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Production of New Adsorbent from *Mango residues* Collected in the Urban Community of Mamou

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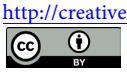

Abstract

Activated coal obtained from *mango residues* is an alternative for the valorisation of these wastes for applications. This work focuses on the production of a new adsorbent from *mango residues* collected in the urban common of Mamou (Republic of Guinea) by chemical activation with potassium hydroxide. To do this, the different rates: humidity, cinders, volatile matter, fixed carbon et iodine indices before activation and after activation at 400˚C and 700˚C were determined which are: (6.28%; 0.97%; 73.80%; 25.23%) respectively. The best indices were found in powdered activated coal compared to grain activated coal for the concentrations used. This study can be an alternative bio-adsorbent for the urban community of Mamou in water treatment.

Keywords

Mango residues, Adsorbent, "Iodine Index" and "Urban Common of Mamou"

1. Introduction

Mango is one of the fruits from the Anacardiaceae family, the most cultivated, accessible and consumed in the tropical and subtropical regions because of its excellent flavor and high nutritional value [1] [2] [3]. It and other fruits are used today in the agro-industry as raw materials in the manufacture of drinks.

According to a report by the Food and Agriculture Organization Statistics

(FOASTAT), West African countries produced 810,000 tons of mangoes in 2010 [4]. However, the demographic development doubled by the increase in agricultural activities and/or industrial activities according to the geographical zones generating enormous quantities of waste of various natures [5]. The prefecture of Mamou (Republic of Guinea) is an area known for the cultivation of fruits, mainly mango. However, the management of waste thrown in the open air or in a landfill generated by the processing units of dried fruit or *mango* juice, the productions intended for direct consumption, are made up of the cores, peelings and rotten mangoes qualified for research remains a concern for the authorities and environmental specialists because they are a source of pollution, the proliferation of fruit flies pathogen disease of the *mango* disease, a threat to this sector [6]. To overcome this scourge of waste management, the Guinean government has set up several SMEs (small and medium-sized enterprises) in charge of collecting and sorting certain waste. But the collection and recovery of mango residues are not listed. This is why the recovery of this waste constitutes a real opportunity for the development of this sector. Among other things, some water purification methods such as filtration, coagulation, flocculation sedimentation have been used and reported [7] [8] [9]. To contribute to minimizing the risks associated with the poor management of waste from mangoes in the prefecture of Mamou, research work is directed towards the recovery of wet waste from mangoes into bio-gas by methanation, and the cores could be used for the production of adsorbent for the purification of polluted water and drying of mangoes in order to minimize the throwing of *mango* waste in the open air, in the production sites [10] [11]. It is in this sense that it was proposed to undertake the production of a new adsorbent from *mango* residues collected in the urban common of Mamou.

2. Material and Methods

2.1. Presentation of the Study Area

This study was carried out in the prefecture of Mamou, which is considered as a crossroads city of the Republic of Guinea. It is located 270 km from Conakry the capital, between 9˚54' and 11˚25' North latitudes and 11˚25' and 12˚26' West longitudes with an area of approximately 8000 km^2 for a population of 318.738 inhabitants. According to the 2014 census, Mamou is one of the administrative regions of the Republic of Guinea and the region of Fouta Djallon called "water tower" of West Africa. The prefecture of Mamou shelters the sources of the three great rivers of the region: Bafing (Senegal River), Konkouré and Kaba. It is located to the east by the prefectures of Dabola and Faranah, to the west by the prefecture of Kindia to the north by the prefectures of Dalaba and Tougué to the south by the Republic of Sierra Leone. Mountainous area with lateritic plateaus of bowés, hills with steep slopes interspersed with plains and fairly fertile lowlands. The average altitude varies from 400 to 800 m from south to north (**Figure 1**).

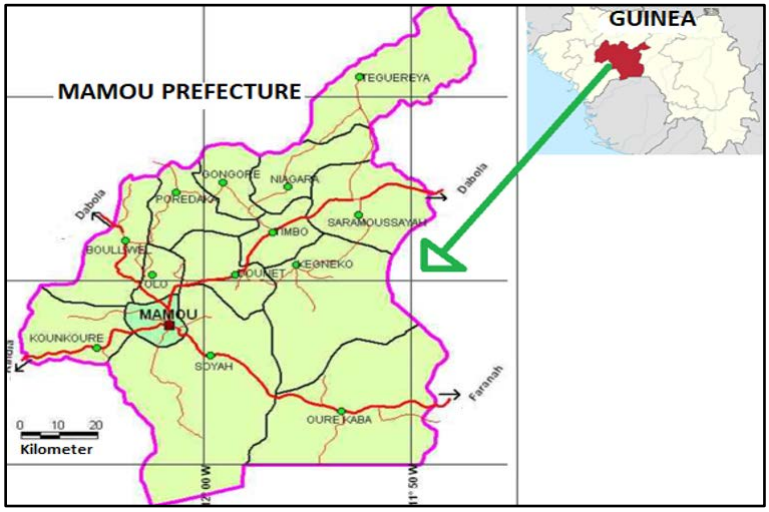

Figure 1. Map of the Republic of Guinea (right and top) showing the map of the Mamou prefecture.

2.2. Framework of Studies

The Laboratory of Chemistry of the Superior Institute of Technology of Mamou, the laboratory of Analytical chemistry of the Gamal Abdel Nasser University of Conakry, and the laboratory of the National Office of Quality Control of Matoto Conakry, served as a framework for studies.

2.3. Collection of *Mango residues*

The *mango residues* composed of mango nuts used for this analysis were collected in the big market of Mamou, sector Dinguirawi, in the prefecture of Mamou from 15 to 31 March 2022 (**Figure 2**).

Before analysis, the nouts were sorted to remove bad and forein matter, then washed and dried at room temperature in the laboratory for 48 hours. Then the second drying at 105˚C in the oven for 30 minutes removed residual contaminants. They were then crushed and subdued. Particles of granulometry size between 1.5 mm and 3.5 mm have been selected for the manufacture of our coals; those with a diameter less than or equal to 1 mm were used for immediate analyzes to determine certain constituents of the biomass.

2.4. Equipment and Solvents Used

- The oven;
- The carbonizer;
- The desiccator;
- The balance;
- Trays;
- Kiln;
- The spectrophotometer;
- The distiller;
- Glassware;

Figure 2. Sample of mango nuts collected for the experiment.

- Potassium hydroxide solution;
- Iodine;
- Hydrochloric acid.

Starch ampoi, sodium thiosulphate pentahydrate were obtained from the chemistry laboratory of the Institute Supérieur of Technology of Mamou and used without purification.

2.5. Mechanism of Operation of the Carbonizer

We used a carbonizer from the local manufacture of the department of mechanical construction and manufacturing of the Institute Supérieur of Technology of Mamou. Carbonization or pyrolysis is the thermal decomposition of the shells of mango pits to produce coal. It occurs in an enclosed space where the air inlet is controlled so that the shell is not burned and reduced to ashes, but turned into husk coal. It includes the following parts: an outer cylinder, an inner cylinder, the chimney between the two cylinders and the combustion zone (**Figure 3**).

Functioning

1) Ignition

The fuel load in the combustion zone is burned through the lower air inlets of the unit. Enter the maximum of air in the furnace. The temperature in the combustion zone rises to 200˚C. At this temperature, the *mango* kernel shells in the inner cylinder lose their moisture (endothermic period where the reactions are provoked by a heat input corresponding to the drying process during which some volatile compounds are carried away by the water vapor. The rest of the furnace rises in temperature. This phase is short; it only serves to form the carbonization front inside the oven).

2) The dehydration

The air inlets are reduced; the *mango* kernel shells release the water they contain. From 200˚C, the less stable constituents of the shells decompose. And the residue of the shells is transformed into roasted shells.

3) The carbonization

From 280˚C, another reaction occurs which is exothermic, which raises the

Figure 3. Photos of the carbonizer.

temperature without external contribution until 350˚C - 380˚C. The phenomenon of combustion is still necessary to maintain the process. A small amount of air is therefore necessary. The average temperature during this phase is between 280˚C and 380˚C. The residue becomes coal, but with a carbon content of less than 80%. If heating is continued until 700˚C to 900˚C, coal for the industry is produced.

To characterize the biomass, we determined some parameters such as moisture, ash, volatile matter and fixed carbon rates.

2.6. Determination of Moisture

Procedure

The moisture content of *mango* nuts was determined by the method of complete desiccation in the oven between 100˚C - 105˚C for 3 hours to the constant weight according to the (formula) [12] [13].

$$H\% = \frac{P1 - P2}{Pe} \times 100$$

wherein "H%" represents Percentage of humidity; P_1; P_2 = Weight of capsule and sample before and after drying; P_e = Weight of the test portion.

2.7. Determination of Ash Content

Ash is a gray or whitish colored residue obtained by the complete incineration of solid biofuels to constant mass. The method consists of incinerating a crushed and sieved biomass sample at a constant temperature of 815˚C until a constant mass is obtained. And the ash content was calculated using the following (Formula).

$$TC = \frac{m3 - m1}{m2 - m1} \times 100$$

TC = center rate; m3 = mass of crucible + sample after cooling; m2 = mass of crucible + sample before heating; m1 = mass of empty crucible and according to

the A.O.A.C method (1975).

Procedure

Take a quantity of each sample and introduce it into a previously tared crucible. The crucible and sample assembly are placed in a muffle furnace at 815˚C for 48 hours. After incineration, remove the assembly from the furnace and place it in a desiccator until completely cooled. Then proceed to weigh [14] [15].

2.8. Determination of the Volatile Matter Content

The percentage of volatile matter (%VM) is determined by the loss of mass in moisture when the biomass is heated to 900˚C for 7 min without contact with air under standard conditions.

Procedure

Into a translucent quartz crucible of known weight (M1), introduce, with uniform distribution, 1 g ± 0.1 g of sample. Determine the weight of the container with the sample (mass M2). Then place the whole (crucible + sample) in the oven at 900˚C for 7 mn. Remove from the oven then cool for 10 mn in a desiccator, determine the weight M3 (mass M3) according to the (formula) [16].

$$\mathrm{MV} = \frac{\mathrm{M2} - \mathrm{M3}}{\mathrm{M2} - \mathrm{M1}} \times 100$$

MV = volatile material; M2 = mass of crucible + sample before heating; M3 = mass of crucible + sample after cooling; M1 = mass of empty crucible.

2.9. Determination of the Fixed Carbon Rate

Fixed carbon is the carbon remaining after the removal of volatile matter and ash. It is expressed in percentage of mass and given by (the formula):

$$\mathrm{CF} = 100 - \left(\%\mathrm{MV} + \%\mathrm{TC}\right)$$

2.10. Production of Activated Carbons

The characterization of activated carbons was carried out in terms of the iodine index (an indicator of the capacity of the carbon to adsorb low molecular weight molecules). This characterization allowed us to evaluate the adsorbing properties of our activated carbons. For the production of our activated carbons, we used the process of physical activation (carbonization) to create pores in the carbon that will increase its porosity and its adsorption capacity [17]. The samples, carbonization temperatures, impregnation rate, activating agent and different carbonization times are reported in Table 1.

Table 1. Circumstances for activation.

Samples	T° of carbonization (en °C)	Impregnation rate	Agent activant	Carbonization time
Samples 1	400	5.0 g coal/50ml	KOH 10^{-1} N, 3×10^{-1} N et 5×10^{-1} N	1 h 30 mn
Samples 2	700	5.0 g/50ml	KOH 10^{-1} N, 3×10^{-1} N et 5×10^{-1} N	1 h 30 mn

3. Results

Our study gave us the following results: this biomass, presents rates of moisture (6.28%); ash (0.97%); volatile matter (73.80%) and fixed carbon (25.23%) that are represented in (Figure 4). For the determination of the iodine value before the activation of the coal, we carried out three testing. The results obtained are: (40 mg; 39.3 mg and 41.6 mg of retained iodine for 1 g of non-activated coal respectively). These results are shown in (Figure 5). However, the iodine value results of powdered activated coals in concentrations 0.1; 0.3; 0.5 normal at 400˚C and 700˚C gave us the following values: 1354 mg 1408.1 mg; 1716.5 mg and 2459.5 mg; 2489.2 mg; 2546.5 mg of retained iodine for 1 g of powdered activated carbon respectively. These results are shown in (Figure 6 and Figure 7). Figure 8 and Figure 9 shows the iodine value results of grain activated coals in the same concentrations and temperatures. The following values were found: 1451.8 mg; 1491.9 mg; 1525.2 mg and 2378.7 mg; 2391.9 mg; 2413 mg of retained iodine per 1 g of grain activated caols respectively.

4. Discussion

The value of the moisture content is 6.28% which would be higher than that found by [15] which is (2.98%). whether the difference of 3.36%. This difference is probably related to their cellular structures [18]. With a low ash content (0.97%)

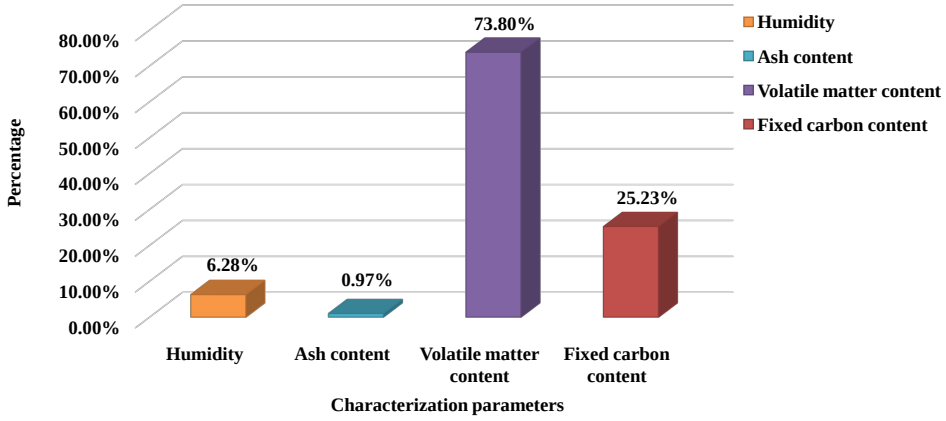

Figure 4. Results of biomass characterization.

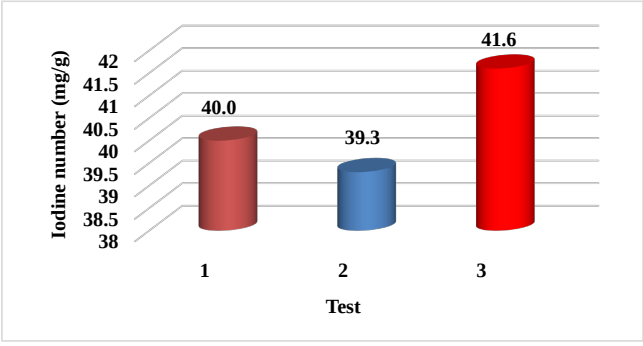

Figure 5. Iodine value of non-activated coal.

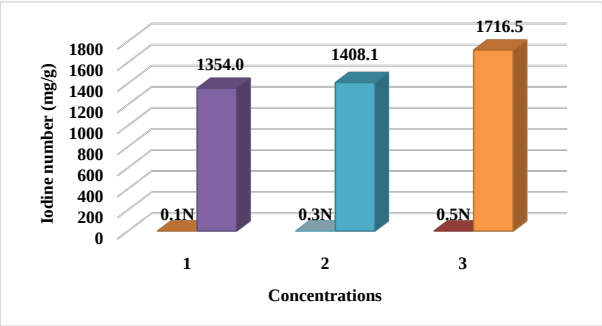

Figure 6. Iodine value of powdeed activated coals to the different concentrations at 400˚C.

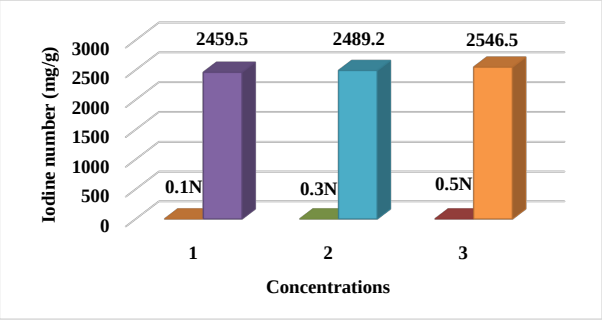

Figure 7. Iodine value of powdered activated coals to the different concentrations at 700˚C.

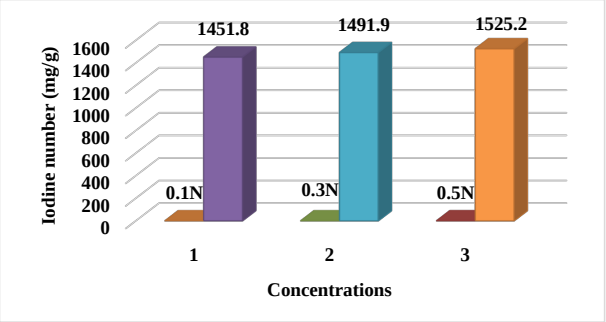

Figure 8. Iodine value of grain activated coals to the different concentrations at 400˚C.

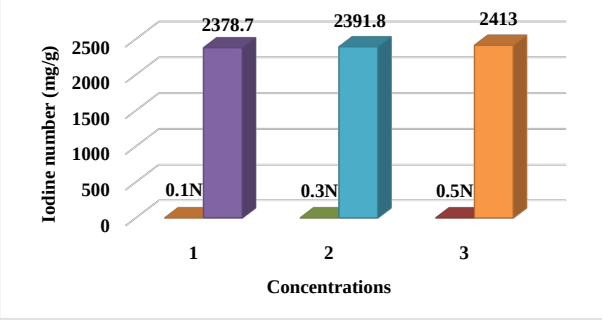

Figure 9. Iodine value of grain activated coals to the different concentrations at 700˚C.

shows that the biomass used is composed of a majority of organic matter; it denotes non-contamination in inorganic products of *mango* kernel shells [15]. This low center rate is a considerable advantage to synthesizing activated coal with a large adsorbent surface [19]. This value of ash content found in this study would still be lower than the values found by [15] (2.92%) for Balanites Aegyptiaca core shell [19], (3.71%) peanut shells and (3.83%) jatropha wood. The high content of volatile matter (73.80%) which is relatively close to that found by [15] (96.14%) will have advantages in the making of activated coal with the input of a high degree of graphitization and amount of functional group. Then we determined the fixed carbon rate which is (25.23%). It should be noted that the quality of coal is a function of the fixed carbon that it contains. The higher this rate, the better the quality of the coal [20]. Compared to the carbon content of coconut (22.45%) and peanut hull (22.62%) of [21], we note that the difference with that of mango shells of the Mamou prefecture would be: 2.61%; 2.78% respectively. We also determined the iodine value to assess the quality, efficiency of the surface and porosity of our coal [20]. Regarding the iodine index, before activation, the values are low and in the vicinity of (39.3 - 41.6) (**Figure 5**). For the powdered coal after activation at the temperature of 400˚C (**Figure 6**), we observe a growth of the iodine index at the concentrations 10^{-1} N and 5×10^{-1} N, with values: 1354 mg/g to 1716.5 mg/g of activated coal. The same trend is observed when the activation is done at a temperature of 700˚C (**Figure 7**) with results: 2459.5 mg/g to 2546.5 mg/g. It is easy to see that the difference in iodine value between the two (2) concentrations at 400˚C is greater than that at 700˚C. This suggests that beyond 700˚C the increase in iodine value between these two extremes of concentration may continue to decrease. Similarly, for in grain coals activated at 400˚C (**Figure 8**), the iodine value increase at 10^{-1} N and 5×10^{-1} N concentrations, whether 1451.8 mg/g to 1525.2 mg/g of activated carbon. However, the same iodine value varies with increasing activation temperature (700˚C) from 2378.7 mg/g to 2413.0 mg/g of activated coal (**Figure 9**). Finally, we note that powdered activated coal (PAC) has a higher iodine value compared to granular activated coal (GAC) for all concentrations used. The main applications of activated coal include purification, decolorization, deodorization, detoxification of drinking water, air, chemicals and food.

5. Conclusions

In this work, we set up a procedure of valorization of the residues of mangoes thrown everywhere in the urban commune of Mamou (Republic of Guinea) to make materials of great utility.

The results of the analysis gave the following values of rates of moisture, ash, volatile matter and fixed carbon: 6.28%; (0.97%); (73.80%); (25.23%) respectively. The iodine indices after activation to temperatures of 400˚C and 700˚C for powdered coal gave the following values: 1354.0 mg/g to 1716.5 mg/g and 2459.5 mg/g to 2546.5 mg/g. Similarly, for granular coals activated at 400˚C and 700˚C,

the values are 2378.7 mg/g to 2413.0 mg/g respectively. Finally, we note that powdered activated coals (PAC) have a higher iodine value than grain activated coals (GAC) for the concentrations used. This study shows that the shells of *mango* kernels can serve as raw materials for the production of adsorbents with porosity elevated and can be used for the removal of small particles or molecules of small molecular weight during the production of drinking water, wastewater treatment and would strongly contribute to the success of the sanitation operations of the city of Mamou organized by the authorities and NGOs to fight against environmental pollution.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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