

Synthesis of cryptocrystalline magnesite–bentonite clay composite and its application for neutralization and attenuation of inorganic contaminants in acidic and metalliferous mine drainage

Vhahangwele Masindi, Mugeru W. Gitari, Hlanganani Tutu, Marinda De Beer

Keywords:

Acid mine drainage

Neutralization

Magnesite–bentonite clay composite

Inorganic contaminants

Adsorption modelling

ABSTRACT

The primary aim of this study was to synthesize cryptocrystalline magnesite–bentonite clay composite by mechanochemical activation and evaluate its usability as low cost adsorbent for neutralization and attenuation of inorganic contaminants in acidic and metalliferous mine drainage. The composite was synthesized at 1:1 weight to weight ratio. The capacity of the composite to neutralize acidity and remove toxic chemical species from synthetic and field AMD was evaluated at optimized conditions. Interaction of the composite with AMD led to an increase in pH ($\text{pH} > 11$) and lowering of metal concentrations. The removal of chemical species was optimum at 20 min of equilibration and 1 g of dosage. The composite removed $\approx 99\%$ (Al^{3+} , Fe^{3+} , and Mn^{2+}) and $\approx 90\%$ (SO_4^{2-}) from raw mine effluent. Adsorption kinetics fitted better to pseudo-second-order kinetic than pseudo-first-order kinetic hence confirming chemisorption. Adsorption data fitted better to Freundlich adsorption isotherm than Langmuir hence confirming multisite adsorption. Gibbs free energy model predicted that the reaction is spontaneous in nature for Al, Fe and sulphate except for Mn. Geochemical model indicated that Fe was removed as $\text{Fe}(\text{OH})_3$, goethite, and jarosite, Al as basaluminite, boehmite and jurbanite, $\text{Al}(\text{OH})_3$ and as gibbsite and diaspore. Al and Fe precipitated as iron (oxy)-hydroxides and aluminium (oxy)-hydroxides. Mn precipitated as rhodochrosite and manganite. Ca was removed as gypsum. Sulphate was removed as gypsum, and Fe, Al hydroxyl sulphate minerals. Mg was removed as brucite and dolomite. It was concluded that the composite has the potential to neutralize acidity and attenuate potentially toxic chemical species from acidic and metalliferous mine drainage.