Temperature-induced modifications in sugarcane bagasse derived biochar: A sustainable solution for nanoplastic remediation

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Abstract

Plastic pollution is a global concern and a challenge to the society and scientific community. What's more serious is the degradation of large plastics into micro (MPs) and nanoplastics (NPs). MPs and NPs are emerging contaminants, which have been proved to be toxic to living organisms. Not only this, but most recent studies have indicated their role to act as potential vectors for other contaminants in the environment. Hence the remediation of MPs and NPs from the environment is the need of the hour. In this study, a common agricultural waste sugarcane bagasse has been converted into biochar by pyrolyzing at different temperatures i.e., 350, 550 and 7500C (BC-350, BC-550 and BC-750 respectively) and utilized for the remediation of NPs from aqueous environment. BC-750 showed $> 98\%$ removal of NPs unlike other two composites BC-550 and BC-350, which showed $< 45\%$ and $< 25\%$ removal, respectively. The highest removal in case of BC-750 was attributed to its high surface area, increased pore volume and least number of negatively charged carbonyl functional groups. The kinetic studies showed instantaneous removal of NPs with an equilibration time of < 5 minutes. Isotherm studies showed a maximum sorption capacity of 44.9 mg/g for BC-750. A better fit of pseudo 1st order removal kinetic model was obtained from non-linear-kinetic modelling while isotherm and thermodynamic modelling confirmed-sorption spontaneity and monolayer nature of NPs sorption. From the results that were obtained from the study of the effect of pH, humic acid and complex aqueous matrices on NPs sorption, it was concluded that enhanced electrostatic repulsion resulted in a decrease in NPs sorption at alkaline conditions, whereas at higher humic acid concentrations, steric hindrances caused limited removal. BC-750 also showed the minimal impact of competing ions on NPs sorption with complete removal in synthetic groundwater. From this study, we were able to conclude that pyrolysis temperature had a significant effect on the physicochemical properties of biochar which affected the sorption capacity of all the biochar types. Biochar can be a promising solution for the remediation of emerging contaminants like NPs.

Keywords: Nanoplastics, pyrolysis, remediation, biochar

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