

Investigating the Acid Mine Drainage (AMD) and Metal Leaching Potential of Naisinyai Waste Rock Dump in the Merelani Area, Tanzania

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Introduction

The Naisinyai Waste Rock Dump (WRD), located in Naisinyai village within the Merelani area of northeastern Tanzania, contains waste rock materials from tanzanite mining—a globally unique gemstone extracted exclusively from this region, established in 2001 by Tanzanite One Mining Co. Ltd. to deter encroachment by local villagers. However, following the company’s cessation of activities in 2017, the WRD was left unrehabilitated, leading to growing environmental and community concerns. During rainfall, the WRD generates leachate that overflows into the surrounding environment. The absence of proper mitigation measures has worsened the situation, leading to visible environmental impacts and raising serious concerns among local communities. Despite these pressing concerns, detailed studies on the AMD and metal leaching potential of the WRD are lacking. Understanding these processes is critical for evaluating environmental risks and formulating effective mitigation strategies. This study aims to investigate AMD generation and metals' leaching potential from the Naisinyai WRD.



Figure 1. Naisinyai waste rock dump

Methodology

In this study, waste rock samples were collected, including fresh rock from an active mine, weathered materials, and precipitates from the Naisinyai WRD, along with water leachates from three ponds at the site. A drone survey provided data on the area's topography and surface drainage.

Based on AMIRA International’s 2002 ARD Test Handbook, geochemical static tests were conducted to assess AMD generation. These included paste pH/EC, NAGpH, and Acid-Base Accounting (ABA) tests, such as MPA, ANC, and NAPP. XRD and XRF analyses determined the mineralogical and elemental composition of the waste rocks. Free-draining column and batch tests evaluated metal leaching potential, while ICP-MS analyzed heavy metal and major element concentrations in leachates. Topographic and drainage patterns were generated using ArcGIS and Global Mapper software

Result and Discussion

Geochemical static tests confirmed that the waste rock materials at the Naisinyai WRD have significant potential to generate Acid Mine Drainage (AMD), with samples classified as Potentially Acid Forming (PAF) characterized by $NAG\ pH \leq 4.5$ and $NAPP \geq 0$. XRD analysis identified pyrite as the primary AMD source, along with secondary minerals like jarosite and halotrichite in precipitates, which contribute to acidity upon dissolution.

ICP-MS analysis revealed high concentrations of metals in leachates from water ponds and leaching tests, including Fe (10–80 ppm), Zn (5–394 ppm), Al (10–5433 ppm), Ni (80–292.43 ppm), Ca (120–200 ppm), Cu (0.5–12.22 ppm), Pb (0.1–4.38 ppm), Cr (0.01–0.5.7 ppm), and As (0.01–0.5.37 ppm). These levels exceed the industrial effluent limits of Tanzania’s Water Quality Standard Regulation (2007).

Topographic and drainage analysis revealed sloping terrain with numerous surface streams, heightening the risk of contaminant transport from the WRD. These findings highlight the critical need for effective waste management measures to mitigate the environmental impacts of AMD and metal leaching at the Naisinyai WRD.

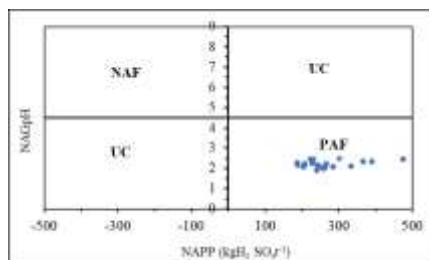


Figure 3. Geochemical classification plot

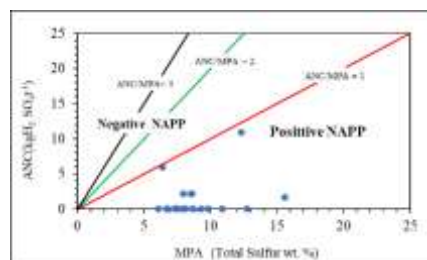


Figure 2. ABA plot