



Much funding of the Water Research Commission has been dedicated to finding solutions to the environmental legacy of the mining sector.

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AMD: Local solutions for local challenges

Current concerns around the present and predicted decanting of acid mine drainage (AMD) from gold mines on the Witwatersrand have again thrust this complex pollution issue into the limelight. But, as Water Research Commission Research (WRC) Manager Dr Jo Burgess points out, the local research fraternity has a range of world-class solutions on offer.

Mine-water related research has become an important research area for the WRC and millions of Rands are spent every year on projects investigating solutions to one of South Africa's most complex water pollution dilemmas. The Commission is the newest member of the Global Alliance of research organisations, which supports the activities of the International Network for Acid Prevention.

Prior to 1990 most South African mine-water related research was conducted by the now disbanded Chamber of Mines Research Organisation. The WRC's involvement in mine-water research was limited to determining the water requirements and pollution potential of gold and uranium mines. Between 1990 and 2000 research focused on the impact mining has on the surface environment, on treatment options for mine

effluents and on the rehabilitation of mining spoils. In the last ten years the emphasis has shifted to the development of predictive tools and modelling techniques, with the focus on treatment options shifting to implementation and passive systems. A brief description of South Africa's contribution towards finding solutions for AMD follows.

IMPROVED PREDICTIVE ABILITY

Two aspects of research related to improved predictive ability have received special attention: firstly, the ability to predict the generation of acid drainage, and secondly, the ability to predict the rise in water levels

and/or time and point of decant when pumping associated with active mining stops.

In view of the plethora of techniques used to predict the likelihood of acid mine drainage, research targeted at opencast coal mining led by the Institute for Groundwater Studies at Free State University started in 1999 to standardise the methods used to quantify the potential and magnitude of AMD. Based on extensive testing of existing static methods, standardised methods of measuring initial pH, neutralisation potential and acid potential of water have been recommended.

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An easy-to-use spreadsheet tool, ABACUS, has also been developed to standardise the interpretation of static acid-base accounting (ABA) data and, where the suggested sampling methodology has been followed, to provide a method for extrapolation to the field through volume-weighted techniques. Although the project focused on ABA, it strived to define a suite of acid-drainage prediction tools.

The researchers coined a new acronym, ABATE (derived from Acid-Base: Accounting, Techniques and Evaluation), for the approach that integrates a range of tools to predict the potential for acid generation. This also helps to prevent confusion arising in the use of the term ABA, since most people associate ABA with the static test component of drainage chemistry prediction, rather than the entire suite of tools. Research is in progress regarding the use of geochemical modelling techniques to predict the evolution of AMD over time.

There are about 270 gold-mine tailings covering 180 km² in South Africa.

Continued efforts to re-mine and consolidate the tailings into mega-dumps, the contamination and reclamation of the footprint beneath them and the degree to which tailing properties and time affect the depth and rate of weathering of typical tailings dams, have been investigated. An empirical model was developed to predict the likely period over which tailings dams will produce acid mine drainage. Efforts are currently underway to develop a coherent process to facilitate transparent and effective regulatory decision-making regarding the sustainable design, operation and closure of residue disposal facilities. A preliminary decision support system to facilitate decision-making has recently been completed, while a refinement of the system is nearing conclusion.

The ability to predict the rise in water levels, and hence when and where decant to surface would take place after the cessation of mining, has received considerable attention. This ability is particularly important in view of the recovery of water levels in deep gold mines and the seepage of AMD from old shafts.

Pioneering research in this regard was undertaken in the 1990s by the Institute for Groundwater Studies whereby the flooding of Central and East Rand gold mines, which have become largely interconnected through mining activities, were investigated. Among others, the research identified the controls over the inflow rate and water quality and was able to predict the future decant points and timeframes for different scenarios.

Elsewhere in South Africa, a series of collaborative research projects between the WRC and Coaltech (a non-profit organisation funded by coal-mining companies) captured the mine plans and coal seams in a three-dimensional GIS, enabling the mines to determine decant points and the extent of intermine flow within the Mpumalanga coal fields. This ability is currently used to determine the position and capacity of plants to treat the AMD emanating from the coal fields.

REDUCING AMD PRODUCTION AND IMPACT

Several approaches have been evaluated in an attempt to reduce the production and impact of AMD associated with mining.

A regional closure strategy was developed and is being implemented by the regulating authorities to ensure the orderly and responsible closing of mines which exploit the same orebody. This represents a fundamental change from the previous dispensation where the approach to address mine closure from the perspective of individual mines resulted in the last mine standing in an area to be saddled with the responsibility for the combined decant and AMD pollution potential of interconnected neighbouring mines.

Under experimental conditions the use of soil to cover acid generating discard material was found to be effective in reducing the ingress of oxygen and water and thus the volume and strength of AMD percolate. However, under field conditions, where large discard dumps had to be covered, it proved difficult to source sufficient soil for an effective cover thickness and to prevent erosion reducing cover depth on side slopes.

An evaluating and modelling of the impact that the release to surface streams of stored saline neutralised

The Emalahleni Water Reclamation plant outside Witbank where polluted mine-water is treated to drinking water standard for the local municipality.



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AMD during high flow conditions would have on water quality contributed to the development of a strategy whereby AMD from Mpumalanga coal mines is released periodically during years with above average runoff.

Several research projects have highlighted the benefits in the form of smaller volumes of water that would accumulate in underground mines if the ingress of water through surface cracks and fissures could be reduced. The Department of Minerals & Energy initiated a multimillion Rand project through the Council of Geosciences to identify and close these ingress points as a priority.

Two interesting projects aimed at minimising the impact of production of AMD are currently being conducted. The first is assessing the viability of extracting good quality groundwater in aquifers overlying deep mines in order to reduce the percolation of good quality water into the mines. The potential benefit is to prevent the subsequent contamination of this good quality water with AMD and in the reduction of the volume of AMD requiring mitigation. The second is an investigation into the feasibility of either removing or accelerating the oxidation of pyrites associated with mining. In this way, mining may be able to deal with AMD problems during the lifespan of a mine, so that mines would not have a post-closure AMD legacy.

The patented BioSure process, which uses sewage sludge as energy source for the neutralisation of acid mine drainage has been successfully applied at full scale.



TREATMENT TECHNOLOGIES

In contrast with water-rich mining regions, South Africa does not only face the high acidity and dissolved metal problems associated with AMD. The limited dilution potential associated with low rainfall exacerbates the contribution of salinity associated with this water to the salinisation of water resources. For example, effluents from gold mines contribute about 35% of the salt load but only 6% of the water flow at the Barrage in the Vaal River (the major water source of the industrial heartland of South Africa). For this reason much of the research into treatment technologies undertaken in the country are focusing on developing technology that would remove sulphate in addition to metals and the neutralisation of acidity.

The research into water treatment technology is currently being implemented and evaluated at a range of pilot and operational scales at a number of locations. In a joint venture, Anglo Coal and BHP Billiton constructed a 20 Mℓ/day reverse osmosis plant at 99% water recovery to produce potable water from AMD. Treated water from the Emalahleni Water Reclamation Plant is sold to Emalahleni Municipality to supplement its water supply. Two similar plants are planned for the treatment of AMD from other Mpumalanga coal mines.

Funded by the WRC, the Rhodes BioSure process, whereby sewage sludge is used as energy source for the biological reduction and removal of sulphates from AMD, has been implemented at ERWAT's Ancor wastewater treatment works. At times, as much as 10 Mℓ/day of toxic mine-water from Grootvlei has been treated this way.

The Western Utilities Corporation, established to treat AMD from four basins in the Witwatersrand goldfields, is planning to

treat 75 Mℓ/day of AMD from gold mines using the CSIR's ABC (Alkali-Barium-Calcium) desalination process, which uses barium to precipitate sulphates. A pilot plant using the degrading packed bed reactor, which overcame the failure that is commonly experienced with passive sulphate removal systems once the easily oxidisable organic material has been depleted, and that significantly improved the efficiency of passive systems, is also currently being constructed. The cost saving associated with using limestone (calcium carbonate) rather than lime (calcium hydroxide), and the effectiveness of the technology for the neutralisation of acid waters, have been demonstrated in a number of applications.

TECHNOLOGY TRANSFER

The Department of Water Affairs has completed a series of *Best Practice Guidelines for Resource Protection in the South African Mining Industry*. The series deals with various aspects from the department's water management hierarchy (integrated mine-water management through to water treatment); through to general water management strategies and specialised mining activities, such as small-scale mining.

Workshop and symposia on aspects surrounding AMD, mine closure and other related activities are organised regularly. In 2009, the Mine-Water Division of the Water Institute of Southern Africa, together with the International Minewater Association hosted a successful International Minewater Conference.

South African activities have made significant contributions on several fronts in the quest to deal with the problems associated with AMD emanating from mining activities.

To access the WRC's AMD-related research, visit: www.wrc.org.za. □