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# Single and competitive adsorptive removal of lead, cadmium, and mercury using zeolite adsorbent prepared from industrial aluminum waste

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**ABSTRACT**

The removal of $Pb^{2+}$, $Cd^{2+}$, and $Hg^{2+}$, which act as endocrine disruptors, from aqueous solutions was performed using a NaP1-type zeolite synthesized from a hazardous aluminum waste. The effects of parameters such as pH, contact time, adsorbent dose, initial cation concentration, and coexisting cations on the adsorption efficiency and capacity of the adsorbent were evaluated. Single-cation adsorption was found to be a fast process well described by the pseudo-second-order kinetic model. Equilibrium was reached in the first 15 min achieving high removal efficiencies: 98.9%, 93.3%, and 99.3% for $Pb^{2+}$, $Cd^{2+}$, and $Hg^{2+}$, respectively. The removal of the metal cations could occur via a homogeneous and physical adsorption process that was satisfactorily described by the Sips isotherm. The maximum adsorption capacities, obtained from the Sips isotherm model, were 245.75, 4.43, and 0.22 mg/g for $Pb^{2+}$, $Cd^{2+}$, and $Hg^{2+}$, respectively. In multi-cation adsorption, the zeolite presented the greatest affinity for $Pb^{2+}$ (due to its smallest cationic size) compared with $Cd^{2+}$ and $Hg^{2+}$. The $Pb^{2+}$ removal efficiency remained practically constant in presence of $Hg^{2+}$ and $Cd^{2+}$, reaching efficiencies near 100% at very low contact times (<5 min). Thus, this zeolite could become an alternative adsorbent to eliminate heavy metals from waters. A synergic effect on the environmental protection could be achieved: the end-of-waste condition of a hazardous waste as well as the water decontamination.

*Keywords:* Heavy metal; Endocrine disruptor; NaP1 zeolite; Adsorption kinetic; Equilibrium isotherm; Competitive adsorption; Water treatment

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