

Acid mine water neutralisation with ammonium hydroxide and desalination with barium hydroxide

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ABSTRACT

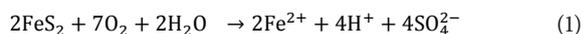
In South Africa, acid mine drainage is polluting increasingly scarce ground- and surface water. The ammonium-barium (NB) process described in this paper consists of neutralisation and metal removal with NH_4OH , sulphate removal with $\text{Ba}(\text{OH})_2$ and Ca removal with CO_2 . Laboratory studies showed that metals are removed to low levels. This includes Fe(II), the predominant metal in mine water. It is first oxidised to Fe(III), whereafter it precipitates as $\text{Fe}(\text{OH})_3$. Sulphate is removed to low concentrations as BaSO_4 . During CO_2 dosing, CaCO_3 is precipitated to its saturation level. The simulation predictions followed the same pattern as the experimental results obtained. This study showed that NH_4OH can be used for treatment of acid mine drainage rich in sulphates and NH_4OH can be recycled in the process. Hydrated lime treatment resulted in removal of the remaining ammonia using a rotary evaporator.

Keywords: acid mine water, ammonium hydroxide, barium hydroxide, sulphate removal

INTRODUCTION

Acidic mine waters are continuously discharged from certain mines to the environment, with little treatment. Acid mine water contains high levels of SO_4 in addition to Fe, Al, Mn and other metals. Coal mining and fertiliser manufacturing are examples of industrial operations that give rise to severe acid pollution (Maree et al., 2004). Clean water is essential for agriculture, domestic and industrial use, and increases in population have led to an increase in the water demand. South Africa (SA) is an arid country, which has exacerbated the problem. It has been predicted that the country's freshwater resources will be fully utilised within the next 20 to 30 years if the current growth in water demand and use (or abuse) is not altered (Van Niekerk and Maree, 2001). In the Western Basin of the Witwatersrand, Gauteng Province, mine water started to decant in 2002. In the Eastern Basin, a single pump station at Grootvlei Mine pumped out between 75 and 108 Mℓ/day of mine-water. The pH can be as low as 2 (Jiménez et al., 2009) and poses a problem because the majority of natural life is adapted to survive at around pH 7. About 540 Mℓ/d of acid mine water is produced in the Gauteng region alone (Hlabela, 2009).

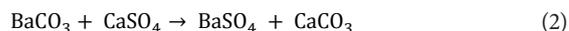
AMD is formed when pyrite in contact with atmospheric oxygen becomes oxidised to soluble iron and sulphuric acid, frequently catalysed by sulphur-oxidising bacteria (Jennings et al., 2008).



Mine-water treatment requires pre-treatment for neutralisation and metal removal, followed by desalination for removal of dissolved salts. The integrated limestone and lime process

was developed for neutralisation and partial SO_4 removal from AMD (Maree, 2003). Limestone and lime are used to increase the pH and, together with aeration, Fe(II) is oxidised and precipitates as $\text{Fe}(\text{OH})_3$. Limestone is used for initial AMD treatment as it is less costly than lime. It is moreover safe to handle and its dissolution occurs at pH below 7, obviating the need for pH control. In the second stage, lime is introduced to precipitate the remaining metals such as Mn and Al. Unfortunately, its successful application is limited as it only lowers SO_4 concentration to around 1 200 mg/ℓ (INAP, 2000). Other treatment techniques have been developed that utilise limestone, which can neutralise acid but does not raise the pH sufficiently to remove metals (Ziemkiewicz et al., 1997). Several other processes can be considered for sulphate removal, e.g., biological sulphate removal, SAVMIN (by ettringite formation), and membrane processes. Barium sulphate is highly insoluble which makes Ba dosing suitable for removal of SO_4 .

BaCO_3 can be used for SO_4 removal according to the following reaction:



Trusler et al. (1988) developed a BaCO_3 method for SO_4 removal by using a two-stage fluidised-bed reactor system to overcome the other problems identified by Kun (1972), i.e. long retention times and the high Ba concentrations in the treated water. BaCO_3 and lime would be added to the effluent to soften the water and produce a precipitate. The disadvantage of Reaction (2) is that BaSO_4 and CaCO_3 co-precipitate. Maree et al. (1989) noted a problem in separating co-precipitated BaSO_4 and CaCO_3 . However, the BaCO_3 became inactive when coated with precipitated metal hydroxide, which made it unsuitable for most mine waters. Alternatively, $\text{Ba}(\text{OH})_2$ can be used in place of BaCO_3 and offers the benefits of rapid reaction times and precipitation of only BaSO_4 .

The purpose of this investigation was to demonstrate that NH_4OH in combination with $\text{Ba}(\text{OH})_2$ and lime treatment offers an attractive solution for treatment of acid mine-water

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