Removal of selected non-steroidal anti-inflammatory drugs from wastewater using reduced graphene oxide magnetite

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\textbf{A B S T R A C T}

The efficiency of reduced graphene oxide magnetite (rGOM) to remove selected non-steroidal anti-inflammatory drugs from wastewater at high concentration was evaluated. Diclofenac sodium (DCS) and aspirin (ASP) were chosen as target pharmaceuticals due to their common persistency in wastewater. rGOM was prepared to form graphene oxide (GO) using a one-step procedure where the reduction of GO and attachment of Fe\textsubscript{3}O\textsubscript{4} particles to the surface of GO was carried out simultaneously. rGOM showed very good efficiency with percent removal of 98.5\% and 90.5\% at the optimum conditions for ASP and DCS, respectively. The optimum condition for removal of DCS is adsorbent dosage 14 g L\textsuperscript{-1}, the contact time of 40 min, and a pH of 5.0. While the optimum conditions for ASP are adsorbent dosage 16 g L\textsuperscript{-1}, contact time 40 min, and a pH of 3.0. The adsorption process was evaluated through different adsorption isotherm and kinetic models. Langmuir isotherm model was found to be the best fitting for DCS adsorption with \(Q_m\) and \(K_L\) values of 12.95 mg g\textsuperscript{-1} and 0.091 L mg\textsuperscript{-1}, respectively. On the other hand, ASP removal was best described by the Freundlich isotherm model with \(K_F\) and \(n\) values of 5.95 and 2.49, respectively. Both processes showed fast kinetics. Thermodynamic properties were calculated using the Sips isotherm model. The adsorption of both drugs was found to be spontaneous with a negative value of Gibbs free energy and positive enthalpy change indicating that the adsorption process was endothermic. Continuous fixed-bed column adsorption was performed, and the data were fitted using different isotherm models and it was observed that adsorption of DCS follows Yan model while adsorption of ASP is described by Bohart–Adams model. A regeneration study was carried out which showed that the removal efficiency was still significant for both ASP and DCS even after three cycles.

\textbf{Keywords:} Pharmaceuticals; Diclofenac sodium; Aspirin; Reduced graphene oxide magnetite

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