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Statistical Analysis of Solid Waste Generation for the Preparation of a Management System

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Abstract*— *The aim of this paper is to develop new technologies that directly impact the environmental reality in solid waste management and in social and environmental education.For this purpose, the focus group is the population of the university campus, where the project is developed.The synthesis project is developed by the Department of Chemical and Environmental Engineering and by students of the Chemical Engineering course at the Faculty of Technology of Rio de Janeiro State University, Brazil.Based on the types of waste generated by the campus, alternative proposals are proposed for their treatment, development of technologies that can be applied to the reality of Brazilian society and standards that encourage society to be part of the waste treatment process, generating a social impact and environmental responsibility.The initial stage of the project work is to survey the types of waste generated by the campus population so that the priority areas for the development of solutions and technological aspects are determined.It was observed that most of the residues generated were from recyclable materials, followed by non-recyclable materials, as observed in other universities, the biggest divergence was in the discrepancy of collected compostable material. After this stage, development divisions are determined for each large campus waste group, subsequently targeting the region industrial reality.

Keywords*— *Solid waste; management; university; environmental.

I. INTRODUCTION

When one speaks about waste management, society collaboration is essential. Until recently, waste management was viewed as a matter of appropriate inventory, collection, transfer, treatment and disposal, and the main effort was to minimize environmental and public health impacts [1].Thus, engineering and logistics tools were sufficient to plan and implement solid waste management systems. However, today, with the introduction of circular economy concepts [2], resources management and social behavior are becoming an integral part of any solid waste management system.They are essential for treatment of rising recycling rates and better qualification of recyclables, for the participation of industrial stakeholders, eco-design initiatives and closed product and material cycles [3].

Solid waste generation and management remains an urgent global problem [4]. According to data from the United Nations (UN), worldwide, 2 billion tons of waste are produced annually, resulting directly from the inadequate disposal and inefficiency of solid waste management. Alarming data indicate that 99% of products purchased by the population are discarded within 6 months [5].

Brazil, as a developing economy, is not immune to this problem. In 2011, the Brazilian population generated 61.9 million tons of solid waste. Growth of solid waste is not the only problem, the disposal of this waste is also a concern.42% of the total solid waste collected in 2011 was improperly disposed of. Part of this waste disposal occurs in the most ecologically sensitive regions of the world [6].During the 1990s, recycling and other waste management methods were considered the most developed models for municipal solid waste management (MSWM) planning.Current models reflect a change in policy where waste planning has moved beyond full confidence in landfills, and has been placed on more comprehensive management techniques based on the principles of integrated solid waste management (ISWM) [7-11].

Municipal or urban waste is often generated from several sources where various human activities are found.Studies indicate that most urban solid waste from developing countries comes from domestic sources (55–80%), followed by commercial areas (10–30%) with

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varying amounts of public, industrial, and other institutions [12-14].Residues from these sources are highly heterogeneous in nature [15] and have variable physical characteristics depending on their sources; They are made up of food waste, yard waste, wood, plastics, paper, metal, leather, rubbers, inert materials, batteries, paint containers, textiles, construction and demolition waste and many others that are difficult to classify.

Embracing solid waste management programs are one of the biggest challenges for achieving campus sustainabilityConducting a waste characterization study is a critical first step in successfully planning waste management and advancing the overall sustainability of a higher education institution [1].This work is done at various universities around the world, such as the Autonomous University of Baja California (UABC) Mexicali I campus in Mexico [16], Southampton University in England [17] and Prince George Campus at the University of Northern British Columbia (UNBC) in Canada [1]. It used waste characterization categories adapted from several characterization methodologies, mainly from the Fraser George Regional District Waste Characterization Study (FGRD) and the Ontario Ministry of Environment's material classification system, in accordance with Regulation 102/94 (Ontario Ministry of Environment, 1994; Regional District of Fraser Fort George, 2007) [1].

Using the campus of the Faculty of Technology of Rio de Janeiro State University (FAT-UERJ) as a target, the Synthesis Project initially proposes to collect data on the generated waste. The purpose of this paper is to show how the analysis of the types of solid waste generated by a population describes important factors in the solid waste management system and guides the standards to be taken in the planning and structuring process of the management system.

II. METHODOLOGY

At UERJ college of technology, a selective waste collection system was implemented from an extension project called the Synthesis project. For this project, posters were produced across the campus to publicize and raise awareness among the academic community about the importance of recycling and how to sort waste. In addition, the technical capacitation of the cleaning team was trained, and garbage bins were produced from recycled containers from the industrial sector, using the concepts of Circular Economy. The waste generated was segregated in a Waste Plant created in this project.

For the production of the trash bins, the containers were composed of closed 200L pylons, 90 cm high and 57 cm in diameter.With a DW300 Tico-Tico saw, a cross section was made at the top to remove a lid for the bin.Another cross section was made to decrease the height of the bombona to 60 cm, in order to facilitate the trash ergonomics.The ends of the cut were sanded using 80-grit water sandpaper. On the cover, two semicircles on opposite sides were cut so that the residue could be discarded and two nylon clamps were fixed for handles to facilitate removal of cover during waste collection. In the upper interior of the bombona four hooks were placed, distributed evenly, protected with rubber to get support to the lid and to prevent the bags from being torn (Figure 1).

Fig.1: Hooksto prevent the bags from being torn

Fig.2: Trash binssticky and placed in trios

The trash bins produced were sticky and placed in trios (Figure 2), one in each of the busiest

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corridors on each floor of the three-storey main campus building. A trio was also placed in the campus cafeteria.In the corridors, there were wall-mounted general waste bins that, after implementation of the project, were converted to compostable waste bins and, next to each of them, a non-recyclable bins were placed.This was produced by means of recycled cardboard boxes, wrapped with brown paper, properly bonded. All rooms had common trash bins that, with the implementation of the project, became trash bins for the disposal of recyclable waste.

The solid waste, previously separated into bags, was weighed daily for 21 working days on a mechanical scales model MIC-1C, whose capacity is 150 kg and accuracy of 100 g. After weighing, the non-recyclable and compostable waste was discarded and the recyclable waste was separated and sent to the Recycle Resende Waste Pickers Association. The collected data were processed using the Excel program.

III. RESULTS AND DISCUSSIONS

Over a total of 45 days, effective 21-day weighing data were collected, while 24 days were for weekends, holidays, and non-academic campus days. Weighing data for these 21 days were plotted on explanatory graphs using Microsoft Excel software. These analyzes help to draw a quantitative and qualitative overview of the solid waste generated on the university campus.

With an active circulation of 800 people on the college campus, the average solid waste generated per day is around 24.45 kg, an expected amount for a high circulation environment.

As it is a university campus, the waste generated is expected to reflect the everyday life of a student environment, where paper, pens, disposable cups, food packaging and leftover food from campus meals are discarded in larger quantities.

The highest and lowest peaks in Figure 3 can be considered as indicative of the movement of people on a given day. High peaks indicate higher waste generation and, consequently, a larger movement of people on campus, such as on days of academic evaluations or receiving loads of products to the university, while lower peaks indicate lower movement of people, usually around dates. on holidays or weekends.

Fig.3: Total solid waste per day.

A more detailed analysis of the waste generated (Figure 4) indicates that most of what is produced per day is recyclable and non-recyclable waste. Being the first composed mainly of plastics, paper and

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cardboard and the second mainly composed of sanitary and laboratory waste.

Importantly, during data collection, there was still a high proportion of mix between recyclable and non-recyclable waste. This fact serves as a measure of the social and environmental responsibility of the campus population and demonstrates that further dissemination of the importance of selective collection and the positive impact that the proper treatment and disposal of this waste generates on society is still needed.

As far as compostable waste is concerned, the low amount presented in the data collected contradicts what is expected for a campus where a large number of meals are served per day. Once again demonstrating a still ineffective selective collection.

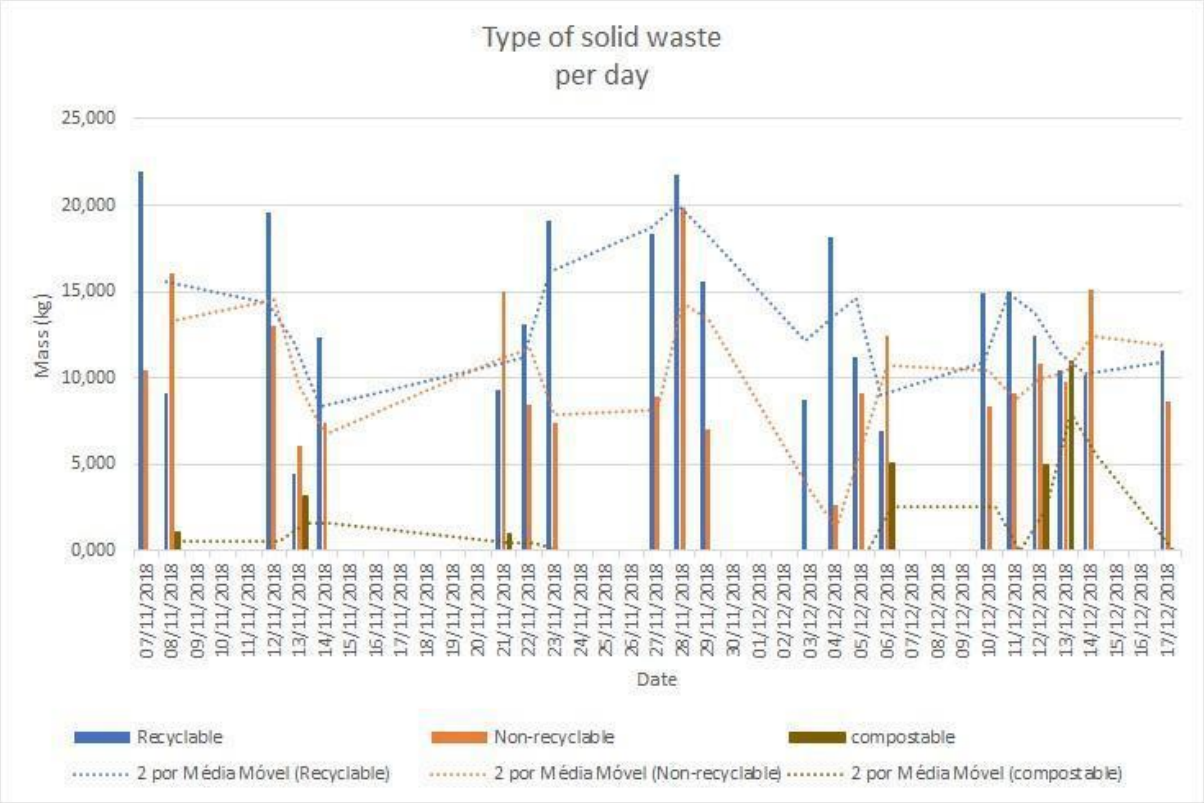

Fig.4: Types of solid waste generated per day.

At the end of 45 days of the weighing step, it was possible to identify how much of each type of waste was produced during this data collection period. Thus it can be shown that more than half of all the waste on the university campus in question is in fact composed of recyclable waste, followed by non-recyclable waste and, to a much lesser extent, compostable waste.

Since the collected garbage is still mixed, the data depicted in Figure 3 are not fully assertive, however, it is a necessary initial basis to elucidate an as yet unfamiliar campus landscape. It is important to emphasize that the implementation of selective collection demands an adaptation of the whole academic society and requires time to be completely satisfactory and with the ideal return.

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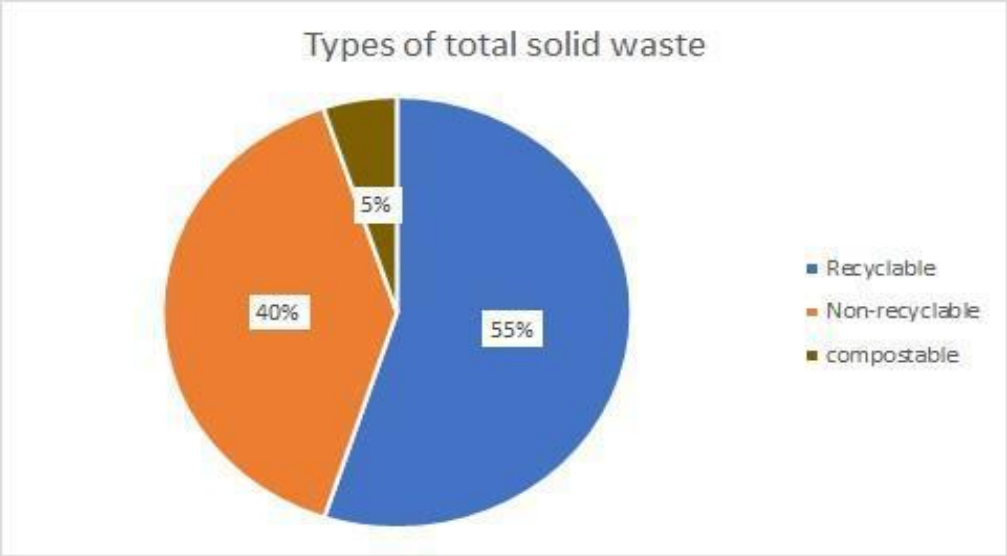

Fig.5: Total solid waste generated.

Comparing the percentages of waste generated on the local university campus (Figure 5) with the percentages of the University of Northern British Columbia Prince George campus [1], where 49.34% is recyclable, 28.42% non-recyclable and 21.61 % is compostable, there is a similarity in the value found for recyclable waste. However, there is a divergence in the values for non-recyclable and compostable, possibly due to the difference in the collection and separation processes.

Based on the data elucidated in the three graphs presented, several strategies can be mapped in the development of alternatives for the proper treatment and disposal of waste generated on campus. Among them, one can cite the best disposal of recyclable waste. Prior to the implementation of solid waste management, such waste was discarded without any sort of separation, however, currently the Resende waste picker association is contacted to give the appropriate destination to the materials that can be reused. As for the waste that cannot be recycled, the collection is done in the traditional way.

In addition, a variety of projects, such as development of composters, installation of used soybean oil collection points, biodiesel production, production of furniture made of PET plastic, among others, are being studied so that their implementation on campus is as quickly as possible, with the collaboration of students, faculty and the entire university community.

IV. CONCLUSION

In order to provide an overview of Campus solid waste generation, the data collected and analyzed here demonstrate that a more effective socio-environmental education of campus-goers is still required for effective and continuous waste management. Still, the data already indicate that several projects aimed at the university itself and the surrounding community can be developed by implementing the development and use of new technologies for the management and treatment of solid waste.

The heterogeneity of waste generated is a major setback in their use as raw material. There is therefore a need for fractionation of waste before it can be subjected to any significant treatment process [18].

The extension project now proposes to base, on the basis of the data collected, the subprojects to be developed in this area, taking into consideration which types of waste are generated the most and that can be viably treated on campus. In addition, new data collections will be made so that it is possible to analyze the progress of education and technological development brought to the campus.

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