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Production of biochar from moringa as an adsorbent for contaminants in water

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Abstract

Biochar from moringa (*Moringa oleifera*) has been considered one of the most important natural adsorbents available, since its residues, such as bark, pods, stems, leaves, and seeds, can be used as biomass for the production of biochar. The use of moringa for this purpose is advantageous due to its availability, low cost, and adequate chemical composition for producing an efficient biochar. In this context, the present study aims to make biochar from moringa biomass (stem, bark, and pods), to use as an adsorbent for nitrate present in water. To achieve these objectives, the TG/DTG for each part of the moringa was analyzed and from this result, the temperature of 350°C was adopted for biochar production. Thus, this study can contribute significantly to developing sustainable and efficient solutions for water purification, using a renewable and abundant resource.

Keywords: Adsorbent; moringa oleifera; water decontamination; nitrate;

1. Introduction

Agricultural waste is disposed of in large quantities every year by many countries as the population grows. The disposal of this waste leads to environmental pollution and causes various health problems for living organisms, including human beings. In view of the problems emanating from the careless disposal of biomass in the ecosystem, there is an urgent call for the optimal use of biomass to reduce various environmental problems, ranging from greenhouse gas emissions to pollution, leaching of nutrients from the soil and the pandemic [1,2].

Biochar is an efficient and low-cost adsorbent, which can be produced from a variety of biomass. It is produced through the thermal treatment of biomass, one of the alternatives for which is pyrolysis, which is a thermochemical process for decomposing biomass in an oxygen-free or low-oxygen environment. The properties of biochar depend on the characteristics of the biomass used, the temperature used, the use of activating agents and the conditions of the activation process [3].

Moringa oleifera stands out among the biomass possibilities for biochar production, as the residue from its cultivation is made up of fresh pods, leaves, roots, seeds and seed casings. Moringa's ease of adaptation and its socio-environmental potential have attracted the attention of researchers and farmers in various parts of the world, and it can be grown without major obstacles by family farmers [4].

The interest in biochar is based on its diversity of applications, which can be used to adsorb metals/metalloids and purify water [5,6,7]. In order to avoid environmental and human health impacts, the Ministry of Health, through Consolidation Ordinance No. 5 of 2017, established, among the potability standards for water supplies, the maximum permitted concentration of nitrate [$N^-NO_3^-$] at 10 $mg.L^{-1}$ [8].

Therefore, this growing concern regarding efficient and economical technologies for removing organic and inorganic contaminants from water has made adsorption using biochar a proposal of relevant scientific and technical interest, considering that the raw material for producing these materials is highly available, in addition to being effective for many varieties of contaminants [9].

In this context, this preliminary work aims to study the production of biochar from moringa biomass in order to enable its use as an adsorbent for nitrate in water.

2. Materials and methods

For the purposes of the research, the stem, pod and seed husks of Moringa oleifera, grown in the semiarid region of Rio Grande do Norte, were used. The seeds were removed from the pod, which was separated and peeled manually. The materials were initially dried in an oven with air circulation at an average temperature of 110 °C for 12 hours to remove moisture, separately. The dry residue was crushed in a knife mill and then sieved through a 32-mesh sieve to standardize the granulometry.

Thermogravimetric analysis (TG/DTG) was performed on the biomasses in order to study the moisture content, volatile matter, fixed carbon content and ash in natura samples of the stem, pod and seed shells of Moringa oleifera. For this purpose, a Netzsch TG/DTG thermobalance (Model STA 449 F3 Jupiter) was used and the biomasses were subjected to a continuous flow of N_2 with a flow rate of 60 mL/min, heating rate of 10 °C per minute from 30 to 900 °C.

3. Results and discussion

For the production of biochar, the waste must undergo a thermal treatment known as slow pyrolysis, the most commonly used thermochemical conversion technology, which involves the thermal decomposition of organic components under an inert or oxidizing atmosphere at a controlled temperature [10].

To determine the ideal carbonization temperature, thermogravimetric tests (TGA) and differential thermal analysis (DTG) are performed, where it is possible to observe the thermal degradation of the synthesized material. Thermogravimetric analyses measure the mass losses in a material as a function of temperature, under a controlled, generally inert atmosphere, identifying the relationship between weight changes and volatilization of sample components, decomposition, oxidation/reduction reactions or other changes [11].

The literature shows that the seed and pod in natura have been studied as adsorbents for the removal of various contaminants [12,13]. Due to their characteristic compositions, a thermogravimetric test was performed to determine the carbonization temperature, the result of which is presented in Figure 1 for the stem, seed shells and pod of the moringa.

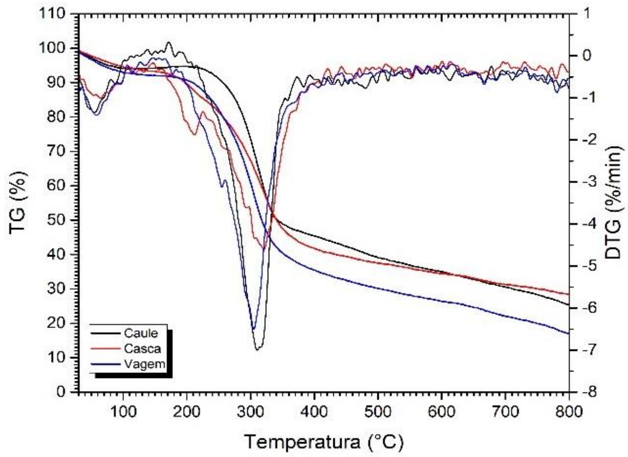

Fig. 1. TG and DTG of *Moringa oleifera*.

With these TG/DTG results, it is possible to observe that the stem, the shells and the pod present a first mass loss event before 100 °C, an event that would be related to the loss of moisture in the biomass. For the three samples, it is also possible to observe that above 300 °C, the last and most relevant event (in terms of mass loss) occurs, which would be related to the decomposition of lignin and combustion of biomass, the stage at which biochar is formed [14]. Based on this result, the temperature of 350 °C was adopted for the production of biochar that will be studied as an adsorbent for water contaminants. In addition, other information was considered in this study, such as production yield, FTIR analyses to prove the occurrence of functional groups and scanning electron microscopy analyses.

4. Conclusion

Based on this study, it is possible to know the production parameters of biochar from moringa and thus obtain an adsorbent with characteristics that allow its use as an adsorbent for contaminants present in water, such as nitrate. It is important to highlight that this is only a preliminary study and that it will serve as a basis for the development of other studies.

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