

# Product development applied to collectors of recyclable materials: a case study in Florianópolis, Brazil

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**Abstract:** The manual hoisting of loads continues to be an activity requiring attention in view of the harmful effects it exerts on the human body. Collectors of recyclable materials are still a key factor in the amount of materials recycled today, but they are unfortunately subject to highly inappropriate working conditions. This paper reports on a study of the Recyclable Material Collectors Association of the city of Florianópolis, SC, Brazil, conducted in response to the City Hall's interest in analyzing the current situation with a view to providing better working conditions and safety and fostering a more efficient performance. This study involved a sampling of 15 workers representing 25% of the total number (60) of collectors. Various techniques and methods were applied to this group of workers to obtain information about their activities and the different body postures and movements they use. The survey revealed that the workers suffer from pains and aches in various parts of the body, basically caused by hoisting heavy weights, by the conditions of the streets where they work, by the effort involved in their physical activities, the distances they travel, the duration of their work day, and especially the conditions under which they load their vehicles. A vehicle adapted to the anthropometric characteristics of the population of recyclable material collectors is proposed here.

**Keywords:** product development, ergonomics, recyclable residues

## 1. Introduction

The new habits of the world population as the adoption of new technologies, intense rhythm of life, high consumption, among others, they bring consequences mainly in what concerns the nature. The amount of disposable products and garbage produced increases in the same rhythm.

The residues generated are natural sub-products of many activities developed by human beings and the amount and variety of them are intimately linked to the technological development level that the country and a more precisely region presents. Daily, hundreds of tons of solid residues that come from animals, minerals, vegetables, etc., of different processes are throw in the environment, which are collected in a small part; great amounts of liquid residues that are chemical or biological products or derived from the combinations of substances or harmful process and gaseous that result, among others, of combustion processes, as well as the chlorine-fluor-carbides used as propellants in aerosols.

Varied definitions of residues can be found in the literature. However, all of them coincide in defining them as sub-products, substances, that are generated by processes and that must be evacuated correctly to avoid problems to the workers, to the process and environment.

By definition, the residues are useless and they are thrown out resulting in an indisposition for the society, however the "better residue" is the one that is not produced. This does not mean that all of them are dangerous, being considered then all those that represent a risk for human's health, environment and for natural means, if its manipulation and elimination do not accomplish in a proper way and by following the rules for each type.

Statistics show's that in the USA it is produced more than 3.3 billions of metrical tons an year of solid residues, representing

45 Kg approximately for inhabitant (ATAILAH & SHAH, 2001). By analyzing this same situation in Brazil, we can observe that in the end of the last century was generated about 241.614 tons of solid residues a day, and 10.1% of this volume just presented an appropriate disposition (MINISTÉRIO DE SAÚDE, 2003), and of a universe of 5.507 Brazilian municipal districts analyzed, that at the time 66% did not have appropriate residue collection.

According to data of the Brazilian Institute of Geography and Statistics (IBGE) the general destiny of the solid residues in Brazil in 2000 was: 74.7% to open sky, 16.4% to controlled embankment, 6.3% to sanitary embankment, 1.3% to composting, 1.1% for recycling and 0,1% for incineration (MINISTÉRIO DE SAÚDE, 2003).

The residue final destination became a global concern and in the city of Florianópolis, located in the South of Brazil, it is not different. The residue production has been increasing more and more in a rate of approximately 10% a year, being even larger in the summer seasons where the amount of 263 t/day increase to approximately 360 t/day, what happens because it is a tourist city. (CENTRO DE INFORMAÇÕES SOBRE RECICLAGEM E MEIO AMBIENTE, 2004).

With the objective of minimizing the amount of residues that should be deposited in the places of final destination, reduce problems caused by the excess of generated residues and reused them for another applications is why the recycling of materials that have conditions of being re-utilized is motivated. The advantages of recycling can be mentioned as follows:

- Decrease of volume residues send to embankments or dumps;
- Smaller extraction of virgin raw material;
- Smaller consumption of energy on material transformation, compared to production when used raw material;

- Population understanding and concerning to their garbage produced; and
- Generation of formal and informal jobs.

According to IBGE data presented previously, the percentage of residues that are recycled is still very low and this benefits not only the environment, but also motivates the economy. In what concerns the generated jobs, there are people working in recycle industries or in informal way in associations, being an alternative of income for unemployed people.

When one thinks about residues recycling, it comes to everyone's mind the workers who dedicate themselves to this activity and normally are known on the streets like "garbage collectors".

Though, it could be important to go deeper on this activity and know how it is made besides asking which factors could be interfering in a direct way on it. Are the dimensions of the load vehicle used according with the psychophysiology capacities of them? Are the streets conditions where they work helping them or not to execute their activities correctly? Would the average weight that they are required to carry be capable of provoking any affectations and alterations in their health conditions? Could the distance traveled by them be over the limits of pushing loads? Would the activities developed by them be causing problems on their muscle-skeletal system?

To avoid work risks, fundamentally back lumbar, when the ergonomic conditions are inadequate during the manual manipulation of loads where lifting, placement, push, traction and movement activities are accomplished, minimum procedures of safety and health should be taken. (MINISTERIO DE TRABALHO Y ASUNTOS SOCIALES, 1997).

Maybe the previous questions are easy to answer when compared with only one question, of existing inadequate conditions for the analyzed workers. Which would be the most appropriate procedures to solve the detected problems?

The Florianópolis City Hall, with the objective to know how the activities of recyclable residues collectors are executed, has requested a study of this population for what a cooperative dedicated to this business was selected.

## 2. Objectives

This study has as main objective analyses the work conditions of recyclable residues collectors proposing procedures to solve the detected problems.

The specific objectives defined for the present study are:

- Analyze in which work conditions the activities of recyclable residues collectors are done;
- Determinate risk factors that recyclable residues collectors are exposed to; and
- Propose procedures that will guarantee the reduction or elimination of the detected risks.

## 3. Materials and methods

The Recyclable Material Collectors Association located in the Florianópolis central area, which the main economic activity is the commerce, has 60 collectors that use a manual vehicle to collect recycled solid residues at the streets, stores and buildings of the area. This population is composed by 45 men that represent 75% and by 15 women that represent 25% of the total that compose the analyzed population. The age groups distribution is presented in the Figure 1.

As it can be observed in the Figure 1 above 67% of the population that works in the Association are in the age group between 18 and 30 years, being considered a hard-working population relatively

young. It was selected of this total a sample of 15 workers that represent 25% of the total, which were applied different techniques to diagnose the current situation of the population in analysis. For the anthropometrical study, it was considered a sample of 43 workers that represent 72% of the population with the purpose of obtaining larger data in order to propose a new design of the vehicle.

Several stages were developed during the execution of this work with the purpose of achieving the proposed objectives and, in each one of them, different techniques and methods were applied. In a first stage, through the technique of the direct observation and of the not-structured interviews, the researchers have acquired the information that allowed them to get used to the activity that is accomplished by the population analysis object. It was discovered that the work routine varies depending on the worker. However, everyone has to accomplish the activities of collecting and separating the materials joined and in general it can be divided in:

- Arrive-unload-leave: the worker leaves to collect the material with its vehicle, comes back to the warehouse, leaves the collected objects in the "trip" and, soon after, he goes back for a next 'trip' (27% of the sample opted for this procedure type);
- Arrive-separate-leave: similar to the previous, but, before coming back to a next 'trip', the worker separates the products collected up to be weighted (46% use this procedure, because according to them, it allows a certain rest because they change of activity); and
- Arrive-unload-leave: after the "trip" the worker finishes his day of service and leave up the separating activity for the next day (20% of the sample use this procedure).

It is important to emphasize that 7% of the sample execute different procedures from the previously explained.

In a second stage, it was elaborated and initially applied a pilot questionnaire to 10% of the population with the objective of validating this technique and, if necessary, accomplish the respective modifications that would help researchers to have an appropriate tool and adapted it to the population characteristics and of the activity to be analyzed.

In a third stage, the questionnaire was applied to the selected sample, demonstrating that the techniques applied in the first stage accomplish a diagnosis of the current situation. This questionnaire has 33 questions and 6 sub-questions totalizing 39 subjects, of these 37 that represent 95% of the total are closed questions, the 5% remaining are open questions and approximately 15% of the total are present justification. The questionnaire was divided in four parts. The first part refers to the demographic data of the analyzed population, which contains 4 questions (10.25% of the total), the second part

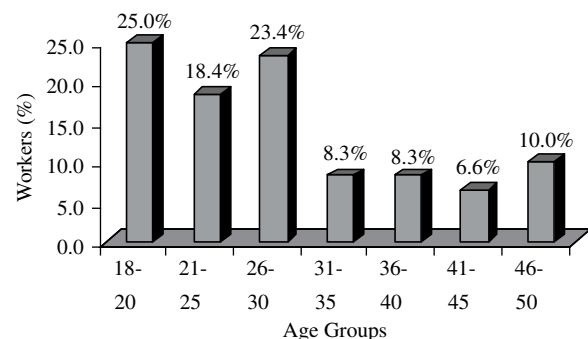


Figure 1. Age groups distribution.

has the objective to know about the daily activities which count 13 questions, representing 33,33% of the total, the third part is focus in the symptoms presented by the workers with 10 questions (25,64% of the total) and finally a fourth part guided to know better about the transportation used in the collection with 12 questions (30,77% of the total).

In a fourth stage, after accomplished the diagnoses and understanding which are the main risks that the collectors were exposed, the vehicle measures important to design it were defined and it was taken the anthropometrics measures of 43 workers that represent 72% of the population.

In a fifth stage, it was accomplished the results analyses and proposed the best procedures to solve the problems detected.

#### 4. Results and discussion

The recyclable material collector profession is characterized by the way of working in autonomy, because each one of them defines how many hours a day they will work, their methods of work and support tools. After the questionnaire application, it was discovered that 53% of the sample works more than 5 years as collector and that 80% works about 5 to 6 days a week, and 10% still works the 7 days of the week and the same percentage 4 days.

Besides the high frequency of work, the rhythm is highly tiring. We can observe that 80% of the sample works more than 8 daily hours and within this percentage, 17% works more than 12 hours. When is noticed that all work risks are referred to 8 hours a day, what would occur with those workers that frequently expose themselves to certain risks in periods that could reach more than 50% of the daily work schedule?

In relation to the quantity of times the worker comes and goes, it was noticed that 40% of the sample do it 3 times a day, 20% two times a day, 20% four times a day or more and the same percentage does it just one time. The duration of each time is particularly defined by the worker, together with the quantity of load carried.

Regarding the traction of loads, considering the total (weight of the vehicle plus the load) it was verified that 46.6% of the sample pulls between 150 Kg and 200 Kg, 40% between 100 Kg and 150 Kg, 6.7% between 200 Kg and 250 Kg and an equal percentage more than 300 Kg, what demonstrates that the 86.6% of the population pulls between 100 Kg and 200 Kg at each time.

When asked about the occurrences of work accidents, it was verified that 20% of the sample reported about their accidents fundamentally with another vehicles on the streets or with their own vehicles, this last because of the conditions they are constructed. In the same way, 66.7% complained about some kind of pain related to the activities executed in the collection of recyclable residues.

Their pains appear for all over their bodies, considering the most referred part as the inferior members with 26.6%, followed by the back lumbar with 20%, the superior members with 13.4%, the shoulder with the same percentage and the dorsal back, with 26.6%. In relation to the intensity of these pains, 73.3% of the sample classified them as strong or intermediate.

The high levels of pain presented, and also their higher intensity reflect the great level of efforts applied in their work as recyclable materials collectors. So, it was detected that the main symptom caused by the work activities developed was the appearing of generated pains in several parts of the body.

As reported by the workers mentioned in this paper, the possible causes they pointed out as a reason for their pains were the vehicle conditions, fatigue, distance that they cover daily and the age of most of them.

Through their work schedule, the collectors come and go several times to collect the materials, covering long distances. The collectors mentioned the distance factor as the main reason they feel painful for all over their bodies, especially over their legs. The fact that the workers stand up for most of their daily work schedule, doing such a strength that concentrate in this part of the body, justify the legs as the most affected part.

The distance to be covered is a very difficult factor to interfere, since the workers are self-employed and consequently have their own way of work. So, it is peculiar to each and every worker to decide about this issue. On the other hand, they are in seek of obtaining a higher quantity of recyclable residue, not taking into account the distance to be covered.

The Association has a motto in which they believe any person can work, not considering their age. As if the age goes by, the body loses its muscles strength and the bones become less resistant, what turns the body vulnerable to diseases, pains and accidents. In a heavy work, in which physical efforts are made, the age factor becomes a catalyze machine in the symptoms appearance. Then, one can notice that when the people are still young the difference between the percentage of the population within this age group and the percentage of the population within this age group that feel painful is large, so, the younger the fewer pains are detected. As the age increases by, this difference decreases, what confirms that if one is older, it is more likely for s/he the appearance of pains from all over their bodies. In the studied sample, it is noticeable that from 31 on all of them feel painful.

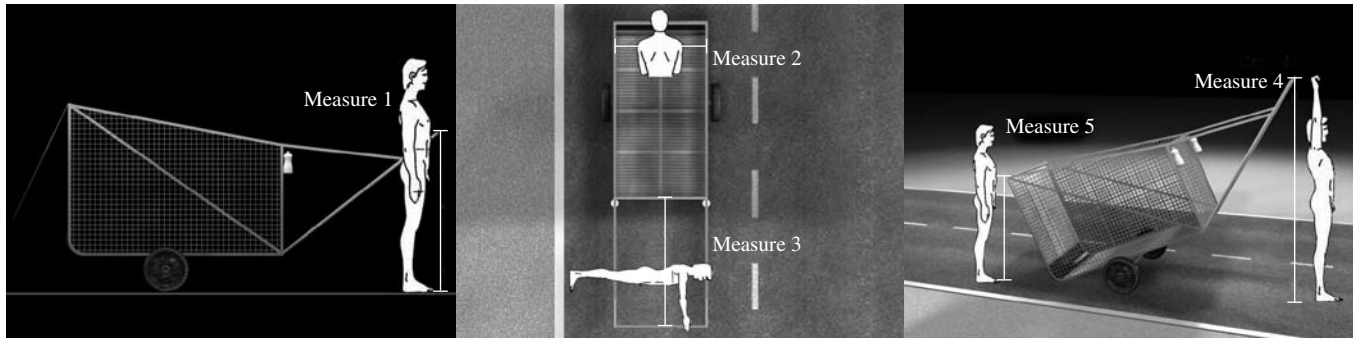
Another analyzed factor was the fatigue caused by the physical need of the whole organism (general body fatigue). The causes of fatigue come from several ways. According to the GRANDJEAN (1998), in a cycle of 24 hours, the addition of the requirements must attend the addition of the recuperation.

It is noticeable that the physiological fatigue predominates (66.7) over the chronicle (33.3%) after asked about the duration of the pains. This statement was confirmed when 100% of them indicated that among those who feel such constant pains, it stops after they get some rest. Among those who not feel such constant pains, but in certain periods of work schedule, it is more frequent to feel the pains at the end of their workday. In the sample analyzed, it was observed that 33.3% of the total showed constant pains in different parts of their bodies, the opposite of 66.6%, which feel non-stop pains. About 26.7% presented pains after a certain time of their workday and 40% at the end of the workday.

When researched about which criteria of them would be the causes of the pain appearance, the results showed that excepting for the distance and accidents, all the other reasons pointed out (to put and to take out the residues of the vehicle, the weight of the vehicle, the strength to develop the activity and the weight of the load that represent 73.3% of the causes) can be directly minimized through the dimensioning of the vehicle.

Considering the previous one, there were determined the relevant dimensions that would allow a new design of the vehicle, in order to adapt the anthropometrical characteristics of the population, deciding what could be done to guarantee that 90% of the population researched, so the anthropometrical design would correspond to the extremity (percents 5% and 95%). In Figure 2 is presented the proposal of the vehicle for collectors of recyclable residues.

- Measure 1: Distance between the ground and the position of the footprint. Determined for the percentage of 5% of the population in relation to the vertical measure that exists from the ground until the depression that forms the union of the arm and the ant arm. It is recommended that the arm should



**Figure 2.** Vehicle for collectors of recyclable residues.

be next of the supposed body doing the strength or movement, or either with the elbows next to the body;

- Measure 2: Distance between the position of the footprint and the beginning of the back part of the vehicle. The correct posture of pulling or pushing is the one that allows to use the weight of the own body in favor of the movement. To push one should incline the body ahead. To pull or push, the horizontal distance between the distant knee and the hands should be 120 cm, the minimum. Determined by the percentage 95% related to the distance between the shoulder and the middle of the arm strained ahead the body, still using some more 40 cm;
- Measure 3: Distance between the ground and the position of the footprint, when the vehicle is not moving. Determined by the percentage 5% of the population in relation to the vertical measure that exists from the ground until the middle of the hand, with the arm strained over the head;
- Measure 4: Distance between the ground and the superior back part, when the vehicle is not moving. Determined by the percentage 5% of the population in relation to the vertical measure that exists from the ground until the depression that forms the union of arm and ant arm;
- Measure 5: Distance between the two lateral sides of the vehicle. Determined by the percentage 95% of the population in relation to the measure that exists between the more lateral and superior points of the acromial apophysis of the omoplata (biacromial diameter). This measure should still have some more additional centimeters to allow free movements of the worker; and
- Measure 6: Diameter of the footprint. It is recommended that the diameter should be of 3 cm.

Considering the criteria developed for SNOOK & CIRIELLO (1991) to determine of the maximum strength to develop:

- Men:  
Strength to begin the movement = 15 Kg; and  
Strength to sustain the movement = 8 Kg.
- Women:  
Strength to begin the movement = 13 Kg; and  
Strength to sustain the movement = 4 Kg.

Bearing in mind the parameters taken into consideration (gender, covered distance, height of the footprint, percentage of the population to be assisted and the frequency of the movements) the results of the maximum loads that can be developed for each gender are:

**Men:**

- Weight of the projected vehicle: 55 Kg;
- Weight of the load according to the projected capacity for the back part: 95 Kg;

- Equivalent strength of the previous addition (150 Kg) = 29,4 Kg > 15 Kg according to values of the Snook table to the initial strength;
- To guarantee the 15 Kg recommended for Snook, the weight of the maximum set should be about 77 Kg; and
- So, the maximum weight of the load should be of 22 Kg.

**Women:**

- Weight of the projected vehicle: 55 Kg;
- Weight of the load according to the projected capacity for the back part: 95 Kg;
- Equivalent strength of the previous addition (150 Kg) = 29,4 Kg > 13 Kg according to values of the Snook table to the initial strength;
- To guarantee the 13 Kg recommended for Snook, the weight of the maximum set should be about 67 Kg; and
- So, the maximum weight of the load should be of 12 Kg.

Considering the previous results, it is recommended to create a prototypal of the vehicle according to the criteria of the authors and to assure the practice, according to the conditions of the streets, the real strength to be developed for the workers and doing the proper adjustments if it is necessary.

**5. Conclusions**

This profession still needs additional studies and researches that could offer good conditions to the workers, because the activity acquires a lot of the physical condition of them. In this paper it was highlighted the age measured, even with most people not having more than 30 years, but already presenting serious problems carried out through the pushing load movement. The age, as one can notice, is a very decisive factor in the appearance of diseases related to bone and muscles body structure.

Regarding the work activities, one of the factors that most called the attention was the intense routine of work of the recyclable garbage collectors, causing the muscle fatigue. This situation must be minimized adopting the Brazilian Working Legislation in relation to the work schedule, food, social relationship and occupational health conditions. It was observed that the main symptoms inherent to the activities done are bone and muscles pain-related, appeared mainly in the inferior members, in the lumbar and dorsal back.

We can conclude that the main reasons for the pain symptoms are the dimensions of the vehicle, that are not corrected adapted to the anthropometrical measures of the population, and the strength required to push it.

To minimize the consequences related to the inadequate vehicle together with the worker, it was developed a methodology for a project of a new vehicle of hand load. This was correctly dimensioned to

cover the strength limits that the worker can be going through, like their anthropometrical characteristics.

Through the acceptance of all measures suggested, it is expected to provide better conditions of work, life quality and safety to the users of the hand load vehicle. The methodology here presented can be extended to some other work-studies that apply a hand load. However, one should remake the researching related to the anthropometrical measures of the population that will be benefited.

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