Optimization of secondary wastewater treatment with biochar-based vertical-flow wetlands

- **Aim:** Our work focused on optimizing parameters such as biochar type, feedstocks, preparation conditions, placement of biochar substrate and percentage (%) of biochar in the substrate, in order to improve treatment performance of vertical flow constructed wetlands.

First study: Optimizing wastewater treatment using different concentrations of biochar-based column filtration systems.

- The main objective of this study is to determine the suitable position of biochar substrate and the optimal concentration of biochar in the filter substrate.

- **First section**: Critical overview of current literature (https://doi.org/10.1016/j.ecoleng.2023.106927)

According to this study, the optimal position of biochar is placing as interlayer substrate between two layers of inert materials, to avoid clogging of the filtration system or biochar flotation.

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Review

A critical review on using biochar as constructed wetland substrate: Characteristics, feedstock, design and pollutants removal mechanisms

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- **Second Section: Experimental**

The wastewater used in these experiments was collected from the primary settling stage of the wastewater treatment plant of Marrakech (Morocco), which treats mixed domestic-textile wastewater.

The experimental set-up was installed in our laboratory at the Department of Biology of the University of Cadi Ayyad (Laboratory of Water, Biodiversity and Climate Change, Faculty of Sciences Semlalia, Marrakech).

In this study, the settled wastewater was treated using four column filtration systems (CFSs) filled with coarse sand and biochar, the latter as an interlayer substrate at the percentages of 10%, 25%, and 50%, to explore the effect of biochar concentration on treatment performance. A CFS was implemented with coarse sand only as control. In detail, the filters are 30 cm high, with two gravel layers of 8 cm, one at the top (2–6 mm diameter) and another at the bottom of the filter (2–8 mm diameter) as a drainage layer. The four CFSs consist of polyvinyl chloride (PVC) with an internal diameter of 7.5 cm, a surface area of 0.004 m², and a total height of 45 cm each (**Figure 1**).

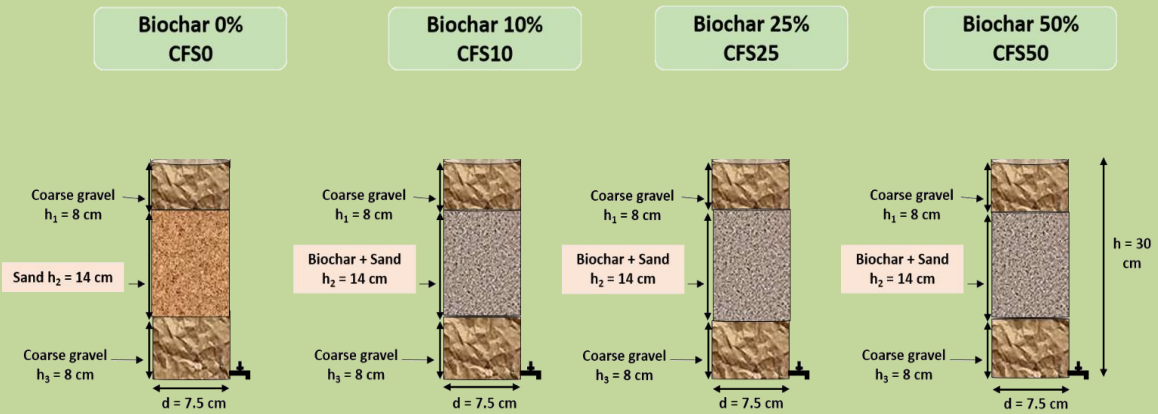

Figure 1 – Experimental device of filtration columns.

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The biochar was obtained from exhausted olive pomace using a semi-pilot scale pyrolysis furnace, at a temperature of 590 °C and maintained for a residence time of 2h with a heating rate of 10 °C/min.

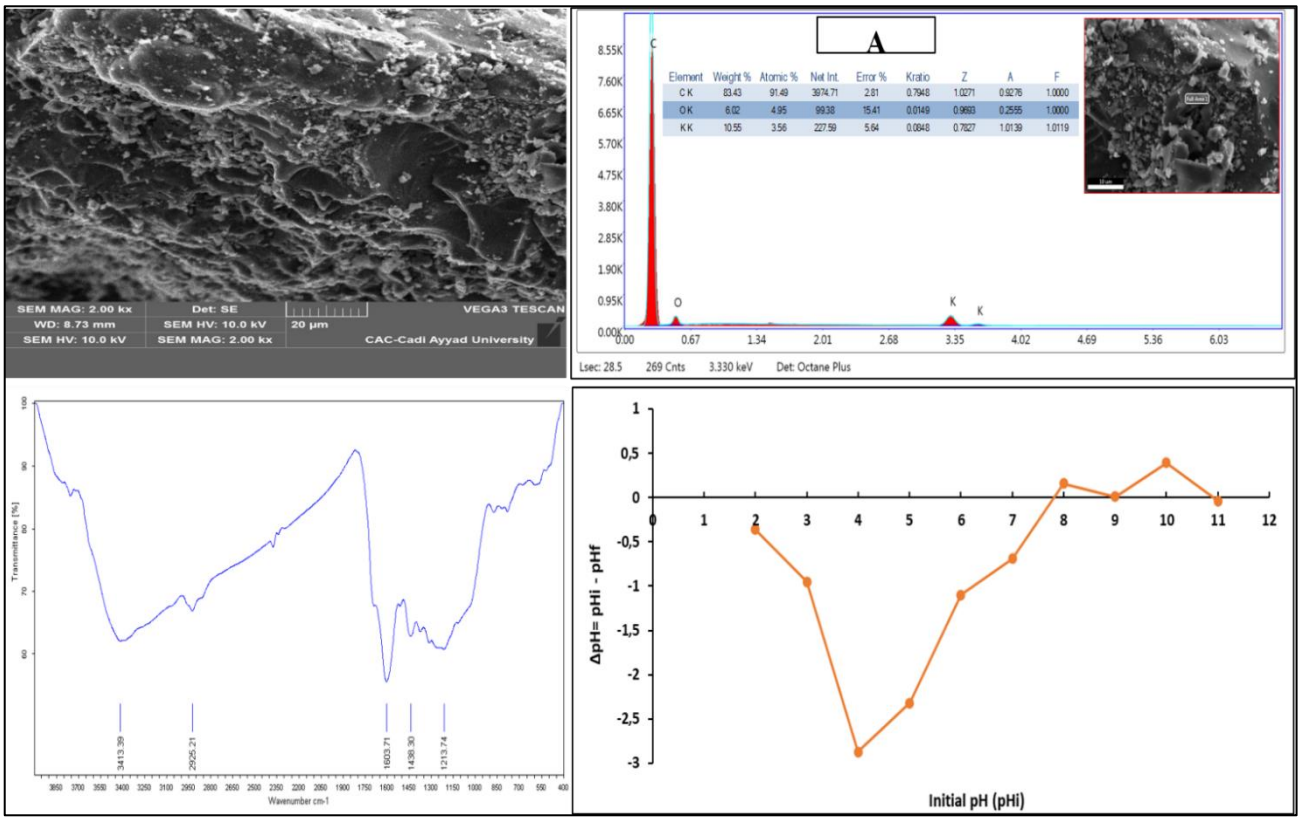

Figure 2 – Surface characteristics of biochar.

All CFSs operated with a sequential filling and emptying mode (3 batches/day), with a total volume of 1 L/day, and an organic loading rate of about 51 g of COD/m²/day. All CFSs operated with a sequential filling and emptying mode (3 batches/day), with COD/Conventional parameters (i.e., pH, electrical conductivity, total suspended solids (TSS), total and dissolved chemical oxygen demand (TCOD; DCOD), TKN, NH_4^+-N, NO_2^--N, NO_3^--N, TP, PO_4^{3-}, SO_4^{2-}, Ca, Mg, and total hardness (TH), as well as absorbances at 254 and 420 nm were weekly determined. In addition, bacteriological analyses of fecal bacteria indicators (total coliforms (TC), fecal coliforms (FC), fecal streptococci (FS)), the pathogen Staphylococcus (SP), and total aerobic mesophilic flora (TAMF) were carried out.

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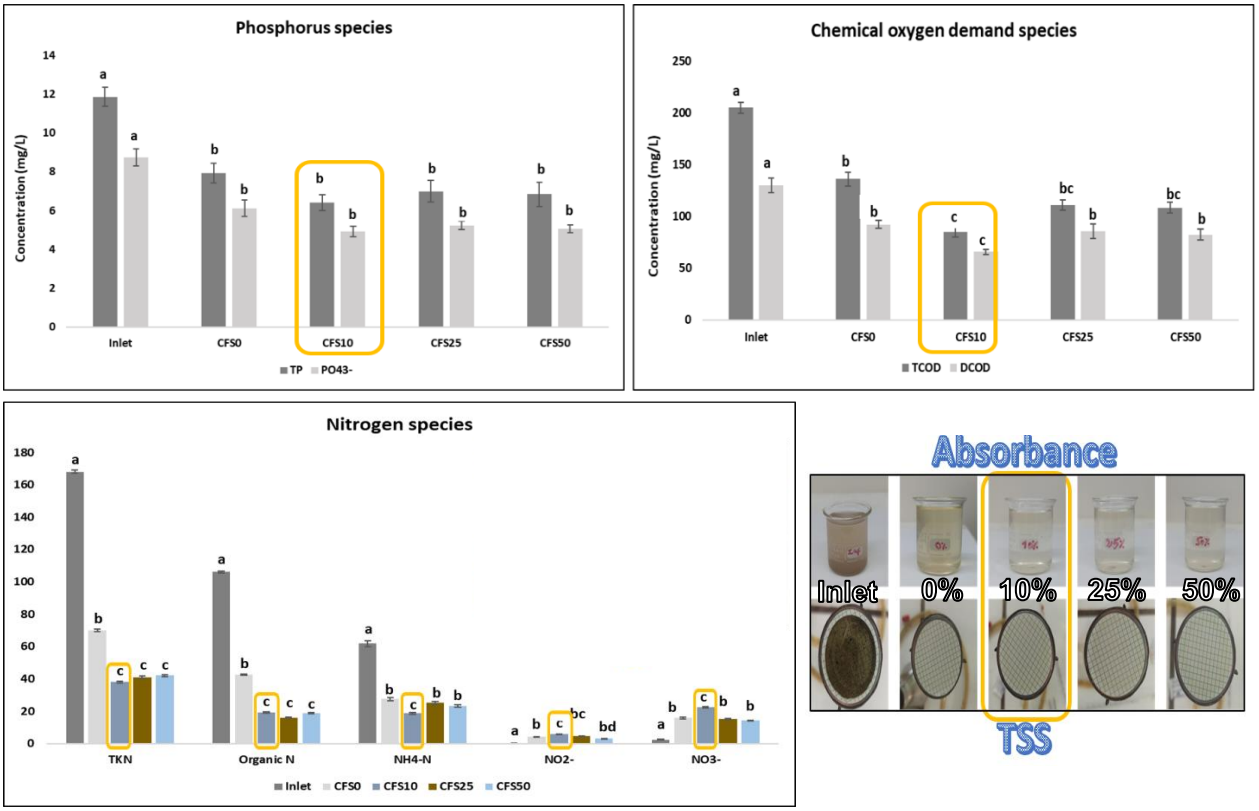

Figure 3 – Overview of the results obtained for conventional parameters.

Based on this study:

- The addition of biochar to sand media showed a significant improvement in removal performance of pollutants in CFS, compared to control filter-based sand.
- The best results were obtained with a lower concentration of biochar (10%), which resulted in a better removal rate.
- Higher amounts of biochar did not consistently improve treatment performance.

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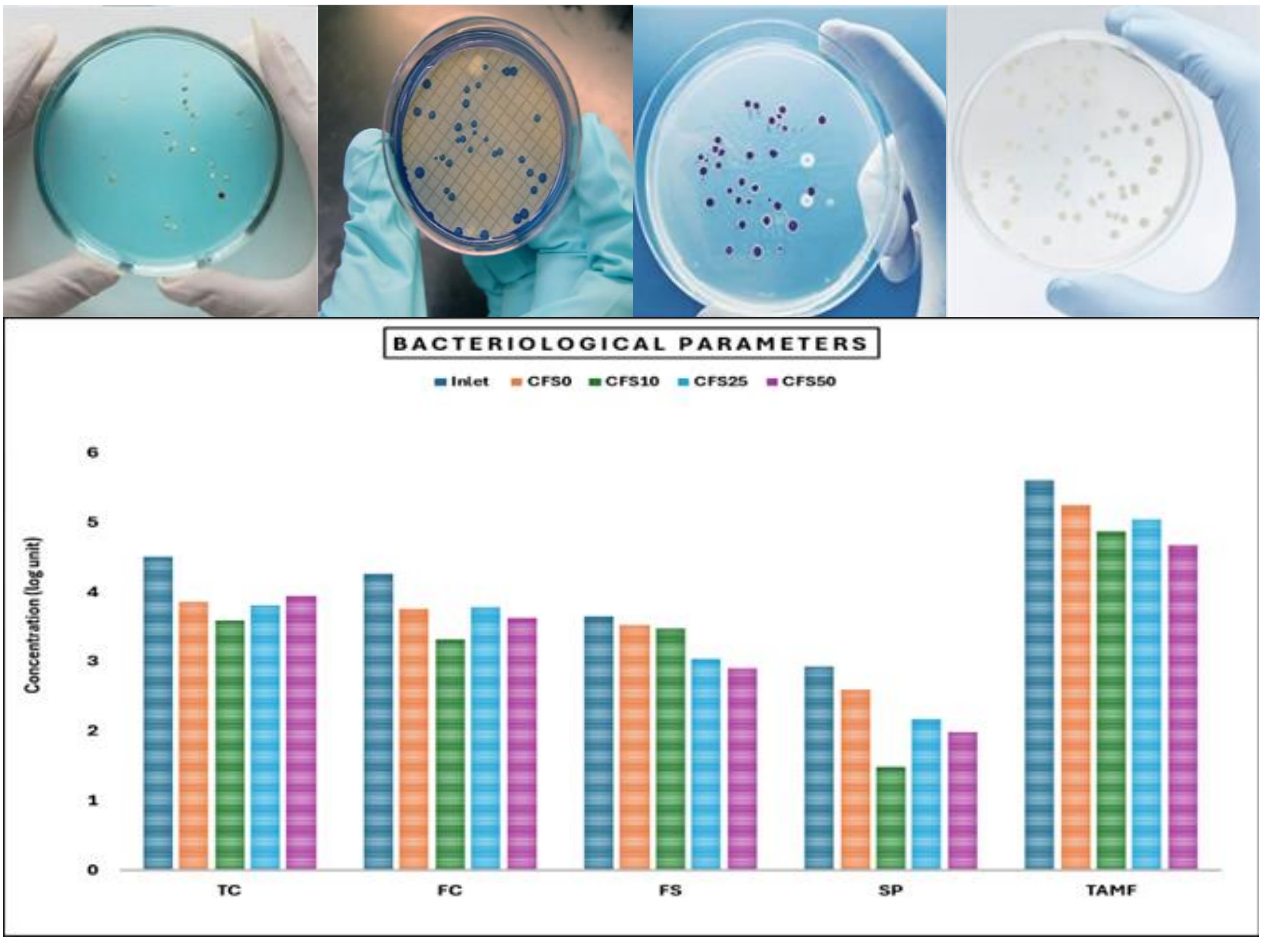

Figure 4 – Overview of the results obtained for bacterial indicator and pathogens.

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