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Synthetic biochar vs forest fire generated pyrogenic carbon: a comparison of physicochemical properties

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Pyrogenic carbon (PyC), commonly referred to as biochar, results from the thermal decomposition of organic materials at high temperatures and in low oxygen environments (known as pyrolysis). Commercial biochar, which is produced in industrial or laboratory furnaces, is pyrolyzed under constant temperatures, typically up to 700 °C, for long periods of time (up to ~6 hours). Biochar is also produced naturally during forest fires, where it burns at higher temperatures (up to 1200 °C) and for very short periods of time (176 s for temperatures >300 °C). While its commercial analogues are well studied, there is scarcity of data pertaining to forest fire derived biochar with respect to its chemical reactivity and composition. Here we investigated the differences in physicochemical properties of biochar produced during a natural forest fire with biochar produced using conventional laboratory furnace conditions. We sampled both unburnt biomass and forest fired derived PyC (FF-PyC) from 5 locations within a recent forest fire along the Western slope of Mount Hunter, near Golden, British Columbia, and compared the physicochemical properties of this FF-PyC with biochar produced in a standard tube furnace from unburnt biomass from the site of the fire. Properties including inherent types and number of reactive ligand sites, FTIR and Raman spectroscopy, pH, total surface reactivity, metal adsorption potential, CHNOS elemental composition, cation exchange capacity, mobility, as well as extracted nanoparticles inherent to the PyC were studied in both the laboratory biochar and FF-PyC, and compared. Fourier transform infrared (FTIR) and Raman spectroscopy was used determine the number and types of functional groups associate with ligand sites. Potentiometric titrations were performed and modelled with FITEQL to determine the acidity constants associated with each site and the total reactive surface area of both synthetic biochar and FF-PyC. Our results provide insights into the potential of FF-PyC as an alternative to synthetic biochar as an amendment tool as well as the conditions needed to produce biochar equivalent to FF-PyC in a laboratory setting, critical to understanding the factors in a fire that control carbon reactivity and PyC colloidal release into soils and groundwater.