International Journal of Engineering and Technical Research (IJETR)
ISSN: 2321-0869 (O) 2454-4698 (P), Volume-6, Issue-2, October 2016

# Waste management in a petrochemical industry: a sustainable practice

**Roberta Zaninelli do Nascimento Zarpelão, Ilna Márcia Oliveira Rocha, Milva Maria Figueiredo de Martino, Isabel Cristina Kowal Olm Cunha, Kátia Simões Parente, Fernanda Drago**

***Abstract*— The concept of sustainability emerged in the mid-1970s from the United Nations (UN) in order to reconcile social development and respect for the environment. Currently one of the biggest challenges faced by modern society is the equating of excessive generation and environmentally safe final disposal of solid waste. The construction industry is responsible for generating environmental impacts due to the consumption between 20% and 50% of the extracted resources and the generation of 0.4 to 0.7 tons of solid waste per capita every year. The global concern on solid waste, especially waste generated in construction and health services has increased due to to the growth of production, the inadequate management and the lack of areas for final disposal of such waste. Given this context, researchers of this study tried to measure the amount of waste collected from the petrochemical industry during the year 2013 and the waste percentage produced by the health services of this industry and seek the benefits, barriers and suggestions to improve the management of solid waste in construction industry and health services. This work it is a retrospective, descriptive and quantitative study held in a petrochemical industry in the state of Sao Paulo. Through the collected data, authors managed to map all waste generated in its facilities and the appropriate final destination given to them. In the year 2013, 4,745.68 tons of solid waste – 115.31 tons of class I waste, 1740.14 tons of class IIA waste and 2890.23 tons of class IIB waste - were collected. Of this total, 50.54% were recycled. Health services waste amounted to 0.77 tons. It was noted that the benefits of effective management of solid waste are linked to financial benefits for the company and to social benefits such as the generation of employment and income for workers directly or indirectly linked to the recycling processes or environmental education.**

***Index Terms*— Medical Waste, Waste, Waste Management.**

## I. INTRODUCTION

Currently one of the biggest challenges faced by modern society is the equating of excessive generation and environmentally safe final disposal of solid waste. The global concern for solid waste has increased due to the growth of production, inadequate management and lack of areas for final disposal [1].

Today, there has been much talk on sustainable development, whose concept emerged in the mid-1970s from the United Nations studies (UN) on climate change. This concept seeks to reconcile the need for economic development of society through the promotion of social development and respect for the environment[2].

The idea of a new development model for the twenty-first century, harmonizing the economic, social and environmental dimensions, appeared to solve as a starting point on a conceptual level the old dilemma between economic growth and reduction of poverty on the one hand and environmental protection on the other, thus promoting the balance between economic and environmental concerns[2].

However, it was only from the Brundtland Report, prepared by the World Commission on Environment and Development in 1987, also known as "Our Common Future", that the term sustainable development and therefore the idea of sustainability were popularized. This commission defined sustainable development as "development that meets the needs of the present without endangering the ability of future generations to meet their own needs." Sustainability must, therefore, be the main target and at the same time constant target of the actions of those formulating and implementing development policies. Such policies should be geared towards a search for balance between man and environment, generating benefits for both sides[2].

Since Rio 92, new priorities for sustainable management of solid waste have been incorporated, which represents a paradigm shift that has driven the actions of governments, society and industry. The reduction of waste in generating sources, the reduction of final disposal on the ground, the maximization of reuse, selective collection and recycling with socio-productive inclusion of collectors and society participation, the composting and energy recovery are included in these priorities [1].

The construction industry is a major area of activity in the Brazilian economy; but it is also responsible for generating environmental impacts. The country's infrastructure construction and maintenance consume between 20 to 50% of extracted resources, and the industry's production chain is the largest consumer of these economy resources [3]-[4].

From 0.4 to 0.7 t/person/year of construction waste (CW) is generated and it represents 2/3 of the mass of municipal solid waste or around twice the amount of domestic solid waste [5].

In addition to the waste generated in construction, this study also presents health services waste, as they are derived from a central outpatient clinic that serves workers who carry out their activities.

Health service waste (HSW) has significant importance in the issue of environmental sustainability and preservation of health [6].

Health service waste (HSW) is that generated by establishments providing human or animal health services: hospitals, medical and dental clinics, clinical laboratories and collection centers, outpatient clinics, pharmacies, local health

**Roberta Zaninelli do Nascimento Zarpelão,** Occupational Nurse, Master in Occupational and Environment Health, PhD at EPE / Unifesp. Sao Paulo (SP), Brazil.

**Ilna Márcia Oliveira Rocha**, Specialist Nurse in Nursing Services Management, Master from EPE/UNIFESP. Sao Paulo (SP), Brazil.

**Milva Maria Figueiredo de Martino**, Nurse, Post-PhD in Nursing. Associate Professor at Unifesp. Sao Paulo (SP), Brasil.

**Isabel Cristina Kowal Olm Cunha**, Nurse, PhD in Public Health at the Federal University of Sao Paulo (UNIFESP). Sao Paulo, Brazil.

**Kátia Simões Parente**, Chemical Engineer, Master and PhD in Public Health, School of Public Health, USP.

**Fernanda Drago**, Environmental engineer.

units, veterinary clinics, educational and medical research institutions, home care services and field work [7].
These residues received legal highlight only in the early 90s, when CONAMA resolution No. 006 of 19/09/1991 was approved, which as of great importance, not by the generated amount (1% to 3%) of the total waste, but due to the potential risk to society and people. They are classified as [6]:
Group A: waste with the possible presence of biological agents which, given its characteristics, may present risk for infection.
Group B: chemical waste.
Group C: radioactive waste.
Group D: common waste.
Group E: sharp waste.
Improper management of solid waste causes socio-environmental impact, so it is increasingly evident that the adoption of sustainable production and consumption patterns and the proper management of solid waste can reduce significantly the environmental and health impact [1].
The issue of sustainability in the generation of solid waste, including medical waste, has led to the pursuit of knowledge in scientific publications and it justifies the present study, since this article will highlight the obstacles, the innovative and transformer aspects of waste management practices, contributing to the management and adoption of best practices, aimed at sustainably of construction industry in the petrochemical sector.

## II. METHOD

This is a retrospective, descriptive and quantitative study held in a petrochemical company located in Cubatão, SP. To obtain the data, authors used an Excel version 3.0 spreadsheet. The data collection period was from January to December 2013. This spreadsheet contained information on the amount of Class I, IIA, IIB waste in 2013, and the final destination.
Regarding the ethical aspects, data collection was authorized by the unit manager. ubmit your manuscript electronically for review.

## III. RESULTS

According to the collected data, the amount of waste generated in the construction work under study in 2013 was 4,745.68 tons, as showed in Table 1.
A total of 115.31 tons of class I solid waste was produced. As seen in the following table, health service waste corresponds to 0.77 tons, accounting for 0.66% of the total. The largest generated class I waste were rags and contaminated personal protective equipment (PPE), totaling 83.82 tons, representing 72% of total.

**Table 01 – Total waste generated in construction in 2013**

| Type of Waste | Amount (tons) | % |
|---|---|---|
| Class I | 115.31 | 2.43% |
| Class IIA | 1,740.14 | 36.67% |
| Class IIB | 2,890.23 | 60.90% |
| Total | 4,745.68 | 100.00% |

Source: Petrochemical industry. Cubatão, SP.

**Table 02 – Total Class I waste generated in construction in 2013**

| **Type of waste – class EI** | **Amount (ton)** | **%** |
|---|---|---|
| Cartridges and printers toners | 0 | 0.00% |
| **Health service waste** | **0.77** | 0.66% |
| Cotton, clothes, rags, hose, timber, paper, cardboard, plastics, ppe's, filters, containers, brushes and rollers contaminated with paints, solvents and varnishes | 2.58 | 2.24% |
| Equipment waste and electric-electronic components (cells and batteries) | 0.001 | 0.00% |
| Equipment waste and electric-electronic components (electric-electronics) | 0.182 | 0.16% |
| Fluorescent lamps | 0.06716 | 0.06% |
| Fluorescent lamps / mercury / sodium steam | 0.05037 | 0.04% |
| Contaminated plastic | 19.85 | 17.21% |
| Waste from sweeping | 7.99 | 6.93% |
| Rags and contaminated ppe's | 83.82 | 72.69% |
| Total | 115.31 | 100% |

Source: Petrochemical industry. Cubatão, SP.

Class IIA waste amounted to 1,740.14 tons, of which 1264.58 tons are common waste, that is, it goes to the landfill, which represents 72.7%. The recycling waste accounted for 12% of total class IIA waste, as showed in the following table. Class IIB waste amounted 2890.23 tons, of which 28.83% are construction debris and 33% are wood waste, both sent for recycling, because the debris is crushed and reused in the construction industry itself, and the wood is used in the manufacture of plywood or as fuel in boilers.
As seen in Table 05, 50% of the waste generated was forwarded to recycling. It is noteworthy that waste such as debris, wood, glass, and even contaminated waste, that is, class I waste, are forwarded to some kind of reuse process. Thus, all waste that is not sent to landfill or incinerated is considered as recycled. Health services waste, therefore, are incinerated and sterilized as required by Article 25 of Resolution CONAMA 358/2005.

**Table III – total class IIA waste generated in construction in 2013**

| **Classe IIA Waste** | **Amount (ton)** | **%** |
|---|---|---|
| Sanding disk | 0 | 0.00% |
| Sanding disk | 0 | 0.00% |
| Vegetation / tree prunnings | 0 | 0.00% |
| Aluminum scrap | 10.92 | 0.63% |
| Copper scrap | 6.04 | 0.35% |
| Ferrous scrap | 234.24 | 13.47% |
| Recyclable (paper / plastic) | 224.36 | 12.89% |
| Common waste (non-recycled) | 1264.58 | 72.66% |
| Total | 1740.16 | 100.00% |

Source: Petrochemical industry. Cubatão, SP.

**Table IV – Total Class II B waste generated in construction in 2013**

| Class II B Waste | Amount (tons) | % |
|---|---|---|
| Construction waste | 1,909.36 | 66.06% |
| Uncontaminated calcium silicate | 5.97 | 0.21% |
| Wood | 0 | 0.00% |
| Wood | 974.9 | 33.73% |
| Glass | 0 | 0.00% |
| Glass | 0 | 0.00% |
| Total | 2,890.23 | 100% |

Source: Petrochemical industry. Cubatão, SP.

**Table V – Total waste generated in construction in 2013**

| Total waste | Tons | % |
|---|---|---|
| Generated | 4745.68053 | 100% |
| Recycled | 2398.41053 | 50% |
| Health services | 0.77 | 0.016 |

Source: Petrochemical industry. Cubatão, SP.

## IV. DISCUSSION

The discussion of this article will be approached from three different topics: benefits of solid waste management, including medical waste and suggestions for better management of solid waste.

**Benefits of Solid Waste Management**

Environment preservation has increasingly become focus of concern of society, and the involved subjects have demonstrated dynamically their ambitions and expectations. The average citizen expects that the government makes laws that are increasingly restrictive and severe to discipline actions against the environment and to supervise effectively the compliance with these laws. The government, in its task of ensuring the community's well-being, exercises its role, effectively regulates these conditions and also has the necessary resources to ensure that they will be fulfilled. The civil society organizations work intensely to defend the interests to which they purpose and do this in a systematic and organized manner. The media publicizes the subject because if it matters to the general public, they must make it attractive and relevant[8].

Effective solid waste management provides economic benefits, as it allows that recyclable materials that have commercial value are sold in specific markets. Thus, the financial result of the operation, which is measured by the difference between the income generated by the sale of materials and the expense of handling and disposal thereof, is a source of quite significant income for companies [8].

The results show the commitment of the said company to waste management. Not only do they measure the amount of waste generated (Table 1) and "catalogue" it, informing all the exact composition and quantity of each type of residue (Tables 2, 3 and 4), but they also reuse a high volume of waste. In this construction work, with about 5,000 employees, around 4,700 tons of waste are generated annually, of which 2,300 were recycled, representing 50% of the total generated in 2013 (Table 5).

As a reduction factor in the volume of waste sent to landfill, there is the construction debris, mentioned in this article (Table 4). In this study, almost half (833.41 tons) of the total construction debris (1909.36 tons) is reused, and the remainder is sent to landfill (1075.95 tons). Construction debris (28.83%) and wood waste (33.7%) are reused in the sector itself.

The health services waste management is a set of management procedures, planned and implemented from scientific, technical, regulatory and legal bases, in order to minimize production and to provide that waste generated is forwarded safely and efficiently, aiming at workers' protection, preservation of public health, natural resources and the environment[9].

There are several factors that have contributed to the increased generation of health services waste in developed countries, such as the continuous increase in the complexity of medical care, the growing use of disposable material, in addition to the increase in the elderly population, who normally requires more health services and is more frequent user of different types and levels of expertise [10].

Resolutions of both the National Health Surveillance Agency (ANVISA RDC No. 306/2004) and the National Environmental Council (CONAMA No. 358/2005) classify waste into several groups, comprising: potentially infectious waste, chemical waste, radioactive waste, common waste and sharp waste. This classification is important for the correct management of waste from the handling to final destination [11].

More recent data in a survey conducted in Canada indicate that healthcare waste generated about 1.46% of total greenhouse gas emissions and represented 1% of the waste management in 2001[12].

In the studied company, the waste generated by health services was 0.77 tons, representing 0.66% of the total (Table 1), and as required by law, it was incinerated or re-sterilized.

By integrating different subjects in the solid waste management process, there is the possibility of generating social benefits in various spheres of society. It goes from the generation of employment and income for workers who are directly and indirectly related to activities of provision of services or recycling industry (recycling companies and cooperatives) to environmental education programs by non-governmental organizations (NGOs) and other organizations promoting ethics, sustainable development and environmental protection; all benefit from adopting this measure [11].

The economic crisis, the new technologies for waste recycling and the search for greater efficiency in production processes have driven the creation of a large market for recyclable inputs and a gradual expansion of the value of these materials. In addition to traditional materials such as paper, glass and tin, other materials such as PET bottles and Tetra Pak cartons, which are present in increasing amounts in urban garbage, have recorded growing demand in the market due to new reuse opportunities [13].

Waste management can be compared to a pyramid. The top is represented by the final destination of waste; the middle of the pyramid consists of the collection and separation of these wastes in their respective classes and the bottom is made up of the treatment given to such waste in the place where it is generated. And this, therefore, depends on education,

information and, above all, the goodwill of individuals, especially at home, where there is no obligation on the appropriate separation of generated waste.

The need to implement the proper management of medical waste already has received more attention in the health services, but the focus given to the final disposal still remains as the most common option. However, soon the great challenge of Brazilian companies with respect to waste generation will not be limited only to recycling, treatment or proper disposal of such waste. They will need to deploy, increasingly, the concept of non-generation and reduction of waste generation at its source, not only because they identify losses and wastage, but also by the inherent issues of market competitiveness, reduction of costs, legal claims, public awareness and environmental preservation [11].

**Suggestions for better management of solid waste**

By recognizing that the planet has a limited carrying capacity and that the pollution control approach has not been enough to match human demand and the availability of natural resources in an ecologically sustainable scale, some technologies have emerged, focusing on pollution prevention and waste minimization as a way to avoid the loss of raw materials and energy, which will be converted into solid, liquid and gaseous waste, responsible for adding costs to production processes and for generating environmental problems[14].

Some actions that lead to reduction of waste generation in construction industry are:

• changes in technology to combat losses;
• improvement and flexibility of the project;
• improved quality of construction in order to reduce maintenance caused by correcting defects;
• proper selection of materials, also considering the extended life of the different components and structure of buildings;
• training of human resources;
• using appropriate tools;
• improving stock and transport conditions;
• melhor gestão de processos;
• encouraging owners to make modifications in the buildings instead of demolitions;
• taxation on waste generation;
• disposal control measures;
• educational campaigns [15].

A sustainability concept that is widely applied and aimed at solid waste management is the 3 R's concept, which concerns both the environmental and the economic and social area. The meaning of the 3 R's is "Reduce, Reuse and Recycle":

- **Reducing** helps eliminating wastage and represents the fact of using and taking from nature only what is necessary. In addition to the reduction of waste and saving of natural resources, reducing also means saving money.
- **Reusing** is the second step of the 3 R's and guides the need to seek new uses for materials that supposedly would not be useful anymore.
- **Recycling** is the physical and chemical transformation of a product, namely, the physical size and its chemical characteristics are changed to the production of a new product. This eliminates the need to extract new natural resources, uses the raw material that has already been generated and increases the useful life of the landfill [8].

Another important concept to be implemented effectively in companies, including in health care institutions, is the eco-efficiency concept. Eco-efficient companies are those that obtain economic benefits - speed in their processes and quality of their products with reduction costs associated with water, energy and material waste - as they achieve environmental benefits through the progressive reduction in solid waste generation, liquid effluents and air emissions, by inserting in their management process the concept of prevention of pollution and occupational hazards. However, the concept of eco-efficiency has still been little applied in the industrial sector and is not yet widespread in the health sector [11].

## V. FINAL THOUGHTS

Solid waste management has been a growing concern for companies, both by the dissemination of sustainability concepts and the impact of these on the environment, and by the increasing demand for quality programs by these companies.

The petrochemical industry under study was able to map all waste generated on its facilities and to give an appropriate final destination to them. In the year 2013, 4,745.68 tons of solid waste was collected – 115.31 tons of class I waste, 1,740.14 tons of class IIA waste and 2,890.23 tons of IIB class waste. Of this total, 50.54% were recycled. Health services waste amounted to 0.77 tons.

Among the benefits of effective management of solid waste there are the financial benefits, measured by the difference between the revenue generated from the sale of materials and the expense of handling and disposing thereof. There are also social benefits such as the generation of employment and income for workers directly or indirectly linked to recycling processes or environmental education.

But there are also some barriers to the success of solid waste management. Proper collection of waste, making it suitable for reuse and recycling is still an obstacle, which tends to reduce with the intensification of educational campaigns.

Some alternatives that have been used consist of increasing and improving solid waste management with the concept of reducing, reusing and recycling (3 R's) and the eco-efficiency, with the reduction of waste generated, while maintaining quality and efficiency standards in production. Only with best practices and education will we have a better and more sustainable world.

REFERENCES

[1] Jacobi PR, Besen GR. Gestão de resíduos sólidos em São Paulo: desafios da sustentabilidade. Estud. av.[online]. São Paulo, v. 25, n. 71, Apr. 2011. Available from: <http://www.scielo.br/scielo.php?script=sci_arttext&pid=S0103-40142011000100010&lng=en&nrm=iso>. ISSN 0103-4014. http://dx.doi.org/10.1590/S0103-40142011000100010. Access on 01 June 2014.

[2] Silva IGP, Rodrigues DF, Pinheiro NV. Cadeia Produtiva da Construção Civil: Uma Análise de Sobre a Sustentabilidade. XI Encontro de Iniciação à Docência. UFPB-PRG. www.prac.ufpb.br/anais/xenex_xienid/xi_enid/.../5CCSADAMT01.pdf

[3] Iriart JAB, Oliveira RP, Xavier SS, Costa AMS, Araújo GR, Santana VS. Representações do trabalho informal e dos riscos à saúde entre trabalhadoras domésticas e trabalhadores da construção civil. Ciênc.

saúde coletiva [serial on the Internet]. 2008 Feb [cited 2013 Oct 21] ; 13( 1 ): 165-174. http://www.scielo.br. Acesso em 10 jan 2013.

[4] 4. Karpinski LA, Pandolfo A, Reinehr R, Guimarães J, Pandolfo L, Kurek J, Rojas JWJ. Gestão de resíduos na construção civil: uma abordagem prática no município de Passo Fundo – RS. [serial on internet]. 2008. Estudos Tecnológicos, vol.4, n. 2: 69-87.

[5] GOVERNO DO ESTADO DE SÃO PAULO/ SECRETARIA DO MEIO AMBIENTE/Coordenadoria de Planejamento Ambiental/ SINDICATO DA INDÚSTRIA DA CONSTRUÇÃO CIVIL DO ESTADO DE SÃO PAULO SINDUSCON-SP. Comitê de Meio Ambiente do SindusCon-SP. Resíduos da Construção Civil E O ESTADO DE SÃO PAULO, São Paulo, SP, 2012

[6] Agapito N. Gerenciamento de Resíduos de Saúde. Grupo de Estudos Logisticos. Universidade Federal de Santa Catarina. GELOG-UFSC.2007.

[7] Alves SB, Souza ACS, Tipple AFV, Rezende KCD, Rezende FR, Rodrigues EG. Management of waste generated in home care by the Family Health Strategy. Rev. bras. Enferm. 2012 Feb; 65(1). Available from <http://www.scielo.br/scielo.php?script=sci_arttext&pid=S0034-71672012000100019&lng=en&nrm=iso>.access on 01 June 2014. http://dx.doi.org/10.1590/S0034-71672012000100019.

[8] Stephanou JJ. Gestão de resíduos sólidos: um modelo integrado que gera benefícios econômicos, sociais e ambientais." (2009). Trabalho de conclusão do curso de especialização apresentado ao programa de pós graduação em administração da Universidade Federal do Rio Grande do Sul, como requisito parcial para obtenção do título de Especialista em Econegócio e Gestão Sócio-Ambiental.

[9] Agência Nacional de Vigilância Sanitária. Resolução RDC n. 306 de 7 de dezembro de 2004. Dispõe sobre o regulamento técnico para o gerenciamento de resíduos de serviços de saúde. Diário Oficial da União 2004 dez 10.

[10] Schneider VE, Rego RCE, Caldart V, Orlandin SM, organizadores. Manual de gerenciamento de resíduos sólidos de serviços de saúde. São Paulo: CLR Balieiro; 2001.

[11] Sisinno, C. L. S., & Moreira, J. C. (2005). Ecoeficiência: um instrumento para a redução da geração de resíduos e desperdícios em estabelecimentos de saúde Ecoefficiency: a tool to reduce solid waste production and waste of materials. Cad. Saúde Pública, 21(6), 1893-1900.

[12] Kagoma Y, et al. People, planet and profits: the case for greening operating rooms. CMAJ. Nov 20, 2012; 184(17): 1905–1911.

[13] TREVISAM J. “Manejo, Mercado e Circulação de Resíduos Industriais”. In: Seminário Lixo e Cidadania: região do grande ABC: Consórcio Intermunicipal do Grande ABC, 2001. P. 95-98.

[14] AZEVEDO GOD. Por Menos Lixo: A minimização dos resíduos sólidos urbanos na cidade do Salvador/Bahia. Dissertação (Mestrado em Engenharia Ambiental Urbana) - Escola Politécnica, Universidade Federal da Bahia, Salvador. 163 f. 2004.

[15] JOHN VM, AGOPYAN, V. Reciclagem de resíduos da construção. In: SEMINÁRIO RECICLAGEM DE RESÍDUOS DOMICILIARES, São Paulo. Disponível em: www.reciclagem. pcc.usp.br .