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RESEARCH ARTICLE

Textile solid waste in product development studies

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Abstract: Textile solid waste disposal and utilization is currently an important concern worldwide. Fashion and traditional articles of textiles are sourcing the solid textile waste generation. An increasing population and consumption of fiber and textile articles emphasize the development studies for the re-use of solid textile waste. Production of textiles is accompanied by the release of volatile emission and effluent during processing, and disposal of fibrous articles are producing solid waste. The hazardous waste generated from the textile can be seen as pre- consumer solid waste (fiber, yarn, and fabric pieces), processing waste (volatiles, chemicals and effluent release during the process), and post- consumer waste (textile fabric, yarn, apparel, home textiles, technical textiles, *etc.*) dispose to environment following the service life. Therefore, re-using the fiber and textile articles can significantly reduce undesired effects to environment. Designing the products using solid textile waste can be a useful source for reducing the environmental hazard. This study describes the re-use of various fiber and textiles, though the case studies, particularly denim fabric, in designing the products for home decoration.

Keywords: fiber, textile waste, denim, post-consumer

1 Introduction

Textile fashion world is playing important role in generating hub of business activities. A variety of fibers and chemicals are used in production to meet the consumer demands. The population around the world in different regions is increasing resulting in higher demand for the consumption of fibers. There remains an increasing trend toward using the fashion and furnishing textiles. Significant increase in consumption was noted in the volume of clothes bought per person; an increase of 40% in EU during 1996–2012 [1]. The fast fashion changing placed demand for more textile consumption. The fast fashion cycle is leading a higher level of consumption and waste generation [2]. The significant rise in textile waste is seen as increasing 811% since 1960, and this is partly an effect of fashion. It was indicated that the number of times a piece of clothing used prior being discarded decreased 36% in the past 15 years [3].

World cotton mill consumption was estimated at 26.3 million tons in 2019. In between 2007 and 2019, the cotton fiber consumption was varying from 26.6 million tons to 26.3 million tons. However, the polyester is an important fiber largely consumed in fashion wear including the polyester- cotton blends, and polyester- cellulose blends. Polyester production is observed to enhance by seven times greater than three decades ago, i.e. increasing from 8.5 million tons in 1989 to 55.5 million tons in 2018 [4]. The world fiber demand is projected to 121 million tons by 2025.

Circular economy is increasingly receiving interest as the end of service of textile articles poses new challenges, and it will be an environmental hazard if not properly disposed. Reusing the textile materials is currently an important subject for material resource recovery, and saving the environment from potential hazardous material. Presently both the industrialized and developing countries need to have good practices and strategies to control the textile waste.

Strategies are now required for the handling and disposal of solid textiles waste [5]. The idea of manufacturing value products from textile waste received interest [6]. Post- consumer textile waste is continuously generated by each individual, relatively more by the people with an increased amount of disposable money for fashion and an improved level of social status in life style. Importantly, more than 90 percent of post- consumer solid textile waste can be re-used. Moreover, the disposing the solid waste through landfill is not an environment- friendly practice. Therefore, waste elimination via reduction, reuse, and recycling of the waste materials is an obvious required activity [7, 8].

The solid waste generation is presently a serious challenge in Pakistan, and particularly in Karachi. A study reported in 2013 has shown that 9,000 tons of solid waste was generated daily in Karachi. This amount of solid wastes was expected to increase with rising population and business activities reaching to 16, 000- 18, 000 tons per day by 2020 [9].

The work reported in this study is addressing the appropriate textile waste utilization in designing the furnishing products. The aim of this study is to find out used textile materials for the possible designing of product through the known means of processing. The products designed through using waste textile materials provided the material hazard mitigation, and at the same time introduced the products that were achieved at relatively smaller cost relative to the competitive products available in the market.

The solid material (yarn, fiber and fabric), release of volatiles, used chemicals and effluent, post- consumer solid textile waste- all pose the hazardous effect to environment and living species. The hazardous waste generated from the textile may be categorized pre- consumer solid waste (fiber, yarn, and fabric pieces), processing waste (volatiles, chemicals and effluent release during the process), and post- consumer waste (textile fabric, yarn, apparel, home textiles, technical textiles, *etc.*) dispose to environment following the service life (Figure 1).

Presently, wastewater coming from the textile solid processing, particularly the textile dyeing process, is the main textile waste concern to eliminate the environmental pollution. There are several textile wastewater treatment methods are currently in studies. These method generally be divided into physical, chemical oxidation, biochemical, and other advanced oxidation processes. Physical methods include precipitation, coagulation, floating, adsorption, flotation, filtration, *etc.* Chemical treatments are neutralization, electrolysis, redox, ion exchange, electrodialysis. Biochemical methods are microbial metabolism turning the wastewater organic pollutants into stable and harmless substances [10].

Textile finishing organizations significantly depends upon the continual energy supply from fiber production to finished fabric. Textile processing areas that heavily consume water and electricity can be significantly improved in terms of reduced energy utilization and minimum energy loses through exercising improved housekeeping and standard management practices [11].

Use of environment- friendly chemicals, dyestuff, pigment, finishing agents, *etc.* is another approach to reduce air pollution, and producing the effluent that is less hazardous to water living bodies.

Processing hazard resulting from the textile industry may be indicated by the textile dyeing process that releasing volatiles, chemicals and effluent. The environmental hazard coming from the textile dyeing industry is resulting from three types of materials including colorants (dye or pigment), chemicals used and solid content (metal, microfiber, *etc.*). Textile dyeing is currently the concern of environment hazard generation. The processing conditions used in dyeing may influences variation in pollutants generated [1, 12]. (see in Figure 1)

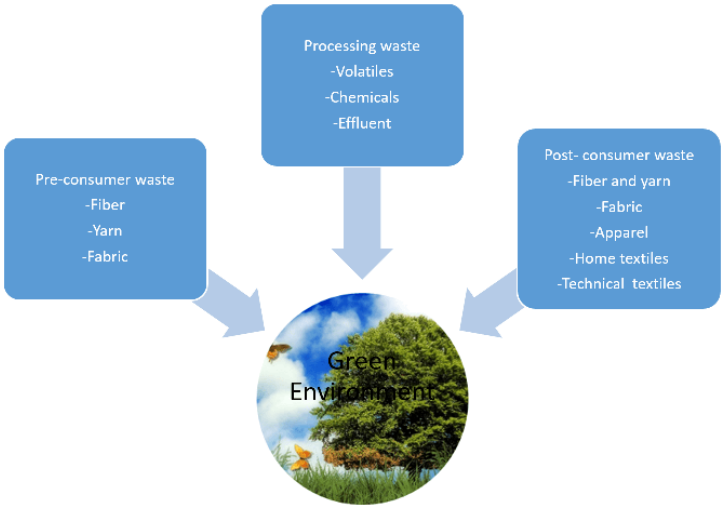

Figure 1 Hazardous waste posed to environment by textile industry

If the textile waste generation continues at same pace, by 2050, the textile sector is estimated to introduce about 26 % of the world carbon. Moreover, the textile and apparel sector's nonrenewable raw material usage will reach 300 million tons resulting in the microplastic quantity to 22 million by 2050 [13].

The denim industry is a known environment polluter introducing water and air hazard [8, 14]. Possibly, since the shifting of denim industry from indigo dye obtained from natural plant source to synthetic indigo dye utilization; the denim industry remain a subject of serious of environmental challenges [15]. Denim waste, utilization can reduce the environment load of denim fabric production, saving the environment from particulates, SO_2, Nitrous oxide, VOCs, PVA, Starch, $Na_2S_2O_4$,soda ash, hypochlorite, formaldehyde and silica [16]. The environmental impacts of indigo and Sulphur dyes, effects of auxiliaries and finishing chemicals used were discussed [17]. Therefore, the wastewater released from the denim textile industry remain the subject of studies, including nano- filtration and biological treatment, to reduce its hazardous effect to environment [18]. Denim processing industries now improving the processes to reduce the environment hazard. It was indicated that 40–60% of the studied washing factories demonstrated an improved filtration system for TDS and TSS values, however, only 40% of factories produced clear wastewater [19].

In fact the fundamental focus of this work is to make the use of textile solid waste taken from the home. The product design was progressed through the research moodboard followed by the element extraction, design development and product making. Incorporating the work from moodboard, motif, design development, and colorways will extend volume of this study too large. Therefore, the product designed product presented with basic structure to demonstrate the usefulness of home- based solid textile waste. Fabric surface design is indeed conventional. Improving the design through embellishment and more creativity is part of the next stage of work.

Indeed different products were developed, however, only selected are reported here as case study. Names of other products are patio area sitting cushion and chairs, beans beg, stool, *etc*. Our further work of adding the embellishment to the product utilized the dyeing and printing effects using the natural plant and fruit waste for coloring the waste and incorporating them in the product design, or using as embellishment.

Indeed the product functionality is an important part of product performance. The functionality tests important for rug include seam strength, tensile strength of fabric strips, elongation at break, abrasion/ pilling resistance, water repellency. Testing for hammock include tensile strength, elongation at break, abrasion/ pilling resistance. However, these were not the part of approved project study.

2 Materials and methods

2.1 Materials

The variety of used fiber, textile and clothing articles collected from home were selected to be re- used without any further chemical processing.

Textile solid waste including fiber, fabric, ball fibers, denim fabric pieces (large and small), rope, threads for stitching. Identification of used fiber types and weave structure was not required since the purpose of work was to use any available waste at home.

Used denim fabric pieces of different colors were used in making the rug. Material used in swing include wood, rope, hooks, denim fabric black, white wool thread, ply for tassel. Materials used in making the cushions include canvas fabric, threads for stitching (white and black), black wool thread, ply for tassels, anchor threads for tying of tassels (beige, pink, sea green, maroon, dark blue, zip for cushions stitching, ball fiber for stuffing the cushion.

2.2 Methods

2.2.1 Product designing

The products were design through using the basic design work including the creation and drawing of elements, motif, and sketches. The main function done was stitching fabric to product design. The final product design presented in this study was based on the product sketch design using mixed media. The work was performed for product designing in terms of the physical shape and structure, and any coloration work was limited to print only.

The filling material used in cushion was containing the used fibers.

The same product can be produced using other high- strength fabric. However, we target the denim fabric, since the denim processing is associated with carcinogenic chemicals and using the waste denim will prevent the further processing to produce it.

2.2.2 Manufacturing

All the product design was based on using the textile waste (fiber, denim fabric pieces, upholstery, threads, ball fibers, *etc*.) from home and converting them in the form required for the

design of the product. Necessary processes including dyeing, printing, product embellishment, and finishing effects were commissioned as required by the product design.

3 Results and discussion

3.1 Case study I: Design of rug

The solid textile waste used in the designing of rug for home interior were the used denim pieces (Figure 2). The denim fabric pieces were cut and sewn to form a patchwork design (Figure 3) for rug to be used in home decoration through stitching and interlocking. The obtained rug design can used in interior home decoration. Variation in the pattern and design of rug color and size is possible depending upon the requirements. Denim fabric waste is produced in industry as pre-consumer pieces during cutting and stitching of denim wear (Figure 4). Post-consumer waste of denim fabric is produced at home that can be converted in fabric stripe and pieces to meet the design of rug.

Figure 2 Denim fabric waste used in the design of rug for home interior

Figure 3 Stitching and interlocking of waste denim fabric pieces for product design

Figure 4 Completed floor rug using waste denim fabric

3.2 Case study II: Design of hammock and cushions

The making of hammock and cushions was initiated with the development of motifs to make the product design attractive. The developed sketches used are provided in Figure 5.

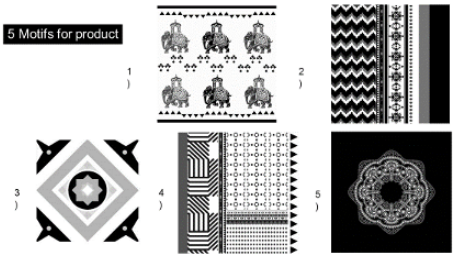

Figure 5 Motifs developed for making the hammock and cushion

Large size used denim fabric can be a source of designing hammock for home and garden area (roofless area). The pieces of denim fabric were cut to fit the design and stitched as shown in Figure 6 and 7. Supporting the hanging of hammock was made possible by a three feet long circular wood stick was used (Figure 8) in circled from that was connected with rope for hanging purpose.

Figure 6 Piece of black denim fabric used in making hammock

Figure 7 Supporting circular wood stick for mounting the hammock

Figure 8 Large pieces of waste denim fabric sewn to form hammock

The waste material consumed in designing the cushion for hammock included canvas fabric, threads for stitching white and black, black wool thread 4 ply for tassels, anchor threads for tying of tassels in beige, pink, sea green, maroon, dark blue colors, zip for cushions stitching, ball fiber for stuffing the cushion. The final product comprising hammock and cushions can be seen in Figure 9.

Figure 9 Final product design comprising hammock and cushions

4 Conclusion

Fiber and textile articles are the need of every individual, therefore, the fiber generation is a continuous effect. Circular economy is presently emphasized with an increasing trend in the human population around the world. Re- using the fiber and textile waste will save the natural environment from solid hazardous materials, reducing the energy consumption in product making, and discharge of chemicals to ground water.

The denim industry is a known environment polluter in terms of producing water and air hazard. Since the denim coloration using the synthetic dyestuffs, the denim industry remain the source of pollutant producer. This study is reporting the case studies where denim waste was used in the design and development of products. The utilization of denim waste can reduce the environment load of denim fabric production and save the environment from particulates, SO_2, Nitrous oxide, VOCs, PVA, Starch, $Na_2S_2O_4$, soda ash, hypochlorite, formaldehyde and silica, *etc.* The environmental impacts of indigo and Sulphur dyes, effects of auxiliaries and finishing chemicals can be reduced.

This study is reporting the case studies where products were designed using the solid textile waste including threads, ball fibers, fabric, and denim fabric pieces, *etc.* The products were successfully developed including rug, hammock and cushions.

Conflict of interest

Authors declare no conflict of interest in the publication of this manuscript.

References

[1] Uddin, F. Environmental hazard in textile dyeing wastewater from local textile industry. Cellulose, 2021, **28**: 10715-10739. https://doi.org/10.1007/s10570-021-04228-4

[2] Pensupa N, Leu SY, Hu Y, *et al*. Recent Trends in Sustainable Textile Waste Recycling Methods: Current Situation and Future Prospects. Chemistry and Chemical Technologies in Waste Valorization, 2017, **375**: 76. https://doi.org/10.1007/978-3-319-90653-9_7

[3] Alexander G. Good, Better, Best- Reducing Textile Waste, 2021. https://earth911.com/home-garden/good-better-best-reducing-textile-waste

[4] Ruiz L. Global Textile Fiber Demand: Trends and Forecast Economist International Cotton Advisory Committee International Cotton Advisory Committee, 2021.

[5] Yalcin-Enis I, Kucukali-Ozturk M, and Sezgin H. Risks and Management of Textile Waste. In: Gothandam K., Ranjan S., Dasgupta N., Lichtfouse E. (Eds) Nanoscience and Biotechnology for Environmental Applications. Environmental Chemistry for a Sustainable World, 2019, Volume 22. https://doi.org/10.1007/978-3-319-97922-9_2

[6] Kazakevičiūtė G, Ramanauskienė R and Abraitienė A. A Survey of Textile Waste Generated in Lithuanian Textile, Apparel and Soft Furniture Industries. Lietuvos Tekstilės, Siuvimo Ir Minkstu Baldu Gamybos Imonėse Susidaranciu Atlieku Apzvalga, 2008, **44**(2): 41-48.

[7] Reis Dos J. Effect of textile waste on the mechanical properties of polymer concrete. Materials Research, 2009, **12**(1): 63-67. https://doi.org/10.1590/S1516-14392009000100007

[8] Ütebay B, Çelik P and Çay A. Textile Wastes: Status and Perspectives, Waste in Textile and Leather Sectors, Ayşegül Körlü, IntechOpen, 2020. https://doi.org/10.5772/intechopen.92234

[9] UN HABITAT. Baseline Study for Solid Waste Management – Karachi, 2013. https://www.unescap.org/sites/default/files/SWM-COMPLETEREPORTKARACHI12-Mar-13.pdf

[10] Pei G, Yu F and Zhang L. Comparative Analysis of dyeing wastewater treatment Technology, International Conference on Civil, Transportation and Environment (ICCTE, 2016).

[11] Uddin F. Energy Management and Energy Crisis in Textile Finishing. American Journal of Energy Research, 2014, **2**(3): 53-59. https://doi.org/10.12691/ajer-2-3-2

[12] Islam MR and Mostafa MG. Characterization of textile dyeing effluent and its treatment using polyaluminum chloride. Applied Water Science, 2020, **10**: 119. https://doi.org/10.1007/s13201-020-01204-4

[13] Ütebay B, Çelik P and Çay A. x Textile Wastes: Status and Perspectives. In (Ed.), Waste in Textile and Leather Sectors, 2020. https://doi.org/10.5772/intechopen.92234

[14] Anon. Report Breathless for Denim Jeans, Clean Clothes Campaign, 2021.

[15] Amutha K. Chapter 2: Environmental impacts of denim, Subramanian Senthilkannan Muthu (Ed.), In The Textile Institute Book Series, Sustainability in Denim, 2017. Woodhead Publishing: pp. 27-48. https://doi.org/10.1016/B978-0-08-102043-2.00002-2

[16] Periyasamy AP and Militky J. Chapter 7: Denim processing and health hazards, Subramanian Senthilkannan Muthu (Ed.), In The Textile Institute Book Series, Sustainability in Denim, 2017. Woodhead Publishing, pp. 161-196. https://doi.org/10.1016/B978-0-08-102043-2.00007-1

[17] Schrott W and Paul R. Chapter 20: Environmental impacts of denim manufacture, Roshan Paul (Ed.), In Woodhead Publishing Series in Textiles, Denim, 2015. Woodhead Publishing: pp. 563-580. https://doi.org/10.1016/B978-0-85709-843-6.00020-2

[18] Sahinkaya E, Uzal N, Yetis U, *et al*. Biological treatment and nanofiltration of denim textile wastewater for reuse. Journal of Hazardous Materials, 2008, **153**(3): 1142-1148. https://doi.org/10.1016/j.jhazmat.2007.09.072

[19] Mohammad S, Mohammad AK, Sayem ASM, *et al*. Quantifying environmental sustainability of denim garments washing factories through effluent analysis: A case study in Bangladesh. Journal of Cleaner Production, 2021, **290**: 125740. https://doi.org/10.1016/j.jclepro.2020.125740