Biosorption Technology: PFAS Removal in Water by the Use of Novel Carbonaceous Materials

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Background/Objectives. The acronym "PFAS" is an umbrella term used to describe a variety of ecologically persistent compounds of anthropogenic origin, in which the carbon chain can be fully (perfluoroalkyl substances) or partially (polyfluoroalkyl substances) fluorinated. Since the beginning of the XXth century, the use of PFAS in the industrial facilities grew rapidly up to the present days, leading to a loose inclusion in many products, along with an ubiquitous contamination. Because of their significant presence in many environmental compartments and highly long-lasting nature, over the years the scientific community had to deal with the possible adverse effects of PFAS on ecosystem and human health. In particular, several international guidelines for the presence of PFAS in drinking water has also been applied. Until now, the challenge regarding the removal of these compounds from the environment lied on the application of effective and viable in situ treatments. In particular, the adsorption technology is increasingly taking hold in remediation methods, due to the low-cost and easily manageable materials. Hence, the aim of this study was to implement this already acknowledged approach using novel and eco-friendly adsorbents (biochar of different origins) for the removal of PFAS in aqueous media.

Approach/Activities. This work investigated the removal of eight different PFAS (PFBA, PFBS, GenX, PFHxA, PFOA, PFOS, PFDA, PFTeDA) in aqueous solution by using adsorbents of carbonaceous material (pinewood and date biochar) on a laboratory scale. Adsorption technology consists of a physical mass transfer process involving weak forces to bind the targeted molecule to the surface area of the adsorbent elected. Unlike the well-known use of the pinewood type in literature, the date biochar used in this study is a new adsorbent deriving from a source of biomass vastly on hand, for which its exceptional physicochemical properties have been recently applied on the removal of contaminants. At first, batch sorption tests were carried out to evaluate the concentration at equilibrium (24 hours) for each substance in relation to the two biochars. Adsorption isotherms (Freundlich and Langmuir) and kinetic models (pseudo-first and pseudo-second order) were also attempted to assess the removal capacity of the two adsorbents. Subsequently, the impact of the sorption efficiency was also examined, taking into account pH, as a potential interfering parameter. All the samples of liquid phase collected were analyzed by a developed and then well-established method: i) pre-treatment in two steps (centrifugation and filtration); ii) determination through high-performance liquid chromatography coupled with mass spectrometry (HPLC-MS/MS).

Results/Lessons Learned. First results evidenced the already expected removal capacity of the biochar material for long-chain PFAS, as opposed to the short-chain ones. However, from the tests performed so far, the date biochar showed an enhanced adsorption towards every compound of choice. For this reason, it is realistic to assume that its characteristic morphology (e.g. porosity, particle size) and chemical structure (e.g. carbon skeleton, non-carbon elements) probably effect the interaction between the molecules and its large surface area. Such premises suggest how this biosorbent is extremely versatile as well as potentially suitable for a wide range of compounds. In the near future, the experiments should be evaluated on a broader variety of PFAS and focus on the practicability of a pilot system, in which the biosorption technology can also be eventually combined with other already successful remediation treatments.