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Characterization of Municipal Solid Waste in Altamira, Tamaulipas

Caracterización de Residuos Sólidos Urbanos en el municipio de Altamira, Tamaulipas

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Abstract

The municipal solid waste (MSW) is the waste generated in the houses by the daily consumption of the habitants; they constitute an environmental and social problem, and they are proportional to the demographic growth. Every day the demographic figures are growing, with this the rate of generation of MSW increases in spite of the efforts to the regulation in topic of MSW for the Mexican government. Therefore, it is necessary to find urgent solutions that avoid the lack of control caused by excessive and unmeasured generation of the MSW. A characterization of the MSW, first that stratifies the population, sampling is carried out in the households, a collection methodology is carried out, the separation is carried out from the generation, the results are obtained and finally the statistical treatment is elaborated, representative and significant. With the results obtained, municipalities will be helped to take decisions to carry out their responsibilities in the field of MSW, taking advantage of resources efficiently. With the characterization of the MSW, per capita generation and composition are obtained in ten categories: cardboard, other consumibles, food waste, garden waste, inert waste, metal, paper, plastics, special waste and glass.

Characterization, Municipal solid waste, Sustainable Development

Resumen

Los residuos sólidos urbanos (USW) son los desechos generados en los hogares por el consumo diario; constituyen un problema ambiental y social, son proporcionales al crecimiento demográfico. Las cifras demográficas van en crecimiento, con ello la tasa de generación de USW incrementa a pesar de los esfuerzos realizados por la regulación en materia de USW por parte del gobierno mexicano. Por ello es necesario encontrar soluciones urgentes que eviten el descontrol que provoca la generación excesiva y sin medida de los USW. Una caracterización de los USW, primeramente que estratifique la población, se realice el muestreo en los hogares, se lleve a cabo una metodología de recolección, se realice la separación desde la generación, se obtengan los resultados y finalmente se elabore el tratamiento estadístico de forma representativa y significativa. Con los resultados obtenidos se ayudará a los municipios a tomar decisiones para llevar a cabo sus responsabilidades en materia de USW, aprovechando los recursos eficientemente. Con la caracterización de los USW se obtiene la generación per cápita y la composición en diez categorías: cartón, consumibles diversos, desechos de comida, desechos de jardinería, desechos inertes, metal, papel, plásticos, residuos especiales y vidrio.

Caracterización, Residuos sólidos urbanos, Desarrollo Sustentable

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1. Introduction

Waste is also a social problem, a problem to the environment, whose environmental and economic management needs to find urgent solutions that avoid its negative environmental impact (Barradas, 2009). Throughout the national territory there are different consumption patterns, for this reason the waste varies in its composition and quantity, depending on the region, the season, the way of life and the economic income.

According to the State Program for the Prevention and Integral Management of Wastes in Tamaulipas (SEMARNAT, 2016), it divides the state into regions, the southern region that includes the municipalities of Tampico, Ciudad Madero, Altamira, González and Aldama, has a population of 846,922 inhabitants (INEGI, 2010) of which 29.58% of inhabitants belong to Altamira, as well as a daily generation of 788 tons / day in the southern region and a generation of 233 tons / day in the municipality of Altamira. In Altamira, there are still no studies on characterization and composition of Urban Solid Waste (USW).

In this PEPGIRT a projection of the municipal solid waste generation of 8% is estimated, for 2023. Altamira has a sweeping system during the seven days of the week in the main avenues of the city, for this it has an employee seven people. It also specifies that 91.7% of Altamira's population receives the collection service, while 90.98% of the waste generated is collected. Regarding the collection units, for 2016 Altamira had 25 collection units, each with a capacity of 7 tons, distributed in 42 routes during the seven days of the week. For the collection of municipal solid waste, Altamira has 328 containers of 240 liters and 20 containers with a capacity of 1.5 tons.

For the final disposal, Altamira has a private sanitary landfill with a reception capacity of 694 tons / day, where the final disposal of the USWs of the metropolitan area is made, together with the municipalities of Tampico and Ciudad Madero. It also has an open-air dump, not controlled by the municipality, but which is out of operation. Regarding the waste of special handling (RME), which are reported by the industries and establishments in the Annual Operation Certificate (COA), 49 COA's are reported that generate a monthly volume of 9197 ton / year.

Within the strategic planning of PEPGIRT, Objective 1, Strategy 3, Line of action 1.2, the separation and differentiated collection of the USWs will begin to be implemented at the source, in the short term in the municipality of Altamira. It is also proposed to promote the closure and sanitation of final disposal sites without operating, in the short term for the municipality of Altamira, as well as to reduce greenhouse gas emissions in sanitary landfills and to promote the use of methane gas (SEMARNAT, 2016).

1.1 Integrated management of municipal solid waste

Martínez (2015) identifies a comprehensive management system for USW such as generation, composition, management, collection, separation, use, recycling and final disposal. Liu, et al. (2016), seeks to achieve the maximum practical benefits of investments and ensure the minimum environmental impacts of waste streams based on collection and transport rates from variable sources, comparing four USW treatment systems, including collection and transport separately.

USW management is a complex task that requires simultaneous modeling of collection, transport, disposal and recycling (Liu, et al., 2016). There are also non-generalized stages, whether due to the socioeconomic level of the population or the characteristics of the place, these can be:

a. Selection, storage and sale of usable materials.
b. Combustion of waste for water heating or for food preparation.
c. Combustion of gardening waste.
d. Accumulation of edible organic waste in small containers.

For the countries of Latin America and the Caribbean, the conservation of the environment takes a back seat to the number of basic needs they must cover; For this reason, in most of these countries, government entities participate in the management of solid waste by carrying out the minimum required for the system and allocating very little financial resources for the sector. This has as a consequence that the processes of collection, treatment, use and final disposal of solid waste are carried out with inadequate technologies.

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The rates of waste generation per inhabitant in these countries continue to rise, reflecting the lack of awareness of citizens about how their consumption patterns influence the volume of waste generated. It requires willingness on the part of government agencies to educate their residents (Sáez y Urdaneta, 2014).

1.2 Impacts generated by excessive production of solid waste

Barradas (2009) identifies three aspects of the problem of USW, firstly identifies the health risk, which is the risk of contracting or transmitting diseases or injuries through contact with garbage, if not collected and disposed of properly; the second aspect is uncontrolled garbage dumps and dumps, since they produce negative impacts on the bodies of water in the environment, leached liquids can reach and contaminate superficial or underground sources of drinking water or agricultural irrigation, as well as bodies of water from interest for aquaculture and tourism; a third aspect is the deterioration and contamination of the environment that produce the large accumulations of garbage dispersed in the territory in an uncontrolled manner in such a way that the landscape is contaminated.

The lack of an adequate service of collection of the USW causes the accumulations without control of garbage that appear by cities, field, gutters of the roads and zones of recreation. Barradas (2009), also explains that the production, collection, transport and elimination of garbage should not be a problem in any country, because there are techniques that are adaptable and adaptable to any municipality, but the scarcity of economic resources in the large Most municipalities prevent adoption of the most appropriate solutions.

Regarding the recovery of recoverable materials, as are all those that can be recovered and from them obtain an extra value: cardboard, glass, metal, paper, battery; There is growing interest in certain groups to separate them from garbage, as this yields profits and undoubtedly generates economy among a small stratum of the population called pepenadores.

1.3 Problematic

Over time, the generation of USW is growing as the population grows, according to statistics from the International Residue Association (ISWA) (Modak, Wilson & Veils, 2015), each inhabitant of the planet generates approximately one kilogram of USW per day average. In areas such as the municipality of Altamira, where population growth has soared by an average of 7% per year in the last 15 years (INEGI, 2015) and, moreover, the economic growth of the area due to port activity contributes to the generation of USW, either domiciliary or of special management, are detonating so that the municipal collection services of the USW can not serve the population as a whole.

The integral management of the waste is the responsibility of the municipal government and the administration of these are of biannual periods which complicates the follow-up of programs for the improvement of the integral management of the residues, nevertheless, considering that the behavior in the growth of the municipal population has the same trend over the next few years, it can estimate the demand that will be required by the inhabitants of the municipality, as well as the characterization of the USW in the area. Currently the collection of USW is done with established routes not separating those waste that can be recycled or that can generate some economic value before reaching the final disposal.

Another problem is not knowing what type of waste and what generation rate there is in Altamira, in order to plan and program the operation of the integral management of the USW in the municipality.

For the government, it is extremely useful to know indicators that show the quality of the integral management of waste, which will help in the management of resources and in the implementation of programs that bring benefits to society.

The objective of this research is to propose a methodology to characterize and determine the generation and composition of the USW and thus evaluate the efficiency of the Integral Management of the USW in the municipalities based on sustainability indicators in the characterization of the USW.

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Through the compilation, analysis and synthesis of the literature corresponding to USW in the international, national, state and municipal spheres, as well as the methodologies that have been applied in the characterization of the USW, subsequently the characterization of the municipal USW and finally define a methodological strategy for the study of the situation in which the management of USW operates, with an adequate database. In this work we try to verify the hypothesis that the characterization is significant with the national statisticians.

Currently, there are several international norms and standards that try to implement integral management models of the USW, so that each time these models must be more sustainable by the demands of international standards, it is difficult to select a guide for the implementation of a model that ensures the sustainability of the integral management of urban waste. For this reason, it is necessary to carry out an investigation that considers all the aspects of the international, national, state and municipal norms and guides to carry out the adaptation to municipal solid waste.

This will benefit the entire value chain of the integral management of municipal solid waste, obtaining a useful tool to measure the sustainability of this activity. The companies and / or municipalities that are dedicated to provide services in any of these stages may know the level of quality in the service they provide and with this being able to plan the realization of their work and may even justify the expenses that are generated in the improvement of the service, the optimization of the resources they currently have, since they will carry out their activities in a sustainable manner.

With all the above benefits the population to have a quality service and thus improve the quality of life of the inhabitants of the municipality, more health, less proliferation of diseases and epidemics, will also be indirectly benefited and of course, the families of pepenadores that subsist from the recycling of materials to which they can be given a value before reaching final disposal.

2. Methodology

To carry out the characterization of the USW in the municipality of Altamira, a primary and secondary information search was carried out, as well as the regulations and sustainability guidelines. Subsequently it was agreed with the municipality of Altamira, the provision of USW volume data collected over a period of time.

2.1. Population and calculation of the sample

The population studied is the 235,000 inhabitants of the municipality of Altamira who inhabit 66,229 homes, which are the generators of USW and receive the collection service of USW through Public Services of the municipality. A stratified probabilistic sampling was carried out, where each stratum is determined by the income of each household, according to AMAI (2010), to determine how many households would be part of the sample for characterization using the formula when the population is known (Torres, et al., 2006), you have to:

$$n = \frac{k^2 * N * p * q}{e^2(N-1) + k^2 * p * q} \quad (1)$$

where:
k = 1.65, value of the constant for the 90% confidence level
N= 66,229 Total number of homes in the municipality of Altamira, Tamaulipas
p = proportion of households receiving the USW collection service, 50% is assumed.
q= proportion of individuals who do not receive the USW collection service, 50% is assumed
e = sample error, for this case of 10%

With these data, the sample must be at least 76 homes. The volume generated by the 76 homes will be the sample that will be used for the generation and characterization of the USW. When referring to the sample size, Tchobanoglous, et. to the. (1994), explains that the samples taken from 90 kg do not vary significantly from those taken in samples of up to 770 kg, obtained from the same load of waste. However, in other investigations carried out by Jiménez (2002), Cotton and Pielke (1998) and Zeng, et. to the. (2005), it is mentioned that the samples taken for analysis can be between 90 and 180 kg.

For their part, Chung and Poon (2001) report that the ranges of sample sizes range from 20 to 30 kg, 90 kg, 100 to 200 kg to samples around five to seven tons of household waste per week. In Mexico, the Mexican standard NMX-AA-015-1985 proposes samples of 50 kg. In this research, the sample used for the quantification of components was 205,985 kg per week, less than the amount proposed in the Mexican standard NMX-AA-015-1985, but according to other research (Chung y Poon (2001); Gidarakos, et. al., (2006); Tchobanoglous, et. al., (1994); Zeng, et. al., (2005)).

2.2. Measuring instrument

A database was designed, where the information obtained from the samples was stored through the measurement instrument that was occupied. A data collection form presented in Annex A was used. The data was analyzed in a general way with the support of the statistical software Minitab 16, emphasizing the variables: total weight of the sample, number of inhabitants in each dwelling, income per household, frequency of receiving the service, type of recipient they use for the collection of the USW, second alternative to dispose of the USW. For the composition part of the USW, they were divided into ten types: 1) Food waste, 2) Garden waste, 3) Paper, 4) Cardboard, 5) Plastics, 6) Metal, 7) Glass, 8) Consumables various, 9) Inert waste and 10) Special waste.

2.3. Data collection technique

The sample was collected in the domicile of the selected dwellings, by economic strata according to the AMAI (2010), during 24 hours of collection of the USW, the USW was separated into the ten categories mentioned in the previous section, then proceeded to weigh with a precision scale each of them with the objective of obtaining the total weight of the sample and the composition percentage of the USW. The process was carried out in three steps, as explained in figure 1.

The list of staggered fractions is shown in Annex A and consists of 10 fractions in Level I, 32 fractions in Level II and 24 fractions in Level III. This nomenclature allowed an easy and transparent classification, facilitating at the same time the flexible grouping of waste fractions and the comparison between the individual areas.

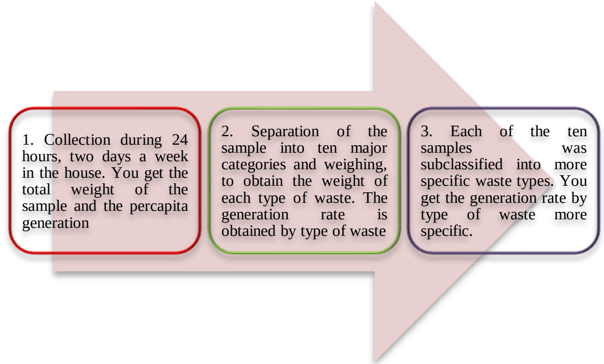

Figure 1 Proceso de recolección de datos
Source: Own design

To be precise in the classification instead of organic material, it was classified as: food waste and gardening waste; For food waste, consumable and non-consumable materials were included, such as vegetable waste and bone waste (vegetable waste could be consumed, while bones were not).

The paper was divided into advertising, books and pamphlets, magazines, newspapers, office paper, telephone directories and miscellaneous paper. Next, the paper was subdivided into envelopes, kraft paper, paper, receipts, stickers, tissue paper and wrapping paper.

The plastic waste was subdivided according to the type of resin (PET, PVC, perishable food packaging and cleaning products packaging) (Avella et al., 2001). Special waste was classified as batteries (individual batteries and specific batteries that are not from the device).

2.4 Methodology of the characterization of urban solid waste

In figure 2, the steps of the characterization methodology are presented.
of the source of generation, which is the result of this thesis. In this section the methodology is explained in detail. See figure 2.

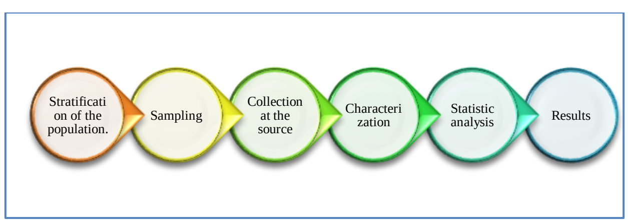

Figure 2 Characterization Methodology from the generation source
Source: Own design

Population stratification

As a first step, the population is stratified according to the socioeconomic levels (SEL), provided by the AMAI, then the representative sample of each one of the SEL is calculated. The data used are the number of total homes in the municipality and the number of inhabitants of the municipality. Then the sample is calculated with statistical formula when the population is known. Once calculating the representative sample, the dwellings that will be sampled in the municipality are determined, trying to cover the study area, for the reliability of the study.

Sampling

Sampling is carried out two alternate days per week to obtain diversity of USW and the sample is more representative, alternates two days since in tests performed the same results are obtained by sampling the whole week in each of the selected homes. To carry out the sampling, materials such as: dark colored polyethylene bag, ten plastic bags to perform a previous separation, precision scale, markers, leagues are used. The safety equipment that is used for this purpose is: gown, safety shoes, lenses, mouth covers, latex gloves, tweezers, shovel.

The sample is first identified by recording in section I. Identification of the sample of the field sheet, with the address of the dwelling, the number of inhabitants, the monthly income, from the monthly income the socioeconomic level (SEL) of the dwelling, the date of sampling, the USW collection route number, in addition to data such as the frequency of collection in the home and the type of container used to collect the USW. The question is also asked: What do you do with the waste in case the truck does not pass? This will serve to evaluate how the inhabitants get rid of the USW.

In section II. Volumetric characteristics of the field sheet, the volumetric weight of the sample is calculated; this refers to the weight of the USW in a cubic meter; to calculate it, it is enough to divide the weight of the sample between the capacity of the sampling container, in this case the black polyethylene bag, which has a capacity of 0.115 m3, if there were two or more bags it is calculated by adding the weight of the bags and dividing between 0.115 times the number of bags used.

Finally, the obtained results are recorded and captured in a statistical software.

Once the sample has been collected; it is separated into ten types of USW, as noted in section III. Classification of by-products, once the sample is separated, the sub-classified products are weighed, the results obtained are recorded again and captured in a statistical software, the total sum of the weights of the ten types of waste must be equal to the weight Total sample.

Collection Methodology

In this stage the houses are provided with the equipment and material so that during two alternate days they collect the waste that is generated in the homes, in this stage a pre-classification is carried out according to the ten categories of the first level of the field technical data sheet. It is important to indicate how many inhabitants are in the house, since this will allow knowing the generation per capita.

Then identify the plastic bags with the ten different types of waste that are shown in the data sheet: 1) Food waste, 2) Garden waste, 3) Paper, 4) Cardboard, 5) Plastics, 6) Metal, 7) Glass, 8) Miscellaneous consumables, 9) Inert waste and 10) Special waste. The USW is separated from generation to facilitate weight. Once each different type of waste has been classified in Level I, each of these levels is separated into 34 subcategories of Level II and finally into 26 categories of solid waste.

Characterization

In this stage the types of waste are weighed starting from the 24 categories of Level III, later they are reunited with the 34 categories of Level II, and finally when gathering all the residues in the ten main categories of Level I. The weights are registered in the technical field sheets and this is how the percentage of composition of solid waste is obtained for each of the categories detailed in the field technical data sheet. It is important to be clear about the types of waste that go into each category in order to make the data reliable.

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Statistic analysis

Once the data recorded in the field technical data sheets is obtained, a database with the information of all the samples taken is elaborated, to facilitate the analysis it can be done in a statistical software, this information allows to obtain results as; the generation per capita, the composition of the USW by municipality, the correlation between socioeconomic level (determined by the income of the household, according to AMAI) and the type of waste that is generated and the correlation between the different types of waste. It also allows the comparison between other studies, since most of them measure the first ten categories that are shown in Level I of the field data sheet. With these and other data provided by national databases such as INEGI, composite indicators can be constructed to show synthesized information on the integral management of solid waste in the area under study.

Results

The results obtained with the application of this methodology are:

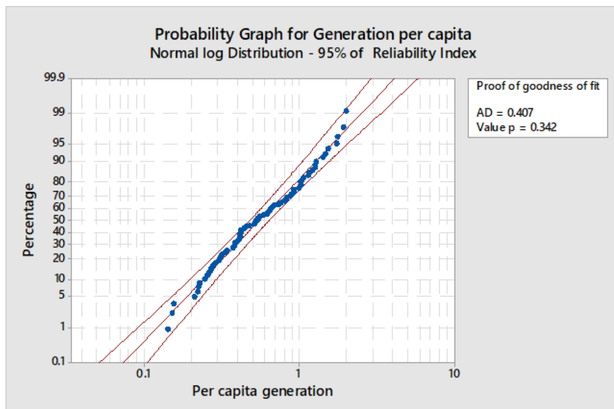
a. Percapita generation of USW
b. Projection of the generation volume
c. Percentage of generation of each type of USW, first in its ten categories of level I and later in the 35 different categories of level III, finally in the 24 categories of level III.

3. Results

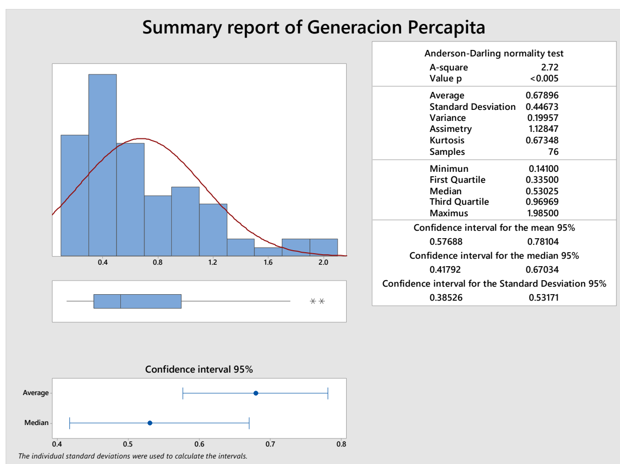
A statistical study was carried out to determine which probability distribution follows the behavior of the data based on the per capita generation of USW, at a level of significance of 95%. The hypotheses proposed for this analysis were the following:

– H_0: The data have behavior of a normal distribution.
– H_1: The data does not have behavior of a normal distribution.

The analysis of the data was done with the statistical software Minitab, in which 16 probability distributions were tested, it is determined that the data of the per capita generation of USW, behave under a normal log distribution as shown in graph 1 and in graph 2, given that the p-value is 0.342, which is why the hypothesis H0 is accepted: the data have a behavior of a normal distribution, with a mean of 0.67896 kg / per capita, and a standard deviation of 0.44673. That is, the logarithmic transformation was applied, since "the logarithmic transformation is in most cases advantageous for the analysis of environmental data, which are characterized by the existence of atypical data and the more asymmetric data distribution" (Reimann, et. al., 2008).



Graphic 1 Test of normality of the samples
Source: Own elaboration from samples



Graphic 2 Summary report of the normality test for the generation per capita of the USW
Source: Own elaboration from samples

Student t test statistical means

To validate the accuracy of the analysis, the samples were analyzed by means of an inferential statistical hypothesis test using the one-half test with the Student's t-statistic.

This was used to determine that despite the fact that there is a minimum per capita increase from 2014 to 2017, the means of the samples are statistically equal

.

The hypotheses proposed are:

Null hypothesis: The average of the daily per capita generation of USW for the samples analyzed is equal to the average generation per capita in Altamira, 0.6347 kg / per capita (INEGI, 2014). That is to say:

H_0: $\mu = \mu_0$

Alternative hypothesis: The average of the daily per capita generation of USW for the samples analyzed is different to the average generation per capita in Altamira, that is:

H_1: $\mu \neq \mu_0$

donde:

μ = The average of the daily per capita generation of USW for the observed samples. Which is 0.67896 kg / per capita.

μ_0 = The average of the daily per capita generation of USW during 2014 for the municipality of Altamira; 0.6347 kg / per capita. At 95% confidence level, this percentage being the most commonly performed in hypothesis tests of inferential statistics.

The test was performed with Minitab and the results presented in figure 4 were obtained, where it can be seen that the p value is 0.39, which is greater than 0.05, so that the H0 is accepted: the average of the The per capita generation of USW per day for the analyzed samples (0.6347 kg / per capita) is equal to the average generation per capita in Altamira, 0.6347 kg / per capita (INEGI, 2014), and its 95% confidence interval is 0.5769 to 0.7810 kg / per capita.

T of a sample: percapita generation

Test of μ = 0.6347 vs. $\neq$ 0.6347

Variable	N	Average	Standard deviation	Standard error of the mean	IC de 95%	I	P
Percapita generation	76	0.679		0.0512	(0.5769, 0.7810)	0.86	0.39

Figure 3 Summary of the means test with the Student's t-statistic
Source: Own elaboration from sampling

Socioeconomic classification of housing

76 dwellings were sampled, of which the proportion of each of the SELs is shown in graph 3, where it can be seen that the sample is 17% Level E, 34% Level D, 30% Level D +, 16% Level C and 3% Level C +, with this we can assure that the sample is representative since there are SEL of all which allows the confidence of the work done.

Comparison of results with world statistics according to the International Solid Waste Association

Modak, Wilson, & Velis (2015), propose in the report presented to the ISWA in 2016, the linear equation y = 109.67 ln (x) - 651.45, with a R2 = 0.72, where; y = annual generation per capita of USW (kg / day) and x = Gross Domestic Product per capita in USD.

Table 1 shows the values of the application of the equation proposed in the ISWA report, which allows us to conclude that occupying this equation Tamaulipas is below the National indicator of generation per capita of USW.

With the application of the methodology described for the characterization of the USW, the results summarized in Table 2 were obtained.

Year	National		State	
	GDP per capita (USD)	Generation per capita in kg / day *	GDP per capita (USD)	Generation per capita in kg / day *
2010	9,421.68	0.93742	9,421.68	0.96470
2015	7,148.64	0.85715	7,148.64	0.88174

Table 1 Calculation of the USW generation per capita
*Source: Own elaboration based on INEGI 2010, 2015. * The generation per capita was calculated with the linear equation y = 109.67 ln (x) - 651.45 (ISWA, 2016)*

Type of waste	Socioeconomic level					Grand Total	%
	C	C+	D	D+	E		
Paperboard	2.427	1.32	4.616	4.255	5.376	17.994	8.74%
Miscellaneous consumables	2.661	1.35	5.647	9.317	9.231	28.206	13.69 %
Disposal of food	8.185	2.9	27.909	16.543	6.73	62.267	30.23 %
Garden waste	3.718	0	4.02	3.558	0.695	11.991	5.82%
Inert waste	0.602	0	3.198	3.714	1.092	8.606	4.18%
Metal	1.638	0	3.675	3.706	0.754	9.773	4.74%
Paper	4.933	0.41	6.987	8.764	2.748	23.842	11.57 %
Plastics	3.096	1.546	4.961	5.306	4.464	19.373	9.41%
Special waste	0.8	0	0.06	0	1.01	1.87	0.91%
Glass	1.054	0	7.645	7.869	5.495	22.063	10.71 %
Grand Total	**29.114**	**7.526**	**68.718**	**63.032**	**37.595**	**205.985**	**100%**

Table 2 Type of waste generated by SEL in the municipality of Altamira
Source: Own elaboration from samples

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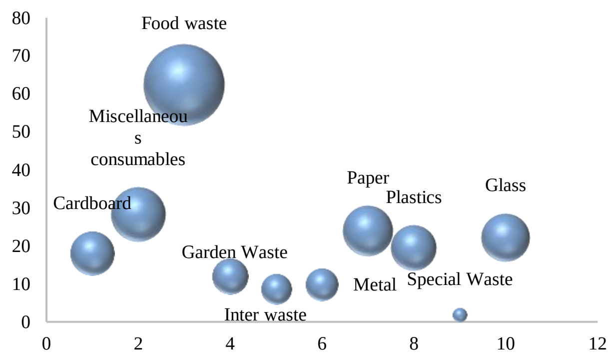
To better understand the results, figure 3 shows that food waste is the type of waste that most generates the population of Altamira, followed by paper and glass with 11.57% and 10.71%.

Regarding special waste, the percentage of composition is very low, because this type of waste usually have another type of handling, that is, they are disposed to their final destination through the old iron carts or are left lying in a landfill not controlled. Another of the recoverable materials is metal, with 4.74%, since it is considered a recoverable material in the USW it does not represent much percentage, however in the special waste that is generated from the construction it could be more representative.



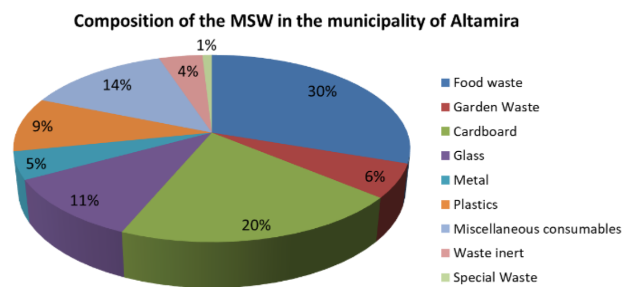
Graphic 3 Composition of the USW in the municipality of Altamira, Tamaulipas
Fuente: Elaboración a partir de muestras (2017)

Determination of the USW generation rate

The USW generation rate was determined in the municipality of Altamira, the results are shown in table 3, where they also complement the information presented by Edjabou (2014) by complementing their work and making comparisons between national and global data; as well as the composition of the USW generation, which can be seen in graph 4, having 30.2% of the total waste generated as food waste, in all countries where a USW characterization study has been carried out. , the percentage of food waste is the highest, followed by paper and cardboard, in this case in Altamira it occupies the second position with 20.3%, as in the other countries studied. Another finding is that in Altamira 10.7% of the total USW glass is generated, a very high figure as in the United Kingdom, however it has a low percentage in plastics occupying the 12th place among the countries studied.

Country	Food waste	Garden waste	Paper and paperboard	Glass	Metal	Plastics	Other consumable waste	Inert waste	Special waste	Others	Total
Mexico [a]	30.2	5.8	20.3	10.7	4.7	9.4	13.7	4.2	0.9		100
Denmark [b]	42.2	3.5	15.8	2.1	2.3	12.6	17.6	3.3	0.7	–	100
Denmark [c]	41.0	4.1	23.2	2.9	3.3	9.2	12.2	3.5	0.7	–	100
Spain [d]	56.2	1.8	19.0	3.3	3.0	10.7	4.9	0.7	0.1		100
Finland [e]	23.9	–	15.3	2.5	3.8	21.4	19.9	10.4	1.7	–	100
Italy [f]	30.1	3.9	23.2	5.7	3.3	10.8	4.5	1.3	8.7	9.4	100
Italy [g]	12.6	–	39.2	5.9	2.4	27.6	14.2				100
Poland [h]	23.7		14.1	9.2	2.1	10.8	10.6	4.5	1.0	24.1	100
Sweden [i]	33.0	9.4	24.0	2.4	2.2	11.7	9.6	7.0	0.6	–	100
United kingdom [j]	32.8	–	21.5	10.6	4.8	6.9	9.3	12.5	1.5	–	100
United Kingdom [k]	20.2	–	33.2	9.3	7.3	10.2	12.0	1.8		6.8	100
Turkey [l]	67.0	-	10.1	2.5	1.3	5.6	9.7	3.9	–	–	100
Korea [m]	12.0	–	33.0	–	–	17.0	32.0	6.0	–	–	100
Canada [n]	18.8	5.6	32.3	3.1	3.4	13.1	14.0	2.9	5.9		100
Malaysia [o]	44.8		16.0	3.0	3.3	15.0	9.5	8.4	–	–	100
China [p]	61.2	1.8	9.6	2.1	1.1	9.8	4.5	6.2	1.2	2.5	100

Table 3 Percentage of composition of the USW in different countries
Source: a Current study Altamira, Tamaulipas, Mexico, Adaptation of bEdjabou (2014), cRiber et al., 2009. dMontejo et al., 2011.e Horttanainen et al., 2013.f Arena et al., 2003.g AMSA , 2008. h Boer et al., 2010. i Petersen, 2005. j Burnley, 2007. k Burnley et al., 2007. l Banar et al., 2009. m Choi et al., 2008. n Sharma and McBean, 2007. o Moh and Abd Manaf, 2014. p B. Gu et al, 2016



Graphic 4 Percentage of composition of the USW in the municipality of Altamira, Tamaulipas
Source: Elaboration from samples (2017)

Variance analysis

The analysis of the variance allowed to contrast the null hypothesis that the means of K populations (K> 2) are equal, where the populations refer to the SELs, in front of the alternative hypothesis that at least one of the populations differs from the others in terms of their expected value. This contrast is fundamental in the analysis of experimental results of this thesis, in which it is interesting to compare the results of the socioeconomic levels with respect to the variable type of waste.

To this end, the following hypotheses were established:

μ_1 = The average of the USW generation for the observed samples is the same in the SELs

μ_0 = The average of the USW generation for the observed samples has at least one variation with respect to the SEL.

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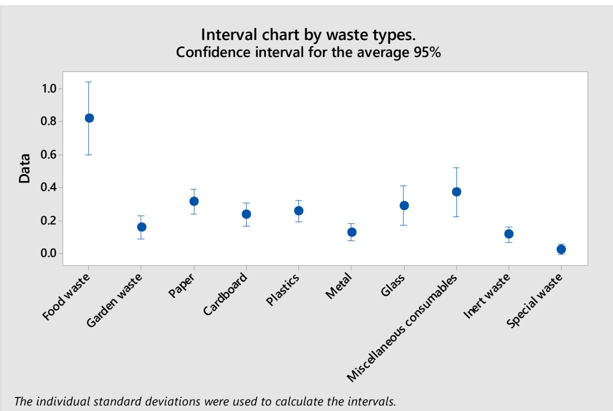
At 95% confidence level, this percentage being the most commonly performed in tests of inferential statistics hypotheses. Graph 5 shows the confidence intervals for the average weight of the different types of waste, where food waste stands out with an average of 0.819 kg / day, well above the average of the rest of the types of waste. In second position are the various consumables with the average of 0.317 kg / day. With the lowest averages are inert waste and special waste 0.113 kg / day and 0.024 kg / day, respectively.



Graphic 5 Confidence intervals for the types of USW generated in the municipality of Altamira
Source: Own elaboration from samples. Minitab

In Figure 4, the Analysis of Variance for two factors is shown, with which it can be concluded that the SEL does not influence the type of waste generated in them, since it has a p-value of 0.777, greater than 0.05 and very close to 1. So statistically it is not a representative factor. On the other hand, the type of waste individually if it influences the average generation of USW, since in this ANOVA has a p-value practically null means that there is variation, between the socioeconomic levels with respect to the USW, being the residues with more variation food waste and special waste.

In the combination of SEL and type of residual does not influence, therefore it can be concluded that the null hypothesis is accepted, because it presents the p-value less than 0.05.

Variance analysis

Source:	GL	SC Adjust.	MC Adjust.	Value F	Value p
Model	49	43.503	0.88782	4.190	0.000
Lineal	13	19.352	1.48862	7.030	0.000
SEL	4	0.375	0.09382	0.440	0.777
Waste type	9	18.977	2.10853	9.960	0.000
Interactions of 2 terms	36	10.221	0.28392	1.340	0.090
SEL * TYPE OF RESIDUE	36	10.221	0.28392	1.340	0.090
Error	710	150.329	0.21173		
Total	759	193.832			

Model summary

S	R-square.	R-square. (tight)	R-square. (pred)
0.460142	0.2244	0.1709	0.1079

Coefficients

Finished	Coef	EE of the coef.	Value T	Value p
Constant	0.2893	0.0251	11.54	0

Figure 4 Summary of the Analysis of the Variance for two factors (SEL and Type of RSE)
Source: Own elaboration from samples.Minitab 2017

4. Conclusions

The methodological proposal of characterization of USW from the source presented in this research work, if it is technically feasible, since it has been adapted and modified from more than 16 works carried out in different countries, in which, as in Mexico, the standardization for the characterization of the USW, lacks updates. The modifications have allowed an adaptation to a methodology that allows to save costs and also can be easy to perform.

The results obtained are significantly similar to those reported in government instances, since they were statistically tested according to the characteristics of the study area, showing that the methodology is effective and valid.

This methodology of characterization of the USW from the source of generation, allows to evaluate the efficiency of the GIUSW, in the municipalities from the sustainability indicators in the characterization of the USW. The characterization of the USW is very important in any municipality, a good characterization of the waste allows, plan, act and decide on the resources that are destined to the programs of integral management of the waste, including allows to distribute the budget better.

It will also allow to know what are the projections of the generation by type of waste in a certain period of time. According to the results obtained in the application of the characterization methodology of the USW, municipalities of the State of Tamaulipas, can resume the work done in this doctoral thesis to have two important data, generation per capita and generation rates of ten different types of USW and thus promote the rationalization and efficient use of technologies by taking advantage of organic waste that represents, as in most countries, the largest percentage of USW generation.

In the case of the Municipality of Altamira, where the demographic growth trend is at an accelerated rate of seven percent per year in the last ten years, so it is expected that in 2030 there will be a population of almost one million inhabitants in the Tampico-Madero and Altamira Conurbation Zone, in which Altamira will have more than 316,000 inhabitants. This being the case and according to the results presented in this paper in which it is concluded that the per capita generation rate of USW is 232 kg / year, by the year 2030 more than 200,000 kilograms of USW will be generated per day, which it is alarming, since the capacity of the sanitary landfill that gives the service to the population reaches its limit.

On the other hand, in a positive context, in which the population has been maturing regarding issues of conscious consumption would be expected a generation of 180,000 kilograms per day of USW as a minimum and in the negative end, 247,000 kilograms per day maximum.

There is evidence that in the colonies and central streets the collection service of the USW is continuous, while the colonies in the periphery or far from the center of the city receive the service in an irregular manner. It is considered that, the method followed, showed acceptable prediction capacity, according to the objective pursued and the results obtained, given the tests performed and comparing the results with international and national statistics.

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