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Assessing fluoride adsorption efficiencies by alum- and ferric (hydr)oxide-based adsorbents

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Mine drainages from metallic ore deposits hosted in granitic rocks are often high in fluoride concentration. Various fluoride removal technologies were developed, including precipitation (as CaF_2), ion exchange, and adsorption. Among these, adsorption by Al and Fe hydroxides is very cost-efficient and can be highly feasible for on-site contaminated drainage. This study was performed to evaluate the efficiency of diverse reactors (absorbents) for fluoride removal, which were 1) the commercial activated alumina (AA)), 2) alum sludge (DENS-10) formed after the municipal water treatment, 3) sludge (YDA) formed after the treatment of Fe-rich drainage in an abandoned coal mine area, and 4) GFH the granular ferric hydroxide (GFH). A pilot scale study was performed for the removal of fluoride in the outflow of an on-site semi-active treatment of contaminated leachates from a tailing dump of the abandoned Sambo Pb-Zn mine, in Korea. The leachates are high in fluoride concentrations (5-8 mg/L.), exceeding the Korean criteria of effluent water (3 mg/L). The results of on-site pilot scale experiments showed that the removal efficiency was higher in the reactors with DENS-10 and AA. The fluoride concentration of outflow water was reduced to 3.5 mg/L within about 2 hours of EBCT (Empty Bed Contact Time) with the reactor AA, and to 3.3 mg/L with the reactor DENS-10 at 0.4 hours of EBCT. On the other hand, the use of the reactors GFH and YDA was not promising. Undissolved $Ca(OH)_2$ in YDA may cause an increase in pH (by 0.8-1.6), lowering the adsorption capacity. This study suggests that adsorbents of the aluminum (hydro)oxide series (AA, DENS-10) can be effectively used for the on-site treatment of fluoride-contaminated mine drainage, while the sorption by iron (hydr)oxides series (GFH, YDA) is not promising. This shows the fundamental importance of similar geochemical affinity between a target contaminant (F) and sorbents (Al or Fe) for the development of sorption technology.