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Waste flow analysis in textile and apparel sector, A case study of textile and apparel wet processing industries in Sri Lanka

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Abstract: Textile and the apparel sector in Sri Lanka, which contributes 10% to the country's national GDP and employs a workforce of 350,000, is one of the key industrial sectors. Though the sector is mostly selling to export markets in the EU and the focus of sustainability is high, the sector's waste generation is not clearly understood. This study surveyed 20 textile and apparel wet processing industries, i.e. garment washing, dyeing plants and fabric mills in the Western Province in Sri Lanka to identify their waste generation rates, composition and current management practices. The data collection was based on the structured questionnaire and face-to-face interviews conducted with the top management of these industries. For the purpose of this study, solid waste generation rate of 0.2 kg/ product kg and 0.180kg/ product kg, excluding hazardous waste, were ascertained in medium and large-scale garment washing and dyeing factories. The waste generation rate in medium and large fabric mills were 0.15kg/ product kg and 0.18kg / product kg, excluding hazardous waste. In addition, the hazardous waste generation rate in each sector was also evaluated

Keywords: Industrial Symbiosis, Recycling, Reuse, Waste treatment

1 INTRODUCTION

The global textiles and apparel industry greatly contribute to world trade flows, particularly, in transitional economy countries where clothing accounts for a large share of their total exports [1]. The textile and apparel industry has acquired an integral part in Sri Lanka's economy. It is the largest net foreign exchange earner in the country since 1992 [2]. In the process of an upward development trend, the country has been experiencing remarkable growth in the textile and apparel sector. The apparel and textile industry contribute six percent to Sri Lanka's GDP while accounting for 40 percent of the country's total exports in 2020

Nevertheless, the development of the textile industry directly causes to increase the pre-consumer waste generation [3]. Hence, the degree of environmental pollution due to waste generation from the textile and apparel sector has seen an increase with the development of the sector. Sri Lanka is faced with a number of challenges in terms of waste management, and this includes challenges in relation to recycling [4,5,6]. Local authorities in particular have failed to cope with the increasing problem of solid waste management [7, 10]. The need for a clear understanding of the quantity and characteristics of the waste being generated is a key component to develop a robust and cost-effective solid waste management strategy [11,12].

Further, the effective control and correct management of industrial waste is vital to manage natural resources, facilitate environmental protection as well as to ensure health and wellbeing of the citizens [13]. On the other hand, improper management of industrial waste creates many problems for humans and the environment; therefore, proper control and management, and comprehensive planning and research are necessary to protect the health of the nation and safeguard the environment [14]. In the absence of accurate information on waste generation and management in relation to Sri Lanka's textile and apparel sector industrial waste, as well as the dearth of research on the same, the present study aims to identify waste generation, its characteristics and management practices through a case study.

2 GOALS OF THE PAPER

The paper intends to:

1. Identify the average waste generation rates of different scale fabric mills, garment washing and dyeing factories.
2. Analyze the composition of different types of waste generated in the above factories.
3. Evaluate current waste management and disposal mechanisms followed by this sector and analyze possible directions for sustainable waste management.

3 MATERIALS AND METHODS

For the purpose of the study, 10 garments washing and dyeing plants and 10 fabric mills were evaluated during the period from January 2019 to January 2020. Prior to selecting the companies for the survey, their consent to participate was obtained. All selected industries are ISO 14,001 Environmental Management System (EMS) certified and export their goods to the EU market

3.1 Data Collection

Screening of the industries was carried out by direct contacts based on their willingness to participate. With 20 industries selected for data collection, they were segmented into medium or large categories. Data collection was based on a structured questionnaire and through face-to-face interviews conducted with the top management of the respective companies. Given below are the key aspects incorporated into the questionnaire:

1.Type of industrial sector
2.Scale of the industry category and the ownership
3.Number of workers
4.Production volume
5.Number of personnel involved in waste management in the factory
6.Types of primary material
7.Types of product
8.Types of waste
9.Characteristics of waste
10.Weight and volume of waste generation per month
11.Types of containers used for waste storage
12.Methods and frequency of waste collection
13.Volume and time of interim storage
14.Re-use, Recycling and on-site procession of waste

15.Disposal methods
16.Cost for waste disposal

Subsequently, the data collected through the questionnaire were analyzed to determine the waste generation and management within the surveyed industries.

4 RESULTS AND DISCUSSION

As per the results of the study presented in Table 1, each waste category in the selected 20 industries was prioritized, arranging them in the descending order of their magnitude. Pareto chart is used for preliminary identification of the most significant waste stream and to discover the 'vital' streams that accounted for 80% of waste generation. The outcome of the analysis is given in Table 1. The average waste generation rate, in a large-scale fabric mill and large-scale garment washing and dyeing factory was 1,914.8t and 673.6t per year respectively while in a medium-scale fabric mill and a medium scale garment washing and dyeing factory generate waste as 855.3t and 299.2t per year respectively. Effluent treatment plant (ETP) sludge was the major waste component generated in both fabric mills and garment washing and dyeing factories.

Fabric and yarn waste were the second major waste component in the fabric mills, irrespective of whether a large-scale industry generates approximately, twice the value when compared to a medium-scale plant. However, its amount was insignificant in the garment washing and dyeing factories.

Table 1: Average waste generation (t/year)

Waste Types	Medium scale Fabric mills (FMM)	Large Scale Fabric Mills (FML)	Medium Scale Garment Washing and Dyeing (GWM)	Large Scale Garment Washing and Dyeing (GWL)
Chemical Containers	2.6	8.8	3.5	7.2
Contaminated Fabric	21.7	51.4	1.5	4.9
ETP Sludge	253.6	811.8	121.3	405.6
E-Waste	0.5	1.2	0.8	1.5
Expired chemicals	2.4	6.0	3.5	5.5
Fabric and yarn waste	319.5	612.	5.6	8.7
Food Waste	15.1	25.34	18.8	22.6
Metal	5.9	8.4	6.9	7.9
Paper & Cardboard	15.6	23.7	10.7	15.9
Polythene	42.6	57.8	31.8	48.9
Thread Cone (Plastic)	41.6	67.	**	**
Waste Oil	1.8	2.8	2.6	2.7
Wood and Wood Pallet	35.8	54.8	43.5	56.9
Mixed waste	96.6	183.3	48.7	85.3
Total	**855.3**	**1914.8**	**299.2**	**673.6**

FMM-Medium Scale Fabric Mills
FML- Large Scale Fabric Mills
GWM-Medium Scale Garment Washing and Dyeing Plant

GWL-Large Scale Garment Washing and Dyeing

Table 2: Summary of waste generation rates (excluding hazardous waste from the calculation) in fabric mills and garment washing and dyeing factories

Table 2: waste generation rate (kg/ kg product)

Category	Waste Generation Rate
FMM	0.15
FML	0.18
GWM	0.18
GWL	0.20

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4.1 Hazardous waste generation

The identification of hazardous waste generation was based on the national schedule waste management guideline. Table 3 shows the amount of hazardous waste from the total waste generation in each industrial segment.

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Table 3: Hazardous waste generation

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FML	46.03
GWM	44.63
GWL	63.50

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GWM	44.63
GWL	63.50

Due to the lack of technology and facilities for hazardous waste treatment and disposal in the country, most of the surveyed industries disposed of their hazardous waste by co-processing in cement kilns and incineration through in-house boilers to recover energy from waste. According to the survey 90 % of hazardous waste generated in the surveyed industries was co-processed at the cement kiln, including 100 % of ETP sludge. Several types of hazardous waste are accumulated in the factories due to the unavailability of treatment options.

4.2 Waste treatment methods

The following options are identified as the most common waste treatment methods adhered to by the companies. The proportion of primary waste disposal methods was calculated and is shown in Fig. 1.

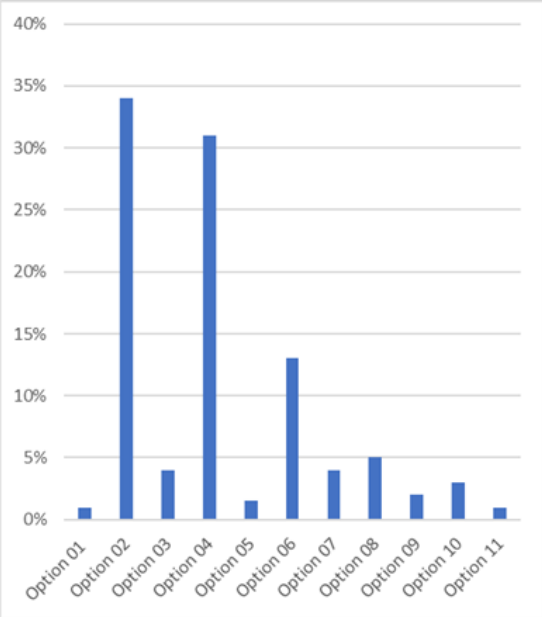

Fig.1: Waste treatment methods (%)

Option 01: Reuse within the facility
Option 02: Reuse for other industries
Option 03: Returned to supplier
Option 04: Co-processing in cement kiln
Option 05: Energy recovery within the facility
Option 06: Sold to licensed recycling company
Option 07: Land filling
Option 08: Collected by scavengers for reuse or recycle
Option 09: Collected by third party and exported for recycling
Option 10: Open dumping
Option 11: Storing
The result showed that 80 per cent of industries separate

Their waste at the generation point. The result also indicated that the most commonly used method for temporary storage of the waste in the industries is, closed space (55.5%) and open space (30.5%). Polyethylene bag (9.5%), box (3.2%) and barrel (1.3%) were the other methods adopted for the temporary storage of industrial waste. The information collected through the survey revealed that 65.5% of industrial waste was disposed of on a monthly basis while 31.5 % was disposed of weekly, with 1.5% daily and 0.5% on an annual basis. The results indicated that 15% of the wastes were disposed of by the industrial owners while the private sector was responsible for the disposal of 85% of industrial waste.

4.3 Waste disposal

Final waste disposal methods are identified and shown in Fig. 2. Of the total waste generation, 33% is used to recover energy, 28% for recycling and 31% for reuse. The rest of the waste end up in land filling (4%), open dumping (3%) and storing (1%) at industries due to the unavailability of a disposal mechanism in the country.

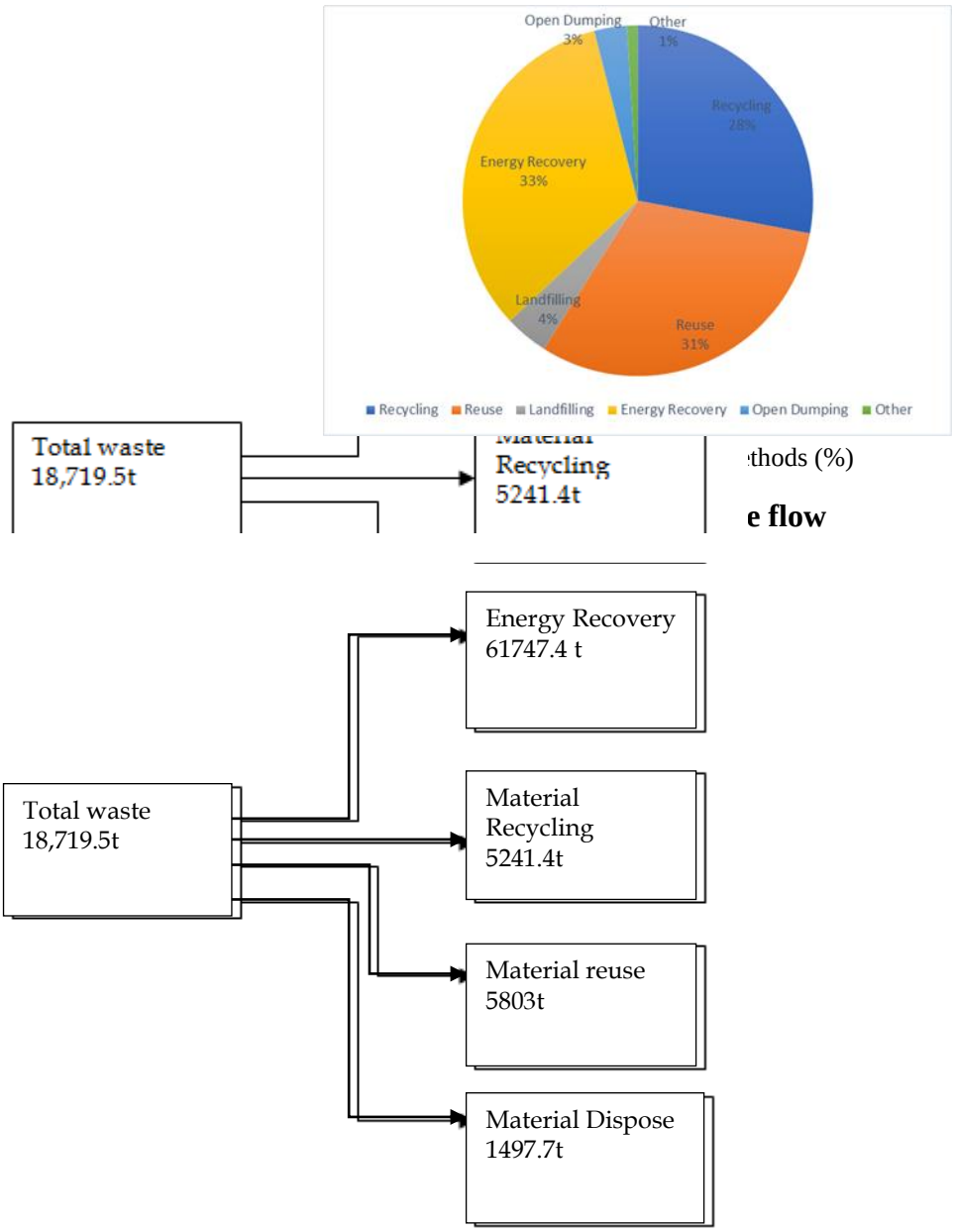

Fig. 3. Waste flow analysis

As shown in Fig. 3, an analysis of the waste flow was carried to evaluate the material and energy recovery from the waste. The textile and apparel wet processing sector generates a significant amount of hazardous waste throughout the manufacturing process mainly due to ETP sludge generation involved in the wastewater treatment process. However, no infrastructure has been developed in the country to dispose of industrial hazardous waste. Nevertheless, the manufacturers are obliged to meet the EU buyers' criteria on waste disposal. Therefore, 90% of industries have opted to co-processing at cement kilns and incineration as their main disposal mechanism for hazardous waste. Hence, the energy recovery forms a large share in the waste disposal options.

The material recycling rate also remains high in this sector. The paper, polythene, cardboard and metal are the common recyclable materials generated in the sector. Ninety percent paper and cardboard, 60% polythene, 70% metal and 30% plastic and chemical container wastes were recycled at the surveyed

industrial supply chain. The reason for the less quantity of polythene and plastic being recycled in this sector is due to the contamination of such material with chemicals. Therefore, these contaminated materials are disposed of by co-processing at cement kilns as hazardous waste.

Due to the unavailability of textile recycling facilities in the country, the selected recyclable fabric and yarn waste are exported for recycling through collectors.

Fabric waste, plastic thread cone, wood, plastic containers and food waste are the main types of waste identified under reuse component. Ninety five percent of food waste generated in the companies are collected by third party collectors and utilized as animal feed for piggeries. It has been identified through the survey that 98% of plastic thread cones are sent to the supplier for reuse.

5 CONCLUSIONS

The paper identified the types of waste generation in two subsectors of textile and apparel wet processing, i.e the fabric mills and the garment washing and dyeing industrial sector during the period from January 2019 to January 2020. Following the study, it was identified that ETP sludge was the dominant waste type generated at textile wet processing industries. However, fabric mills generate larger quantities of fabric and yarn waste during the manufacturing process although it is insignificant in the garment washing and dyeing sector. The result highlights a larger quantum of solid waste generation in this sector, including a considerable amount of hazardous waste.

However, given that Sri Lanka currently lacks the capacity to dispose hazardous waste, a major portion of such waste is co-processed at cement kilns. While the waste management and its disposal are at an acceptable level, the most common waste disposal mechanism in the sector is energy recovery through co-processing, recycling and reuse. Only 8% of waste is disposed of without any resource

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