Energy valuation of municipal solid waste for energy obtaining in Santiago de Cuba city

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SUMMARY
In this work we present a study for the use of municipal solid waste in Santiago de Cuba. In it, the characterization of the municipal solid waste (MSW) appears, the lower calorific value and the generation potential of the same are determined. For the characterization of the MSW, the average annual composition was used, without taking into account 90% of the glass and 95% of the metals that are removed by the recycling process. The lower calorific value was determined by the mathematical model proposed by Moratorio et al., (2012) for the determination of the chemical physical composition of the MSW. This model allows establishing the potential of generation of thermal energy, electric power and the potential of losses. It also appears an evaluation of the economic potential of the by-products obtained from the classification of the RSU, which allows evaluating, how feasible it is to recycle the usable part of them.

INTRODUCTION
In the city of Santiago de Cuba, around 250 daily tons of Municipal Solid Waste (MSW) are generated, which originate in the waste generated in residential areas, businesses, businesses and hospitals. Actions have been taken to determine the composition of the MSW, where it was determined that the average annual composition is 5% biomass, 25% cardboard, paper and processed wood, 30% glass, 10% metals and 15% organic matter, Of which 90% of the glass and 95% of the metals are recycled. These studies took into account the time of year in which the MSW are discharged and the area of the city in which the waste is generated. The municipality of Santiago de Cuba has around 600 000 inhabitants of which 450 000 inhabitants live in the city of the same name.
Urban solid waste collected in the municipality of Santiago de Cuba is an important source of pollution, which does not have an adequate final disposal in our city, which has generated environmental problems such as river pollution, generation of bad odors, accumulation of toxic gases, among others, putting the population at risk due to the focus of infections that are generated. According to Pérez et al., (2010) and Nadal (2007), the contamination of soils, unlike air and water, can be an irreversible process, which, in turn, causes pollution in the environment and indirectly, facilitates the introduction of toxins in the food chain. Reason for which the characterization of Municipal Solid Waste is a priority in our municipality since it allows optimizing the waste management, achieving a decrease of the MSW in landfills, taking advantage of the power generation potential that they can have.
In order to determine if the MSW of a community can be used for power generation, the first step is to determine the low calorific value (ICP) of the same. Llanes and Kalogirou (2016), state that the minimum value of this variable is 7 MJ / kg, other authors such as Moratorio and Rocco (2011), state that the minimum value is 6.5MJ / kg. Typically, an approximate value of the PCI of the RSU is 9-11 MJ / kg (Saidur et al., 2011). The PCI was determined from the chemical composition of the RSU by means of the equation presented by Moratorio et al., (2012).
These authors also presented a mathematical model to determine the thermal and electric generation potential of the RSU based on the energy diagram of a typical cogeneration cycle exposed by the Department of Energy and Climate Change in 2012 and the physico-chemical composition of the MSW.
The objective of this research is to determine the lower calorific value and the generation potential of the MSW in the municipality of Santiago de Cuba using the average annual composition as data, without taking into account 90% of the glass and 95% of the metals that are removed by the recycling process.

MATERIALS AND METHODS
For the characterization of the solid waste collected in each area of the city, a representative daily sample of these was selected, during 5 at different times of the year, by means of the quartering method taking into account the recommendations of the Official Mexican Standard NOM-AA- 015 (SECOFI 1985) and Cuban Standard NC 123-12: 2007. The total sample taken at the quarter was 2000 kg for each of the MSW deposits and the sample for physical characterization of the residuals was 100 kg. From the sample for characterization, the by-products were selected according to the classification of Gómez et al., (2009). Different screenings were carried out and the residues were classified into categories, each of the

individual components constituting the bulk MSW sample was described, and their relative distribution in percentages by weight.

RESULT AND DISCUSSION

Table 1 shows the physical composition of the MSW collected in September 2017, January 2018 and November 2018. From that moment the PCI values of the MSW were determined, which were 7.44 MJ / kg (September 2017).), 7.37 MJ / Kg (January 2018) and 7.42 MJ / kg (November 2018). As can be see, there is no significant variation of these values for different times of the year.

Table 1. Physical composition in MSW fractions (depending on the time of year).

Fraction	September, 2017	January, 2018	November, 2018
Organic	48.4	45.2	47.2
Paper and paperboard	16.3	15.8	15.1
Plastics	10.9	12.6	10.8
Metals	1.5	2.2	2.1
Glasses	4.8	5.6	6.9
Others	18.1	18.6	17.9
Generation per capita (kg/per capita)	1.31	1.28	1.30

Table 2 shows the thermal energy generation potential (EGP), the electric power potential (EPP) and the losses of the MSW based on the value of the PCI calculated for each of the samples collected.

Table 2. Average daily generation potential for one ton of MSW collected.

	September, 2017	January, 2018	November, 2018
EGT (MW/T)	0.043	0.043	0.043
EPP (MW/T)	0.026	0.026	0.026
Losses (MW/T)	0.017	0.017	0.017

The results shown allow appreciating that there is no variation between the generation potential.

CONCLUSIONS

With respect to the physical characterization of the MSW, it was determined, by the method of quartering, that organic waste represents the largest percentage of the physical composition of the RSU, with an average value of 46.93%. According to the results obtained, it can be seen that there is not a great variation in the consumption habits and therefore in the physical-chemical composition of the RSU.

From the RSU samples of the physic-chemical composition it was determined that the lower calorific value obtained in all the samplings carried out is above 7 MJ / T, with a dispersion lower than 10%, which indicates the reliability of the calculation models of the PCI and the feasibility of the use of the MSW collected in the city of Santiago de Cuba for the generation of electrical and thermal energy.

The results allow to appreciate that there is no variation between the generation potential so that for an amount of MSW of approximately 250 T could generate 10.54 MW of thermal energy and 6.25 MW of electric power with a 4.25 MW in losses.

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