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Kinetic characteristic of phenanthrene sorption in aged soil amended with biochar

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Biochar has been recently highlighted as an amendment that affects yield of the crops by increasing pH, cation exchange capacity and water retention, and reduces the lability of contaminants by increasing sorption capacity in the soil system. Biochar's physico-chemical properties, high CEC, surfaces containing abundant micropores and macropores, and various types of functional groups, play important roles in enhancing sorption capacity of contaminants. Aging through a natural weathering process might change physico-chemical properties of biochar amended in soils, which can affect the sorption behavior of contaminants. Thus, in this study, the sorption characteristics of phenanthrene (PHE) on biochar-amended soils were studied with various types of chars depending on aging time.

To do this, 1) soil was amended with sludge waste char (SWC), wood char (WC), and municipal waste char (MWC) during 0, 6, and 12 month. Chars were applied to soil at 1% and 2.5% (w/w) ratio. 2) Several batch kinetic and equilibrium studies were conducted. One-compartment first order and two-compartment first order model apportioning the fraction of fast and slow sorbing were selected for kinetic models.

Where, q_t is PHE concentration in biochar-amended soils at each time t, $q_e$is PHE concentration in biochar-amended soils at equilibrium. f_f is fastly sorbing fraction and (1-f_f) is slowly sorbing fraction. k is sorption rate constant from one-compartment first order model, k_1 and k_2 are sorption rate constant from two-compartment first order model, t is time (hr). The equilibrium sorption data were fitted with Fruendlich and Langmuir equation. 3) Change in physico-chemical properties of biochar-amended soils was investigated with aging time.

Batch equilibrium sorption results suggested that sorbed amount of PHE on WC was greater than SWC and MWC. The more char contents added to soil, the greater sorption capacity of PHE. Sorption equilibrium was reached after 4 hours and equilibrium pH ranged from 6.5 to 8.0. Sorption capacity was reduced with aging time. From kinetic results, two-compartment first order model was more suitable than one-compartment first order model. Fast sorption site of biochar-amended soils dominated total sorption process (i.e., Fraction of fast sorption site ranged from 0.55 to 0.96). Reduced sorption capacity with aging time could be attributed to changes in physico-chemical properties of biochar-amended soils (e.g., reduced pores and increased hydrophilic carboxyl and carbonyl functional groups). Verification is FI-IR and SSA. It is assumed that biochar is a suitable material for PHE contaminated soil in order to reduce the lability of PHE. However, aging effects would lessen biochar benefit for reducing the sorption capacity of PHE by forming hydrophilic functional group and reducing pores.