

## **The story of textile waste- Reasons and solutions**

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### **ABSTRACT**

Alarming bell is being rung by nature again and again to become serious about saving natural resources. Textile waste is generated in abundance and has various adverse effects which need to be recycled or up-cycled like other harmful toxic, nontoxic, liquid or solid waste. Since a very long time various textile recycling and up-cycling activities were performed at craft sector or household levels. Purpose of those recycling and up-cycling was lack of resources by poor class but Contemporary Recycling and up-cycling techniques has emerged with new motive to overcome the adverse effects of excess use of resources. The new inventions in recycling and up-cycling techniques by designers, researchers and industries are very interesting and give opportunities to work in various creative and experimenting directions. This paper is all about textile wastes, reasons of textile waste generation, various recycling and up-cycling techniques and their benefits.

**Key Words :** Textile waste, Pre-consumer, Post-consumer, Recycling, Up-cycling

### **INTRODUCTION**

The textile industry is considered one of the most complex and polluting industries. This is complicated because it involves a very long and variegated production of raw materials, textile manufacturing, garment making, distribution and disposal. It is polluting because not only production but also consumption produces a lot of waste. Textile manufacturing processes also uses an extravagant amount of natural resources used in extraction, agriculture, harvesting, processing, manufacturing and shipping. For an efficient management of the textile and its waste, it is necessary to consider all the stages of the manufacture of the textiles from fiber to fashion fashionable fiber. There is immense need for recycling and up-cycling of textile waste to stop its adverse effects on nature and its creatures.

Some facts about textile wastes trigger researchers and industries to think seriously in the direction of management of textile wastes

- Clothes are the second largest source of pollution after oil. This industry is responsible for 10% of global carbon emission and becomes world's fifth biggest emitter of carbon dioxide.
- Textile industry is one of the top 3 water wasting industries and pollutes fresh water resources badly. Approx 8500 litres and 2600 litres of water are required to produce a pair of jeans and one single t-shirt, respectively.
- Various operations of textile industry consume approx a quarter of total chemicals produced

worldwide.

- In 2013, the global consumption of fibres and yarns increased to 90.1 million tons from a record of 82 million tons in 2011. To produce fibers in 2011, it required 145 million tons of coal and a couple trillion gallons of water (Leonas, 2017).

- It is estimated that 150 billion garments are produced annually which are enough to provide 20 new garments to every individual in a year. In between 1999 and 2009 the generated post consumer waste has grown by 40% while the recycling rate has grown by 4% only.

- Average lifetime of a piece of clothing is about 3 years and more than 1 million tonnes of textiles are thrown away every year, with most of this coming from household sources. Textiles make up about 3% by weight of a household bin.

- The textile recycling industry is able to process 93% of the waste without the production of any new hazardous waste or harmful by-products (Hawley, 2006).

- Now in these days approx 80- 90% of textile wastes are non biodegradable as it consist of polyester having PET (Poly Ethylene Terephthalate) polymer similar to plastic bottles. Natural fibres are biodegradable and will eventually break down, but synthetics are quite resistant and are not so easily disposed of (Tortora *et al.*, 1997).

- Textiles in landfill biodegrade to form methane gas which is released into the air and is not suitable for human consumption, which is one of the most effects, that recycling is addressing by diverting textile from landfill (Roznev *et al.*). Since most of these are non-biodegradable, they clog out drainage and water ways. If thrown into incinerators, they cause pollution and cause more damage to the air around us (Vishnoi, 2013)

- Cotton is the world's most commonly used natural fiber and is in nearly 40 per cent of our clothing. Worldwide, cotton uses about 3% of farmland, 10% of agricultural chemicals and 25% of world's pesticides (Chen and Burns, 2006). In addition, cotton requires large amounts of water for growth. It is estimated that on average 10000 liters of water are necessary to grow 1 kg of cotton. (Farrant, 2008) The WHO report points out, that every year 20,000 farmers die because of insecticides and their harmful effects. Cotton being a very fertilizer dependant crop, has an undisclosed fact: that 65% of the chemicals used during cultivation enter both directly and indirectly into our food chain, which is highly agonizing (Aishwariya, *et al.*)

- Organic cotton is a much more sustainable alternative, but today it is only about one per cent of all the cotton grown worldwide and quite expensive to grow compared to conventional cotton, approx 5,000 gallons of water is required to manufacture just a T-shirt and a pair of jeans. Organic cotton still needs large amounts of water, and the clothing made from it may still be dyed with chemicals and shipped globally, meaning that there's still a big carbon footprint with cotton garments carrying the "organic" tag.

- Water level of two rivers in Central Asia *i.e.* the Amu Darya and Syr Darya, of Uzbekistan has reduced to 10 % what they were 50 years ago. Pakistan's Indus River, Australia's Murray-Darling Basin and the Rio Grande in the U.S. and Mexico have also been affected badly because of cotton agriculture.

- Polyester and Nylon are not biodegradable, made from petrochemicals and manufacturing of both uses great amounts of energy so they are unsustainable by their very nature. Polyester accounts for 65 per cent of the textiles produced each year. Its production required 70 million barrels of crude oil every year and once sent to landfill will take an estimated 500 years to biodegrade. (Styles, 2014). Nylon also emits a large amount of nitrous oxide, a greenhouse gas, during manufacturing. The impact of one pound of nitrous oxide on global warming is almost 300 times

that of the same amount of carbon dioxide, the most ubiquitous greenhouse gas.

- More than a half trillion gallons of fresh water are used in the dyeing of textiles each year. The dye wastewater is discharged, often untreated, into nearby rivers, where it reaches the sea, eventually spreading around the globe. Clothing manufacturers dumped their chemicals into the river, making them open sewer containing with lead, mercury, arsenic, nonylphenol and lots of other toxins. Water becomes highly alkaline which can badly affect the health of locals and aquatic life. The Citarum River of Indonesia is considered one of the most polluted rivers in the world due in great part to the hundreds of textile factories lining its shores.

- Release of chemicals in waste water during the manufacturing processes. During the use stage, the discharge to wastewater of phosphates contained in washing powders and liquids promotes excessive growth of green algae which can harm some water-based organisms (Farrant, 2008) Some chemicals still remains in our clothes after they are produced, and only come out after a few washes.

- New technologies, such as waterless dye technologies have been developed, but have not yet been deployed at most manufacturing sites. The textile industry, which has been using copious amounts of water to dye garments for hundreds of years, may be reluctant to embrace this change. After all, this new technology is expensive to install and only works on certain fabrics.

- More than 60 per cent of world clothing is manufactured in developing countries. Asia is the major clothing exporter today, producing more than 32 per cent of the world's supply. Raw materials and manufactured articles are put in shipping containers and eventually rail and trucks for the global supply. Worldwide, but 22 billion new clothing items are bought by Americans per year, with only 2 per cent of those clothes being domestically manufactured. In total, some 90 per cent of garments are transported by container ship each year. These ships do not consume fuel by the gallon, but by tons per hour. Pollution by the shipping industry, which has boomed over the past 20 years, is beginning to affect the health of those living in coastal and inland regions around the world.

Waste is generated at every stage of production of textile from fiber to fashion. 5 R's of textile waste management are very important tools to overcome the problem of textile waste by conserve natural resources, landfill spaces and energy. These are: rethink, reduce, reuse, recycle and reintroduce.

### **Rethink:**

Thought of environment friendless should be of prime concern. It's the first and most effective component of waste management. Whether it is production, manufacturing, buying and after use of textiles, one should take wise decisions.

### **Reduce:**

It means to minimize the burden on environment by limited use of natural resources. Consumer should buy the materials which are of high strength and durability so that less waste is generated. Manufacturing methods that require fewer resources and generate less waste can be adopted.

### **Reuse/ up-cycle:**

The textile materials instead of being wasted should be reused again. Reuse means; use the textile material without any reprocessing for example use of discarded clothes as second hand clothes. Up-cycling is reusing waste without destroying it in order to form something new. Up-cycling is more energy efficient then recycling. According to (Farrant, 2008), "Reusing helps in

reducing the use of new resources. It lengthens product life, delays the time when the products enter the municipal solid waste stream, prolongs the life of available waste management facilities and helps to avoid the cost of recycling.”

**Recycle:**

Recycling means to reprocess the used items into raw materials which are further used to make new items thus, recycling refers to the processing back to fibers to make new products. Recycling takes waste products, breaks them down, and then forms them into something new. For example reclaimed fibers are made from scraps of fabrics collected from clothing factories, which are processed back into short fibers for spinning into a new yarn.

Waste of potentially useful materials can be converted into new products which reduces consumption of fresh raw material, reduce energy usage, reduce air pollution (from incineration) and water pollution (from land filling). (Farrant, 2008). According to (Sule, 2001), Recycling can be describes as obtaining wealth from waste. This is a strategy now adopted widely (Sule, 2001).

**Reintroduce:**

The recycled products should be reintroduced with full respect and potential market. They can be launched as new brand which is based on recycled products. They are given equal place like virgin materials in the market by the consumers.

**Classification of textile waste :**

Textile waste is mainly classified as pre-consumer and post-consumer waste. Other classification of waste can be done as manufacturing and recovered/ reclaimed waste, soft and hard waste, wool and non wool waste and clean and dirty waste etc.

***Pre-consumer waste:***

It is also called manufacturing waste, clean waste and post-industrial waste. Pre consumer wastes are generated throughout the first stages of the supply chain. This type of waste can be generated at any point of the production line, from spinning to weaving to cut-make-sew operations. It includes comber noils (short fibers of cotton or wool separated from the long fibers in combing),



**Fig. 1 :** Silk selvage waste collected in Mantero’s mill in Italy. Courtesy of Mantero(Source: <https://www.cooperhewitt.org/2016/11/15/textile-waste/>)

yarn waste, garment cutting excess, trimmings, print trials, errors in dye lots, production surplus and end of rolls. According to Beitch, 2015 ” on average, about 15 % of fabric used in garment production is cut, discarded, and wasted in the process, which con-tributes to post-industrial waste” (Beitch, 2015). Firms either arranges their own waste disposal services or use council managed services and pay landfill fees according to how much is dumped. (Chavan, 2014). Each year 750,000 tons of this waste is recycled into raw materials for the automotive, furniture, mattress, coarse yarn, home furnishings, paper and other industries. Approximately 75 per cent of the pre-consumer textile waste is recycled. (Wang *et al.*, 2003).

***Post-consumer textile waste:***

It’s also called house hold waste and dirty waste. It consists of any type of garments or household article, made of some manufactured textile that the owner no longer needs and decides to discard. These articles are discarded either because they are worn out, damaged, outgrown, or have gone out of fashion. They are sometimes given to charities but more typically are disposed of into the trash and end up in municipal landfills. Approximately 1,250,000 tons of post-consumer textile waste (4.5 kg per capita) is recycled annually. However, the recycled amount represents less than 25 per cent of the total post-consumer textile waste that is generated. Almost half (48 %) of the recovered post-consumer textile waste is recycled as secondhand clothing, which is typically sold to third-world nations. Approximately 20 per cent of the material processed becomes wiping and polishing cloths. Finally, 26 per cent of this post-consumer waste is converted into fiber to be used in products similar in nature to those manufactured from pre-consumer textile waste (Wang. *et al.*, 2003). Nylon can also be recycled and large source of post-consumer nylon waste in the form of fishing nets left in the ocean. (Leonas, 2017)

***Soft and hard waste:***

Waste from carding, combing, drawing and spinning are called soft waste while wastes produced after spinning and twisting and in the process of weaving and knitting is called hard waste.

**Causes of textile waste generation :**

***Industrialization:***

Perspective of age old days: population was less, needs were few and resources were abundant. The generation of waste was such that it got naturally recycled, being mostly biodegradable. Conversely, after the advent of industrial revolution, different types of wastes came into existence which are often both non-biodegradable and highly hazardous (Vishnoi, 2013). After synthetic fibers came onto the market in the 20th century, there is boom in textile industry in terms of production and supply of textiles of all kinds of garments. Now different quality of textile is available in abundance to target different consumer groups which leads to more pre consumer and post consumer textile waste.

***Contemporary lifestyle:***

Our lifestyle is totally influenced by western civilizations. Western lifestyle is a significant contributor to landfill waste. Not only products are consumed at a high level, but also western goods are often over-packaged, contributing even more to the waste stream (Hawley, 2006). Now this ever changing fast fashion has also very deep roots in developing nations like India, which has drastically changed the buying behavior of upper middle classes and middle classes. This change in

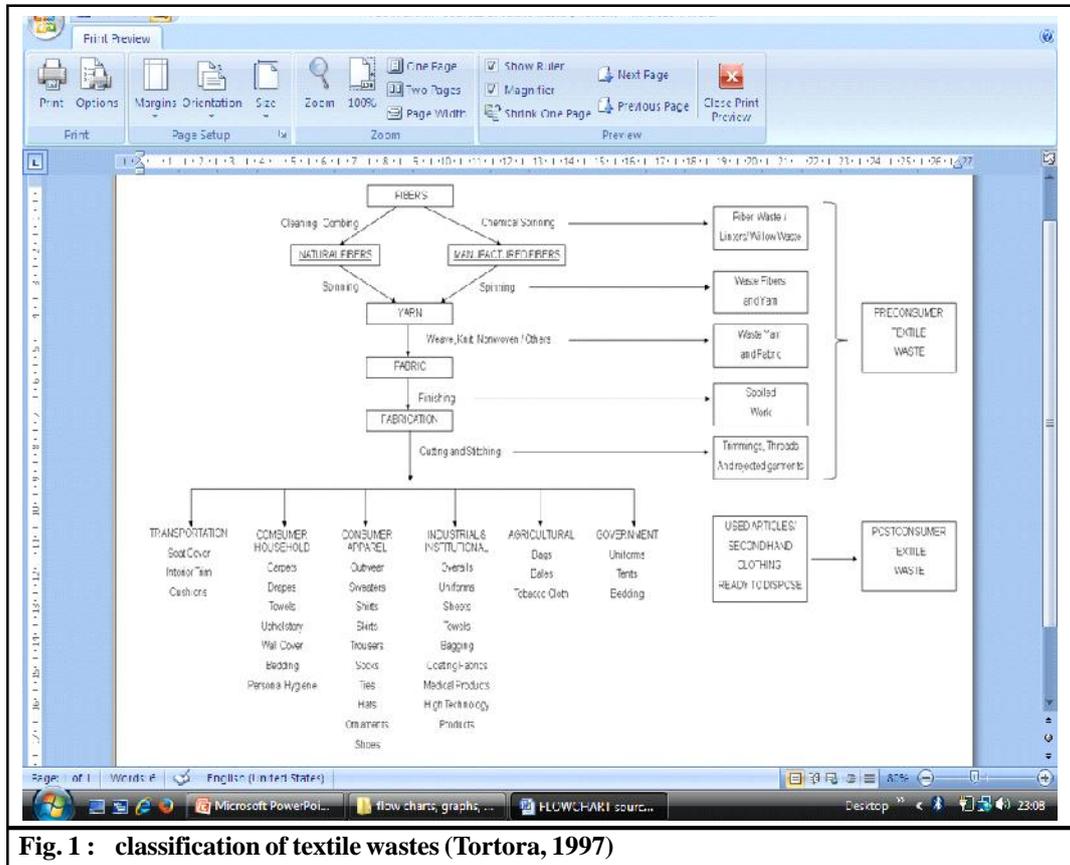


Fig. 1 : classification of textile wastes (Tortora, 1997)

mentality is good for the growth of fashion business but has adverse effect on environment and through certain extent on their respective cultures.

**Rapid change in fashion :**

Fashion fuels the momentum for change, which creates demand for ongoing replacement of products with something that is new and fresh. (Hawley, 2006). According to Birtwistle and Moore (2007), a trend of ‘throwaway’ fashion attitudes is growing among consumers, especially young fashion leaders. The short fashion life cycle and low price have contributed to the growth of unwanted clothing items. (Joung *et al.*, 2013). As clothes are getting cheaper and go out of fashion quicker, more and more garments are purchased. Consequently, the world demand for textile fibers from which clothes are made keeps increasing reveals that the demand for manmade fibers has nearly doubled in the last 15 years while the demand for natural fibers has remained approximately constant (Farrant, 2008).

**Change in life style:**

In last 10 years culture of fast fashion has tremendously changes the purchasing power of consumers which has led the problem of over consumption. Globalization after removal of quota system in (2005) allows not pay very much for clothes. According to Linda Welters “If people buy at a deeply reduced priced, they have a throwaway mentality about clothes. Shopping

has become a way of life, a weekly pastime, and for many an addiction. Shopping malls, glossy fashion magazines, catalogs, Internet ads, Lucrative brand promotion offers, Easy and click of a button e-commerce sites provides entertaining opportunities to spend more money on fashion. This fast fashion trend promotes very quick movement of designs from catwalk to store. This fast fashion culture these is cheap and bulk buying mentality which ultimately churns out massive amount of cloths, accelerating carbon emissions and global warming. Swedish giant H&M is the current largest clothing retailer in the world at \$20.2 billion in sales (as of January 2015) followed by Zara, another fast fashion specialist.

***Easy and cheap availability of textiles:***

Despite rising cost pressures for manufacturers and importers, retail prices for apparel have fallen due to the availability of cheap clothes from low-wage countries. Further, globally oriented ‘fast fashion’ suppliers (e.g. H&M, Zara, Top Shop, etc.) have offered low-priced clothing with a short life cycle for young US consumers. The majority of consumers perceive the lifetime of clothing to be shorter than ever before. (Joung *et al.*, 2013). For clothing only, the expenditure represented 4.9%, compared to 5.5% in 1995. While the total budget spent on clothing has been decreasing during the last ten years, the number of items purchased has increased tremendously, mainly due to price drop. It has been calculated that in the UK “over the last ten years women have doubled the average number of women’s wear items they buy in a year”. The same article also states that “since 1995, according to the office for National Statistics, the price of women’s clothing has fallen by 34%”. At present in the UK, about 17 kg of clothes (35 kg of textiles) are purchased per capita per year. This trend is supporting the development of a throwaway society with associated environmental costs (Farrant, 2008).

***Lake of consumer awareness about environment friendliness:***

In the life cycle of any textile product, consumer disposal behavior and there awareness about environment plays a significant role in reducing the waste. At the end-of-life, instead of sending to landfill, if consumers opt more to reuse the product till its end of life and then forward the product to recycling rather than landfill will certainly reduce the textile waste to an appreciable level. (Muthu *et al.*, 2012) But insufficient recovery of textile waste is the biggest obstacle to textile recycling. It is critical to promote appropriate textile disposal practices to meet the goals of recovering textile waste in order to reduce the environmental impact of textile waste (Joung *et al.*, 2013).

***No strict government policies :***

So recycling has become one of the popular thrust areas for the research. Specially developed countries are vigorously working in this direction to make stream line flow of waste, proper disposal of waste, consumer awareness, strict norms and high charges to end up in landfills but developing countries like India where environment legislation is very stringent but poorly enforced. The policies are good enough however, these policies are poorly enforced. Trading of second hand cloth is not properly. According to Lucy “trading of SHC in India is neither freely not fairly” (Norris, 2015). Therefore government’s initiatives and strict policies for trading of SHC, disposal of waste and awareness camps can be of great help to save environment.

***Lack of classic designs:***

Defining characteristic of today’s textile and clothing industry. Its combination of high speed,

large volume and low-cost production puts pressure on working conditions, design component and environmental standards (Fletcher, 2008). Design for durability, on the other hand, is often seen as a sustainable approach, an antidote to fashion change. Before the industrial revolution and the mass production of ready to wear clothing, clothes were individually tailored according to the user's wishes, thus having a high user involvement in the design process. Today, the mass producing clothing companies usually have confidence in their own internal knowledge and competence, and seldom involve regular users in the product development and design process. The fashion information is often received from trend forecasting companies, fashion shows and media. Sizing and fitting of clothing is tested on fit models and graded to the other sizes, and not necessarily tested on other bodies before production, thus causing problems with poor fit, especially in larger size groups. (Laitala, 2010) Longevity of clothing is that it should full fill functional (physical durability, wearing comfort and ease of maintenance), expressive and aesthetic (as per social setting) consumer needs. If these values are addressed correctly in the design, the clothes often remain useful for longer time and even resist fashion and change over time.

***Low popularity of second hand clothing:***

Second hand clothing is generally considered for low economy countries and low income groups. It is not appreciated as a good substitute of virgin clothes who have direct impact on environment. On the other hand Second hand clothing markets and shops are not widely spread and people are not much aware about them so they are not easily available to huge masses.

***Lack of consumer's textile care knowledge:***

It is clearly mentioned that most of the pollution occur at the use phase of the garment in washing by using water and other chemicals like detergents, bleaches etc. so consumers' motivation for proper clothing maintenance, effects of maintenance on the environment and to the clothing, technical material quality, the expected lifespan of clothing items, and the real use of clothing related to laboratory based test results are very important and should be mentioned clearly. Proper eco labeling is compulsory in higher quality products but low quality domestic productions are freely traded without any eco labels. Especially in countries like India people are least bothered about the maintenance of clothes according to their labels. They have set traditional patterns of washing clothes which degrades actual life of clothes and spread water pollution.

***Lack of systematic pipeline of textile recycling:***

Textile recycling practices are given lot of importance at research level for their present need and future requirements. But people are not much aware and concern about textile recycling and use of recycled product. Especially in country like India there is no strict government policy to control textile waste and to regulate textile recycling practices. That is why textile recycling, up cycling and reverse logistics pictures are not so clear. Pre-consumer wastes are comparatively easy to collect but there end users should be classified properly and it's the one of the thrust area for research, while post consumer waste and its recycling activities has their own associated environmental impacts related to collection, sorting and transportation (Farrant, 2008).

***Up-cycling and recycling of textile waste :***

The wastes of textile are very interesting and varied in terms of its type, quality, shape, size color and form. Almost 100% usable textile waste can be converted into various innovative and

functional products either by up-cycling or recycling techniques.

**Up-cycling** or reuse refers to an existing product being used again within the same production chain. For centuries, end products were repurposed or refurbished after they have reached the end of the use in one product. There are a variety of methods in which reuse occurs. The used product can be disassembled and then reassembled into a new, and possibly different, product. Reuse and up-cycling process requires considerable amount of creativity and vision. The developed up-cycled product is a kind of handmade and sustainable product. For example up-cycling includes weaving a Durri (carpet) using the strips of Sarees.

**Recycling** refers to the breakdown of product into its raw materials to create new products. Textile recycling may involve reclaiming pre consumer waste or post consumer waste. For centuries, textile products (apparel and fabrics) were broken down to the yarn stage and the yarn was used to produce different knitted or woven fabrics. In some cases, the yarns are further broken down to the Fiber stage and then the fibers were re-spun into yarns to be used in new textile products. Stages of textile waste recycling are as follows:

- Primary recycling: to recycle a product to its original form. It is the original recycling process, which is the most beneficial and intended for man-made fibers such as polyester.
- Secondary recycling: to convert the waste into a new product, probably with a lower level of physical, mechanical, and/or chemical properties and the recycled product may not have the same application as original product. Secondary recycling is intended for waste textiles, which will be converted to some other purposes such as wipers for industrial use, involves lots of processes such as cutting, shredding, carding, etc.
- Tertiary recycling: It includes Pyrolysis, gasification, and hydrolysis processes which convert the waste into basic chemicals or fuels for example conversion of plastic waste into its original chemicals.
- Quaternary recycling: it refers to burning the fibrous solid wastes and utilizing the generated heat (Muthu *et al.*, 2012)

**Table 1 : Differences between recycling and up-cycling**

Sr. No.	Recycling	Upcycling
1.	Recycling refers to the breakdown of product into its raw materials to create new products	Up-cycling or reuse refers to an existing product being used again within the same production chain.
2.	Textile recycling may involve reclaiming of pre and post consumer textile waste into reclaimed fibbers	Textile up-cycling may involve disassembling and then reassembling of textile waste into a new, and possibly different, product.
3.	High technical understanding is required	No technical understanding is required.
4.	Performed at industrial level	It can be performed at both household and industrial level
5.	Recycling is a very technical work.	Up cycling is a very creative work
6.	This process required more energy	It is comparatively energy efficient process.
7.	Recycling processes requires machinery setup so it's not a cost effective process.	Up-cycling is a cost effective process
8.	Recycling is less sustainable process as compare to up-cycling.	Up- cycling is a more sustainable process

**Textile waste reuse/Up-cycling processes :**

Both pre and post consumer textile waste can be reused using number of techniques and

artistic brain. There are many house hold and craft based examples where excellent use of textile waste is done to create magnificent products. There are many examples in history where nonwoven, braiding, weaving, knitting, quilting, patchwork, puppets etc. techniques were used at both household and craft sectors to create useful and decorative products.

***Textile waste reuse/up-cycling processes at house hold level:***

The up- cycling of textile waste for household products is a part of day to day life in many communities. These practices are lasting since long and generally considered as low standard and substitute to overcome financial crises.

- Useless, outgrown or no longer in style apparel was remade to fit someone else or redesign to create more stylish garment.
- No longer useful products as their original products are used for various other purposes like use of old cloth for new born child as they are comparatively soft, free from surface finishes, easily available and low in cost. Soft cotton clothes and sarees are commonly used as very good substitute of sanitary napkins as these are more hygienic and cheaper. Use of old clothes for dusting and moping in household activities, Use of fabric scraps for stuffing soft toys, pillow and mattresses, use of old precious silk sarees in making of cushions, curtains, bedcovers and other household items (Jain *et al.*, 2016).
- Passing precious traditional textile pieces generation to generation as memento are some of the very common practices still continue in India and many parts of world.
- The historic Buddha robe known as ‘Kasaya’ is said to made of patched pieces of donated cloth throughout his life. Lord Buddha is depicted in painting and sculpture with such a robe draped over his body.
- Japanese Boro textile which was made after mending and repairing of indigo dyes cotton cloth scraps by the poor communities to form kimono, sleeping futone covers etc. these patched articles were passed generation to generation for further patching. These hand crafted Boro textile were embellished with the help of Sashiko stitch (running stitch).
- Appliqué quilts or patched quilts embellished with various unique embroideries by Americans are an excellent example of up-cycling waste fabric scraps.
- Examples of repurposing are frequently seen in pop culture including a scene from *Gone with the Wind*, where Mamie removed the green velvet drapes and repurposes them into a gown for Scarlett O’Hara (Mitchell, 1936, Leonas, 2017).

***Textile waste reuse/up-cycling practices at crafts sector:***

Apart from various household activities there are some up-cycling based crafts as well who probably immersed either to show creative expression or as a good and cheap substitute of raw materials. These recycling based crafts are mainly female dominated activities and later became source of livelihood for their communities or tribes.

- Kantha work of Bengal can be considered as one of the oldest textile recycling practices in craft sector where excellent use of old muslin sarees is done as the base material to engrave beautiful hand embroidery using running stitch.
- According to Bairagi, 2014, the nomadic Bakkarwal and Gujjar tribes of Jammu and Kashmir and Rajasthan use various recycling based textile craft which is a part of their tradition, culture and to preserve the old textiles. Tribes belong to Jammu and Kashmir converts the old woollen felt blankets into handmade rugs by doing handmade needle work embroidery using acrylic yarns.

Similarly tribe belongs to Rajasthan do patch work, embroidery and mirror work to enhance the beauty of their textile products. Lot of accessories like cap, bags, wall hangings, mojaris (footwear), cushions etc. are also created by recycled textiles (Bairagi, 2014).

- Chindi durries of Haryana, where Durrly weaving on pit looms is a very common practice at every next door of rural areas. Strips of old sarees, shawls, dupatta and other garments are used as raw material for rough weaving.

- Traditional, square Korean Bojagi (wrapping cloth), made from textile scraps and patchwork is known as “Chogak bo”. These cloths were created from small segments (“Chogak”) of leftover fabrics. Both regular’ and irregular’ patterns are sewn randomly to create Chogak bo.

- Various African tribes are famous for creating beautiful handcrafted jewellery using various kinds of textile wastes and trims in their own unique way.

### **Textile waste recycling process :**

#### ***Mechanical recycling:***

For products of single fiber content fabrics, mechanical recycling is generally used to reclaim the fibers, yarns and the fabrics. The discarded textile is opened up, apparel is disassembled, and fabrics are cut into smaller pieces. It is then passed through a rotating drum to continue the breakdown and fibers are obtained. This process is known as garneting. The resulting fiber characteristics of length, fineness, strength, polymer, and color determine the quality and what the most appropriate new end product would be. Typically, waste collected from the manufacturing supply chain will produce higher quality recycled fibers that those collected from post-consumer wastes. Height quality yarns are used in apparel, sheeting, and upholstery. Lower-quality fibers are used as reinforcement in other structures (*i.e.*, concrete), nonwoven fabrics, carpet underlays, shoe inlays, automotive sound and thermal insulation, home insulation, stuffing for toys, and other end products.

- The recycling of wool is hundreds of years old. After apparel (*i.e.*, wool sweaters) had been worn threadbare, it was collected and shredded into individual fibbers and then converted into blankets.

- Shoddy industry of Panipat which is also known as global textile recycling capital is perhaps one of the most effective, successful and comparatively oldest industrial textile recycling practices in India, which recycle approx 1,44,000 tonnes of SHC (Second Hand Clothing) discarded by many developed nations every year. Bulk amount of textile wastes especially SHC (Second Hand Clothing) is used as raw material to create low quality products like blankets, shawls, carpets etc. Approx 3 tonnes of fabric produce 1.5 tonnes of shoddy yarns. The garments are sorted and then the entire garment is opened and broken up into fibrous mass on garneting machines. These fibres are then dyed, carbonized and converted into woollen spun yarns from which blankets are made. According to an article published by Ravasio, 2013, some 22,028 tonnes of used clothing were imported in 2006/7. This number grew to 37,000 tonnes in 2007/8 and then nearly 6 times that (218,698 tonnes) in 2008/9 for shoddy production. But in last few years this world famous recycling industry is at decline and losing its identity, profit and charm due to its tough battle with polyester blanket which are cheaper, warmer and light in weight and many other problems like economic slowdown and limited product range of shoddy yarns. According to an article published by Rebello, 2015 there were around 600 to 700 shoddy yarn and textile manufacturers in Panipat up until 2012; now there are barely 150 units. The production value has decreased drastically from Rs. 35 crores to 90 crores a month Import of SHC containers have also reduced from 800 containers/month to 300

containers/ month.

### ***Chemical recycling:***

It is a type of recycling process which is mainly used for recycling of synthetic fibers and blends. Synthetic fibers including polyesters, polyamides, and polyolefins can be recycled chemically. Chemical recycling falls under the tertiary class of recycling which requires the breaking down of the synthetic fibers for re-polymerization. Blends are in particular challenging to recycle due to the disparate physical and chemical properties of the fibers in the waste. The chemical recycling procedures require more energy consumption and there is high capital investment so this option is only practical for large-scale manufacturers.

- PET plastic water bottles, used polyester apparel, fabric scraps, yarns waste, or other plastics, are broken into small pieces from which chips are produced. The chips are decomposed to form dimethyl terephthalate, which is then repolymerized and spun into new polyester fibers, filaments, and yarns.

- Cotton and polyester blends are one of the most commonly used apparel and home textile items. Chemical recycling has proven successful when used with blended materials as it uses a selective degradation method. In products of cotton and polyester, the fibers can be chemically separated and then reformed into new fibers. Currently, there is a process being developed using *n*-methylmorpholine-*N*-Oxide, which dissolves cellulose. The dissolved cellulose and polyester are separated by filtration and the captured polyester is re-spun into a fiber, filament, or yarn. The dissolved cellulose can be used in the production of regenerated cellulosic fibers including Lyocell (McGregor, 2015b; Zamani, 2011).

- Nylon and spandex is a blend commonly found in high-performance sportswear and active wear. Generally, the percentage of nylon is much greater than that of spandex and nylon can be recycled and reused. It is known that spandex can be removed from blended fabrics by dissolving it in solvents such as *N*-dimethylformamide. However, this solvent is expensive and there are environmental concerns with its use. There has been success by first treating the blended fabric with heat to degrade the spandex, and then exposing the fabric to a washing process using ethanol, which effectively removes the spandex residue leaving only the nylon (Yin *et al.*, 2013)

According to Leonas (2017) Unifi, Tenjin, Aquafil, Martex fiber, Evrnu, Ecoalf, Timberland, Nike, Speedo, Adidas, Hanes, H&M, The North Face, Patagonia, Cone Denim, Levi Strauss and co are some of the brands who are utilizing recycled content in their products.

### **Benefits of textile waste management :**

Benefits of textile waste management are infinite which can't be listed properly and some of them are as follows:

#### ***Help to reduce environment burden :***

Textile waste management helps directly or indirectly to environment by reducing pesticides used in cotton farming, the toxic dyes used in manufacturing and the extravagant amount of natural resources used in extraction, farming, harvesting, processing, manufacturing and shipping etc. For example every kilogram of virgin cotton displaced by second hand clothing approximately 65 kWh is saved, and for every kilogram of polyester around 90 kWh is saved. Therefore, the reuse and recycling of the donated clothing results in a reduction in the environmental burden compared to purchasing new clothing made from virgin materials (Woolridge *et al.*, 2006).

***Helps to raise economy of country:***

Textile recycling is a fascinating story. In some parts of the world it is part of an underground economy. So in many cases it is not even accounted for in national economy figures. Trade laws prohibit the free flow of used textiles between some nations, crying infestation and negative impacts on fledgling industries as reasons for banning the trade. But no doubt, textile recycling has positive impact on many entities (Hawley, 2006). Recycling contributes to the improvement of economic condition of family and nation at large. In India survival of Wagdi community is totally dependent on collection and further trading of SHC (second hand clothing).

***Provides clothes for the poor and disaster relief:***

Donations provide clothes for people unable to purchase their own. SHC collected from developed nations by charity organizations are exported to underdeveloped countries. These clothes are available on very reasonable prices to improve their living conditions. Recycled shoddy blankets are widely used for disaster relief because of their cheap and bulk production.

***Reduces the amount of pesticides and chemicals in garment production:***

Recycling and up-cycling techniques help to reduce the amount of pesticides used in cotton farming and excess use of chemicals in every stage of production from fiber to fashion.

***Reduces energy consumption:***

The reuse of 1 tone of polyester garments only uses 1.8% of the energy required for the manufacture of these goods from virgin materials and the reuse of 1 tons of cotton clothing only uses 2.6% of the energy required to manufacture them from virgin materials.

***Help to save natural resources:***

According to (Chavan, 2014), if 75% textile waste diversion is done then 4.2 trillion gallons of water would be saved. That's enough to supply 27.8 million homes. 17 million tons of CO<sub>2</sub> would be saved. That's equivalent to taking 3.5 million cars off the roads, 7.5 million cubic yards of landfill space will be saved. That could fill the Empire State building 5.8 times.

***Reduces pressure on virgin materials:***

Logic suggests that by recovering textiles, the demand for virgin resources is reduced. Material washing and energy consumption still occur in the recycling processes, but they are considerably less resource intensive and polluting than the processes involved in manufacturing textiles from virgin fiber (Vishnoi, 2013)

***Reduces pollutant emissions:***

For every pound reused or recycled, textiles account for more greenhouse gas savings than paper, plastics and glass combined (Chavan, 2014)

***Enhance the creative ability:***

New concept and upcoming trend from sustainability and environmentalism has given a new thought and new meaning to fashion industry to find fashion in thing which are sustainable. There are designers, industries, policy makers, researchers and various organizations who are thinking creatively to sustain in their own unique ways so that new products, policies can be developed

which will go hand in hand with the environmentalism.

***Contribute to generate business:***

Recycling and up-cycling provides multipronged opportunities to generate various businesses at craft level, industrial level and household level. Companies can realize larger profits because they avoid charges associated with Reducing the cost of purchase material, Increasing profitability, Minimizing Solid Waste treatment and disposal costs, generating an alternative income stream if there is a market for recycled fiber and improving waste quality and reducing treatment costs.

According to the Secondary Materials and Recycled Textiles Association (SMART) and the Council for Textile Recycling more than one thousand businesses and organizations employing many tens of thousands of workers divert some 2 million tons of textile waste from the solid waste stream (Wang *et al.*, 2003).

***Helps to create job:***

Recycling and up-cycling is an integrated process that begins with recyclable material collection from locations such as households, drop-off points, construction and demolition centers and businesses. After collection, these recyclable materials go through a thorough sorting process to separate various materials as well as different quality goods. Recycling businesses need varying degrees of skilled and semi-skilled employees to perform jobs. Many recycling companies and associations play a significant role in building social awareness by providing recycling training services. According to ISRI, the U.S. scrap industry generated over 150,000 direct jobs and 323,000 indirect jobs in 2015.

***Contribute to connect nation:***

Waste management is not beneficial for a single person or nation. The whole world is concerned about the waste and its side effect on ecosystem. Collectively efforts are being made to solve the problem. This helps to connect the nations. Textile recycling business is both a small and grand phenomenon. Many of the rag dealers are small, family owned businesses that work independently; yet they are tightly knit to a global network that move used clothing around the world through brokers and long-time associations that have taken generations to establish (Hawley, 2006). In other words the SHC of developed nations are mostly consumed by developing or underdeveloped nations. It's a two way benefit for both the sender and consumer in different way.

***Contribute to goodwill association:***

All the sustainable efforts contribute to goodwill associated with environmentalism to organizations, companies and nations.

***Contribute to the social responsibility:***

When materials are recycled or up-cycled there is an environmental benefit as a result of avoiding the environmental burden associated with the manufacture of new products and the disposal of wastes. Environmental credits can be awarded when it can be shown that environmental burden can be prevented (Woolridge *et al.*, 2006).

***Contribute to social progress:***

The multi-billion dollar worldwide recycling industry performs a vital social and environmental

function. The industry has no peer in terms of conserving the world's resources which leads social progress (Vishnoi, 2013).

### **Conclusion :**

Imprudent use of resources has created a problem of waste which needs to be managed and solved as early as possible. Textile waste is a kind of solid waste which generates waste as it starts to take its first form as fiber till its end use which land up in the form of post consumer textile waste. There are various R's of textile waste management which seems to be very powerful tool to overcome the problem of textile waste. Recycling and up-cycling of textile waste are prevalent since long time at household level, craft sector and at industrial level throughout the world. There are various reasons of textile waste generations and infinite benefits of textile waste management which are motivating to work more and more in this direction.

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