A New Hysteresis Coefficient Based on a Differential Approach for Characterizing the Adsorptive-Desorptive Behavior of Contaminants in Soils

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In this work, a new hysteresis coefficient is proposed and its usefulness for determining the adsorption-desorption behavior of pollutants on soils is examined. In soil pollution and remediation, the adsorption and desorption play a key role on pollutants availlability and transport. In other processes of environmental interest, such as the removal of toxicants and persistent organic compounds from wastewaters using activated carbon packed bed columns, the adsorption and desorption also are the basis of process sizing, design and operation. Most of the research has been focused on adsorption, and relatively less attention has been devoted to desorption. For several pollutants and solid matrices, the desorption pathway is different from that of the adsorption. This phenomenon is known as hysteresis. Here, we define a hysteresis coefficient C_H as the ratio of the slope (derivative) of the adsorption curve and the slope of the desorption curve in a given point (C_i,q_i) of interest. We demonstrate that: *i)* C_H is dimensionless; *ii)* when hysteresis is not important, C_H =1, i.e., the adsorption is reversible; *iii)* when hysteresis is important, C_H >1, i.e., the adsorption is irreversible; *iv)* the larger the hysteresis, the larger the C_H; *v)* the C_H can be determined at any convenient point (C_j, q_j) of interest of the adsorption curve, peforming a few consecutive desorption steps, and there is no need to determine the full adsorption-desorption cycle; *vi)* the C_H is consistent (i.e. $C_H \geq 1$) with the most common isotherm models (linear, Freundlich and Langmuir); *vii)* there exist also analytical, particular, simple equations for finding C_H for the linear, Freundlich and Langmuir isotherm models; and *viii)* the C_H shows several advantages over the well known hysteresis indices defined by Huang and Weber (1997) and Ma *et al.* (1993). Using experimental data from refereed literature, we also show that the C_H provides a quantitative basis for *i)* comparing the irreversibility of the adsorption of different individual pollutants on a given soil; *ii)* comparing the irreversibility of the adsorption of a given pollutant on different soils; *iii)* determining the effect of aging and weathering on adsorption irreversibility; and *iv)* evaluating the effect of *in vitro* addition of surfactants and solvents. Overall, the C_H allows for the quantitative determination of pollutant availability and this, in turn, could be a valuable tool for estimating the remediation potential of polluted soils.