Marine Pollution Bulletin xxx (xxxx) xxx–xxx

Contents lists available at ScienceDirect

Marine Pollution Bulletin

journal homepage: www.elsevier.com/locate/marpolbul

Management of plastic wastes at Brazilian ports and diagnosis of their generation

Clarice Neffa Gobbi[a,b], Vânia Maria Lourenço Sanches[c], Elen Beatriz Acordi Vasques Pacheco[d,e,*], Maria José de Oliveira Cavalcanti Guimarães[a], Marcos Aurélio Vasconcelos de Freitas[b,f]

[a] Escola de Química, Universidade Federal do Rio de Janeiro, Brazil
[b] Instituto Virtual Internacional de Mudanças Globais/Programa de Planejamento Energético, Coppe, Universidade Federal do Rio de Janeiro, Brazil
[c] Programa de Doutorado em Meio Ambiente, Universidade do Estado do Rio de Janeiro, Brazil
[d] Instituto de Macromoléculas Professora Eloisa Mano/Programa em Ciência e Tecnologia de Polímeros, Avenida Horácio Macedo 2.030, Centro de Tecnologia, Bloco J, Universidade Federal do Rio de Janeiro, CEP 21941-598, Brazil
[e] Escola Politécnica/Programa de Engenharia Ambiental, Universidade Federal do Rio de Janeiro, Av. Athos da Silveira Ramos 149, Centro de Tecnologia, Bloco A, CEP 21941-909 Ilha do Fundão, Rio de Janeiro, Brazil
[f] Programa de Planejamento Energético/COPPE, Universidade Federal do Rio de Janeiro, Brazil

ARTICLE INFO

Keywords:
Plastics
Wastes
Brazilian ports
Waste management

ABSTRACT

This study evaluated the management of plastic wastes at 20 Brazilian maritime ports, from three sources: vessels, leased and non-leased areas. The data were obtained from documents on port wastes organized in a relational database with defined protocols (closed form). Analysis of the spreadsheets prepared and field visits revealed that the main bottleneck in managing plastic wastes at ports is their segregation. In general, more material is segregated and sent for recycling from leased areas than non-leased ones (administered by the government). This relatively better performance in managing the wastes generated in leased areas is probably due to the need for private operators to comply with the international standards such as the Code of Environmental Practice to satisfy the international market.

1. Introduction

The development and operation of port installations unquestionably make a significant contribution to the growth of seaborne trade and the economic development of coastal countries, with generation of direct and indirect jobs. However, port operations and activities also have negative consequences, especially on the environment, if their generation of wastes is not properly managed (Bramati, 2016; Puig et al., 2014; Peris-Mora et al., 2005).

Increasing concern for environmental preservation in recent decades has prompted an increase in activities to deal with environmental questions by the port sector throughout the world (Jaccoud and Magrini, 2014). Among these questions, management of the solid wastes generated by ports (specifically by vessels and in operational and administrative areas) is a substantial challenge (Lithner et al., 2011; Guerrero et al., 2013). The aim of such management is to eliminate or control situations that pose risks to the health and well-being of people working at and residing near ports (Bellezoni et al., 2014). Besides environmental protection, efficient management of the wastes generated by ports is also important for the commercial competitiveness of Brazilian ports, since at European ports this question has been one of the environmental priorities for port authorities since 2004 (Bramati, 2016; ESPO, 2013).

Studies have shown that despite the existence of international conventions and local environmental and sanitary laws and regulations, solid waste management programs at Brazilian ports have not yet been fully implemented or consolidated (ANTAQ, 2010; Porto, 2011; Murta et al., 2012; Carmo et al., 2014; Gobbi et al., 2015). According to the Special Secretariat of Ports of the Presidency of the Republic (SEP/PR), the body of the Brazilian government responsible for formulating policies and guidelines for the country's ports (Brasil, 2016), some factors exist that limit the effectiveness of waste management at Brazilian ports. Among these are lack of training programs for workers, discrepancies in the procedures of the various local and national agencies involved, and a dearth of applied research to generate primary data (Brasil, 2012).

* Corresponding author at: Instituto de Macromoléculas Professora Eloisa Mano/Programa em Ciência e Tecnologia de Polímeros, Avenida Horácio Macedo 2.030, Centro de Tecnologia, Bloco J, Universidade Federal do Rio de Janeiro, CEP 21941-598, Brazil.
E-mail addresses: claricegobbi@gmail.com (C. Neffa Gobbi), vaniasanches@ivig.coppe.ufrj.br (V.M. Lourenço Sanches), elen@ima.ufrj.br (E.B. Acordi Vasques Pacheco), mjg@eq.ufrj.br (M.J. de Oliveira Cavalcanti Guimarães), mfreitas@ivig.coppe.ufrj.br (M.A. Vasconcelos de Freitas).

http://dx.doi.org/10.1016/j.marpolbul.2017.07.004
Received 18 January 2017; Received in revised form 12 May 2017; Accepted 2 July 2017

In this context, mention should be made of the National Solid Waste Policy (*Política Nacional de Resíduos Sólidos*, or PNRS), as the Directive 1999/31/CE (European Union Law, 1999), shows the same goals, is intended to prevent or minimize the negative impacts of landfill to surface water, groundwater, soil, air and human health. The PNRS was established by Law 12,305 of August 2, 2010 (Brasil, 2010a) and regulated by Decree 7404 of December 23, 2010 (Brasil, 2010b). The PNRS provides the regulatory framework for solid waste management in Brazil and contains the guidelines for this management, considering a product lifetime perspective. Among other aspects, the PNRS establishes a priority for destination of solid wastes and measures to reduce generation and increase treatment, reuse and/or recycling, through technically and economically viable processes, to minimize the need for disposal in sanitary landfills. The overall idea of the PNRS is that wastes should be considered as economic assets, and all efforts for their reuse should be made.

Among solid wastes, plastics represent a significant portion (Rios et al., 2003; Carpenter and Macgill, 2005; Pacheco et al., 2012), since plastics of various types are used in many applications due to their general low cost, lightness and versatility through the possibility of adjusting aspects like flexibility and resistance (Andrady and Neal, 2009). The accumulation of this material in the environment from improper disposal pollutes soil and water bodies, clogs drainage systems, thus intensifying flooding (Lithner et al., 2011; Thompson et al., 2009).

In Europe, proper management of solid wastes generated by ports has been a priority in the past eight years. In 1996, the theme of solid wastes was not among the top ten environmental priorities for ports, while in 2009 it was in third position, and in 2013 in second place, in line with the rising importance given to the theme internationally (ESPO, 2013).

This study was a response to the need for scientific research to help in structuring the management of solid wastes at Brazilian ports, in conformity with the national policy (PNRS). The choice to focus on plastic wastes was due to the large amounts of these wastes and the environmental and economic advantages of recycling them (Pacheco et al., 2012). In addition, up to moment, no other studies have been identified that address the subject from the perspective of this work. Therefore, the aim of this work was to assess the scenario regarding plastic wastes generated by Brazilian ports and to ascertain the level of compliance with the management practices in line with the requirements of the National Solid Waste Policy.

2. Methodology

2.1. Selection of the ports and study period

The study presented in this article had its origin in a project supported by the Brazilian government in partnership with the Federal University of Rio de Janeiro –"Program for Conformity of the Management of Solid Wastes and Liquid Effluents at Brazilian Maritime Ports". This project was organized in partnership between the Special Secretariat of Ports, linked to the Ministry of Transportation, Ports and Civil Aviation (MTPA), and Rio de Janeiro Federal University, through its Virtual Institute on Global Climate Change (IVIG) (Prodanoff et al., 2014).

It was selected 20 of the 37 Brazilian maritime ports (Brasil, 2016), under the oversight of the SEP/PR, from different regions of the country, spread along the country's extensive coastline of approximately 5632 km. These ports account for 55% of the country's maritime ports. The selected ports are shown in Fig. 1 and their main characteristics and uses are described in Table 1.

The information on the wastes generated at the ports was divided according to origin into three categories. The first was non-leased areas, i.e., spaces controlled by the government, including wharves and other infrastructure, such as administrative buildings, workshops, restaurants and infirmaries. These areas are temporarily rented by operators according to the need to operate solid bulk materials, such as salt, wheat, pig iron, gypsum; Or bulk liquids such as alcohol derivatives.

The second waste source category was leased areas, which are areas controlled by private companies under lease or concession from the government. They are companies that operate continuously within the port. The contracts are of long term, on average 25 years, and the companies operate containerized cargoes and automobiles.

The third source was vessels, which offload their solid wastes for disposal on land, among them plastic wastes. Most ports offer the option to discharge the vessel waste, whether by cargo or passenger ships. In this case, the vessel owner company who contracts the land service to remove the waste will be responsible for the withdrawal, and it is the responsibility of the public agencies to supervise and control the destination of the waste.

However, for some ports studied there has been lack of information about the three sources for some reasons, among them: terminals do not always send inventories on the generation of waste to port administrations. Another situation is that the port administration does not authorize the discharge of ship waste because it understands that the port does not have the minimum infrastructure to carry out this action. Or, in the case of the port of Rio de Janeiro, the solid waste from public areas is characterized as urban waste (Carmo et al., 2014).

2.2. Typology of wastes

It was only used data on solid wastes classified as Class II (non-hazardous) according to Brazilian Standard NBR 10,004 (2004). The plastic wastes in this category do not need any special treatment before reuse or disposal (free of chemical substances or oil), and include, among others: packaging materials; films (wrappers, sacks); cups, bottles and jars; equipment housings; and barrels and similar containers.

The information about the wastes from the different ports was in general presented with diverse nomenclature regarding classification and typology. Therefore, it was established a standardized typology of wastes to systematize the data and enable analysis, in four categories, as described in Table 2.

2.3. Data sources

The quantitative and qualitative data were provided by the various port administration entities, through a declaratory system of reporting data from waste inventories and manifests (documents that accompany waste for transport). Some qualitative information, such as personal impressions of supervisors, was obtained from personal contacts with the environmental control sectors of the port administration organizations. These contacts were by e-mail, phone calls and in many cases in person, at the port. It was also considered qualitative information from our own observations.

The data from the waste inventories included: name of the port; generation source; date of exit of the waste from the port (day, month, year); quantity of waste and the respective metric (kg; m^3); name of the companies responsible transport and reuse or disposal; and final destination (landfill, incineration or recycling). The data studied was from the period from 2010 to 2013. It was verified the consistency of the data to exclude incomplete information or data not pertinent to the study. Incomplete information was defined as data from inventories filled out incorrectly or not completely. The valid data were organized in a database to allow statistical processing.

The system used to organize and process the data was a relational database with defined protocols (closed form), with the aim of reducing the file manipulations, to guarantee the integrity of the data in standardized form. With this assurance of uniformity, the data were monitored, analyzed and compared with respect to different periods or ports.