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Colloidal dynamics of soil clay under the effect of fine-sized biochars: Implication for biochar amendment towards preventing clay loss and soil erosion

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In soils clay loss by leaching and surface runoff is one of the initial steps increasing the risk of erosion. Here we set out to determine the effect of fine-sized biochar amendment on colloidal dynamics of soil clay, with the aim of answering whether biochar addition enhances or curbs soil erosion. Fine-sized biochar samples were prepared from fern Dicranopteris linearis's biomass under non-biochar-oriented pyrolysis (open heating) and biochar-oriented pyrolysis (N_2-supported heating) over a temperature range from 400 to 900°C. The clay fraction (< 2 µm) separated from a clay-rich soil in a hilly area of the Red River basin containing relatively high amounts of kaolinite was tested for its dispersion properties under the presence of the prepared biochars. Surface charge of biochar-soil clay mixtures was determined by polyelectrolyte titration using a particle charge detector, while corresponding colloidal properties of the mixtures were examined by the test tube method. Both, the soil clay fraction and biochar samples showed strongly negative surface charge and their surface charge was variable depending on pH. In a pH range from 3 to 10 and at an electrolyte background of 0.01 M NaCl, surface charge of the clay fraction decreased from -1.68 to -44.75 $mmol_c\ Kg^{-1}$, while the biochars surface charge varied from -0.6 to -48.8 $mmol_c\ Kg^{-1}$. Soil clays were more strongly dispersed in the presence of biochars by increasing electrostatic repulsive forces. The biochar preparation method had a crucial role for surface charge properties of biochars and in consequence colloidal dynamics of biochar-clay mixtures. The N_2-supported pyrolysis at lower temperatures does not increase charge density but creates a more porous structure, thereby increasing the total negative net charges. As a result, the N_2-supported biochars favor clay dispersion more effectively, while the open-pyrolysis biochars showed lesser effects. Our results indicate that fine-sized biochar amendments generally enhance the risk of clay loss, however, such techniques for creating low-charged biochars can help to decrease clay dispersibility when applying biochar for soil.