Mine water and the alarming water situation in SA

At the Gauteng Branch's annual dinner at the Wanderers Club on April 20, 2017, which followed SAIChE's annual general meeting, Mariette Liefferink, CEO of the Federation for a Sustainable Environment (FSE), delivered a keynote address on acid mine drainage (AMD) and the state of South Africa's water resources. *MechChem Africa* attends and reports.

Liefferink's first slide shows that, in terms of water availability in South Africa, 12 of our 19 Water Management Areas (WMAs) require intervention, with the requirements exceeding or very close to exceeding total water availability. For South Africa as a whole, our current requirement is already perilously close the 14 000 million m^3/annum currently available to us.

By 2025, all four international river basins – the Orange, the Limpopo, the Incomati and the Maputo – will move into absolute water scarcity leading to economic stagnation and potential social decay. This before taking climate change into account.

The Limpopo River Basin is already over-allocated by about 120% and is facing a 241% increase in demand by 2025, Liefferink says, referencing a 2009 study by Ashton.

She cites some reasons for the dramatic increase in water demand in the region, which include: current and proposed mining activities; Sasol's proposed Mafuta coal-to-liquid fuel projects; the exploitation of the vast coal reserves in the Waterberg; the expansion of the Grootegeluk coal mine to supply the Medupi Power Station; Medupi, Kusile and proposed new Eskom power stations; and the implementation of the Ecological Reserve, which is expected to result in serious deficits in some of the main river catchments.

Touching on the DWS' 2014 Reconciliation Strategy for the Orange River, she points out that supply and demand are currently at the crossover point. While intervention is required immediately, the situation will not improve before the Polihali dam is completed in around 2023 – and this will only achieve temporary relief.

As well as growing water shortages, however, the salinity in the Orange River is increasing alarmingly because current AMD treatment strategies involve neutralisation only, which results in water containing dissolved salts being discharged into the river.

Mariette Liefferink and the FSE

Since its inauguration in 2007, the FSE has become the most prominent environmental activist in the mining industry. Its directors, most notably, Mariette Liefferink, are listed among the 100 most influential people in Africa's Mining Industry and the Federation's contributions to environmental and social justice have been recognised via a number of environmental awards.

Mining and AMD

There is wide acceptance that acid mine drainage (AMD) is responsible for the most costly environmental and socio-economic impacts. AMD is a long recognised problem within the gold mining industry; it was referred to as an established phenomenon concerning pumped water on the Witwatersrand back in 1903.

AMD has a low pH and high acidity, but in addition to the acidity of AMD minewater, a number of other elements/determinants are also present in the water, mostly metals. Many of these are present in toxic concentrations in the water. Radioactive metals also occur in the water.

AMD, says Liefferink, is associated with surface and groundwater pollution; degradation of soil quality; for harming aquatic sediments and fauna; and for allowing metals to seep into the environment. Long-term exposure to AMD-polluted drinking water may lead to increased rates of cancer; decreased cognitive function; and the appearance of skin lesions.

In addition, metals in drinking water could compromise the neural development of the foetus, which can result in mental retardation, she points out.

Highlighting a problem relating to radioactive water contamination, she says that test results indicate that U-levels (uranium) in water resources of the whole Wonderfonteinspruit catchment have increased markedly since 1997, even though U-loads emitted by some large gold mines in the Far West Rand have been reduced. This apparent contradiction is explained by the contribution of highly polluted water that decanted from the flooded mine void in the West Rand from 2002 to 2012.

Coetzee *et al*, 2003 reported a uranium concentration in a surface-water body next to the northern watershed of the headwater region of the Wonderfonteinspruit (Robinson Lake) of 16 mg/ℓ after underground mine water decanting into the Tweelopiespruit was pumped into the lake. This resulted in the National Nuclear Regulator (NNR) declaring the lake a radiation area. This extreme concentration is believed to be the result of remobilisation of uranium from contaminated sediment by acidic water.

The potential volume of AMD from the Witwatersrand Goldfield amounts to an estimated 350 Mℓ/day (1.0 Mℓ = 1 000 m^3). This represents 10% of the potable water supplied daily by Rand Water to municipal authorities for urban distribution in Gauteng province and surrounding areas – at a cost of R3 000/Mℓ.

The gold mining industry in South Africa, principally the Witwatersrand Goldfield, is in decline, Liefferink points out. The post-closure decant of AMD is, therefore, an enormous threat – and this could become worse if remedial activities are delayed or not implemented.

The treatment problem

The current (immediate and short term) treatment of AMD is by means of neutralisation or a pH adjustment. In most cases, metals will precipitate out of solution if the pH is adjusted upwards, that is, the water is made more alkaline. It should be noted that the metals do not simply disappear but change to a different oxidation state, changing them from a soluble form to a solid form. The metals are still there, in the area where the precipitation has occurred in the first place. This means that the process can be reversed and the contaminants re-mobilised, should the water become acidic again

Above: *The numerous open pits in the West Rand Goldfield have been identified as a source of ingress.*

Right: *West Rand, 2002 to 2016: Current AMD treatment by means of neutralisation or pH adjustment precipitates metals out of solution, which are being deposited as metal sludge into unlined pits.*

The numerous open pits in the West Rand Goldfield have been identified as a source of ingress of AMD into the West Rand Basin, the study commissioned by the mining industry estimating that these contribute approximately 30% of the total ingress.

From a salination perspective, the sulphate concentrations in neutralised AMD remain high (2 000 to 3 000 mg/ℓ). High concentrations of sulphate are associated with acute health effects, diarrhoea, for example. Sulphate concentrations of 600 mg/ℓ and more cause diarrhoea in most individuals and adaptation may not occur. The numerical limit for sulphate in terms of the resource quality objectives (RQOs) for the Upper Vaal is between 200 and 500 mg/ℓ depending on the water use.

Apart from health issues, elevated sulphate concentrations also increase the corrosion rate of metal fittings in water distribution systems.

In livestock watering, it was found that sulphate levels above 250 mg/ℓ suppress copper and selenium, which result in poor fertility and animal condition.

The Department of Water and Sanitation's Feasibility Study for the Long Term Treatment of AMD (2013) and the Reconciliation Strategies for the Integrated Vaal River System warned that the additional salinity as a result of AMD would create water security risks. In order to comply with the regulatory limit of 600 mg/ℓ of sulphates, good quality water will have to be released from the Vaal Dam in order to ensure that the water below the Vaal Barrage is fit for use, that is, by means of dilution.

The projected demand for increased releases from the Vaal Dam of expensive Lesotho water is also sure to increase the stress upon the water supply. The additional volume of water that has to be released as a result of the salinity associated with AMD has resulted in a considerable reduction of water supply to the Upper Vaal, so much so that the total capacity of Phase 2 of the Lesotho Highlands scheme will be completely nullified.

Approximately 100 Mℓ of AMD is currently neutralised within the East Rand Basin and the same volume is discharged from the East Rand basin into the Blesbokspruit. A further 80 Mℓ from the Central Basin is discharged into the Elsburgspruit.

The resulting metal sludge, which is in toxic concentrations and contains uranium, is currently deposited in Grootvlei Shaft 3 and boreholes within the Eastern Rand gold fields. These are on unlined tailings storage facilities within the Central Rand gold fields. The risk of our watercourses becoming re-contaminated following flooding is apparent.

The May 18, 2016 launch of the Long Term Treatment of AMD document estimated the capex cost of the long-term treatment of AMD to be in the region of R10 to R12-billion, with ongoing opex costs of R25-million per month. The preferred treatment options, according to Liefferink, are to use modern reverse osmosis and ion exchange technologies to replace pH treatment using lime. Financing of the Long Term Treatment of AMD is to come from a combination of Treasury (67%) – to be recovered through an environmental levy from current mining companies – while the public via increased water tariffs will fund the remaining 33%.

Implementation is currently scheduled for 2020. ❑

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