

A study of management of steel parts leftover generated by the maintenance of heavy vehicles

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ABSTRACT

The objective of this study was to analyze the waste management in a maintenance workshop for heavy vehicles. To achieve this, purpose a study in the state of São Paulo - Brazil was conducted in a maintenance workshop for heavy vehicles providing services for the major plants of this sector in the region. Data were collected over a period of 18 months, using the Wuppertal method to measure the environmental gains. It was observed that more than 245 tons of abiotic materials are no longer generated by the practice of reuse in the steel production chain. Moreover, 2,000 tons of water and 20 tons of air no longer were used to process the same steel amount that is sent for reuse in the production chain.

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1 Introduction

The occurrence of environmental accidents like the explosion of a nuclear reactor at Chernobyl in the Soviet Union in 1986; the oil spill in 1990 from the oil tanker Exxon Valdez, among other episodes, forced companies to shoulder high costs in damages, environmental recovery, damage control, in addition to the negative image generated by the environmental damage. In response, companies with pollution potential began to develop and implement environmental management in order to contribute to reduce the risk of environmental incidents and accidents without reducing their competitiveness (Barata, 2007).

According to the Ministry of the Environment (2015) after the approval of the National Policy for Solid Waste in August 2010, the society as a whole has become responsible for the environmentally adequate management of solid waste. If managed properly, it acquires commercial value and can be used in the form of new raw materials or new inputs. The implementation of a management plan will result positively in the social, environmental, and economic scope, as well as reducing the consumption of natural resources, providing new markets, generating labor, employment and income, and decreasing the environmental impacts

caused by improper disposal of residues.

The activities carried out by maintenance companies related to the automotive sector, generate different types of solid waste and effluents. Thus, for the disposal be suitable for new destinations appropriate treatment which does not cause damage to the environment and public health is necessary. Among services such as: change of lubricating oil, coolants and hydraulic fluids, spare parts, overhaul of engines, fuel injection, suspension, brakes, engine tuning, alignment and balancing, among others, large amounts of solid waste are generated. Among this solid waste the main ones are: used parts, tires, tins, flannel, cotton waste, cardboard and packaging of lubricating oils and parts pieces (Nunes and Barbosa, 2012).

According to Lacourt (2012) for the disposal of solid waste it is advisable a waste management logistics once it is necessary the waste to be placed in locations that ensure the preservation of the environment, or depending on the material a treatment such as recycling, incinerating or composting is needed. This treatment aims to reuse or destroy it in order not to harm the environment and the people's health.

In this context, this study analyzes the following problem: How is the management of steel parts leftover generated by the maintenance of heavy vehicles? Thus, the objective of the research was to analyze the waste management in a maintenance workshop for heavy vehicles.

Guided by a qualitative methodology of exploratory nature, the data analyzed correspond to a period of 18 months. As a result, it was observed an average of 1.4 tons of steel parts leftover per month that are sold to other companies using the material that would be disposed of in ordinary trash but were able to generate income and environmental gain in the chain; furthermore, about 2 million liters of water were not spent for production of new products as well as 20 tons of air were no longer polluted.

2 Theoretical Framework

2.1 Automotive Industry

The automotive industry has great relevance in the world economy. According to OICA (2016a), the sector employ about 9 million people directly in making the vehicles and the parts that go into them. This is over 5 percent of the world's

total manufacturing employment. It is estimated that each direct auto job supports at least another 5 indirect jobs in the community, resulting in more than 50 million jobs owed to the auto industry. Brazil has a great potential and effective domestic market, competent industrial park, both vehicles and part systems, solid base of automotive engineering and structured dealer network with national coverage.

Brazil is among the largest vehicle producers in the world. In 2016 it was the ninth largest producer (OICA, 2016b). The country has 31 different manufacturers supplied by more than 620 auto parts companies. There are 65 manufacturing plants considering automobile manufacturers, automotive agricultural machinery, engines and components spread across eleven states and more than 50 municipalities. It is an industrial complex with an installed capacity to produce 4.5 million vehicles per year (ANFAVEA, 2016).

With the potential automotive market, there is the concern with waste management and environmental problems. As Sebrae (2015), a small vehicle during their first year of life, generates on average 12 liters of used oil, five kilograms of waste as cotton waste, packaging, oil filter, fuel and air and inputs used in car checkups. Vigsø (2004) most of the wastes generated at dealerships do not have adequate final destination. In general, companies are concerned with environmental issues, but do not know what fate to give to these wastes. Disposing waste improperly results in several problems such as depletion of landfill, clogging elements of the urban drainage system and groundwater contamination, among others.

The CONAMA (National Environment Council) established by resolution 275 that all waste from the mechanic workshop activities, office and cafeteria should follow a color-coded for different types of waste, as well as the identification of collectors and transporters. It is a form of easy viewing of waste segregation at source, thus being able to enormously reduce the provision in landfill the materials which can be recycled.

For some waste disposal, such as lubricating oil from garages CONAMA 362/2005 says that external transport must be performed by licensed company for this purpose. Companies that make this transport must be registered with the

Regulator Authority of Petroleum Industry and licensed by the competent environmental agency.

2.2 Recycling and Solid Waste Reuse

Since the Industrial Revolution large-scale production has made the volume and diversity of waste generated in urban areas increase. Humans are experiencing the era of disposability (Fehr, 2014). Most products are used and then thrown away or incinerated, causing considerable damage to the environment. Currently, more stringent laws and growing consumer awareness are driving companies to think about their responsibility for their products after use (Veiga, 2013).

Recycling is defined as returning waste materials to the processing line in order to reduce process costs and open up new possibilities (Braga Junior & Rizzo, 2010; Veiga, 2013). According to Motta (2011), the word recycling was introduced to the international vocabulary when it was found that the sources of oil and other nonrenewable raw materials were (and are) running out. To this author, recycling is a reverse channel revaluation, where materials discarded from post-consumer products are extracted industrially, turned into secondary raw materials, not directly taken from nature or recycled and are then incorporated into the manufacture of new products. Recycling saves energy, saves natural resources, and brings materials back to the productive cycle that were thrown out or discarded.

For Mano, Pacheco, and Bonelli (2005), the potential benefits of recycling include: a) "Reduction in the consumption of non-renewable natural resources, when replaced by recycled waste; b) Reduction of consumption of the virgin material for production process; c) Reduction of pollution" (John, 2000); and d) "Reduction of areas required to landfill as waste is used again as consumer goods" (Pinto, 1999).

The recycling and reuse of materials that would be discarded and the remains that arise over the activities of the grocery retail create a reverse flow (Braga Junior et al., 2009). The reverse flow of goods that were not consumed becomes an important tool for the sustainability of organizations (Braga Junior & Rizzo, 2010).

Authors such as Gonçalves (2003) and Mano et al. (2005) explained that reducing the generation of waste, and instead reusing, and recycling these materials, are parts of the clean

production targets and cleaner production processes initially employed by the industry and today have been adopted by various business sectors.

To meet the demands imposed by the National Policy on Solid Waste - NPSW, Law No. 12,305 / 2010, increased investment in technology is needed in education and knowledge management. The NPSW sets standards requiring major market players to provide a suitable destination for solid waste that is generated in the manufacturing process and after consumption of various goods. Thus, one must have a means that enables the return of products and post-consumer packaging for the industry to adopt the processes and the most suitable procedures to recover waste components with the lowest environmental impact. In this sense, Dowlatshahi (2000) explained that reverse logistics can be a tool in waste management because it is a process in which the manufacturer receives the waste generated after the consumption of products and may thus recycle, remanufacture, or dispose of.

Dias and Braga Junior (2015) explain that the National Policy for Solid Waste sets standards requiring major market players to provide a suitable destination for solid waste that is generated in the manufacturing process and after consumption of various goods. Thus, one must have an environmental management that enables the return of products and post-consumer packaging for the industry to adopt the processes and the most suitable procedures to recover waste components with the lowest environmental impact.

According to the ISO 14000 (2004), environmental management can be understood as a set of well-defined steps and procedures which, if applied correctly, can reduce and control the impact on the environment.

The NBR 10004 - Solid Waste - Classification, revised in 2004, defines solid waste as:

"Residues in solid and semi-solid state that result from industrial and domestic origin, hospital, commerce, agriculture, service and sweeping. In this definition it is also included the sludge from water treatment systems, those generated in equipment and pollution control facilities as well as certain liquids whose

characteristics make it impossible to be launched in the public sewage system or water bodies, or require for it technical solutions and economically unviable in the face to the best available technology."

The NBR 10004 divides waste into two classes, being: waste Class I - Hazardous waste and Class II - Non-hazardous (II A - Not inert and IIB - Inerts). Class I Waste - Hazardous have physical, chemical or infectious properties, which can cause risks to public health and the environment. Class II Wastes - Not Hazardous are divided into inert and non-inert.

The non-inert one's exhibit properties such as: biodegradability, combustibility or solubility in water. Inert ones are any waste that, being sampled in a representative way and subjected to dynamic and static contact with distilled or deionized water at room temperature, do not have any of its constituent solubilized at concentrations higher than the standards for water portability, except for appearance, color, turbidity, hardness and flavor.

According to the new law no. 12.305 of 2 August 2010, the preliminary provisions for solid waste, described in Chapter I of Title III, set in Art.9 the order of priority of solid waste management that are the not generation of solid waste, its reduction, reuse, recycling, treatment and environmentally final disposal.

The management plan is a tool that helps the company to achieve an improvement in the environmental aspect, facilitating its consistency in legal requirements. The RMP (Risk Management Plan) should ensure that all waste will be managed properly and safely, from generation to final disposal. The correct handling and packaging of waste will enable the maximization of opportunities to reuse and recycling (Lopes and Kemerich, 2007).

Develop and implement a waste management plan is essential for any company that wants to maximize opportunities and reduce costs and risks associated with solid waste management (Paes et al, 2014; Maroun, 2006).

According to Liu et al (2010), to proper management of solid waste take place is necessary the correct segregation, conditioning, temporary storage, external transport, treatment or final disposal of waste generated by each project. Thus, Recycling and reuse saves energy and natural

resources, bringing materials that were thrown out or discarded back to the productive cycle (Brogaard and Christensen, 2012; Dias and Braga Junior, 2015).

Taking into account the environmental issues that are involved in the automotive sector, specifically in the maintenance sector of heavy vehicles, which generate different types of solid waste and effluents, it is necessary to define practices that reduce the generation of solid waste, separating it at the source, properly disposing the waste as well as reducing its generation and its treatment before being released into the sewage system (Paulino, 2009).

Motor vehicle maintenance companies consume large volumes of water for cleaning of employees, floor and parts. The effluents generated in these enterprises have potentially polluting characteristics due to the presence of used lubricating oil, grease and solvents (Paulino, 2009).

3 Method

As the aim of the research was to analyze the waste management in a maintenance workshop for heavy vehicles, the research was carried out along with a workshop for maintenance of heavy vehicles which provides services for major plants in the sugar and alcohol sector in the State of São Paulo /Brazil.

The exploratory and qualitative character of research sought to quantify the volume of waste that cease to be discarded in the environment in a workshop of heavy vehicles. As the automotive industry has a high profile of the types and volumes of waste it generates, as a matter of access and availability of the company in participating in the research making available its data so that the analysis could be performed, it was possible to measure the amount and the main wastes generated in the process.

To analyze the environmental benefits generated by the waste management, the Wuppertal Institute developed an analysis method for environmental benefits that can assess the environmental changes associated with resource extraction from the natural ecosystems based on the life cycle of products (Ritthoff, Rohn & Liedtke, 2002).

This method uses the calculation of Material Input Per Service unit (MIPS), in short it means

input material per unit of service. Its function is to estimate the environmental impact caused by the production of a product or service, and indicate the amount of resources used for this product or service. This calculation can be done at the organizational, regional, national and global level (Ritthoff, Rohn & Liedtke, 2002).

Indirectly MIPS calculation says that all material input becomes an output: waste or emissions. If each input becomes an output, it follows that through the measurement of the inlet it is possible to estimate the potential environmental impact. By measuring the inputs, we cannot come to an impact assessment (qualitative), but a valuable indicator (quantitative) of the potential environmental impact on the environment of a product or service (Ritthoff, Rohn & Liedtke, 2002).

Table 1. Data for steel conversion – MIPS (kilograms)

	Abiotic Material	Biotic Material	Water	Air
Steel	9.32		81.86	0.77

Note. Adapted from “Calculating MIPS: Resource productivity of products and services”, by Ritthoff, Rohn, & Liedtke (2002)

In the case of this research the MIPS calculation was used to measure the environmental benefits of management for steel pieces’ leftover generated in the maintenance of heavy vehicles. For the calculation a period of 18 months (October 2013 to March 2015) was considered and, based on the conversion table (Table 1) data relating to steel sent for recycling were measured as the compartments analyzed by the method.

4 Results

The company subject of study has been on the market for about 60 years in the automotive industry, specifically in the maintenance of heavy vehicles and has a diversification of products and services that are showing in Table 2.

Table 2. Products and Services in the company subject of study

Products and Services
Installation of 2 nd steering axle
Installation of 3rd axle (approved)
Chassis stretching and wheelbase
Suspension – exchange of springs and

- accessories
- Hauling service and alignment
- Support and truck springs
- Bushing shaft sleeve
- Installing bumpers
- Commerce of parts
- Modification Service for rear suspension

Source: research data

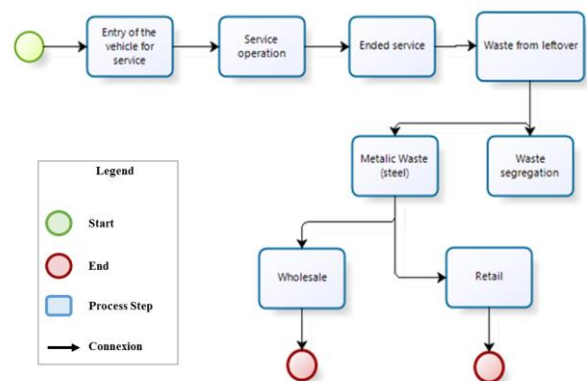
The studied company receives distinction for its main services both in its regional and nationwide scope, serving almost all the sugarcane mills of Alta Paulista region, providing maintenance service on their trucks. It is also nationwide remarkable in services of axle installation, chassis stretching and wheelbase. In this segment the company receives clients from all over Brazil.

Whereas the company has a significant number of products and services, it is observed that in this regard the services and products offered generate wastes during the transformation process. In this context, one of the main services of the company is the installation process of the 2nd and 3rd axles and maintenance of truck suspension, which are presented in Figure 1.

As shown in Figure 1, the processes generate waste from leftover material of the services performed in the company under study, a selection of waste is carried to its destination; scrap metal, in the case of the company the remains of steel parts, are intended to wholesale and retail.

The wholesaling is made to companies working in the scrap metal marketing and retailing sector is made for metalwork companies that look for the company in order to buy the material.

Figure 1. Flow of maintenance process/axle installation.



The volumes of steel scraps generated during the period of analysis are presented in Table 3. In this table the data are consolidated into two periods totaling 18 months, once the studied company uses a strategy of waiting to have a significant amount of pieces of steel scraps in order to have a greater bargaining power at the time of sale. This volume corresponds in the first period to an amount of 12,800 kg and in the second period an amount of 13,500 kg. This data will be showing in the Table 3.

After the MIPS calculations it was possible to measure the economic and environmental benefits of managing leftover of steel pieces generated by the maintenance of heavy vehicles made by the company studied. The following table presents the environmental gains made by this administration.

Table 3 - Consolidated amount of steel scraps (kilograms)

Period	Steel
Oct/13 - Jul/14	12,800.00
Aug/14 - Mar/15	13,500.00

Source: research data

As shown in Table 4, considering the analyzed period 245 tons of abiotic materials were generated and no more than 2,000 tons of water have been used for the production of this new material, and more than 20 tons of air was no longer polluted. Accordingly, when the values are distributed per month (considering the 18-month period analysis) reducing abiotic material generated is more than 13 tones, and more than 119 tons of water not used for the production of a new product and over 1 ton of air is no longer polluted.

Table 4. MIPS calculation for the total amount of steel generated by the company - (kilograms)

	Abiotic Material	Biotic Material	Water	Air
Steel (kg/kg)	245,116.00		2,152,918.00	20,251.00
Total	245,116.00	0.00	2,152,918.00	20,251.00

Source: Research data

Considering the data in Table 5, the economic gains made in the period of analysis may not pose a significant amount for such a period once it was obtained R\$ 13,185.00 with a monthly average value of R\$ 732.50. But this gain

is the company's opportunity not to miss it economically and apply the reverse logistics of the analyzed residue (steel) to generate value on what would be considered disposal. With this result, the company has invested in activities for the development of the business and the people who work in it.

Table 5. Financial results – Steel selling

Period	Kind of sale	Amount	Value	Total
Oct/13 - Jul/14	Wholesale	9,000.00	0.38	3,420.00
	Retail	3,800.00	0.80	3,040.00
Aug/14 - Mar/15	Wholesale	9,500.00	0.35	3,325.00
	Retail	4,000.00	0.85	3,400.00

Source: Research data

6 Conclusion

With the occurrence of environmental accidents and their impacts on the environment, the companies have been considered responsible and shouldered with financial losses caused by them, once besides the negative image generated from the occurring, it is remarkable that these episodes unleash reactions to develop and implement environmental management, aiming at reducing the risk of incidents and accidents without reducing their competitiveness.

In this context, laws were created for a correct management of waste which, besides avoiding environmental risks, can be analyzed with an economic view, as if performed a planning and an efficient implementation can achieve financial gains that can be invested in the development of business or persons involved in such business.

As for the provided environmental benefits, the implementation of waste management can be performed at the organizational, regional, national and global levels, once recycling the material it is possible to reduce the environmental impact avoiding the production of new products and thus reducing the generation of abiotic materials, water and air pollution.

In the present study it was possible to demonstrate that the management of steel parts leftover made by the company studied had significant environmental and economic benefits, once more than cooperating with the environment, reducing polluting effect and negative impact, the

company can obtain financial gains that can be invested in the development of your business and the people who work in it.

It is noteworthy that as a consequence of the strategy adopted for the management of scraps of steel parts the company is able to quantify its environmental records in addition to winning in bargaining power when selling these materials.

A limitation presented by this study lies in the fact of the Wuppertal Institute to explain that conversion data of biotic and abiotic materials, water and air are very close to real and that there is no way to show accuracy, but it is an appropriate way to quantify the environmental advantages being very important for the scientific context.

Finally, a contribution of this study is the knowledge of how the solid waste generated in the heavy automotive sector can be treated using the concept of reverse logistics demonstrating that this can be an alternative to direct economic gains and environmental benefits for society in search for sustainability.

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7 References

Associação Brasileira de Normas Técnicas – ABNT. NBR ISO 14001. (2004). *Sistemas da gestão ambiental – Requisitos com orientações para uso (Environmental management systems - Requirements with guidance for use)*. Rio de Janeiro.

Associação Brasileira de Normas Técnicas – ABNT. NBR ISSO 10004. (2004). *Resíduos sólidos – Classificação (Solid wastes – classification)*. Rio de Janeiro.

Barata, M. M. L. (2007). O setor empresarial e a sustentabilidade no Brasil. *Revista Pensamento Contemporâneo em Administração*, 1(1), p. 70-86.

Braga Junior, S. S. & Rizzo, M. R. (2010) Sustentabilidade através do aproveitamento de resíduos: Um estudo dos processos implantados por um supermercado de médio porte. *Revista Brasileira de Engenharia de Biosistemas*

(UNICAMP), 4(2), 108-125.

Braga Junior, S. S. B., Merlo, E. M., & Nagano, M. S. (2009). Um estudo comparativo das práticas de logística reversa no varejo de médio porte. *Revista da Micro e Pequena Empresa*, 3(2), 64–81.

Braga Junior, S. S., & Santos, R. B. M. (2015). Environmental gains from the practice of reverse logistics retail supermarket. [Ganhos ambientais com a Prática da Logística Reversa no Varejo Supermercado] *Espacios*, 36(5), 14.

BRASIL. PNRS – Política Nacional de Resíduos Sólidos. Subemenda Substitutiva Global de Plenário ao Projeto de Lei nº 203, de 1991, e seus apêndices. Disponível em: <<http://www.revistasustentabilidade.com.br/reciclagem/reciclagem/documentosinteressante/relatorio-final-da-politica-de-residuos>>. Acesso em: 28 mar, 2014.

Brogaard, L. K., & T. H. Christensen. (2012). Quantifying capital goods for collection and transport of waste. *Waste Management & Research* 30(12): 1243–1250. doi:10.1177/0734242x12462279

Casotti, B. P., & Goldenstein, M. (2008) Panorama do Setor Automotivo: as mudanças estruturais da indústria e as perspectivas para o Brasil (Panorama of the automotive sector: structural changes of the industry and prospects for Brazil). *BNDES Setorial*, Rio de Janeiro, (28), 147-187.

Conselho Nacional do Meio Ambiente – CONAMA. (2001). Resolução nº 275, de 25 de abril de 2001.

Conselho Nacional do Meio Ambiente – CONAMA. (2005). Resolução nº 362, de 23 de junho de 2005.

de Melo Santos, N., & Martins, R. (2012). Gestão de relacionamentos por meio da logística no setor farmacêutico brasileiro. *Revista de Negócios*, 17(3), 3-19.

Dias, K. T. S., and Braga Junior, S.S. (2015). The use of reverse logistics for waste management in a Brazilian grocery retailer. *Waste Management & Research* 34(1): 22-29. doi:10.1177/0734242X15615696

Dowlatsahi, S. (2000). Developing a theory of reverse logistics. *Interfaces*, 30(3), 143–155.

Fehr, M. (2014). The management challenge for household waste in emerging economies like Brazil: Realistic source separation and activation of reverse logistics. *Waste Management &*

Research, 32(9), 32–39.

Gil, A. C. (2010). Métodos e técnicas de pesquisa social. In: Atlas(Ed.) Métodos e técnicas de pesquisa social. Location: Sao Paulo, Atlas.

Gonçalves, P. (2003). A reciclagem integradora dos aspectos ambientais, sociais e econômicos. FASE, DP&A.

Horvath, P. A., Autry, C. W., & Wilcox, W. E. (2005). Liquidity implications of reverse logistics for retailers: A Markov chain approach. *Journal of Retailing*, 81(3), 191–203.

John, V. M. (2000). Reciclagem de resíduos na construção civil: Contribuição à metodologia de pesquisa e desenvolvimento. Universidade de São Paulo, 102.

Kokkinaki, A. I., Dekker, R., de Koster, R., & Pappis, C. (2001). From e-trash to e-treasure: how value can be created by the new e-business models for reverse logistics (No. EI 2000-32/A). *Econometric Institute Research Papers*.

Lacourt, J. Z. (2012). Plano de gerenciamento de resíduos sólidos da mecânica de máquinas pesadas Lacchini (Lacchini Solid waste management plan the mechanics of heavy machinery). *Passo Fundo* 1(1): 106.

Leite, P. R. (2003). Logística reversa. São Paulo: Pearson.

Liu, R. P., Guo, B., Ren, A., & Bian, J. F. (2010). The chemical and oxidation characteristics of semi-dry flue gas desulfurization ash from a steel factory. *Waste Management & Research* 28(10): 865-871. doi:10.1177/0734242x09339952

Lopes, G. V., & Kemerich, P. D. D. C. (2007). Resíduos de oficina mecânica: proposta de gerenciamento (Mechanics workshop waste: Proposal for Management). *Disc. Scientia. Série: Ciências Naturais e Tecnológicas*, S. Maria, 8(1): 81-94.

Mano, E. B., Pacheco, É. B. A. V., & Bonelli, C. M. C. (2005). Meio ambiente, poluição e reciclagem. Location: Edgard Blücher.

Marchi, C. M. D. F. (2011). Cenário mundial dos resíduos sólidos e o comportamento corporativo brasileiro frente à logística reversa. *Perspectivas em Gestão & Conhecimento*, 1(2), 118–135.

Maroun, C. A. (2006). *Manual de Gerenciamento de Resíduos: guia de procedimentos passo a passo (Waste Management Manual: step by step procedures guide)*. 2ª ed. ISBM: Rio de Janeiro.

Motta, W. H. (2011). Logística Reversa e a

Reciclagem de Embalagens no Brasil. VII Congresso Nacional de Excelência em Gestão (pp. 5–9).

Nunes, G. B., & Barbosa, A. F. F. (2012). Gestão dos resíduos sólidos provenientes dos derivados de petróleo em oficinas mecânicas da cidade de Natal/RN. Encontro Nacional de Educação, Ciência e Tecnologia/UEPB (Management of solid waste from oil products in machine shops in the city of Natal - RN. National Meeting of Education, Science and Technology / UEPB.). Natal, p.11.

OICA - International Organization of Motor Vehicle Manufacturers. (2016b). *World motor vehicle production by country and type (survey 2014-2015)*. Disponível em: <http://www.oica.net/wp-content/uploads/Total-2015-Q4-March-16.pdf>

OICA - International Organization of Motor Vehicle Manufacturers. (2016a). *A growth industry*. <http://www.oica.net/category/economic-contributions/>

Paes, M. X., Gianelli, B. F., Kulay, L. A., Medeiros, G. A. D., & Mancini, S. D. (2014). Life cycle assessment applied to municipal solid waste management: a case study. *Environment and Natural Resources Research*, 169-177.

Paulino, P. F. (2009). *Diagnóstico dos resíduos gerados nas oficinas mecânicas de veículos automotivos do município de São Carlos/SP (Diagnosis of waste generated in the machine shops of automotive vehicles in the city of São Carlos – SP)*. Rio Claro: [s/n] 59f.

Pinto, T. D. P. (1999). Metodologia para a gestão diferenciada de resíduos sólidos da construção urbana (Unpublished doctoral dissertation). Universidade de São Paulo, Location: São Paulo.

Ritthoff, M., Rohn, H., & Liedtke, C. (2002). Calculating MIPS: Resource productivity of products and services (No. 27e). Wuppertal Spezial, Wuppertal Institut für Klima, Umwelt und Energie, 2002.

Rogers, D. S., & Tibben-Lembke, R. S. (1999). Going backwards: reverse logistics trends and practices (Vol. 2). Pittsburgh, PA: Reverse Logistics Executive Council.

Santos, R. B. M., Braga Junior, S. S., Silva, D., & Satolo, E. G. (2014). Analysis of the economic and environmental benefits through the reverse logistics for retail. *American Journal of Environmental Protection*, 3(3), 138–143.

Serviço Brasileiro de Apoio às Micro e Pequenas Empresas - SEBRAE. (2015). Setor automotivo: Como ser mais sustentável (Automotive: how to be more sustainable).

T. Hazen, B., Huscroft, J., J. Hall, D., K. Weigel, F., & B. Hanna, J. (2014). Reverse logistics information system success and the effect of motivation. *International Journal of Physical Distribution & Logistics Management*, 44(3), 201-220.

Veiga, M. M. (2013). Analysis of efficiency of waste reverse logistics for recycling. *Waste Management & Research*, 31(10), 26–34.

Vigsø, D. (2004). Deposits on single use containers-a social cost-benefit analysis of the Danish deposit system for single use drink containers. *Waste Management & Research* 22(6): 477-487. doi:10.1177/0734242x04049252

Yin, R. K. (2003). *Estudo de Caso: Planejamento e Métodos. (Case Study: Design and Methods)*. Bookman Editora: Porto Alegre.