

## ABSTRACT

The occurrence of arsenic in groundwater and its associated severe health impact raises the global concern, which in turn promotes extensive research on arsenic remediation from drinking water. The present research stems from the necessity of the development of the eco-friendly adsorbent and its subsequent application on sorptive removal of arsenic. Calcined Mg-Fe-(CO<sub>3</sub>) layer double hydroxide was synthesized by a co-precipitation method at low supersaturation, and the major influencing preparation process parameters, viz. the molar ratio, formation pH, and calcination temperature were optimized targeting the arsenic removal. The multivariate optimization technique was attempted through response surface methodology coupled with a 3<sup>3</sup> factorial design. The influence of calcination temperature was found to be more prominent than the other two factors. The characterization of the materials clearly showed that the variation of the process condition has a significant impact on elemental composition, crystallinity, surface morphology, and other physico-chemical properties of the adsorbent. The effect of adsorption process parameters was also modeled with multivariate optimization by an artificial neural network (ANN) for adsorption capacity and removal efficiency. The adsorption equilibrium, uptake rate, mechanism, performance, and feasibility of the present adsorptive removal system was demonstrated by isotherm, kinetic and thermodynamic modeling. The isotherm modeling revealed the applicability of the Freundlich and Temkin equation for the adsorption of As(III) and As(V), respectively. The multi-component sorption analysis in the presence of several competitive anions reflected the pronounced synergistic effect of calcium and iron and the antagonistic impact of phosphate. The binary isotherm modeling for the arsenic and phosphate shows that the modified competitive Langmuir equilibrium model describes the adsorption of both arsenic and phosphate in the binary system. The fast uptake of As(III) and As(V) was observed during the initial phase of the process, which reached equilibrium at 240 min following the Elovich model. The diffusion kinetic model exhibited that the rate-limiting step of adsorption was controlled by film diffusion as well as intraparticle diffusion for the adsorption of both As(III) and As(V). The thermodynamic modeling exhibited that the occurrence of an endothermic reaction concerning the positive value of the  $\Delta H^0$  in congruence with the synergistic effect of temperature on adsorption. The negative values of  $\Delta G^0$  in study temperature suggested the spontaneity of the adsorption process. The adsorbents possess good adsorption potential for arsenic removal; however, the low hydraulic

conductivity hindered the column-based operation. A suitable alternative, i.e. sequential batch type reactor (SBTR) for column-based operation pertaining to continuous study has been used for the removal of arsenic in a continuous mode. The real-time arsenic bearing groundwater was used in batch and continuous mode to simulate field scenarios, and substantial-high performance was achieved. The sludge management was conducted exploring the various opportunities of regeneration, recycle, reuse, and sludge disposal followed by leaching toxicity analysis, which reflected that the sludge is non-hazardous, thereby facilitating disposal in landfills. The adsorptive removal of arsenic by the LDH material exhibited to be a promising technique without creating any hazardous waste.

**KEYWORDS:** Arsenic removal; Layered double hydroxides; Adsorption isotherm; Adsorption kinetics; Adsorption mechanism; Thermodynamic parameters; Competing cations and anions; Multi-component adsorption; Multivariate optimization; Sequential batch type reactor; Real-life groundwater; Sludge management