Journal of Sustainability Perspectives 1 (2), 2021, 117-121

Journal of Sustainability Perspectives

journal homepage: https://ejournal2.undip.ac.id/index.php/jsp/

# Biocarbon from Pruning and Gardening Residues on The Santander University Campus, Using a Pirolisis System with Minimal Gas Emission

*Walter Pardavé Livia*[1,*], *Nadia Fernanda Mantilla Suarez*[2]
[1,2]Environmental Group of Applied Research, Faculty of Engineering, University of Santander Bucaramanga Colombia
[*]corresponding author: wal.pardave@mail.udes.edu.co

## Article Info

**Received:**
15 March 2021
**Accepted:**
25 May 2021
**Published:**
1 June 2021

**DOI:**
https://doi.org/10.14710/jsp.2021.11750

**Abstract** A pilot – level system of the termal pirolisis process was developed to obtain biocarbon with minimal emission of polluting gases, from the solid waste generated in the pruning gases, from the solid waste generated in the pruning and gardening of the university campus of the University of Santander in Bucaramanga Colombia. The pilot – level system has a processing capacity of 50 kilograms of prunning and garden waste, and the operating variables ser 500ºC of temperatura and 120 minutes of processing. The prunnig and gardenning samples were divided into two. The first simple consisted of Woody-type residues (pruningn), the second simple consisted of grass and leat litter remains. The biocarbons obtaneid were characerized physicochemically, by close analysis and last chemical analysis (CHN). For its part, the morphology of the biocarbons and the microchemical anlysis of the ash particles that they possessed was carried out by means of scanning electron microscopy coupled with chemical microanalysis by means of X-ray dispersive energy spectroscopy. The biocarbon obtained can be used as soil additions to increase the forests that surrond the University campus.

**Keyword:**
Biocarbon, prunning and gardening waste pirolisis, pilot plant

## 1. Introduction

According to Carvajal and Mera [1], in the last twenty years, the application of biofertilizers in Colombia has grown remarkably due to the wide demand for raw materials in industrial processes that use agricultural products, including the food industry.

Biofertilizers [2] are usually natural materials, such as fertilizers or decomposing organic matter residues, wich facilitate the restoration of the composition and structure of the degraded soil by regulating the pH, the incorporation of nutrients, the retention of humidity and recovery of soil texture.

Too biofertilizers based on cultures enriched with microorganisms are used directly, wich are more used because of their ability to transform numerous chemical compounds into compounds available to plants [3]. Another possibility is the addition of carbonaceous material of plant or animal origin to the soil, such materials are known under the generic name of biocarbons [4]. The addition of biochart to the soil is widely used, since it is characterized by having among its main effcts the mitigation of climate change by capturing C form the atmosphere [4]; improving soil fertility through increased water and nutrient retention [5]; the improvement of the microbial activity that, in turn, allows to increase the productivity of the crops [6]; and the increase of the soil surface [7]. Additionally, it is possible to regenerate the soil through the degradation of pollutants, recover waste (if biomass is used for this purpose) and produce energy (if it is recovered from the biochar production process) [8].

Pyrolisis has been defined as a thermochemical process that allows transforming low energy density biomass (and other organic materials) to high energy density liquids (bio-oils), solids of the same energy density (Biochar) or gases with low energy density (gas of synthesis) [11]. Involves heating organic materials to temperatures above 400 ªC in deficit or absense of oxygen. At such temperatures, thermal decomposition of the material used as a substrate occurs, allowing the release of vapors that, in turn, are cooled and recirculated, giving way to condensation of high molecular weight polar liquid compounds called biooils. While this occurs, low molecular weight volatile compounds (synthesis gases) remain in the gas phase, as do small amounts of hydrogen. These gases are used in industry, depending on the arrangement that you want to give it. A residual solid phase called biochar is also obtained, consisting of large amounts of carbon and other elements typical of the substrate, wich can be used in aggregates to improve soil conditions [12].

## 2. Materials and Methods

For the present investigation, a discontinuous pyrolisis reactor (furnace) was built, which consists of two concentric chambers and partially isolated from each other, as shown in Figure 1. In the external chamber, or combustión chamber, it places as matter fuel the same plant residue that undergoes pyrolysis.

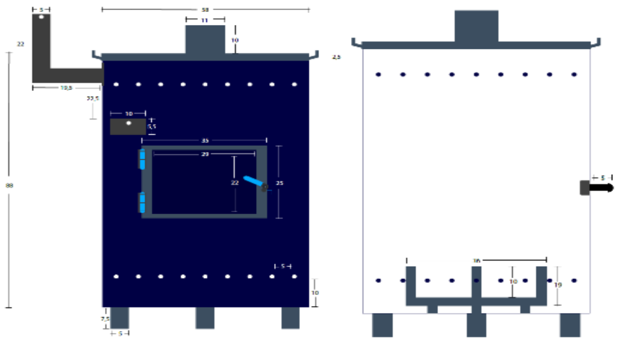

Figure 1. Chamber and gasifier of the pyrolisis system

Figure 2 shows the first pyrolisis system developed for preliminary tests, wich contains the operation of the discontinous reactor for pyrolisis of pruning residues. Figure 3 shows the complete pyrolisis system developed. The partial closure of the same guarantees a limited processing in oxygen, wich guarantees the colatilization of the gaseous components present in the pruning residues. These volátiles exit through holes located in the lower part of the internal chamber and go into the external chamber, where they enter combustión along with the added fuel charge. Finall, by natural draft, the combustion gases are extracted form the system throgh the chimney.


Figure 2. Pyrolisis system for preliminary tests  Figure 3. Pyrolisis system developed

The pruning and gardening residues, consisting of tree and shrub branches, leaves, grasses and sedes, came form the gardens of the campus of the University of Santander in Bucaramanga Colombia (see Figure 4).

Two samples of pruning and gardening residues, of differents relative composition, were taken form the accumulations of plant material collected during the maintenance of the gardens. All the samples were subjected to the pirolisis process for 2 hours, average time in wich the external combustion process concluded with all the material used as fuel.


Figure 4. University of Santander Bucaramanga Colombia

## 3. Results and Discussion

The next analysis, shown in Table 1, constitutes a group of gravimetric tests that help establish its main characteristics, particularly if you want to use it as a combustible substance.

Table 1. Results of the next analysis (Mass%) perfomed on the four biochar samples produced in this work

| No. | Humedity, % | Ash, % | Volatile materia, % | Carbon fix, % | Heating power, cal/g |
|---|---|---|---|---|---|
| **1** | 3.26 | 9.74 | 37.82 | 49.18 | 6,270.40 |
| **2** | 1.95 | 16.87 | 47.83 | 33.35 | 5,089.12 |

Table 2 shows the results of the last analysis of the two biocarbons obtained in the present study. This analysis shows the total percentages by weight of carbón, hydrogen and nitrogen of these materials. Simple 1, which had higher fixed carbón content, also showed higher total carbón contents. The observed difference between the percentage content of total carbón in Table 2 and the fixed carbón reported in table 1, indicates the carbón fraction reported in table 1, indicates the carbón fraction that is in the material that is associated with the remaining volatile fractions in the biochar, after pirolisis of the initial biomass has taken place. It can be seen, then, that the biochar with the remaining volatile fractions in the biochar, after pyrolisis of the initial biomass has taken place. It can be seen, then the biochar with the highest, volatile carbón content is 2, wich was derived form grass and dry leaf waste.

Table 2. Chemical analysis (last) of carbón, hydrogen and nitrogen of each of the biochar samples produced in this work.Mass percentages

| No. | Carbon, % | Hydrógen, % | Nitrógen, % |
|---|---|---|---|
| **1** | 67.66 | 3.58 | 1.44 |
| **2** | 55.40 | 3.49 | 1.16 |

## 4. Conclusion

Significant variations were found, both morphological and physicochemical, depending on whter the pruning and gardening waste was composed mainly of Woody debris or grass and leaf litter. The biochar obtained form Woody waste (simple 1), presented higher percentages of fixed carbón and more appropriate characteristics for posible applications of fertilization of acidic soils with low wáter retention capacity. The biochar produced form litter and grass waste (simple 2), had a greater presence of ash stablizing the soil aggregates (aluminosilicate type) and a greater amount of volatile matter (labile), wich would make it applicable in remediation processes. Of soils affected by industrial – type activities. Further research will be conducted to effectively test these posible applications of both materials.

**References**


1. Carvajal, J. & Mera, A. (2010). Fertilización biológica: Técnicas de vanguardia para el desarrollo agrícola sostenible. Producción + Limpia 5(2), pp. 77-96.
2. Benítez, T. et al. (2004). Biocontrol mechanisms of Trichoderma strains. International Microbiology 7, pp. 249-260. 250
3. Ettwig, K. et al. (2010). Nitrite-driven anaerobic methane oxidation by oxygenic bacteria. Nature 464, pp. 543-550.

4. Lehmann, J., Gaunt, J. & Rondon, M. (2006). Bio-char sequestration interrestrial ecosystems - A review. Mitigation and Adaptation Strategies for Global Change 11, pp. 390–406.
5. Lehmann, J., Gaunt, J. & Rondon, M. (2006) Bio-char sequestration interrestrial ecosystems-a review. Mitigation and Adaptation Strategies for Global Change 11, pp. 403-427.
6. Lehmann, J. et al. (2011). Biocarbón effects on soil biota: A review. Soil Biology & Biochemistry 43, pp. 1812-1836.
7. Sohi, S. et al. (2009). Biocarbon's roles in soil and climate change: A review of research needs. CSIRO Land and Water Science Report 64.
8. Manyà, J. (2012). Pyrolysis for Biocarbon Purposes: A Review to Establish Current Knowledge Gaps and Research Needs. Environmental Science & Technology 46, pp. 7939-7954.
9. Luna, C. (2007). Aumento de la Productividad de Caña de Azúcar por Unidad de Área Cultivada. Online [May 2016].
10. Burbano, H. (2002). La enseñanza de la Ciencia del Suelo: Referentes para su análisis y proyección en Colombia. Suelos Ecuatoriales 32(2), pp. 335-340.
11. Laird, D. et al. (2009). Review of the pyrolysis platform for coproducing bio-oil and biocarbón. Biofuels, Bioproducts & Biorefining 3, pp. 547-562.
12. Verheijen, F. et al. (2009). Biochar application to soils - A critical scientific review of effects on soil properties, processes and functions. Office for the official publications of the European communities, Luxembourg.