FACTORS AFFECTING THE SORPTION OF PERFLUOROALKYL SUBSTANCES IN BIOCHARS AND OTHER CARBON-RICH BYPRODUCTS

Joel Fabregat, Chemical Engineering and Analytical Chemistry, University of Barcelona, Spain
joel.fabregat.92@gmail.com
Amaia Fernández-Iriarte, Chemical Engineering and Analytical Chemistry, University of Barcelona, Spain
Miquel Vidal, Chemical Engineering and Analytical Chemistry, University of Barcelona, Spain
Anna Rigol, Chemical Engineering and Analytical Chemistry, University of Barcelona, Spain

Key Words: Biochar, Carbon-rich byproducts, Sorption, Desorption, Perfluoroalkyl Substances

Biochar is the solid byproduct obtained after the pyrolysis process of biomass waste, and it is usually applied in agricultural soils to increase soil organic carbon, and improve soil structure and water retention, among other benefits. As long as it has been demonstrated that biochar successfully sorbs either organic and inorganic pollutants, the investigation of other potential applications, such as water remediation, are of increasing interest (1). Similarly, other carbon-rich byproducts such as compost or coal fines are supposed to have similar properties than biochar. In this study, the sorption properties of biochars of different characteristics have been investigated and compared with those of other carbon-rich materials. As target compounds, we have used perfluoroalkyl substances (PFASs), which are pollutants of concern because of their high bioaccumulation, extreme persistence and toxic properties, and widespread in different environmental compartments, among them soils and waters (2). Sorption parameters of seven PFASs with different perfluorinated chain length have been determined in biochar, compost and coal fines, using batch experiments according to the OECD 106 guidelines. Biochars of different biomass wastes were obtained by slow pyrolysis at 350^{o}C and a rate of 5^{o}C min^{-1}, achieving biochar yields between 40% and 90% depending on the feedstock (3). The effect of various experimental conditions (contact time, initial PFASs concentration, pH and composition of contact solution) in the sorption capacity of the materials was evaluated. Sorption was slightly faster for the long-chain PFASs, with more that 90% of sorption of PFNA in 24 h in all materials. For longer times, in almost all materials, a 100% of sorption was reached. Linear isotherms were obtained for all the PFASs in all materials in a wide range of concentrations, allowing the calculation of a solid-liquid distribution coefficient (K_d) and a solid-liquid distribution coefficient referred to the organic carbon of the material (K_{oc}) for every PFAS-material combination. Similarly, in a previous work (4), linear isotherms were also obtained for the same PFASs in soils, using similar experimental conditions. The sorption process in all matrices was considerably irreversible, especially for the long chain PFASs. The obtained log K_{oc} values for each PFAS in each material were successfully correlated with the number of CF_2 units of the alkyl chain and the log K_{ow} values of the PFASs, which suggest that hydrophobic interaction is the main mechanism controlling PFASs sorption in biochar and other carbon-rich materials. Moreover, the sorption of PFASs in the materials was negatively correlated with the dissolved organic carbon (DOC) of the aqueous solution, which was attributed to a competitive sorption process of PFASs with the dissolved organic matter. Therefore, materials with low DOC, as is the case of most biochars, are the best candidates for PFASs sorption. Low pH values and high cationic content of the aqueous solution also contribute to a decrease of DOC and, therefore, leads to optimum PFASs sorption in the material.

(1) M. Ahmad et. al. Biochar as a sorbent for contaminant management in soil and water: A review. Chemosphere 99 (2014) 19 – 33.
(2) K. Prevedouros, I.T. Cousins, R.C. Buck, S.H. Korzeniowski. Sources, fate and transport of perfluorocarboxylates. Environmental Science & Technology 40(1) (2006) 32 – 44.
(3) M.E. Doumer et. al. Slow pyrolysis of different Brazilian waste biomasses as sources of soil conditioners and energy, and for environmental protection. Journal of Analytical and Applied Pyrolysis 113 (2015) 431 – 443.
(4) J. Milinovic, S. Lacorte, M. Vidal, A. Rigol. Sorption behaviour of perfluoroalkyl substances in soils. Science of the Total Environment 511 (2015) 63 – 71.