International Journal of Science and Research (IJSR)
ISSN (Online): 2319-7064
Index Copernicus Value (2015): 78.96 | Impact Factor (2015): 6.391

Recycling Pre-Consumer Textile Waste Using Water Soluble Film Technology for Promoting Environmental Sustainability

Dr. Charu Gupta[1], Neeti Vaid[2], Akanksha Jain[3]

[1, 2, 3]University of Delhi, Institute of Home Economics, F-4, Hauz Khas Enclave, New Delhi- 110016, India

Abstract: ***Environment sustainability is need of an hour. Hazardous waste should be managed properly otherwise it may cause harm to people and environment both. The objectives of the 3R 'Reduce, Reuse and Recycle referred to as the waste hierarchy are to cut down the amount of waste thrown in the landfills thereby conserving natural resources, landfill space and consequently energy. Of these the final R, 'Recycling' is a key component in the process of converting waste into useful products. Garment production in India exists in both organized and unorganized sector. There is a large clutter of industry, street side tailors, and boutique owners which generate bags of fabric waste which eventually land in the landfill. This waste is not recycled in any supply chain. Since it is a pre- consumer waste, they are bright and virgin in nature. The present study is an effort to create sustainable fashion using pre-consumer textile waste and further aims to sensitize business houses and NGOs towards an eco-friendly and user friendly technology which has social as well as commercial implications. In this study textile waste was collected, segregated, assessed and then converted into a fabric using water soluble fabric technology. Water soluble film is non-toxic and can be dissolved at room temperature. The fabric designed out of this technology was further used for designing a product range. This technology is then shared with enterprises at all levels who are struggling to reduce their ecological foot prints. This study has been conducted under a project supported by Delhi University Innovation Project Scheme.***

Keywords: Textile Waste, Environment Sustainability, Recycle, Innovative Technology

1. Introduction

Environment sustainability is need of an hour. Hazardous waste should be managed properly otherwise it may cause harm to people and environment both. The objectives of the 3R 'Reduce, Reuse and Recycle referred to as the waste hierarchy are to cut down the amount of waste thrown in the landfills thereby conserving natural resources, landfill space and consequently energy. Of these the final R, 'Recycling' is a key component in the process of converting waste into useful products. Waste is any product that has no further use or value for the person or organization that owns it, and which is, or will be discarded. Textile waste can be classified as either pre-consumer or post-consumer waste. Pre-consumer textile waste consists of byproduct materials from the fiber, yarn, fabric and garment producing industries, including off cuts, selvages, shearings and rejected materials. The post-consumer textile waste comprises of garments or made-ups which are discarded either because they are worn out or have gone out of fashion. Both type of waste have multiple utilizations, but are not very well documented and have a lot of scope of further explorations. Environmental norms are very stringent in the developed world giving way to many successful ventures of recycle and reuse. However in India there exists a lack of systematic textile waste management policy, and despite a network of waste collectors a lot of it enters the landfill a large percentage being polyester which is non-biodegradable.

3R's - Reduce, Reuse and Recycle. Reduce – The first component of waste hierarchy is reducing the waste created. Reuse – The textile material instead of being wasted should be reused again. Recycle – Process of converting the waste into new products to prevent waste of potentially useful materials and reduce the consumption of new raw material. Recycling system uses 20 percent less energy and reduces carbon dioxide emissions. It reduces environmental load through the efficient use of resources and energy and the recycling of used products. Individuals are doing more than promoting the health of the environment through recycling. Recycling include petroleum savings, greenhouse gases reduced, energy conserved. It reduces the need for landfill space. Textiles present particular problems. In landfill as synthetic (man-made fibers) products will not decompose. It reduces pressure on virgin resources. It aids the balance of payments as we import fewer materials for our needs. It results in less pollution and energy savings, as fibers do not have to be transported. The concept of recycling and sustainability is not new for Indians. The origin of the traditional kantha embroidery technique is a process of recycling where a few layers of used cotton fabric are held in place one over the other and embellished with exquisite embroidery using the thread which has been pulled out of the colored borders of the same old fabric. There are many other techniques used in craft sector for textile recycling.

Need for Recycling Textile Waste

The process involved in making of fibers consume fossil fuel which increases the amount of Carbon dioxide. Carbon footprint can be reduced by recycling..Non-biodegradable waste such as polyester waste has created serious environmental issues. PET can be treated with the help of textile recycling. Another factor in degradation of textile waste is the problems of incineration which includes the process of combustion of organic and inorganic substances contained in waste material. Inorganic waste gets converted to toxic ash, flue gas, heat leading to air pollution. Maximization of recycling can help resolve the problem of incineration.

Patagonia, a well-known US brand sells a range of outerwear

made from recycled PET bottles. Maryland based SMART diverts some 2000,000 tonnes of textile waste from entering solid waste stream. There are many western brands which are working on sustainable solutions of product design, consumers are given points for depositing discarded clothing in textile banks which further sort and redistribute garments in the vintage and collectible market as well as to the underprivileged (Luz Claudio, 2007).The town of Panipat in Haryana is India's largest recycling hub where imported clothes are slashed, sliced and shredded to develop waddings, blankets etc. The 'Lawar' textile cluster in Meerut makes durries and khes from industrial and post-consumer waste which is collected door to door. Some such efforts are also seen in Gwalior, Bijnor, and Rampur to make products like cords, ropes, rugs etc. Refurbish and recycle is aggressively gaining ground as the cost of waste disposal is going up. In US and EU this has given way to a cult of designers who are only working on 'sustainable fashions' (Joy Annamma, 2013) whereas fashion in our country continues to have an extravagant statement of conspicuous consumption. The 'cradle to cradle' approach of product design needs to be enthused in garment production and design.

Water Soluble PVA (Poly Vinyl Alcohol) film is a nontoxic, nonwoven material which has the property of being water soluble in a matter of seconds. PVOH films is made from water soluble polymers having appearance of common plastic films which can be dissolved in water at room temperature. The dissolved film disappears in water like sugar or salt and the ingredients of the film change their appearance. The rate of dissolution depends upon agitation, water temperature and thickness of film. It is used in many versatile ways but largely for packing agricultural chemicals and pesticides. If irregular assortment of textile scraps are sandwiched between two such PVA films and machine quilted, after dissolution these scraps become interconnected and form a lace-like textured fabric having its own unique aesthetic appeal which can be used as accentuating trims. PVOH has been recommended by ENVIRONMENTAL PROTECTION AGENCY (E.P.A) in packaging agriculture chemicals and pesticides in water soluble film.

Advantages of Water Soluble PVA Films

PVA film has small elasticity. Fast dissolving speed under normal water temperature. It does not impact the color. No wire drawing, nodal point, wire break, offset direction etc. Final products are CO2 and H3O, non-toxic and without formaldehyde. It can be used in all embroidery machines. It is fully bio-degradable. No residue. It can replace paper or non-woven fabrics as it avoids deformation or fading.

Water Soluble film absorbs moisture easily. Physical property changes according to variation in water content. It becomes rigid in winter under low temperature and humidity. It becomes soft in spring and summer under high temperature and humidity. Recommended storage conditions: 7-30 degree C and 20-70% RH, moisture proof, dry, light and heat prevention and sealed in regular plastic bags. Intensive stirring, higher water content and temperature will decrease the rinse time.

2. About the Study

2.1 Aim of the Study

This paper aims to develop a new user friendly technology using pre-consumer textile waste to develop a fabric, which can be used as accentuating trims, the cost of which would be primarily the labour cost.

2.2 Objectives

1) To collect, analyse textile waste from tailors, boutique owners and export units of garments and home furnishings.
2) To conduct the assortment and analysis of collected pre-consumer textile waste in terms of fibre type, fabric size and fabric colour.
3) To develop fabric patches using water soluble film technology
4) To design a product line using the developed fabric.

2.2 Methodology

The study is divided into three phases:

Figure: Different Phases of Study

Phase I: Collection of waste fabric from tailors, boutique owners and large manufacturing Units

Collection of waste from street side tailors, boutique owners and large manufacturing units was done from different zones of Delhi. The waste was collected from 10 different manufacturing units in every 20 days. Fabric waste of small size and uneven dimensions were willingly given by them. Bigger size fabrics were kept by them for personal use, and interesting embroidery pieces were also kept for design effects. On an average a tailor making 2 suits in a day generates a kilo of waste in a week. Large manufacturing units generate much larger quantum of waste, some of which is recycled and some thrown in the bin.

Phase II: Assortment and analysis of collected pre-consumer textile waste: Sorting, segregation and analysis of waste was done as per

1) **Fiber type:** Segregation of the textile waste was done according to the different types of fiber. Burning test was used to identify natural fibers, manmade fibers or blend of both.

2) **Fabric size**: On an average, the minimum size of the waste fabric collected was as small as 5cm X 5 cm and the maximum size was 50 cm X 50 cm.
3) **Fabric color:** color assortments, shape assortment, size assortment was done. Trims like fancy yarns, laces, small appliques and patch works were used to enhance the patches

Phase II: Development of Fabric using Waste and Water Soluble Films

I. Survey of Availability of Water Soluble Film

A comprehensive list of different brands and specifications of Water Soluble PVA Films was conducted. The list of brands is as follows:

Table: List of brands of Water Soluble PVA Films

S. No	Brand Name	Country of Origin
1	Sulky Solvy	USA
2	Pellon	USA
3	Madeira	Germany
4	Aquasol	UK
5	Romeo	UK
6	Aquabond	UK
7	Laxmi International, Surat	India
8	Suvi fabrics & Linings Pvt Ltd, New Delhi	India
9	C K Interfabs, New Delhi	India
10	Super Interfabs, New Delhi	India
11	Arrow Coated Products Ltd, New Delhi	India
12	Bengal Polymers Pvt Ltd, Howrah	India
13	Amtrex Nature Care Pvt Ltd, Mumbai	India
14	Star Trading Agencies, New Delhi	India
15	Jiangmen Proudly Water Soluble Plastic Co., Ltd	China
16	Dongguan Jianxing Clothing Accessories Co., Ltd	China
17	Yongan Sanyuanfeng Water Soluble Films Co., Ltd	China
18	Fujian Zhongsu Biodegradable Films Co., Ltd	China
19	Beijing Guanghui Textile Co., Ltd	China
20	Sheng Hung International Co., Ltd	China
21	Shanghai Shuoxaing Plastic Co., Ltd	China

Specifications of Water Soluble PVA Films are:
Thickness (micron)
25/30/35/40/45/50/55/60/70/75/80

Length
500m – 1000m/roll

Width
200 mm- 3000 mm

Texture
Plain or embossed

Dissolving Temperature Types
- Type Z: above 5 degree Celsius
- Type C: above 15 degree Celsius
- Type W: above 25 degree Celsius
- Type M: above 45 degree Celsius
- Type H: above 65 degree Celsius

Films in various weights and textures were procured from Kotla Mubarkpur and Govindpuri.

Specification: Rate- Rs. 20/- Width- 40 inch

II. Making fabric using waste and water soluble film

Around 150 patches have been developed using the following steps:
1. Making Design Pattern
2. Cutting the Fabric Scraps
3. Assembling and Basting
4. Stitching
5. Rinsing and Drying

1. Making Design Pattern

Firstly, the length and the width of the new fabric to be made is decided. Then a block ABCD is made on water soluble film with a fine line permanent marker where AB is the length & BC is the width of the fabric to be made. Grid is drawn & design is made on the grid. This design acts as guideline for assembling and sewing. The design can be made of different size, shape, orientation.

2. Cutting the fabric in desired pattern

Fabric scraps are selected from the bundle according to different color ways & fiber types.

The fabric scraps are then cut in different shapes (square, triangle, rectangle, circular, strips) according to the design pattern that has already been made on the water soluble film/stabilizer.

Figure: Cut fabric scraps

3. Assembling and basting

Firstly, one layer of water soluble film on which the design is drawn is placed on a flat table. This will be the bottom layer. On this layer of water soluble film the cut fabric scrap was arranged according to the design made. These fabric scraps were then basted so that they do not move from its places. Trims like fancy yarns, laces, small appliques and patch works were used to enhance the patches. Waste threads can also be added. Now, on top of this another layer of water soluble film is placed. This layered fabric can be tightened in an embroidery frame for stitching.

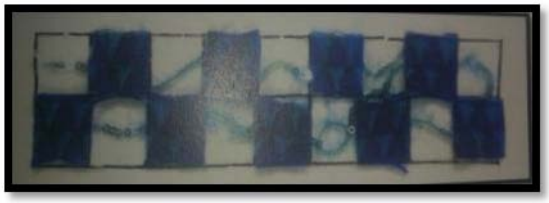

Figure: Arrangement of cut fabric pieces according to design pattern and tightened in embroidery frame

4. Stitching

The layered fabric scraps and water soluble film is stitched together. The stitches can be of any direction i.e. vertical, horizontal, circular, random. The density of the stitches is considered an important factor for the strength of the fabric. Increase in the stitches increases the fabric strength. The strength of the stitches also depends upon the spacing given between the stitches made. Free motion stitching is the easiest way to stitch.

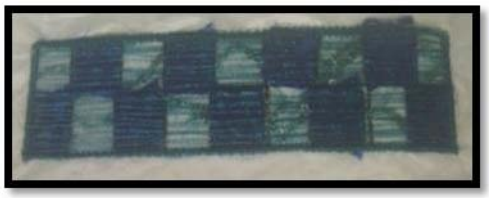

Figure: After stitching the sample

5. Rinsing and drying

Post sewing, the whole fabric is soaked in water for 5 minutes. Then, rinsed in cold running water till all the water soluble film is dissolved in water and is completely removed. It can be hanged for drying or ironed to dry. After drying the rough edges of the fabric was cut and patch was finished. What is left is a beautiful, delicate fabric ready to be used for product development.

Figure: Rinsing after stitching
Sample after drying

Phase III: Creation of Different Products from the Fabric

An array of products has been developed using fabric developed from this technology. It includes bags, pouches, lampshades, stoles, basket, cushion covers, etc. the products have been selected depending upon the quality of fabric produced. As this fabric cannot be used as a base fabric for product development, it can only be used as patches or design effects to accentuate the aesthetic appeal of different products developed in areas where strength is not a prerequisite. They are liked more far a delicate lacelike, spider web type, airy, textural effect which is unique by itself. Thus, a collection of such effects was planned based on four themes to synchronize various elements of design. Out of all the samples of developed fabric, the product line has been developed for cushion covers, stoles and lampshades.

The steps for making the fabric using water soluble film and trims were recorded in digital form and a CD has been developed.

Themed Product Lines

Four product lines have been developed based on the following themes:
1. Moods of Water
2. Christmas
3. Ethnic Indigo
4. Fire

A variety of fabric assembly was done in different colour ways, dimensions and over lapping, and basted between two films. In some patches the design effect was enhanced by lace, lurex, applique etc. Various types of quilting stitch type with novel threads and spacings was used to play upon the desired look. The quilted assembly was immersed in water to dissolve the water soluble film giving way to interconnected fabric trims. Since the time taken in making the fabric is the main determinant of the cost of the samples, it was calculated individually for all the patterns.

Some of the Sample of Patches Created for Product Development

Sample 1:
Time Utilized in Cutting the Fabric: 25 mins
Assembling Time: 10 mins
Stitching Time: 25 mins
Rinsing Time: 5 minutes
Drying Time: 5 minutes
Total Time: 1 hr 10 mins

Figure: Sample 1 of patch

Sample 2:
Time Utilized in Cutting the Fabric: 25
Assembling Time: 15 mins
Stitching Time: 25 mins
Rinsing Time: 5 minutes
Drying Time: 5 Minutes
Total Time: 1 hr 15 mins

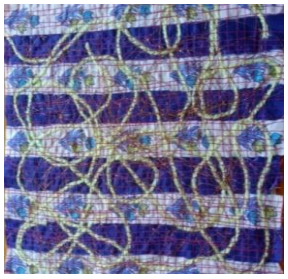

Figure: Sample II of patch

Hence, time taken for developing these samples was different for each sample. In random arrangement of sample, the time consumed was less as compared to the samples in

which appliqués were inserted and the cut fabrics were placed in a particular pattern. More time was consumed in the development of samples in which stitch density was more as compared to the samples in which the stitch density was less. After this exploration, some products were designed so that these novel fabrics developed out of waste are judiciously used as patches of design areas.

Some of the products developed are:

Collection of Cushion covers was developed on theme "Ethnic Indigo" and "Christmas" using various waste fabrics, threads and yarns combining it with base fabric.

Figure: Products developed from this technology

A collection of lamps were developed using colourful and variety of waste yarns and fabrics. This spider web type effect was designed so that light can pass through it and create a beautiful effect.

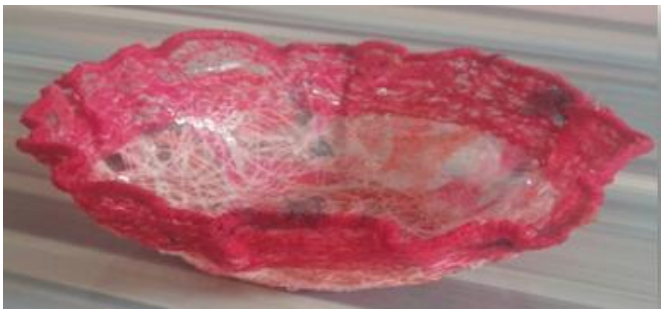

Figure: Fabric Bowl developed from this technology

This elegant looking fabric bowl was developed using pieces of waste fabrics like nets, nylon and embroidery threads inserted in it. It can hold any light weight items.

A collection of stoles was designed, entirely using waste fabric. The strips of fabric were arranged overlapping each other and leaves of nylon fabric were placed. Long embroidery threads were inserted on overlapping net fabric at the ends.

3. Discussion

1) On an average a tailor making two ladies suit in a day generates a kilo of waste in a week. Twenty fabric pieces were taken as samples for testing.
2) Out of 20 samples, two were identified as Silk, 3 samples of Cotton, 5 samples of Nylon and 10 samples of Polyester and its blends.
3) Segregation and analysis of fabric waste showed that 75% of the samples were non-biodegradable and will not degrade when thrown in landfills.
4) 150 samples were developed. The time taken to develop these samples vary according to design.
5) The time consumed in arrangement of samples was less as compared to the samples in which appliques were inserted.
6) This fabric cannot be used as a base fabric for product development; it can only be used as patches or design effects to accentuate the aesthetic appeal of different products developed in areas where strength is not a prerequisite.
7) Despite the fact that the fabrication of these products is time consuming making it an expensive product, the recycling component of this product attracts the niche market. Since the customers are becoming more environmental conscious, some brands needs to work upon this idea of recycling waste and bring the change in the mode of handling waste trims in India.

4. Conclusion

Technological innovation of using water soluble films in an innovative manner to convert textile waste into patches of fabric. This can create awareness amongst the various stakeholders both at manufacturing and consuming ends to find sustainable ways of recycling pre-consumer waste. It's a step towards systemization of textile waste management system due to absence of its policy measures. It can also reduce ecological footprints of textile fabrication units by adopting this technology as part of their corporate social responsibility compliance. It can generate livelihood option for a semi-skilled labor.

5. Acknowledgements

This work is supported by a grant under Delhi University Innovation Projects 2015-2016.

References

[1] Vishnoi. A, "Environment Protection by Textiles Recycling: A Route to Sustainability", 2013.
[2] Muthu. S, "Carbon footprint reduction in the textile process chain: Recycling of textile materials", Fibers and Polymers, The Korean Fiber Society, 2012.
[3] Norris. L, "Recycling Indian clothing: Global Contexts of Reuse and Value", 2010.
[4] Bairagi. N, "Recycling of Textiles in India", 2014.
[5] Council for Textile Recycling, Don't Overlook textiles, (1997).
[6] Hawley. J, "Digging for Diamonds: A Conceptual Framework for Understanding
[7] Reclaimed Textile Products", 2006.
[8] Abraham, N. (2011).The apparel aftermarket in India- a case study focusing on reverse logistics. Pearl academy of fashion, New Delhi, India. journal of fashion marketing and management : An international journal, vol **15** iss 2 pp. 211-227
[9] Agarwal, R., Sharan, M. (2015). Municipal textile waste and its management. Research journal of family, community and consumer sciences. Vol. **3**(1), 4-
[10] Eryuruk, S. H. (2012). Greening of the Textile and Clothing Industry. Department of Textile Engineering, Textile Technologies and Design Faculty, Istanbul Technical University, Istanbul, Turkey, Fibres and Textiles in Eastern Europe 2012, 20, 6A (**95**): 22-27.
[11] Farrant, L. (2008).Environmental benefits from reusing clothes. Master thesis. DTU technical university of Denmark, Department of management engineering.
[12] Farrant, L., Olsen, S. I., Wange, A. (2010). Environmental Benefits from Reusing Clothes, Discussion Article. Int J life Cycle Assess (2010) 15: 726- 736, Department of Management Engineering (DTU- MAN) Technical University of Denmark.
[13] Fletcher, K. (2008). Sustainable fashion & textiles Design Journeys. London: Earthscan.
[14] Gardetti, M.A., Muthu, S.S. (2015). Sustainable apparel? Is the innovation in the business model? - The case of IOU project. Textiles and clothing sustainability, a Springer open journal, (2015).DOI 10.1186/s40689-015-0003-0
[15] Wilson, L.(2015) the sustainable future of the scottish textiles sector: challenges and opportunities of introducing a circular economy model, textiles and clothing sustainability, a springer open journal, 2015,doi 10, 1186/ s40689-015-0005-y
[16] Yacout, M.M.D., AbdEl- Kawi, M.A.(2015), Hassouna, S.M., applying waste management in textile industry: case study an Egyptian plant, the open conference proceedings journal, 2015,6, 35-40.
[17] Zonatti, W. F., Guimaraes, B. M. G., Duleba, W., Ramos, J.B.(2015), Thermoset composites reinforced with recycled cotton textile residues, textiles and clothing sustainability, a springer open journal, (2015). DOI 10.1186/s40689-014-0001-7
[18] Yee, L.W., Hassan, S.H., Ramayah, T. (2016). Sustainability and philanthropic awareness in clothing disposal behaviour among young Malaysian consumers. a springer open journal, January-March 2016:DOI: 10.1177/2158244015625327
[19] http://cdn.intechopen.com/pdfs-wm/32561.pdf Accessed on 17 August, 2014
[20] http://ukwin.org.uk/oppose-incineration/Accessed on 25 August, 2014
[21] http://homeguides.sfgate.com/meaning-three-rs-reduce-reuse-recycle-79718.html Accessed on 12 September, 2014
[22] http://textilelearner.blogspot.in/2012/02/textile-recycling-importance-of-textile.html Accessed on 27 September, 2014.

Author Profile

Dr. Charu Gupta has been teaching PG courses of 'Dyeing and Printing' and 'Retail merchandising' for the last 8 years. She has guided 8 PhD and has 3 ongoing currently. She has several Innovation Projects funded by the University of Delhi to her credit titled 'Extraction of Microbial colorant from fungus for use as a textile dye'; 'Sourcing if fabrics for home furnishings in India'; 'Developing products using textile waste and water soluble films' in the span of 2013-2016. She has published several research papers in journals having high impact factors. Apparel Textile & Design Centre (ATDC) has appointed her member a Technical Expert for their Board of Governers for 2013 onwards

Neeti Vaid received the B.Sc. and M.Sc. degrees in Development Communication from University of Delhi in 2005 and 2007, respectively. Since 2008, she has been working as Assistant Professor in the Department of Development Communication and Extension, Institute of Home Economics, University of Delhi. She has various research projects at her credit titled 'Participatory Communication for Ward Transformation', 'Opportunities for Women Empowerment through Value Added Food Products', 'Positive Deviance approach to identify positive micro behaviors in Urban Delhi Slums and Bihar on family planning' and 'Assessment, Awareness and Action against Female Foeticide for Achieving Gender Equality and Women's Human Rights' .Currently, she is working as project investigator on a research study on recycling of pre-consumer textile waste funded by Delhi University Innovation Project Scheme 2015-2016.

Akanksha Jain received the B.Sc and M.sc degrees in Textiles & Clothing from Delhi University. Cleared NET exam in 2008 and completed B.Ed. She have 2 years of industry experience in buying house (Speciality Merchandising Services) and fashion house (Paridhi a digital printing brand), few years of entrepreneurship experience (participated in many exhibitions with own designed collection), 5 years of teaching experience in private and government institutes including Delhi University. Designed and shot online teaching modules. Currently working as a Guest lecturer in Institute of Home Economics, Delhi University and project investigator in Innovation Projects 2015-2016 under Delhi University.