Analysis of the biomass produced in the furniture factories of the municipality of Ocaña

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Abstract. Due to the lack of application of new technologies in the municipality of Ocaña on energy inputs such as biomass, a great amount of material such as sawdust is being wasted, which could be used for energy consumption, such as the replacement of firewood that is in great demand in rural areas for food preparation. The purpose of this research is the identification of the main sources of biomass production, the performing of moisture and ash tests to observe if they have the properties required for biomass production from the different types of sawdust in the laboratory of Francisco de Paula Santander University Ocaña. The type of research used in the project is experimental research. Thanks to the characterization study of sawdust residues in the furniture factories of the municipality of Ocaña for energy production, some characteristics are obtained of the properties of ash and moisture of the types of wood that are used in the zone, which were Oak, Colombian mahogany, wild cashew, Higuerón, cedar and sapan (Clathrotropis brunnea Amshoff) that can be usable fuels in the future for furnaces or boilers.

1. Introduction
Small-scale renewable energy technologies represent an economic and environmental alternative, feasible for the provision of energy to remote rural communities and for the expansion of installed electrical capacity, either through isolated systems or through grid-connected projects. Biomass as a renewable resource is characterized by a low carbon content, its characteristics provide advantages and benefits that make it an attractive product for energy exploitation [1]. In addition, these technologies can reduce environmental pollution caused by gas emissions from conventional systems that use fossil fuels, such as coal, and petroleum products. These gases contribute to the greenhouse effect and global warming of our planet [2].

However, there are barriers to the further development of this type of energy: lack of knowledge of the technologies and still incipient institutional and technical capacities. For the majority of the world's population, the most familiar forms of renewable energy are those that come from the sun and the wind. However, there are other energy sources such as biomass, firewood, charcoal, rice hulls, which provide a high percentage of the energy consumed in the world and have the potential to supply even larger quantities [3]. Due to the lack of knowledge and application of new technologies in the municipality of Ocaña on energy inputs such as biomass, a great quantity of material such as sawdust residue from furniture factories is being wasted, which could be used for energy consumption, such as the replacement of firewood that is in great demand in rural areas for food preparation. Another problem on a large scale is the great pollution of the environment by greenhouse gas emissions (CO₂)
from conventional systems that use fossil fuels that help global warming generating a great impact on our planet.

The use of waste and residues is a very important issue; at present recycling is a way of reducing the consumption of ecosystem materials thus giving the reincorporation into the material production cycle. For this reason, a study carried out in the municipality of Ocaña Norte de Santander on the characteristics of the different types of sawdust that are produced in the different furniture stores of the municipality allowed to have good knowledge of their physical properties through moisture and ash tests of the sawdust, which is a renewable resource for implementation in systems of clean energy generation for biomass production [4].

2. Materials and methods

The type of research used in the project is experimental research because it allows selecting or elaborating instruments to carry out the experiment on wood samples and to measure their results by organizing them in an appropriate statistical form so that the effect can be clearly observed [5].

The biomass sources that can be used for energy production cover a wide range of materials and sources, such as waste from forestry and agriculture, urban waste and energy plantations that are generally used for modern conversion processes involving large-scale energy generation, focused on the substitution of fossil fuels [6].

To evaluate the technical and economic feasibility of a conversion process of biomass into energy, it is necessary to consider certain parameters and conditions that characterize it. These that are explained below, determine the most appropriate conversion process and allow projections of expected economic and environmental benefits [7], such as:

- Type of biomass,
- Chemical and physical composition,
- Relative humidity (RH),
- Ash percentage,
- Calorific value,
- and Moisture content.

The following phases are expected for the execution of the project:

- Identification of the main sources of sawdust production in the city of Ocaña and from which part of the country the wood is extracted.
- To carry out moisture and ash tests on the different types of sawdust in the laboratory of Francisco de Paula Santander Ocaña University.
- Analysis of the results obtained from the moisture and ash tests to see if it meets the properties required for biomass production.
- Detection of the different types of sawdust analyzed, if they present better characteristics for biomass.
- Once the percentage of moisture has been calculated for each of the samples, the results are analyzed to identify which has the lowest water content.

The equipment used for the measurements are:

- Muffle furnace: to dry the sample and maintain it at the required temperature.
- Precision Balances: Those that have an adequate precision for the weight of the sample.
- Containers: Appropriate containers made of a material resistant to corrosion and changes in mass when subjected to repeated heating, cooling and cleaning operations.

3. Results and discussion

3.1. Geographical location of the sawmills in Ocaña Norte de Santander

The sawmills are located in the northern part of the municipality of Ocaña. After identifying the sawmills, samples (types of sawdust) were collected to classify the wood and from which parts of the country they are extracted [8]. The samples were taken from the different furniture factories located in the northern part of the municipality from which samples of wild cashew, Higuerón, Colombian mahogany, Sapán (Clathrotropis brunnea Amshoff), cedar and oak were taken, in the same way, these woods come from the Caribbean region of Colombia and mostly from San Martin Cesar.
3.2. Laboratory tests
For the development of the moisture tests of the different types of sawdust collected, it was convenient to go to the laboratory of soils of Francisco de Paula Santander University Ocaña, for the determination of the water content of the different samples. In addition, the ASTM D 2216-98 Laboratory Testing Standard was used (Laboratory determination of water (moisture) content of soil, rock and soil-aggregate mixtures) [9].

3.3. Moisture test procedure
The humidity test was carried out in the materials and alloys laboratory of Francisco de Paula Santander University. The first thing is to determine and record the mass of each one of the clean and dry containers using an electronic weighting. After determining the mass of each container, the wet sample is placed inside the container to determine its weight; this is done for each sample. Subsequently, the container with the wet material is placed in the furnace in order to dry the material until a constant mass is obtained [10]. The drying furnace is maintained at a temperature of 110° ± 5° C, unless otherwise specified. The time required to obtain a constant mass may vary depending on the type of material, specimen size, furnace type and capacity, and other factors. In our case, the time recommended by the laboratory technician was 24 hours.

3.4. Data acquisition
Determination in laboratory of the water content (moisture) is carried out from the different types of sawdust of the woods used in the furniture stores of the municipality of Ocaña using the ASTM D 2216-98 standard, Table 1 shows the values of corresponding mass of each one of the samples and its container, in the same way, the weight is shown after being in the furnace for 24 hours.

| Sample          | Weight (kg) Container | Weight (kg) Sample | After 24h furnace | Water content of the sample (%) |
|-----------------|-----------------------|--------------------|-------------------|---------------------------------|
| Oak             | 78.05                 | 106.14             | 102.01            | 17.23                           |
| Sapan           | 79.65                 | 103.05             | 100.72            | 11.058                          |
| wild cashew     | 80.86                 | 99.97              | 94.73             | 37.779                          |
| cedar           | 83.9                  | 98.18              | 93.83             | 43.806                          |
| Colombian mahogany | 79.63             | 92.44              | 90.94             | 13.262                          |
| Higuerón        | 83.62                 | 91.48              | 90.24             | 18.731                          |

3.5. Calculation of the water content of the material
The following equation was used to determine the relative humidity percentage (see Equation 1) [10]:

\[ W = \frac{w_1 - w_2}{w_2 - wc} \times 100 \]  

Where: \( W \) = water content %, \( w_1 \) = mass of the container and wet specimen, g; \( w_2 \) = mass of the container and dry specimen, g; \( wc \) = container mass, g.

After having all the values as can be seen in Table 1, Sapan is the one with the least percentage of relative humidity followed by the Colombian mahogany, being these the ones with the best properties that can be used as fuel (Biomass).

3.6. Procedure for carrying out the ash test
The determination of the ash content was carried out expressing as a percentage the residual amount existing when subjecting a sample of material to dry oxidation until achieving the total elimination of carbonaceous matter. This laboratory was carried out according to the [11]. The samples were placed
in porcelain containers, clean and dry to be weighed in an Electronic Weighing Scale; Table 2 shows the approximate weight of 1 g for each of the samples.

| Samples            | Weight of approximately 1g of sample. |
|--------------------|----------------------------------------|
| Oak                | 1.0121                                 |
| Sapan              | 1.0014                                 |
| Wild cashew        | 1.0057                                 |
| Cedar              | 1.0004                                 |
| Colombian mahogany | 1.0196                                 |
| Higuerón           | 1.0019                                 |

Table 2. Approximate sample weight.

The samples were previously heated in the furnace for one hour at (250 ± 10)°C to allow the volatiles to evaporate before ignition. The samples were then heated for one hour at (550 ± 10)°C. The temperatures in the furnace were also checked with the necessary protections.

When the porcelain containers were removed from the furnace, they were immediately weighed to avoid weight alterations due to the capture of humidity at room temperature.

Table 3 shows the container weight of each of the samples and the container weight with ash in order to determine the ash residue and the percentage of ash, the difference in weight, between the container with ash and the container alone, results in the ash residue of each sample.

The procedure to obtain the percentage of ash is achieved from the following equation [11].

\[
\text{Cens(\%)} = \frac{\text{mash}}{\text{ms}} \times 100
\]  

Where: \( ms = \) Dry solid mass and \( mash = \) ash residue mass.

| Samples               | Weight of container plus ash in grams (g.) | Container weight in grams only (g.) | Ash residue (g) | % Ash |
|-----------------------|--------------------------------------------|-------------------------------------|-----------------|-------|
| Oak                   | 76.8740                                    | 76.8695                             | 0.0045          | 0.4446|
| Sapan                 | 76.1092                                    | 76.1082                             | 0.0010          | 0.0998|
| Wild cashew           | 81.6681                                    | 81.6377                             | 0.0304          | 3.0227|
| Cedar                 | 75.9430                                    | 75.9421                             | 0.0009          | 0.0899|
| Colombian mahogany    | 83.1628                                    | 83.1580                             | 0.0048          | 0.4707|
| Higuerón              | 79.9623                                    | 79.9220                             | 0.0403          | 4.0223|

Table 3. Weight of the container plus the ash of each sample.

3.7. Procedure for the percentage of ash in the samples

In this case, Table 3 shows that sapan and cedar were the ones that left the least amount of ash in the container at the end of the test in the furnace, which means that these two samples are the ones that would provide the best properties as biomass used for fuel [12].

According to the tests carried out in the laboratories of Francisco de Paula Santander University Ocaña of relative humidity and ash content with the standards that govern these tests, it was possible to identify that Sapan was the one with the best values in the two tests (11.058% moisture and 0.0010 g of ash), followed by the Colombian mahogany (13.262% moisture and 0.0048 g of ash), and the Oak (17.23% moisture and 0.0045 g of ash).

If these forest residues (Biomass) were to be used in the municipality of Ocaña as fuel in the form of pellets for boilers, etc. [13], it would be recommended to use the sawdust residues mentioned above that gave the best results in the tests since these would be the ones that would produce the best benefits at the time of producing any type of energy [14].
4. Conclusions

With the analysis of the results it is observed that Sapan and Colombian mahogany samples have low moisture content unlike the other samples. Their water content percentages were 11.058% and 17.23% respectively, which allows for use in electricity generation or cogeneration applications, for the production of pellets for boilers, as well as in the determination method for ash content. The samples with the lowest percentage are Cedar and Sapan with 0.0009% and 0.0010% respectively, which provides a low percentage for applications in power generation.

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