Efficiency of Plastic Waste Management in the Apparel Industry

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Abstract— Managing of waste can be a very challenging task in the apparel sectors since they have to deal with a wide variety and large volumes of different kinds of waste. Hence a well-structured and a comprehensive plan of action for the management of these waste is required because this has become an important and an integral part of the society. Heavy attention should be given on the efficient and sustainable management of plastic waste in the apparel industry due to the increased cost and the decreasing availability for landfill space for sanitary landfills and care should be taken to implement such a process with the minimum possible environmental impacts.

This analysis explained and identified how the factors affecting the efficiency of the processes helps to improve the efficiency of the process and also to investigate the current situation and various ways of handling plastic waste along with analysing whether further generation of waste is minimized as output. A significant positive relationship between the independent variables product design and reworks with the plastic waste management was identified based on the Pearson correlation coefficient while a positive relationship which was insignificant was obtained between the independent variables lead time and reworks respectively with the dependent variable plastic waste management.

This paper also contributes with proposals for future research such as the need of a more qualitative approach to yield better results and the need to expand the currently selected base for the research with a greater number of statistical analytical tools along with the proposal of novel and developed methods of sustainable plastic waste management in the apparel industry.

Keywords— **plastic waste, apparel industry, recycling**

I. INTRODUCTION

Apparel industry has an important place in Sri Lanka's economy. It has become Sri Lanka's largest export industry since 1986. It is also the country's largest net foreign exchange earner since 1992. According to the studies conducted by Weerakoon et al.(1996), the major types of waste identified were fabric (43%), paper (4%). cardboard (5%) and polythene (4%). The remaining percentage (44%) of waste include sand, overlock waste and gunny bags. Due to the observation of a rapid improvement of the apparel industry in the recent years and also due to its well-known and a clearly visible fact that plastic waste generation has increased immensely due to the economic growth, growth of the global resource consumption and changes in consumption and production patterns; an efficient and a sustainable system is much needed.

But according to Siddiqui et al. (2013), currently only between 5 to 25% of plastic waste is being recycled. Hence various approaches and strategies will be used to manage plastic waste in apparel industry, which would otherwise be dumped into landfills, and eventually contaminates the environment.

Thus, the importance with regard to the reduction of waste generated is highlighted as follows;

"*There is significant potential for reducing the total quantity of waste generated by industries by adopting techniques of minimisation, recovery or re-use and re-cycling, prior to treatment and disposal in an integrated waste management system."* Weerakoon et al. (1996).

Also Weerakoon et al. (1996) highlights the following as well;

"*Waste minimization is in its infancy in the garment industry due to the extremely low disposal costs for wastes."*

Heavy attention should be given on the efficient and sustainable management of plastic waste in the apparel industry due to the increased cost and the decreasing availability for landfill space for sanitary landfills and care should be taken to implement such a process with the minimum possible environmental impacts. The basic concept of managing plastic waste is to use the discarded materials to produce novel products without generating new additional plastic material. Hence this study is carried out to identify the efficiency of plastic waste management and its effects on the apparel industry.

A. Scientific Problem

Can the production lead time, design of the product, rework and system breakdowns (identified as the independent variables) cause an impact on the plastic waste management (the dependent variable) in the apparel industry and how it will indirectly cause an impact to the efficiency of the output. A noted significant research gap with regard to the current study area mentioned, will be addressed by conducting the selected research activity.

B. Goal of the paper

To show that there exists a relationship between the independent variable and the dependent variable; to investigate the current situation and various ways of handling plastic waste; analyse whether further generation of waste is minimized as output with the effect of plastic waste management; to propose novel and developed methods of sustainable plastic waste management in the apparel industry.

II. LITERATURE REVIEW

In the modern industrialised world, there can be several different ways in which waste can be generated. Municipal solid wastes (MSW) is often described as the waste that is produced from residential and industrial (non-process wastes), commercial and institutional sources with the exception of hazardous and universal wastes, construction and demolition wastes, and liquid wastes (water, wastewater, industrial processes) (Tchobanoglous & Kreith, 2002). Thus the banned materials cannot be disposed of, where alternative methods need to be used for processing; typically through recycling, reuse or composting. Careful attention need to be provided for the fact that the designation of materials into specific categories differ from area to area and also from country to country where organizations need to adhere to the laws.

Waste that are potentially hazardous to human health or to the environment is called as hazardous waste which require proper disposal techniques. It is equally important to consider that the material property and the concentrations impacts the dangers and the risks posed by them to the surrounding and the human beings. Another major stream of waste can be identified as construction and demolition waste and it consists of materials produced as a result of construction, demolition or renovation projects. Accordingly, Universal waste can be defined in a number of different ways. It can be defined as a set of hazardous materials that is generated in a wide variety of settings, by a vast community, which is present in significant volumes in non-hazardous waste systems (USEPA, 2005). And also it restricts the definition to four classes of materials as well.

A. Recycling

According to Hornby (2005), recycling can be defined as the process of treating things that have already been used so that they can be used again. Recycling in the apparel industry involves the manufacturing of the new clothing product from recycled consumer waste; plastic or waste polyester yarns or fabrics. Negligence in the above mentioned activity will give rise to numerous problems such as loss of resources and energy, thus it will have an impact on the profitability of the industry. According to Gulich (2006b), confirmed that raw materials as well as waste disposal are becoming more and more expensive. Reusing is a method that avoids the item being thrown away and instead used back again to complete the final unit. Both these methods offers organizations with important benefits. The improvement of the production processes which will have an immediate impact in delivering the output and also will contribute to absorb benefits from an environmental point of view. But only a handful of companies are involved in recycling and reusing. Many of the processes are very labour-intensive, for example the sorting of waste (Larney et al, 2009). Hence, this can be a negative point to improve the efficiency of the process, thus if improvements are made, it will create a huge impact on the efficiency of the processes of the industry.

Studies had been conducted in Georgia with regard to the determinants of recycling common types of plastic product waste in environmental horticulture industry in the year 2015. According to Meng et al. (2015), considerations such as difficulties in finding new landfill sites, and restrictions on incineration are forcing the development of more environmentally acceptable alternatives for managing waste such as recycling. For investigation purposes, the study was based on data collected from a survey from environmental horticulture firms in Georgia, where the preliminary focus of the study is to examine the relationship between selected firm features and decisions to recycle commonly used plastic products. Thus it is concluded that the gained insights can be used to lower landfill burdens by enhancing environmental horticultural firm participation in plastic waste recycling (Meng et al, 2015). Based on the findings by Meng et al. (2015), it can be stated that that level of education and awareness provided makes a difference, and respondents with a higher level of educational attainment level are less likely to discard plastic waste in a manner that will damage the environment and its surroundings.

Chemical recycling also known as tertiary recycling and is a term that is used to refer to advanced technology processes which convert plastic materials into smaller molecules, usually liquids or gases, which are suitable for use as a feedstock for the production of new petrochemicals and plastics (Mastellone, 1999). The term chemical is used, due to the fact that the chemical structure of the polymer can undergo an alteration and products of chemical recycling is proven to be useful as a fuel (Al-Salem, S.M. et al, 2009). In order for the chemical recycling to be successful, the technology behind this is the process of depolymerisation, where the end result is a high product yield and minimum waste. The possibility of treating heterogeneous and contaminated polymers with limited use of pre-treatment can be stated as the main advantage of chemical recycling (Al-Salem et al, 2009).

Mechanical recycling is the process which is much familiar with the terminology secondary recycling, is mainly of recovering plastic solid waste for the re-use in manufacturing plastic products via mechanical means as defined by Mastellone (1999). Nevertheless, mechanical recycling opens an economic and viable route for recovery of plastic solid waste, especially for the case of foams and rigid plastics (Zia et al., 2007). It should be noted that even the process of mechanical recycling has its own drawbacks and problem creations is because of the degradation and heterogeneity of plastic solid waste. In order to maintain the cost of the mechanical recycling process at the lowest possible level, the recyclers exert the maximum effort to reduce the number of steps involved. The initial step of the process is the size reduction of the plastic to a more suitable form, and this is usually achieved by milling, grinding or shredding (Zia et al., 2007).

Eco Gear manufactures environmentally friendly apparel by using cutting waste, shredding it into small fibres and combining it with continuous polyester thread made from recycled bottles (McDavid 2008). By using the plastic waste in combination with other substances, the waste managing process can be carried out much efficiently. Also by separating the individual components from the plastic waste, the efficiency can be increased further. Moreover, the zero waste approach mainly harp on the waste prevention rather than waste management at the end of the process. This encompasses more than eliminating waste through recycling and reuse; it focuses on restructuring production and distribution systems to reduce waste (Young et al., 2010). There may be certain obstacles that has to be overcome in order for this concept of prevention rather than reduction. Sometimes it can be unrealistic to achieve complete zero waste condition mainly due to naturally causing errors such as human errors. Yet this theory provides a guiding framework to continuously work towards eliminating waste successfully.

The prime focus of this is to eliminate waste from the outset, which clearly indicates that this will be an impossible task without the heavy involvement from the government and the industry. According to Connett & Sheehan, (2001) zero waste will not be possible without significant efforts and actions from industry and government. Industry and the organizations can take control over matters such as the product design, manufacturing process and other related matters. Government and other institutions will be involved in policy making and implementing the rules and regulations with regard to the matters controlled by the industry and the organizations. Together, both parties will be considerably responsible for the success or failure of achieving a zero waste condition at the end.

B. Independent Variables of the Study

The product design is a terminology that is closely linked with the design for environment concept and this involves the environmental considerations during product and process design (Jackson et al., 2015). The principle underlying the design for environment, as stated in the study conducted by Jackson et al. (2015), is the integration of environmental considerations at the inception of the product and process design phase (Allenby, 1994). The definition of design for environment according to Hsu et al. (2013) is the environmentally-conscious design of a product that aims to minimize negative environmental impacts of the product throughout its useful life to promote positive environmental practices such as recycling and reusing of the product or its packaging. With the above said, a definition and a relationship had been developed by Jackson et al. (2015), that construct of design for environment as the environmentally-conscious design of a product and its related processes with intent to minimize negative environmental impacts throughout the useful life of the product, and promote positive environmental practices such as recycling and reusing of the product, its materials and components, and/or its packaging.

Lead time can be defined as the amount of time that elapses between start and the end of a process ad this is examined closely in the fields of manufacturing, supply chain management etc., and in reality companies look forward to reduce the lead time to greater extent. During the last decade, lead time compression has been receiving increasing attention by researchers, because of its potential to generate competitive advantage in the supply chain, in terms of reduction of inventory levels and costs, and better service level delivered to customers (Womack and Jones, 1996). According to the studies conducted by Bertolinia, M. (2007), propose two main approaches to achieve lead time reduction and both approaches are successfully applied in the apparel supply chain.

According to Jaber et al. (2003), he determined that there is a chance or a possibility that a process goes out of control creating a deviation, thus this will produce defective items that definitely need to be reworked and he also highlighted that this happens in many of the practical scenarios and situations. Yet, studies that had been conducted so far indicates that most of the manufacturing processes are subjected to defects and they are not defect free thus results in items that require rework (Gopalan et al, 1995; Agnihothri et al, 1995). And according to Geren et al. (1999), there exists a validity on the possibility of a process going out of control thus leading to deviations from the normal routine and the efforts taken to engage in the reworks of the defective items must be accounted for. The previous findings harp on the impact of reworks on the process yield and also the necessary action that need to be taken play a vital role in minimizing the amount of rework generated.

Based on the investigations conducted by Taneva et al. (2010), the study paved the way to achieve an initial understanding, from a process- oriented perspective, of the in-depth features of breakdowns. Thus the researchers arrived at a conclusion with respect to their study and built the groundwork for a theoretical model of breakdowns in perioperative activities. At the same time, they took the effort to propose a design approach that tackles breakdowns during the early stages of system development. Abboud N.E. (2001) derived at a conclusion based on his study, that inventory of finished goods are normally carried as safety stocks mainly due to the reason that a production system is normally subject to stochastic breakdown.

III. EXPERIMENTAL DESIGN

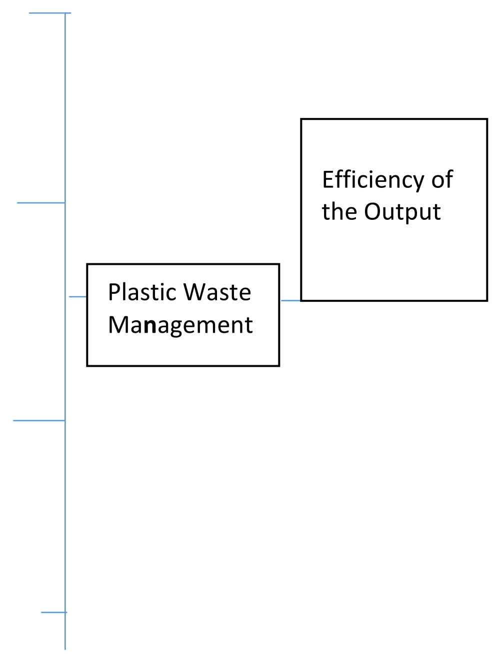

Figure 1. Conceptual Framework

This is a conceptual model which is mainly used to identify the network relationships among the variables. The conceptual framework as shown in figure 3.1 was developed in relevance to the findings and the theoretical explanations as given in the literature review. We deductively derived a conceptual framework for plastic waste management in the apparel industry. The model provides a possible explanation for the relationship among variables found in our study. Future refinements and further validation of the links are deemed beneficial. Nevertheless, at present the model facilitates an improved understanding of the processes of the apparel industry and the plastic waste management.

The philosophy of the current study is based on positivism because the investigation pertaining to the research work is conducted in a scientific and a quantitative manner. The approach that had been undertaken with regard to the study is a deductive approach as it contains a research hypothesis, research objective, analysis, discussion and a conclusion about the findings relevant to bridge the identified research gap. Strategy related to the current study is the survey methods as the research was based on questionnaires, semi-structured questionnaires, interviews etc,. The choices of the research was based on the mixed method as investigation contains both qualitative and quantitative components. The investigation was conducted by selecting a sample from the total population and by giving a questionnaire to the selected sample, responses were obtained. Through a detailed analysis of the responses, it paved the way to present a discussion and a conclusion along with a summary of the research work.

A. Sample Profile

The sample profile for the study was selected based on simple random sampling method to gain a diverse and a balanced sample, in order to investigate on the efficiency of plastic waste management in the apparel industry. The population for the study is based on the employees who are engaged in work in the apparel industry, and a sample of 50 was randomly chosen in order to obtain the feedback for the structured questionnaire. The rationale behind selecting simple random sampling as the basis, is consistent with Weerakoon (1996).

B. Data Collection, Analysis and Presentation

The questionnaire was developed after a thorough literature survey and in order to obtain responses related to the variables of the study, thus enabling to address the purpose and objectives of the study and also to conduct the investigation of the study area in a much more successful manner. The questionnaire was designed in a manner to correlate with the provided conceptual framework. There were eleven questions to determine the identified factors affecting the plastic waste management in the work environment and for the presentation of questions, a '5 point Likert scale' which ranges from which ranges from 1 to 5 indicating Strongly Disagree, Disagree, Moderate, Agree, Strongly Agree was used. The results obtained from the regression analysis was linked to the '5 point Likert scale', by selecting a range of values that corresponded to the points within the Likert scale. All questions were required to select a single option out of the 5 points of the Likert scale, thus the questions were close ended. The questionnaire was distributed among the leading companies of the apparel industry in Sri Lanka and the responses were mainly obtained by employees from the Executive level and above, thus enhancing the reliability of the responses obtained for the questionnaire.

In order to conduct the current study, the data tools available in IBM SPSS Statistics 22 were used for the analysis of data in a manner which enhanced the capability of successfully proving the research hypothesis and addressing the respective research objectives. The collected and analysed data will be presented in a user friendly and a convenient manner, simply in order for the viewers to strike an idea about the study undertaken, within the shortest time frame, without creating any complication. Further guidance will be obtained from the supervisor to ensure that the presentation caters the requirements of the study.

IV. RESULTS

Table 1. Mean, Mode, Median and Deviation

	Product design	Reworks	Lead time	Breakdowns	Plastic waste management
Mean	12.12	11.58	7.4	10.8	8.2
Mode	12	12	8	12	8
Median	12	12	8	11	8
Standard deviation	1.92	1.91	1.53	2.27	1.54
Coefficient of variation	16%	16%	21%	21%	19%

The mean value of the results in the independent variable of product design is 12.12 whereas the median value of the obtained results relevant to this is 12. Moreover, product design has a mode value of 12 which is also the same as the

median with regard to this. The standard deviation of product design is 1.92 which is a measure of dispersion. Also the coefficient of variation indicates that 16% of the data values are concentrated around the mean value of 12.12.
When considering about the reworks and its obtained results, the mean is indicated as 11.58 whereas the value of median is 12. Measure of dispersion of reworks is 1.91 and the mode value with regard to this is 12. Thereby, the coefficient of variation provides an indication that approximately 16% of the data values are concentrated around the mean value.

The average lead time scale lies at 7.4 whereas the median value related to this is 8. Furthermore, the standard deviation in this is 1.53 and the mode value obtained is 8 in respective of lead time. The variable of breakdowns indicates a mean value of 10.8 and a median value of 11. The value obtained for mode is 12 and the results indicates a standard deviation of 2.27 with respect to the results obtained for the lead time. The coefficient of variation indicates that an approximate of 21% of the data values are concentrated around the mean values of both the lead time and breakdowns.

The dependant variable which is plastic waste management has a mean value of 8.2 and a median of 8 according to the results, as shown in Table 4.2. In addition, the mode value of the dependant variable is 8 and the value obtained for the standard deviation is 1.54. Thus, the coefficient of variation implies that approximately 19% of the data values are concentrated around the average of the plastic waste management scale of 8.2.

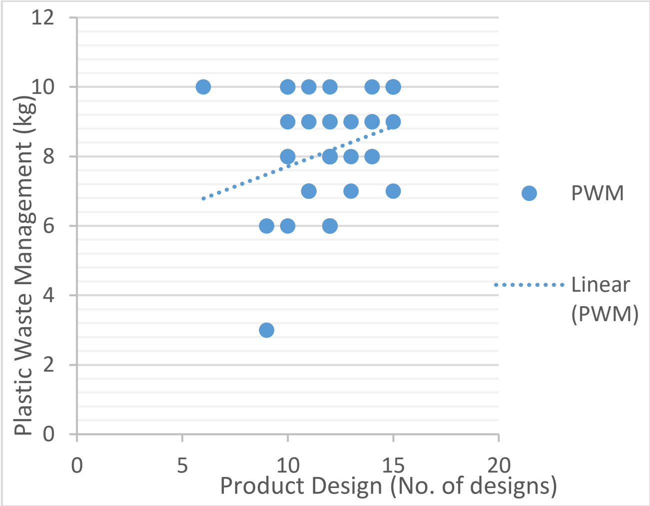

Figure 2. Relationship between Product Design and Plastic Waste Management

The x-axis and the y-axis corresponds to the total number of responses obtained from the selected sample for the provided questionnaire. The 5 point Likert scale corresponded to the number of designs in the x-axis. Accordingly, results obtained as Strongly Disagree, Disagree, Moderate, Agree, and Strongly Agree from the Likert scale corresponded to the product design (no. of designs) from 0 to 20 in the x-axis. Nevertheless, under the assumption that when all other factors are kept constant, a positive relationship between design of the product and plastic waste management process in the apparel industry in Sri Lanka, can be seen in the graph as in Figure 2. In other words, when the product design is created and maintained properly, efficiency of plastic waste management improve. Thus, the impact of product design to the plastic waste management is 8.31%.

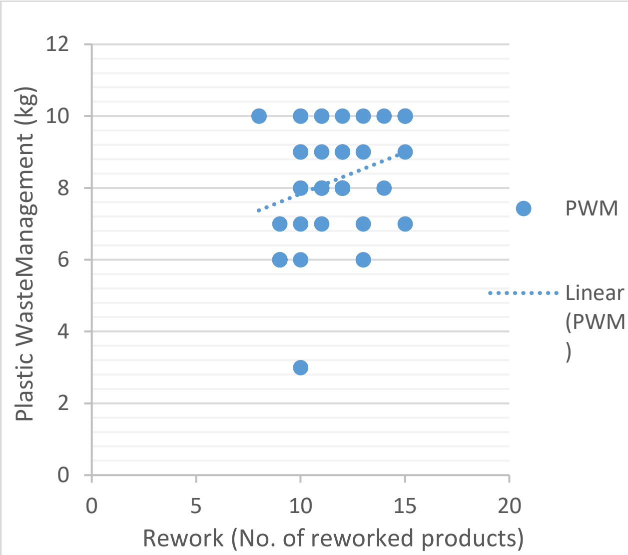

Figure 3. Relationship between Rework and Plastic Waste Management

The numerical values represented by the x-axis and the y-axis of Figure 3 are the number of responses obtained from the sample pertaining to the current study. The 5 point Likert scale corresponded to the number of reworked products in the x-axis. Accordingly, results obtained as Strongly Disagree, Disagree, Moderate, Agree, and Strongly Agree from the Likert scale corresponded to the reworks (no. of reworked products) from 0 to 20 in the x-axis. Assuming when all other factors are constant, the above graph illustrates a positive relationship between rework and plastic waste management in the apparel industry in Sri Lanka. In other words, proper handling of the reworks generated throughout the processes will enhance the plastic waste management process in the apparel industry. Thereby, a positive relationship between the reworks and plastic waste management of 8.21% is denoted in Figure 3.

The x-axis and the y-axis of the graph below represent the number of responses provided by the sample profile. The 5 point Likert scale corresponded to the lead time in the x-axis. That is results obtained as Strongly Disagree, Disagree, Moderate, Agree, and Strongly Agree from the Likert scale corresponded to the lead time with a class interval of 3. That is strongly disagree corresponded to 0-3 range of values in the x-axis. At the same time, the Figure 4 denotes that there is a weak positive relationship between lead time and plastic waste management in the apparel industry in Sri Lanka, assuming when all other factors are kept constant. In other words, when the production lead time is properly managed, it will improve the efficiency of the process of plastic waste management. The impact of lead time to plastic waste management is 1.28% as shown in Figure 4 below.

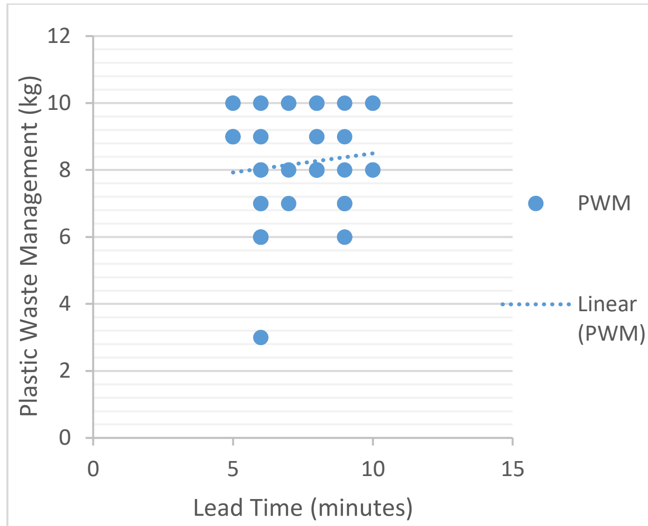

Figure 4. Relationship between Lead Time and Plastic Waste Management

The x-axis and the y-axis of the above representation from Figure 5 corresponds to the number of responses provided by the respondents with regard to the current study. The 5 point Likert scale corresponded to the number of breakdowns in the x-axis. Accordingly, results obtained as Strongly Disagree, Disagree, Moderate, Agree, and Strongly Agree from the Likert scale corresponded to the breakdowns (no. of breakdowns) from 0 to 20 in the x-axis. In addition, along with the assumption that when all other factors are kept constant, a positive relationship which is weak, is indicated between the system breakdowns and plastic waste management in the apparel industry in Sri Lanka. Accordingly, when the system breakdowns are properly managed, it will lead to enhancement of the efficiency of plastic waste management as denoted in the graph in Figure 5. There is a positive influence of 0.17% to plastic waste management with respect to the system breakdowns in the apparel industry in Sri Lanka.

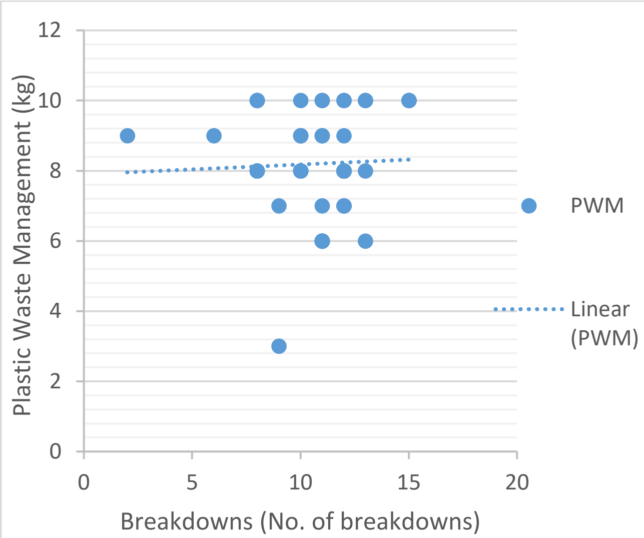

Figure 5. Relationship between Breakdowns and Plastic Waste Management

When considering and analysing the about the findings relevant to the identified variables namely the product design, reworks, lead time and system breakdowns, influences the process of plastic waste management in the apparel industry positively. By enhancing the impact of these independent variables, the efficiency of the process of plastic waste management can further be improved in the apparel industry of Sri Lanka.

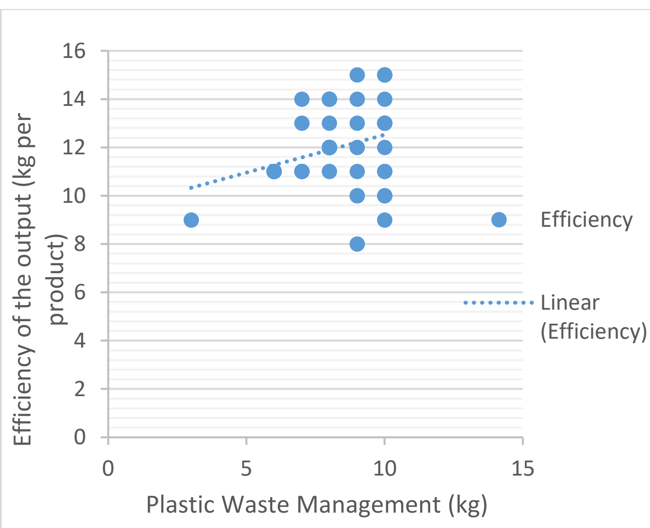

Figure 6. Relationship between Efficiency of the output and Plastic Waste Management

Similarly, the x-axis and the y-axis of the above illustration indicates the number of responses provided by the sample relevant to the current study. The 5 point Likert scale corresponded to the plastic waste management in the x-axis. That is results obtained as Strongly Disagree, Disagree, Moderate, Agree, and Strongly Agree from the Likert scale corresponded to the plastic waste management in the x-axis, with a class interval of 3. That is strongly disagree corresponded to 0-3 range of values in the x-axis. As per the above illustration, there exists a weakly positive relationship between the concept of plastic waste management and the efficiency of the output. . The impact of plastic waste management to the efficiency of the output is 8.79% as shown in Figure 6 above.

V. DISCUSSION

The recycled non – hazardous waste include segregated paper, cardboard, poly covers and plastic which are collected from the end of the process and sent to the collection point which is situated outside the processes and this procedure is called as in - situ segregation. At present, the collected plastic is then weighed and sent to the vendor for the process of recycling. The thread cones which also contains plastic will either be recycled or reused and the mixed waste component will be incinerated since these cannot be effectively recovered, thus contributing to the energy recovery process. The annual graphical representation is of paramount importance in order to efficiently identify the variations in the amounts of plastic collected and this can be used as a starting point to investigate backwards and identify the root cause for the sudden variations.

Jackson et al. (2015) found that there is a positive relationship among design for environment, quality management innovation and environmental performance in the U.S. manufacturing companies. He mainly harped on the fact that the product design need to be developed based on environmental considerations, in a manner such that the related processes will have the least possible negative environmental impacts. Therefore, a quantitative and a descriptive analysis was conducted in order to identify a clear defined relationship between the two variables, product design and the plastic waste management. The correlation coefficient values between the product design and plastic waste management is 0.288 at a significance level of 0.05. This implies that there is a positive relationship between the product design and plastic waste management, where above 0.5 values has been identified as strong positive relationship according to Pearson's correlation coefficient scale. Therefore, with the support of the previous research findings along with the correlation coefficient value obtained, it can be said that there exists a positive relationship between product design and plastic waste management.

The findings of Gopalan et al. (1995) and Agnihothri et al. (1995), indicated that almost all the manufacturing processes are subjected to defects which creates items that require rework. This provide an insight to the significance of rework on the processes and through quantitative analysis, it was observed that a numerical value of 0.287 was obtained as the Pearson correlation coefficient in order to derive at the relationship between the reworks and plastic waste management which is significant at the confidence level of 0.05. Thereby, a confident agreement can be made that there is a positive relationship between the above mentioned two variables.

As identified by Bertolinia et al. (2007), the adoption of ICT tools immensely reduces the lead time and also proved that through the simultaneous adoption of supply chain management programmes could provide integration between the firm and its suppliers. The findings of the quantitative analysis conducted through IBM SPSS Statistics 22 indicates a correlation coefficient value of 0.113. Thus, indicates that there is a positive relationship between the lead time and the plastic waste management which is not a strong nor a weak relationship. Although the two variables had been discussed separately by previous researchers, a significant study had not been conducted to identify the relationship between the two mentioned variables. Although there is a positive relationship, since this is not significant, an exact agreement cannot be made with regard to the relationship between the two variables.

The findings of Abboud N.E. (2001) stated that since the production systems are normally subjected to stochastic breakdowns, inventory need to be carried, thus harped on the random machine breakdowns that can occur in a process. In order to determine the extent to which the system breakdowns impacts the efficiency of the process of plastic waste management, a statistical analysis was undertaken with the IBM SPSS Statistics 22 software that yielded a Pearson correlation coefficient value of 0.041 which depicts a positive relationship, between system breakdowns and plastic waste management which is not significant at the considered level of significance. Thus, this does not provide a greater contribution to arrive at an agreement that there exists a significant positive relationship between the above mentioned two variables. It should be noted that the Pearson correlation coefficient is significantly positive only for two independent variables; at 0.05 level of significance. Yet, it can be agreed that there exists a positive relationship between the identified independent variables product design, lead time, system breakdowns, reworks and the dependent variable plastic waste management.

Based on the findings of the study, it can be proposed that the proper collection and handling of waste from process to process throughout the production system will enhance the efficiency of the process of waste management and specifically the process of plastic waste management pertaining to the current study area. Moreover, it will provide an overview of the situation of the collected plastic waste then and there itself, giving guidance to enhance the process efficiency, thereby creating a paramount importance and an impact on the efficiency of the delivered output.

Although there exists a positive relationship between the identified independent variables product design, reworks, lead time, system breakdowns and the dependent variable plastic waste management based on the Pearson correlation coefficient, the hypothesis developed for the current study cannot be proven due to the obtained p-values from the t-test conducted, being insignificant at an alpha of 0.05.

The t-test was conducted with the use of IBM SPSS Statistics 22 software. Consequently, due to the inadequate presence of significant statistical evidence in favour of the hypothesis developed for the current study, the research topic will remain as an open topic that will provide a pathway to participate in several future research directions.

V. CONCLUSION

The current study mainly emphasize on improving the efficiency of the process of plastic waste management and the Apparel industry was chosen as the area to conduct the current study since it had been considered as one of the fastest growing industries in Sri Lanka. Yet, based on the statistical tools used to conduct the study, the real demonstration of the hypothesis could not be reflected, thus the research was concluded with the situation of neither accepting nor rejecting the research hypothesis. Additionally, while conducting further study of the interplay between the variables of the study, the Pearson correlation coefficient related to all the independent variables and the dependent variable indicated a weak positive relationship indicated that the conclusion reached by the researcher supported the research hypothesis. However, based on the correlation coefficient analysis results, the researcher was able to reach a conclusion that supported the research hypothesis up to a considerable extent which was formulated based on the findings from the thorough literature survey. Our study provides support for the existence of a positive relationship.

VI. RECOMMENDATIONS

In order to obtain better results, the limitations of the current study has to be overcome by using the most appropriate statistical tools which will enable a more detailed and an accurate analysis of the study under consideration and will provide the true reflection of the concept behind the research hypothesis. Thus, the current study was limited to remain as an open topic as a future researchable area, due to the lack of a suitable and an adequate support from the hypothesis testing. At the same time, it was deeply observed throughout the analysis that a research approach that is more towards the qualitative nature would have yielded better results and displayed the outcomes of the identified objectives more in a more appropriate manner.

However, this can be regarded as an initial exploration of the interaction between the factors affecting the efficiency of the process of plastic waste management and by expanding the currently selected base for the research, number included in the sample profile and with a greater number of statistical analytical tools, an opening will be created for future viable research studies. It can also be inferred that the continuous improvement of the identified independent variables; product design, rework, production lead time and the system breakdowns, can enhance the process of plastic waste management thus significant opportunities may exist which will be of utmost importance to improve the performance of the involved processes. Consequently, the valuable insights of the current study will be of significant importance for immediate further extensions.

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REFERENCES

Abboud, N.E. (2001). A discrete-time Markov production-inventory model with machine breakdowns. *Computers & Industrial Engineering*, 39, pp. 95-107.

Agnihothri, S.R. & Kenett, R.S. (1995). The impact of defects on a process with rework. *European Journal of Operational Research*, 80, pp. 308–327.

Allenby, B. (1994). Integrating environment and technology. *Design for environment. In the Greenin of Industrial Ecosystems*, pp. 137-148.

Al-Salem, S.M., Lettieri, P. & Baeyens, J. (2009). Recycling and recovery routes of plastic solid waste (PSW). *Waste Management*, 29, pp. 2625–2643.

Bertolinia, M., Bottania, E. & Bevilacquab, M. (2007). Lead time reduction through ICT application in the footwear industry. *Int. J. Production Economics*, 110, pp. 198–212.

Connett, P. S. (2001). *A citizen's agenda for zero waste.* Retrieved from http://www.grrn.org/zerowaste/community/activist/citizens_adenda_4_print.pdf

Gopalan, M.N. & Kannan, S. (1995). Expected number analysis of a two-server queuing network subject to inner-stage inspection and rework. *Computers and Operations Research*, 22, pp. 935–946.

Geren, N., Redford, A. (1999). Cost and performance analysis of a robotic rework cell. *International Journal of Production Economics*, 58, pp. 159–172.

Gulich, B. (2006b). Development of products made of reclaimed fibres. In: Wang Y. ed. *Recycling in Textiles.* Cambridge, UK: Woodhead Publishing Ltd, pp. 117–120.

Hornby, A.S. (2005) Oxford Advanced Learner's Dictionary, pp.1219. Oxford University Press, Oxford, UK.

Hsu, C., Tan, K., Zailani, S. & Jayaram, V. (2013). Supply chain drivers that foster the development of green initiatives in an emerging economy. *International Journal of Operations and Production Management* 33(6), pp. 656-688.

Jaber, M.Y. & Guiffrida, A.L. (2004). Learning curves for processes generating defects requiring reworks. *European Journal of Operational Research,* 159, pp. 663–672.

Jackson, S.A., Remani, V.G., Mishra, R. & Napier, R. (2015). Examining the Impact of Design for Environment and the Mediating Effect of Quality Management Innovation on Firm Performance. *Intern Journal of Production Economics*, 173, pp. 142-152.

Larney, M. & Aardt, A.M. van., (2009). *Case study: Apparel industry waste management: a focus on recycling in South Africa*. North-West University: South Africa.

Mastellone, M.L. (1999). *Thermal treatments of plastic wastes by means of fluidized bed reactors*. Ph.D. Italy: Second University of Naples.

McDavid, S. (ed.) (2008), The next step in recycled textiles. AATCC review, 8, 22.
Meng, T., Klepackab, A.M., Florkowskic, W.J. & Bramand, K. (2015). Determinants of recycling common types of plastic product waste in environmental horticulture industry. Georgia.

Siddiqui, J & Pandey, G. (2013). A Review of Plastic Waste Management Strategies, Department of Civil Engineering, M.M.M. Engineering College, Gorakhpur (U.P.) vol 2(12).

Taneva, S., Grote, G., Easty, A. & Plattnera, B. (2010). Decoding the perioperative process breakdowns: A theoretical model and implications for system design. *International journal of medical informatics*, 79, pp. 14–30.

Tchobanoglous, G. & Kreith, F. (2002). *Handbook of solid waste management*. 2nd ed. McGraw-Hill.

U.S Environmental Protection Agency2. 2005. *Introduction to universal waste*. [ONLINE] Available at: http://www.epa.gov/osw/inforesources/pubs/hotline/training/uwast05.pdf. [Accessed 07 November 15].

Weerakoon, T.P., Pilapitiya, S.C., Kotagama, H.B. & Senanayake, Y.D.A. (1996). *A Study on the Generation and use of Solid Waste in the Garmnet Industry*.8, pp.262-272.

Womack, J.P. (1996). *Lean Thinking*. 1st ed. New York: Simon and Schuster.

Young, C.-Y. N.-P.-S. (2010). Working towards a zero waste environment in Taiwan. Waste management & research. *The journal of the International solid wastes and Public Cleaning Association,* 28(3), pp. 236-44.

Zia, K.M., Bhatti, H.N. & Bhatti, I.A. (2007). Methods for polyurethane and polyurethane composites, recycling and recovery. *Reactive & Functional Polymers,* 67 (8), pp. 675–692.