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Interactions of low molecular weight aromatic acids and amino acids with goethite, kaolinite and bentonite with or without organic matter coating

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Interaction of organic matter molecules with the soil's solid phase is a key factor influencing the stabilization of carbon in soils and thus forms a crucial aspect of the global carbon cycle. While subject of much research attention so far, we still have much to learn about such interactions at the molecular level; in particular in the light of competition between different classes of organic molecules and in the presence of previously adsorbed soil organic matter. We studied the interaction of a group of low molecular weight (LMW) aromatic acids (salicylic, syringic, vanillic and ferulic acid) and amino acids (lysine, glutamic, leucine and phenylalanine) on goethite, kaolinite and bentonite with and without previously adsorbed dissolved organic matter (DOM). For this we used batch experiments at pH = 6.0 where some of the organic compounds were positively charged (i.e. lysine) or negatively charged (i.e. glutamic and salicylic acid) while the minerals also displayed positively (i.e. goethite) or negatively charged surfaces (i.e. bentonite).

We found much higher sorption of salicylic acid and lysine than other compounds. On the bare minerals we found a great variety of sorption strength, with salicylic acid strongly adsorbed, while syringic, vanillic and ferulic acid showed little or no adsorption. For the amino acids, protonated lysine showed a stronger affinity to negatively charged kaolinite and bentonite than other amino acids. While deprotonated glutamic acid showed the strongest adsorption on goethite. Leucine and phenylalanine showed hardly any adsorption on any of the minerals. When present concurrently, amino acids decreased the sorption of salicylic acid on the three types of mineral, while the presence of LMW aromatic acids increased the sorption of lysine on kaolinite and bentonite and the sorption of glutamic acid on goethite. The presence of previously adsorbed DOM reduced the sorption of salicylic acid and lysine.

The results confirm that interactions of different classes of organic molecules with solid soil phases cannot be understood in isolation, but must be interpreted in the context of the presence of other classes of molecules. It seems that the presence of methoxy groups decreases the adsorption of aromatic acids to minerals. We did not find evidence for protein conditioning of any mineral surface, i.e. increased adsorption of aromatic acids after adsorption of amino acids.