

ABSTRACT

Acid Mine Drainage (AMD) can result in significant and permanent ecological, chemical and physical alterations to the receiving environment. In 2002 a major surface decant of AMD effluent first entered the Tweelopies River upstream of the Krugersdorp Game Reserve, near Johannesburg. Within the game reserve the Tweelopies River intersects the Charles-Fourie Dam. The function of this dam, as a sink of dissolved AMD contaminants (sulfate and iron), in the contaminated river was investigated in this study between September 2013 and August 2014. A water mass balance approach was used to estimate fluxes of dissolved contaminants. Additionally, compositional changes in sediment chemistry (total Fe, S, Al, Mg, Ca, Cu, Ni, Pb, V, and Zn) were investigated in order to quantify the storage or accumulation of contaminants in the sediment, which would indicate the long-term mitigatory function of the dam.

The accumulation of high concentrations of metals and non-metals in the sediment of the dam (including $121.0 \text{ g S.kg}^{-1}$ and $34.7 \text{ g Fe.kg}^{-1}$) indicate that the dam stored both total iron and sulfur (AMD constituents) in the long term. Assuming that there was an average sediment depth of 19.3 cm in the dam, it was estimated that 18 tons of total iron, and 5 tons of total sulfur were present in the sediments of the dam. Additionally, the mass balance indicated that in total the dam acted as a sink for both sulfate and iron ($14\,853 \text{ kg SO}_4^{2-}$ and 5.5 kg Fe respectively) between September 2013 and February 2014, when the pH of the Tweelopies River was circumneutral (pH 6.1 – 7.6). However, the storage of contaminants in the dam also allowed iron and sulfate to be remobilised from the species and compounds it was stored in in the dam over the 2013-2014 study period. This is the result of changes in the water quality between March and July, when the pH of the river was lower (pH 2.9 – 3.6) and both dissolved iron and sulfate were remobilised ($18\,219 \text{ kg SO}_4^{2-}$ and 210 kg Fe respectively). In total the dam remobilised sulfate and iron in the 2013-2014 study period (increasing the flux by 0.4% or $3\,366 \text{ kg}$ and 8.7% or 202 kg Fe respectively).

The data collected indicate that pH is the primary driver governing the dam to act as a sink and also remobilise dissolved iron and sulfate from the species and compounds they are stored in in the dam. When the pH is low the dam remobilises

AMD constituents and acts as a sink when the pH is circumneutral. Therefore, it is evident that continual neutralisation of the water limits the degree to which the dam remobilises dissolved contaminants from the species and compounds they were stored in and that maintaining a neutral pH in the river should be prioritised by management. Additionally, the concentrations of total Fe, S, Ni, Pb, and Zn in the sediments exceeded the maxima probable effect level for the protection of aquatic life (by 3, 69, 20, 1.6, and 4.9 times respectively). The accumulation of contaminants in the sediment have very likely had a long-term adverse impact upon biodiversity and may present challenges to future rehabilitation efforts. Future management plans should avoid high investment loss to short-term remediation efforts and rather take a long term approach that incorporates these findings.