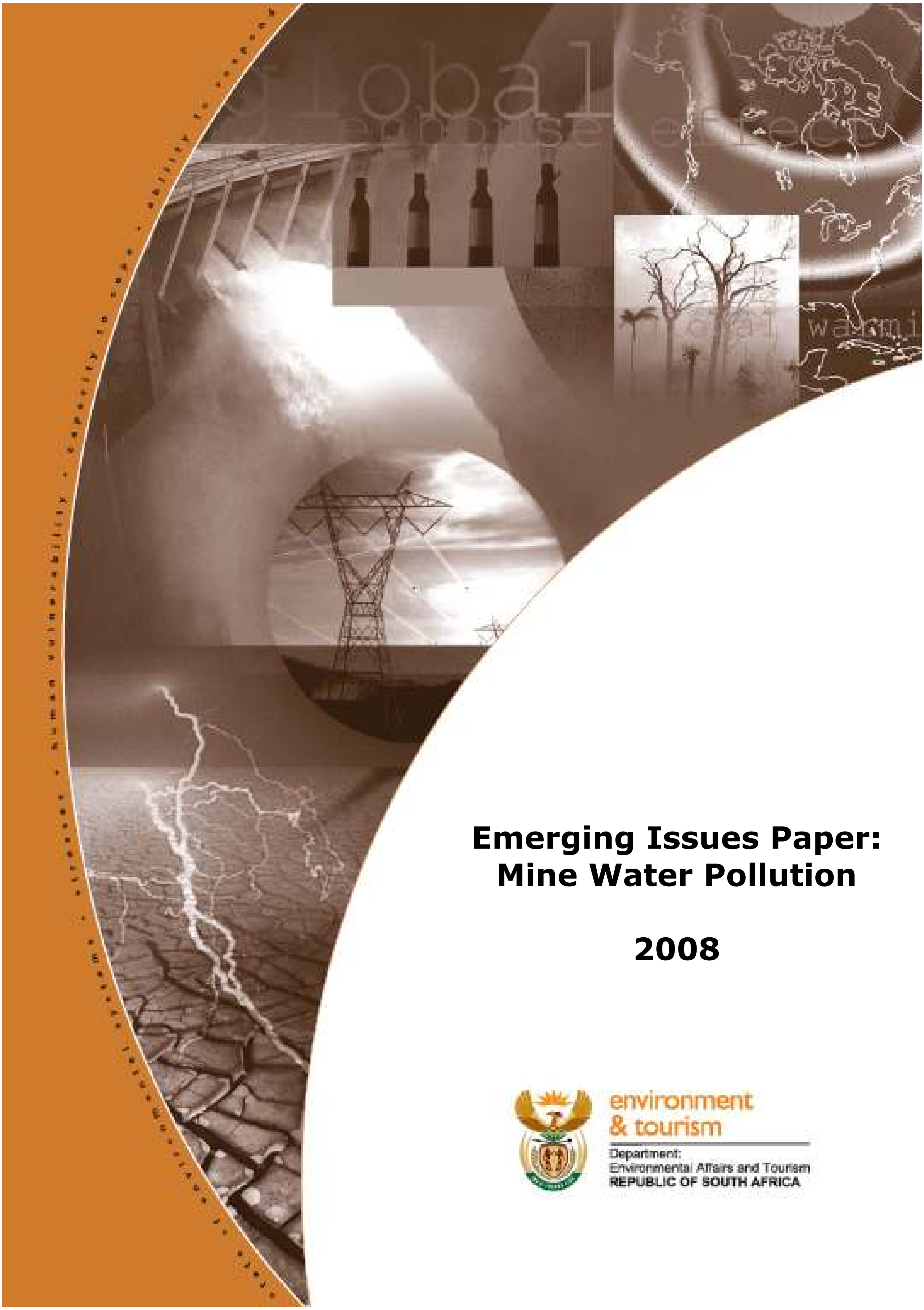

Emerging Issues Paper: Mine Water Pollution

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MINE WATER POLLUTION - ACID MINE DECANT, EFFLUENT AND TREATMENT: A CONSIDERATION OF KEY EMERGING ISSUES THAT MAY IMPACT THE STATE OF THE ENVIRONMENT

This document provides information on emerging issues that may affect the future state of the environment. The purpose of this paper is to draw attention to issues in preparation for the next state of environment reporting cycle.

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Introduction

A major environmental problem relating to mining in many parts of the world is uncontrolled discharge of contaminated water (or decant) from abandoned mines (Banks et al., 1997, Pulles et al., 2005). Commonly known as acid mine drainage (AMD), there is wide acceptance that this phenomenon is responsible for costly environmental and socio-economic impacts. While South Africa has made significant progress in shifting policy frameworks to address mine closure and mine water management, and the mining industry has changed its practices to conform to new legislation and regulations, vulnerabilities in the current system still remain.

AMD is characterized by low pH (high acidity), high salinity levels, elevated concentrations of sulphate, iron, aluminium and manganese, raised levels of toxic heavy metals such as cadmium, cobalt, copper, molybdenum and zinc, and possibly even radionuclides. The acidic water dissolves salts and mobilizes metals from mine workings and residue deposits. Dark, reddish-brown water and pH values as low as 2.5 persist at the site (Akcil and Koldas, 2006). AMD is not only associated with surface and groundwater pollution, but is also responsible for the degradation of soil quality, aquatic habitats and for allowing heavy metals to seep into the environment (Adler and Rascher, 2007). An exacerbating characteristic of AMD is its persistence – it is extremely difficult to rectify.

Certain expert assessments by the Environmental Protection Agency in 1987 concluded that "problems related to mining waste may be rated as second only to global warming and stratospheric ozone depletion in terms of ecological risk. The release to the environment of mining waste can result in profound, generally irreversible destruction of ecosystems". In many cases the polluted sites may never be fully restored, for pollution is so persistent that there is no available remedy (EEB, 2000).

In South Africa, an example of AMD is occurring on the West Rand in Gauteng Province. Acid mine water started to decant from defunct (closed) flooded underground mine workings on the West Rand in August 2002. "Decant has subsequently been manifested at various mine shafts and diffuse surface seeps in the area. Up until early-2005, and completion of storage and pumping facilities to contain and manage on average of 15 Mega-Litres per day (ML/d) of decant, the AMD found its way into an adjoining natural water course and flowed northward through a game reserve, and towards the Cradle of Humankind World Heritage Site" (Oelofse et al., 2007).

In April 2005, the media drew attention to the West Rand basin with news headlines such as "A rising acid tide" and "Acid river rocks Cradle of Humankind". The reports went on to state that "South Africa's renowned Cradle of Humankind in Gauteng, home to one of the world's richest hominid fossil sites, is under threat from highly acidic water pollution..." (Independent online, 14 April 2005) and "It is also threatening to drown the Sterkfontein caves." (Mail and Guardian, 12 April 2005). The Mail and Guardian also accused scientists, mining companies and government of reluctance to discuss the mine water decant and its impact publicly "…and yet it is the start of a problem of such magnitude that it will affect our environment and health for decades to come" (Mail and Guardian, 12 April 2005). More recent media reports have drawn attention to mine water pollution contaminating the Loskop Dam, Randfontein and Wonderfontein Spruit areas.

Specific water quality problems that are highlighted in the South Africa Environment Outlook Report (DEAT, 2006) include salinity and acidification. Acidification is directly related to mining, while mining is but one contributing factor leading to increased salinity (DEAT, 2006). The effect of mining on the environment includes the release of many chemical contaminants into water resources, environmental damage that can persist for a long after mine closure, and the health and safety of nearby communities being compromised.

Discussion

Discharges of contaminated water from abandoned, derelict and/or ownerless mining sites is common to all countries where mining started prior to the promulgation of environmental legislation. In South Africa, the defunct Chamber of Mines Research Organisation (COMRO) conducted studies on the impact of gold mining activities on the environment of the Witwatersrand. More recently, the European Commission's 5th Framework R&D project carried out by the ERMITE (Environmental Regulation of Mine waters In The European Union) Consortium arguably represents the most comprehensive attempt to develop guidelines aimed at understanding and addressing mining impacts on the water environment within the context of catchment management strategies. This project has no doubt to some extent addressed the substantial gap in consistent information on how mining wastes are managed in different countries (Pulles et al. 2005), at least within the European Union.

The potential impacts of mining on the water environment are subdivided (ERMITE, 2004a) into those associated with phases of mining operations, namely:

- the act of mining itself;
- seepage of contaminated water from mine residue deposits (waste rock dumps and tailings dams) resulting from mineral processing/beneficiation;
- dewatering of active mining operations; and
- rewatering (flooding) of defunct/closed mine voids and discharge of untreated mine water.

A definition of "mine water" after ERMITE (2004b) reads "Mine water is water in mined ground including waste rock/tailings depositories and/or draining into an adjoining body of water including streams, lakes, aquifers, wetlands, and oceans". Sulphide minerals such as pyrite occur in most metal sulphide deposits and associated mining waste. The oxidation of these minerals in the presence of oxygen and water, produces acid mine water which manifests as AMD. Surface sources of AMD that present the greatest threat to the environment are coal discard dumps and slurry dams, gold tailings/slimes dams and waste rock dumps, and uranium slimes dams. Subsurface impacts are generally associated with water ingress (flooding) into underground mine workings, with the attendant threat of dewatering the source (and often pristine) groundwater regime and, in the post mining phase, providing a source of acid mine water for potential migration into the groundwater environment during rewatering (Banister et al., 2002).

A further consideration is the potential long-term pollution threat, since production of AMD may continue for many years after mines are closed and tailings dams decommissioned (Johnson and Hallberg, 2005). The persistent nature of AMD has been discussed by Younger (1997), who recognizes two components in its evolution over time. The shorter term component is associated with vestigial acidity (generated during rewatering) that declines over a period of 10 to 40 years. The longer term component is associated with the generation of juvenile acidity (formed in the zone of water table fluctuation after rewatering), and which "…will persist for several hundred years until mineral sources are depleted." (Younger, 1997).

The release to the environment of mining waste can result in profound, generally irreversible destruction of ecosystems. In 1989, it was estimated that about 19 300 km of streams and rivers, and about 72 000 ha of lakes and reservoirs worldwide had been seriously impacted by mine effluents, although the true scale of the environmental pollution caused is difficult to assess and quantify accurately (Johnson and Hallberg, 2005).

A study by Naicker et al. (2003) revealed that the groundwater in the mining district of Johannesburg, South Africa, is heavily contaminated and acidified as a result of oxidation of pyrite contained in the mine tailings dumps, and has elevated concentrations of heavy metals. Where the groundwater table is close to surface, the upper 20 cm of soil profiles are severely contaminated by heavy metals due to capillary rise and evaporation of the groundwater. The polluted groundwater is discharging into streams in the area and contributes up to 20 % of the stream flow, causing an increase the acidity of the stream water. The effect of the contaminated water from the mines can persist for more than 10 km beyond the source (Naicker et al., 2003). Evidence of radionuclide pollution was found in the Wonderfonteinspruit Catchment (Wade et al, 2002; Coetzee et al, 2006; National Nuclear Regulator, 2007).

AMD is the most difficult mine waste problem to address (Durkin and Herrmann, 1994). Elaborate pumping systems were employed in the beginning of the 20th century to increase profits, resulting in the modification of the water table, the appearance of sinkholes, and elevated levels of water, air, and soil pollution (Adler and Rascher, 2007; Adler et al., 2007; IIED, 2002). Post-closure decant from defunct coal mines is estimated at 62 ML/d (DWAF, 2004), and in the order of 50 ML/d of acid mine water discharges into the Olifants River Catchment (Maree et al., 2004). It is clear, therefore, that significant volumes of polluted water need to be managed on a continuous basis for decades to come. These circumstances, however, do not imply only doom and gloom. The Emalahleni Water Reclamation Plant at Witbank is a state-of-the-art treatment plant able to treat 25 ML/d of acid mine water to a potable water standard (Günther et al., 2006). Although the principal beneficiary of the treated mine water is ostensibly the Emalahleni Local Municipality, it is arguably the receiving aquatic environment of AMD that benefits most, albeit incalculably, from the initiative in that less than AMD reaches it (Hobbs et al., in press). In a water scarce country such as South Africa, this key emerging issue also represents an opportunity.

A high confidence study of the fate and pathway of heavy metals and radionuclides associated with mine decant and AMD should be undertaken. This study will reveal where the pollution is traveling and if there is human risk involved, and therefore where management intervention is required. In addition a high confidence epidemiological study of off-mine populations impacted by mining activities is required. To date there are no reliable data on human-related impacts associated with mining activities.

The extent of mine pollution impacts need to be determined. Remediation priority areas and actions need to be identified based on location and extent of mine pollution impacts. AMD follows the same flow pathways as water, and can therefore best be controlled by controlling water entry into the site of acid formation, by diversion of surface water away from the residue storage areas, prevention of groundwater infiltration into the mine workings, prevention of hydrological seepage into the affected areas and controlled placement of acid-generating waste (Akcil and Koldas, 2006).

Research is also required on strategies to utilize the storage potential of defunct/closed underground mine voids in optimally managing the generation of AMD in order to control its potential impact on the receiving surface and groundwater environments. Research is required on the further field impacts of AMD on potentially receiving dolomitic (karst) environments and the re-activation of springs dried-up due to dewatering.

Conclusions

AMD is the single most important environmental concern from mining activities. It is a common problem in all countries where mining started prior to the promulgation of environmental legislation. Many mines are reaching the end of their productive life and as a result, dewatering is terminated and rewatering results in the decant of AMD, often at unpredictable locations. In addition, tailings dams and waste rock dumps constitute surface sources of AMD.

The threat of AMD to the environment is not solved in the short to medium term; it is likely to persist for centuries to come. Whilst AMD threatens the scarce water resources of South Africa, and as a result also human health and food security in mining areas, it also presents an opportunity to provide usable water through appropriate treatment technologies.

The legacies of the historic sites will remain problematic for many years to come due to the vast magnitude of the associated impacts. There are no easy solutions to the problem, but concerted efforts could lead to vast improvements and reductions in the environmental impacts associated with the historic sites. The primary management issues therefore include long term decant risk, acid mine drainage, water pumping and treatment and allocation of responsibility especially in light of the interconnectedness of the mines (Pulles et al., 2005).

Institutional fragmentation and overlapping or vaguely defined roles and responsibilities regarding the management and control over mining waste are common to Europe, the United States of America and South Africa (Godfrey et al., 2007). In general, waste management falls within the mandate of environmental authorities or agencies, while mining is addressed by mining authorities with little or no specific reference to mining waste. A single law devoted to mining waste will remove confusion and ambiguity in legislation. Policy and/or regulations based on sound scientific evidence, including the research described in this essay, should be developed.

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