Reception: **April 30, 2016** | Acceptance: **July 29, 2016**

# MANAGEMENT OF NON-HAZARDOUS SOLID WASTE IN AN INSTITUTION OF HIGHER EDUCATION

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*— Abstract—*

In general, the higher education institutions gather many people, so they are considered as sources of high rate of solid waste generation, thus requiring for strategies and well-established protocols to ensure the proper management of solid waste to avoid the problems generated and the risks posed to both public health and the environment. In University City (CU), an institution of higher education in the city of Tuxtla Gutierrez, Chiapas, Mexico. A study was conducted to determine the solid waste management, which included the generation, collection, storage, equipment and infrastructure, in addition to the characterization, economic aspects and implementation of a tool to learn about environmental education focused to solid waste. The results show that 677,6 kg / day of solid waste is generated, with 0.143 kg/person-day, management has a cost of $7.00/kg and 10 fractions which potentially can be exploited at least four of them, hoping for a reduction of up to 63% of the generation were identified. Education becomes a necessity to achieve this reduction.

**Keywords**

*Solid Waste, Institutions of Higher Education, Waste Management.*

Solid waste management involves aspects ranging from its generation, management, treatment and final disposal in order to minimize the impact to the environment. Residues can be classified according to their physical state (solid, liquid and gaseous), their chemical characteristics (organic and inorganic), the degree of degradation in the environment (biodegradable and non-biodegradable), their physical characteristics (Inert and combustible), by the activity that originates it (municipal, industrial, mining, hospital, etc.) and by its type of management (dangerous, potentially dangerous, non-dangerous, special and dangerous biological infectious) (Buenrostro 2001) .

Problems generated by the inadequate management of solid waste have been widely doUCmented, putting the public health of the surrounding population at risk. This risk increases and is associated with the proximity of final disposal sites, low growth rate (Ocampo et al., 2008) and in other cases from asthma to cancer, which ends with the death of minoSW (Paschkes and Palermo, 2010).

On the other hand, some of the problems caused by the mismanagement, but especially the inadequate disposal, are: blockage of water UCrrents, deterioration of recreation sites, contamination of aquifeSW and bodies of surface water, salinization of soils, proliferation of noxious fauna and generation of bad odoSW (Cortinas, 2001). When garbage is burned, particles and all kinds of substances are emitted, including dioxins and chlorinated compounds with high toxicity (Cortinas, 2003), capable of causing a variety of negative effects in animals such as: weight loss and liver problems, impaired reproductive function, immune response and defects in the offspring (Olea et al . , 2002 Armengi et al, 2005)..

The proper management of solid waste represents a commitment for higher education institutions that have a greater commitment to social challenges, strengthening the social responsibility of univeSWity students and fostering a univeSWity committed to the society that surrounds it. At the global level, there have been studies foUCsed on solid waste management in institutions of higher education, such as that reported by Espinosa et al. (2003), at the UniveSWity of Granado, Spain, whose purpose was to know the environmental impact generated by the activities of its univeSWity centeSW and to define the strategies to be followed in environmental management. As a result, in 1998 it implemented a plan that includes the principles that constitute the institutional framework of the environmental management of this univeSWity. The doUCment highlights the importance of the joint participation of teacheSW, researcheSW, administrative staff and students.

In America, a study of solid waste composition conducted at Brown UniveSWity, in 1992, found that 45% of waste generated at this institution

was recyclable. This univeSWity has had a recycling program since 1972 and in 2004 recycled 31% of its waste (Brown Programs, 2004). It should be considered that in the United States of America, it is mandatory for schools and univeSWities to have waste reduction and recycling programs.

Mexico has worked in several institutions of higher education. The Autonomous UniveSWity of the State of Morelos has established the UniveSWity Environmental Management Program, and the best known case is that integrates eleven institutions of higher education in an organization called the Mexican Consortium of UniveSWity Environmental Programs for Sustainable Development (COMPLEXUS), whose main objective is the collaboration and coordination of univeSWity environmental programs, committed to the incorporation of the environmental dimension in the substantive tasks of their institutions (Bravo, 2003).

For the state of Chiapas, there have been incipient efforts in relation to waste management, specifically in the UniveSWity of Science and Arts of Chiapas (UNICACH), the fiSWt with the creation of the UniveSWity Environmental Program and in the second, a study foUCsed on environmental education exclusive to the student population with respect to the generation of the solid waste that they did not deepen in subjects of handling. Since planning, the univeSWity has two instruments that observe this heading:

1) Policy of quality "that establishes the transveSWal incorporation of its commitment to sustainable development, quality and continuous improvement of its administrative processes and services; promotes the culture of pollution prevention and the preservation of the environment in the univeSWity community , and integrates the sum of professionalization aimed at increasing the compliance with the legal and regulatory framework".
2) The UniveSWity Environmental Program (UEP), which aims to "promote the incorporation of environmental action and sustainability within its substantive functions, research, teaching and extension, which are made in the various UNICACH educational programs, as well as promoting environmental awareness in the univeSWity community and in the state."

In order to reinforce the idea of knowing the state of the management of residues, this study was conducted at the main campus, "UniveSWity City" (UC) of the UNICACH, in the City of Tuxtla Gutiérrez, Chiapas, Mexico, with the purpose of having a solid waste management approach. A diagnosis of the generation, collection, management, equipment, infrastructure, characterization and finally the application of a survey on environmental

education foUCsed on the knowledge and management of solid wastes was carried out.

## MATERIALS AND METHODS

In order to know about the solid waste management within the facilities, a study was carried out in three stages.

### *FiSWt stage*

Aimed at knowing the equipment, infrastructure and economic aspects of solid waste, an interview was conducted with the head of the Department of General Services of UC responsible for waste management to know the economic aspects in terms of expenses and day-to-day management. Solid waste peSWonnel assigned for that purpose were observed. In addition, a tour of the UC facilities was carried out to collect and compare information on the number and type of equipment and infrastructure such as containeSW, boats, general warehouse, etc.

### *Segunda Etapa*

The generation and characterization of the solid residues inside UC for eight days was determined, taking as reference and adapting the Mexican technical standards such as those related to the method of quarantine (SECOFI, 1985a), the selection and quantification of byproducts (SECOFI , 1985b) and generation determination (SECOFI, 1985c).

The residues were collected in plastic bags, randomly taking 10% of the total accumulated in the day (Ruíz, 2012). In order to homogenize the sample, the residues were mixed and then divided into four equal parts, eliminating two opposing quarteSW and accepting the remaining two.

From one of the two accepted parts, the generation per peSWon per day was determined, weighing with a Nuevo Leon brand scale with a 500kg capacity , with a sensitivity of 10 g of the accumulated material and was divided among the number of people.

From the last part, the identified fractions were separated and classified, and later weighed separately. The percentage by weight of each of the by-products was calculated with the following expression:

Equation 1: $PC=(G1/G)*100$

Where:

PC = Percentage of component considered.
G1 = Weight of the by-product concerned, in kg..
G = Total weight of the sample, in kg.

*Third stage*

In order to know about the education and knowledge of solid waste management in UC, a descriptive type instrument was designed with semi-closed questions evaluated with the Licker scale. A pilot test was performed to verify its validity, using the Cronbach's alpha statistical test to 3% of the sample for reliability, which yielded 0.070, which was then applied to 20% of the population. The sample was stratified (Program, groups, careeSW and semesteSW), making a total of 945 individuals of which 856 were students, 80 teacheSW and 13 administrative staff.

## RESULTS

*Equipment and Infrastructure*

For the storage of SW in buildings and facilities, there are 42 metal containers of 20 l capacity, fixed to the floor in pairs: one for the inorganic and another for the organic. Their distribution is shown in Table 1.

**Table 1.** Number of containers and distribution in UC

| Facultades y/o escuelas | Contenedores (Orgánica) | Contenedores (Inorgánica) | Total por Facultad |
|---|---|---|---|
| Ing. Ambiental | 3 | 3 | 6 |
| Alimentos, Nutrición y Gastronomía | 2 | 2 | 4 |
| Energías Renovables | 1 | 1 | 2 |
| Centro de Lenguas | 1 | 1 | 2 |
| Ciencias de la Tierra | 1 | 1 | 2 |
| Biología-Laboratorios | 1 | 1 | 2 |
| Psicología | 2 | 2 | 4 |
| Facultad de Topografía e Hidrología | 2 | 2 | 4 |
| Odontología | 1 | 1 | 2 |
| Consultorios de Odontología y Nutrición | 1 | 1 | 2 |

| | | | |
|---|---|---|---|
| Biblioteca Central | 3 | 3 | 6 |
| Auditorio | 3 | 3 | 6 |
| **Total** | | | **42** |

In addition to the equipment listed in Table 1, there are other containers of plastic material of approximately 15 l capacity, one in each classroom and generally in all spaces, such as offices, laboratories and cubicles. There are only 4 containers with an approximate capacity of 1m$^3$, where only PET (number 1), located in buildings of Surveying, Environmental Engineering, Biology and Earth Sciences is received.

In terms of infrastructure, it basically consists of a temporary warehouse for solid waste with dimensions of 9 x 9 m, roofing and fencing that prohibit the entrance of fauna but which in turn has sufficient ventilation, with a firm floor that prevents the infiltration of leachate to the subsoil, with access and circulation pathways. Residues from the different areas of UC are stored without further treatment for six days and collected every Wednesday by the city's cleaning service.

In signage there is a sign indicating that the waste must be deposited at the bottom of the warehouse. Finally, there are neither fire safety measures nor their corresponding signaling. No other activity is performed.

*Economic analysis of solid waste management*

Equipment and infrastructure costs were not included. Only two items were found where economic resources are invested. One is 40 cleaning workers whose activities include sweeping and collecting solid waste daily from containers, common areas and salons, with a nominal wage per worker of $ 3,800.00 / month.

Two: all the containers are supplied with a plastic bag that facilitates the handling of the material. For this item $ 2,300 / month are allocated.

With these costs, the total sum $ 5,143.33 / day and $ 7.00 / kg, handled in UC, not including collection, transportation and final disposal.

The revenues generated from the solid waste, by sale of the PET that is collected in containers is shown in Table 2.

**Table 2.** Monthly average of the sale of recovered PET from the UC.

| PET en Kg | Ingreso en $ | Ubicación | PET en Kg | Ingreso en $ | Ubicación |
|---|---|---|---|---|---|
| 33 | 66 | Ing. Ambiental y Topografía | 8.3 | 20.8 | Biología y Ciencias de la Tierra |

The average monthly income is $ 86.80, and this amount does not enter the University. The average decrease of solid waste specifically for the fraction of PET, is 41.30 kg / month equivalent to 1.37 kg / day and has not been included in the generation study, however, since there is no data for a comparison it becomes evident the need to develop specific economic indexes and thus have solid references for successful waste management (Acquatella, 2002).

### *Generation*

To calculate the per capita generation a total population of 4,728 people including both full and part time teachers, administrative staff and service, undergraduate and graduate student population were considered.

The study was carried out for half a semester during the period of January-June 2015, when there is the largest influx of people in UC and therefore corresponds to a generation called typical maximum (Ruiz, 2012) taking the sample directly from the warehouse. With the weights of the samples we projected the total generation per day and the total average. The data are presented in Table 3.

**Table 3.** Solid waste generation per day in UC

| Día | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | Promedio |
|---|---|---|---|---|---|---|---|---|---|
| Peso Total generado en kg. | 634,42 | 585,08 | 715,5 | 809,81 | 240,05 | 809,92 | 805,67 | 730,6 | 677,6 |

Therefore, taking into account the total population and the total SW average, the generation corresponds to 0.143 kg / person-day, lower than the 0.33 kg / person-day reported by Ruiz (2012) in a study carried out in the Universidad Iberoamericana, but very close to the 0.132 kg / person-day reported by Cruz, et al. (S / F) in a study carried out for a school in CONALEP, in the state capital of Puebla.

### *Characterization*

We identified 10 different fractions or components and their daily quantity, as well as the average of the 8 consecutive days, variance and standard deviation. These data are presented in Table 4.

**Table 4.** Composition of solid waste

| Componentes | Día | | | | | | | | Prom. | Varianza | Des. Están. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | | | |
| Unicel | 22,11 | 6,83 | 32,8 | 0 | 0,86 | 3,81 | 5,29 | 6,05 | 9,72 | 116,94 | 10,81 |
| Plásticos | 18,72 | 127,41 | 136,9 | 346,66 | 93,76 | 106,77 | 180,21 | 217,9 | 153,5 | 8380,27 | 91,54 |
| Vidrio | 30,19 | 141,12 | 11.1 | 53,66 | 2,01 | 259,48 | 82,75 | 56,96 | 89,45 | 6445,56 | 80,28 |
| Cerámica | 81,71 | 8,47 | 0 | 0 | 0 | 0 | 229,86 | 0 | 40,01 | 5847,59 | 76,47 |
| Aluminio | 8,33 | 7,22 | 13,8 | 20,47 | 0,83 | 14,78 | 6,67 | 4,98 | 9,64 | 34,59 | 5,88 |
| Papel | 35,73 | 29,4 | 75,4 | 44,48 | 3,87 | 85,01 | 114,93 | 56,39 | 55,65 | 1082,32 | 32,90 |
| Cartón | 6,74 | 95,39 | 73,1 | 19,77 | 57 | 133,59 | 4,37 | 29,89 | 52,48 | 1856,59 | 43,09 |
| Madera | 164,2 | 0 | 0 | 0 | 0 | 9,38 | 0 | 0 | 21,7 | 2910,42 | 53,95 |
| Mezcla | 188,5 | 61,72 | 0 | 188,51 | 30,72 | 34,42 | 0 | 89,36 | 74,15 | 5125,13 | 71,59 |
| Orgánico | 78,19 | 107,52 | 383,5 | 136,26 | 51 | 162,68 | 181,59 | 269,1 | 171,2 | 10402,36 | 101,99 |
| Total: | 634,42 | 585,08 | 715,5 | 809,81 | 240,05 | 809,92 | 805,67 | 730,6 | 677,6 | 32063,52 | 179,06 |

The variances reflect an enormous dispersion in the generation of both the totals and fractions that were identified, which would be reflected in the moment of making the proposals for containers and equipment oriented to its handling. The fractions that have economic potential in the local markets are: paper, cardboard, aluminum and plastics, of the latter is separated and a small part is sold. The percentages of each component with respect to the total are presented in Figure 1.

**Figure 1.** Percentage of the components of the SWU generated in UC

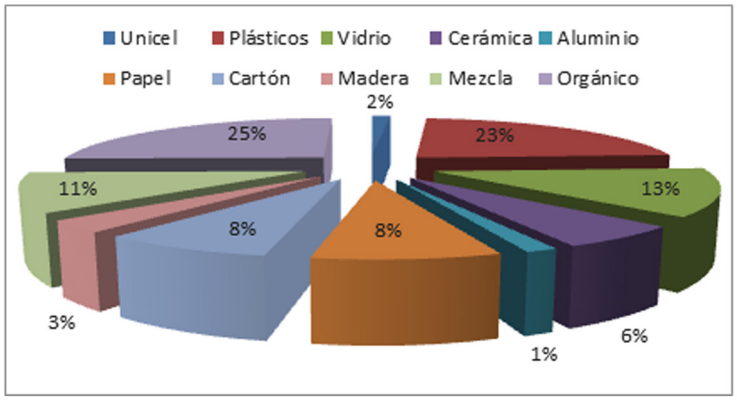


Figure 1 shows that the major component is organic matter with 23%, very close to 26 and 28% reported by Buenrostro (2010) and Goya-García (2001), respectively. The next major components were plastics with 23%,

and glass with 13%; Paper and cardboard 8% for each one, close to what was reported in the study by Maldonado (2006). The components with the lowest percentages were residues such as aluminum (1%), Styrofoam (1.5%) and wood (3%). With these data and according to university conditions, it is estimated that it can reach a decrease of about 67% (Maldonado, 2006) or up to 80%, as long as the residues are separated into their components (Armijo et al. , 2006).

The detected fractions invariably are mixed, which makes manual separation difficult, and reflects 11% of the mixed components found in the compositional study. In a study carried out by Hilerio (2005), it was reported that for that year, only in the Faculty of Biology of UNICACH a separation process was carried out. This reflected the low sensitization of the university population.

*Environmental education*

In the survey on environmental education, the following results were obtained: 39% say they know enough about solid waste and 33.9% say they know little; Only 5.9% have participated in training for the management of solid waste, while 35.6% know enough about organic and inorganic waste. 22.9% always separates solid waste by depositing it in containers while 9.3% never do it, 35.6% said they do not know the solid waste management plan of the Institution and only 11.8% know it. Finally, 85% of the respondents commented that if the University implemented courses for the solid waste management plan, they would participate.

The results reflect the need to continue environmental education activities, as reported by Hilerio (2005).

It has been recognized that environmental education is the most powerful tool to motivate new habits, attitudes and values in the population, as well as a trigger for social co-responsibility in solving environmental problems (SEMARNAT, 2005), which in the case of higher education institutions take on a larger dimension.

As an example of the importance of environmental education in schools, Barrientos (2010) reports that in a university in Costa Rica, education and improvements in organization and labeling increased the separation of fractions.

## CONCLUSIONS

Making a comparison on the management of non-hazardous solid waste in UC of UNICACH with other universities, whether national or foreign, when data and working protocols are not available is difficult, considering that each educational institution has its own environmental management and are often different from each other.

The study yields a generation of 0.14 kg / person-day, the collection was done manually and there was no separation. Many areas of opportunity are presented and the characterization presents fractions that can easily be exploited, such as aluminum, organic matter, paper, paperboard and plastics. This means that it can potentially be reduced by up to 63%, but it is necessary to establish and operate a system that includes environmental education to ensure the separation of waste.

The sum of $ 5,143.33 / day and $ 7.00 / kg were appointed in UC of UNICACH, for the activities of sweeping, collection and storage of solid waste, without any amount for the recovery from PET, however, as there is no data for a comparison and it is necessary to develop specific economic indexes to have clear references on the management of solid waste.

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