Neutralisation treatment of AMD at affordable cost

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ABSTRACT

Acid mine drainage (AMD) has for many years been a major environmental challenge associated with the mining industry, especially in the Eastern, Central and Western mining basins of Gauteng. The aims of this article are to: (i) demonstrate the suitability of the sequencing batch reactor (SBR) system for both neutralisation of free acid and removal of iron(II), often the main component in AMD, using limestone, the cheapest alkali, followed by lime treatment for removal of heavy metals, and partial sulphate removal through gypsum crystallisation; (ii) compare the alkali cost of the alternative SBR system where limestone and lime are used for treatment, with conventional lime treatment, and (iii) present the capital cost of the SBR system.

The conclusions of this study are that: (i) precipitated calcium carbonate can be used for complete removal of iron(II) in an SBR system within 90 min reaction time; (ii) lime can be used for complete removal of heavy metals after pre-treatment with precipitated calcium carbonate; (iii) the alkali cost for treatment of AMD from the Western Basin will amount to R2.80/m^3 in the case of limestone/lime treatment compared to R5.83/m^3 if only lime is used; (iv) the alkali cost for treatment of 85 Mℓ/d acid mine water from both the Western and Central Basins will amount to R60 m./a in the case of limestone/lime treatment compared to R136.9 m./a if only lime is used; and (v) the capital cost for the SBR system amounts to R3.5 m. per Mℓ/d.

Keywords: Acid mine drainage, sequencing batch reactor, neutralisation, limestone

INTRODUCTION

Acid mine drainage (AMD) has for many years been a major environmental challenge associated with the mining industry, especially in the Western, Central and Eastern mining basins of Gauteng. The Western Basin AMD decants uncontrolled at a flow rate of 10–60 Mℓ/d. This water has a pH of 2.8 and contains Fe(II), free acid, manganese and uranium, is detrimental to the environment and the health of humans and animals, is unsuitable for irrigation and threatens the stability of the dolomitic rock at the Cradle of Humankind World Heritage Site. The immediate construction of a neutralisation plant is required for removal of free acid, metals and uranium, and for partial sulphate removal. Similar situations exist in the Central Basin near Boksburg and in the Eastern Basin near Springs. In the Central Basin the water was at a depth of 540 m below the decant level at the time of writing, and rising at an average daily rate of 0.7 m. It is anticipated that decanting of acid mine water, at an expected rate of 60 Mℓ/d, may start in 2013/14. The quality of this water is also acidic and saline, similar to the AMD decanting from the Western Basin.

Mine water typically contains 4 main components: free acid, iron(II), a number of heavy metals and salts (Maree, 2012). The formation of AMD can be attributed to the convergence of the following events:

- dissolution of limestone/dolomite up to its solubility level in natural, ingress water
- pyrite oxidation by bacterial action as a result of oxygen-rich ingress water running through broken pyrite-containing rock within the mine environment and producing acidity, Fe(II), sulphates and other salts
- partial neutralisation of free acid due to natural alkalinity contained in the mined and broken rock media
- reciprocating contact of pyrites-rich rock with water and oxygen when the water level fluctuates as a result of water being pumped out at a constant rate, whilst the water recharge varies with seasonal rainfall.

The Expert Team of the Inter-Ministerial Committee on Acid Mine Drainage investigated the matter in 2010 and recommended specific actions to further manage and control the AMD associated with the Witwatersrand mining boom (Expert Team of the Inter-Ministerial Committee under the Coordination of the Council for Geoscience, 2011), as follows:

- installation of pumping facilities in each of the mining basins to maintain the water level below the Environmental Critical Level (ECL)
- construction of measures to reduce the water ingress and recharge to the underground mine workings
- treatment of the excess mine water
- comprehensive monitoring
- investigation of and addressing other sources of AMD
- investigation of and research work to find long-term sustainable solutions
- investigation of the feasibility of implementing an environmental levy on operating mines to fund environmental rehabilitation
- ongoing assessment and research work.

An important consideration related to AMD is the management of sludge produced during treatment of acid mine water. Zinck (2006) has described various ways to deal with such sludge. Ruto et al. (2011) described the GypSLiM process that can be used for processing gypsum into sulphur and $CaCO_3$. Chemical desalination processes, such as CSIR ABC, TUT MBO and Mintek Ettringite processes, can produce drinking water from AMD in a cost-effective way without a resulting

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Received 11 June 2012; *accepted in revised form 27 March 2013.*

http://dx.doi.org/10.4314/wsa.v39i2.7
Available on website http://www.wrc.org.za
ISSN 0378-4738 (Print) = Water SA Vol. 39 No. 2 April 2013
ISSN 1816-7950 (On-line) = Water SA Vol. 39 No. 2 April 2013