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A Magnetic Hydrochar Nanocomposite as a Potential Adsorbent of Emerging Pollutants

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Abstract : Water pollution is of worldwide concern due to its importance as an essential resource for life. Industrial and urbanistic growth are anthropogenic activities that have caused an increase of undesirable compounds in water. In the last decade, emerging pollutants have become of great interest since, at very low concentrations (µg/L and ng/L), they exhibit a hazardous effect on wildlife, aquatic ecosystems, and human organisms. One group of emerging pollutants that are a matter of study are pharmaceuticals. Their high consumption rate and their inappropriate disposal have led to their detection in wastewater treatment plant influent, effluent, surface water, and drinking water. In consequence, numerous technologies have been developed to efficiently treat these pollutants. Adsorption appears like an easy and cost-effective technology. One of the most used adsorbents of emerging pollutants removal is carbon-based materials such as hydrochars. This study aims to use a magnetic hydrochar nanocomposite to be employed as an adsorbent for diclofenac removal. Kinetics models and the adsorption efficiency in real water samples were analyzed. For this purpose, a magnetic hydrochar nanocomposite was synthesized through the hydrothermal carbonization (HTC) technique hybridized to co-precipitation to add the magnetic component into the hydrochar, based on iron oxide nanoparticles. The hydrochar was obtained from sunflower husk residue as the precursor. TEM, TGA, FTIR, Zeta potential as a function of pH, DLS, BET technique, and elemental analysis were employed to characterize the material in terms of composition and chemical structure. Adsorption kinetics were carried out in distilled water and real water at room temperature, pH of 5.5 for distilled water and natural pH for real water samples, 1:1 adsorbent: adsorbate dosage ratio, contact times from 10-120 minutes, and 50% dosage concentration of DCF. Results have demonstrated that magnetic hydrochar presents superparamagnetic properties with a saturation magnetization value of 55.28 emu/g. Besides, it is mesoporous with a surface area of 55.52 m^2/g. It is composed of magnetite nanoparticles incorporated into the hydrochar matrix, as can be proven by TEM micrographs, FTIR spectra, and zeta potential. On the other hand, kinetic studies were carried out using DCF models, finding percent removal efficiencies up to 85.34% after 80 minutes of contact time. In addition, after 120 minutes of contact time, desorption of emerging pollutants from active sites took place, which indicated that the material got saturated after that t time. In real water samples, percent removal efficiencies decrease up to 57.39%, ascribable to a possible mechanism of competitive adsorption of organic or inorganic compounds, ions for active sites of the magnetic hydrochar. The main suggested adsorption mechanism between the magnetic hydrochar and diclofenac include hydrophobic and electrostatic interactions as well as hydrogen bonds. It can be concluded that the magnetic hydrochar nanocomposite could be valorized into a by-product which appears as an efficient adsorbent for DCF removal as a model emerging pollutant. These results are being complemented by modifying experimental variables such as pollutant's initial concentration, adsorbent: adsorbate dosage ratio, and temperature. Currently, adsorption assays of other emerging pollutants are being been carried out.

Keywords : environmental remediation, emerging pollutants, hydrochar, magnetite nanoparticles
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