17th World Congress on Ergonomics

Improving the collection of recyclable materials: an ergonomic approach of the equipments used

Rita de Castro Engler
Silvia Resende Xavier
Universidade do Estado de Minas Gerais

The garbage collection of recyclable materials consists in sorting the waste where it is produced and collecting it separately. This procedure is a fundamental part of the recycling process. In the city of Belo Horizonte the municipality provides a service of garbage collection of recyclable materials since 1993 and to carry out the collection equipments such as bins, containers and trucks are used. However these equipments have not been designed for this type of collection, therefore they are normally not adequate. As a result of this situation, several problems may occur. The efficiency of the curbside collection of recyclable materials is affected. The working conditions of the garis (employees in charge of the garbage collection) are endangered as well, affecting their security and health. A deeper analysis of the garis' working conditions would be important in order to improve it. However, this would be a broad and complex research involving several factors which do not relate directly to this field of study. It will not, therefore, be part of the scope of this paper. The aim of this study is to make an analysis of the work carried out during the curbside collection of recyclable materials in order to identify mistakes and gaps in the conceiving process of the equipments. The lack of a deeper study when designing these equipments compromises the development of curbside collection of recyclable materials and its evolution.

INTRODUCTION

The evolution of the Industrial Revolution led to an intensification of natural resources exploration in order to supply the increasing demand for manufactured products, due also to the exponential growth of global population. In this scenario a capitalist society characterized by the consumption of industrial goods has been consolidated, where industries play a vital role. As a consequence of this process there was a significant augmentation in the amount of residues produced, above all in the major urban centers.

The permanence of this process of natural resources exploration, large industrial production and subsequent increase in the residues production has been the source of serious environmental degradation. This issue has recurrently been discussed and shown thru the media due to the consequences that the damages caused to the environment can entail.

One of the problems faced today is pollution generated by the inadequate discard of inorganic solid waste. When thrown directly in the environment, been it urban or natural, these residues can eventually contaminate rivers, forests and seas. Even when sent to landfills these residues accumulate, once their degradation process is very slow. This can cause environmental and also socioeconomic impact.

Another problem is related to the natural resources exploration, a process which demands great amount of energy. Some nonrenewable raw materials, such as fossil fuel, tend to became scarce while the exploration of resources considered renewable can be harmful to the natural environment.

Nowadays, one of the most viable alternatives to minimize environmental degradation caused by the inorganic solid waste consists in reusing industrially processed materials, such as glass, plastic, metal and paper in order to manufacture new products, process known as recycling. Besides reducing waste accumulation, which optimizes utilization of landfills, such process diminishes the demand for raw materials exploration, minimizing the impacts caused by this procedure.

The first step in recycling process is the collection of recyclable materials. This type of collection consists in sorting the residues where they are produced and collecting them separately.

This procedure is a fundamental part of the recycling process. If the residues are not properly sorted, recyclable materials can be contaminated by organic waste, what would demand an expensive cleaning process to enable the materials to be recycled. Nowadays the garbage collection of recyclable materials is a service offered by many municipalities around the world.

A short history of recyclable materials collection in Belo Horizonte

Belo Horizonte is the administrative capital city of the state of Minas Gerais, which is located in the southwest of Brazil. It is a major urban centre, playing an important role in

the regional economic scenario. Belo Horizonte has a population of almost 3 million people, reaching over 5.5 million in the official Metropolitan Area. Despite its dimensions, the capital is relatively young, 110.

Initially Belo Horizonte was a planned city which was conceived to substitute the old administrative capital of Minas Gerais. The city was designed and constructed during the 1890s and it was founded in 1898. In the beginning it was planned to be inside an area limited by a principal avenue. Nonetheless, over the years, the city grew far beyond what was planned, reaching an area of 330,954 km².

Belo Horizonte is today approximately 7 times bigger than it was supposed to be. The planned area is today considered as only the centre of the city, characterized by the surrounding avenue, and there are eight more regions besides the centre. As the city and its population grew with no order, so did production of residues and all problems related to it, which also increased.

Since 1973 the municipality of Belo Horizonte provides a service of garbage collection in the town. This service is held by a municipal division called SLU (Superintendencia de Limpeza Urbana). All domiciliary and commercial waste collected in the city was sent to a landfill located nearby the urban centre until the year of 1993, when the municipality introduced a recycling program. Since this year recyclable materials such as glass, paper, plastic and metal started to be collected separately and to receive a different destination.

Before starting a full program of collection of recyclable materials, an initial experience was carried out in only one region of the city. The results of this experience enabled the identification of the strengths and weaknesses of the program.

According to the analysis of this previous experience a full collection program was planned, based on the collection thru volunteer handling. For the volunteer handling type of collection, population must sort out the recyclable materials and carry them to specific places settled by the municipality, where normally there are containers to receive the materials.

According to Mara Luisa Alvim Motta, coordinator of the garbage collection of recyclable materials during 1997, a relevant aspect of the collection program in Belo Horizonte is the choice for the volunteer handling kind of collection, instead of the home collection normally chosen by other municipalities when implanting a collection program of recyclable materials. (Motta, 1997)

However, later on, in the year of 2004, home collection was planned and introduced in some regions. For this type of collection, population must present the recyclable materials in established days to be collected by municipal vehicles.

Nowadays approximately 4,000 tons of garbage is collected per day in Belo Horizonte. According to a study carried out by the municipal authorities in 2003, 26% of the waste produced in the city is recyclable. Nonetheless, only 0,5 % of these materials are collected separately.

In order to evaluate the evolution of the program of recyclable materials collection held in Belo Horizonte a "measure of the benefit" has been made, as it is suggest by Cempre. Cempre is a nonprofitable organization formed by private companies of different sectors. Its goal is to promote the recycling as part of an integrated management of residues.

This measurement consists in calculating the "deviation tax" of the collection of recyclable materials which is the percentage of recyclable materials collected in relation to the total amount of residues collected in the city. (Cempre, 1999)

Based on this evaluation system, table 1 has been constructed. It shows the annual "deviation taxes" since the beginning of the collection of recyclable materials in Belo Horizonte.

Year	Deviation Tax
1993	-
1994	-
1995	0,07%
1996	0,07%
1997	0,11%
1998	0,33%
1999	0,37%
2000	0,41%
2001	0,44%
2002	0,37%
2003	0,46%
2004	0,47%
2005	0,56%
2006	0,51%

Table 1 - Annual Deviation Tax
Source: XAVIER, S.

It is important to notice that there are no records of the amount of recyclables materials collected in the first two years of collection. Furthermore, the numbers registered between the years of 1995 and 1997 count only for the amount of glass collected. Only after 1997 the other materials (paper, metal and plastic) started to be counted up as well.

Analyzing the data it is possible to notice that, in a general way, the amount of recyclables materials collected has increased over the years since the collection started. Nonetheless, there have never been a significant increase in the figures, the maximum been 0,56% in the year of 2005.

THE SITUATION OF PEOPLE WORKING IN THE COLLECTION OF RECYCLABLE MATERIALS

The social aspect related to the collection of recyclable materials is a factor which significantly differs collection programs adopted throughout Brazil and most undeveloped countries from programs carried out in developed countries. The collection of recyclable materials has long been the source of income for several people living under precarious conditions. In many Brazilian cities the catadores (people who collect and sell recyclable materials as a way of obtaining money) used to carry out a collection of recyclable materials before the implementation of official collection programs held by the municipalities.

This is the case of the city of Belo Horizonte, where the catadores (here we will call them collectors) can be considered the precursors of the recyclable materials collection. Belo Horizonte can also be considered a pioneer in including the collectors as part of the official collection program because of a successful agreement made between the municipality and Asmare (collectors'association) in 1993.

Asmare was organized and formed by a group of

collectors in 1990. The aspiration of the collectors who founded the association was to organize their category. Therefore the agreement between Asmare and the municipality of Belo Horizonte was of great relevance once it marked the recognition of the collectors' work, inserting them in the formal work market as municipal cleaning agents.

Today Asmare has two hangars, one receiving the materials from the municipality's collection and the other receiving the materials collected by the collectors. In both of them the associates work sorting the types of materials. The workers receive a weekly pay based on the amount of material sorted.

Nowadays the municipalities of many Brazilian cities adopt this kind of partnership with the collectors' associations, including them as part of the official recyclable materials collection program. These agreements benefit not only the collectors, but also the municipalities, once it lowers the collection's costs.

Mara Luisa Motta pointed that one of the determining aspects for the development of the recyclable materials collection program in Belo Horizonte was the insertion of the collectors as priority agents of the collection. (Motta, 1997) Nevertheless, as the collection program held by the municipality developed, the collectors' associations faced some problems.

In a report made by SLU in 2001 it was pointed that Asmare was increasingly pressuring its associates to augment their production, in order to maintain a minimum monthly production. Besides, the unemployment increase led a considerable number of people to make the collection recyclable materials as a way of living.

Consequently there was a collapse of the sources for obtaining recyclable materials by the traditional collectors. This situation led to a competition between Asmare's associates and other people circumstantially involved in the collection.

This problem has been intensified when the home collection started, once it generated a kind of competition between the collectors and the municipality's collection. In the established days for the home collection held by the municipality it is common to see collectors gathering the materials disposed by the citizens before the municipal truck passes.

This situation must be revised once it does not benefit the citizens. The home collection held by the municipality is an expensive service, once it involves the use of trucks and demands a major number of people working. The citizens end up by paying more for a service which is not efficient.

THE EQUIPMENTS USED IN THE COLLECTION

To carry out both of the types of collection held by the municipality equipments such as bins, containers and trucks are used. The overall majority of these equipments have been adapted in order to enable the collection of recyclable materials.

Average trucks, which had an open truck, have been transformed. A covered truck has been installed in order to contain the recyclable materials. (SLU, 2002) This kind of truck is shown in picture 1.

Picture 1 - Covered truck
Source: XAVIER, S.

Regarding the containers, Motta states that some models have been developed and evaluated by SLU. (Motta, 1997) The container colors follow the Resolution n°. 275 settled by

Conama (National Environment Council) in 2001, which establishes a color code that should be adopted for the identification of the different types of recyclable residues to be collected. According to this Resolution, blue stands for paper, yellow stands for metal, green stands for glass and red stands for plastics. (Conama, 2001)

Among the container models, one made with boards and a galvanized wire grid was chosen because of its relative low production cost. (Motta, 1997) Picture 2 shows this type of container.

Picture 2 - Container model
Source: XAVIER, S.

This container allows the visualization of its contents, which permits to easily identify if it is filled. It is locked with a regular padlock, as shown in picture 3.

Picture 3 - Container locked with regular padlock
Source: XAVIER, S.

Some problems have been identified along the use of this container model. The equipment happened to be fragile, been easily depraved. SLU ordered that modifications should be made in the existing containers. The girds have been replaced by metal plates, aiming to minimize the violations. (SLU, 2002)

In the year of 2002 a different container model was introduced. It has been argued that it is stronger and more visible than the model used before. Picture 4 shows this type of container.

Picture 4 - Container model
Source: XAVIER, S.

This kind of container is more robust. It is locked by a locking device incorpored to its body, as shown in picture 5.

Picture 5 - Incorporated lock device
Source: XAVIER, S.

The collection process

In order to evaluate the efficiency and adequacy of the equipments used, a collection procedure has been accompanied. The process of emptying the container, packing the recyclable materials, and putting them into the truck has been documented thru photographs.

Picture 6 shows the opening of the container. The man in charge of withdrawing the container must have three different keys, each one for one compartment. This is a factor which made the process slower, once he had to try the keys for opening.

Picture 6 - Opening
Source: XAVIER, S.

Picture 7 shows the withdrawing of the container. The man must use gloves, once he has direct contact with the waste been collected. It is important to notice that all the waste collect goes to the same bag.

Picture 7 - Withdrawing
Source: XAVIER, S.

Even though the population puts the different types of materials separately in each compartment of the container the materials are mixed up when collected, as shown in picture 8.

Picture 8 - Separated materials are mixed
Source: XAVIER, S.

Picture 9 shows the municipality's truck collecting the materials. It is important to notice that although the truck has different doors, supposedly to carry separately the different types of materials, there is no real separation inside the truck body. Again, the materials which had been sorted by the population are mixed up.

Picture 9 - Truck collection
Source: XAVIER, S.

CONCLUSIONS

In general, the curbside collection of recyclable materials in Belo Horizonte cannot be considered efficient and there are some aspects that must be revised in order to improve it. Two relevant issues that have been identified are the subject of the environmental education and the problem of adequacy of the equipments used.

The environmental education reflects directly on the success of the collection program. Above all for the volunteer handling kind of collection it is vital the involvement and participation of the population once it is their responsibility to sort out and spontaneously transport the materials until the established places.

According to Cempre the success of the volunteer handling type of collection is directly related to investments in environmental education of the population. (Cempre, 1999) It is preferable to invest in this kind of collection once it has been proved to be the one more efficient with lower costs.

It is important to point out that the environmental education of the population can also have influence in the conception of the equipments. It has been identified that there were necessary changes and great investments to prevent violations in the containers. If the whole population was aware of its role in the recyclable materials collection program and its importance, vandalism can be avoided.

Furthermore, regarding the equipments used in the collection it has been verified that the overall majority of the bins and containers are conceived in an empiric way, normally without a study or project. The trucks have been adapted, not being designed for carrying out the collection of recyclable materials. Therefore, these equipments are not adequate for this collection.

As a result of these situations, several problems may occur and the efficiency of the curbside collection of recyclable materials is affected. The materials that had previously been separated by the population are frequently mixed up during the collection, making it necessary to sort and separate them again. Besides delaying the process and the demanding extra work, this can discourage the population to participate, once they perceive their effort to sort the materials to be useless.

Finally we can conclude that it is crucial to direct investments not only to the education of the population but also to the development of adequate equipments to the collection. The environmental education is rather a political and cultural issue.

In the other hand, the problem of the equipments demands a further interdisciplinary study, which involves ergonomics as well as economic factors and usability aspects. This kind of study must be developed and should be encouraged, above all in the industrial design area, which has much to contribute in this issue.

REFERENCES

1. Cempre (1999). *Guia da coleta seletiva de lixo*. São Paulo: Cempre

2. Costa, A. B. F., & Quintiliano, E. F. (2006). *Modelo de Gestão de Resíduos Sólidos de Belo Horizonte*. Belo Horizonte: FGV

3. Eigenheer, E. M. (org.) (2003). *Coleta seletiva de lixo: experiências brasileiras n.4*. Rio de Janeiro: In-Fólio

4. Hollnagel, E. (2006). Task Analysis: why, what and how. In G. Salvendy (Ed.), *Handbook of Human Factors and Ergonomics - 3rd edition* (pp. 373- 383). Hoboken: John Wiley & Sons

5. Iida, I. (2005). *Ergonomia – projeto e produção*. São Paulo: Edgar Blucher

6. Lucio, C. C. [et al.] (2004) A importância dos catadores de materiais recicláveis para o desenvolvimento sustentável: uma alternativa de aplicação da ergonomia e do design industrial. *Revista da Faculdade de Engenharia, Arquitetura e Tecnologia Universidade de Marília*, v.6, n.1

7. Manzini, E., & Vezzoli, C. (2005). *O Desenvolvimento de Produtos Sustentáveis – Os Requisitos Ambientais dos Produtos Industriais*. São Paulo: Editora da Universidade de São Paulo

8. Monteiro, J. H. P. [et al.] (2001). *Manual de Gerenciamento Integrado de resíduos sólidos*. Rio de Janeiro: IBAM

9. Motta, M. L. A. (1997). *Coleta Seletiva de Belo Horizonte*. Belo Horizonte: Superintendência de Limpeza Urbana

10. Oxley, L., Pinder, A., & Cope, M. (2006). *Manual handling in kerbside collection and sorting of recyclables*. Health and Safety Laboratory. Retrieved March 8, 2009, from http://www.hse.gov.uk/research/hsl_pdf/2006/hsl0625.pdf

11. PBH (2001). *Limpeza urbana na Belo Horizonte centenária*. Belo Horizonte: Prefeitura de Belo Horizonte

12. Resolução Conama nº 275/2001 (April 25, 2001). Conselho Nacional do Meio Ambiente. Retrieved March 8, 2009, from http://www.mma.gov.br/port/conama/legiabre.cfm?codlegi=273

13. Ribeiro H., & Besen G. R. (2007). Panorama da coleta seletiva no brasil: desafios e perspectivas a partir de três estudos de caso. *Interfacehs - Revista de gestão integrada em saúde do trabalho e meio ambiente* v.2, n.4, 2007

14. SLU, elaborado e editado pela equipe de coleta seletiva (2005). *Coleta seletiva no município de Belo Horizonte*. Belo Horizonte: Superintendência de Limpeza Urbana

15. SLU. Relatórios anuais da SLU 1993 – 2007. Belo Horizonte: Superintendência de Limpeza Urbana