Plastic Solid Waste Recycling and the Significance of Reverse Logistics in Developing Economies

Bupe G Mwanza and Charles Mbohwa
School of Engineering Management
University of Johannesburg
South Africa
bupe.mwanza@gmail.com, cmbohwa@uj.ac.za

Abstract

Plastic solid waste (PSW) recycling can lead to sustainable resource utilization and reverse logistics is a concept that can enable the recovery of this waste type in the supply-chain. In developing economies, informal waste recovery is predominant and in need of recycling and reverse logistics systems to enable sustainable recoveries. The paper analyses studies that have focused on recycling and reverse logistics in order to determine the significance of this relationship to sustainable resource utilization and waste management. The study has identified a number of merits in implementing reverse logistics systems and these can benefit the developing economies. Nevertheless, most of the studies analyzed have been conducted in developed economies were plastic waste recycling and reverse logistics are in existence. The study identified no studies on reverse logistics and plastic recycling in Africa and therefore recommended that more research is needed on this topic to enable plastic manufacturing companies and waste managers make sustainable decisions and systems.

Keywords
Plastics, Reverse Logistics, Recycling, Sustainability

1. Introduction

Plastic materials have captured the manufacturing industry because of their favorable properties. These properties have enabled the production of many products out of plastic materials. However, the manufactured plastic products continue to increase the amount of waste generated and there is need for proper management and disposal of this waste type (Ferri et al., 2015). The continuous use of plastic materials in the packaging industry has resulted in more virgin resources been used and solutions to prevent the diminution of the virgin resources is needed. Every year, several million tons of plastics are produced and used as packaging materials (Papong et al., 2014; Blanco, 2014). Approximately 50% of manufactured plastic products are used for single-use disposable applications (Hopewell et al 2009). As a result of this, there is a rapid increase in the amount of plastic solid wastes (PSWs) produced as most plastic products’ life is short.

Reverse logistics is an engineering management concept that has been used in the recovery of end-of –life or end-of-use plastic products by manufacturing companies. It is described as a means of assisting firms perform, resulting in the recovery of materials that were once generated as waste as well as helping in the reduction of environmental and social impacts (Chaves et al., 2014; Santos et al., 2014). According to Fehr et al (2010), the scarcity of raw materials and the increasing public awareness regarding the preservation of the environment, combined with the idea of opposing waste are some of the factors behind the development of reverse logistics systems. These developments are planned as economic motives and environmental concerns. As a result, many firms have been encouraged to explore on the take back and recovery of products as a way forward to sustainable management of waste.

The relationship of reverse logistics and waste management involves activities in the reverse distribution channel such as reuse, recycle and proper disposal of waste. Due to this, recycling is one of the options considered sustainable for the management of plastic solid waste. It is considered one of the best options in the waste
management hierarchy. Recycling is defined as returning waste materials to the processing line in order to reduce process costs and open up new possibilities (Braga Junior and Rizzo, 2010; Chaves et al., 2014; Veiga, 2013). As a result of the ability to recapture value in discarded products by bringing them back to the production line, reverse logistics with the aspect of recycling has become an important source of opportunity for companies to improve visibility and profitability and lower costs across the supply chain (Chiou et al., 2012; Frota-Neto et al., 2008). However, in developing economies, most of the waste is recovered by the informal waste sector which lack proper recovery and management tools and as such the amount of waste recovered is little. A number of studies have affirmed that, in developing economies, informal waste recovery is predominant (Ezeah et al., 2013; Scheinberg et al., 2011; Guterlet, 2010; Medina 2007; Coelho, 2011). As a result of such predominance and non-existence of reverse logistic systems for most recyclable wastes, the wastes recovered by the informal waste sector are usually not sustainable.

This study analyses research that has focused on reverse logistics and recycling. Recycling refers to the separation and collection of plastic wastes from the generators to the plastic converters or manufacturers. Reverse logistics is considered the concept or tool used in returning these end-of-use or end-of-life plastic products from the generators to the users. The purpose of the analysis is to determine if there is need for studies on reverse logistics of plastic solid wastes (PSWs) in developing economies such as Africa. The first section of the paper begins with a review of literature on the recycling and reverse logistics. The results and discussion follows and finally the conclusion.

2. Literature Review

Application of reverse logistics has become an important aspect to sustainably manage natural resources and one of the options of achieving this, is by recycling. Zhou and Wang (2008) highlighted that, the first known definition of RL referred to the role of logistics in recycling materials. There a number of studies related with reverse logistics. Nevertheless, this study mainly focuses on recycling in reverse logistics systems and attention is paid to plastic wastes. Therefore, literature is reviewed regarding this perspective.

2.1 Recycling

Due to the continuous extraction and usage of natural resources, the availability of many of the natural resources is at risk (Borvczko et al., 2014). As a result of this sustainability challenge, it is necessary to implement the existing sustainable waste management options such as recycling in order to preserve our natural resources. Instead of concentrating on waste disposal methods, waste should be considered as the next new resource, so called ‘waste-as-resources’ (Huysman et al., 2015). Recycling is an option capable of considering waste as resources. It contributes to diverting materials with economic value from the main waste flow thus reducing quantities of waste to be collected and disposed (Matter et al., 2013; Troschinetze and Minelic, 2009). Further it saves energy and natural resources, bringing materials that were thrown out or discarded back to the productive cycle (Dias and Braga Junior, 2016). Despite the application of recycling as a resource recovery option as well as a waste management option, in most developing economies, there is still need for the development and application of effective and efficient recycling systems in order to fully tap and benefit from its advantages. There is need to balance the economic growth and resource consumption by way of utilizing resources more efficiently (BIO-SEC=SERE, 2012).

2.2 Reverse Logistics

Carter and Ellran (1998) define RL by highlighting recycling as a means to which companies can become environmentally efficient. This is affirmed by Rogers and Tibben-Lembke (2001) as they acknowledge that activities in the supply-chain reduce on the environmental impact of the supply chain. Reverse logistics accords companies the ability to recapture value in discarded products by bringing them back to the production line and with the aspect of recycling, opportunities to improve visibility and profitability and lower costs across the supply-chain are also presented (Chiou et al., 2012; Frota-Neto et al., 2008). Manufacturers in developing economies should seriously consider the application of reverse logistics for their valuable end-of-life plastic products. However, in most developing economies, reverse logistics chains comprise of a vast number of the informal sector (Kinobe et al., 2015). These RL chains are usually not organized and rely on recyclables collected from temporary garbage dumpsites and trucks delivering waste to landfills (Matter et al., 2012). As a result of this, wastes that could have qualified for recycling usually end up at the dumpsite or never recovered. Despite the fact that RL is considered substandard and with less value addition in developing economies
due to less gains accrued (Fleischmann et al., 2001). The fact is that, RL has environmental and economic benefits if it is sustainably implemented for example encouraging source segregation to ease sorting and grading (Kinobe et al., 2015).

2.3 Reverse Logistics and Recycling

In developed countries, a lot of research has been conducted to determine the best ways manufacturing companies can recapture back the plastic waste and use it as input material in their manufacturing processes. Baaran (2012) conducted a research on what makes manufacturing companies more desirous of recycling. The study was aimed at finding out if there are some relationships between recycling options and some characteristics of manufacturing companies. The results indicated that some characteristics that were expected to have relationships with the treatment options were supported by the two analyses while others were not. Coelho et al (2010) conducted a research on PET containers in Brazil: opportunities and challenges of logistics model for post-consumer waste recycling. The study analyzed in an integrated manner, the best alternatives to improve the recycling system by examining the Pet bottle life cycle in Brazil. An alternative system for recycling considering social, economic and environmental aspects with an integrated long term perspective was proposed. The results of the study identified the need to structure the post-consumer reverse chain and engage industrial sectors and government through the Pet bottle production chain. Zhang and Wen (2014) conducted a study on the consumption and recycling collection system of Pet bottles: a case study of Beijing china. The study analyzed the current collection and recycling practices of Pet bottles worldwide from the aspect of Pet consumption, recycling rate and recycling collection methods. The results indicated that 90% of post consumed Pet bottles were collected by informal collectors; Pet bottles are reprocessed by small factories not designed with pollution control equipment. The studies by Baaran (2012), Coelho (2010) and Zhang and Wen (2014) have addressed the need to recycle waste. Baaran (2012) study indicates the needs to identify factors that can make manufacturing companies desire to recycle while Coelho (2010) and Zhang and Wen (2014) have addressed the need to develop reverse logistics chains for PET recycling.

The table below gives a summary of studies on reverse logistics and recycling. The purpose of the summary is to find out the type of study previously carried out, methodology adapted and to identify the research gap.

Table 1: Summary of some studies on Reverse Logistics and Recycling

<table>
<thead>
<tr>
<th>Source</th>
<th>Type of Study</th>
<th>Waste Type</th>
<th>Method Used</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bing et al (2014)</td>
<td>Analysis of a logistics network and the design of decision support tools for analyzing the effects of various collection, separation and treatment systems of household plastics, from PET bottles to plastic wrappings</td>
<td>Household plastic waste</td>
<td>Scenario study approach (mixed integer linear programming)</td>
</tr>
<tr>
<td>Coelho et al (2010)</td>
<td>Analyzed in an integrated manner, the best alternatives to improve the recycling system by examining the PET bottle life cycle in Brazil</td>
<td>PET Bottles</td>
<td>Review</td>
</tr>
<tr>
<td>Dias and Braga Junior., (2016)</td>
<td>Analyzed the practices of reverse logistics performed by a retailer and measure the amount of waste generated by each department</td>
<td>retail waste ( plastics and cardboards)</td>
<td>Wuppertal method, Qualitative</td>
</tr>
<tr>
<td>Fehr et al (2014)</td>
<td>Pursued the objective of shifting opportunities from tipping to reverse logistics in order to close the balance.</td>
<td>Household waste</td>
<td>Qualitative, Quantitative</td>
</tr>
<tr>
<td>Ferri et al (2015)</td>
<td>Proposes a reverse logistics network involving MSWM to solve the challenge of managing these wastes in an economic way considering the new legal requirements and the inclusion of waste pickers.</td>
<td>Reverse logistics in MSWM</td>
<td>generic mathematical modeling</td>
</tr>
<tr>
<td>Kinobe et al (2015)</td>
<td>Analyzed in details the collection, re-processing, re-distribution and final markets of these products into a reversed supply chain network&quot;</td>
<td>MSW Reverse logistics at a landfill</td>
<td>Qualitative and Quantitative</td>
</tr>
<tr>
<td>Zhang et al (2011)</td>
<td>proposed an inexact reverse logistics model for municipal solid waste management systems</td>
<td>MSW</td>
<td>Model development</td>
</tr>
<tr>
<td>Silva and Neto (2011)</td>
<td>Examines the feasibility of introducing reverse logistics in the plastics industry in the city of Teresina, capital of Piaui, Brazil.</td>
<td>Plastic waste</td>
<td>Quantitative</td>
</tr>
<tr>
<td>Matar et al (2013)</td>
<td>o present an original model for the production-recycling-reuse of plastic beverage bottles.</td>
<td>PET Plastic Bottles</td>
<td>Model Development</td>
</tr>
</tbody>
</table>
3. Results and Discussion

The main observations from the review and analysis of the studies indicate that most of the studies have looked at implementation of reverse logistics in MSW and household waste. Network design is another area that has received a lot of research attention in the field of reverse logistics using mathematical programming (Bing et al, 2014; Ferri et al, 2015; Ferri et al., 2014; Chaves et al., 2014). Few studies have investigated reverse logistics and plastic recycling in developing countries (Matar et al, 2013; Coelho et al, 2011). However, the application of such studies in developing economies of Africa is little. Kinobe et al (2015) looked at the application of reverse logistics at a landfill and attention was paid to MSW. Further, only few of the studies presented in table 1, have assessed reverse logistics and recycling from an industry point of view. It is important to note that, Coelho et al (2011) indicated the need for structuring post-consumer reverse chains and engaging industrial sectors and government by way of public policies in order to support cleaner technologies along the PET bottle production chain. This broad conclusion is significant for the development of reverse logistics systems in developing economies of Africa as it provides a foundation. It is necessary that sustainable ways of recovering plastic wastes are implemented in developing economies in order to cover the current waste challenges been faced as well as cater for resource utilization. Despite the study by Ferri et al (2015) focusing on model development for MSW, the study has proposed a reverse logistics network that incorporates legal, environmental, economic and social factors. This proposition is significant for manufacturing industries as well as waste management during the development of RL systems for plastic wastes. Even though the proposition can be complex, the need to incorporate sustainability dimensions in recovery programs is significant.

With much of the waste been recovered by the informal sector in developing economies, the reviewed work has provided insight on the need for designing proper RL systems in order to tap into the benefits of recycling. However, in order to achieve sustainability in the arena of RL and recycling, most technological innovation and research activities in addition to creation of markets for recycled products is needed (Siliva and Neto (2011). Further a number of benefits such as reduction of environmental impacts and economic costs as well as job creation are some of the advantages of implementing reverse logistics.

4. Research Gap

There is serious need for studies on reverse logistics and recycling in developing economies such as Africa. Future research should focus on development of reverse logistics systems for recycling plastic solid wastes.

5. Conclusion

Generation of plastic solid wastes is occurring at a rapid rate. In developing economies where a number of economic developments and rapid urbanization is happening, it is likely that the percentage of PSW will increase in the coming years. In order to over the challenges of managing plastic wastes, sustainable means of resolving the problem are either reusing it or recycling. The study has highlighted the significance of developing sustainable systems for managing waste through recycling.

The benefits of reverse logistics systems and recycling can proof sustainable and provide a number of solutions to the challenges of managing waste faced in developing economies. Incorporating reverse logistics in the manufacturing and waste management sector can reduce disposal capacity at the landfills, lesser emissions from dumpsites, reduce expenditures on collection and energy utilization, reduce litter and provide more jobs to the people involved in the recoveries. The research has also shown that more studies on reverse logistics and recycling systems are needed in developing economies of Africa.

However, it is important that waste managers and manufacturers understand that the implementation of such systems is not easy. An understanding of the needed outcomes from the system is necessary before the actual implementation. It is also necessary to identify the needed players in the recovery programs in order to optimize the recovery of the PSW. In developing economies, where most of the waste is recovered by the informal sector, it is necessary to consider the incorporation of the informal waste sector in the recycling and reverse logistics systems to enable sustainable recoveries.
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References


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**Biography**

**Bupe Getrude Mwanza** is a PhD student with the School of Engineering Management at the University of Johannesburg, South Africa. She is a holder of a BSc in Production Management from The Copperbelt University and MEng in Manufacturing Systems and Operations Management from the National University of Science and Technology. She has research interests in solid waste management, manufacturing technologies, maintenance management, cleaner production and operations management. She has taught Maintenance and Reliability Systems, Production and Operations Management, Integrated Production Systems and Manufacturing Technology. She has published and presented works on Maintenance Management and Solid Waste Management. Bupe has served as a Process Associate for Konkola Copper Mines in Zambia. She also served as a Lecturer at Harare Institute of Technology in Zimbabwe and at The Copperbelt University in Zambia. She is a member of the Engineering Institute of Zambia (EIZ) and The Southern Africa Institute for Industrial Engineers (SAIIE).

**Prof. Charles Mbohwa** is the Vice Dean of Postgraduate Studies, Research and Innovation, Faculty of Engineering and the Built Environment, University of Johannesburg, South Africa. As an established researcher and professor in sustainability engineering and 312Proceedings of the 2016 International Conference on Industrial Engineering and Operations Management Kuala Lumpur, Malaysia, March 8-10, 2016 operations management, his specializations include renewable energy systems, bio-fuel feasibility and sustainability, life cycle assessment, and healthcare operations management. He has presented at numerous conferences and published more than 150 papers in peer-reviewed journals and conferences, 6 book chapters and one book. Upon graduating with a BSc in Mechanical Engineering from the University of Zimbabwe in 1986, he served as a Mechanical Engineer at the National Railways of Zimbabwe, Zimbabwe. He holds an MSc in Operations Management and Manufacturing Systems from the University of Nottingham, United Kingdom, and completed his doctoral studies at Tokyo Metropolitan Institute of Technology, Japan