Mining Waste Management for Sustainable Mining Practices

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Abstract

The mining sector is one of the key economic drivers in Southern Africa. However, due to mining and minerals processing activities, huge amounts of waste are generated that have potential negative impacts to the environment. Various wastes such as wastewater, particulate gases, overburden, waste rocks, tailings and slag are generated during the value addition of the ores. Although there is potential for metal recovery and wastewater re-use from this waste generated it is critical that before a mining activity is done, an environmental impact assessment be done for sustainable mining activities.

Keywords: Environment, mining, waste management, value addition

1. Introduction

The mining industry is one of the industries that contributes significantly to the gross domestic product (GDP) capita of all mining countries, in Zimbabwe alone, the mining sector contributes at least 8% towards the GDP (Adler and Rascher, 2007; Hawkins 2009; Malinga, 2018). Table 1 gives a summary of the GDP growth in the mining sector.

Table 1. Mining sector performance in Zimbabwe (Nyasha Mahonye and Leonard Mandishara (2015)

Period	Average annual mining exports (USD millions)	GDP growth rate p.a (%)	Mineral exports share in comparison to total exports (%)
1980-1988	533	-2.5	41.2
1990-1999	629	-1.8	32.3
2000-2008	720	5.6	40.4
1980-2008	564	1.3	37.8

In Zimbabwe the most common minerals produced are gold, chromite, base metals and coal (Figure 1).

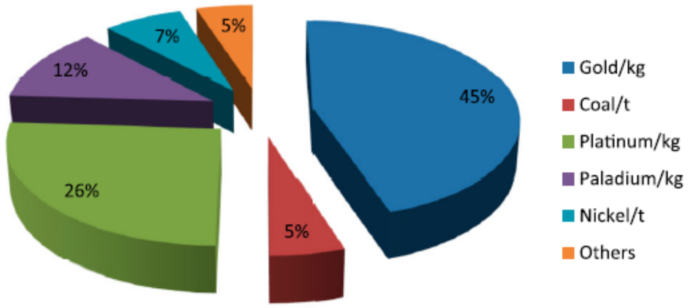

Figure 1. Share of minerals in Zimbabwe (Chamber of Mines Zimbabwe, 2016)

However, due to the various mining activities a lot of waste is also generated as waste and this waste must be properly managed. The amount of waste generated is dependent on the minerals resource being mined, the technology applied and the geology of the mining site. There is therefore need to have proper waste management plans in order to minimise environmental degradation and pollution (Chenje et al., 1998). The waste management strategies to be put in place must include the waste storage area, its design and long term plans for waste destabilization post mining closure. Figure 2 shows the mining stages and the various wastes generated.

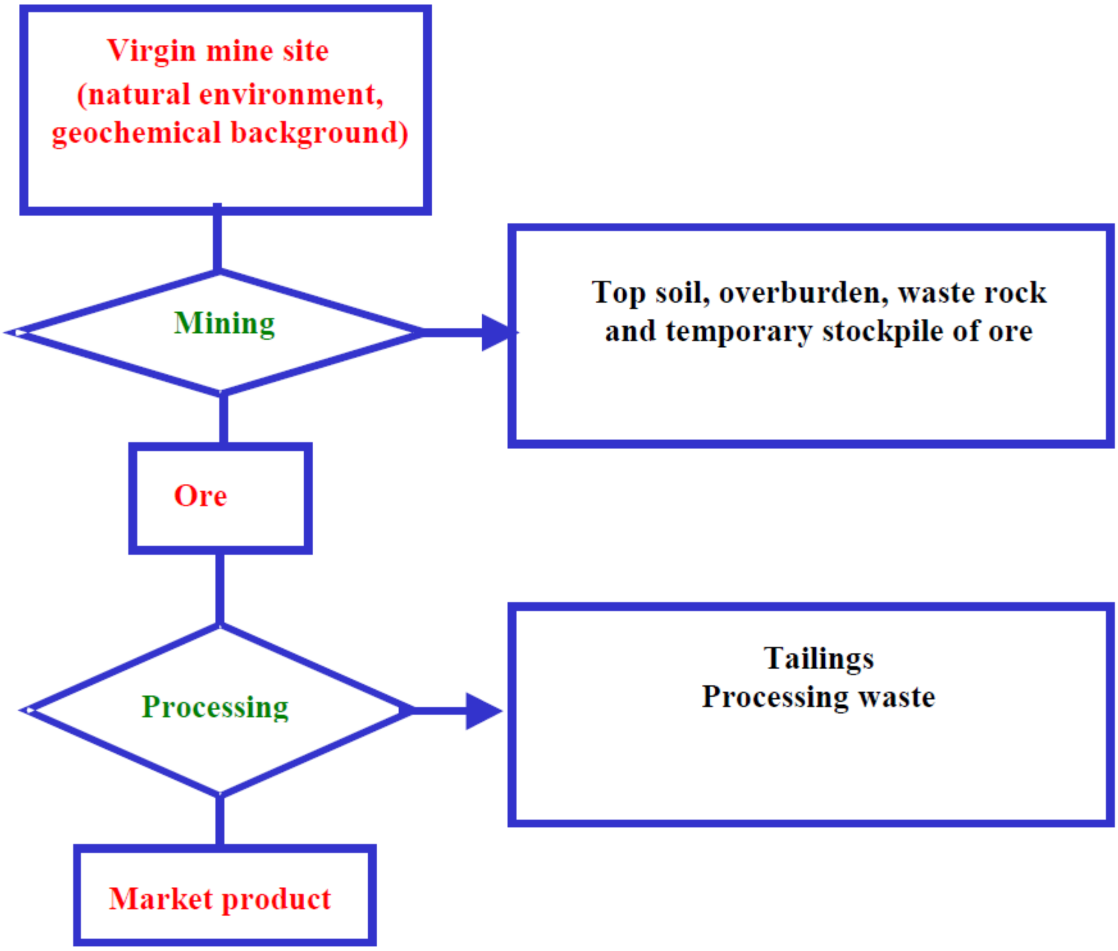

Figure 2. Mining value chain and the various wastes generated

2. Resource recovery from mining waste

Mining operations generates a lot of waste which can be considered of little economic value. This waste may include rocks that are removed to gain access, gases and wastewater from the processing. Application of up-to-date technology and value addition strategies can however result in the recovery of some minerals from the waste solid and liquid materials (Das et al., 2000).

3. Classification of mining waste

Waste generated from the mining industry can be classified as overburden, waste rock, tailings, slags, mine water, water treatment sludge and gaseous waste. The various waste per mineral are indicated in Table 2 with an indication of the various mining techniques.

Table 2. Types of wastes generated from various metals

Mineral	Mining method (s)	Processing techniques	Waste generated
Gold-silver	Surface, underground, in-situ, experimental	Cyanidation, elution, zinc precipitation, milling, base metal floatation, smelting, amalgamation	Wastewater, overburden, tailings, spent ore
Lead-zinc	Underground	Milling, floatation, sintering, smelting	Wastewater, waste rock, overburden, tailings, slag, mine water
Copper	Surface, underground, in situ	Milling, floatation, smelting, acid leaching,	Mine water, wastewater, overburden, tailings, slag,

		iron precipitation	spent ore, spent leach solution

3.1 Overburden

The overburden waste includes rocks and soil that is removed to gain access to ore deposits during open pit mining. Overburden waste has minimal environmental contamination impact and is usually used for landscaping at the mine site as well as for revegetation during mine closure.

3.2 Waste rock

The waste rock is the type of waste that contains minerals in low concentrations that are too expensive to be extracted. Waste rock is usually stored in heaps, dumps or underwater with tailings especially for those with high sulphide concentrations. Resource recovery technologies can be applied for minerals recovery in the waste rock when the market prices increase. Waste rock dumps can also be covered and revegetated post mining closure.

3.3 Tailings

Tailings are ground rock and mineral waste from the processing line. Tailings contain left over minerals and processing chemicals and usually sored in tailing ponds. For example, manganese tailings have been applied un the forestry industry, as construction material as well as in glass manufacture as part of waste management initiatives whereas clay rich tailings have been used cement, bricks and tiles manufacture (Zhang et al., 2005).

3.4 Slags

Slags are non-metallic by-products of minerals processing usually from slag (Chen et al., 2012). Slags can find wide applications in the road construction sectors and in some instances brick manufacture.

3.5 Mine wastewater and sludge

Wastewater is generated from minerals processing and has potential to result in surface water and ground water contamination. Wastewater management solutions must be put in place to minimize the amount of wastewater produced as a well as possible to avoid environmental contamination. Treated wastewater can be reused in the process for either minerals processing or suppression of dust. Wastewater treatment sludge is produced at the mines wastewater treatment sites and has low economical value. The sludge may comprise of heavy metals like arsenic and cadmium and therefore becomes hazardous waste for example sludge that is rich in iron has been used for iron pigments application. Other sludge wastes that may contain bauxite red mud produced from aluminium refiners can be used in soil amendment, as well as a raw material for ceramics and bricks manufacture.

3.6 Gaseous waste

Gaseous waste generated in the mining industry includes particulate matter and sulphur oxides during high temperature processes such as smelting. Control mechanisms such as cyclones, wet scrubbers, gravity separators and electrostatic precipitators are usually capable of removing more than 90% of the contaminants. However, some smelters utilize the sulphur oxide emissions to produce sulphuric acid.

4. Mining waste environmental impacts

The impact on the environment for the various mining waste generated is dependent on the type of waste generated, the technology used as well as the type of ore being mined. Ores that have high sulphides have potential to result acid rain. These waste rocks therefore must be characterized, monitored and treated to avoid environmental damage.

5. Mining waste management during and post closure

Mining waste management is critical to minimize water, soil and air contamination. Waste management plans are usually planned for during the environmental impact assessment (EIA) stage following the set international standards (Mahonye and Mandishara, 2015). In Zimbabwe the EIA process is monitored under the Ministry of Water, Environment and Climate Change under the Environmental Management Act (CAP 20: 27) of 2002 which has made it mandatory for any prospective miners to have proper waste management initiatives through the EIA. Waste must be contained at the source and treated to make it environmentally safe for disposal. Post mining closure it must be ensured that the tailings are covered and that there escape from the environment is minimized in order to prevent groundwater contamination. Mining closure and post closure waste management initiatives must form part of the environmental impact assessment.

6. Conclusion

As a way forward in mining waste management there is need for a waste management plan o for the pre-opening, operations and post closure of a mine so that mining becomes a sustainable and environmentally friendly industry. Technologies that generate minimal waste must be employed and in addition resource recovery initiatives for all the types of waste generated.

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Biographies

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