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RESEARCH ARTICLE

CALORIFIC VALUE ENHANCEMENT DUE TO COMBINATION OF BIOCHARS FROM CORN COBS, TENDER COCONUT HUSKS AND PALM KERNEL SHELLS.

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Abstract

In this paper, the lower calorific value of corn cobs, palm kernel shells and tender coconut husks were determined and were respectively 24 760 J/g for corn cobs; 25 096 J/g for palm kernel shells and 16 550 J/g for tender coconut husks. Then, the mixture of different amount of corn cobs and palm kernel shells were made. The determination of their lower calorific value has shown that the mixture of 40% of corn cobs and 60% of palm kernel shells in mass has increased, 25 667 J/g, compared to the initial biochars. These values are lower compared to charcoal one’s, 29 061 J/g. To bind the mixture as fuel briquettes, addition of 13.04% in sample total mass of clay is made. Binder decreases samples lower calorific value as 20 842 J/g for corn cobs, 13 527 J/g for tender coconuts husks and 21 377 J/g for palm kernel shells. For the mixture of 50% of corn cobs and 50% of palm kernel shells, lower calorific value decreases less compared to others.

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Introduction:-

Since industrial era, the world economy is based on fossil energies fuels essentially coal, gas and petroleum; followed by fuel wood energy (Abdu and Sadiq, 2014; Chevalier, 2003). The emergence of some countries as China, Brazil, India ... increases fossil fuel consumption which supplies will eventually run out (Amit et al., 2014; Bobin et al., 2007). In addition, the use of fossil fuels is the source of greenhouse gases such as carbon dioxide, methane ... (Jude, 2016). Therefore, it is important to make a transition toward the renewable and more cleaner energies. Among these energies, the fuel wood is the most used in the world (Abdu and Sadiq, 2014; Madhuri and Deben, 2017). In developing countries such as Togo, fuel wood and biomass are essentially utilized by households for cooking, mainly in rural and peri-urban area, whereas charcoal and sometimes butane gas are used in urban area (Madhuri and Deben, 2017; Okia et al., 2017). With the growth of the population, fuel wood consumption steadily on the rise. This, associated to other uses of wood threatens the tropical forest existence. It’s therefore a necessity to look for alternative energy in order to lighten the pressure on tropical forest.

It is well known that agriculture, forest and municipal wastes are good sources of energy (Aries , 2017; Abdu and Sadiq, 2014). Being an agricultural country, agricultural and forest products are abundant in Togo. For example, in 2013, the contribution of agriculture in the gross domestic product (GDP) is 40% (Colonel Agadazi, 2013). However, before used, agricultural and forest wastes need to be subjected to some treatments in order to make them non-hazardous and more efficient for the user (Anshul et al.). As a matter of fact, raw biomass materials have low density and provokes irritation when it burns due to the smoke and burning gas (Xing et al., 2017). That is why they

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are mainly used in peri urban and rural areas, in an open environment with less efficiency. To allow their utilisation in urban area, in replacement of charcoal, they must be carbonized and reduced in powder before converted in burning briquette. This conversion can be made by pressure application or by binding with binding agent (Aries, 2017).

The present study aims to investigate the energy potential of different mixtures of biochar from Tender Coconuts Husks (TCH), Corn Cobs (CC) and Palm Kernel Shells (PKS) in order to make them as competitive as charcoal, reducing charcoal utilization as energy source.

Material and method:-

All tested samples were collected in Lomé (Republic of Togo, West Africa) and its surroundings. Shells of palm kernel were collected in a small traditional oil mill, tender coconuts husks were provided by coconut water sellers and corn cobs were obtained from a farmer. Charcoal was bought in market.

After sun dried for nine hours per day during four days, they were carbonized separately in a metallic biochar stove made in Laboratory. For each carbonization, about 6.0 kg of palm kernel shells, 200 g of corn cobs and 200 g of tender coconut husks can be introduced. Once the carbonization completed, each biochar were ground in aluminium mortar. The obtained powder were dried in a desiccator at 105°C for 24 hours. Then we collected an amount m_0 of each sample at which we make different combination before determining their lower calorific value. To make burning briquettes, we use a clay as binder.

To evaluate the lower calorific value of samples, we use the adiabatic oxygen bomb calorimeter, PARR Calorimeter, model 1241 with the Standard Test Method for calorific value.

Results and discussion:-

Fig.1 represents pictures of raw biomasses and their correspondent biochar in comparison of charcoal one's.

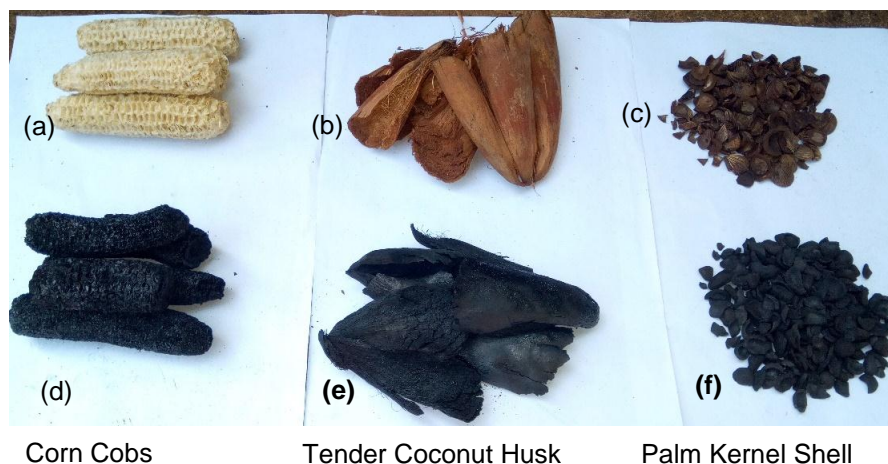


Fig .1:- Picture of raw biomass (a) CC; (b) TCH; (c) PKS and respectively their correspondent biochars (d), (e), (f)

It is to be noticed that corn cobs (CC) and tender coconut husks (TCH) samples had lowest density in comparison to the palm kernel shells (PKS) samples. During experiences, we found that PKS does not readily burn whereas CC and TCH, more lighters, catch fire quickly. Lower calorific value measurements have shown that among the studied samples, charcoal has the highest lower calorific value (29 061 J/g) followed by PKS (25 096 J/g), CC (24 760 J/g) and at the end TCH (16 550 J/g). Then, the potential candidates for biochar briquette making are PKS and CC.

As demonstrated by Gino et al., a mixture of 50% coconut shells biochar to 50% corn cobs biochar induces lower calorific value increase of the resultant sample compared to the individual one's (Gino et al., 2015). Based on this

result and, in order, to allow optimum combustion of briquettes made with PKS, we mixed to PKS biochar some amount of CC and TCH biochar.

In Fig. 2, is presented the lower calorific value of pure samples and, the mixture in the same proportion of PKS respectively with TCH and CC. It was noted that the lower calorific value of sample with 50% PKS and 50% CC has increased in comparison of the single samples.

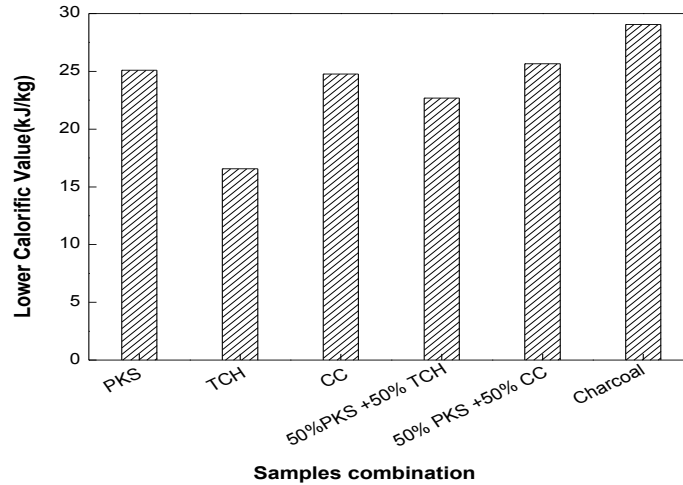


Fig .2:-Lower calorific value of biochar from PKS; TCH; CC and their mixture in comparison to charcoal one's

In light of this, we decided to determine the lower calorific value of different configuration of mixture of PKS and CC, in expect to identify the combination that had higher lower calorific value.

To achieve this goal, we have elaborated samples of PKS with different amount of CC. Fig. 3 shows the result of these experiences. It shows that the optimum mixture for highest lower calorific value is for 60% of PKS and 40% of CC.

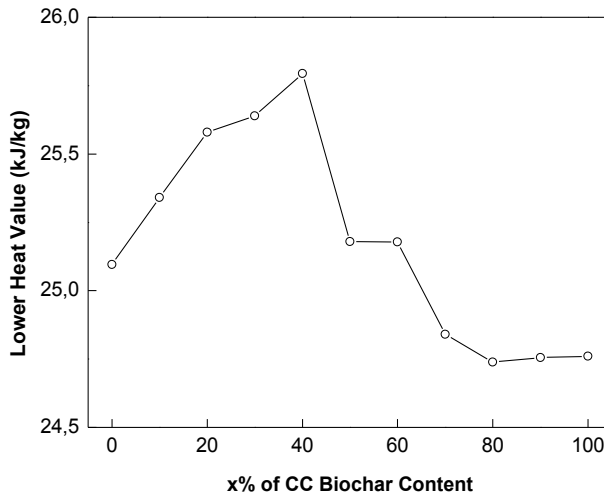


Fig .3:-Lower calorific value of biochar from PKS mixed to x% of biochar from CC

To produce briquettes from biochar, we can use a binder or hydrostatic press (Koteswararao et al., 2016). Among these techniques, binder utilization is more accessible for people especially the most vulnerable and poorest. However, in some cases, the binder is derived from food (Koteswararao et al., 2016; Sipahutar et al., 2017). This poses a number of problems as it is always the case when we use crop production or agricultural lands to produce energy (bioenergy). To avoid as much as possible these difficulties, we test clay as binder.

We have assumed that the amount of clay to add to biochar is 13.04% of the mass of sample. As we know, clay is not organic material, and in consequence samples lower calorific value will decrease. In order to allow us to access the decrease ratio, we determine the lower calorific value of the samples. The results are shown in Fig. 4.

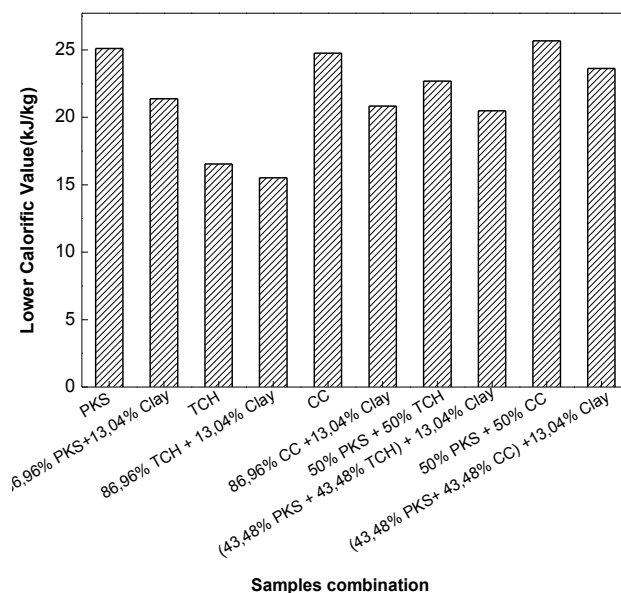


Fig .4:-Lower calorific value of biochar from different combination of biochars from PKS, CC and TCH

Related results of Fig. 4 have been recorded in table 1, in which the energy balance shows the lower calorific value decrease induced by clay addition and their increase when we use the combination of 50% PKS plus 50% of CC or TCH.

Table 1:-Energy balance induced by clay addition

Biochar	Lower calorific value (J/g)	Energy decrease rate (%)
PKS	25096	
TCH	16550	
CC	24760	
50%PKS + 50% CC	25667	
50%PKS+ 50%TCH	22686	
86,96% PKS + 13,04% Clay	21377	85,18
86,96%TCH + 13,04% Clay	13527	81,73
86,96% CC + 13,04% Clay	20842	84,18
43,48%PKS+ 43,48%TCH +13,04% Clay	20492	90,33
43,48%PKS + 43,48% CC +13,04% Clay	23631	92,07
Charcoal	29061	

Conclusion:-

Among available biomass in Togo, there are corn cobs, palm kernel shells and tender coconut husks which are not well valued as energy source apart for corn cobs and palm kernel shells sometimes. This is due to the lack of knowledge on their utilization conditions, which makes their utilization less energy efficient. This study shows that the combination of biochar produced from corn cobs mixed up to equal amount of biochar from palm kernel shells increases the lower calorific value of the result fuel, so enhances the energy it contains.

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