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Acid Mine Water Drainage
Debating a sustainable solution to a serious issue

Introduction

Water supplies around the world are becoming increasingly scarce due to rising global populations, increasing industrial processes, pollution and inequitable water distribution. South Africa is a nation under stress when trying to meet water requirements. As the demand for water increases, so too does the abstraction from our water systems. Exacerbating this situation is an increasing pressure on environmental systems from Acid Mine Water Drainage (AMD). It serves to stand that the longer the problem goes untreated, the more costly and insurmountable the problem becomes. This paper aims to unpack the size of the problem and the availability of the solutions to deal with the issue facing South Africa's water systems.

How bad is the situation really?

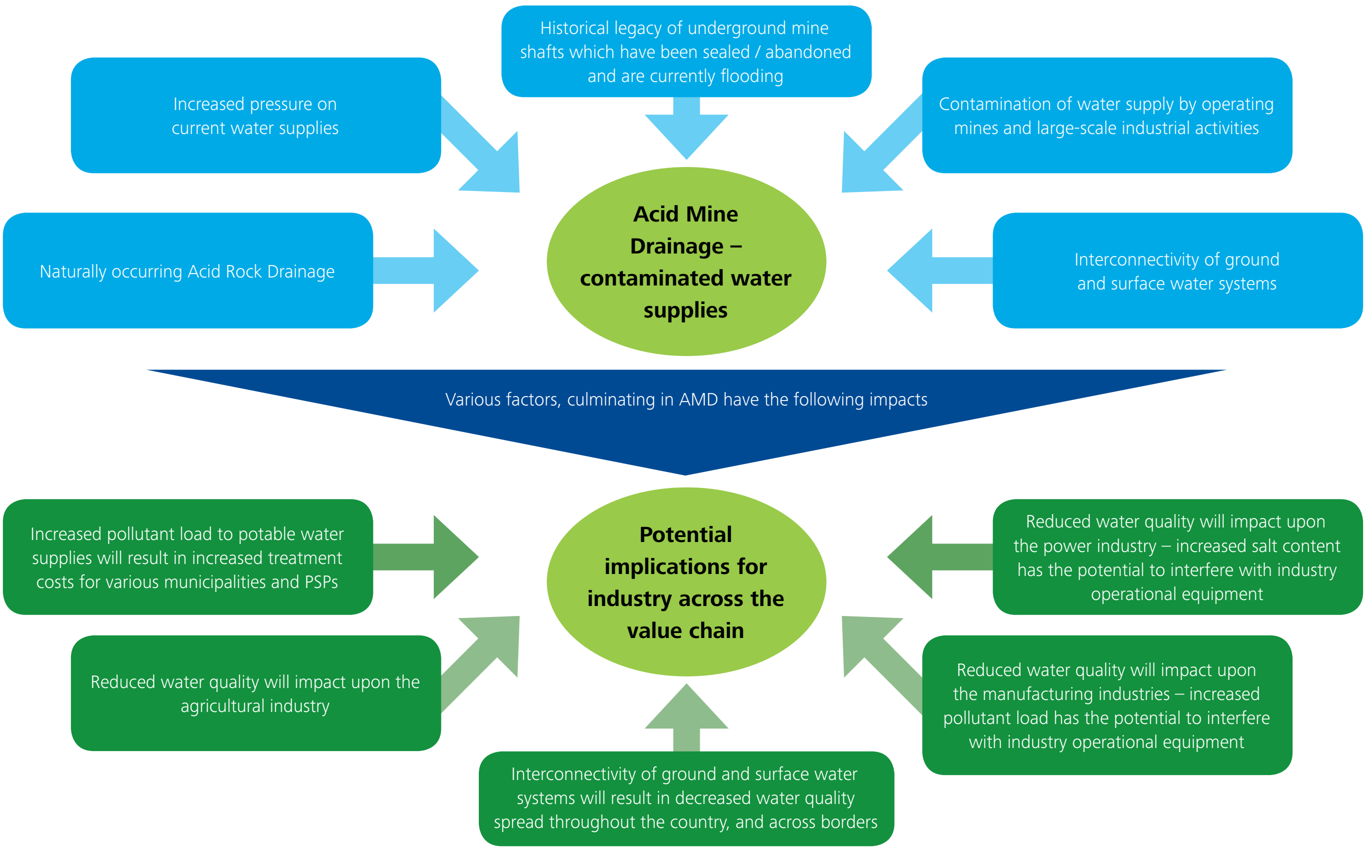
What is AMD?

Acid mine water is characterised by a low pH, and high salt and heavy metal content. AMD predominantly arises from rock types which contain an abundance of sulphide minerals, particularly pyrite, which are associated with various base metal- containing ores. This process is aggravated by large scale earth disturbances, such as those activities characteristic of mining.

The question is, why all the fuss?

Due to the interconnectivity of ground and surface water systems in South Africa, high volumes of polluted water have the potential to severely impact upon the quality of South Africa's water supply. This impact has the potential to affect all major industries, across the value chain. Preventing the formation or the migration of AMD from its source (mining pits, waste storage facilities, and underground workings), is generally considered to be the preferable option, although this is not feasible in many locations, and in such cases, it is necessary to collect, treat, and discharge mine water. This is a costly business, financially impacting both industry and the supply chain. For this reason, the prediction, prevention, containment and treatment of AMD must be considered carefully and with great specificity.

Figure 1: AMD factors and implications across industry value chain



The legacy issues surrounding the problem – the issue of accountability

Although South Africa has a long history of mining, the country has only recently developed and implemented comprehensive legislation to regulate environmental management and mine closure processes.

After the promulgation of the Minerals Act of 1991, all operational mines were required to provide funds to enable environmental and social rehabilitation and mine closure. This was followed by the Minerals and Petroleum Resources Development Act (MPRDA) of 2002, which, together with General Notice Regulation 527 of 2004 and associated guidelines, provided for a methodology which allowed for the financial estimation of the closure quantum to be provided by the mine. This estimation is to be revisited annually, to ensure sufficient provision of funds.

However, prior to this legislation, numerous historical mining operations had been abandoned by their operators with little or no provision for the rehabilitation of the impacts caused by mining.

How the matter is addressed may well affect the sustainability of mining in South Africa for the foresee-able future.

The size of the problem

There are two logical questions which arise following contemplating the challenges surrounding AMD:

1. How does AMD and the associated resulting issues affect our country's water resources?
2. What is the cost of addressing this issue?

After more than 120 years of deep level gold mining on the Witwatersrand, mining and dewatering has stopped in most areas due to the exhaustion of gold resources or due to the uneconomic nature of the remaining reserves (DWA, 2010).This has resulted in the groundwater levels rising, and decanting of acid water into surrounding river catchments.

Risks Associated with the current and future AMD challenges

The potential for AMD to affect river systems has been identified in Mpumalanga, Free State, Gauteng, Limpopo, North West and the Northern Cape.

In a report published by the Inter-Ministerial Committee under the Coordination of the Council for Geoscience to the Government in 2012, the following risks have been identified with respect to the flooding of the mines in the priority areas and the subsequent decant of AMD.

Risks owing to flooding of the mines

- Contamination of shallow groundwater resources required for agricultural use and human consumption
- Geotechnical impacts, such as the flooding of underground infrastructure in areas where water rises close to urban areas
- Increased seismic activity which could have a moderate localised effect on property and infrastructure

Risks owing to the decant of AMD to the environment

- Serious negative ecological impacts
- Regional impacts on major river systems
- Localised flooding in low-lying areas

Risks associated with AMD on water security:

- Food security
- Cross-border water supply
- Water quality following incidences such as droughts and/or flooding
- Provision to industrial giants

How much is too much? Where does one define the tipping point for AMD?

How to quantify the impact of AMD? The challenge is, when comparing a drop of diesel that will make 1 mega litre of water unfit for human consumption, acid mine water has a range of acidities which affect various systems. This may be the biggest challenge of all – the unknown.

What solutions are available?

Working toward a sustainable solution

Much attention with regards to AMD has been focused on the Witwatersrand Basin. However, platinum bearing ores in the Bushveld Igneous Complex mined for platinum group metals and base metals, and coal mines in parts of Mpumalanga, Kwazulu-Natal and the Limpopo provinces contain significant amounts of pyrite of which pose a potential AMD threat. The potential for AMD occurrence and impact at each phase within the mining chain needs to be fully explored and understood. Only then can the full development potential of technology solutions be implemented.

Figure 2: Lifecycle of the mining value chain

Current solutions in dealing with the decanting of AMD in the Witwatersrand include pumping of acid water using submersible pumps to maintain acid water below the environmental critical levels (ECL), and neutralisation. Current pumping rates in the Western Basin are 27ML/day at base load and 84 ML/day at peak pumping rates. It is estimated that peak pumping rates will be at 110 and 84 ML/day in the Eastern and Central basins respectively.

The issue with these types of solutions is that they are merely reactive and not sustainable. Pumping stations can be easily flooded in the event of pump failure. Furthermore, pumping current and projected throughputs place a significant energy burden on an already strained grid system. Although limestone dosing neutralises the pH of acid water, it creates a secondary issue of sludge disposal which does not deal with the heavy metal content in AMD.

The development of an effective water treatment solution/technology is usually a trade-off between a combination of factors like capital cost, operational cost and effluent water quality (in line with prevailing regulatory specifications) as conceptually shown.

Figure 3:Water treatment/technology solution trade off

Technology type	Capital Cost	Operational cost and maintenance	Effluent water quality
Reverse osmosis	High	High	High
Biological treatment	High	Medium	Low
Limestone treatment	Medium	Low	Medium

● Low ● Medium ● High

Furthermore, the scale of the AMD throughput experienced in the Witwatersrand, and changes in chemical composition in AMD require the development and implementation of solutions that are able to address scale and variability in input water quality. A commercially sustainable and cost-effective solution is required.

What sustainable solutions are available for consideration?

One such technology solution with the scale to deal with AMD decant in the Western Basin was proposed by the Western Utilities Corporation (WUC). The CSIR's ABC water treatment process is designed to achieve neutralisation as well as metal and sulphate removal from AMD by the optimal (efficient) use of readily available and affordable chemicals. The water stage is integrated with a sludge processing stage to recover alkali, barium and calcium (A,B,C) from the chemical sludge produced in the water treatment part of the process[1]. However, due to the lack of "buy-in" from relevant stakeholders, the implementation and commissioning of these AMD treatment plants has not been realised.

Figure 4: ABC water treatment process

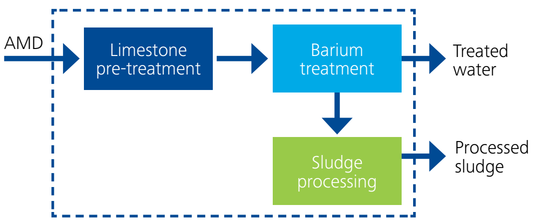
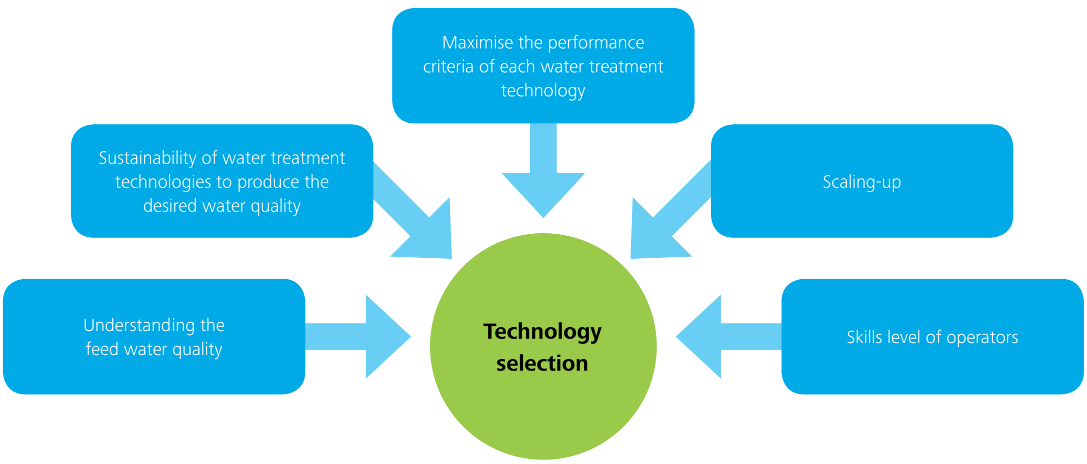


Figure 5: Technology selection process



Emalahleni Water Reclamation Plant – A success story

The Emalahleni Water Reclamation Plant was designed and built to recover potable water from acid mine drainage from several mines in the Emalahleni (Witbank) area. The project is a joint initiative between mining companies Anglo Coal and BHP Billiton Energy Coal South Africa (BECSA). Commissioned in 2007, the plant desalinates rising underground water from Anglo Thermal Coal's Landau, Greenside and Kleinkopje collieries, as well as from BECSA's defunct South Witbank Mine[2] using the HI recovery Precipitating Reverse Osmosis (HiPRO) process. Figure 5 shows the considerations that were made in the selection of the appropriate technology[3].

After a decade of research and development, Anglo Thermal Coal entered into a R300 million joint initiative with BECSA and a bulk supply agreement with the water-stressed Emalahleni Local Municipality. The result was two competing global resource companies coming together to solve a common problem, and provide a sustainable solution that benefits the communities that reside around their mining operations. The success of the implementation of this project resulted in identifying the need to develop a sustainable, cost effective AMD solution and an active contribution from all affected stakeholders to the realisation of the project.

1 M de Beer, J. P Maree, J. Wilsenach, S Motaung, L Bologo, V Radebe: Acid Mine Water Reclamation using the ABC Process
2 B. Hutton, I. Kahan, T. Naidu, P. Gunther: *Operating and Maintenance Experience at the Emalahleni Water Reclamation Plant*
3 P. Gunther, W. Mey: *Selection of Mine Water Treatment Technologies for the Emalahleni (Witbank) Water Reclamation Project*

Conclusion

In an already water-scarce country, any potential threats to water security (potable, industrial, and agricultural alike) should not be taken lightly. It is imperative that the needs and the potential for AMD in each region are well understood and mitigated against. Indeed, the various committees and bodies which have been formed, and solutions proposed, indicate an intimate understanding of the issue, and insightful solutions. However this will be driven not only by technological solutions, but active engagement from all stakeholders.

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