

PRODUCTION OF BIOCHAR IN CHAB CONCEPT FOR REDUCING CO₂ CONCENTRATIONS IN THE ENVIRONMENT AND SUSTAINABLE AGRICULTURAL DEVELOPMENT

Mihai ALEXE¹, Alexandra DIMA²

¹ Hydraulics and Pneumatics Research Institute – INOE 2000 IHP, mihai.aalexe@gmail.com

² University of Politehnica of Bucharest, dima.alexandra1992@gmail.com

Abstract: *In this paper is presented the synergistic concept CHAB (Combined Heat and Biochar production) and production of biochar from biomass by TLUD gasification process. Micro-gasification units using TLUD process are easy to operate, safe, simple and relatively cheap. Quality of biochar is easily controlled and defined in current standards, unlike other artisanal devices where there is no control over the thermal regime, resulting in uncertain quality of biochar. TLUD micro-gasification units can be used in a wide range of practical applications: heating greenhouses, dryers, food preparation, home heating, water heating, etc. Biochar resulting from TLUD micro-gasification can be used as soil amendment in agriculture, proportions of 5-15%. The carbon from biochar remains sequestered in agricultural soil increasing the soil fertility by 10-30 %. Applying the CHAB concept fully exploits the chemically and energetic potential of biomass, helping to increase energy independence in agriculture with a negative carbon balance, and therefore the concentration of CO₂ from the atmosphere.*

Keywords: *biomass, biochar, TLUD gasifier, CHAB, carbon balance*

1. Introduction

The planet's climate is changing due to increased level of pollution. This was well stated at the international conference in Paris in December 2015. The population should be united in order to reduce the increasing slope of CO₂ concentration and further lowering its absolute value.

Thermo-chemical gasification of biomass, a process known and used for over 130 years, converts biomass into a combustible gas with high energy conversion efficiency and low emissions of solid particles. The gas produced can burn efficiently and cleanly. Installations for gasification are relatively complex, large-sized and using generator gas called gasgen, or syngas, in internal combustion engines, requires cooling and filtering operations with equipment which greatly increase the cost of the installation. These aspects have influenced the increased use of more external combustion steam cycles, conventional or organic Rankine for producing electricity in cogeneration mode, even if these devices are more expensive than internal combustion engines. Direct burning of gasgen doesn't require cooling and filtering, which substantially reduces the cost of energy installations.

To apply CHAB concept is proposed to use the TLUD gasification process of biomass, which produces fuel gas and biochar. The TLUD process can gasify a wide variety of agricultural biomass or from other origin, shredded between 10 and 50 mm and with humidity below 20 %. These characteristics allow efficient use of local resources of biomass and increases energy independence of farms. Minimal mechanical processing, transport distances below 15 km and with natural ventilation lead to a very low cost of thermal energy produced, estimated at a maximum of 5 € / GJ, which is 6 times less than that obtained from diesel. Harnessing heat that is produced simultaneously with biochar is substantially reducing the actual cost of thermal energy by an average of 85% using biomass wood waste and 22% from pellets. Using the residual biomass in a farm can make its own heat with very little cost, approaching to zero. This is a clear advantage of using local or regional minimal processed residual biomass, which is abundant and does not

require long distance transportation. In time by storing it at the farm, the biomass it natural dries without energy consumption.

By incorporating the biochar into the agricultural soil it can be obtained an organic sequestration of the atmospheric carbon on an average of about $-400\text{kg.CO}_2/\text{t.bm}$, which is very economical compared to other methods proposed and tested. Development and research is needed to increase the efficiency of biochar, which can be produced on farms, both to increase agricultural soil fertility an as filter material for air and water.

BCH embedded in the soil is the most economical and ecological way of atmospheric carbon sequestration for long journeys.

2. Conditions for biochar production

Biochar is produced by pyrolysis of biomass, a process in which organic substances are decomposed at temperatures from $350\text{ }^\circ\text{C}$ to $1000\text{ }^\circ\text{C}$ in a thermal process with low oxygen (<2%). For the production of heat from biomass are currently used the following processes:

- hot water boilers which are burning in layers
- gasification and combustion in the same enclosure, in hot water boilers
- gasification and combustion in a gas-producing heat exchanger

Each method has advantages and disadvantages, and are used depending on the specific applications. [2]

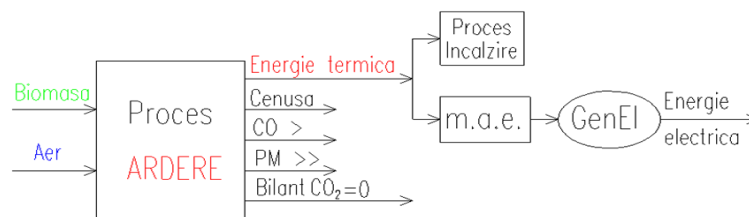


Fig. 1. Energy produced by the combustion of biomass [5]

Biomass used in the TLUD micro-gasification process separates energy and mass in two parts: a part of the biomass is completely converted into gas and biochar remains in an incandescent layer after gasification. For example, in table 1 are shown the chemical composition and calorific values of the biomass derived from the apple trees pruning and a part of integral gasified part. The ash from biomass remains in biochar and the water is part of the gasified biomass. [5,6,8].

TABLE 1: Properties of biomass from apple tree pruning [3]

Size	UM	Biomass chopped	Biochar	Biomass gasified
Relative mass	%	100.00	15.00	85.00
Carbon	%	43.11	73.60	36.78
Oxygen	%	35.57	10.80	39.94
Hydrogen	%	5.12	2.20	5.63
Ash	%	1.20	8.00	0.00
Water	%	15.00	0.00	17.65
P.C.I.	MJ/kg	15.30	22.40	14.05
Rate of energy use	%	100	21.96	78.04

If the biochar is not gasified, it can use only 78% of the potential energy from the biomass charged in the reactor. When applying the CHAB concept, if the biochar has not gasified, it is removed from the reactor, cooled and stored. It has been discovered that in the infertile soils that have not been

incorporated the biochar and in those that biochar has been incorporated, even today, are very rich in minerals and have high fertility rate.

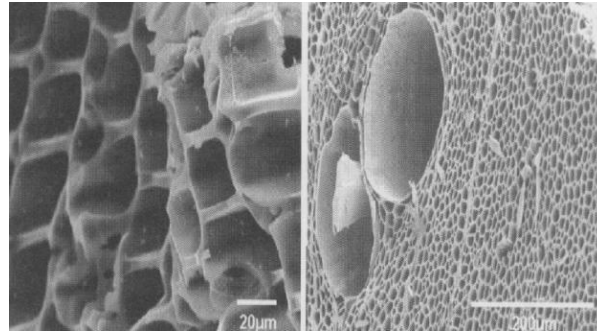


Fig. 2. Microscopic structure Biochar [2]

The current alternatively ways of exploiting the current energy potential of biomass extends CHAB (Combined Heat And Biochar production) concept incorporating the use of biomass in production of heat and biochar. [8]

The most effective method to apply the CHAB concept is the use of TLUD micro-gasification process. The TLUD process functional diagram, presented in fig. 2, is effective because it can gasify a wide range of biomass, conditioned to the fact that the moisture rating should be below 20% and shredded between 10 to 50 mm, in order to produce top quality biochar.

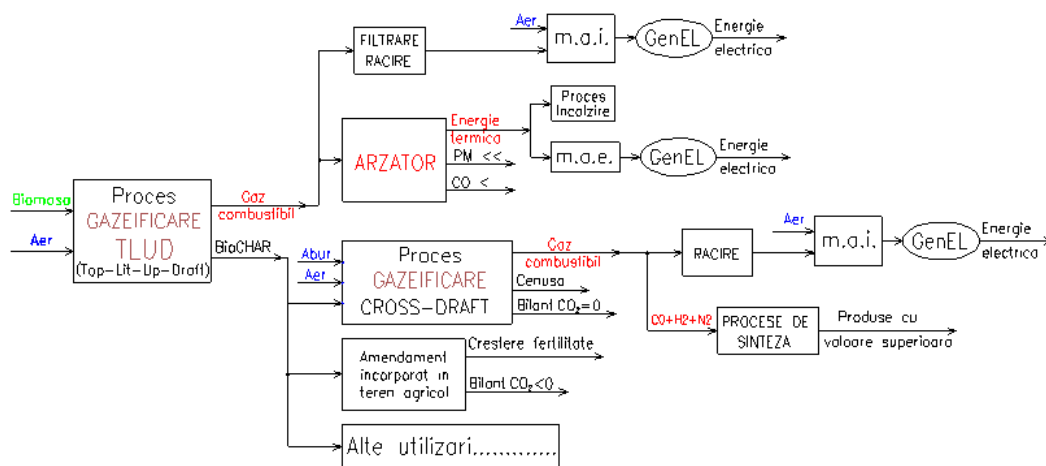


Fig. 3. CHAB concept applied to the TLUD gasification process [1]

3. The efficiency of using biochar in vegetable growing

In order to use, it must be taken to account that biochar is a tool to manage soil quality for the long time, improving its quality and resulting in improving the crop production, while retaining in the soil significant amounts of CO_2 , and protecting it against climate change [4]. It is important to understand that biochar is not an actual fertilizer for soil, even if it contains ashes that can provide plants with nutrients such as calcium, magnesium and potassium. It represents a very good amendment for soils poor in nutrients, where the first application of biochar ash, it can increase the productivity of farms. Also biochar contains no significant amount of nitrogen, but contains decomposed carbon also called "unstable". Where biochar is applicable and the nitrogen supplied is insufficient, immobilizing it can reduce the crop yield. This can be solved through the use of compost (where, the C/N ratio is too high) [3]. Biochar has a high pH >9 , and for the best results should not be used in combination with a soil which the pH exceeds the limit. So, before use, should be measured precise amount of pH in the soil. Also in order to use the biochar it should be

dried to 20% moisture, to not lose the property of maintaining the water and the nutrients in the soil, in order to reduce CO₂ emissions [8].

Molar mass ration H/C must be less than 0.6 and the ration of the molar mass ration O/C must be less than 0.4. Higher values are indicative of inferior characteristics and deficiencies of pyrolysis and high levels of VOC. [8]

Mixing of biochar with composts and manures may reduce odors, and improve nutrient performance over time due to slower leaching rates. Mixtures may be applied for uniform topsoil mixing, or top-dressed in tree plantations without incorporation. Although the airborne dust fraction would be minimized, the biochar dosage application may be relatively low per ha, and additional equipment would be needed to incorporate applied compost into top soils thereby increasing costs and carbon footprint. Line trenching and backfilling may lend itself to high biochar application rates in soil for carbon sequestration while still increasing the agronomic performance of soils. Though labor and carbon intensive, the combination of high saturation rates and improved agronomic productivity may make the practice viable. However, like deep banding, it is unknown how well biochar migrates vertically through the soil profile. [8]

Vegetable growing is a profitable branch of agriculture, but can be even more profitable when done well and efficiently organized. Therefore as was previously effective way to produce more vegetables and tasty at the same time to increase soil fertility is to incorporate biochar in the used soil. For example the influence biochar dosage of plant growth is shown in fig. 4.

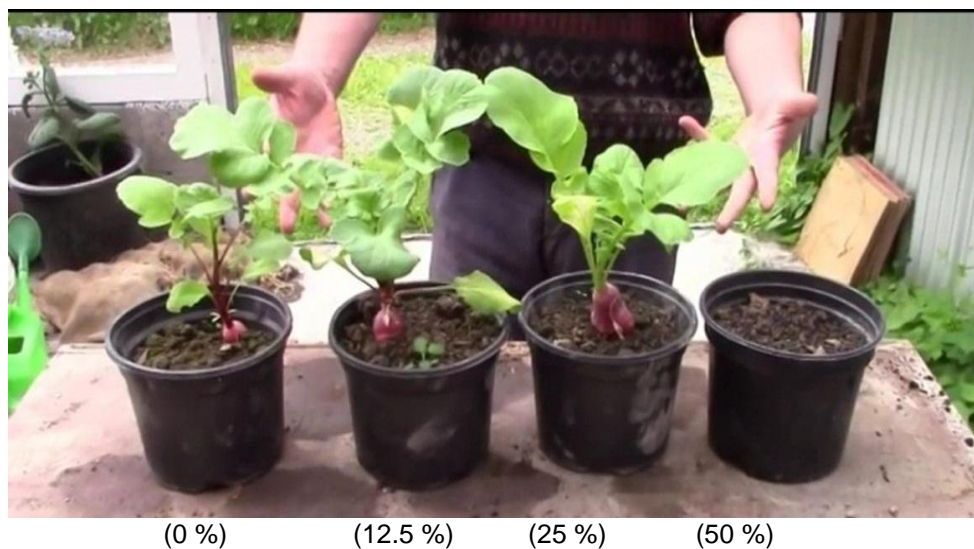


Fig. 4. Evolution of radishes in soil with different dosage of biochar

At the Bodenkultur University in Vienna there have been conducted experiments with various sorts of products from different sources of biochar and different pyrolysis temperatures. It has been used two concentrations of biochar 1% and 3%

TABLE 2: Varieties of biochar[8]

Pos.	Base biomass	Pyrolysis temperature layer(°C)
1	Energy grass	525
2	Wood chips	525
3	Vine strings	400
4	Vine strings	525

The main characteristics of biochar used presented in the following figures:

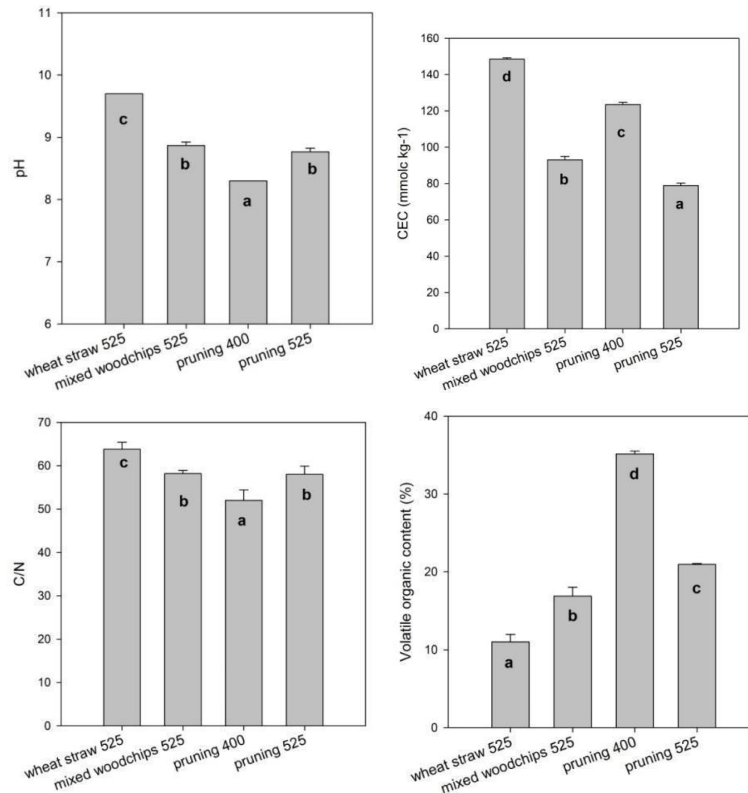


Fig. 5. Biochar features for the experiments [1]

A first conclusion is that the VOC concentration is decisive in many situations and therefore the less biochar is in VOC it is more effective as agricultural amendment. A low concentration of VOC is obtained at higher temperatures of the flaming pyrolysis, in TLUD micro-gasification regime, between 650°C and 750°C. [1]

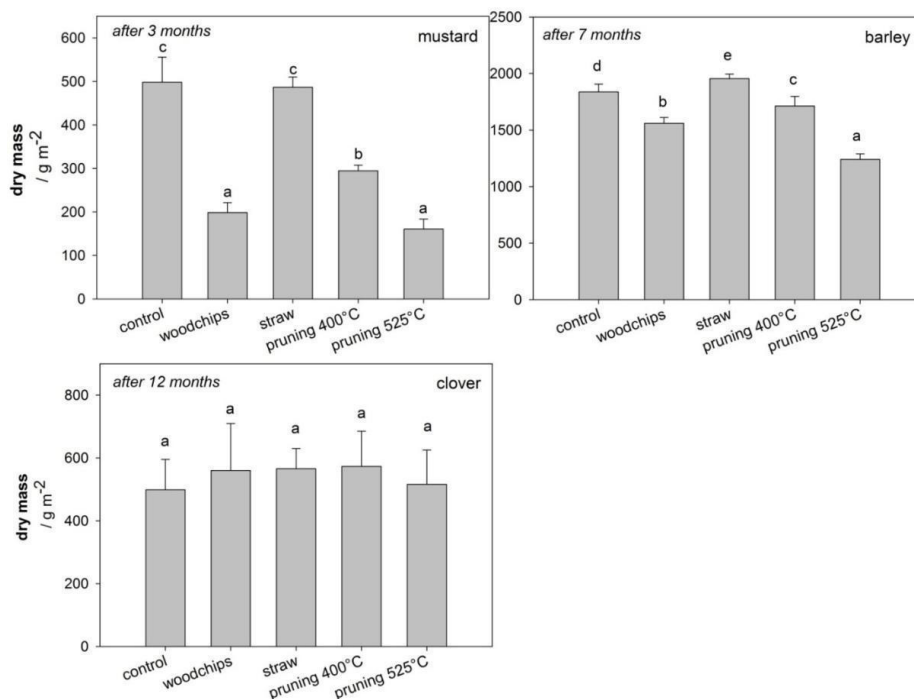


Fig. 6 The influence of using a concentration of 1% [1]

Conclusions

Taking into account of the needs and social conditions in Romania, it is appropriate that the widespread of CHAB concept by producing useful heat and biochar in households, farms, industry, etc, by helping to reduce CO₂ emissions and increase production capacity from agriculture.

The biochar incorporated in the agricultural soil must have the characteristics necessary for an effective increase of the soil fertility. As a result it has to be produced in facilities with effective control of operating mode, to maintain quality in the desired limits.

Against the mirage of low production costs there are not recommended the use of homemade micro-gasification units which use open fire containers, without any thermal control system, resulting in a biochar with a high VOC of a doubtful quality.

Applying the CHAB concept in farms can effectively contribute to the lowering costs of production of thermal energy required, with values up to 20%, capitalizing resources from the farm and increasing the competitiveness of agricultural production.

Since from various sources of biomass is obtained biochar with different characteristics, which each crop plant responds optimally only on certain level of biochar concentrations between 10% and 30%. There are necessary experiments to continue to optimize the dosage of biochar in each agricultural area.

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