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Fate of sulphate removed during the treatment of circumneutral mine water and acid mine drainage with coal fly ash: Modelling and experimental approach

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Abstract

The treatment of acid mine drainage (AMD) and circumneutral mine water (CMW) with South African coal fly ash (FA) provides a low cost and alternative technique for treating mine wastes waters. The sulphate concentration in AMD can be reduced significantly when AMD was treated with the FA to pH 9. On the other hand an insignificant amount of sulphate was removed when CMW (containing a very low concentration of Fe and Al) was treated using FA to pH 9. The levels of Fe and Al, and the final solution pH in the AMD–fly ash mixture played a significant role on the level of sulphate removal in contrast to CMW–fly ash mixtures. In this study, a modelling approach using PHREEQC geochemical modelling software was combined with AMD–fly ash and/or CMW–fly ash neutralization experiments in order to predict the mineral phases involved in sulphate removal. The effects of solution pH and Fe and Al concentration in mine water on sulphate were also investigated. The results obtained showed that sulphate, Fe, Al, Mg and Mn removal from AMD and/or CMW with fly ash is a function of solution pH. The presence of Fe and Al in AMD exhibited buffering characteristic leading to more lime leaching from FA into mine water, hence increasing the concentration of Ca^{2+}. This resulted in increased removal of sulphate as $CaSO_4{\cdot}2H_2O$. In addition the sulphate removal was enhanced through the precipitation as Fe and Al oxyhydroxysulphates (as shown by geochemical modelling) in AMD–fly ash system. The low concentration of Fe and Al in CMW resulted in sulphate removal depending mainly on $CaSO_4{\cdot}2H_2O$. The results of this study would have implications on the design of treatment methods relevant for different mine waters.

Graphical abstract

Keywords: Fly ash; Circumneutral mine water; Acid mine drainage; PHREEQC geochemical modelling and sulphates