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Environmental Management

Case study: characterization of solid waste management system in metallurgic companies of Joaçaba/SC

Estudo de caso: caracterização do sistema de gerenciamento de resíduos sólidos em empresas metalurgicas de Joaçaba/SC

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ABSTRACT

The development of a country is intimately linked to the industrial development that is responsible for wealth generation, jobs and income, however, it is followed by serious environmental impacts caused by production and incorrect disposal of waste. The present research aimed to characterize the solid waste management system in metallurgic companies from Joaçaba/SC. For this, a research instrument was applied containing twelve open questions for the heads of seven companies. The questions included the identification of solid waste generated in the production process and the disposal method, as well as information about environmental licensing and reverse logistic. The research showed that only one company has an environmental management system and has a better understanding about its environmental responsibilities, both the management of waste generated by the production process and the importance of preserving the environmental.

Keywords: Environmental management system; Solid waste; Metallurgic industry

RESUMO

O desenvolvimento de um país encontra-se intimamente ligado ao desenvolvimento industrial que é responsável pela geração de riquezas, empregos e renda, porém, é acompanhado de graves impactos ambientais ocasionados pela produção e descarte incorreto de resíduos. A presente pesquisa objetivou caracterizar o sistema de gerenciamento de resíduos sólidos em empresas metalúrgicas do município de Joaçaba/SC. Para isso, aplicou-se um instrumento de pesquisa contendo doze questões abertas para os responsáveis de sete empresas. As questões contemplavam a identificação dos resíduos sólidos gerados no processo produtivo e o método de descarte, além de informações acerca de licenciamento ambiental e logística reversa. A pesquisa mostrou que apenas uma empresa possui sistema de gestão ambiental e apresenta melhor compreensão acerca das suas responsabilidades ambientais, tanto no tocante ao gerenciamento dos resíduos gerados pelo processo produtivo como da importância em preservar o meio ambiente.

Palavras-chaves: Sistema de gerenciamento ambiental; Resíduos sólidos; Indústria Metalúrgica

1 INTRODUCTION

The industrial activity is a department that exercises great importance to the economy of any country, but beyond that, it is responsible for the generating uncountable jobs, as well as promoting transactions that directly impact the GDP, in which, currently the industry represents 21,4% Brazil's PIB, accounting for 69,22% of exports of goods and services and for 69,2% of business investment in research and development (PORTAL DA INDÚSTRIA, 2022).

However, this industrial growth, driven by the increased in the demand for industrialized products, generates high rates of waste, that in most cases does not have the correct destination. The metallurgic industry can be considered a great polluter, because its productive process present a large amount of waste and polluting gases capable of causing impacts and risks to the environmental, and in most cases it can be irreversible or takes years to recover, such as water contamination, air pollution, change in fauna and flora, unbalance of food chain (DA SILVA, 2009).

A way to reduce these environmental impacts caused by solid waste is to manage it, in other words, implement the Environmental Management System Plan in the industry, which is a planned methodology with the goal of proposing improvement opportunities, and the reduction in the generation of waste, applying ways of packaging, storage, transport and proper final disposal. Therefore, it is a way to guarantee the population's quality of life and fundamentally for the environmental, as well as the condition of attending the environmental legislation in force and achieve sustainable development (SEIFFERT, 2017).

Given this context, the present research aimed to characterize the solid waste management system of metallurgic companies located in Joaçaba/SC.

2 THEORETICAL FOUNDATION

This item presents in detail the state of art regarding the environmental management system and its mechanisms, as well as the pertinent legislation.

2.1 Solid waste, national waste policy (PNRS) and reverse logistic

Solid waste is all materials that are no longer useful in a company's production processes or that have reached the end of their useful life, and can be classified as dangerous or non-dangerous. According ABNT NBR 10.004:2004, solid waste are those that:

> [...] result from activities of industrial, domestic, hospital, commercial, agricultural, service and sweeping origin. Included in this definition are the sludge from water treatment systems, those generated in pollution control equipment, as well as determined liquids which the particularities make their release into the public sewerage system or water sources unfeasible, or demand technic and economically solutions for that, unfeasible given the best technology available.

There's a number of specific laws and regulations applicable to solid waste in Brazil, however, on August 2nd from 2010, the Federal Law n° 12.305 was enacted and sanctioned regulated by Decree n° 7.404/2010, which stablish the National Solid Waste Policy and all others auxiliars legislation submit to this law. In addition to the NSWP, there are specific rules for transportation of dangerous waste, as the ANTT 5232 and the general rule to waste transportation, NBR 13.221/2000.

There is also the Ordinance n° 280/2000 which stablishes the Transportation of Waste Manifest – TWM national, as a management tool and declaratory document for implantation and operationalization of the waste management plan, which provides for the National Solid Waste Inventory.

The PNRS established a regulatory mark for the solid waste sector in the country, gathering a set of principles, objectives, instruments, guidelines, goals and distribution of responsibilities for a shared management of solid waste, with actions that involves Federal Government, State, Federal District, Cities and the Industrial Sector, in addiction the civil society, because according to the law 12.305/2010, these wastes must have a environmentally correct destination (BRASIL, 2010).

Among the ways to the effectiveness of this public policy there is the reverse logistic, consisting in an instrument of economic and social development characterized by a set of actions, procedures and means intended to enabling the collection and

restitution of solid waste to the business sector, for reuse, in its cycle or other productive cycle, or other environmentally appropriate final destination (BRASIL, 2010).

Oliveira *et al* (2015) defines the practice of reverse logistics as the process of efficient and effective planning, implementation and control of raw material flow, products in stocks, finished products and related information from the consumption point to the reprocessing point, being the most appropriate way of join sustainability and profit in the productive process of an industry, reflecting its benefits in society.

Reverse logistic can be seen as a new area of business logistic, which directs the preoccupation of provide solutions in the logistical aspects of the return to the productive cycle of different types of industrial goods, of their constituent materials and industrial waste, through the controlled reuse of the good and its components or the recycling of the constituent materials, giving rise to new raw materials, which can be reintegrated into the productive process of each industry (RAMIRO; NOGUEIRA, 2016; MEADE, SARKIS, & PRESLEY, 2007).

In the reverse logistic process, there is a set of activities in which the company collects, separates, packs and dispatches used, damaged or obsolete items, from the consume points to the reprocessing locations for reprocessing, resale or discard. However, to return to the logistic system, these products can return to the supplier to be resold, under appropriate conditions of commercialization; refurbished, if there is economic justification; or recycled, when there is no possibility of recovery (RAMIRO; NOGUEIRA, 2016).

2.1.1 Waste classification

Solid waste receives different classifications based on certain properties or characteristics. But, before being destined for treatment and final disposal, the industrial waste must be segregated and classified according to its dangerousness, which as specified by Norm 10.004 by Brazilian Association of Technical Norms, follows the criterion of potential risks to the environment.

The dangerous waste – Class I are considered solid waste or mixtures of waste that, due to their inflammability characteristics, corrosivity, reactivity, toxicity, pathogenicity, may present risk to public health and/or present adverse effects to the environment, when improperly manipulated or arranged. As an example, there is industrial waste and batteries (ABNT, 2004).

The non-dangerous waste – Class II: The A (not inert) are the solid waste or mixtures of solid waste that do not fit on Class I – dangerous or on Class II B – inert. These may have properties as combustibility, biodegradability or water solubility. Basically, they are waste with the domestic garbage characteristics. And the B (inert) are those that, when submitted to solubilization tests, do not have any of their constituents solubilized in higher concentrations than the standards of water potability. These residues do not degrade or do not decompose when disposed on the soil, slowly degrading. In this classification, as an example, the demolition rubble, stones and sands removed from excavations.

Also, according to Norm 10.004 of Brazilian Association of Technical Norms (2004), industrial waste corresponds to approximately 70% of the total waste generated in the most industrialized and populated regions of the Brazilian territory. Therefore, the destination of these waste is always the responsibility of the industry that generated it, which it should hire a third company for disposal in a controlled landfill, becoming co-responsible for the waste.

2.2 Environmental impacts, environmental licensing and environmental management system (EMS)

According to resolution n° 001 of January 23, 1986 of CONAMA, the environmental impact is “any alteration in the physical, chemical and biological properties of the environment”, which are caused by human actions that “direct or indirectly affect the health, the security and the welfare of population, social and economic activities, the biota, the sanitary conditions of environment and the quality of environmental resources” (BRASIL, 1986).

The prevention and reduction of environmental impacts are provided in the Brazilian legislations and norms as consist on Federal Law n°9.605 of February 12, 1998 which provides for penal and administrative sanctions derived from conducts and harmful activities for environment (BRASIL, 1998).

It is a fact that all industrial activities have polluting potential and in order to minimize the environment damage, the Constitution of the Federative Republic of Brazil (CFRB/88) determined that all the activities that may result in damage to the environment need control by public authorities, one of the most important mechanisms being the Environmental License. Through licensing, the Public Administration, in the use of its power, can establish conditions and limits for the exercise of certain activities (ANTUNES, 2000).

The licensing is one of the instruments of the National Politic of Environment (NPE), which objective is acting preventively to protect the common good of the people – the environment – and make its preservation compatible with economic-social development. Both essentials to society, are constitutional rights. The goal is to ensure that the exercise of a right does not compromise another equally important (BRASIL, 2007).

Some companies adopt the Environment Management System as a tool in the minimization of impacts, these have as priority to alleviate the problems caused to the environment and this makes society recognize and value the organizations that use them and work in favor of the environment, so that it can be represented for some as an important competitive advantage (SEIFFERT, 2017).

While implementing an EMS is a voluntary and strategic decision of each organization, which spontaneously decides to adopt “environmentally appropriate” practices in its process, the environmental licensing process is a mandatory process, defined by law, representing an intervention by the Public Power in business activities. Thus, it is neither “politically incorrect” nor inconsistent not agreeing with certain procedures in the environment licensing process and simultaneously adopt and effective EMS (DIAS, 2006).

3 METHODS AND TECHNIQUES

The research is characterized as exploratory and initiated with the quantification of the number of industries present in the city of Joaçaba/SC and their respective activities through a search in database of observatory of the FIESC (Federation of Industries of the State of Santa Catarina). Sequentially, was selected as a sample to further studies the most representative branch of activity in the city in terms of number.

After selection of the, aiming to characterize the Environmental Management System and solid waste of companies, as well as the level of knowledge of the responsible about the environment causes, legislation and means of waste disposal, a research instrument was applied (Table 1) composed by 12 (twelve) open questions.

Table 1 – Research instrument applied to industries

Numbers	Questions
1	Has environment licensing?
2	Know what is an EMS?
3	Has EMS/has interest?
4	Know the NSWP?
5	Heard about or has knowledge of reverse logistic?
6	What is the destination of the waste?
8	In the company, is it performed some kind of action aimed at reducing, recycling or reusing the solid waste generated, such as lamps, batteries and other materials?
7	It has documentation with waste destination?
9	The company sees the treatment of solid waste as an competitive advantage or only as environmental conscientization?
10	The company utilize indicators to evaluate the actions of the EMS?
11	Periodically, is it performed analysis to define a continuous improvement in EMS?
12	The company has some support from the city hall?

Source: the authors

After the application of the questionary, it was selected among the samples, the company which is better structured in terms of Environment Management System (EMS) to continue the studies.

4 RESULTS AND DISCUSSIONS

The initial research in relation to the most prominent segment in the city of Joaçaba showed that the metal-mechanics industries are the most numerous, in a total of twenty-seven industries identified, twelve are in this branch, however, only seven agreed to participate of the research.

The industrial processes of this branch produce a diversity of waste that have in their formation iron, steel, chips of them (filings), tow contaminated with lubricating oil, non-ferrous metal packaging for conditioning the lubricating oil and paints, generate rests of lubricating oil, paints, cardboard boxes, plastics, office and cleaning supplies. Precisely because of this wide range of production, the sector is characterized by presenting great polluting potential, demanding special attention in the accompaniment of its effluents that are generated in the steel fabrication and steel products, production of iron castings, production of laminates, production of welding and anodes, galvanizing, among other activities (PEDROTTI; MISTURA, 2010).

According to Brazilian Norm n° 10004 ABNT (2004) in the classification of non-dangerous waste, basically in class B are ferrous metal scrap, non-ferrous metal scrap (brass, among others), paper and cardboard waste, polymerized plastic waste, wood residue, textile material residue, non-metallic mineral residues, foundry sand which are the residues detected in the companies of this study. The lubricating oil and paint waste are classified as Class D, dangerous from the process of construction or reform (ABNT, 2004).

Despite its great economy importance, the industries of metallurgic sector are among the main sources of waste causing environmental degradation, making waste treatment indispensable in mitigating impacts on the environment. The contact of toxic substances with the soil can change its physic-chemical characteristics, contribute with the dissemination of diseases, harm the local fauna and flora and reduce agricultural production, in addition, pollution by industrial waste can still occur in the atmosphere with the release of toxic gases, industrial particles, among others (DA SILVA, 2009; FRAISOLI; LAZARI; PANSANI, 2016).

The results obtained through application of the research instrument showed that 57,14% of companies have an environmental license, whereby one of these, in 2006 received the ISO14001 certification. On the other hand, 42,86% of the companies do not have an environment licensing, they are in the process of solicitation or regularization of the licensing and one of the companies interviewed is prevented from obtaining the license because it is located in an area that does not respect the minimum distance from the water course as determined by law and in this case, as the shed is rented, the company will move to another city in the region of the state of Santa Catarina.

Since 1981, according to Law n° 6.938/1981 which provides for the National Environmental Policy and brings a set of norms for environmental preservation, the environment licensing has become mandatory in all national territory and the effective activities or potentially polluters cannot operate without proper licensing. Since then, companies that work without the Environment License are subject to sensations provided for by law, including the punishments listed in the Environment Crimes Law, instituted in 1998, warnings, fines, embargoes, temporary or permanent stoppage of activities.

The Environment Management System (EMS) can be considered a tool, an operational model or even an organizational structure that an organization can adopt in order to achieve continuous improvements in environmental performance. The main objective of the system is to identify and reduce the environmental aspects and impacts, creating a healthier and with more quality work environment (SEIFFERT, 217).

As for the knowledge and interest in the EMS implantation by the companies the results showed that in two of them, their representatives have knowledge about the subject and show interest in implanting it. Oppositely, other two responsible know what it is about but are not interested in implementing it. In two others, their managers reported that they do not have knowledge about EMS and only one of them showed interest in the implementation. Only one company the manager highlighted that he has knowledge about the EMS, this one implanted the system and follows it rigorously.

About the vision of the company about the fact of correct destination of the solid waste constitutes a competitive advantage, as an environmental action or only as legal obligation, three companies, the managers related that they do not consider this as a competitive advantage. Another three managers believe that proper management of the solid waste, at the same time that it brings a competitive advantage, collaborates with the environment preservation and that currently many consumers prefer to negotiate with companies that attend environment legislations. According to a representative of one of the companies "this action at the same time that helps in the conquest of new clients, improves the image and impacts positively in the economy of the company".

The referring results to the knowledge about the National Policy on Solid Waste (NPSW) showed that only one of the respondents interviewed does not know what the law is about and is the only to not know the objectives of the reverse logistic. This fact may be associated to the late dissemination of environmental education which according to Carvalho (2008) has as purpose to disseminate knowledge about the environment in order to help its preservation and sustainable utilization of its resources. The author explains that this is a permanent process, in which individuals and the community become aware of their environment and acquire knowledge, skills, experiences, values and the determination that make them capable of acting individually or collectively in the search for solutions to the present and future environmental problems.

Ramiro and Nogueira (2016) explain that the laws that govern the disposal of solid waste contribute to the minimization of contamination of the environment that in a directly way results in damage to the health of the population and that investments in recycling systems should be a priority.

Many of the metallurgical companies that join the reverse logistic not only as a way of reducing coasts, but also to integrate the organization's strategy. In the material reuse strategy, they may have a cost reduction through the use of secondary raw material instead of primary raw material. In addition, metallurgical companies can also

obtain return through the collect of defective products so that they can be evaluated and given the appropriate destination (AMOAMO *et al.*, 2014).

According to Santos *et al* (2013), the main reasons that lead companies to act more strongly in reverse logistic are, in order of priority, the environmental legislation, which forces companies to return with their products and take care of the necessary treatment; the economic benefits of using products that return to the production process, in detriment of the high costs of correct disposal of trash and the growing environmental awareness of consumers and the differentiated image that the company can acquire towards its customers, suppliers and society associate with the programs aimed at the development of environmental education.

As for the destination of waste and the actions aimed at reducing, recycling or reusing of the solid waste generated, in a company the cans, scraps of iron and metal are sold or changed for other materials in the scrap yard. As for office papers, both sides of the sheet are used for printing, after the disablement they are grouped with plastics and other waste that can be recycled and sent to the city's recycling system.

In another company, the iron waste is resold to the foundry and other amount is exchanged for other materials in the scrap yard. The papers, boxes, plastics are delivered to the autonomous collectors and the other items are collected by an accredited company (CETRIC) which is proposed to do the correct destination.

The other company resells the waste to the foundry and the other scraps are sold to the junk yard, while the lamps are discarded in a specific company which takes responsibility for the final destination.

Another company directs the waste to the industrial landfill, which are controlled, materials that can be recycled are removed from the company by autonomous collectors, as for the metal waste is sold to the junk yard, the oil is also sold and the effluent is treated.

A company, which is considered small size, related that the waste from office supplies are delivered to the city's recycling program and the others are sold or exchanged for other materials along the junk yard.

One of the companies, which works exclusively with aluminum, the manager reported that the chips of this material are sold to the junk yard, the lamps and batteries are discarded in stores that collect these materials after use and the organic residues and other materials that can be recycled are collected by the city.

Another company, the person in charge explained that the iron chips are melted and reused and that the foundry sand is destined to an industrial landfill. In addition, the company has actions aimed at reducing waste generation, however it has not explained what these actions are.

Industrial landfill is the place where the industrial waste is sent according its classification for treatment and final destination, thus the landfill used by the interviewed companies is located in the city of Chapecó/SC. As the organic waste from all the interviewed companies is collected by the city's government.

Table 2 – Waste destination from companies participating in the research

Waste destination						
Waste	**Cans, iron, metal, foundry sand**			**Papers, plastics, lamps and other recyclable materials**		
Companies	**Sold**	**Exchanged**	**Landfill**	**City's recycling**	**Autonomous collectors**	**Accredited company**
01	X	X		X		
02	X	X			X	X
03	X					X
04	X		X		X	
05	X	X		X		
06	X			X		X
07			X			

Source: the authors

Table 2 presents a summary regarding the disposal of waste from the companies participating in the research.

After knowing about the destination of each company's waste, it was questioned whether the process can be proven through documented records. The research results pointed that five of the companies have documents (contracts, invoices) that prove the

destination of solid waste and that this control is a prerequisite for compliance with the legislation. Only two companies, their managers reported not having records of activities.

The use of environmental indicators to evaluate the actions of the Environmental Management System (EMS), is only performed by the company that have this system, which performs analyzes annually when they undergo through audits.

All the companies claim not to receive support or incentive from the city's government for the environmental practices and that the government agency is only responsible for the collection of organic and recyclable waste.

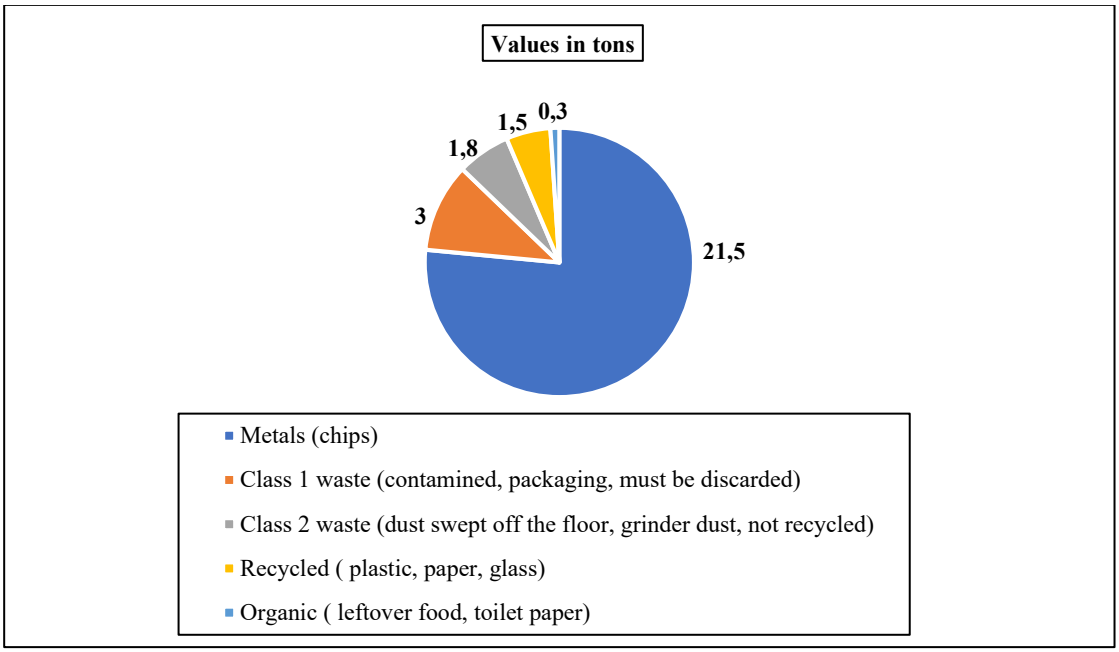
After the application of the questionnaire it was selected from the sample, the best structured company in terms of Environmental Management System (EMS) to continue the study.

The selected company received the ISO 14001:2015 certification which is an Environmental Management System that allows the company's management to improve its environmental performance, fulfilling the commitments and objectives of this certification. That is, the company's management is capable of managing the environmental impacts, both immediate and long-term of the products and processes performed in the organization (ABNT, 2004).

With this certification, the company managed to develop its activities of production with more tranquility, without worries because it is attending the current environmental legislation in the country, when it comes to the environment.

The graphic 1 represent the amounts in tons of solid waste generated by the company in the year of 2020.

Graphic 1 – Quantification (tons) of solid waste generated by the company in the year of 2020



Source: the authors

Table 3 – Summary of the destination of the waste generated by the company

Waste	Destination	Collection frequency	Amount received (R$/kg – R$/L)
Metals	Junk yard	15 days	2,50/ Kg
Recyclables	Donation (cooperative)	1 day of the month	No value
Class 1 e 2	Company CETRIC	1 day of the month	No value
Organic	Discarded (city's government)	Twice a week	No value
Batteries and lamps	Taken to companies that make the correct discard	No frequency	No value
Oil	Sold to companies	3 times a year	5,00/liter

Source: the authors

For the destination of all solid waste, the company has output control, specifying the type of waste, the truck plate (MTR) and contract with the companies

that make the collection. Chart 3 presents a summary of the destination of the waste generated by the company

The company understand that the reverse logistic applied to the solid waste improves the corporative image, generates a great visibility towards the clients and the community, cause great positive economic impact for the company, in addition, of course, it is part of the legal requirements set out in the environmental laws for obtaining environmental licensing (MARCHI, 2011).

5 CONCLUSION

Though this case study, it was sought to characterize the management system of solid waste in metallurgic companies in the city of Joaçaba/SC. Based on the research results it was possible to evidence that the vast majority of companies generate non-dangerous waste from Class B and few generate dangerous waste from Class D.

It was also evidenced that of the seven companies surveyed, four have environmental licensing, and one of these, in 2006, received the ISO14001 certification, two do not have environmental licensing and one of the companies because it is located in a watercourse area and cannot obtain the license, so it decided to move to another city.

The application of the questionnaires about SGA, PNRS and Reverse Logistics demonstrated the lack of knowledge of the representatives of the companies about the themes, which also explains the lack of interest in the implementation of waste management system in the companies, limiting the actions to the prerequisites for the obtaining and maintaining environmental licensing. In addition, only a minority of three companies have solid waste treatment with a competitive advantage for the company.

However, it is believed that the study presents important analysis for the comprehension of the environmental management system in metallurgical companies from the city of Joaçaba/SC, its main difficulties in the process of solid waste management and reverse logistics, allowing the development of new studies on the mentioned topic. Therefore, it is proposed to expand the study, developing it in medium

and large companies, covering perhaps the region or even the state, expanding the unit of analysis, because at the time the research was being conclude it was noticed that the number of companies increased.

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