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Removal of Hexavalent Chromium from Wastewater: A Column Filtration Study Using Date Palm Stems

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ABSTRACT

The primary objective of this study is to propose an environmentally friendly and cost-effective method to eradicate hexavalent chromium Cr(VI) from the wastewater at the Ben Chaabane treatment plant, located in Blida state, Algeria, using an agro-industrial by-product: Date stems. This innovative approach seeks to capitalize on readily available and economically viable materials for wastewater treatment. The investigation focused on optimizing various experimental parameters, including contact time, solid support height, and feed rate, to maximize the efficiency of Cr(VI) removal in a dynamic setting using a fixed bed of Date stems. Our research findings indicate that the process can eliminate Cr(VI) with a remarkable efficiency exceeding 90%. Specifically, after a contact duration of 90 minutes, coupled with operational conditions of a 1 cm fixed bed height and a 1 ml/min feed rate, the Cr(VI) removal efficacy reached an astounding 99.26%, corresponding to a residual concentration of 0.031 mg/L. This value is significantly below the Algerian discharge standard of 0.1 mg/L. Given these encouraging results, our study offers a viable and practical solution to address the challenge of heavy metal contamination in wastewater at the Ben Chaabane treatment facility.

Keywords: Hexavalent chromium Cr(VI), Wastewater treatment, Date stems, Experimental parameters, Removal efficiency.

1. Introduction

Water contamination, primarily from the release of untreated wastewater, contains toxic compounds, posing environmental and health hazards. Proper disposal and treatment are essential, employing various techniques in wastewater plants [1]. Urban and industrial effluents carry diverse pollutants, requiring comprehensive treatment approaches [2]. Numerous processes, including membrane filtration and ion exchange, are explored for chromium removal [3]. Adsorption offers an effective method for heavy metal removal, with activated carbon being a prominent technique [4]. Physicochemical methods, notably activated carbon adsorption, play a vital role in metal elimination processes. This study aims to investigate the potential of date stalks for hexavalent chromium removal in wastewater treatment.

2. Experimental

This experimental study utilized sophisticated laboratory equipment and various reagents for precise investigation. Specialized instruments like a desiccator, oven, grinder, sieves, pH meter, UV-Visible spectrophotometer, and centrifuge were employed. Procedures were meticulously conducted, including dissolution, filtration, and analyses using pH meter and UV-visible spectrophotometer, offering insights into hexavalent chromium treatment. The intricate process of preparing solid support from date stalks involved drying, washing, cutting, grinding, and sieving to achieve finely processed particles (Figure 01(a)).

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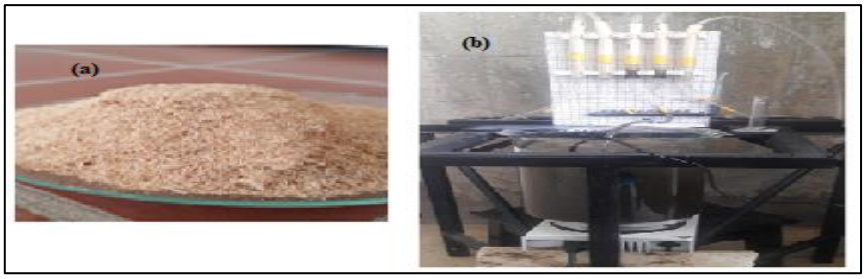

Figure 1: a): Crashed date pedicels; (b): Experimental setup designed for column tests

Column experiments utilized glass columns filled with crushed date pedicels, maintaining a continuous upward flow of chromium-containing wastewater for analysis (Figure 01(b)).

3. Results and Discussion

Characterization of date stem adsorbents (pHzpc at 7.8, FTIR, XRD) provided insights into their properties [5-6]. Dynamic analyses illustrated the effects of contact time, bed height, and flow rate on Cr(VI) retention. An optimal bed height of 1 cm reached equilibrium in 90 minutes, with a flow rate of 10 ml/min balancing efficiency [7-8]. These findings offer practical guidance for wastewater treatment (Figures 2(a) and 2(b)).

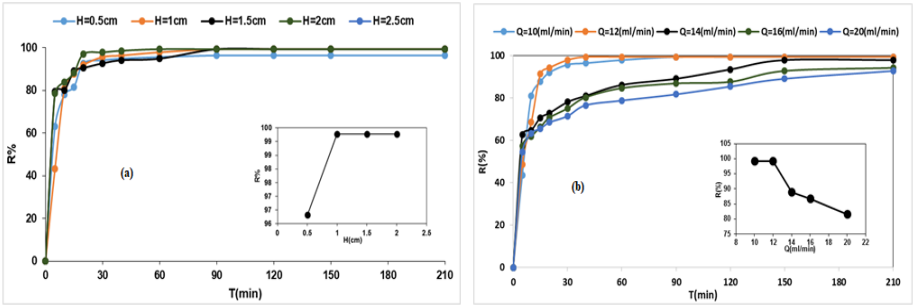

Figure 2: (a): Effect of adsorbent height of Cr(VI) removal (Q=10 ml/min); (b): Effect of feed rate on Cr(VI) removal rate (H=1cm)

4. Conclusions

The study highlights the rapid adsorption of Cr(VI) by date stalk support initially, with equilibrium reached after 90 minutes for lower flow rates and 120 minutes for higher ones. An inverse relationship between feed rate and removal efficiency is observed, with optimal removal at 10 ml/min. Higher flow rates lead to quicker bed saturation due to reduced interaction time, underscoring the critical role of flow rate in optimization. A 10 ml/min flow rate emerges as the most effective for Cr(VI) removal using crushed date stems, offering essential guidance for wastewater treatment. This research contributes to developing efficient methods for treating chromium-contaminated water, benefiting environmental protection and public health.

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