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SUSTAINABLE PRACTICES: RECYCLING OF BIOMASS OF *EICHHORNIA CRASSIPES* IN THE PRODUCTION OF BRIQUETTES

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ABSTRACT

The search for alternative energy sources has driven many researches in the whole world. In this sense this study aimed to investigate the production of briquettes from biomass of the aquatic macrophyte *Eichhornia crassipes*, more commonly known as water hyacinth. The aguapé is taken as a species is harmful to the environment due to its rapid growth in ponds, in some cases reaching to cover the entire surface of the lakes. This fact prevents the passage of light and affect the oxygenation of the water. In this way the production of briquettes from biomass of *Eichhornia crassipes* can contribute to minimizing the environmental impact that this aquatic macrophyte causes in dams and on the other hand can still provide solid fuel for applications in industrial boilers, bakeries and thermoelectric plants. The briquettes produced were compressed in a hydraulic press with a pressure of 10 Ton/cm^2 and subsequently submitted to the analyzes of moisture, ash and volatile. As a bonding agent, it was investigated the application of crude glycerine, obtained from biodiesel production, in the proportions of 5, 10 and 15 mL per 100g of biomass. The results showed that the biomass of the aguapé is adapted very well to the production of briquettes, it was observed that the moisture content of the briquettes is directly proportional to the concentration of the binder. These presented a value of 14% of the ash content and volatile content of 84.7%, fairly satisfactory, considering that the more volatile content, the greater will be the calorific value of the fuel. Finally, it concludes that the production of briquettes from biomass of water hyacinth, is a very viable alternative and can contribute to the provision of solid fuels, renewable energy sources, and also contribute to reducing the environmental damage caused by the exaggerated growth of aquatic macrophyte in waters of reservoirs.

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INTRODUCTION

The decadence of the petroleum resources, the gradual increase in the consumption of energy and the need for rules more effective in combating environmental pollution are increasing considerably the search for alternative energy sources and renewable energy sources, such as the residual biomass. In accordance with studies performed on the development or reuse of inputs, the biomass is gaining prominence because of its several advantages in comparison with the petroleum resources, such as, for example, renewable nature, wide availability, biodegradability, high calorific value, low cost and among other advantages (LEUNG et al., 2010). According to Santos (2015), it is apparent the need for immediate replacement of petroleum sources of energy by renewable sources, because every day that passes it becomes untenable in the harmful effects to the environment, caused by these non-renewable sources of energy. The problems caused by the use of fossil sources are not only evidenced by the fact that the deforestation of forests, but also by the impact on the climate, generated by global warming, which may cause in Brazil, for example, an imbalance in the frequency of rainfall,

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causing some regions spend long periods raining while other regions remain dry during these same periods, causing an extremely negative social impact to the energy security of the country. In this scenario, the biomass gain space through as an energy source, through the reuse of solid waste that directly affect the environment fairly negative. One of the main problems of pollution is the inadequate disposal of solid waste generated by the industries in effluents, thus generating expressive disorders to environment and society. For Granato (1995) the use of biological agents for treating effluents is presented in a way more easy and economical in comparison to the use of chemical processes, particularly in the final processing of solutions that have a low concentration of substances, but continue to be inappropriate to discard. According to Gonçalves Junior, Selzlein and Nacke (2009), *Eichhornia crassipes* (water hyacinth) is effective on the adsorption and removal of the metals Cu, Zn, Cr, Cd and Pb in aqueous solutions contaminated. For Jorge (2013), the water hyacinth proved effective in removing biodegradable and non-biodegradable materials, nitrogen, ammoniacal and turbidity. In the studies by Silva *et al*. (2014), the water hyacinth has proved to be efficient in the removal of phosphorus in effluent. In relation to the reuse of solid waste, it has as a product of the briquettes, for the processing of briquetting. According to Pereira (2015), the briquette consist in an ecological wood obtained from the homogeneous compaction of forest wastes or industries, under pressure and high temperature, being used as an alternative source of energy in the replacement of fossil fuels, which features high calorific and among other numerous advantages.

The briquette is a propicio product to be used as an energy source in bakeries, pizzerias, restaurants, potteries, restaurants, breweries, dyeing industry, ceramics, dairies, residences, distilleries, slaughterhouses, paper industry, soft drink industry, laundries, metallurgical industries, bullets, soybean oil industry and among other establishments. Biomax (2016) and Lippel (2016) ensures that the process of briquetting is the compaction of environmental waste, which occurs through the "breaking" of the natural elasticity of the fibers of the waste, with the objective of transforming these wastes in solid fuels of high calorific value. The "break" this elasticity can be done through two processes: high temperature and/or high pressure, because without this break occurs, the briquettes produced will have little durability, becoming thus unfit for transport and storage. "The humidity of a material is related to the content of water, in the case of the briquette the value of 10 to 12% of moisture is considered low in relation to the conventional wood that is 30 to 40%" (ZAGO, *et al.,* 2010, p. 25). Considering the above, the screen research aims to explore the use of *Eichhornia crassipes* to manufacture briquettes, which consists of solid waste compressed.

MATERIALS AND METHODS

The sample of water hyacinth was collected directly from the Weir Grande, located in Cajazeiras, Paraíba state. To obtain the ratio of surface area and the mass of water hyacinth, the collection was performed using a square with 1.20 meters of hand making a square area of 1.44 m^2. The collection was carried out in a place whose depth was, on average, a metro.

After collection, the material was taken to Universidade Federal de Campina Grande of Pompeii and placed to dry in an outdoor environment and with exposure to direct sunlight. Periodically review the material was revirado to accelerate the drying process. After eight days of drying, the material was very dry. The dried material was ground using a harvester, thus obtaining a material with a particle size suitable for the manufacture of briquettes. The particulate material was subjected to analyzes of moisture content, ash and volatile. In the study of the ash content, the samples were subjected to muffle furnace the temperature of 1000oC to 120 minutes with a gradient of climb of 5 degrees per minute. The ashes were determined in three parts of the plant, namely: the root, leaf and stem (float + rhizome). An important fact in samples of biofuels is the volatile content. This parameter is directly related to the heat capacity of the sample. According to the ABNT/NBR 8112 the volatile content can be checked by the following expression:

Equation 1- Volatile Content

$$TMV = \frac{Pms - Pmv}{Pms}\ x\ 100$$

Where:
TMV = content of volatile matter (%)
Smp = weight of the sample dry weight (g)
Pmv = mass of the sample after exposure to 1000oC (in grams)

For the determination of moisture content, the sample was placed in an oven 110ºC. Periodically checked-if the mass of the sample until the same did not present more significant variation in weight. For the manufacture of briquettes was used a form, shown in Figure 1, in which the biomass of *Eichhornia crassipes* was pressed in a hydraulic press. As a substance ligand, was tested the glycerin in varying concentrations. In relation to the Pressings, it was verified the study of the time at which the material was submitted in the trouser and also the pressure applied in this process. After the formation of a new study of ash and moisture was performed in order to verify the influence of the ligand on such factors.

Source: Personal Archive (2016).

Figure 1. Form used for the manufacture of briquettes

RESULTS AND DISCUSSION

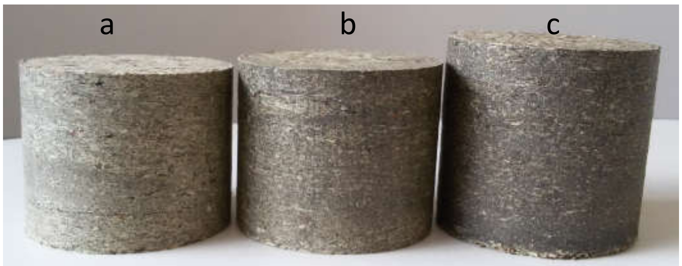
The mass of water hyacinth collected from 1.44 m^2 in the weir yielded 2.7 kg of dry material. With this we can affirm that, on average, the water hyacinth provides approximately 1.875 kg of dry biomass per square meter of area covered in the pond. The moisture content of after the period of drying in the sun was determined in triplicate and presented an average of 6.5%. This value can be considered adequate, because if on the one hand the moisture decreases the calorific power, on the other hand it can act as a binder for proper training of briquettes. The ash content of the dried samples was also measured in triplicate. Initially the content was quite high reaching the level of 16%. This is a value that can be quite high for Biomasses wishing to be used as solid biofuels. To investigate the cause of high value, a study was conducted of the ash content for each part of the plant. In this way, if new sample collected from biomass and after the drying process separated three distinct parts of the plant, namely: roots, stem (float + rhizome) and leaves. Table 1 presents the ash content of the samples calcined at 500ºC. It is observed in Table 1 that the great responsible for high ash content of the samples are complete, the roots of these plants. This indicates that for a better utilization, the roots must go through a process of washing before the drying process in order to remove the inorganic material (earth) aggregate. For the case of the production of briquettes the ash content of high compromise the heat capacity of the product.

Table 1. Ash content of the parts of the water hyavinth

	Root (%)	Float + stem (rhizome)(%)	Sheets (%)
Ash Content	28.3	6.9	5.4

Source: Author itself (2016).

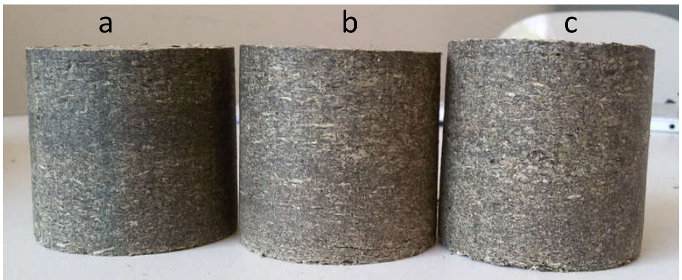
Among the various materials that can be used as binders or ligands in the production of briquettes, was tested for crude glycerine, obtained from biodiesel production, in the proportions of 5, 10 and 15 mL per 100 grams of biomass. The biomass was also evaluated in the formation of the briquettes without the presence of any ligand. Figure 2 presents the briquettes produced with various concentrations of glycerol and also the sample without binder. The briquettes presented in Figure 2 were compressed in a hydraulic press with a pressure 10 Ton/cm^2 and maintained under this pressure for 15 minutes. It should be noted that all the briquettes presented with good compression and adequate training to use as solid fuel. The samples added glycerin (Figures 2b and 2c) showed higher volume than the sample without glycerol (Figure 2a) because for all samples was used as a standard weight of 100g of biomass. The samples, without binder presented some ease of Zvr close to the edges of the briquette, indicating that it is possible to produce briquettes of Waterhyacinth without binder, but these would make losses during transport.



Source: Author itself (2016).

Figure 2. Briquettes produced

Figure 3 presents the briquettes obtained with different times of pressing for a concentration of glycerin of 5 mL/100g of biomass, the sample being of Figure 3a capillary for 10 minutes, Figure 3b capillary for 3 minutes and Figure 3c capillary for 1 minute. It is observed that the samples 'a' and 'b' button pressed for 10 and 3 minutes respectively, presented the same compression factor and that the sample 'c' presents itself with a volume a little higher. This result shows that for a briquette the pressing time can vary, but after 3 minutes the briquette already reaches its maximum degree of compaction.



Source: Author itself (2016).

Figure 3. Briquettes produced with the addition of glycerine

The moisture content of the briquettes produced from biomass of *Eichhornia crassipes* was real, presenting moisture values shown in Table 2. It is observed that the moisture content of the briquettes increases with the addition of glycerine, so directly proportional, as well, the moisture content of the briquettes is related to the moisture content of crude glycerine is used as binder. These results indicate that the crude glycerine added this experiment adds, on average, 0.13% moisture at each mL used as binder.

Table 2. Moisture content in briquettes

Concentration in mL/100g	Moisture in % of the mass
15	8.5
10	8.2
5	7.4
0	6.5

Source: Author itself (2016).

The ash content of the briquettes produced, was conducted with a sample produced with 15mL/100g of biomass, presenting value of 14% of the ash content. It is observed in Table 1 that the ash content of the dry biomass was 16%, therefore, the difference between the ash content of the briquette, with glycerin, and the dry biomass (2%) can be explained by the low presence of ash in the glycerine is used. The volatile content calculated from the briquette with concentration of 15mL of glycerine per 100g of *Eichhornia crassipes*, presented a value of 84, 7%. This result is in concordance with the studies of Schutz, Anami And Travessini (2010), who worked with biomass from the dust of beans and corn and obtained a volatile content of 82.9%.

Final Considerations

Before the great Brazilian and world energy consumption, studies that provide alternatives to clean energy production are extremely important, taking into consideration the great environmental impacts caused by the use of non-renewable energy sources. The results were expressed in this research show that it is feasible to reuse the biomass of *Eichhornia crassipes* in the production and solid biofuel briquettes, a high value-added products and strong substituent of fossil fuels. The briquettes produced showed good compression and conformation, with both the absence and the presence of agglutination. In general, the binder used, the crude glycerine, obtained as a byproduct of biodiesel production, proved to be very effective in the production of briquettes. It is intended to continue this study analyzing other compositions for briquetting of biomass of Waterhyacinth and still testing the viability of the production of briquettes hybrids, with the addition of other biomasses in addition of *Eichhornia crassipes,* as for example, the shell of coconut and the dust of sawdust.

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