Desalination and Water Treatment
www.deswater.com

doi: 10.5004/dwt.2021.27825

241 (2021) 146–158
November

Improvement of the coagulation–flocculation process using graphene oxide for ciprofloxacin removal from surface water

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Received 9 February 2021; Accepted 12 September 2021

ABSTRACT

For the first time, the effect of the chemical reduction of graphene oxide (GO) on the adsorption of ciprofloxacin (CIP) was investigated. Furthermore, GO was applied in the coagulation–flocculation process for CIP adsorption from surface water. Moreover, the application of Fe_3O_4 for enhancing sedimentation rate and reducing sludge volume was investigated. The results showed that the functional groups of GO have a significant impact on the adsorption of CIP, and chemical reduction of GO resulted in reducing the adsorption capacity. The analysis of variance showed that the quadratic model was consistent with the experimental data. Furthermore, pH and GO dosage were more effective than $FeCl_3{\cdot}6H_2O$ in removal efficiency. Under the optimum conditions (GO dose: 0.08 mg L^{-1}, pH: 6.0, and $FeCl_3{\cdot}6H_2O$:10 mg L^{-1}) removal efficiency of 83.1% was achieved for the sample containing10 mg L^{-1} of CIP. The adsorption efficiency increased by increasing total dissolved solids to 800 mg L^{-1}. The maximum removal efficiency of 95.3% was achieved at the contact time of 15 min The Langmuir isotherm model was able to predict the experimental adsorption data and indicated a maximum capacity of 185 mg g^{-1}. The sedimentation kinetic data were appropriately fitted to the pseudo-first-order model. Finally, the reusability of the absorbent was studied, and the results showed a 65% reduction in removal efficiency after three cycles. In conclusion, the application of graphene oxide in the coagulation–flocculation process enhances the performance of the unit for adsorption of ciprofloxacin. Furthermore, the magnetite nanoparticles have a significant impact on the reduction of sludge volume and increase sedimentation rate.

Keywords: Graphene oxide; Ciprofloxacin; Coagulation–flocculation; removal; Surface water

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