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Implementation of a Solid Waste Management System in an Early Education Center and an Educational Unit in the South of the City of Quito, Province of Pichincha

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IMPLEMENTATION OF A SOLID WASTE MANAGEMENT SYSTEM IN AN EARLY EDUCATION CENTER AND AN EDUCATIONAL UNIT IN THE SOUTH OF THE CITY OF QUITO, PROVINCE OF PICHINCHA

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Abstract. This work includes the implementation of a solid waste management system developed in an Educational Unit in the Quito Canton, Chillogallo Parish. The institution has a kindergarten (CEI), elementary, middle school and high school. A characterization of the waste generated in each of the facilities was carried out. The per capita production rate (PPC) of the initial education center was of 0,184 $\frac{kg}{student*day}$, while in the rest of the Educational Unit it was of 0,097 $\frac{kg}{student*day}$. The waste with the highest generation in the CEI was organic waste, with a 36,69% and non-reusable wastes (RNA) in a 33,54%. In the rest of the Educational Unit there was a generation of organic waste (OW) of a 38,23 and a 26,05% of plastic residues (RP). The residues had a moisture content of 73,29%, a lower calorific value (LCV) of 0,0179 $\frac{kcal}{g}$, presence of coliforms, aerobic bacteria, molds and yeasts.

Keywords: characterization, residues, PPC, lower calorific value, humidity.

1 Introduction

At present, the generation of solid waste is increasing significantly and is causing people to talk about a "garbage crisis"[1]. The actions implemented to intervene in the management of solid waste from the time it is generated to its final disposal seek to reduce the negative impacts caused by poor waste management. In a solid waste management system, certain points are considered: generation of waste, separation and classification from its origin; control in its operation and storage until its evacuation [2].

By implementing a solid waste management system, it is possible to control large amounts of waste in a more efficient way, by promoting actions through activities involving the people who are part of the institution, to promote prevention, recycling and reuse of different waste, thus minimizing the amount of waste that reaches its final destination and consequently reducing gas emissions and giving value to waste through reuse and recycling [3].

2 Methodology

2.1 Site description

The analysis of the handling and management of waste within the institution was carried out through the following activities: an analysis was made during the morning hours and the activities were observed, as well as the extracurricular activities that are carried out in the afternoon hours. The current solid waste management and the distribution of containers and trash garbage cans within the educational unit were observed. Photographic records were taken of the school's facilities. The information and quantitative data provided by the school's administrative personnel were analyzed and used to evaluate the school's waste management and generation.

2.2 Calculation to determine the sample size for a finite population

The following equation was used [4]

$$n = \frac{N*Z^2*p*q}{e^2+(N+1)+Z^2*p*q} \quad [1]$$

n = sample size

N = total population

p = estimated probability 0,98

q = estimated probability 0,02

he = acceptable margin of error 0,05

z = standard value 1,96

The formula was used to find a reference for the number of respondents. Two different surveys were conducted: the first one for students and cleaning staff and the second one for teachers. The survey #1 was carried out at 50 students and 4 janitors working at the institution. The survey #2, was carried out at 20 teachers.

3 Methodology for solid waste characterization

The methodology was based on the guide for the characterization of household solid waste, presented at the Pan-American Center for Sanitary Engineering and Environmental Sciences (CEPIS), as an adaptation of the one formulated by Kunitoshi in 1982, which has different phases [5]:

3.1 Field Phase

It was carried out at the institution's facilities, where solid waste accumulates during the day.

3.1.1 Early Childhood Education Center

A black plastic sheet was used: 2 m long by 4 m wide, which was placed on the floor to avoid spills on the ground (fig. 1). All the plastic bags containing solid waste from the CEI were collected throughout the day. The bags were weighed with a mechanical floor scale to calculate the total weight of solid waste produced at the facility.

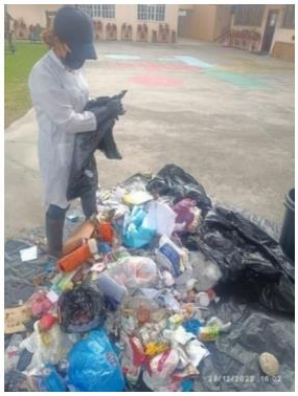

Fig. 1. Emptying of the collected bags on the plastic

3.1.2 Educational Unit

The Educational Unit has basic, secondary and high school education, as well as extracurricular activities in the afternoons. The first step was to spread the black plastic,

of the dimensions already mentioned, over the place chosen for the work. Subsequently, the plastic garbage bags were accumulated from each of the 16 containers available throughout the campus. The weight of the waste was calculated with a scale.

3.2 Density of solid waste

Both, in the CEI and in the rest of the Educational Unit, the waste was placed on the plastic on the floor, and a 12-liter container was used (fig. 2), where the waste was deposited without compacting it up to the edge of the container. The container was tapped against the ground three times from a height of approximately 10 cm and was again leveled, without pressing the contents of the container. It was weighed on the balance and divided by the volume of the container.

Fig. 2. The waste was placed on the plastic on the floor

3.3 Cabinet Phase

Both in the CEI and in the rest of the Educational Unit, solid waste was classified into: organic and garden waste, plastics, paper and cardboard, glass, tetra pack. Subsequently, the solid waste was classified in each labeled bag and finally each bag was weighed.

3.4 Percentage each of solid waste

The bags with the sorted solid waste were weighed to establish the percentage of each one of them.

3.5 Per Capita Production (PPC)

To determine the total amount of solid waste generated during the day, the total weight of waste collected is divided by the total number of students in the school.

3.6 Laboratory analysis

They were carried out in the laboratory of the Faculty of Chemical Sciences of the Central University of Ecuador. A one-kilogram sample was collected from each of the CEI and Educational Unit facilities, and the following were measured: humidity, lower caloric value and microbiological analysis in terms of aerobic bacteria count, total coliforms, molds, yeasts and *Escherichia coli*.

4 Results and discussion

4.1 Current management of solid waste at the CEI and the Educational Unit.

Solid waste produced by children in the CEI during school hours is deposited in trash cans located in each classroom and waste generated during recess is collected in the dumpster located in the courtyard. The collection is done by the cleaning staff. The final disposal is done in the containers provided by the Metropolitan District of Quito (DMQ).

The waste generated by the educational unit comes from the prekindergarten, school and high school. There are garbage cans distributed throughout the facilities and 16 containers of 100-liter strategically distributed in the school yard. At the end of the day, the cleaning staff collects the waste from each garbage can and places it in the containers. There are also 4 collection sites for plastic bottles. The waste collected during the day is disposed of in the DMQ containers located in front of the facility.

4.2 Sources of solid waste generation

The facility's facilities were toured in order to identify the frequency and type of waste generation and the different areas and the type of waste generated by each one was located. Once the source of generation was determined, it was concluded that the main problems in the institution were:

- Bad habits for placing garbage in the trash can by the people who occupy the institution.
- Improper disposal of waste both in classrooms and in the general playground.

4.3 Per Capita Production.

- **Early Childhood Education Center**

Table 1 shows the daily values of residues obtained in the CEI and their total PPC.

Table 1. PPC of the Initial Education Center

1 day	2 day	3 day	4 day	5 day	6 day	7 day	**Total average (kg)**	**Nº total staff**	**PPC** $\left(\frac{kg}{student*day}\right)$
19,6	16,8	19,8	19,1	19,4	17,9	17,7	**18,61**	**101**	**0,184**

- **Educational Unit**

Table 2 shows the daily values of waste obtained in the Educational Unit and its total PPC.

Table 2. PPC of the Educational Unit

1 day	2 day	3 day	4 day	5 day	6 day	7 day	**Total average (kg)**	**Nº total staff**	**PPC** $\left(\frac{kg}{student*day}\right)$
63,7	46,37	48,2	49	47,6	44,7	46,9	**49,50**	**512**	**0,097**

Table 3 shows the percentages of each of the waste components found in the CEI:

Table 3. Percentage of solid waste from the CEI

SOLID WASTE	**DAYS**							**TOTAL WEIGHT (Kg)**	**% TOTAL**
	1	**2**	**3**	**4**	**5**	**6**	**7**		
Organics	6,4	6,2	8,7	4,1	6,1	6,4	7,3	45,2	**34,69**
Not usable	4,1	7,4	7,2	10,5	5,2	5	4,3	43,7	**33,54**
Plastic	4,2	1,9	3,1	2,5	4,1	3,4	3,1	22,3	**17,11**
Paper and cardboard	3,6	0,8	0,3	1,3	3,5	2,3	0,9	12,7	**9,75**
Tetra pak	1,3	0,4	0,5	0,7	0,5	0,8	2,1	6,3	**4,83**
Glass	0	0,1	0	0	0	0	0	0,1	**0,08**
TOTAL (kg)	**19,6**	**16,8**	**19,8**	**19,1**	**19,4**	**17,9**	**17,7**	**130,3**	**100**

On day 3, the total weight was 19,8 kg, due to the fact that a Christmas program was held on that day, unlike the second day, when the total weight was 16,8 kg, because the students finished their day at 10:00 am, which reduced the production of waste.

Table 4 shows that the total weight of solid waste was 191,2 kg. On days 4 and 5, more waste was generated, while on day 1 there was less waste. The most generated solid waste was organic waste (38,23%), followed by plastics (26,05%). The following were also found: cosmetics, textiles, personal hygiene products, paper and cardboard (7,74%), tetra pak (4,76%) and glass (0,52%).

Table 4. Percentage of solid waste from the Educational Unit

SOLID WASTE	DAYS							TOTAL WEIGHT (Kg)	% TOTAL
	1	2	3	4	5	6	7		
Organics	12	8,6	9,3	11,2	11,5	9,2	11,3	73,1	**38,23**
Plastic	5,2	6,1	8,1	7,4	9,8	6	7,2	49,8	**26,05**
Not usable	7	8	6,7	5,7	5,2	5,5	5,3	43,4	**22,7**
Paper and cardboard	0,6	1,5	2,1	2,1	2,1	4,3	2,1	14,8	**7,74**
Tetra pak	0,5	2,3	0,9	1,2	1,3	1,3	1,6	9,1	**4,76**
Glass	0,2	0,4	0	0,2	0,2	0	0	1	**0,52**
TOTAL (kg)	**25,5**	**26,9**	**27,1**	**27,8**	**30,1**	**26,3**	**27,5**	**191,2**	**100**

The two facilities of the Educational Unit do not have a solid waste management system, for this reason all solid waste, including that generated in the bathroom, is mixed and therefore the waste is not valorized since it is not disposed of in separate containers for each type of waste, but only for plastic bottles.

4.7 Laboratory analysis.

The analyses performed at the laboratory of the Universidad Central del Ecuador were as follows:

The Lower Calorific Value was of $0{,}0179\,\frac{kcal}{g}$. The sample from this study presented a moisture value of 73,29%. The results of the sample from the institution do not have the presence of *Escherichia coli.*

4.8 Solid Waste Management Development.

Posters were made with ecological information to promote good environmental practices and were placed in the CEI and the rest of the educational unit. The results of this work were also presented to the school authorities and it was recommended that color-coded bins be implemented. It was suggested that the waste be sorted and transported to the nearby ecological point located in front of the school. The project "Bottles of

Love", a project aimed at recycling, is focused on reducing flexible waste by placing it in a plastic bottle and then selling it as a raw material to be sold and obtain an economic benefit (fig. 3).

Fig. 3. Solid Waste Management Development Activities

4.9 Discussion

In the study conducted by [7], in the Jesús Ordoñez school in the Quito Canton, with a total of 171 students, consisting of children from 3 to 11 years of age (similar to this study, where children from 2 to 5 years of age attend), a PPC of $0{,}024\ \frac{kg}{student*day}$. The CEI had a total of 101 students and a CFP of $0{,}184\ \frac{kg}{student*day}$. One of the reasons for this is that the Jesús Ordoñez school, being a public school, the Ministry of Education delivers drinks in cardboard containers and the institution has a collection center for cardboard and PET bottles, material that is sold to an informal recycler, unlike the CEI, which, according to the Ministry of Education, has a collection center for cardboard and PET bottles, material that is sold to an informal recycler [8], as a private institution, it tends to generate a greater amount of solid waste, due to the fact that they carry out extra activities and the students stay more hours at the institution.

The PCI was $0{,}0179\ \frac{kcal}{g}$, by comparing it with the study of [9] which determined a PCI of $4{,}66\ \frac{kcal}{g}$, but only from the biodegradable organic fraction of urban solid waste

produced in neighborhoods in southern Quito. According to the results of this study, it would not be feasible to apply an energetic use of the biodegradable organic fraction.

The sample of this study showed a moisture content of 73,29%, i.e., the result obtained is the amount of water present in the waste [9], mentions that 50 to 60 % is an optimal range, since the generation of bad odors is caused by the excess of humidity in an aerobic degradation.

The microbiological dynamics of bacteria will depend on the interaction of physical and chemical parameters and their involvement in the degradation of RO [10]. The results of the sample of the institution do not have the presence of *Escherichia coli*, which favors the Educational Unit, as it does not present risks to students or cleaning personnel in the cleaning and sanitation process.

5 Conclusions

The CEI characterization showed: organic waste 34,69%, non-usable waste 33,54%, plastic waste 17,11%, paper and cardboard waste 9,75%, tetra pak waste 4,83% and glass waste 0,08%. It was concluded that there is no proper management, since at the time of collecting organic waste, it is mixed with other waste, causing the loss of waste components that can be easily used. In the Educational Unit, the characterization of solid waste was: organic waste 38,23%, plastic waste 26,05%, paper and cardboard waste 7,74%, tetra pak waste 4,76%, glass waste 0,52%. There are several factors that cause that these are not managed correctly, the main cause is not disposing of the waste plastic bags, which are inside containers at the end of the school day.

The PPC value in the CEI was 0,184$\frac{kg}{student*day}$, this data shows that there is a high amount of solid waste production, compared to the low number of personnel, which is why it is considered important to implement a Solid Waste Management System, through good environmental practices. By means of information on billboards and socialization of the work done, we began to raise awareness among the students in order to initiate a change in consumption habits; it was of great help that 46% of the students have knowledge of the 3Rs (reduce, recycle, reuse), data taken from the survey. In addition, we coordinated the delivery of the most commonly generated recyclable waste, duly classified, with grassroots recyclers.

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