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Abstract

Unveiling the Efficiency of Biodegradable Chitosan-Based Hydrogel Composites for Wastewater Treatment †

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Abstract: This work presents the efficiency of interpenetrated chitosan-based hydrogels (IPNs) in the treatment of WW in a laboratory micro-pilot device which allowed both the use of a larger volume of compounds and an improved stirring of the samples throughout the test period.

Keywords: hydrogels; wastewater; chitosan; bacteria and pathogens removal

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Introduction: Over the past few decades, the expansion of industrial activity has involved significant challenges for urban environments, primarily stemming from inadequate management of wastewater (WW) resulting from various manufacturing processes. Industries such as paint, battery production, food processing and pharmaceuticals have been particularly implicated in this issue. The discharge of contaminated effluents from these sectors poses a substantial threat to both the environment and human health. This threat is multifaceted, as it involves the introduction of a range of pollutants into the ecosystem [1]. These pollutants can encompass heavy metal ions, organic solvents, dyes and even antibiotic-resistant bacteria. As these contaminants infiltrate the environment, they can have far-reaching consequences, potentially entering the food chain and causing harm to aquatic ecosystems. The need for comprehensive solutions to address this pressing environmental concern is evident, as it underscores the urgent necessity for effective WW management strategies within the industrial sector [2]. Hence, various methods have been employed to eliminate these types of contaminants, and, nevertheless, absorption has been recognized as one of the most efficient techniques due to its simplicity of operation and exceptional effectiveness [3]. As previous studies suggest [4], interpenetrated chitosan-based hydrogels (IPNs) have been used as potential WW treatments, thanks to their customizable attributes and remarkable absorption capabilities. Accordingly, this work presents the efficiency of the materials in the treatment of WW in a laboratory micro-pilot device, which allowed both the use of a larger volume of compounds and an improved stirring of the samples throughout the test period. The samples have been subjected to the first purification cycle, evaluated, reconditioned and then reused in a second purification cycle. In order to recondition chitosan-based materials, a purification process similar to the purification

step after the synthesis of hydrogels was used, following the same principle of the diffusion of harmful compounds retained from the 3D polymer network.

Materials and Methods: The new chitosan-based composite materials containing two types of chitosan (CC—commercial and SHC—extracted from shrimp shells) have been used in two cycles of WW treatment by putting them in contact with WW from an industrial source for 24 h in a laboratory micro-pilot device under continuous stirring. After the first evaluation of the bacteriological indicators, the materials were reconditioned and reused in the same conditions.

Results: The first bacteriological evaluation of the composite hydrogels indicates a decrease of 68–70% in the Gram-positive bacteria population and a decrease of 60–80% in the Gram-negative bacteria population. After reconditioning, the evaluation indicates a rather small value of almost 45% decrease in Gram-positive bacteria and almost 32% decrease in Gram-negative bacteria populations.

Conclusions: The samples presented a high affinity towards retaining both Gram-negative and Gram-positive bacteria from an industrial WW source. The reconditioning stage was carried out successfully, thus ensuring the ability to reuse the new materials in several treatment cycles. The obtained results mark impressive antibacterial potential and assure a promising application for the future of wastewater treatments.

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