Prediction of acid mine drainage occurrence at the Inata gold mine-Burkina Faso, West Africa

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ABSTRACT

The Inata Gold Mine (Northern Burkina Faso) is the fifth mine in Burkina Faso, and it started operating in December 2009. The mine has generated about 90 million tons of tailings which are exposed to the ambient air mine, and thus constitute a potential source of acid mine drainage (AMD). Despite the negative impacts of acid mine drainage on the environment, no studies, to best knowledge, have yet evaluated or predicted acid mine drainage in Burkina Faso. In order to better understand the processes that control the occurrence of AMD under semi-arid conditions, the present study used a static test to predict the fate of tailings in Inata Gold Mine. A total of 50 samples were collected in different locations in the tailing storage facilities, waste dam and in waste rock piles of northern, central and southern pits for physico-chemical and geochemical analyses. After sample characterization, their pH, conductivity and buffering capacity were measured. Total sulfur and total trace element concentrations of the samples were also determined. High pH values (9.23-10.04) of the samples suggested alkalinity, meaning that the mine wastes were not subject to oxidation and/or gold processing in basic media. This observation was also corroborated by low conductivity values (50.00-124.00 μS/cm), except for the sample from the waste rock dump of the south pit (WDFS3; 967.00 μS/cm). Based on the low sulfur contents (<0.3%), it is unlikely that the mine wastes undergo oxidation process in the presence of water and oxygen. That is, the low sulfur contents of the samples except for samples RPA2 and RPB2, suggest that their acidification potential, is not significant enough to produce acid mine drainage although the waste rock dump of the southern pit represents some serious concerns. However, the buffering capacity and the potential for neutralization of all samples are relatively low, and thus the system may not be able with time to resist pH variations. According to static test analyses, the possibility of AMD generation in the Inata Gold Mine site is low. However, preventive measures are necessary in case environmental conditions change, and the system is unable to neutralize a potential acidity.

INTRODUCTION

In recent years, the mining sector has been gaining importance in many parts of the world due to substantial rise in gold price on the world market. In 2009 gold became the first export commodity in Burkina Faso. Nowadays, there are seven active mines in the country. The opening of the gold mine in Taparko (northern Burkina Faso) by the Taparko mining company (SOMITA) in 2007 marked the beginning of the revival of mining after the closure of the Poura gold mine in 1999. Mining contributes significantly to the country’s economy, the fight against the poverty and
unemployment. Despite, these economic advantages, mining poses serious threat the environment. The various phases of mining (exploration, production and post-production) can have dramatic impacts on the environment and the social fabric of the local populations. The mining industry generates large quantities of waste rock, gangue and tailings materials during extraction and ore valorization process. This is explained by the low ore contents in rocks and the huge volumes of rock that must be removed, treated and discharged. The majority of base metals (e.g. Cu, Pb, Zn, Fe) and precious metals (e.g. gold, manganese) are associated with sulphide minerals which are released into the environment after extraction of the targeted metal. The natural oxidation of the sulphide minerals such as pyrite, chalcopyrite, pyrrhotite, arsenopyrite, when exposed to air and water can be oxidized and produce acid effluents that dissolve and mobilize potentially toxic heavy metals into the environment. This phenomenon is known as acid mine drainage (AMD), and it is a major health and environmental concern owing to the mining industry. According to US-EPA (2000) and Kalin et al. (2006), by general consensus, AMD is the most critical environmental problems that can be caused by mining activities.

Once in the environment, heavy metals will greatly affect the quality of surface and groundwater resources and be detrimental to aquatic and terrestrial organisms US-EPA (2000). AMD derived toxic substances can find their way into food chain and reach humans. In humans, the metals are stored in most soft tissues, particularly the liver and kidneys, but also in the bone (Collon, 2003).

Methods for the AMD treatment and restoration of abandoned sites have been developed (chemical or biological methods), but different studies show that their application and effectiveness depend on many factors including acid generation potential, acid neutralization of mine tailings, characteristics of the wastes, environmental conditions (lithology, climate, topography and hydrology), the residence time of the waste, efficiency of control measures and the sensitivity of the receiving environment against the AMD (Kawatra and Natarajan, 2001; Aubertin et al., 2002; Akcil and Koldas, 2006). The methods based on reduction or elimination of one of the three main driving forces of AMD (water, oxygen and sulfur content) is generally expensive.

For this reason, prediction and prevention of AMD are the most sustainable management plan that can protect the environment and human health against AMD. The main method to prevent or control AMD is static and mineralogical tests which aim to assess the ability of a mine tailing sample to produce an acid drainage and its capacity/inability to neutralize it (Aubertin et al., 2002).

The main objective of this paper is, thus, to predict the production of AMD from mine tailings of the Inata Gold Mine in northern Burkina Faso. It aims the prediction of AMD so that its impacts on the ecosystem can be monitored and if necessary, to suggest a treatment plan and an appropriate management scheme for potentially hazardous tailings. Because mining is recent in Burkina Faso (since, 2007), this work is one of rare research activities dealing with AMD in the country.

STUDY AREA

The Inata Gold Mine is located in north-eastern Burkina Faso approximately 280 km from the capital city Ouagadougou (Figure 1). With an average annual rainfall less than 600 mm, the study area is suited with in the semi-arid Sahelian climatic zone. As a result, the region faces an inherent low availability and accessibility to drinking water. The majority of the local populations live mainly on substance farming and livestock.

Deterioration of the quality of the water resources through AMD will have dramatic effects on the populations that are highly dependent on these scarce resources. Apparently, no studies have been carried so far on AMD since the discovery of the ore deposit. Gold mineralization in Inata is usually associated with stock work of quartz-carbonate-sulfide or albite-carbonate-sulfide, but also with epiclastites and felsic volcano-clastic rocks. Although pyrite is the dominant sulphide minerals, other sulphide minerals such as chalcopyrite, galena, pyrrhotite, bornite, tennantite, linneite, mackinawite, arsenopyrite, sphalerite are found in trace amounts in veins, fractures or disseminated (Gbm, 2007).

Inata is the fifth gold mine in Burkina Faso, and it was opened in December 2009. The mine is a conventional open pit mine with selective logging. The treatment plant is designed on the model of activated carbon in leach (CIL) formed by six tanks. In total 30 tons of gold are expected to be extracted throughout the lifespan of the mine (~7 year). Since its opening, Inata Gold Mine has produced more than 90 million tons of tailings.

METHODOLOGY

Sampling

Fifty (50) samples each weighing 5 kg have been collected according to the targeted sampling protocol of waste rocks (CEAQ, 2009) in the waste rock “rompad” (place of storage of the ore), in the “tailing dam” (tailings management facility), in the embankment tailing facility and in each of the “wastes dump” (waste rock piles) of the three main pits namely the Central, Northern and Southern pits (Figure 2). Representative mine waste were collected by targeted sampling. Targeted sampling typically involves taking samples at locations where it is suspected to contain the presence of contaminants, or where it is desired to know the background or to demonstrate the presence or absence
of contamination in a given area (CEAEQ, 2008). The distance between two successive sampling sites varies between 50 and 200 m and is a function of the thickness and the height of the pile, that is, the volume of tailings. The total of 50 samples were collected, in such a way that 10 from each of the "waste dump" of the 3 main pits, 5 from the "Rompad", 8 from the tailing dam, and 7 from the embankment tailing facility. The number of samples taken in each site was a function of the representativeness of the rock type. The majority of samples were collected either at the base or on the slope of the dumps, places highly exposed to intense leaching during the rainy season.

Static tests

Analyses were performed at the Geological Survey of Burkina Faso "Bureau des Mines et de la Géologie du Burkina (BUMIGEB)" at the Environmental Laboratory at Laval University in Canada and at the Acme Labs at South Africa (Johannesburg). The method used is Aqua Regia digestion ICP-MS analysis. Conductivity, pH, sulphide contents, buffering capacity and metals contents were determined. Parameters determined were: acidification potential (AP), neutralization potential (NP), net neutralization potential (NNP) and net acid generation.

Analyzes were also performed in duplicate or triplicate and the possibility of rejecting the extreme values was evaluated statistically for a confidence interval of 95% according to APHA method (1989). In the present study, deionized distilled water and standard reagents of high quality were used. Matrix of white was also used for each analyzed sample.

Contrary to kinetic, static tests are cheap, and capable to predict AMD generation. The various parameters determined during a static test include acidification potential (AP), neutralization potential (NP), net neutralization potential (NNP) and the net acid generation (NAG).

Acidification potential (AP)

Acidification potential derived from total sulfur content

**Figure 1.** Geological map of Burkina Faso showing distribution of the main mines across the country (modified after Castaing et al., 2003).
Figure 2. Map of Inata Gold Mine showing sampling sites (Gmb, 2007).
This test consists of oxidizing sulphides present in the sample with 15% of hydrogen peroxide (H₂O₂) that simultaneously triggers acidification and neutralization reactions of the sample. The sample is also heated to allow the remaining unreacted peroxides to react. At the end of the reaction the pH (NAGϕH) of the dough is measured. Samples with NAGϕH values below 4.5 were titrated with a solution of sodium hydroxide (NaOH) to obtain a final NAGϕH of 4.5 so that the quantity of acid produced can be determined (kgH₂SO₄/ton) (Miller et al., 1997; Brunet, 2000; EPA, 2000; Tran et al., 2003).

\[ NAG = \left( \frac{49 \times V \times C}{m} \right) \]

Where: \( V \) =is the volume of NaOH upon titration; \( C \) =is the concentration of NaOH; \( m \) =represents the mass of the sample titrated and 49 = is related to half of the molar mass of H₂SO₄.

## RESULTS AND DISCUSSION

### pH and conductivity

The pH values of the samples were alkaline ranging from 9.23 to 10.04 (Table 1) suggesting that they may be non-acid generating materials. According to Brunet (2000), samples with pH values greater than 6 are in Class IV of AMD diagnosed, as this class does not present a risk of generation of AMD (Table 2). This also implies that samples are not oxidized which can be attributed to the relatively recent mining activities around Inata. Since the values of conductivities of the samples (Table 1) are below 500 μS/Cm, except for the sample WDFS3, there is no AMD generation risk (Brunet, 2000). The samples are therefore classified as Class IV of AMD (Table 2).

However, the sample WDFS3 with a conductivity value of 967 μS/Cm is classified in class II suggesting an AMD generation risk (Table 2). As the pH value of this sample was greater than 9, it could be assumed to be non-acidogenic.

### Sulphide contents of the samples

Table 1. pH and conductivity values of the samples.

<table>
<thead>
<tr>
<th>Sample</th>
<th>Description</th>
<th>pH</th>
<th>Conductivity (μS/cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>TDR6</td>
<td>Fine grained (~100 μm), dark gray, from tailing management facility</td>
<td>10.04</td>
<td>102.00</td>
</tr>
<tr>
<td>WDFS3</td>
<td>Coarse grained (~2 cm), gray, waste rock</td>
<td>9.46</td>
<td>967.00</td>
</tr>
<tr>
<td>WDFN4</td>
<td>Coarse grained (~3 cm), gray, waste rock</td>
<td>9.61</td>
<td>71.00</td>
</tr>
<tr>
<td>WDFC8</td>
<td>Coarse grained (~3 cm), dark gray, waste rock</td>
<td>9.88</td>
<td>50.00</td>
</tr>
<tr>
<td>TDD2</td>
<td>Coarse grained (~3 cm), light gray, from the slope of the tailing management facility</td>
<td>9.48</td>
<td>124.00</td>
</tr>
<tr>
<td>RPB2</td>
<td>Coarse grained (~2 cm), gray, from the ore</td>
<td>9.23</td>
<td>81.00</td>
</tr>
</tbody>
</table>

The net neutralization potential (NNP) is the difference between the neutralization potential and acid production, and it can have a positive or negative value. \( NNP = NP - AP \)

This test consists of oxidizing sulphides present in the sample with 15% of hydrogen peroxide (H₂O₂) that simultaneously triggers acidification and neutralization reactions of the sample. The sample is also heated to allow the remaining unreacted peroxides to react. At the end of the reaction the pH (NAGϕH) of the dough is measured. Samples with NAGϕH values below 4.5 were titrated with a solution of sodium hydroxide (NaOH) to obtain a final NAGϕH of 4.5 so that the quantity of acid produced can be determined (kgH₂SO₄/ton) (Miller et al., 1997; Brunet, 2000; EPA, 2000; Tran et al., 2003).

\[ NAG = \left( \frac{49 \times V \times C}{m} \right) \]

Where: \( V \) =is the volume of NaOH upon titration; \( C \) =is the concentration of NaOH; \( m \) =represents the mass of the sample titrated and 49 = is related to half of the molar mass of H₂SO₄.

### Neutralization potential (NP)

Neutralization potential is determined by processing the sample with an excess of hydrochloric acid (HCl) 0.1 N (2 g per 20 ml), adjusting with 120 ml distilled water, then titrating the excess acid with sodium hydroxide (NaOH) 0.1 N to a final pH value of 8.4 (Sobek method). The consumed acid is subsequently converted into carbonate equivalent, which can be easily calculated from the stoichiometry equation of the reaction (Colon, 2003). The acid neutralization potential is expressed in kg CaCO₃ per ton of sample, and it is calculated using the following formula:

\[ NP = \left( \frac{N_{HCl} \times V_{HCl} - N_{NaOH} \times V_{NaOH}}{50} \right) \times m \]

Where: \( NP \) = Neutralization Potential (kg CaCO₃ per ton) of the sample; \( N_{HCl} \) = Normality of the hydrochloric acid; \( V_{HCl} \) = Volume of hydrochloric acid (ml); \( N_{NaOH} \) = Normality of sodium hydroxide; \( V_{NaOH} \) = Volume of sodium hydroxide (ml); \( m \) = Mass of sample (g); 50 = Constant used in the calculation of the acid neutralization potential.

### Net neutralization potential (NNP)

The net neutralization potential (NNP) is the difference between the neutralization potential and acid production, and it can have a positive or negative value. \( NNP = NP - AP \)

### Net acid generation (NAG)

This test consists of oxidizing sulphides present in the sample with 15% of hydrogen peroxide (H₂O₂) that simultaneously triggers acidification and neutralization reactions of the sample. The sample is also heated to allow the remaining unreacted peroxides to react. At the end of the reaction the pH (NAGϕH) of the dough is measured. Samples with NAGϕH values below 4.5 were titrated with a solution of sodium hydroxide (NaOH) to obtain a final NAGϕH of 4.5 so that the quantity of acid produced can be determined (kgH₂SO₄/ton) (Miller et al., 1997; Brunet, 2000; EPA, 2000; Tran et al., 2003).

\[ NAG = \left( \frac{49 \times V \times C}{m} \right) \]

Where: \( V \) =is the volume of NaOH upon titration; \( C \) =is the concentration of NaOH; \( m \) =represents the mass of the sample titrated and 49 = is related to half of the molar mass of H₂SO₄.
Academia Journal of Environmental Sciences; Gordio et al.

Table 2. pH and conductivity values with their corresponding AMD classes.

<table>
<thead>
<tr>
<th>pH</th>
<th>Conductivity (µS cm⁻¹)</th>
<th>Class of AMD</th>
<th>Diagnosis</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH ≤ 4</td>
<td>&gt; 1000</td>
<td>I</td>
<td>Proved acid mine drainage</td>
</tr>
<tr>
<td>4 &lt; pH &lt; 5</td>
<td>&gt; 750</td>
<td>II</td>
<td>Confirmed acid mine drainage in development</td>
</tr>
<tr>
<td>5 &lt; pH &lt; 6</td>
<td>&gt; 500</td>
<td>III</td>
<td>Potential development of acid mine drainage</td>
</tr>
<tr>
<td>pH &gt; 6</td>
<td>≤ 500</td>
<td>IV</td>
<td>No risk of acid mine drainage</td>
</tr>
</tbody>
</table>

Figure 3. Sulphide percentage versus sulfur contents of samples from Inata Gold mine compared to the threshold value of Miller et al. (1991).

Buffering capacity of the samples

To determine the buffering capacity, 20 ml of acid or base are added in 20 tubes (10 in the acidic domain and 10 in the alkaline range) containing 2 g of pulverized sample. The series of concentrations of acid or base were as follows: 0.02, 0.04, 0.06, and 0.08 ..., to 0.20 (HNO₃ mol/1 or NaOH/l). Centrifugation was performed at 3600 rpm for 10 min, and the supernatant was removed using a pipette and the pH values were measured.

Figure 4 shows pH variation of the samples as a function of the concentration of hydroxide (OH⁻) and hydronium (H₃O⁺) ions per kilogram of sample. It represents the buffering capacity of the samples, that is, their ability to oppose changes in pH due to additions of a moderate amount of acid or base. These figures also show that the mining residues are sensitive to additions of acid (HCl) or base (NaOH) even at very low concentrations. It can therefore be noted that the buffering capacity of the samples are sufficiently low to counter a possible change in pH following environmental changes after an acidification considering that the pH values of the samples are initially alkaline. The initial pH and conductivity values suggest that the mine wastes produced by the Inata mine do not pose a risk of AMD generation. However, given the weak buffering capacity of the samples, it can be concluded that changes in combustion using a LECOS230 device coupled to a computer. The principle of LECOS230 is to burn a pre-weighed sample at more than 1200°C in pure oxygen and in the presence of accelerators. Carbon and sulfur are completely oxidized to CO₂ and SO₂ respectively with the possible presence of CO, which is converted to CO₂ through the catalyst (vanadium pentoxide). CO₂ and SO₂ gases are led through pipes to distinct cells infrared (IR) detection that can measure them. The device is connected to a computer that records on an Excel spreadsheet.

Sulfur contents of the different samples are presented on a diagram according to Miller et al. (1991) which illustrates 0.3% threshold under which samples are not acidogenic, otherwise they are potentially acid generating (Figure 3). All samples have sulfur contents below 0.3% threshold, and therefore the tailings can be considered as non-acid generating. In other words, these samples are not likely to release AMD into the environment.
environmental conditions are likely to produce AMD.

**Static tests**

The results of the static tests are shown in Table 3. These results show that the AP values of different samples are relatively low (generally less than 1%). This means that the mine wastes are not acid generating, and the risk that they might cause acidification is negligible. The critical threshold AP values at which there is a risk of acid generation is 9.375% or 0.3% × 31.25 (Miller et al., 1991), whereas the highest AP value obtained in these analyzes is 5%.

The values of NP of the samples are also very low. Neutralizing Potential (NP) corresponds to the capacity of the sample to neutralize a given quantity of acid, produced by sulphide oxidation, expressed in kg CaCO₃/ton. diPretoro and Rauch (1988) found sites with >3% NP as calcium carbonate equivalent in over burden produced alkaline drainages, while acidic drainage resulted at <1% NP. Brady and Hornberger (1989) suggest threshold values of NP > 3% and S < 0.5% as guidelines for delineating alkaline-producing strata. Brady et al. (1994) showed that 3% net NP in an overburden caused alkaline drainage while less than 1% net NP produced acidic drainage from 38 mines in USA. Mining practices (such as selective handling, and concurrent reclamation) enhanced the effect of alkaline addition on reducing acidity (Skousen et al., 2000). For these reasons samples from Inata Gold mine are problematic, according to their NP values less than 1%.

NP is linked to the presence of acid consuming minerals (such as carbonate) in the samples capable of neutralizing any acidification. The gold mineralization at Inata is associated with veinlets of quartz-carbonate-sulfides or albite-carbonate-sulphides. Neutralization Potential of samples derived from mine tailing facilities (TDR4 and...
TDR6) are high compared to other samples. This is due to the use of lime for pH adjustment in the processing of ore particularly during the tank leaching operation. This could also be attributed to the presence of organic matters derived from mineral processing.

The net neutralization potential (NNP) is used to classify the samples according to the criteria of Miller et al. (1991) that distinguish samples as probably acid generating or not. These criteria are used when the values of sulfur content is above 0.3% (Miller et al. 1991) while the maximum sulfur content obtained in the analysis is less than 0.3%.

Regarding the NAG, titration with sulfuric acid was not performed on the samples with pH (NAGpH) values above 4.5 following titration with sodium hydroxide solution (NaOH) because they are considered non-acid generating as their NAG is null (Miller et al., 1997; EPA, 2000; Tran et al., 2003; Villeneuve 2008). In others words, a sample is considered potential acid generator if NAGpH is < 4.5 and non-potential acid generator otherwise (MEND, 2009). The study conducted by Stewart et al. (2003) showed that NAG test oxidation of pyrite, pyrrhotite, arsenopyrite and chalcopyrite produced a final NAG solution with a pH < 4.5. Sphalerite, galena, bornite, chalcocite and covellite produced a final NAG solution with a pH > 4.5 due to the lack of hydrolysis of copper, lead and zinc below pH 4.5. However, according to Gmb (2007), at Inata, pyrite is the dominant sulphide minerals, other sulphide minerals such as chalcopyrite, galena, pyrrhotite, bornite, tennantite, linneite, mackinawite, arsenopyrite, sphalerite.

Heavy metal concentrations, except those of Fe, of tailing samples are low, and they vary greatly between samples and among metals (Table 4). The lowest metal concentrations are those of Ag, Cd and Hg. The low concentrations of heavy metals suggest that tailings do not pose a serious threat of metal mobility in the surrounding environment. Given the contents of these metals, one might assume that they are not problematic. However, these concentrations are based on absolute concentration, and do not take into account the factors that may govern their geochemical distribution over time. Dissolution of these metals during following onset of AMD may enhance their mobility, and thus posing serious environmental concerns.

<table>
<thead>
<tr>
<th>Sample</th>
<th>Acid Neutralization Potential: AP (kg CaCO₃/ton)</th>
<th>Neutralization Potential: NP (kg CaCO₃/ton)</th>
<th>Net Neutralization Potential: NNP (kg CaCO₃/ton)</th>
<th>Net Acid Generation: NAG (kg H₂SO₄/ton)</th>
<th>NAGpH</th>
</tr>
</thead>
<tbody>
<tr>
<td>RPA2</td>
<td>0.12</td>
<td>-59.00</td>
<td>-59.12</td>
<td>13.32</td>
<td>2.81</td>
</tr>
<tr>
<td>RPB2</td>
<td>0.22</td>
<td>-48.00</td>
<td>-48.22</td>
<td>5.09</td>
<td>3.37</td>
</tr>
<tr>
<td>WDFN1</td>
<td>0.29</td>
<td>-56.25</td>
<td>-56.54</td>
<td>1.76</td>
<td>3.18</td>
</tr>
<tr>
<td>WDFN4</td>
<td>0.27</td>
<td>-45.75</td>
<td>-46.02</td>
<td>0.00</td>
<td>4.92</td>
</tr>
<tr>
<td>WDFC6</td>
<td>0.45</td>
<td>-57.75</td>
<td>-58.20</td>
<td>0.98</td>
<td>3.68</td>
</tr>
<tr>
<td>WDFC8</td>
<td>0.27</td>
<td>-57.50</td>
<td>-57.77</td>
<td>0.19</td>
<td>4.30</td>
</tr>
<tr>
<td>TDD2</td>
<td>0.23</td>
<td>-56.75</td>
<td>-56.98</td>
<td>0.00</td>
<td>5.60</td>
</tr>
<tr>
<td>TDD7</td>
<td>0.43</td>
<td>-45.50</td>
<td>-45.93</td>
<td>0.98</td>
<td>3.90</td>
</tr>
<tr>
<td>TDR4</td>
<td>1.23</td>
<td>-22.00</td>
<td>-23.23</td>
<td>0.00</td>
<td>6.00</td>
</tr>
<tr>
<td>TDR6</td>
<td>0.80</td>
<td>-14.00</td>
<td>-14.80</td>
<td>0.00</td>
<td>6.01</td>
</tr>
<tr>
<td>WDFS1</td>
<td>0.62</td>
<td>-57.00</td>
<td>-57.62</td>
<td>0.58</td>
<td>4.00</td>
</tr>
<tr>
<td>WDFS3</td>
<td>5.09</td>
<td>-56.50</td>
<td>-61.59</td>
<td>1.56</td>
<td>3.17</td>
</tr>
</tbody>
</table>

Table 3. The various parameters derived from static tests.

Table 4. Heavy metal concentrations of the samples (in ppm).

<table>
<thead>
<tr>
<th>Element</th>
<th>Cu</th>
<th>Pb</th>
<th>Zn</th>
<th>Ag</th>
<th>Ni</th>
<th>Co</th>
<th>Fe (%)</th>
<th>As</th>
<th>Cd</th>
<th>Cr</th>
<th>Hg</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TDR6</td>
<td>66</td>
<td>12.6</td>
<td>59</td>
<td>0.5</td>
<td>43.7</td>
<td>31.9</td>
<td>5.54</td>
<td>193.8</td>
<td>0.2</td>
<td>46</td>
<td>&lt;DL</td>
</tr>
<tr>
<td>WDFS3</td>
<td>47.1</td>
<td>2.7</td>
<td>31</td>
<td>&lt;DL</td>
<td>36</td>
<td>7.1</td>
<td>4.6</td>
<td>19.7</td>
<td>&lt;DL</td>
<td>63</td>
<td>&lt;DL</td>
</tr>
<tr>
<td>WDFN4</td>
<td>142.1</td>
<td>6.9</td>
<td>75</td>
<td>&lt;DL</td>
<td>79.4</td>
<td>21.1</td>
<td>3.43</td>
<td>27</td>
<td>0.2</td>
<td>107</td>
<td>&lt;DL</td>
</tr>
<tr>
<td>WDFC8</td>
<td>78.7</td>
<td>5.4</td>
<td>76</td>
<td>0.2</td>
<td>43.2</td>
<td>18.2</td>
<td>4.17</td>
<td>31.1</td>
<td>&lt;DL</td>
<td>29</td>
<td>&lt;DL</td>
</tr>
<tr>
<td>TDD2</td>
<td>140.2</td>
<td>4.6</td>
<td>100</td>
<td>0.2</td>
<td>44.6</td>
<td>13.3</td>
<td>4.08</td>
<td>50.5</td>
<td>&lt;DL</td>
<td>39</td>
<td>&lt;DL</td>
</tr>
<tr>
<td>RPB2</td>
<td>84.9</td>
<td>4.4</td>
<td>102</td>
<td>0.2</td>
<td>70.8</td>
<td>31.6</td>
<td>6.45</td>
<td>70.2</td>
<td>0.1</td>
<td>65</td>
<td>&lt;DL</td>
</tr>
</tbody>
</table>
Conclusion

The fact that oxidation of tailings from the Inata Gold Mine don’t exist is probably due to their fairly young age and the arid climatic conditions of the area. Furthermore, this is verified by different parameters of the static test and the low sulfur contents of no acid generation potential of the samples. However, the low buffering capacity and weak neutralization potential of the samples are indicative of low resistance to a possible acidification, following a variation in environmental conditions (e.g., oxidation).

Based on total sulfur contents and conductivity, the wastes dump "(waste rock piles) samples collected in the Southern pit appear to pose the most serious environmental threat among the sites.

It would be judicious to set up a pH monitoring plan of the Inata mine tailings so that changes related to a possible occurrence of oxidation can be identified on time. Hydrogeological modeling of seepage in these residues could also allow development of a prevention method.

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