feedstocks, provides a 30% CO_2 reduction while its manufacturing process reduces GHG emissions by 63%, compared to conventional nylon made from petroleum. Polymers fiber products with optimized properties including improved dye ability.

Reduction of chemicals in textile wet processing:

Every operation under wet processing such finds its basis in lower generation of waste, minimum use or reuse of water and chemicals, overall environment friendliness and application of appropriate machinery and technology. In developing green synthetic strategies, the Indian textile industry needs to adopt innovative textile chemicals and processing technologies. There is need for ecofriendly wet processing that is sustainable and beneficial methods (Kidwai, 2006). Number of sustainable practices has been implemented by various textile processing industries such as Eco friendly bleaching; Peroxide bleaching; Eco friendly dyeing and Printing; Low impact dyes; Natural dyes; Azo Free dyes; Phthalates Free Printing. Use of enzymes in wet processing, ecofriendly dyestuffs and textile auxiliaries, elimination of organic solvents and chemicals altogether are some of the approaches towards green chemical processing of textiles. Industrial enzymes, which are basically proteins, replace harsh chemicals used to remove impurities from the fiber or fabric, which reduces energy costs, water consumption and also improves the feel of the fabric.

Desizing:

Both natural and synthetic sizes contribute high BOD and COD to the effluents. Use of Amylase and Lipase enzymes for desizing reduces effluent and can be used for continuous/ batch desizing. The enzymatic removal of Sericin involves use of Proteolytic, Sericinases enzyme and surfactant, which improves degumming efficiency, imparts soft feel& ensures maximum weight reduction. Enzymes such as Lipases, proteases are used in wool processing, which impart antifelting property and also improved dye uptake.

Scouring :

Scouring operation generates large BOD, oil and grease.

(a) Incorporation of persulphate in scouring eliminates the separate desizing stage. Simultaneous desizing and scouring can be carried out by padding fabric with potassium persulphate (2 - 3 gpl) and NaOH (40 - 50 gpl) and subsequently steaming in J-box.

(b) Enzymatic Bioscouring (EBS) system uses Pectinase, Protease and Lipase to remove pectins, proteins and oils, fats or waxes, respectively. It removes pectins from cotton causing loosening of hydrophobic waxes which are easier to get rid off in subsequent washing. The action of lipase subsequently brings about hydrolysis of such hydrophobic waxes. It eliminates core alkali neutralization; byproducts are readily degradable, less load of salt effluent reduces waste water treatment. This rinse water can be reused in desizing.

(c) Solvent assisted scouring makes use of 5% solvent, which is emulsified and also can be coupled with bleaching and desizing. Here, hydrogen peroxide acts both as bleaching agent and oxidative desizing agent in processing of cotton.

(d) In case of silk as well as wool, solvent such as perchloroethylene is used, provided sophisticated machinery is available for total recycling of solvent. The carbonisation of wool after solvent treatment is done with H_2SO_4.

Bleaching:

(a) REDOX Bleaching - Single step desizing, scouring and bleaching – is ecofriendly. Ultrasonic assisted process reduces consumption of auxiliaries/chemicals and the effluent load.

(b) Sodium silicate as stabilizer for H_2O_2 bleaching may be replaced by organic stabilizers like Polyhydroxy carboxylic acids and their ammonium salts, Polyacrylic acids, Polyphosporic acids and their alkali metals and ammonium salts to minimize the impact of effluent.High catalytic power and eco-friendliness of Catalase enzymes to decompose residual H_2O_2facilitates dyeing in the same bath.

(c) Fabrics bleached with glucose oxidase obtain whiteness index 15-20 degree improvement with low strength loss. Amyloglucosidases, Pectinases, and glucose oxidases used for bleaching improve whiteness, absorbency, dyeability and tensile properties of the fabrics (Abadulla *et al.,* 2000).

(d) Now-a-days Zeolite and Bentonites which are clay materials which are also used as stabilisers. Bleaching with per acetic acid has been reported as eco-friendly process in which case it is produced using hydrogen peroxide and glacial acetic acid.

(e) Bleaching with ozone - Ozone-oxygen mixture is highly unstable liberating hydroxy radicals giving good degree of whiteness in a short time at room temperature, the absence of harmful chemicals and use of low quantity of water. Ozone bleaching operation could be made continuous too.

(f) Potassium permanganate is also used as powerful oxidizing bleaching agent and said to be economic and non-polluting. Use of sodium chloride solution for bleaching results in its electrolysis in which chlorine is liberated at the cathode.

Dyeing :

The major pollutants of dye bath are unabsorbed dye, heavy metals and salts for dye fixation.

(a) Low Impact- Fiber Reactive Dyes have high take-up rate of dye, so less dye is wasted. Recycling of dye bath, separation of salts by reverse osmosis, use of quaternary ammonium compounds to increase the affinity may add to sustainability.

(b) Discharge of sulfides from liberated hydrogen sulfide during reduction of sulphur dyes is dangerous to life. Indirect cathodic reduction processes using Thiourea dioxide or Glucose/NaOH, application of various reducing D-sugars reduces the sulfide impact.

(c) Pre-treatment of cellulose with cationic, nucleophilic polymers enables reactive dyeing at neutral pH without electrolyte addition; maximize colour fixation, minimise colour effluent.

(d) Supercritical Fluid Dyeing uses liquid Carbon dioxide as the fluid medium to carry dyes and pigments on disperse-dyed synthetics, eliminating aqueous effluent. In this case under very high pressure CO_2 is liquefied in which disperse dye dissolves and is used for dyeing of synthetic fibre. The liquid CO_2 has the advantage of very high diffusibility and it has low viscosity than any normal liquid (Malik and Kaur, 2005).

(e) Use of radio waves for drying minimizes bleeding of dye into effluent. Ultrasonic waves and reduce size of dye particles and break them, accelerate diffusion and increase colour yield. Low temperature dyeing leads to energy saving, reduced processing time, less consumption of auxiliaries/chemicals, increased colour yield and less effluent load (Vankar and Shankar, 2008).

(f) The use of natural dyes becomes obvious expectation of eco-friendly dyeing. Many plants and some animals' are potentially rich in natural dye content. The lac industry gives lac dye as a byproduct which is extracted from insect coccuslacca.

(g) Attempts have also been made to synthesize natural dye having similar structure. Genetic modification of certain fungi has produced Anthraquinone dye.

(h) The new area in natural dyes can be colours from micro-organisms. The microbial dyes have dye ability towards polyester similar to disperse dye having uniformity without dispersing agent requiring no addition of dispersing or leveling agents during dyeing.

(i) Cotton fibers containing natural polyester, such as polyhydroxybutyrate (PHB), enhanced dyeability, improved dimensional stability, reduced shrinking and wrinkling.

(j) Aftersoaping agent for dyeing can reduce the processing time and water consumption compared to the conventional system.

(k) The revolutionary air technology for dyeing requires only one-fourth of water and also reduces energy and chemicals consumption.

Printing :

PVC and phthalates used in plastisol printing paste have high BOD.

(a) Plastisol inks used in screen printing can be replaced by acrylic-based inks referred to as non-PVC and non-phthalate plastisols. Most of these inks can be re-used, have good shelf life.

(b) Inkjet Printing Droplets of disperse dye solution eliminate photographic screen making. It decreases the use of water, dyes and solutions.

(c) Digital textile printing eliminates all of the toxic chemical processes, contains no formaldehyde, halogenated flame retardants, vinyl plasticizers, heavy metals, carcinogens, or volatile organic compounds involved in conventional digital and screen printing. Digital printing, using ink from the dyes, wastes neither fabric nor ink and does not use harmful salts and significantly reduces the environmental footprint.

(d) Transfer paper (the only waste product) used in Heat Transfer Printing may be recycled.

(e) Formaldehyde-free pigment printing system, which ensures "zero add-on" of formaldehyde during production and needs no further treatment

Finishing:

Textile finishing sector requires different chemicals, which are harmful to the environment.

(a) In spite Of formaldehyde containing resins non formaldehyde containing DMEDHEU (n,n,dimethyl 4,5 dihydroxyethylene urea), citric acid (tricarboxylic acid) or BTCA (1,2,3,4 butane tetra carboxylic acid) can be used to provide ecofriendly resin finishing (Gulrajani and Gupta, 2011).

(b) Regenerated cellulose fiber, having anti-bacterial properties, can be created by wet spinning using a butyl-methyl-imichloridazolium chloride (BMIM ionic liquid) as a solvent.

(c) C6-based fluorocarbon finish can be used for stain repellency and release which reduces CO_2 emissions.

(d) Singeing replaced by biopolishing of natural fibreswith Cellulases enzyme prevents pilling.

(e) Biosoftening of protein fibres with Cellulases, Lignases and Pectinases modifies wool without damage and markedly reduce the AOX contents in effluents (Joshi *et al.*, 2009).

(f) Color Fast Finish, is a one-step-process of textile can reduce the processing time and carbon dioxide emissions.

(g) Innovative machine that applies finishes to fabrics using foam, which conserves water.

Effective laundry management:

While effective laundry management has always included a comprehensive effort to contain energy and labor, green initiatives will force the adaptation of technology and business methodologies that will create profound change in the way laundries work. The ultimate goal of a green initiative should be to achieve effective stewardship of natural resources and to work toward carbon neutrality (zero net carbon emission through reduction of emissions and sequestered or offset carbon amounts). For laundry, green chemistry would include elimination of certain detergent/surfactant ingredients such as alkylphenol and ethoxylates, and other chemicals including phosphates, chlorine, carcinogens and/or heavy metals. Alternative bleaches to chlorine include peracetic acid and hydrogenperoxide that, while hazardous, are more biodegradable and therefore considered greener than chlorine. Underscoring the need for careful chemical selection is that hydrogen peroxide requires higher operating temperatures than chlorine. All the pros and cons of chemical selection should be evaluated.

Use of natural light to serve most of its illumination needs, upgrading the lighting systems, installing of heat recovery plants and developed energy efficient in-house weaving and other equipments, efficient use of energy sources to generate water temperature and for the drying and finishing of textiles, as well as environmental control to include facility heating, cooling and lighting, methods for transporting textiles to use areas, as well as those used by the laundry's labor force to get to and from work should be considered in order to reduced carbon footprint. While outside the laundry operator's direct control, the electricity/steam source has a substantial impact on the operation's carbon footprint. Business travel, outsourced activities, the extraction and processing of purchased materials, and the use of sold products and services also have their impact on GHG.

Reuse :

Effluents of chemically treated textiles are discharged in water. Treatment of wastewater obtained from chemically treated textiles is a must. Use of chrome mordant dyeing and limiting the emission of copper, chromium and nickel into water reduces impurities in dyes and pigments. Using dyeing carriers with high chlorine content should be evaded. During the process of bleaching, alternative agents that are less or not hazardous can be used.

Households currently throw out 1.17 million tonnes of textiles each year, most of it clothing, which could be recycled or reused. It's therefore important, whether as designers, retailers or consumers, that we begin to tackle some of these issues that have been highlighted today.

Recycle :

The textile and apparel industry should more utilise recycled fibers. The environmental impact of recycling worn-out polyester or cotton waste into new polyester or cotton fiber, respectively, for instance, is significantly lower than making that same fiber a new. A wide range of innovative, sustainable clothing can be made from recycled textiles. We should take care of the ways to combat 'fast-fashion' and to reduce its negative environmental impact as the issues of textile recycling, cheap clothing or "throwaway fashion' affects us all.

(a) Eco Circle environmentally friendly closed-loop recycling system chemically converts used polyester products into new polyester raw materials. The reclaimed polyester is of purity comparable to virgin fibers, but the system reduces energy consumption by 84% and CO_2 emissions by 77%. Recycled polyester products include Ecopet polyester fiber made from recycled polyethylene terephthalate (PET) bottles, Eco Circle fibers and recycled polyester fiber recreated from used clothing and uniforms.

(b) Rayon, which is produced from wood pulp, seems to be an attractive option, but the manufacturing process still consumes large quantities of energy and creates significant amounts of wood waste. Introduced in the early 1990s, Lyocell is also made from wood fiber (harvested from tree farms). It is biodegradable and recyclable, and the production process is more sustainable and includes recovery of most chemicals.

(c) Ingeo fiber is the first man-made fiber from 100% annually renewable plant sugars, is supplied into apparel, home textile, and increasingly the personal care and hygiene (nonwovens) markets.

Development of standards and labels :

The Global Recycle Standard:

This brand new standard was developed to help verify claims regarding recycled products. The Gold level requires products to contain 95 – 100% recycled material; Silver requires 70 – 95% and Bronze contains a minimum of 30%. The definition of "recycled" under this standard is based on criteria already laid down by Scientific Certification Systems. In addition, the standard contains environmental processing criteria and strick raw material specification (water treatment and chemical use is based on GOTS and Oeko-Tex 100) and

Fig. 1 : Carbon footprint label

social responsibility is incorporated – which ensures workers health and safety and upholds workers rights in accordance with International Labor Organisation (ILO) criteria.

In the U.K., the Carbon Trust, working with Continental Clothing, has developed the world's first carbon label for clothing. The new label will provide the carbon footprint of the garment, from raw materials and manufacture to use and disposal.

There exist several third party certifications which we think every conscious consumer of fabric should be aware. We should all know what the certification does – and doesn't – cover.

Global Organic Textile Standard (GOTS) is a tool for an international understanding of environmentally friendly production systems and social accountability in the textile sector. It covers the production, processing, manufacturing, packaging, labeling, exportation, importation and distribution of all natural fibers. That means, for example: use of certified organic fibers, prohibition of all GMOs and their derivatives and prohibition of a long list of synthetic chemicals. Formaldehyde and aromatic solvents are prohibited; dyestuffs must meet strict requirements (*i.e.*: threshold limits for heavy metals, no AZO colorants or aromatic amines); and PVC cannot be used for packaging. A fabric that is produced to the GOTS standards is more than just the fabric. It's a promise to keep our air and water pure and our soils renewed; it's a fabric, which will not cause harm to you or your descendants. An organic fiber fabric processed to GOTS standards is the most responsible choice possible in terms of stewardship of the earth, preserving health, limiting toxicity the load to humans and animals, reducing one's carbon footprint – and emphasizing rudimentary social justice issues such as no child labor.

Cradle to Cradle (C2C)'s minimum requirement for certification is that a product be 67% recyclable or biodegradeable. Oeko-Tex, GreenGuard and SMART (Sustainable Materials Rating Technology) are some other examples of these certifications.

Educate consumers to change attitude:

Consumer education about the huge carbon footprint of mainstream textiles helps in inspiring consumers to change their habits**.** It also assists in changing consumer attitudes. Their inclination towards "organic fabrics" not simply fabric made from organic fibers; eco-friendly fibers, not cotton or synthetics; minimizing purchase of fabrics that are blends of natural and synthetic fibers (*i.e.*, cotton and polyester), or blends of two or more different synthetic fibers (polyester and acrylic), because there is no hope of recycling these fabrics right now; Search for a fabric or product that is certified by any third party, independent textile certification agency - GOTS, SMART, C2C, etc.; paying attention to the carbon footprint of the fabrics they buy; Keeping themselves educated on the progress of the eco-textile community – are few of the steps that will truly reduce carbon footprint of textile and apparel industry. To maintain and grow their customer base of this new generation of environmental and ethically aware consumers, retailers in particular are pushing sustainability requirements back down their global supply chains.

Low-carbon manufacturing programmes and carbon accounting in factories, carbon footprint calculation projects, benchmarking energy consumption across the textile and apparel supply chain are few of the strategic measures required to reduce carbon footprint of textile and apparel industry in India.

Conclusion:

The global textile industry has taken several strides towards reducing its carbon footprint and meeting the challenges of building a more sustainable future. At the same time there is a growing awareness of environmental issues among consumers who are increasingly now increasingly insisting on textile products complying with environmental standards. These complementary trends will hopefully continue to drive the industry toward offering the consumer products that are not only red, blue, white etc. but also green. Beyond fiber production, the dyeing and finishing sector is the largest energy and water consumer in the whole textile chain and has the highest potential for energy and water savings and efficiency improvements. Action is needed, but the industry cannot do it alone. National and multinational governments should support the industry with incentive plans to change old technology with modern equipment. The present day scenario in textile wet processing calls for environment friendly approaches. This may be achieved by the various methods such as the use of radiofrequency, electrochemical dyeing, microwaves, infrared heating etc. There is need for implementation of sustainable processing by various textile industries. Green chemistry can lead to various positive impacts as it reduces the need to use hazardous chemicals and also uses less water and energy during manufacturing. It is a sustainable solution, the green, environmentally-conscious alternative for manufacturing textiles in the 21st century.

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