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Study of the Physical, Chemical and Thermal Potential of Biochar Produced from Agricultural Residues in Faranah, Republic of Guinea

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Abstract* - The objective of this study is the valorization of agricultural residues in the production of biochar in Faranah. The availability of plant material made it possible to process the rice bran and peanut shell on site. The rice bran was directly used after drying in the sun for 72 hours. The peanut shell after sun-drying for 72 hours was processed by pyrolysis using a barrel carbonizer. The operating speed of a single barrel carbonizer is characterized by small bottom openings 25% air holes, a 50% upper cylindrical opening for the exit of charred material. The carbonization time is 1h15mn. A manual experimental retor press was designed for the manufacture of cylindrical bio-charcoal briquettes. Analysis of the raw dry matter of rice bran and peanut shell yields highly microporous materials of elemental composition, rice bran: Carbon (C) = 34.85%; Hydrogen (H) = 4.10%; Oxygen (O) = 33.67%; Nitrogen (N) = 1.13%; Ash content (Tc) = 12.25%; Volatile matter (Mv) = 14% and a moisture content (Th) = 11.45%. Elemental analysis of the peanut shell gives the following results: Carbon (C) = 38.85%; Hydrogen (H) = 6.02%; Oxygen (O) = 32.54%; Nitrogen (N) = 1.95%; Ash content (Tc) = 8.79%; Volatile matter (Mv) = 11.85%, moisture content (Th) = 6.85%. This made it possible to make different mixtures to obtain biochar according to a proportional percentage composition. The most efficient from an energy point of view is: Clay (A) + Rice Bran (SR) + Peanut Rooster (CA) = (A20% + SR20% + CA60%) with the elementary fraction: Carbon (C) = 38.25%; Hydrogen (H) = 5.85%; Oxygen (O) = 48.90%; Nitrogen (N) = 0.65%; Ash content (Tc) = 6.35%; and a humidity level (Th) = 6.85%; Calorific value (PC) = 16 (MJ / kg). These different results show that the biochar produced can be used as an alternative energy source for cooking food.

Keywords: Study, potential, physico-chemical, thermal, biochar, agriculture, Guinea.

I. INTRODUCTION

It is now established that climate change negatively influences natural resources, ecosystems, infrastructure and human health. They risk jeopardizing the survival of humanity and life on our planet. This is why, like many countries in the world, Guinea, by ratifying in 1993 the United Nations Framework Convention on Climate Change (UNFCCC), committed to work for a sustainable development policy, based on the rational use of natural resources and the improvement of production techniques [1].

The main environmental constraints in Guinea are inappropriate agricultural practices, the abusive and anarchic exploitation of forest and wildlife resources, surface mining, bush fires, extreme poverty (53% of the population), poor management of domestic, agricultural, industrial waste, climate variability and change [1].

The main climatic disturbances listed are the drop in rainfall, recurrent droughts since the 1970s, early and frequent flooding (Kankan- 2001, Boké - 2003, Gaoual - 2005) and disturbances in the rainfall regime. They are the cause of the drying up of watercourses, the drying up of the soil, the destruction of plant cover, the decline in agricultural production, the resurgence of water-borne diseases, particularly in the area. north of the country [1].

Analysis of rainfall data from 1960 to 2004 shows an almost constant drop in rainfall across the country and an increase in average temperature. This situation is more marked towards the north of the country (Middle and Upper Guinea) [1].

For the period 2000-2100, temperatures are expected to vary from 0.3 to 4.8 ° C in Middle and Upper Guinea and from 0.2 to 3.9 ° C in Lower Guinea and Forest Guinea.

Also, anthropogenic environmental constraints, such as carbonization to find charcoal, a source of energy for cooking in households is in the same vein [1,2].

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In addition, cooking energy is essential energy for populations. The population's access to butane gas, wood, charcoal or other cooking fuels must be ensured in order to guarantee food, healthy, economic and social security in the country. However, in Guinea, it is increasingly difficult for a household to have access to these fuels. Resources are becoming increasingly scarce and are confined in areas more and more distant from major centers of consumption.

This is why the Guinean government has launched an urgent appeal to various donors in general and to the Global Environmental Fund (GEF) in particular, for the financing of environmental projects. Their implementation enables resources and socio-economic groups in Guinea to protect the environment and adapt to climate change.

In this case, could biochar be used as household fuel for households and reduce overexploitation of forests?

To answer this question, an approach was adopted through a general objective which targets the technique of transforming certain agricultural residues into biochar. More specifically:

- Determine the energy quality of the biochar;
- Conduct a study of the physical, chemical and elemental potential and determine the energy quality of biochar; in perspective;
- Introduce farmers to the technique of transforming certain organic residues into biochar;

To achieve this, an approach through the material and the method below has been adopted.

II. MATERIAL AND METHOD

In this part, it would be a question of identifying the necessary material and the methods to be followed according to the objective assigned to carry out the research work.

2.1 Material

2.1.1 Presentation of the Study Area

The Faranah Administrative Region is the central part of the country which stretches between Fouta Djallon, Forest Guinea and Upper Guinea. It is located at 8o50 and 12o north latitude and 9 ° 15 and 11o29 west longitude. It covers an area of 35,581 km^2[2, 1].

It is bounded to the east by the Administrative Region of Kankan, to the north by the Republic of Mali, to the west by the Administrative Region of Mamou and Labé, to the southwest by the Republic of Sierra Leone and to the west. south by the Administrative Region of N'Nzérékoré.

The climate is of the Sudano-Guinean type with the alternation of two seasons: rainy which extends from (May to October) and dry which extends from (November to April). The region is subject to the influence of three types of micro climates which are: the tropical mountain type or the "Foutanian" climate, the sub-Sudanese tropical type and the sub-equatorial type. The relief is not very rugged and consists of the mountain ranges of Daro in the south-east and Fitaba in the north-east. The Sankaran and Oulada plateaus are generally lateritic with an altitude varying between 200 and 400 meters cut by the rivers of Niger, Tinkisso and Banié, leading to the formation of numerous flood plains. The soils are of the ferralitic, clayey-silty and hydro-morphic type [2,1].

Demographically, Faranah has a total population of 1,006,314 inhabitants in 2016, it is one of the least populated regions of Guinea (7th out of 8). Women make up a little more than half of the population with 523,941 inhabitants. It is predominantly rural (80%). The average density is 24 inhabitants per km^2 [2].

2.2 Method

To carry out this research, several methods were used during our works which are among others:

- In situ observation method, makes it possible to make a summary qualitative and quantitative evaluation of the materials intended for the production of biochar;
- Quantitative analysis method, to identify the percentage rate of the different chemical elements (Carbon, Oxygen, Hydrogen, Nitrogen);
- Qualitative analysis method, to identify the energy efficiency (calorific value) of biochar.

III. RESULTS AND DISCUSSION

3.1 Results

Rice bran taken from the site was analyzed; moisture and volatile matter calculations were made on the basis of dry matter. The results are shown in the tables below.

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Table 1: Elemental analysis results of raw samples of rice bran and peanut shell

Sample	**Element**(%)						**Humidity rate Th** (%)
	carbon**C**	Hydrogen**H**	Oxygen**O**	Nitrogen**N**	Ashes	Volatile matter**Mv** (%)	
Rice bran (SR)	34,85	4,10	33,67	1,13	12,25	14	11,45
Peanut Shell (CA)	38,85	6,02	32,54	1,95	8,79	11,85	6,85

This table 1 shows the different results of the analysis of the raw sample of rice bran and peanut shell. We noticed that the moisture content is 11% for the rice bran and 7% for the peanut shell; this shows that the raw materials have been dried well. During pyrolysis, there will be production and release of synthesis gas ($CO + H_2$). Hydrogen (H_2) comes from the presence of hydrogen content in the shell of peanuts. The proportion of nitrogen in the residue is less than 2%, because during the pyrolysis there will be a release of N_2. The low nitrogen content in the residue suggests that this residue can be used as a fertilizer, in reality it is not a fertilizer per se [3]. Because, its decomposition into nutrients is difficult. Table 2 shows all the results of the biochar analysis.

Table 2: Analysis results of some samples of biochar, composed of rice bran and peanut shell

Mixed	**Sample**	**Élement**(%)					**HumidityHm** (%)	**Calorific power PC** (MJ/kg)
		Carbon**C**	Hydrogn**H**	Oxygen**O**	Nitrogen**N**	AshCdre		
Clay (A) + Rice bran (AR) + Coq Peanut (CA)	$A_{15\%}$ + $SR_{20\%}$ + $CA_{65\%}$	36,65	6,35	46,7	1,85	8 ,45	12,45	12
	$A_{20\%}$ + $SR_{20\%}$ + $CA_{60\%}$	38,25	5,85	48,90	0,65	6 ,35	12,25	16
	$A_{25\%}$ + $SR_{20\%}$ + $CA_{55\%}$	38,95	5 ,35	42,65	0 ,49	12,56	10 ,25	15

In this table 2, we found that the average value of the humidity level is 11%, this is due to the winter period, also it is not easy to extract the amount of water which is strongly related to the atom of the material (in the form of bound water). The energy efficiency blend consists of: Clay (A) = 20%; Rice Bran (SR) = 20% and Peanut Shell (CA) = 60%, for a Calorific Value (PC = 16 MJ / kg). The graphs (1 and 2) show the different results of the briquette drying and combustion test.

On fig 1, we observe that the drying time is relatively long, 50 days and more, this is due to the period of the climate (winter season). The high concentration of the drying points between the 35th and 40th drying day means that the mass of the material stabilizes and the weight remains constant, it is deduced that the drying point has been reached.

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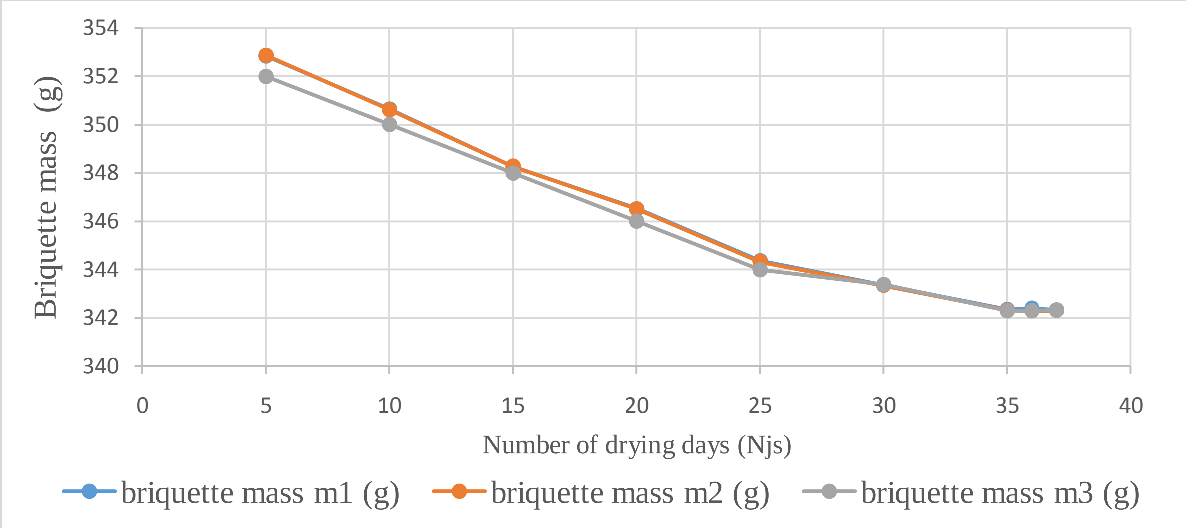

Figure 1: Evolution curve of the drying of biochar briquettes

Figure 2 shows the comparative evolution of the temperature of the charcoal and biochar combustion test, this graph tells us that biochar is very slow to ignite for about 20 minutes than charcoal. This means that the cooking time will be relatively slow than charcoal because the boiling temperature of water of 100 ± 5 ° C is only obtained after 40 minutes. Thus, this is what makes it can burn with less smoke than charcoal and more energy efficient.

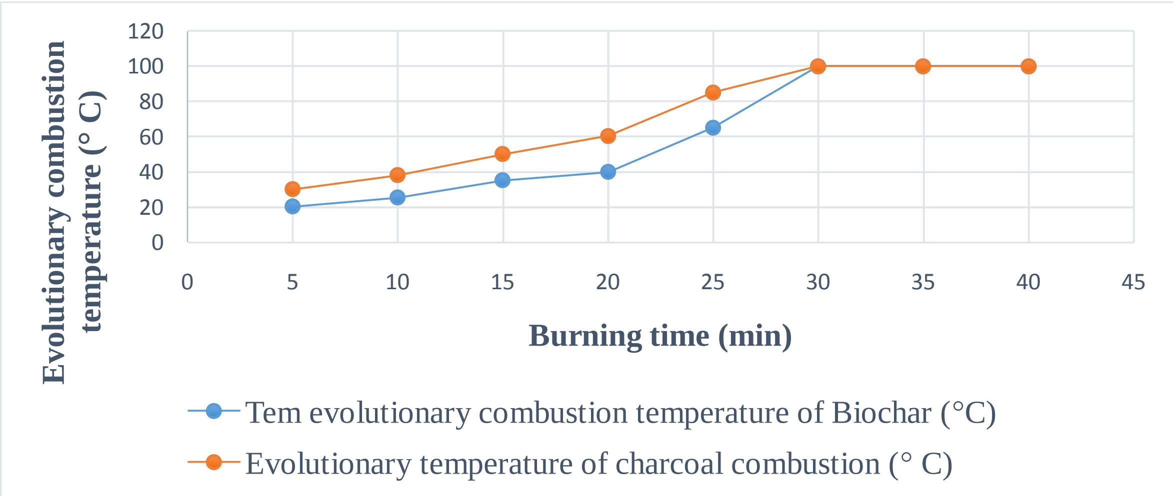

Figure 2: Evolutionary temperature and combustion time of biochar

3.2. Discussion

In this part, we will proceed to discussions by analysis of the various results obtained while making a comparison with those obtained in the bibliographic literature.

The results of the immediate analysis of the rice bran give a moisture content of 11%. This result is similar to that obtained by Prins R. et al. (2011) in their work [3, 4].

This rate is within the standard range of the pyrolysis process (humidity level below 15%). We can say that the initial biomass was fairly well dried in the sun before it was used in the pyrolysis drum for the different types of biochar. This result is of great importance for the determination of the proportional percentage composition. An ash content of 12% is observed in the rice bran. It does not approach that obtained by (Neya. B, 2002) [5, 6]. It could present problems during pyrolysis, during combustion or during gasification.

Therefore, the precaution was taken to stop the pyrolysis process with moderate time, to avoid the formation of a high rate of ash. The level of volatile matter is in the greatest proportion within the peanut shell. It is similar to that obtained by Nataranja et al (2009) [4]. There will therefore be a great loss in mass and volume of the peanut shell, a significant release of pyrolysis gases during the production of the residue.

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According to chemical elemental analysis, rice bran has a relatively low carbon and nitrogen content compared to that obtained by Neya B., (2002) [5]. As for the hydrogen content, it is substantially proportional.

However, these results are close to those obtained by Mansaray and Ghaly (1997) [6]. This may be due to the origin of the rice bran used to perform the analyzes.

Rice bran during its combustion as bio-charcoal loses at least 50% of its initial carbon content in the form of CO2 and CO (Lehmann et al., 2006) [9, 8]. The carbon remaining in its residue (bio char) is then more stable. By burying this residue of bio char (bio char) in the soil, it will have the advantage not only of storing and sequestering the remaining carbon, also, of improving crop productivity (Glaser. B et al. 2002) [11].

During pyrolysis, there will be production and release of synthesis gas (CO + H2). H2 comes from the presence of hydrogen content in the peanut shell. The nitrogen content in the residue will probably be less than 2% since during pyrolysis there will be evolution of N_2. The low nitrogen content in the residue suggests that in reality this residue can be used as a fertilizer, but it is not a fertilizer itself. Because, the rate of decomposition and the release of nutrients are slow.
Depending on the aeration holes of the single-barrel carbonizer, different values of mass yields (on a dry matter basis) of biochar production were obtained. For an average production yield of (36% - 45%) corresponds to an average carbonization time of 1 H 15 min. These results are close to the range of those obtained on the "Pyro-6F" pilot reactor installed in Senegal. It should be noted that the moisture content of the biomass used was on average 11% [6].
The ash content in the analysis of rice bran, peanut shell and bio charcoal differs from that determined by (Hazouli .H. 2007) [11,12].

The moisture content of bio charcoal is 12%. This rate is lower than that obtained by (Hazouli .H. 2007). These allow us to say that the carbon and oxygen levels are also slightly increased [12].

The primary objective of bio charcoal produced from rice bran and peanut shell (pyrolysis) is the possibility of its use as an alternative source of energy for cooking. To do so, it requires certain basic analyzes which include the determination of its calorific value (PC). After this analysis, a calorific value (PC) of 12 MJ/kg, 15 MJ/kg and 16 MJ/kg was obtained according to the different percentage compositions obtained. This result confirms that of ADEME (2002), which mentions that the calorific value of fuelwood varies proportionally to the humidity rate and goes from 18 MJ/kg (5% humidity rate) to 9.5 MJ/kg (45% humidity) [10, 11].

On the other hand, the experiment is carried out on the combustible fraction of bio coal with a low average humidity of 12%, this gives an appreciable calorific value.

IV. CONCLUSION

The objective of this work was first to identify the different types of biomass available in the Faranah region for the production of biochar from certain agricultural residues. Next, set up an experimental conservation chamber of 16m² for drying the biochar briquettes.

Also, the development of an experimental research retor press. This approach was followed by the technical tests of the equipment for the transformation of agricultural residues available on the site into biochar and finally to evaluate the physical, chemical and thermal potential of the biochar for its use as an alternative energy source in cooking food. At the end of this work, it emerges that the identified biomasses are rice bran and peanut shell. The fact that these agricultural residues are only transformed by carbonization in the open air and which have nowhere been valued. The potential could be estimated at 500 tonnes per year in certain areas of Faranah and surrounding areas for the production of biochar.

The results of the technical and experimental tests show that the single-barrel carbonizer has a 25% lower air opening and a (45 - 50%) upper air opening for the production of biochar from the shell. peanut and rice bran. The most effective mixture has a percentage composition (clay 20%, rice bran 20% and peanut shell 60%) and having for calorific value (PC) 16 MJ/kg, combustion tests have shown that this biochar burns and can bring water to its boiling point (100 ± 5 ° C). This is why these different results show that the biochar produced can be used as an alternative energy source for cooking food.

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