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Understanding biochar-metal interactions using combined spectroscopic and surface complexation modelling approaches

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Pyrolytic carbon – often termed biochar – is produced naturally through fires and commercially for applications in agriculture, pollutant control, and carbon sequestration. The physicochemical properties of biochar, including its surface functionality and reactivity, vary considerably as a function of source biomass, pyrolysis temperature, heating rate, and the composition of the gas in which pyrolysis occurs. The extensive literature on metals binding to biochar shows it to be highly reactive; however, few of these studies have investigated the coordination environment of metals at the biochar surface and still fewer have developed models that can predict metal binding behaviors across a wide range of environmental conditions. Predicting the metals binding behavior of biochar in the environment is critical for both accurate estimates of its efficacy in water and soil treatment applications, and in understanding the role of pyrolytic carbon in transporting metals and nutrients now and in the geologic past. In this presentation, we discuss the application of X-ray and infrared spectroscopic approaches, combined with potentiometric and isothermal titration calorimetry, to understand metals binding at the surface of biochar. These data are used to inform the development of surface complexation models that can predict the speciation of metals at the biochar surface and in solution across a wide range of pH, solution ionic strength, and biochar-to-metal ratios. The framework we propose allows for the integration of experimental results from disparate empirical studies to predict metals adsorption by biochar across a broad range of solution chemistries.