# Synthesis, characterization and application of biochar from dyeing sludge in the removal of dyes


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## Introduction

Biochar is produced from the pressed sludge collected in an industrial laundry wastewater treatment plant (WTP) and applied in the WTP itself to improve pollutants removal.

Currently, the sludge generated by physico-chemical treatment is pressed and sent to landfill, which causes high disposal costs for the company, reaching 21,000 Brazilian Reais in 2019.

**Figure 1: Textile wastewater treatment plant (WTP) at Joanópolis city – São Paulo State - Brazil**

**Figure 2: Textile WTP pressed sludge**

Biological treatment was tried in the past in this company, however did not have a satisfactory result, adding the complexity of the operation, it was discontinued.

The conversion of these residues into charcoal for use as an adsorbent in wastestreams treatment is a trend and a promising alternative from an economic and environmental point of view.

## Results & Discussion

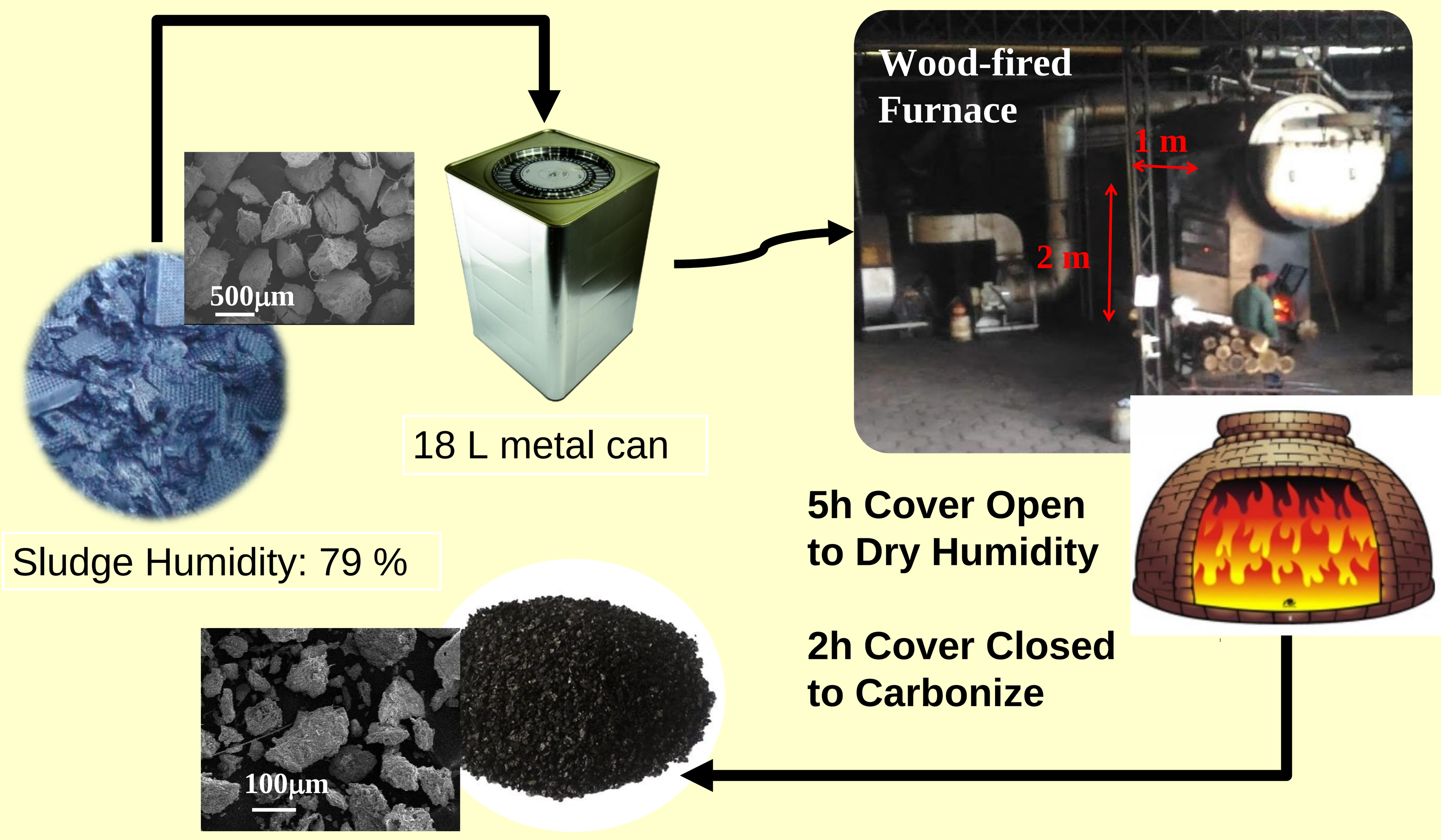


**Figure 3: Textile sludge To Biochar synthesis Flow**

Carbonization was performed in a wood-fired furnace, simulating the existing Boiler at the Laundry plant. Pressed sludge was deposited inside a metal can, and first dried for 6 h uncovered, and then sealed and carbonized for 2 h.

A high percentage of Al (14.6%) was detected by SEM-EDS, which is due to the aluminum polychloride coagulant added to the wastewater treatment. Mn (0.18 %) and K (0.40 %) were also detected, corresponding to potassium permanganate used at the textile processing.

Obtained biochar has 70 % of the particle size larger than 0.212 mm, considered a coarse material. Biochar was applied in the laundry wastewater adsorption without size separation or any other further treatment.

**Table 1. Textile Sludge and Biochar Pore Surface Area ($m^2 g^{-1}$)**

| Reference | Sludge | Biochar |
|---|---|---|
| This work (BET) | 70 | 176 |
| Wong (2018) $H_2SO_4$ activated (BJH) | 90 | 221 |
| Kaçan (2016) KOH activated (BJH) | 9 ~27 | 336 |

**Table 2. Textile Sludge Biochar Surface Functional groups**

| Surface groups | ($mmol g^{-1}$) |
|---|---|
| Total acidity | 3.93 |
| Carboxylic | 2.72 |
| Lactonic | 1.05 |
| Phenolic | 0.16 |
| $pH_{PZC}$ | 6.7 |

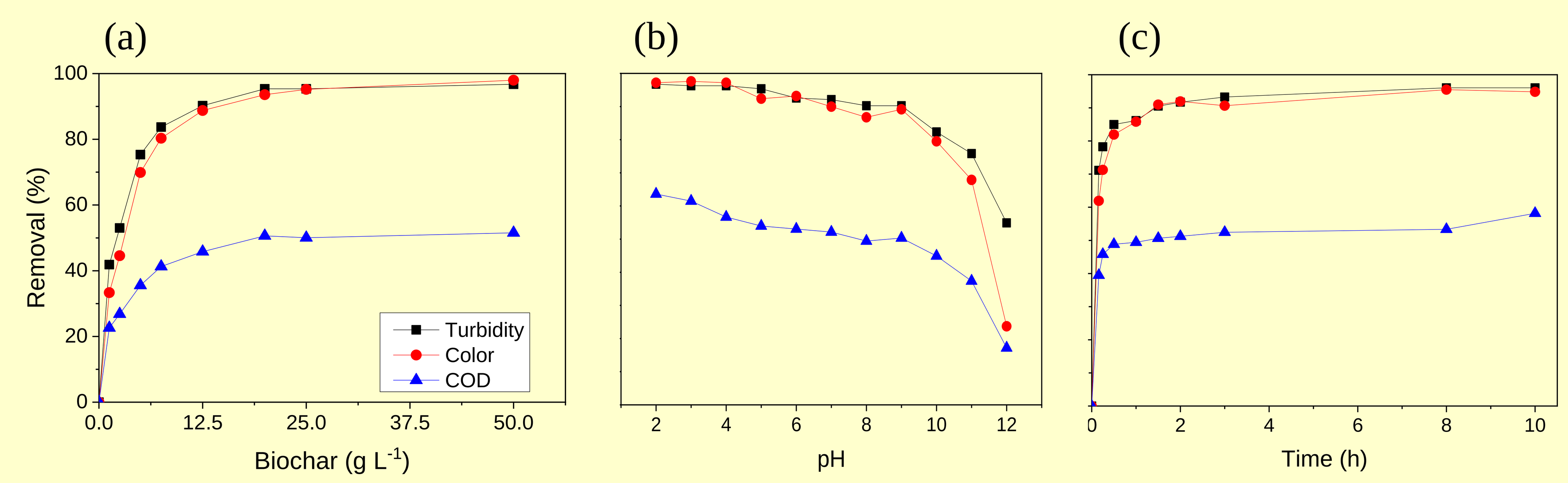


**Figure 4: Turbidity, Color (452 nm) and COD removal rate, under room temperature accordingly to (a) Biochar mass variation; (b) pH variation; (c) kinetics at pH = 6, 16 $g_{biochar}$ / $L^{-1}{}_{wastewater}$**

**Starting condition of the real Textile Laundry Wastewater:**

**Turbidity: 499 NTU**
**COD: 1,659 mg $L^{-1}$**

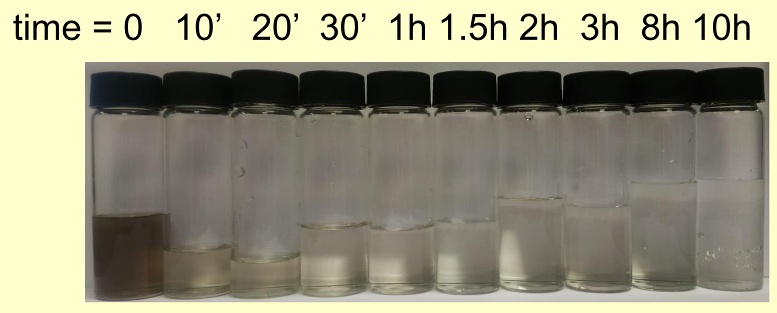


**Figure 5 : Real Textile wastewater aliquots during adsorption kinetics by biochar at pH 6, room temperature**

For pH values above 6, the removal rate dropped quickly, leading to only 17% Chemical Oxygen Demand (COD), 55% turbidity and 23% color removal at the pH 12. This result matches the biochar's PZC of 6.7, since at pH values below that, the biochar is positively charged facilitating the adsorption of negative species such as anionic reactive dyes, which are the most commonly used dye in textile industries.

## Conclusions

The biochar produced from the laundry WTP sludge, without any reagent addition, showed a high pore development with 56 % mesopores. A condition commonly only achieved with a strong chemical activation.

As it was used a real WTP wastestream, with a combination of dye types and other pollutants, it is not possible to measure dye concentration, therefore COD was used as the parameter for removal rate. Optimal adsorption condition was pH =6, a biochar rate of 16 g $L^{-1}$ and contact time between 30 min and 2 h.

The sludge carbonization is an interesting process because in addition to decreasing the volume of the material, it increases the stability of metal leaching, mitigating the risks of environmental pollution, as well as valorizing the residue that can be applied as adsorbent. Moreover, it can be produced inside the industrial laundry plant itself, using the waste heat source from the boilers.

## References


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