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Achieving Environmentally Sustainable Supply Chain in Textile and Apparel Industries

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***Abstract*—**Most of the manufacturing entities cause negative footprint to nature that demand due attention. Textile industries have one of the longest supply chains and bear the liability of significant environmental impact to our planet. Issues of environmental safety, scarcity of energy and resources, and demand for eco-friendly products have driven research to search for safe and suitable alternatives in apparel processing. Consumer awareness, increased pressure from fashion brands and actions from local legislative authorities have somewhat been able to improve the practices. Objective of this paper is to reveal the best selection of raw materials and methods of production, taking environmental sustainability into account. Methodology used in this study is exploratory in nature based on personal experience, field visits in the factories of Bangladesh and secondary sources. Findings are limited to exploring better alternatives to conventional operations of a Readymade Garment manufacturing, from fibre selection to final product delivery, therefore showing some ways of achieving greener environment in the supply chain of a clothing industry.

***Keywords*—**Textile and apparel, environment, sustainability, supply chain, production, clothing.

I. Introduction

TEXTILE and apparel industries have been very successful in drawing the attention of environmental activists since long. This industry poses threat towards our environment at different stages of its fibre, yarn, fabric and garment manufacturing, coloration, finishing, delivery and disposal. Sustainable clothing supply chain includes eco-friendly material preparation, sustainable production, green distribution, green retailing, and ethical consumers [1]. Sustainable fashion supply chain helps companies to promote their brand reputation and to reach a wider range of ethical consumers [2]. As a result, for firms, being sustainable is a way to showcase their responsibility to society and environment which results in competitive advantage in the market as well [3]. The demand to minimize the environmental pollution from clothing industry is not only from fashion firms but also from consumers [4] and there is no way forward to achieve a sustainable growth in this sector without taking ecological consideration into account.

Sustainable fashion got considerable attention from scholars and industrialists in the area of textile and supply chain management [5]. Moore and Ausley showed that productivity can be increased through greener production by ensuring stakeholders cooperation [6]. Wu et al. [7] investigated the relationship between green supply chain management drivers like organizational support, social, capital and government involvement and global supply chain management practices like green purchasing, eco design, investment recovery and cooperation with customers.

Preparation of readymade garments from raw materials is a long process. Industrial manufacturing starts with fibres though in reality, raw material production process initiates even before.

Fig. 1 Primary flow chart of a garment supply chain

Manufacturing process of a garment very often gets longer and more complicated subject to different style and requirements from buyers. This supply chain causes huge negative environmental impact [8], [9]. Guo et al. [10] examined the green supplier evaluation and selection process in global apparel manufacturing. Yang and Dong investigated sustainable apparel manufacturing strategy where products are partially produced using recycled materials [11]. Shi et al. [12] evaluated economic and environmental performance in the fashion supply chain from a power perspective. Implementing sustainability into the textile and apparel supply chain is a value addition not only for the products but also for society and ecology. LoMonaco-Benzing and Ha-Brookshire [13] examined the moral values on personal level and corporate level in the textile and apparel supply chain. Oelze [14] studied the existence of consensuses in the perception of enablers and barriers of sustainable transformation of the supply chain in the textile industry. Supply chain of clothing industry is labor-intensive and highly sensitive to environment and society. It is

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actually crucial for fashion firms to build up a sustainable supply chain, which covers all aspects of Triple Bottom Line [15]. Implementing sustainability in textile and apparel supply chains is also quite challenging [16].

This paper is based on analysis from the secondary sources and personal experiences gained from the industries in Bangladesh. Information was derived from scholarly articles followed by recommendations to reveal ways of achieving sustainable supply chain in Textile and Apparel industries.

II. Challenges in Textile and Apparel Production

Global textile and apparel consumption is estimated to be more than 30 million tons a year, which causes serious social and environmental impact within supply chain [17]. This industry has been considered as one of the most harmful industries for ecology and also one of the major contributors to carbon footprint. According to the report of Earth pledge, a non-profit organization, at least 8,000 chemicals are used to turn raw materials into textiles which cause irreversible damage to people of the environment [18]. According to World Health Organization (WHO), 20,000 deaths occur annually in developing countries due to the poisons of pesticides used in crops [19]. Textile waste is of two types: pre-consumer and post-consumer. Pre-consumer textile waste is the byproduct materials formed during production process and post-consumer textile waste refers to any type of garments or household articles discarded either due to they are worn out, damaged, outgrown, or have gone out of fashion. More than a million tons of textiles are thrown away each year, most of which by households rather than industry [20]. Often they are given to charities but in maximum cases, are disposed to trash and eventually finish up in municipal landfills. Textile and apparel industry offers threat to environment at various stages of manufacturing process. The major environmental problems associated with textile industry are typically those associated with water pollution caused by the discharge of untreated effluents. Other environmental issues of equal importance are air emission, notably Volatile Organic Compounds (VOC)'s, Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD) excessive noise or odor as well as workspace safety.

TABLE I
Summary of the Wastes Generated during Textile Manufacturing

Process	Emission	Wastewater	Solid Wastes
Fibre Preparation	Little or none	Little or none	Fibre waste; packaging waste
Spinning	Little or none	Little or none	Packaging waste; fibre waste; cleaning processing waste
Slashing/Sizing	VOCs	BOD; COD; metals	Fibre lint; yarn waste;
Weaving	Little or none	Little or none	Packaging waste; yarn fabric scraps; off-spec fabric; used oil
Knitting	Little or none	Little or none	Packaging waste; yarn fabric scraps; off-spec fabric; used oil
Desizing	VOCs from glycol ethers	BOD from sizes, lubricants; biocides; anti-static compounds	Packaging waste; fibre lint; yarn waste, cleaning maintenance materials
Scouring	VOCs from glycol ethers scouring solvents	Disinfectants, insecticide residues; NaOH; detergants, oils; knitting lubricants; spin finishes; spent solvents	Little or none
Bleaching	Little or none	H_2O_2, stabilizers; high pH	Little or none
Singeing	Small amount of exhaust gases from the burners	Little or none	Little or none
Mercerizing	Little or none	High pH, NaOH	Little or none
Heat Setting	Volatilization of spin finish agents	Little or none	Little or none
Dyeing	VOCs	Metals; salts; surfactants; organic processing assistants; cationic materials; dyes pigments; BOD; COD; sulphide; acidity/alkalinity; spent solvents	Little or none
Printing	Drying and curing oven emissions combustion; gases	Suspended solids; urea; solvents; colour; metals; heat; BOD; foam	Little or none
Finishing	VOCs; formaldehyde vapors; combustion gases	COD; suspended solids; toxic materials; spent solvents	Fabric scraps trimmings, packaging waste
Garment Manufacturing	Little or none.	Little or none.	Waste of finished fabric, pattern, marker, threads, tapes, fusing rolls, polybags, stickers; packaging waste
Washing	VOCs	Metals; organic processing assistants; BOD; COD; soap, detergents	Little or none

As a prime textile raw material, cotton has been dominating the fibre industry since long. But cultivation of this natural fibre requires huge amount of pesticides, fertilizers and water. For instance, making one cotton T-shirt requires 2700 litres of water of water, 150 gm of toxic pesticides and fertilizers [21]. In India, producing 1 kg of cotton needs 10,000 litres of water, 8000 litres for a pair of cotton jeans [22]. In USA, 38 million pounds of pesticides were used on cotton and cotton ranked fourth in terms of fertilizer use on crops, almost 973 million pounds in year 2014 [23]. Thus conventionally grown cotton has a severe impact on ecology consuming lots of water, more than 25% of worldwide insecticides and 10% of the pesticides. Cotton and Polyester together contribute for about 80% of the worldwide fibre demand [21]. Polyester requires less water but double energy for its production in terms of cotton.

Various stages of manufacturing yarn from fibre (blow room operation, carding, drawing, combing etc.), different techniques of converting yarn into fabric (knitting, weaving, non-woven

etc.) cause threat to environment at several points of their processing. During sizing, starch pastes consist of preservatives are applied on yarn in order to protect the yarn from micro-organisms. Preservatives like penta-chloro phenol, obtained from phenolic or chlorinated compound, possess a toxic effect on human skin. Oil stain gets formed on fabric surface from machine parts during grey fabric production as lubrication is essential for periodical machine maintenance.

Wet processing unit of a textile industry which involves pretreatment, dyeing and finishing of grey fabric, do the most of the damage towards ecology. Not only huge amount of resources: water, chemicals, auxiliaries and energy is required for day to day operation but also highest volume of waste water and highest degree of pollutants is generated from it. Toxic chemicals, dyes, bleaching agents, banned amines mark a significant impact on surroundings. Besides emission of acetic acid and formaldehyde during heat setting, drying or curing process; nitrogen and sulphur oxides from boilers play their own role for further damage. Chlorinated or oxalic acid bleaching push the ecology injury worse. Researchers have also put a lot of emphasis to improve the process for confirming best reuse of this water resource [18-20].

Processes involved in apparel manufacturing from finished fabric (sketching, pattern designing, sample making, production pattern, grading, marker making, spreading, cutting, sorting, sewing, pressing, inspection and packaging) go against green environmental actions at every stage. Huge amount of waste is generated in the form of cardboard boxes, labels, tapes, threads, stickers, fabric scraps in sections like spreading, cutting and sewing.

III. How to achieve environmentally sustainable supply chain

There is no easy guideline to achieve a sustainable supply chain as every single part of process of the long manufacturing flow chart of garment need to be safe for the environment. Some recommendations are as follows:

1. Organic cotton is a better choice of fibre where no chemical fertilizers, pesticides and genetically modified organisms are used. Preferable alternatives of conventional cotton from natural sources includes bamboo, hemp, jute, tencel, ramie, organic silk, organic linen which need less pesticides, irrigation and other inputs; from synthetic source viscose, lycra, lyocell, corn are there.
2. Preservatives like penta chloro phenol which is used in starch paste during sizing operation should be avoided as chlorinated or phenolic compound causes toxic effect on human skin. Synthetic starch can significantly contribute to reduce health hazards replacing phenolic and chlorinated preservatives. Proper care is required to prevent oil stain in fabric and stain remover may be applied to remove oil stain before going for chemical treatment.
3. An integrated chemical pretreatment (combined desizing, scouring, bleaching) is recommended to save water, energy and chemicals. Dyes that forms carcinogenic amines therefore increase BOD or COD; chlorinated bleaching agents; leveling agents containing chloro benzene, tri chloro ethylene; formaldehyde resins chemicals containing acetic acid need to be avoided as a measure of preventive use of toxic chemicals in dyeing, printing and finishing treatment. Use of urea should be lessened during reactive dyeing. Carriers lebeling agents must contain less chlorinated or phenolic portion in polyester dyeing in other cases. Dyes made from natural pigments and soymilk tends to create a gentler dyeing environment. Use of hydrol as a substitute of sodium sulphide is recommended for sulphur dyeing. Optional stabilizers like aminotrimethylene phosphoric acid, ethylene di amine tetra methylene phosphoric acid are also suggested as peroxide stabilizers.
4. Selection of eco-friendly elements and their appropriate use needed to be ensured while apparel manufacturing. Plastic button should be avoided; use of fusible interlinings that incorporate chemical like formaldehyde need to be skipped; biodegradable trims are preferred against synthetic trims; use of heavy metals like chrome, lead, nickel as zipper button are considered harmful for environment. Biodegradable PVC-free packaging which is 100% recyclable is preferred for packaging.
5. Effluent Treatment Plant (ETP) set up in the industries is on increase to comply with government legislation by treating the wastewater of dyeing and finishing mill to make it neutralized before discharging to surface.
6. Reducing, reusing and recycling should be done whenever possible in product supply chain. Reducing is a way of minimizing the consumption of limited resource and energy, reusing is the idea of using parts of used goods in manufacturing activities and recycling refers to the activities performed to recover raw materials from end products. Reducing means reduction of pollution as well as reduction of water and energy consumption, reduction of demand of dye and fixing agents. Today approximately 50% of all textiles collected are reused and 50% are recycled.

IV. Conclusion

Sustainability issues are of great importance to the textile and apparel industries. A sustainable fashion supply chain should follow the triple bottom line concept, which refers to the three pillars of People, Planet and Profit. It requires time to implement sustainable supply chain as it requires fundamental change in the ways company design, procure, manufacture, distribute, dispose and recycle their products. Leap into this involves sincere consideration of ecological dimension of entire production and supply chain process including packaging, eco labeling and recycling at the end of the products life cycle. A commitment to go green is necessary by all stakeholders, not alone by the industry but also by the financiers, suppliers, business clients, consumers, NGO, unions and media; specifically government and sector associations have significant role to play here.

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