The removal of As(V) ions by lime-modified fly ash and reuse of the exhausted adsorbent as an additive for construction material

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Coal thermal power plants (TPP) actively generate numerous solid combustion by-products, including fly ash and bottom ash. These TPP by-products have already found use in a variety of civil engineering applications, such as a substitute for sand and gravel in structures, as well as a binding component in certain types of cement (generally, concrete and masonry). Furthermore, such by-products have become a subject of increasing interest in environmental engineering as a low-cost and effective adsorbent for the removal of organic pollutants and heavy metals from wastewaters.

In order to minimize the impact of material cost, novel solutions for the development of a high capacity and long-term adsorbent have provided a high performance adsorbent for practical applications. This study is focused on the use of modified fly ash (MFA) activated by lime (Ca(OH)₂) as an effective and low-cost adsorbent for the removal of As(V) ions. The adsorption capacity of the MFA adsorbent was found to be 35.40 mg g⁻¹, while the kinetic and thermodynamic parameters indicated a spontaneous and endothermic process. Due to the low desorption potential of the exhausted adsorbent (MFA/As(V), their effective further material reuse was established to be feasible. The reuse of the exhausted adsorbent was obtained through pozzolanic MFA particles and Ca(OH)₂ thereby formulating a construction material of a cementitious calcium-silicate hydrate. The toxicity leaching test (TCLP) and mechanical properties of the new construction material containing exhausted MFA (CM-MFA/As(V)) confirm its safe use in the laboratory as well as its semi-industrial application.

The specific objectives of this study have been: (i) to improve the adsorption performance of the MFA; (ii) to evaluate the material's equilibrium, as well as the process' kinetic and thermodynamic aspects, including estimating its limiting step; and (iii) to investigate the possible reuse of the exhausted adsorbent in the production of construction materials. The kinetic data were successfully fitted by a pseudo-second-order equation and the Weber-Morris model. The metal-desorption experiments performed on the exhausted FA and MFA indicate a low recovery of the selected pollutants.

The major outcome of this study, indicates that double-valorization of fly ash opens new directions for waste management toward reuse in effective practical applications; i.e., for actual water-purification systems, as well as in the production of construction material.