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Risk assessment methodology for shut-down and abandoned mine sites in Namibia

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ABSTRACT

Mining has a long history in Namibia. Legacies of old operations are evident in numerous shut-down and abandoned mines, posing severe to moderate environmental and health risks. It is the responsibility of the government to deal with these risks, firstly by assessing their magnitudes, and then deciding on those that need the most urgent attention. The Geological Survey of Namibia, in cooperation with its partner, the German Federal Institute for Geosciences and Natural Resources (BGR), and their consultant, the Southern African Institute for Environmental Assessment (SAIEA) developed a Risk Assessment Manual for shut-down and abandoned mines, which takes the environmental conditions prevailing in Namibia into consideration. This manual provides a useful tool for the scientific and practical evaluation of the risks. It can be further developed and customized for adoption in other countries. In this article, we present the methodology adopted in the manual.

1. Introduction

Mining has taken place in Namibia for at least the last 500 years, as evidence from archeological research in the area on copper occurrences along the Matchless Belt in the vicinity of Windhoek suggests (Fig. 1). In the Otavi Mountainland, local people have been smelting copper in anthills with the aid of charcoal, and a vivid trade in copper was witnessed by the first Europeans visiting the area (Galton, 1853). A port was consequently established at Walvis Bay, signaling the formal commencement of exploration and mining activities in Namibia. Since the 1880s widespread exploration took place and most mineral deposits that we know today were discovered and subsequently opened up for mining. Base metals and diamonds have been the main commodities, with uranium, industrial minerals and gold following on more recently (Schneider, 1998).

Early exploration and mining activities were conducted with little regard for the environment, and rehabilitation measures were not put in place. Extraction methods used were not very efficient, and tailings left behind are now prone to acid mine drainage. Smelting commenced in the Otavi Moutainland as early as 1906, and heavy metals released by the smelter contaminated the surrounding soils (Fig. 2). Heavy metals retained by the slag presented another problem when the slag was disposed of. Environmental awareness in exploration and mining only started in the 1990s. As the responsible companies have long ceased to exist, the problem of abandoned and un-rehabilitated mine sites has been left on the shoulders of the current generation of Namibians and the Namibian government.

In this context, it is imperative for the Namibian government to understand how mining activities, and particularly abandoned mines, affect the ecosystem and the health of adjacent communities, and to establish the most appropriate rehabilitation technologies and remedial actions for contaminated sites.

2. Abandoned mines in Namibia

The legacy of Namibia's long mining history is represented today by an inventory of 157 shut down and abandoned mine sites (SD/AMS) countrywide, where no rehabilitation at all was done following mine

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Fig. 1. Archeological site with an almost 500 year old (Vogel and Visser, 1981) slag from copper smelting near the Matchless Belt.

closure (Fig. 3). The list of problems and safety hazards is long, and ranges from contamination of soils and groundwater, unsecured underground mine structures and open pits, rock falls and failing of tailing dams to acid mine drainage as illustrated in (Fig. 4) where the orange color indicates acid mine drainage from the tailings of the Otjihase copper mine. Rehabilitation is very expensive, and coupled with inadequate funding and lack of knowledge, it is prohibitive in many cases and therefore limited to selected cases. Prioritization based on the individual risks posed by any site is hence a prerequisite for decision makers before the commencement of site-specific rehabilitation.

The inventory of SD/AMSs was compiled by the Geological Survey of Namibia, and serves as a basis of this organization's effort to monitor these sites, assess their hazard potential and risks, and provide recommendations for rehabilitation measures. Such recommendations are directly provided to stakeholders and decision makers, including the Cabinet of the Republic of Namibia.

3. The risk assessment manual

Risk assessment for an SD/AMS must be undertaken in a systematic way, so that the data may be used in the future as a baseline for further monitoring. In this regard a "Risk Assessment Manual" was developed, using a similar manual produced by the Federal Institute for Geosciences and Natural Resources (BGR) of Germany for Chile, as the basis (Golder Associates, 2008). The specifics of minerals mined in the past, beneficiation processes used, environmental conditions, and the legal framework in the past and present were taken into consideration, and the manual was thus adapted and customized for the Namibian situation (SAIEA, 2010).

The manual prioritizes the hazard potential and accordingly identifies mitigation requirements of the most severe risks. It includes guidelines for assessing safety and contamination risks, with further details for classifying the risk according to the geological and physical situations on the ground. The evaluation of the risks of any SD/AMS using the manual starts by carrying out a desktop study, which is followed by a simplified risk assessment for safety and contamination at the site, and, if necessary, a Detailed Risk Assessment. This leads to the classification and prioritization of an SD/AMS according to the identified risks.

The manual also includes questionnaires for the different components of a mine (works, installations, support services, infrastructure), so that an appropriate evaluation is carried out in a systematic way and according to guidelines. This also facilitates the entry of collected data into a database. The manual classifies risks of contamination and risks to safety in terms of sources, exposure pathways and receptors (eg. humans and the environment).

4. Risk assessment methodology

The risk assessment of a given abandoned mine involves the identification of hazard scenarios and potential receptors, and assessing the likelihood of occurrence and the severity of consequences (Fig. 5). A hazard scenario is a situation that involves a threat to safety, such as an open mine shaft, an open pit, or an unsafe tailings dam. The potential receptors are chiefly people and the environment (aquatic life, fauna and flora, environmentally sensitive areas), as well as economic activities such as agriculture, tourism, and animal husbandry, including game farming.

It also involves the assessment of situations that affect physical safety and chemical (contamination) safety, which includes looking at the exposure pathways, which will bring the receptor into direct contact with the source of contamination; and the source of contamination if present in concentrations that will generate undesired effects on receptors (Fig. 6).

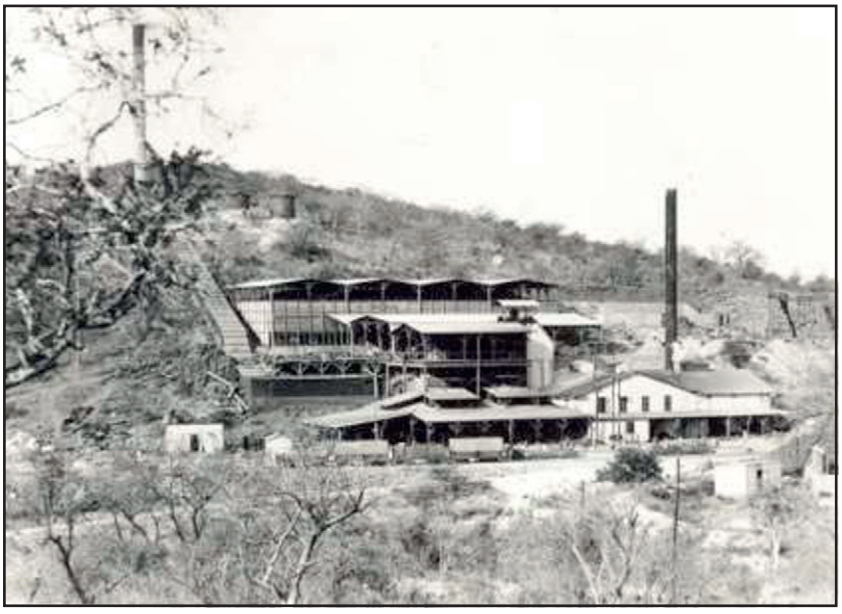

Fig. 2. The Tsumeb smelter in 1909.