Short-term adsorption of gold using self-flocculating microalga from wastewater and its regeneration potential by bio-flocculation

Supplementary material

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Adsorption isotherm

The Langmuir isotherm model (1918) essentially describes the monolayer type of adsorption and it is expressed as the following linearized Eq. (1):

$$C_e/q_e = C_e/q_m + 1/bq_m \quad (1)$$

Where, q_e is the amount of metal ions absorbed at equilibrium (mg g^{-1}); C_e is the equilibrium concentration of metal ions remaining in the solution (mg L^{-1}); q_m represents the maximum adsorption capacity (mg g^{-1}) and *b* is a constant related to the energy of adsorption (L mg^{-1}).

The Freundlich isotherm (1906) is represented by the linearized equation as follows:

$$\ln q_e = \ln K_f + 1/n \ln C_e \quad (2)$$

Where, K_f is the Freundlich constant related to adsorption capacity of biomass, and *n* is a constant indicative of biosorption intensity.

Adsorption kinetics

The linearized expression for the Pseudo-first-order is given by the following equation:

$$\ln(q_e - q_t) = \ln q_e - k_1 t \quad (3)$$

The expression for the Pseudo-second-order is given by the following linearized equation:

$$t/q_t = 1/k_2 {q_e}^2 + t/q_e \quad (4)$$

Where, k_1 is the rate constant of Pseudo-first-order adsorption (min^{-1}) and k_2 is the rate constant of second-order adsorption (g mg^{-1} min^{-1}).

Thermodynamics of adsorption

Based on the thermodynamics, the relation between ΔG^o and the equilibrium constant (K) is given by the equation (5):

$$\Delta G^o = - RT \ln (K) \quad (5)$$

Again, ΔH^o and ΔS^o of the reaction at constant temperature is related to the ΔG^o according to the following equation:

$$\ln (K) = \Delta S^o / R - \Delta H^o / RT \quad (6)$$

Where, K can be considered as the Langmuir constant, b if the system follows Langmuir isotherm and R is the universal gas constant (8.314 J mol^{-1} K^{-1}). The thermodynamic parameters determine the spontaneity of the reaction and randomness of the system during the sorption process. The ΔH^o and ΔS^o values of adsorption are measured from the slope and the intercept of the plot between 1/T verses ln (K).