

Cd Sorption to Goethite-Humic acid-Bacteria Composites: Combined ITC, EXAFS and SCM study

CHENCHEN QU^{1,2}, WENLI CHEN¹, PENG CAI^{1,2}, XINGMIN RONG², KE DAI², QIAOYUN HUANG^{1,2*}

¹ State Key Laboratory of Agricultural Microbiology, Huazhong Agricultural University, Wuhan 430070, China (*correspondence: qyhuang@mail.hzau.edu.cn)

² Key Laboratory of Arable Land Conservation (Middle and Lower Reaches of Yangtze River), Ministry of Agriculture, Huazhong Agricultural University, Wuhan 430070, China

The interfacial reactions between iron (hydr)oxides, bacteria and humic acid (HA) have significant impact on both the capacity and mechanisms for heavy metal adsorption. Cd adsorption onto goethite-HA-*Pseudomonas putida* binary and ternary composites were studied by combination of batch adsorption, surface complexation model (SCM), Cd K-edge extended X-ray absorption fine structure (EXAFS) spectroscopy and isothermal titration calorimetry (ITC).

We found approximately 8% reduction in adsorption on goethite-*Pseudomonas putida* 1:1 composites at high Cd concentrations, and “Component Additivity-Site Masking” model was built by adding the blockage reactions between *P. putida* and goethite. In goethite-HA complex, the increase in negative charge and steric advantage for HA result in an enhanced capacity for Cd immobilization. Meanwhile, slightly more adsorbed Cd ions were located on HA fraction than expected. The site masking exists in ternary goethite-HA-*P. putida* composites, and the adsorption capacity for Cd reduced across pH 3-7 at high Cd concentrations. Besides, the EXAFS and ITC reported Cd ions migrated significantly to HA fraction in the ternary composites, compared to component additivity prediction. The model calculation also indicate the site masking lead to approximately 50% reduction of the functional groups on bacteria.

This work suggests a universal adsorption behaviour for Cd adsorption, in which the concentration and organo-mineral interfacial reactions are crucial parameters for determining Cd uptake. The component additivity method is only suit in systems when there is an increase in reactive sites at high Cd concentrations, or site masking exists meanwhile the Cd concentration is low. Therefore the interfacial reactions that occur between iron (hydr)oxides, HA and bacteria and concentration should be taken into account when predicting Cd speciation.