Predicting Reduction in Sorption Capacity of In Situ Activated Carbon Amendments Due to Fouling

Wardah Azhar (azharw@cdmsmith.com) (CDM Smith, Denver, Colorado, USA)
Danny Reible (danny.reible@ttu.edu) (Texas Tech University, Lubbock, Texas, USA)

Background/Objectives. Activated carbon is increasingly being used at contaminated sediment sites as an amendment material for in situ treatment and sediment caps. It has proved to be extremely effective at adsorbing most organic and some inorganic contaminants present at sediment sites. However, when applied in situ it shows substantial reduction in performance as a result of fouling and competitive adsorption. For performance prediction of activated carbon or any amendment it is important to be able to predict the sorption capacities based on the physical and chemical properties of amendments and contaminants. Even though multiple studies have shown that activated carbon is prone to fouling in the presence of natural organic matter (NOM), this phenomenon has not been categorized sufficiently to incorporate it into performance prediction estimates. The objective of this study was to modify the Polanyi-Dubinin Manes (PDM) adsorption model to be able to predict reduction in sorption capacity of activated carbon when used in the field as an in situ amendment by evaluating the effects of NOM on performance degradation.

Approach/Activities. Multi-component PCB sorption studies on two types of activated carbons and an organophilic clay were conducted using dissolved organic matter (DOM) loaded water as well as organic free water. Sorption isotherms were developed to compare reduction in sorption capacities of the two types of amendments. In order to develop a model to predict the reduction in activated carbon sorption capacity due to fouling, Polanyi isotherms were obtained from the sorption studies and normalized using measured micropore volumes for virgin and DOM-loaded activated carbon resulting in a single correlation curve. Micropore volume normalized correlation equations were then obtained to predict the adsorption potential of the activated carbon at other sites just by using physico-chemical parameters and knowledge of the micropore volume of fouled activated carbon. Chi-square tests were used to confirm the goodness of fit of the predicted isotherms for three PCB congeners compared to experimental isotherms in each case.

Results/Lessons Learned. The sorption experiment results confirmed that there is almost an order of magnitude reduction in the sorption capacity of activated carbon in the presence of DOM. Using the approach outlined above, the PDM model was accurately configured to incorporate the effects of NOM, making performance prediction independent of site specific fouling. The model correctly predicted reduction in PCB sorption due to fouling for two different activated carbons, two different porewaters, and DOC concentrations ranging from zero to 25 mg/L. This model allows prediction of activated carbon performance based primarily on physico-chemical properties of the amendment and contaminant without the need to develop site specific adsorption isotherms. By incorporating fouling effects of NOM into the Polanyi adsorption prediction model the field performance of an in situ amendment for PCB contaminated sites can be predicted with greater accuracy.