URBAN SOLID WASTE MANAGEMENT IN CAXIAS DO SUL/BRAZIL: PRACTICES AND CHALLENGES

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Abstract: Solid waste management is becoming a challenge for the cities' authorities in developing countries mainly due to the rapid economic growth and population increasing. In cities of the developing world, the informal sector plays an important role in the management of urban solid waste. This work examines the participation of scavengers in an integrated municipal solid waste management system. The paper is based on direct field observations, interviews with scavengers and characterization of the urban solid waste generated in Caxias do Sul. The partnership between municipal government and local scavengers were also evaluated as well as the contribution of the scavengers in the urban solid waste management system. The study reveals that it is necessary to realize a campaign for improving the waste segregation at source. The infrastructure of the scavengers associations need to be improved and finally the scavengers need to be more deeply involved in the policies associated with the urban solid waste management system adopted in the city.

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INTRODUCTION

Economic development associated with rapid industrialization, urbanization and population growth have accelerated the dynamics of the urbanization process in developing countries (Pradhan *et al.*, 2012). The rising level of prosperity in industrialized cities causes an increase in the number of products and services that are being produced and consumed. As a result, the waste generation increases and the solid was management is becoming a challenge for many cities around the world (Salhofer *et al.*, 2008).

In many urban areas the government and local authorities are responsible for the management of municipal solid waste system from the initial point of collection to final destination (Pradhan *et al.*, 2012). The current practice of municipal solid waste management usually involves the collection and subsequent disposal, with partial or no treatment/processing (Pradhan *et al.*, 2012). However, most municipal governments fail to provide good services, due to several reasons. This may result in such consequences as pollution and economic losses due to failures in recycling and composting valuable components of municipal solid waste (Damghani *et al.*, 2008). Furthermore, unsuitable solid waste collection and management practices may also result in serious urban, sanitary and environmental problems such as an unpleasant odor, proliferation of insects, groundwater contamination (Mor *et al.*, 2006) and also result in waste pickers activities in urban areas and in landfill.

In Brazil the municipal solid waste generation increased 1.3% from 2011 to 2012, reaching 62 730 096 t, according to ABRELPE (2013). This leads to many problems related to the proper disposal of this waste, involving environmental, economic and social factors (Ramos *et al.*, 2013). However, some local governments are implementing actions for try to improve the waste management situation in their cities, driven by the creation of stricter federal laws and by increasing of people concerned about environmental issues. According to IBGE (2010), the number of selective waste collection programs has increased in Brazil, rising from 58 in 1989 to 994 in 2008. Following this trend, depending on the economic conditions of Brazilians, there are a growing number of waste pickers or scavengers who earn income from the collection of recyclable materials and contribute to strengthening the recycling chain (Ramos *et al.*, 2013). However, in many developed cities around the world, the informal scavengers are a challenge for municipal authorities because their activities are not inserted as part of the municipal solid waste management system (Nzeadibe, 2009).

Nevertheless, there are no public policies that contribute to the real social and economic inclusion of these workers in the municipal solid waste management system (Ramos *et al.*, 2013). Several works in the literature (Ramos *et al.*, 2013; Guerreo *et al.*, 2013; Talyan *et al.*, 2008; Rockson *et al.*, 2013; Medina, 2000) presented a conflict situation between local government, population and waste pickers. Therefore, this work presents the results of a case study based on the participation of formal scavengers in the municipal waste management of Caxias do Sul city. The results included Caxias do Sul municipal solid waste management, urban solid waste characterization and the effects of the inclusion of waste pickers into the municipal solid waste management system.

METHODOLOGY

To determine the composition of the urban solid waste from Caxias do Sul 12 samples from the organic waste stream collected by a garbage compactor truck and another 12 samplings from the recyclable waste stream collected by a garbage non-compactor truck were evaluated between January 2008 and December 2008. The choice of each sampling took into account the geographical location of the city area, the season of the year and the income level of the neighborhood. Of the twelve samplings from each waste stream, three came from upper-class neighborhoods, three from middle-class neighborhoods, another three from poor neighborhoods and the last three from containers from downtown.

From selected trucks, approximately 7 m^3 of garbage was dumped and spread on the ground, forming a pile approximately 1 m high. Closed garbage bags were randomly chosen from several points of the pile, opened, and their contents separated into different categories including organic matter, plastics, paper and cardboard, metal, glass, tetra-pak and others. After the items were separated, each type of waste was weighed to identify the composition in terms of mass.

The diagnostic of the scavengers associations, also called sorting units, occurred by means of interviews with the scavengers. Out of 200 scavengers, 60% were interviewed. The questionnaire was administered by personal interviewers from the local university and contained several questions related to the pavilion architectural structure, difficulties related to solid waste management, and a profile of the scavengers.

RESULTS AND DISCUSSION

Background information about the city

The municipality of Caxias do Sul lies in the southern region of Brazil and is located in the state of Rio Grande

do Sul. Its altitude varies from 760–800 m and the climate is subtropical with a mean temperature of 16°C (mean maximum and minimum of 35°C and −8°C, respectively). According to IBGE (2010) the municipality has an area of 1638 km² and a population of more than 410 000 inhabitants. The average population density is 205 inhabitants per km². The main sectors of the economy can be divided into industry, representing 50% of the total, followed by trade and services, and agriculture, with 38% and 4.5%, respectively (Caxias do Sul government, 2012). The city is a metal-mechanic pole with several automotive manufacturers, but furniture manufactures and plastics manufacturers also form part of the city's mixed economy.

Municipal solid waste management system

The *Companhia de Desenvolvimento de Caxias do Sul* (CODECA), a local authority which forms part of the municipal government, is responsible for waste collection and transportation and as well as street sweeping. The organization has approximately 260 employees involved with waste collection and has 29 trucks. The waste collection occurs Monday to Saturday on all three shifts. In Caxias do Sul, waste collection is divided into regular collection for organic waste and selective collection for recyclable wastes.

The city has had selective collection since 1991. Organic and selective wastes are segregated at the moment of generation by households; then the municipality collects these solid wastes using two methods. First, municipal employees collect the solid household waste door-to-door. In the central area and in the neighborhoods nearby, the collection is daily; in other neighborhoods, it takes place three times a week. Second, the Caxias do Sul municipality has provided public waste containers as part of its program for the mechanized collection of solid waste in the central area. Two different types of containers were placed on streets in the central area of the city, one for collecting organic waste and the other for recyclable waste.

After collection by compactor trucks, the organic waste is transported to landfill sites. The recyclable waste collected by non-compactor trucks is delivered by CODECA to scavenger associations without any cost to the scavengers. In addition, manual collection is carried out by informal waste collectors using various types of equipment including push carts and vehicles. Some animal traction carts are also still in use.

According to CODECA (2014), Caxias do Sul generates 450 t of urban solid waste per day. Based on the total amount generated daily, 360 t are organic waste while 90 t are recyclable waste. The

Table 1. Composition (%) of organic waste stream in Caxias do Sul in different seasons

Season	Organic matter	Plastic	Paper/ cardboard	Metal	Glass	Tetra-pak	Others
Spring	53.1	10.6	9.9	1.4	1.6	1.3	23.4
Summer	56.8	11.2	10.3	1.5	1.4	1.2	18.8
Autumn	58.2	9.9	10.0	0.6	1.4	1.5	19.9
Winter	66.3	8.3	6.8	1.2	2.5	1.1	14.9
Average	58.6	10.0	9.3	1.2	1.7	1.3	19.3

410 000 residents in the city living in 110 000 households and is estimate that the per capita waste generation is around 1.10 kg per day.

The composition of the organic waste stream in Caxias do Sul is shown in **Table 1**. The major component is organic matter. Wastes classified as others include sanitary pads, diapers and other hard-to-classify materials in solid waste.

However, the quantity of recyclable waste present is approximately 20% in all seasons. This considerable amount of recyclable waste improperly disposed of together with organic waste is destined for disposal in a landfill. The amount of recyclable waste present in the composition of the organic waste steam represents approximately 72 t improperly discarded daily. This result reveals that municipal government needs to invest continuously in education programs for correct segregation of solid waste, avoiding that potential recyclable materials may be landed. On the other hand, the composition of recyclable waste stream is presented in **Table 2**.

It can be seen that paper and cardboard followed by plastic are the major components. This may be the result of a shift toward plastic packaging, a reflection on the improved living standards and consumerist attitude of people (Mancini *et al.*, 2007) in the city. However, the organic matter is still present with potentially recyclable waste, which can result in the impracticability of recycling such wastes and confirms the necessity of public investments to improve correct waste segregation by the citizens.

Materials with higher added potential for recycling, such as plastics, paper and cardboard, glass and metal, make up approximately 70% of the recyclable waste

Table 2. Composition (%) of recyclable waste stream in Caxias do Sul in different seasons

Season	Organic matter	Plastic	Paper/ cardboard	Metal	Glass	Tetra-pak	Others
Spring	8.0	24.5	29.6	3.9	10.3	6.6	17.1
Summer	5.0	27.5	29.4	4.3	15.3	4.6	13.9
Autumn	6.7	33.2	30.9	4.0	10.1	5.7	9.4
Winter	14.1	25.7	28.4	4.3	7.8	5.1	14.6
Average	8.5	27.7	29.6	4.1	10.9	5.5	13.8

stream, representing 63 t/day. The higher generation of plastics waste, approximately 25 t/day, compared with some of the other categories, has aroused the interest of the scavengers in setting up recycling plants. According to Mancini *et al.* (2007), plastic wastes collected in quantities that exceed 1 t day^{-1} are sufficient to supply medium-sized recycling plants. Based on these results, municipal government should develop public policies in conjunction with the formal scavengers to development recycling plants to process the plastic waste, increasing the value obtained by selling this important raw material to the approximately 400 plastics manufacturers located in the region of Caxias do Sul. However, it is known that the degree of recycling of a material depends on the income level, the existence of local and national markets, the need for raw materials, level of government intervention and financial regulations, prices of virgin materials, international trade of materials and relevant treaties (Wilson *et al.*, 2006). Then, the implantation of recycling plants in the city need to be done with care after a deep study of the market.

An effective waste management system is a way to ensure socioeconomic development for all of the agents included in the urban solid waste management process. In this way, the urban solid waste management approach adopted in Caxias do Sul incorporates the scavengers into the waste management system by means of scavengers associations.

Scavengers associations

The scavengers associations were created in 1997. The city has nine of these centers. Collectively, they receive approximately 90 t of recyclable waste per day delivered directly by the municipal selective collection system at no cost, generating jobs and income for 200 scavengers and their families. **Figure 1** shows the location of the scavengers associations in Caxias do Sul.
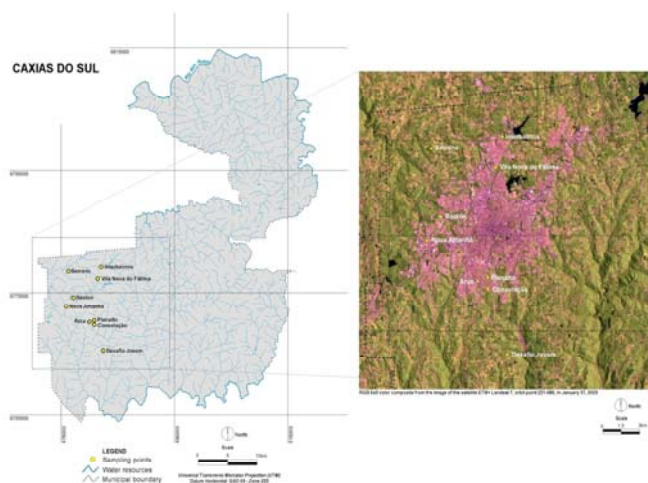
The sorting performed by these associations is of fundamental importance to the community with regard to sustainability, from the point of view of the reuse and recycling of waste. According to Romansini (2005) the proper management of urban solid waste and the high costs for collection, transportation and proper disposal of these wastes shows that waste pickers, by exercising their role contribute to reducing these costs, even if this work is invisible to society.

The production process commonly occurs in five steps, usually performed in a linear way. The first step starts with the receipt of the material, which is delivered to the association by the non-compactor trucks that carry out the selective collection. This material is deposited into a basket collector located at the back of the association. The second step is the classification of waste, which is performed on tables and is usually performed by women. The selection occurs through the deposition of materials into small containers according to type of material. The transport of the sorted material for temporary storage in boxes comprises the third step of the process. The pressing is performed in the fourth step. This pressed material is processed into bales subsequently forwarded to the fifth and final stage, the sale.

Interviews were conducted at scavengers associations with a sample of 60% of the workers in order to determine the factors that influence the behavior of scavengers in relation to solid waste management. The mixture of organic matter and recyclable materials was one of the main difficulties faced in relation to solid waste management by the scavengers, as shown in **Table 3**.

Lack of financial support from the local government also appeared with high frequency followed by difficulties related to the lack of internal organization, difficulties associated with separating the waste and the

Fig. 1 Location of scavengers associations.

Table 3. Problems associated with solid waste management obtained from the interviews with the scavengers

Problems	%
Mixture and inappropriate materials for recycling	15.8
Lack of financial assistance / support by government	15.8
Lack of organization in the association	12.3
Doubts related to the waste separation	12.3
High turnover of scavengers	12.3
Low price of the material	7.0
No unity among the workers	7.0
Pavilion architectural structure	5.3
Bad odors	3.5
Low productivity	3.5
Low amount of material from the selective collection	3.5
Few buyers	1.8

high turnover of scavengers. These problems seem to be commonly faced by scavengers as previously related by Oliveira (2007). According to the author waste pickers face various difficulties as unemployment, precarious working conditions, and exclusion from the formal market and from social life, they have no access to social and labor security which result that their work becoming a way to occupy their mind and forget their problems.

The scavengers' profile evaluation reveals that 38% are male and 62% are female. This result is very similar to other studies done in Brazil. According to the survey conducted by Ramos *et al.* (2013) with waste pickers from several Brazilian regions 56% of the sampled waste pickers are female. A plurality, 30.6%, are older than 45 years, whereas 19.4% are between 36 and 44 years old, 26.9% are between 26 and 34, and 23.2% are between 18 and 35. With regard to schooling, 93.3% have had some type of instruction, however with low level of education, while 6.7% of workers are unable to read or write. This result confirms the findings of Medina (2000), Romansini (2005) and Ramos *et al.* (2013) among others, about the low educational level of pickers.

The results show that most of the scavengers in Caxias do Sul are former factory workers out of work from the factories that exist in the region, due to low education and increasing age. It was also observed that approximately 50% of workers had been working in their association for less than a year. The lack of professional qualification and the consequent informality, as previously identified by Romansini (2005) and Ramos *et al.* (2013) was also confirmed in this study that found a low educational level among the interviewees and that they had previously worked in other professions.

When asked about possible solutions to the difficulties encountered in waste separation, 16.9% suggested an improvement in the infrastructure of the pavilion, creating a more suitable space in which to perform the activity. For another 14.6%, the solution lies in better segregation of the waste at the source, while 13.5% mentioned better unity among the workers, and 11.2% the value of materials on the market. Moreover, 11.2% suggested holding training courses aimed at better segregation, plastic recycling and closer cooperation between the members of the associations. Additionally, possible solutions mentioned as possibilities to improve their income included government assistance, higher prices gained from the sale of the sorted materials, and the elimination of middlemen by selling the segregated materials directly to industry.

Manufacturers that consume recyclable materials in developing cities in some cases encourage the existence of middlemen in order to ensure an adequate volume and quality of materials (Medina, 2000). Industry demands a minimum quantity from its suppliers and will not buy low quantities of recyclable materials (Imam *et al.*, 2008). The formation of scavengers' cooperatives attempts to circumvent middlemen and thus obtain higher prices for cooperative members (Bortoleto and Hanaki, 2007). This, in turn, translates into a higher income and a better standard of living for the scavengers (Pimenteira *et al.*, 2005; Medina, 2000; Bortoleto and Hanaki, 2007). It is possible for scavengers to organize themselves into cooperatives or associations in order to bypass middlemen and break the "vicious circle of poverty" in which most scavengers find themselves (Medina, 2000). At the same time, as cooperatives begin to operate regularly, it is expected that the population and the local government will come to value this activity more and will provide scavengers with cleaner recyclable materials, which will consequently earn a higher price on the market (Pimenteira *et al.*, 2005).

Future challenges

It is thus clear that effectively managing its municipal solid waste is an onerous task for the Caxias do Sul municipality. Moreover, the data indicate that as the population and economy grow, the per capita municipal solid waste generation will consequently increase; thus, some significant challenges lie ahead.

Based on the municipal solid waste composition and the results of the formal scavengers' interviews, a question can be formulated. Why does the municipal government not invest in a more intense partnership with the formal scavengers? The most interesting approach to the management of municipal solid waste in the future probably is to promote a more intensive inclusion of the formal scavengers into the municipal solid waste system along with correct source separation of waste into organic and recyclable components. This will be a lengthy exercise because it involves attitudinal changes in people and will have to be carried out with careful planning (Sembiring & Nitivattananon, 2010). The general public will first have to be sensitized toward the whole concept and educated regarding the need for and advantages of correctly separating waste (Damghani *et al.*, 2008). The success of waste minimization relies largely on education, i.e., increasing public awareness and people's willingness to change their wasteful habits (Ağdağ, 2009). For this reason, waste minimization and education must be implemented as a first step.

Second, composting units need to be created. The quantity of composted waste can be increased by extending source separation. Recycling and composting processes reduce the quantity of waste requiring
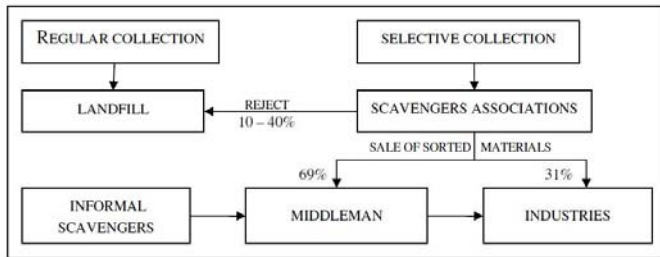
Fig. 2 Current organization of the recycling chain in Caxias do Sul.

landfilling, and thus reduce the required landfill area.

Third, the participation of scavengers in municipal solid waste needs to be broadened to avoid the involvement of middlemen and to create recycling centers to recycle plastic wastes for sale to local industry. The present situation in urban solid waste management is shown in **Fig. 2**.

The presence of middlemen in the system means that scavengers sell the majority of their sorted materials to agents at lower prices than those paid by industry. Based on the results of the interview, the proposed new organizational structure to be implemented in the municipality, presented in **Fig. 3**, aims to integrate the few informal collectors that still collect recyclable waste in the streets into the supply chain and minimize the action of middlemen in the system, adding more value to the final product.

The creation of a trading post aims to enable the informal scavengers to sell the waste scavenged from the streets directly to the scavengers associations, creating a stronger link between them and possibly attracting these informal workers to the formal system and enticing them to join it. The creation of a recycling plant for waste plastics aims to increase the amount paid to collectors for this residue and to bring the scavengers closer to the manufacturers in order to prevent the action of middlemen, who usually take the greater part of the profits. Thus, this will increase the income of the scavengers and improve their life quality. For this reason, it is important that the focus for the future be on interdisciplinary strategies that include socioeconomic, environmental, and technological aspects (Lino & Ismail, 2013).
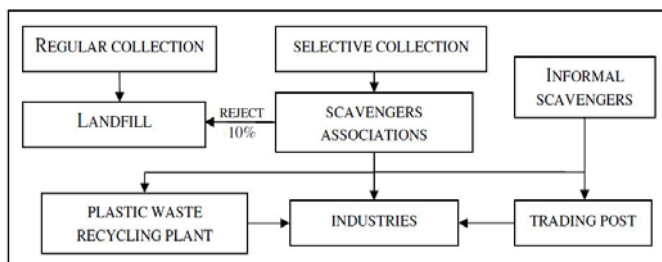
According to the interviews, another challenge is improving the infrastructure of the buildings housing the scavengers associations. The scavengers use inappropriate buildings to segregate the waste material. In some cases, scavengers have breakfast and lunch in the same area occupied by the waste. Thus, it is proposed to enlarge the building and create spaces for additional activities such as kitchens, refectories and locker rooms, as shown in **Fig. 4**. An addition proposal is to build a covered space that will serve as a deposit area for the wastes that today are exposed to weathering.

Finally, waste recovery and recycling are effective ways to save resources and reduce the need for landfill areas (Agamuthu, 2010). From this point of view, incorporating scavengers or waste recyclers into waste management system and recycling programs can be economically viable, socially desirable and environmentally sound (Agamuthu, 2010). However, all of these actions can only be implemented if local government and the formal scavengers work together and consolidate the partnership. For this purpose, creation of a municipal waste management council with representation from both the scavengers and local government is proposed. The council will discuss and
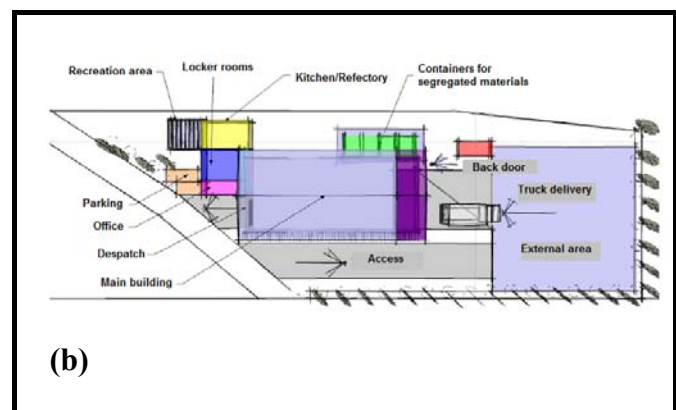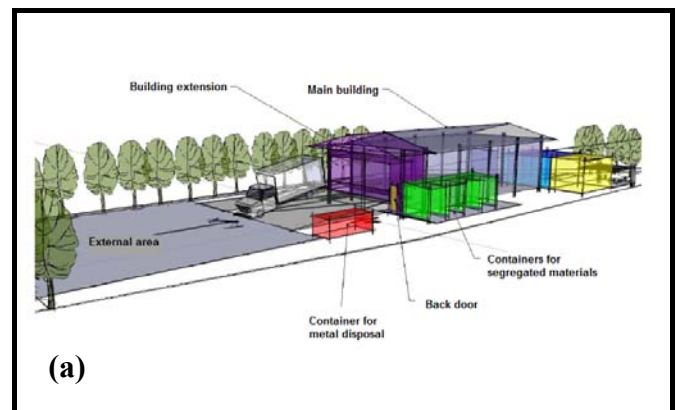

Fig. 4 New proposal for external (a) and internal (b) infrastructure of the scavengers associations.

Fig. 3 New proposal for the organizational structure of the recycling chain in Caxias do Sul.

implement the improvements together. As a result, it will be possible to increase the income of the scavengers and to promote an improvement in life quality of these valuable waste management agents. Additionally, financial and environmental gains for the city will be noted by the municipal government because land filling of potentially recyclable wastes will be substantially reduced.

CONCLUSIONS

The municipal solid waste management system in Caxias do Sul was evaluated. Population growth and rapid economic development caused a significant increase in the quantities of waste generated. As a result, the municipal solid waste management system needs to be renewed. Waste minimization, education of the population, composting of biodegradable wastes and an improvement in the partnership between local government and scavengers were identified as areas for further development. This approach will facilitate greater social and economic inclusion of informal and formal scavengers in the recycling chain, thereby addressing the needs and problems associated with these agents with the waste management system adopted in the city.

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