**Efficiency of Acacia Gummifera powder as biosorbent for simultaneous decontamination of water polluted with metals**

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**Electronic Supplementary Material**

**Biosorption thermodynamics**

The spontaneous nature of the adsorption process and its feasibility can be assessed from a thermodynamic study. From the linearized forms of equilibrium constants at different temperatures (Equations 1 and 2), thermodynamic parameters for the adsorption process such as free energy ΔG° (J.mol- 1), entropy change ΔS °(J.mol- 1.K- 1) and enthalpy change ΔH ° (J.mol- 1.K- 1) can be calculated as follows:

 $ K\_{L}=\frac{∆S^{0}}{R}-\frac{∆H^{0}}{R}\left(\frac{1}{T}\right)$ (1)

 $∆G^{0}=∆H^{0}-T∆S^{0}$ (2)

Furthermore, the standard variation of Gibbs free energy (ΔG°) of the biosorption process can also be obtained from the estimated Langmuir adsorption/desorption constant, using the following equation:

 $∆G^{0}=-RTlnK$L (3)

Where kL ($ K\_{L}= \frac{C\_{e}}{(C\_{0}-C\_{e})}$) is the Langmuir equilibrium constant, R is the universal gas constant (8.314 J.mol-1.K-1) and T is the absolute temperature of the solution (K). Values of ΔG0, ΔS0 and ΔH0 for the biosorption of Pb2+ and Cd2+ onto *Acacia Gummifera* are given in Table 1.

Negative ΔG0 values indicate that the biosorption is thermodynamically feasible and of spontaneous nature. According to equation 3, ΔS0 and ΔH0 parameters may be computed from the slope and intercept of the plot lnKL against 1/T, respectively (Fig. 1).



Figure 1. Plot of lnKL vs. 1/T for estimation of thermodynamic parameters for biosorption of Pb2+and Cd2+onto gum of Acacia Gummifera.

All ΔH0 values for both metal ions were negative (table 1) suggesting an exothermic nature of the adsorption, which confirms results obtained with Temkin isotherm model. Moreover, all ΔH0 values were less than 40 kJ.mol-1, indicating a physical adsorption involving electrostatic interaction between sorption sites and both metal ions (Abdel-Ghani and Elchaghaby, 2007). Likewise, all ΔSo values were negative, which indicates a decrease in random adsorption at the interface solid/solution suggesting some structural changes in the biosorbent and the adsorbate (Manohar et al., 2002). Furthermore, negative ΔS0 (Pb2+,Cd2+) values indicate formation of more stable *Acacia Gummifera*-Pb2+ and *Acacia Gummifera*-Cd2+complexes. Also, negative ΔG0 values indicate that the spontaneous adsorption is inversely proportional to temperature.

Table 1.Thermodynamics of Pb2+and Cd2+ions biosorption onto gum of *Acacia Gummifera*.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Metal ion | Temperature (K) | ΔG0(kJ/mol) | ΔS0(kJ/(mol K) | ΔH0(kJ/mol) | R2 |
| Pb2+ | 303 | -5.258 | -0.076 | -28.288 | 0.9722 |
| 313 | -4.498 |  |  |  |
| 323 | -3.739 |  |  |  |
|  |  |  |  |  |  |
| Cd2+ | 303 | -9.309 | -0.038 | -21.082 | 0.9958 |
| 313 | -8.920 |  |  |  |
| 323 | -8.531 |  |  |  |

# References

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