Prevention of waste from textile in Sweden

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Abstract

With the population growing gradually and economy booming in the world, the need of textile product accordingly increases rapidly, which results in the big generation of textile waste. The disposal of textile waste brings in many adverse effects on environment, such as the landfill occupation. The production of textile product itself also causes much environmental concerning. In order to cope with the increasing textile waste and reduce the pressure of waste management, waste prevention is primary, as well as effective choice. The prevention of waste from textile can return ideal revenue from economic, social and environmental aspects. So many countries have conducted some researches and practices on the prevention of waste from textile. Sweden also has some existed prevention measures. But these prevention measures mainly focus on two stakeholders: consumer and charitable organization.

Associated with the practical situation in Sweden, some existed prevention measures are transferred to the Swedish circumstance and then suggest a new prevention scheme about textile waste in Sweden. The suggested prevention scheme is based on four stakeholders’ (designer, retailer, consumer, charitable organization) point of view.

Keywords: Waste prevention; Textile waste
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Abbreviations

**CRI**: China International Radio  
**WTO**: World Trade Organization  
**MSW**: Municipal Solid Waste  
**LBNL**: Lawrence Berkeley National Laboratory  
**US DOE**: United States Department of Energy  
**US EPA**: United States Environmental Protection Agency  
**UNIDO**: United Nations Industrial Development Organization  
**NIOS**: The National Institute of Open School  
**DEFRA**: Department for Environment, Food and Rural Affairs  
**MISTRA**: The Foundation for Strategic Environmental Research  
**SMED**: Swedish Environmental Emissions Data
1 Introduction

Everyone is familiar with textile, since it surrounds our daily life. The quilt, the toothbrush, the towel and your clothes are connected with textile. Except for the household life, the textile also appears in military field, such as the bullet-proof vest, the helmet. In the upholstery, the carpet on the floor is textile. In the hospital, the medical textile plays an important role. In the electronic field, textile also takes up some space, such as the electronic textile which is fabrics that have electronics and interconnections woven into them. In one word, beyond the apparel, textiles are used in miscellaneous products, sometimes hidden from your view, but mainly demanded in clothing, home furnish and industrial use.

When concerning the textile product, the environmental problem derived from material resource, process procedure, end-of-pipe disposal and increasing consumption of textile appears. In order to relieve the environmental problem from textile product and waste, the prevention of textile waste needs to be researched.

Even if the textile waste just takes up a small proportion in the total MSW, the amount is very big. In order to reduce the textile waste, some countries give high priority to waste prevention. As for the prevention of waste from textile, reuse is a common method. Actually the designer and consumer can contribute much to prevent the textile waste, while the practical situation makes the prevention of textile waste difficult, since the dominant element for the designer and consumer is apparel itself, not the environmental issue of the textile product, although they understand deeply the environmental concerning is very important for a product.

It needs to be declared firstly this report just focuses on the textile product, not the textile industry. For any product, the fundamental principle of waste prevention is almost the same, so this report doesn’t have an innovative scope to prevent the waste from textile. After reviewing and summarizing the former research about prevention of waste from textile, this report suggests a new prevention scheme based on the practical situation of textile waste in Sweden.

Clothing, manufactured from textile, is a very important part of our life both in function and for fashion. According to the study in European countries, clothing accounts for 3% of all expenditure on consumption products, which is on the similar level to health and communication products (Tukker & Jansen, 2006). Due to the paramount proportion in textile waste, waste from clothing is the dominant factor when suggesting a new prevention scheme.

1.1 Aims and objectives

There are some existed prevention measures about textile waste in Sweden, which mainly focused on reuse. But these prevention measures don’t involve all of the
stakeholders into it, which results in some limitations of textile waste prevention. The aim of this report is to review the prevention measures of waste from textile in the world, especially in Europe and then suggest a new prevention scheme in Sweden based on the existed prevention measures, simultaneously associated with the Swedish practical situation of textile waste. The new prevention scheme involves four stakeholders into it. The objectives to realize the aim are:

- Analyze the situation of textile product and textile waste
- Study the textile product from environmental aspect
- Review the existed prevention measure in the world and Sweden
- Suggest a new prevention scheme in Sweden

1.2 System boundary

For the review of exited prevention measures of textile waste, this report takes the whole world’s situation into consideration in order to obtain an overall understanding about textile waste prevention. When suggesting the new prevention scheme, this report just considers the Swedish circumstance. So the new prevention scheme just adapt to Swedish situation. If apply the new prevention scheme into other country, further research should be done.

2 Methodology

In order to get an overall perspective of the prevention of waste from textile, a literature study is conducted. Most of the literatures are scientific articles and institution reports, popular science articles online, published books, investigation report of the statistics authority and government.

For a further understanding of the textile waste and apparel consumption situation in Sweden, some young Swedish friends of mine are interviewed to understand their consumption behavior of apparel. To understand the market of secondhand textile product, an on-the-spot investigation is made in the secondhand store and curbside collection site. An email contact with David Palm from IVL (Swedish Environmental Research Institute), who has published the relevant report about textile waste management, is implemented to obtain some explicit textile waste datum and textile waste management methods.

3 Theory of waste prevention

By reviewing EU waste directive (European Commission, 2008), the waste hierarchy can be summarized into the following, see figure 1:
As figure 1 showed, waste prevention is the most preferable option for the waste management. As the first and also the most effective step of waste management system, waste prevention gets more and more attention recently due to the great defects of traditional pollution control, for example, as a kind of pollution control measure, the incineration of textile waste will result in the effluent of waste gas. Pollution control, as a kind of end-of-pipe treatment method, brings huge improvement for the environment quality. But it also brings in great side-effects when reducing pollutants, such as the secondary pollution problem, the extra investment for the treatment facility and so on. Totally, the pollution control is an inefficient way for waste management. Inversely, waste prevention has much more superiors than pollution control. For example, waste prevention can reduce the landfill use and material consumption. Although waste prevention can’t solve the entire waste emission problem, it offers a cost-effective ways to minimize the generation of waste and finally can improve the public fame for a company or a country.

Personally understand waste prevention refers to the reduction of pollution sources, including the reduction of waste before final waste disposal. Based on the EU waste directive (European Commission, 2008), ‘prevention means measures taken before a substance, material or product has become waste, which can reduce: the quantity of waste, including through the reuse of products or the extensive of the life span of products; the adverse impacts of the generated waste on the environment and human health; the content of harmful substances in materials and products.’

4 Background

As the basic material of clothing, textile has a great significance in human history. From the animal skin to the synthetically fiber, the development of textile reflects the improvement of technology and development of civilization, as well as culture. With the growing of population and improvement of living standard, the consumption of textile subsequently increases rapidly. In 2004, the world export of textile is valued at about 148€ billion, representing 2.2% of the total world merchandise trade (WTO, 2005). Taking the cotton as an example, world cotton consumption is forecasted at 119.5 million bales in 2011/12, which is the largest since 2007/08 (China Texnet, 2011).

Textile industry takes up a great economic position in many countries or districts, such as China, US. As the traditional industry, Chinese textile industry has developed rapidly and played a great role in earning foreign exchange and contributing to Chinese economic development (CRI, 2005). In Europe, the textile industry has also played an important role in the GDP increasing, employment and other aspects. According to European Statistics (2006), the textile, clothing and leather production sector generated 66€ billion
of value added in 2003 with 3 million employees, while, compared with the value added (with 3% of total industrial value added), the employment (with 8.5% of total industrial employment) is more significant. In EU-27, Italy, France, UK, Germany and Spain are the biggest producers of textile, accounting for around three quarters of EU-27 total production of textile and clothing [European Commission, n.d.]. With the intra-EU trade included, EU is the world biggest textile exporter and simultaneously the biggest importer of textile [Mcnamara, 2008].

In terms of business, textile is a great contributor to the economic prosperity and poverty reduction. But everything has two sides, textile included. As the improvement of consciousness in environmental protection and sustainable development, many countries begin to consider the bad effect of textile product on environment from cradle to grave. One problem derived from the textile product is the textile waste. Great production and consumption of textile product not only leads to the scarcity of raw material, but also seriously generates a lot of textile waste to pollute the environment, which will be explained later. As one part of the solid waste, textile waste has obtained great concerns these years.

In UK, over 1 million tons of textiles are thrown away every year, of which only 25% are recycled. More seriously, it is estimated that textile waste is arising between 550,000-900,000 tons each year in UK. The discarded textiles are sent to the landfill, which almost takes up 12% of the landfill site and causes some environmental problems [I&G Cohen Limited, n.d.]. On average, around 10 million tons of textile waste are currently deserted in Europe and America each year [Wang, 2006].

According to the world resource institute (1992), the post-consumer textile amounts for 4% by weight of the total municipal solid waste. Compared with other wastes, the amount of post consumer textile is not so notable in the whole MSW. But if you take the whole world into consideration, the discarded textile is an astronomical data.

5 Incentives to prevent waste from textile

Encompassing the textile waste and textile product, many environmental problems come into being. These environmental problems resulted from the textile waste inspire some European countries to transfer the attention to the waste prevention, not only the end-of-pipe disposal.

5.1 Problems from the material resource and process procedure

Based on the environmental analysis in table 2, the textile manufacturing always causes some adverse impacts on environment. On the whole, none of the textile manufacturing is environmental friendly. Some come from the renewable resources, such as the cotton, but the production process will bring in soil erosion or water pollution due to the extra use of fertilizer, herbicide and pesticide. Some textiles are made from non-renewable
sources, such as the nylon made from petroleum, that is not a sustainable behavior if great consumption of this resources, although the global petroleum conservation can support the demand of resource for at least another several hundred years at the rate of current consumption (Wang, 2010).

The textile industry is composed of many sub-sectors, covering the whole circle from raw material production, semi-process to final products (European Commission, 2003), which involves much energy consumption and waste emission into it. Water is the principal medium for removing impurities, applying dyes and so on, while chemicals, such as the organic dyestuffs/pigments, sodium hydroxide, are necessary for dyeing and scouring of the textile product (European Commission, 2003). The most dominant environmental issue is the waste water emission and chemicals discharging in the waste water. In terms of energy, the textile industry is not an energy-intensive industry, but considering all of the textile plants, the textile industry still consumes a significant amount of energy. For example, the textile industry accounts for about 4% of the final energy use in manufacturing in China (LBNL, 2007), while less than 2% in the USA (US DOE, 2009).

5.2  Problem from the end-of-pipe disposal

Recycle is an environmental choice for the post-consumer textile, since it can improve the material efficiency and reduce the consumption of the energy. But the recycling rate of textile is very low because of the diversity of fibrous waste, structure and high recycling cost. For example, the cotton is usually not recycled due to the presence of dyes and other fibers. In the USA, only 15.9% of textile waste was recovered in 2007 (US EPA, 2008), the unrecovered textile waste accounted for about 4% of the content of landfills (Divita & Dillard, 1999). That proves the textile recycle is still not enough, which results in the high cost of the final disposal. Except for that, the recycling process is very complicate. Figure 2 depicts the explicit recycling process. As can be seen from this diagram, the recycling process itself will involve not only energy but also second-pollution (such as the waste water from cleaning process) and consequently doesn’t have significant environmental benefits over the prevention of textile waste.
Landfill is the last and inefficient choice for the textile waste disposal. The biodegrade of organic textile, such as the cotton, will generate the methane and ammonia, while the former is an important greenhouse gas, the latter is highly toxic in terrestrial and aquatic environment. In terms of economic aspect, the increase of landfill fee is also a formidable obstacle for the textile waste disposal.

Clearly, as landfill disposal of solid waste is less and less option, other means on handling textile waste must be found. Some experts suggested waste-to-energy conversion through the incineration of textile waste, but incineration is accompanied with the emission of hazardous substance such as dioxin, heavy metal, acid gas and dust particle, all of which are harmful to human health and environment. Although some facilities are equipped in the incineration plant, it is impossible to remove the hazardous substance thoroughly.

5.3 Problem from the increasingly consumption of textile

UNIDO has portrayed the relationship between world population and total textile demand. Assuming a global environment in which world population will grow from the present 5.4 billion to 10 billion in 2050, and further to 11.6 billion in 2150 when it is expected to reach a static state, the total textile consumption is forecast to double (UNIDO, 1992), while Europe is the main leader of the double consumption of textile, because Europe plays the key role in textile importing and exporting. Europe is the top textile exporter (81 Billion US Dollars) and importer (88.67 Billion US Dollars) in terms of the total amount in 2009 (WTO, 2010). It means Europe leads the great production and consumption of textile.
6 Textile introduction

Textile refers to the object which is woven from natural or synthetic fiber, that is to say textile is fibrous material. Textile technologies have evolved over millennia and the term ‘textile’ now has a very broad meaning. Originally reserved for woven fabrics, the term now applies to fibers, filaments and yarns, natural or synthetic, and most products derived from them. This includes threads, cords, ropes and braids; woven, knitted and non-woven fabrics; hosiery, knitwear and garments; household textile, textile furnishing and upholstery; carpets and other fiber-based floor coverings; industrial textiles, geotextile and medical textile (Long, 2005). Fibers are woven into yarns and plies, and then into textile (Long, 2005).

Textiles can be made from many kinds of materials which totally are divided into two types, natural fiber and synthetic fiber. The primary natural fibers come from animal (wool, silk), plant (cotton, flax, hemp) and mineral (asbestos, glass fiber), while synthetic fibers are primarily made from the petroleum. With the development of technology, now many new materials have appeared in the textile industry, such as the nano-material. Different materials have different properties and usages. Silk is smooth and shiny, cotton is smooth but dull. Wool is rough, but keeps you warm. Cotton is cool to wear and can be washed easily but needs to be ironed after washing for a neat look. Nylon and polyester are washed very easily and need almost no ironing after washing. Silk is either dry cleaned or washed with gentle soaps. (NIOS, n.d.)

7 Fiber introduction

Fiber can divided into different types based on different guidelines. According to the length, fiber can be divided into two types: staple fiber and filament. According to the origin, fibers can be classified into two types: natural fiber and manmade fiber, while the manmade fiber can be divided further into regenerated fiber and synthetic fiber. Table 1 gives a summary of the textile type for clothing. This report chooses two representatives from every type to be interpreted.

<table>
<thead>
<tr>
<th>Natural</th>
<th>Regenerated</th>
<th>Man-made</th>
</tr>
</thead>
<tbody>
<tr>
<td>Existing</td>
<td>Cotton, Flax (line), Silk, Wool</td>
<td>Viscose, Acrylic, Nylon, Polyester</td>
</tr>
<tr>
<td>Emerging</td>
<td>Flax (Short), Hemp, Jute, Nettle, Ramie, Spanish Bloom</td>
<td>Bamboo, Lyocell, Modal, Soybean, PLA, PTT</td>
</tr>
</tbody>
</table>

7.1 Natural fiber

Nature fiber mainly comes from plant, animal and mineral. Take cotton and wool as an example.
Cotton, accounting for 35% of the global clothing fiber market (Mistra, 2010), is a soft, white and fluffy staple fiber which mainly grows in tropic or subtropical region around the world, such as America, Africa, India and partial region of China. As the most traditional apparel material, cotton takes up the highest share in the textile industry. As one of the biggest export country of textile, China is the largest cotton producer in the world and consequently makes cotton production occupy a vital position in propelling the economic development and especially sustaining Chinese small-scale peasant economy which thousands of millions of peasants’ livelihood depends on.

Wool is the most important textile fiber obtained from the hair of sheep or other animals due to its many specific properties. It is highly flame resistant and highly durable, able to stretch up to 50% when wet and 30% when dry. Additionally, wool has excellent moisture wicking properties, pulling moisture into the core of the fiber so that it doesn’t feel wet or soggy to the wearer. The quality and price of wool mainly depends on the fiber diameter.

7.2 Regenerated fiber

Regenerated fiber refers to the fiber regenerated by extrusion and precipitation from the natural raw material such as cellulose and protein with the help of chemicals.

The first regenerated fiber is rayon made from the most abundant natural polymer—cellulose. Rayon, as with the cotton, is hydrophilic and biodegradable (Hergert & Daul, 1977). Depending on the manufacturing process, rayon can be weak and extremely water-absorbent or as strong as some of the strongest fibers made, including steel (Hergert & Daul, 1977). In history, there are two methods to produce rayon: the viscose discovered by Cross Bevan, and Beadle in 1892; the cuprammonium developed by Despaissis (Hergert & Daul, 1977).

Tencel (also named by Lyocell) is another kind of regenerated cellulosic fiber made from wood pulp. Lyocell is soft like cotton, strong like polyester and warm-keeping like wool.

7.3 Synthetic fiber

Synthetic fiber is made from chemical substances and usually produced by using heat to melt the fiber polymer to a viscosity suitable for extrusion through the spinnerette (US EPA, 1995), forming the thread. Synthetic fiber takes up half of all fiber usage, with application in every fiber and textile technology. In all synthetic fibers, nylon, polyester, acrylic and polyolefin dominate the market, which accounts for nearly 98% by volume of synthetic fiber production, with polyester alone accounting for around 60% (Mcintyre, 2004). These fibers are essentially non-biodegradable.

As the first synthetic fiber, nylon appeared as the substitute to silk in 1930s, which is used in fabrics, bridal veils, carpets, musical strings and rope. Nylon has many good
characteristics, such as light weight, incredible tensile strength, durability and resistance to damage. One reason which nylon is used so commonly, from clothing to toothbrush bristles, is that nylon is versatile, easy to dye and easy to produce. Nylon dries easily, but is sensitive to heat and should be washed and dried on the cool atmosphere.

As the most commonly used fiber, polyester, accounting for 40% of the global clothing fiber market (Mistra, 2010), was invented in early 1940s in Britain and became common in 1950s due to its versatility and specific properties. Polyester is resilient and resistant to biological damage such as mildew, but may cause irritation for some wearers. The production process of polyester is similar to nylon (Chen & Davis Burns, 2006). As with plastic drinking bottle, polyester is also made from polyethylene terephthalate (PET) that is produced from ethylene glycol and either dimethyl terephthalate (DMT) or terephthalic acid (TPA) (US EPA, 1995).

8 Environmental analysis of the fiber

Two examples are taken from every type of fiber to analyze the environmental effects in the whole production process.

8.1 Cotton and wool

Cotton is the most common apparel fiber in the world and lets many consumers consider it as environmentally friendly product, since it is biodegradable. Actually, cotton in itself is not so environmentally responsible but renewable. Cotton is prone to be attacked by the insect and fungi, which leads to the heavy use of pesticide and fungicide, consequently contaminating the soil and underground water. According to Yates (1994), it is estimated that cotton uses only 3% of the world’s farmland, but about 25% of the world’s pesticides. Except of the pesticide and fungicide, some other chemicals such as the defoliants are also used before the harvest of cotton (Grayson, 1984). Water consumption is also serious in cotton production. The global cotton products demand 256 Gm$^3$ of water per year (based on the period 1997-2001), which takes up 2.6% of the global water consumption (Hoekstra et al., 2005).

From cotton on the farmland to the textile fiber in the market, there is a long chemical and physical process procedure, which many toxic and harmful substances are added. For example, in order to improve the wrinkle recovery of the fabrics, formaldehyde or related products have been used on cotton in the durable-press finish (Needles, 1986).

From the above, in spite of natural characteristics, cotton production also has negative environmental impact. Of course, scientists are trying their best to offset the bad effect of the cotton production. The transgenic cotton has appeared on the farmland, which can reduce the use of pesticide and fungicide due to the property of resistance to insect and fungi in itself (Myers & Stolton, 1999). Color cotton, developed through selective breeding from natural mutant, can reduce the use of dyes (Robbins, 1994). But
unfortunately, the color cotton still didn’t replace the conventional white cotton. The traditional cotton remains keeping the dominant role in the cotton product (Chen & Davis Burns, 2006).

Although wool is a renewable product, it still has some side-effect on the environment. The notable problem is the soil erosion because of overgrazing. Overgrazing makes the soil become compact and less-porose. The soil aeration is also affected. The result from these damages is that the seeds can’t germinate due to the lack of air and water from the soil. The reduction of grass finally lets the soil lack ability to absorb the water and then drained away by rain. Another problem is that the excess sheep manure can create runoff contamination (Kadolph & Langford, 2007).

Just like the cotton, the wool also needs to be processed with some chemicals, such as dye, to change or improve the performance characteristics. Now scientist can breed a kind of sheep with colored wool, which can reduce the use of dye. But it is still far away to replace the conventional wool with the natural colored wool (Chen & Davis Burns, 2006).

8.2 Rayon and tencel

Although the raw material is renewable, the process procedure of rayon still brings in some environmental problems because of the appliance of chemicals. For example, the viscose is treated with alkali (European Commission, 2003). Tencel appeared on the market as an environmentally friendly product in the early 1990s. It is produced through a solvent spinning process, which uses the amine oxide as the solvent. The whole process don’t create any by-product, and fortunately all of the solvent in the process can be recovered, purified and recycled (Kadolph & Langford, 2007). In addition, the Tencel is biodegradable, but it is still a relative new fiber and is not as widely used as rayon (Chen & Davis Burns, 2006).

8.3 Nylon and polyester

Although the solvent and washing are not involved into the production process of nylon, the production process still emits nitrous oxide which can deplete earth’s ozone layer. Except for dyes, some chemicals are often added to the spinning solution to change physical and chemical properties of the filament before the fibers are formed (Chen & Davis Burns, 2006). As with other petroleum products, nylon is hard to decompose in normal condition, resulting in the long-time accumulation in the landfill if not recycled. The carpet industry has been working on recycling nylon from carpet by converting nylon fibers into caprolactam, which is used as the raw material for nylon6 (Chen & Davis Burns, 2006), but unfortunately most of the nylon reaches the garbage dumps (La Mantia, 2002), since it is expensive to recover valued product and furthermore with much more adverse effect in recovering process.
Unlike nylon, polyester can be recycled and turned into new polyester fiber again, which reduces landfills. It is estimated that 2.4 billion bottles are kept out of landfills each year in USA through the manufacturing of 100% recycled polyester fibers (Rudie, 1994,). Furthermore, compared to the production of polyester fibers from the new raw material, it is estimated that producing polyester fiber from the recycled polyester fiber can reduce by as much as 85% air pollution (Chen & Davis Burns, 2006), but the quality of recycled polyester may be not as good as the virgin polyester (Kadolph & Langford, 2007).

The environmental analysis of fiber can be concluded as table 2.

Table 2: Environmental analysis of fiber (adapted from Chen & Davis Burns, 2006)

<table>
<thead>
<tr>
<th>Textile product</th>
<th>Nonpolluting to obtain, process, and fabricate</th>
<th>Made from renewable resources</th>
<th>Fully biodegradable</th>
<th>Reusable/Recyclable</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cotton</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Wool</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Rayon</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Lyocell</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Nylon</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Polyester</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
</tr>
</tbody>
</table>

According to table 2, it is obvious that all of the fibers selected in this report have adverse environmental impact, but can be recycled for reuse. The fibers from the nature can be biodegradable, while the synthetic fiber can’t be biodegradable.

9 Existed measures to prevent the waste from textile

Since the textile waste has caused a long-period concern, there is some prevention methods applied in the practical case. For different textile waste resources, the prevention methods are not the same. So the textile waste resource should be defined before discussing the prevention method.

9.1 Textile waste resource

In order to prevent the waste from textile, the first step is to find where the waste comes from. Generally, the textile waste comes from two paths: pre-consumer textile waste, post-consumer textile waste.

Pre-consumer textile

Pre-consumer textile means the textile that doesn’t reach the intended use or users. Pre-consumer textile waste consists of by-product material from textile or fiber
industries, that is to say, it is generated by the manufacturer, not the consumer. Taking the garment factory as an example, the textile waste is created because of mistakes in design communication, craftsmanship problem, wrong color or shade, fabric faults, machine problems, trimming scrap and so on. It is estimated that between 0.681 and 0.862 million tons of new fiber and fabric wastes are generated annually by fiber producers, textile mills, and fabric manufacturers, which the apparel manufacturers contribute 450 to 600 million tons annually in the form of apparel cuttings in the USA (Kron, 1992).

**Post-consumer textile waste**

Post-consumer textile waste, consisting of any type of garments or household articles made from manufactured textile, is produce by the consumer or the retailer of apparel. The owner of post-consumer textile doesn’t need it again and decides to discard it either because they are worn out, damaged, outgrown, or have gone out of fashion.

### 9.2 Review of the prevention method

Waste prevention is an effective way to attain the compliance of the environmental requirement, so is the textile industry. Overall, the waste prevention methods can be divided into the following sectors: industry, agriculture, commerce, mining, construction, transport, energy and consumers. Considering this report just focuses on the prevention of waste from textile product itself, especially the apparel, this report just discusses the industrial, commercial and consumptive prevention methods.

Industrial prevention method analyzes the life-cycle impact of the product on environment and then prevents the waste generation from product design, improved plant operations, in-process recycling, process modification, materials and product substitutions, and material separations.

Commercial and consumptive prevention method emphasizes waste prevention from the social and economic aspect, such as encouraging sustainable consumption, public education.

As for the prevention of waste from textile, the efforts from the following scopes are made:

**Reuse**

Either for the pre-consumer textile or for the post-consumer textile, the common and popular method to prevent the waste is to collect and then reuse them.

As for the pre-consumer textiles, they are usually broken down and remade into similar or different materials, or sold to the third-party buyer as the raw material to produce
products. According to the Council for Textile Recycling (1997), each year 750,000 tons of pre-consumer textiles are recycled into raw materials for the automotive, furniture, mattress, home furnishings, paper and other industries, which divert almost 75% of the pre-consumer textile waste from the landfills and recycled.

About the post-consumer textiles, figure 3 shows a typical disposal process. According to the definition of prevention in this report, the primary and secondary recycling measures could be regarded as the waste prevention methods. Primary recycling involves recycling scraps, namely, reuse, while secondary recycling involves simple mechanical processing of a post-consumer product. In figure 3, donating the post-consumer textile waste to the charity is a typical primary method to prevent the waste from textile. These donated clothes are sold as secondhand clothes to consumers especially in third-world countries. Another prevention method showed in figure 3 is to reuse the textile waste after some simple mechanical disposal, such as shredding. The shredded textiles are treated as raw material of other functions, such as the cleaning cloth, stuffing material, roofing material. Reusing the clothes between siblings or relatives is also a popular way to prevent the waste from textile.

![Figure 3: Schematic of post-consumer textile option (adapted from Hawley Jana, 2008)](image-url)

**Consumer and designer’s responsibility**

In order to prevent the waste from textile effectively, the designer and consumer of apparel can provide a good portal since they decide when the apparel becomes waste
and how much waste of the apparel. This issue about consumer and designer is more important in developed country than in developing country, where most low-income consumers buy secondhand apparel exported from developed country (Chen & Davis Burns, 2006).

The designer must consider many problems before the apparel pattern comes out, such as the material use, the style, and the aesthetics. For an eco-designer, he must consider the following elements: create a longer-lasting and better-functioning product, thereby reducing the need to replace it; use recycled pre-consumer, post-consumer waste in your collection; reduce the weight and volume of a product by using fewer or lighter materials; offer an upgrading and/or a repair service to your customer; reduce the waste impact of disposing your product by making it recyclable; make the product have a second life (adapted from British Fashion Council, n.d.). If the designer emerge these elements into his design, it can prevent the waste from textile effectively.

For the consumer, they should make environmentally friendly decisions when they make purchase decisions, during product usage and maintenance, and at the time of product disposal (Chen & Davis Burns, 2006). Consumers can buy the apparel that is more durable, long lasting and made from the recycled raw textile materials.

10 Prevention scheme in Sweden

As the third largest country in EU, Sweden just plays a small role of production or consumption of textile. Only a small part of textiles consumed in Sweden are produced here. According to the Business Register, Statistics Sweden, there are about 4,600 companies and 8,000 employees in the textile and clothing industries in Sweden, more than 80% of which have no employee (SMED, 2011). Some famous Swedish apparel retail companies are: H&M, Lindex, RNB(Brothers/Sisters/JC/POP), Kappahl, MQ, Gina Tricot, Boomerang, Åhlens, Stadium, Intersport, Hemtex, IKEA, Indiska.

The total consumption of textile in Sweden has risen notably in the last 10-15 years (SMED, 2011). From 2000 to 2009, the textile consumption had increased by about 40% in Sweden, but the value of export nearly kept constant (SMED, 2011). The most important reason for the increase in the volume of textiles is due to the combination of economic prosperity and lower price of textiles (Defra, 2007).

In 2008 the net inflow of clothing and home textiles to Sweden was 131,830 tons. Used clothes and rag is the biggest exported textile in Sweden, which almost 30% of the textile product exported in 2008 is used clothing and rags. Compared with the import, the domestic production nearly can be ignored due to small proportion in the textile inflow, just 1.5% of the imported textile in 2008. In some textile group, such as baby clothes and blanket, there is no production in Sweden and all of them are imported from other countries in 2008. (SMED, 2011)
Swedish people consume 15kg of textiles per capita and year based on clothing and home textile, of which roughly 8kg are incinerated, 3kg are reused by charity organizations and the remaining 4kg either accumulates (e.g. in a closet or wardrobe) or are handled through other means of waste management where it is difficult to measure (e.g. recycling centers) (Palm, 2011). About 26,000 tons of textile waste goes to 8 large charitable organizations (Myrorna, Erikshjälpen, Röda Korset, Läkarmissionen, PMU Intertrade, Stockholms Stadsmission, Humana Sverige and Emmaus Björkå) in 2008, of which 73% exported, 11% sold in Sweden, 15% sent to incineration or landfill (SMED, 2011). Figure 4 describes a detailed flow of textiles and textile waste. As can be seen from figure 4, most of the textile waste goes to waste company directly, not pass through the charitable organization, and then is incinerated to recover energy or land filled. According to Avfall Sverige (2010), in 2008 and 2009, the total bag or container waste from municipality is 2,226,700 tons and 2,167,800 tons respectively. Based on the investigation, the average proportion of textile waste in the total waste from the municipality is 3.2% (SMED, 2011), so in 2008 and 2009, there are nearly 71,254 tons and 69,230 tons respectively going to the waste company.

**Figure 4: Schematic flow of textile and textile waste in Sweden in 2008 (Unit: ton)**
(adapted from SMED, 2011)

### 10.1 The existed prevention measures in Sweden

The EU waste directive (European Commission, 2008) emphasizes the member state should establish national program for waste prevention. The textile waste (focusing on apparel) in Sweden mainly comes from household, region operations and apparel retailer (SMED, 2011). As one stream of MSW, although just a small proportion, prevention of waste from textile can reduce greatly the pressure of waste management in Sweden. There are some existed prevention measures for textile waste in Sweden.

The most dominant prevention method of textile waste in Sweden is reuse. There are many different curbside recycling facilities of textile waste in Sweden, which is under operation of different secondhand company, such as Myrorna. These secondhand
companies, or so-called charitable organizations, play a key role in the reuse or recycling of textile waste in Sweden. Just as showed in figure 4, the textile waste from the retailer’s donation or household discarding is collected by the charitable organizations and then sold in Sweden, or exported to other country, especially less-developing country for foreign exchange or donate to the poor in other area, such as Africa.

10.2 Suggested prevention scheme in Sweden

The needs lead to the consumption, while the consumption generates the waste. The citizen’s needs can’t be forbidden, so the waste is always generated. In order to prevent the waste from textile, the fundamental principle is to reduce the consumption, reduce the material use and reduce the obstacle of reuse.

Considering most of textile product consumed in Sweden is imported from other countries and the domestic production can be ignored, the prevention method can be focused on the following stakeholders: designer, retailer, consumer, charitable organization. In this prevention scheme, these stakeholders have their own responsibility, but they also cooperate with one another. The consumer and charitable organization are mainly responsible for the reuse of textile waste. Actually, there is a big potential for the reuse of textile waste in Sweden. According to SMED (2011), just 26,000 tons of textile wastes are collected by the charitable organization, of which 84% is reused, while the total textile waste in Sweden is about 131,830 tons in 2008. That means the reuse rate of textile waste is only around 17%.

**Designer**

Design is the first and also the most important step for the apparel. To some extent, the design can decide the amount of textile waste, because the design can dominate the style, material use, fashion time and life span of the apparel. The designer should pay much attention to the following aspects.

In material use aspect, the designer should choose the easy-recycling and reuse materials as possible as he can, such as polyester which can be recycled and reused 100%, not the difficult-recycling materials, such as the cotton which is difficult to be recycled from post-consumer products because of the presence of dyes and other fibers (Chen & Davis Burns, 2006). Except that, the designer should try to remove the unnecessary accessory of the apparel in order to reduce the material use without offsetting the aesthetic value of the apparel. Another is that, if possible, try to use the recycled material from pre-consumer or post-consumer textile product.

In life span aspect, the designer should try their best to prolong the use time of garment and create better or multi-function apparel. That apparel is outdated in a short time results in the great amount of textile waste. Making efforts to prolong the fashion time of apparel is the key element to prevent the textile waste. Due to economic prosperity
and low cost of textile, price is not the decisive factor for the purchase of apparel, while the decisive factors are fashion, brand and aesthetic value. One way to prolong the life time of apparel is that the designer can preserve the upgrading space for the designed apparel. If the apparel is outdated, the designer can provide some upgrading suggestions to the consumer (British Fashion Council, n.d.). Of course, better and multi-function apparel will reduce the demand of apparel and consequently prevent the waste from textile, since one garment can be used in different seasons and different situations.

**Consumer**

Consumer can contribute to the prevention of waste from following aspects: make the discarded textile product reuse; sustainable consumption; put the discarded textile product into collecting site, not the residual waste bin.

Consumer can make their discard textile be reused via different methods. They can sell the discarded clothes on internet, such as Blocket, Tradera. Clothes are the eighth most sold product on Blocket (Palm, 2011). The other way for the reuse of textile is to share clothes between family members, friends and so on. For example, sibling can share clothes with each other, since the discarded clothes has no adverse effect on health if washed thoroughly. Another way to reuse the textile waste is to transform the textile waste into other product. For example, the discarded apparel can be shredded to make mop, table cloth, curtain and so on. There is a good practice to transform the discarded textile into curtain in students’ corridor in Kungshamra, Solna. Some students directly utilize the discarded bed sheet as curtain.

Sweden has obtained outstanding establishment in environmental protection aspect. Swedish people have a high consciousness on environmental protection. So it is possible for the Swedish government to encourage sustainable consumption via cooperation with the media. Sustainable consumption means ‘consumption that supports the ability of current and future generations to meet their material and other needs without causing irreversible damage to the environment or loss of function in natural system’ (Morgan & Birtwistle, 2009, cited in Jakson, 2004). Under the guide of sustainable consumption, the consumer should try to buy the environmental friendly textile product. For example, they can purchase some apparel made from recycled material or buy secondhand apparel from secondhand store or website store.

As showed in figure 4, most of the textile waste (nearly 70,309 tons) goes to the waste bin, not the collecting site of the charitable organization. These textile wastes goes to the waste bin will be disposed in the waste company simply via landfill or incineration. The consumer should try to put the discarded textiles into the curbside collection site, not the residual waste bin.
**Retailer**

Every big supermarket has the facility to collect the beverage bottle. This experience can be used into textile waste collecting in order to encourage the consumer to put the textile waste into charitable organization’s system. Of course, it needs the cooperation between retailer and charitable organization. The retailer can add the recovery fee into the apparel cost and mark it on the label when the apparel is sold. If the consumer doesn’t need the apparel, they can return it to the apparel store to get the recovery fee back or obtain a voucher of this store. The collected can be sent to the charitable organization to be sorted and reused via different ways. This measure can not only encourage donations, but also increase the sales at the participated store. UK has conducted a similar practice. Oxfam is the charity shop, while Marks & Spencer is the clothing retailer. Marks & Spencer has set up a partnership with Oxfam, whereby, for every bag of unwanted Marks & Spencer clothing donated to Oxfam, the consumers can receive a £5 voucher redeemable against purchases at Marks & Spencer to the value of £35 or more (Morgan & Birtwistle, 2009, cited in Marks & Spencer, 2008).

**Charitable organization**

The charitable organization can put the collection facility in every municipality, but the problem is that the collection rate is very low. As showed in figure 4, just 26,366 tons of textile wastes from the household go to charitable organization. In order to improve the collection rate, the charitable organization can cooperated with the retailer as mentioned in the retailer part. Just 15% of textile waste collected by charitable organizations is reused in Sweden. In order to reuse the textile waste completely, the charitable organization must cooperate with other countries to open the market. In recent years, these textile and garment-making waste reprocessing industries are shift from Europe to Southeast Asia, since Southeast Asia is one of the main textile manufacturing centers in the world (Chang et al., 1999, cited in Minhas, 1995). These countries have a complete chain of textile industry, which can not only reuse the textile waste directly, but also transform the textile waste into other product or function, such as carpet, stuffed material in couch by some simple mechanical disposal, such as shredding. About the cooperation model, the charitable organization provides sorted textile waste, and then transported to the reprocessing country of textile waste.

10.3 The description and explanation of the suggested prevention scheme

The suggested prevention scheme can be summarized as figure 5:
The aim of this prevention scheme is to reduce the amount of textile waste in waste company, improve the material efficiency and finally reduce raw material and energy consumption. It will benefit the environmental improvement and sustainable development in Sweden and the world. The fundamental principle of this prevention scheme is: reuse the textile product, reduce the material use and prolong the life time of textile product. So this scheme will finally lead to the reduction of the textile product and raw material. The participants in product and raw material production, such as, energy, water, pesticide, and waste gas emission, are also reduced.

This prevention scheme focuses on four stakeholders: designer, retailer, consumer and charitable organization. The retailer and charitable organization are the paramount stakeholders in this prevention scheme. In order to prevent the waste from textile, the effective method for the relevant institutions is to collect as much textile waste as they can, and then reuse in Sweden or, especially at abroad. The retailer is just responsible for the collection of the textile waste in this project, while charitable organizations participate in all of the steps of the prevention project, such as collection, sorting, resold in Sweden, export or donate to other countries.

11 Discussion

As can be seen in figure 4, the existed prevention measures in Sweden mainly emphasize the participation of the charitable organization and consumer. Compared with existed prevention measures, the suggested prevention scheme in this report combines four stakeholders together, each of which has their own responsibility for the prevention of textile waste, and of course play different roles in the whole suggested prevention scheme.

Swedish waste company usually disposes the textile waste with two methods: landfill and incineration (see figure 4). The total amount of textile waste in landfill and incineration is nearly 73,824 tons. This scheme can reuse the textile waste and consequently prevent the textile waste from going to the landfill and incineration plant. It can reduce the land use, leachate discharge, waste gas and particle emission, soil and
underground pollution. The consumer’s participation is the decisive factor of this prevention scheme, so it will increase the load of consumer. But the consumer’s feeling of well-being and amenity will increase, since the waste prevention can increase the amount of recycling and reuse of discarded textile and consequently improve the environmental quality.

Any prevention measure should be analyzed from different aspects to prove it feasible or not.

For the designer and consumer, the measures are not so viable. In the real world, these two stakeholders usually don’t consider the environmental aspect in consumption and design process, or just consider a little. For the designer, the priority in their design is that how their design can attract the consumer in order to take more market shares and get more investment return, while, for the consumer, the priority in their consumption process is the amenity, aesthetic value, style and price of the apparel. The price plays a key role in the purchase of apparel. Some apparel made from the recycled material is even more expensive than from the virgin material (Meyer, 2001). So it is very difficult to prevent the textile waste from the designer and consumer’s stance.

For the retailer, the retailer can cooperate with the charitable organization to collect the textile waste. It is very effective to collect the discarded textile if imitate beverage bottle collection model in Sweden. To some extent, this measure can give the consumer a great incentive to send the clothes to collection facility, not the household waste bin. The retailer of course can increase the sale of textile product due to the provision of voucher or recovery fee. But the problem is that the sale increasing will result in the consumption increasing of apparel in turn.

For the charitable organization, the charitable organization is in charge of the whole process of this prevention scheme, from collection to disposal. They can obtain many economic benefits from the sale or export of second-hand clothes. But if the charitable organization wants to cooperate with other countries, the transportation problem is a big limitation, not only the transportation cost, but also the environmental pollution resulted from the transportation, such as the emission of carbon dioxide. To avoid the adverse effect of transportation, Sweden can develop its own reprocessing industry of textile waste. Of course, there are many barriers for the development of reprocessing industry, such as the amount of the textile waste. The textile waste collected by the charitable organization is just 26,000 tons per year.

For the implementation of this suggested prevention scheme, the government should be involved. Although these four stakeholders realize the importance of textile waste prevention, except for the charitable organization, the other three stakeholders can obtain just a few economic benefits from this suggested prevention scheme. There is no practical incentive to encourage the designer, retailer and consumer to prevent the textile waste. So it needs some compulsive forces from the government to implement
the suggested prevention scheme.

12 Conclusion

Unlike the industrial waste prevention focusing on the producing process, the prevention measure from all detailed product waste is very similar, which have no so much innovative space, so is the textile waste. For Swedish circumstance, the textile industry is not the dominant industry. To some extent, the textile industry in Sweden even can be ignored in the prevention of waste from textile. Compared with the textile waste from other country, the textile waste in Sweden is also very small. All of these situations determine that it is impossible to develop a complete disposal chain of textile waste, except for cooperating with other countries. Due to these constraints, the prevention measure of textile waste has some limitations in Sweden.

After considering the situation of textile industry, textile waste and textile consumption in Sweden, this report gives a new prevention scheme from the scope of designer, consumer, retailer and charitable organization. The designer provides eco-design plan, while the consumer purchase environmental friendly product and send the discarded textile to the retailer and charitable organization or reuse it. Finally, the charitable organization is in charge of the recycling and reuse of discarded textile. In order to implement the suggested prevention scheme very well, the following elements should be considered:

- The apparel made from the recycled materials is less competitive than one from virgin materials due to low price of virgin materials. It is necessary to levy environmental tax to the virgin material in order to improve the market competitiveness of the secondhand clothes or apparel made from recycled materials.

- The scale of textile waste in Sweden is very small, which is a big obstacle for the development of textile waste disposal industry. This situation decides that the charitable organization, or called secondhand company, must cooperate with other countries’ disposal company in order to reuse the textile waste effectively.

- For the stakeholders involved into the textile waste prevention, most of them can’t obtain visual benefit from the textile waste prevention. The policy maker should establish some measures to stimulate the stakeholders to increase reuse or recycling of textile waste, for example, offer financial subsidy to the stakeholders.
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