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Achieving Sustainable Mine Waste Management Practices through Capacity Building of Stakeholder Engagement the Case of the Zambian Minerals Industry

Mwiya Songolo[a*], Wilson S. Moono[b], Wilfred M. Mwenya[c]

[a,b,c]*Copperbelt University, School of Mines and Mineral, P.O. Box 21692, 10101, Kitwe, Zambia*
[a]*Email: msongolo@gmail.com*
[b]*Email: moonows1@gmail.com*
[c]*Email: wmmwenya@gmail.com*

Abstract

Sustainable mine waste management is a matter that is always at the centre stage of the mining industry. This is because there has been a challenge in achieving sustainable mine waste management practices in the mining sector. It's a known fact that mining operations respect no boundaries and it is therefore important that every mining company directs its efforts towards the achievement of a sustainable mine waste management practice regardless of the geographical location. Despite the development of mine waste management practices which in most cases present good engineering designs on how mine waste should be disposed, achievement of a sustainable mine waste management practice in most cases has been a challenge. This is because there is always a demand from the communities and other stakeholders like governments and local authorities within which mining operations take place.

This study, thus, endeavoured to focus mining companies towards capacity building in the area of stakeholders' engagement if sustainable mine waste management practice is to be achieved from commencement of any mining operation to the time of closure without incurring huge added costs.

Key words: Capacity Building; Sustainable Challenge; Coordinated Interaction; Stakeholder.

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* Corresponding author.

1. Introduction

Sustainable mine waste management is a matter that is always at the centre stage of the mining industry. There is always a unique relationship between a mining company and the community in which the mining operations are being undertaken. This is because there is always a demand from the communities and other stakeholders like governments and local authorities within which mining operations take place. There should not be any argument that good relationships with stakeholders need to be fostered in any mining area. This helps not only enhance the development and operation of a mining project but also facilitates a smooth closure of the mine or decommissioning of a mine project and the subsequent transfer of the custodial rights. Once such development is undertaken, the needs of the present would be met and going forward, the ability of the future generations to meet their own needs would not be under compromise [1].

It should also be realised that what may be the actual cost of disposing waste from a mining project is not simply the cost for the disposal of that waste but may also include the cost incurred if a mining project is delayed due to lack of good relationship with the community or other stakeholders. It is therefore important that mining companies should be developing strategic partnerships with community and conservation groups, aid organisations, governments and other stakeholders not only to communicate about issues related to their projects, but also to seek shared value [2].

Further, it should not be arguable that long term environmental matters should be considered in the management of mining waste disposal facilities [3]. While mining has historically affected its surrounding environment, advances in technology and changes in management techniques mean that many negative impacts are now avoidable [4]. Throughout the mining cycle, mining companies should be heading towards making efforts to reduce the environmental impact of mining and minimise the footprint of their activities. Mining can thus become more environmentally sustainable by developing and integrating practices that reduce the environmental impact of mining operations [5]. A Guide to Leading Sustainable Development in Mining [6] suggests that, for mine managers to be on track in establishing a sustainable mining operation, they need to focus on five areas which include *safety, environment, economy, efficiency and community and/or stakeholders engagement.* It is understandable that a mine needs a "social licence to operate" and unless the community is engaged and supportive of a mining operation, there would always be opposition and confrontation that may ensue during the operation of a mining company [6]. In order for a mine company to obtain and safeguard its social licence to operate in a community, a commitment to leading practice sustainable development is critical [7].

In Zambia, strides have been made in leading practices of mine waste management. The industry has made strides particularly in the area of tailings management with regard to design and operation, however, the industry is still striving to achieve a sustainable mine waste management practice with regard to community or stakeholder engagement. In the execution of a number of mining projects in Zambia, there seems to be a dysfunctional community interaction with the industry and this has, to a large extent, been diverting managements in the Zambian mining sector from its main focus of efficiently running the mine. The insights, approaches and practical discussion about the challenges that the mining industry may encounter as they engage with local communities and seek to contribute to their short and long-term development are important to achieve

a sustainable mine waste management practice. For example, hazardous materials management [8] requires that appropriate operational and environmental information on the management of hazardous or dangerous goods is made available to stakeholders, including the community. Thus the focus of this study was to point Zambian mining companies towards building capacity through the involvement of different stakeholders so as to achieve sustainable mine waste management practices without incurring huge added costs.

2. Methods

As there has been a challenge in achieving sustainable mine waste management practices in Zambia, the mining industry has been faced with the challenge of either delayed project commencement or sometimes failure to go ahead with a project due to misunderstandings between the mining companies and stakeholders with regard to leading practices in the management of mine waste. As a way to ameliorate this challenge, it was important to look at information that provides answers to the following research questions: (i) does the design of tailings storage facilities (TSF) in Zambia meet acceptable international standards (ii) does the Zambian Mining sector need to capacity build through stakeholder engagement before undertaking any mining project?

In the quest to answer the above questions, an assessment of case studies from six mining companies which include Luanshya Mine, Chambishi Metals, Sino Metals, Mopani Copper Mines, First Quantum's Trident Mining Project, and Konkola Copper Mines was undertaken on the Copperbelt and North-Western provinces of Zambia. Luanshya Mine, Chambishi Metals and Sino Metals were mainly assessed on the basis of design of TSFs whereas the other mines were assessed on both the design and stakeholder engagement.

2.1 Design of Tailings in Zambia

There are commonly two types of dam design in Zambia which include the following:

(i) dams with central decant (see Figures 1 through to 5) and an emergency spill way and
(ii) dams with spillway and no central decant

Figure 1: Open-ended Tailings Storage Facility - Musi Dam, Luanshya

Figure 2: Open-ended Tailings Storage Facility - Musakashi Dam, Chambishi

Usually, an impounding dam wall (see Figures 4) is used to restrain the flow of the deposited material and to create a dam of tailings behind the wall. The principle behind these design is to have the slag collect in one place, allow the suspended solids and part of dissolved solids settle to the bottom and clear water is discharged through the central decant or through the spillway at the back of the lake (see Figures 1 through to 4). The emergency spillway is for controlled emergency discharge in the event that uncontrollable situation arises.

Figure 3: Musakashi Dam in Chambishi

Figure 4: Central Decant Discharge - Musakashi Dam in Chambishi

In Zambia, companies operating tailings leach plants have to deal with problems associated with effects of acidic discharge (see Figures 5 through to 7) to the environment in the event of accidental spills of acidic tails. They have to deal with ground water contamination problems in the event that the acidic fluid finds crack or conduits in the ground. The TSFs are normally closed system with only evaporation as the only means by which the fluid is allowed to escape to the environment or depleted from the system. The design involves the excavation to near bedrock and laterite is laid at the base and on the sides and then compacted. This is followed by laying of a geo-membrane to make the dam impervious. The Geomembrain used is usually high density polyethylene (HDPE). When the solids have settled resulting solution is pumped back to the agitation tanks for reuse as the solution is acidic and may contain some leached copper.

Figure 5: TSF lined with HDPE at Sino Metals Leach Dam

Figure 6: Leach Raffinate clear of solids ready to be pumped back to agitation tanks at Sino Metals Leach Dam

Figure 7: Sino Metals Leach Dam

2.2 Mopani Copper Mines' Uranium Tailings

2.2.1 AMCO Uranium Tailings at Nkana Mine

In 2009, Copperbelt Environment Project (CEP) spent over US$1.3 million to dispose 40.000 metric tonnes of uranium tailings stored at TD 11 and TD 13 (Figure 8) from mining activities in the 1960s in Kitwe's AMCO community near Mindolo Mine Township. The tailings were a health and environmental hazard to the surrounding area and community and thus required to be relocated. In achieving the sustainability of the storage of the tailings, a public disclosure meeting with Armco residents was held on the movement of the uranium tailings in Kitwe to a disposal site at Mopani Copper Mines dump. The community in Mindolo's Armco compound had been sensitised about the exercise and what to expect and avoid increase of spillage. As a measure to protect the community, a new road had also been constructed in the mine area to be used by the local residents even after the exercise.

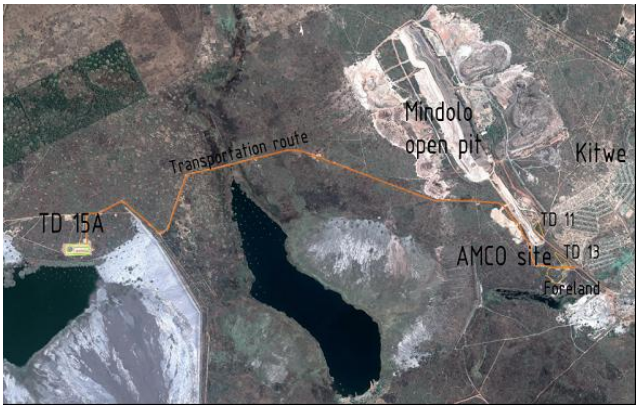

Figure 8: Uranium Tailings at TD 11, TD 13 and TD 15 in Kitwe

2.2.2 Engineering Characterisation of the Disposal Site

The first task was to find a safe location and this was identified at TD 15A (Figure 8) copper tailings dump for Mopani's Nkana mine.

In selecting the site for tailings disposal, several geotechnical issues were considered. These included the geology, ground and surface hydrology, soil and underlying rock characteristics, proximity to mining operations, social issues and many more. The studies involved:

(i) Study of rainfall pattern
(ii) Soil and base rock characteristics
(iii) Dumping rate by Mopani to the point of covering the cell/capsule
(iv) Ground water flow regimes

Care was taken to avoid incidences of poor engineering judgment as it can lead to catastrophic consequences. An example is the 1970 Mufulira disaster in which 83 miners perished when tailings inrush occurred after they were disposed on top of the mine workings. Again in 1986 Mufulira TD11 failed on the eastern side.

2.2.3 Method of Disposal MCM's Uranium Tailings at Nkana Mine

The uranium tailings were disposed of in a sealed containment within the tailings management facility. The method of disposal involved basically encapsulating the tailings in a specially designed cell. Both existing tailings sites (TD 11 and TD 13) had to be cleaned up down to clearance levels. The clearance levels were set to guarantee that no radioactive material remained at the sites. The uranium tailings were relocated for storage and buried (Figure 9) in a disposal cell covered with laterite of minimum thickness of 2 m and vegetation at a Mopani Copper Mines dump site. The cell was dug to about 3.5m depth; special clay was laid and compacted (1.5m thick). The compaction was done to reduce the void ratio to approximately 0.2 making the clay layer almost impermeable. Drainages were constructed around to endure no water percolated through or ponded on the sides. A humus soil layer was placed on top and grass planted.

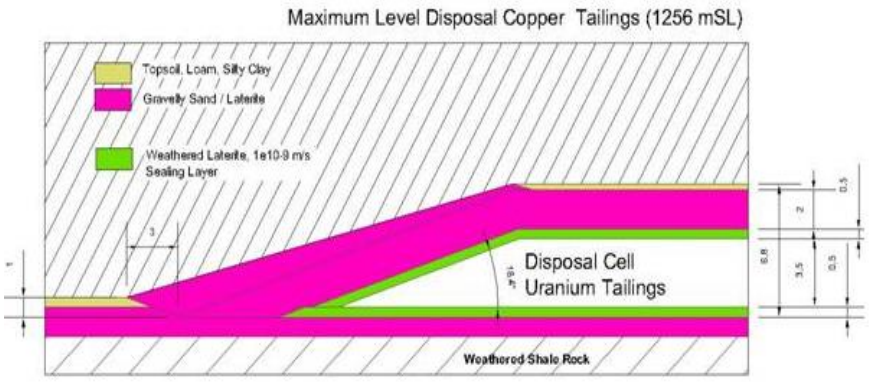

Figure 9: Design of the Capsule for storage of Uranium Tailings

2.3 First Quantum Minerals (FQM) Ltd: Trident Project

Kalumbila Minerals Limited is a mining company in the North-Western Province of Zambia. It was acquired in February 2010 by First Quantum Minerals. Kalumbila Minerals owns five mining licenses, and these include the copper-sulphide Sentinel Deposit and the Enterprise (nickel) and Intrepid (copper) targets [9]. The project in this area is called the Trident Project. The project was located in the Chief's customary land and a dam called Chisola Dam was earmarked for construction as a tailings storage facility (TSF). Prior to the commencement of the project, it was agreed with the chief and his subjects that the dam once completed would be used on one side by the locals for fishing purposes while the other side was meant for mine waste management of tails. However, the investor had an interest in converting the acquired customary land to statutory land, governed and regulated by the government [10].

In spite of many different stakeholders, including provincial government representatives, the Zambia Development Agency and the Zambia Environmental Management Agency (ZEMA) having had participated in the discussions in the early stages of the investment, it was reported by Miller and others [10] that the new investment had witnessed a breakdown of communication between the company and village representatives in the Kalumbila area. This was at the point when the mine requested 75, 000 Hectares from the chief which was resisted, reducing it to 51,800 Hectares.

2.3.1 FQM's engagement with the Community

Upon learning that the company had plans to convert the customary land to statutory land [10], the villagers decide to form a taskforce called Musele Task Force (Figure 10). This was done in an effort to work as a liaison group between the community and the mine. As the investment became locally contested, the villagers were aggrieved as there was breakdown of communication between the mine owners and the task force. This was compounded by a horrible drowning of a woman after being chased by a mine security dog as she was fishing at one of the dams.

Figure 10: Engagement of the local community in Kalumbila [9]

2.3.2 FQM's engagement with Government

Following discussions with Government, Kalumbila applied to ZEMA for approval for additional components to their project which included the Chisola Dam. However, it was felt by the mine at some point that there was a delay in the approval of the project which would affect the payback of the mine project. With time, conditional permission to continue construction of the dam which would cover 200 hectares of woodland was given by the Ministry of Lands, Environment and Natural Resources to Kalumbila Mines Limited. It was argued by the government that Chiefs were not allowed to give out large pieces of land as such powers were vested in the President of the Republic of Zambia.

With the coming on board of the government, it was felt by the community that they would have no say over their land and that the resettlement action plan would bring great insecurity to them. The community did not welcome the investor's direct dealing with government. It was felt that the role of the royal establishment in their deliberations was overlooked. The Chief and his subjects complained that they were no longer consulted about any developments, after being approached at the start of the project. The chief complained that he had no knowledge of the company's plans at any point, except that the company was encroaching on land used for livelihood by his subjects.

2.3.3 Trident Investment Halted

Due to the misunderstandings, the Chief appealed to the government through office of Vice President. The misunderstandings led to the halting of the investment and the interested parties were asked to make submissions to the Government Task Force that was eventually created. In the meantime, FQM had since decided to lay off 500 workers at the Sentinel mine Project which was under construction [11]. Again there was an outcry for employment by the local community. After the investigation, the Government settled the matter with both the company and the villagers and permits were finally issued to the company.

It is important from the dynamics of the inter-actors that there is need to build capacity in the engagement of stakeholders for the minerals industry in Zambia.

2.4 Konkola Copper Mines' Importation of Copper Concentrate

In 2015, Konkola Copper Mines (KCM) imported copper concentrates from Chile, which contains arsenic. The first consignment of 3,000 tonnes was received in the country in May 2015 and the second consignment of 2,000 tonnes was yet to be shipped to make a total of 5,000 tonnes to be processed at its smelter in Chingola. Studies have shown that concentrated arsenic content can contaminate groundwater, leading to widespread epidemics and causes arsenic cancer. The importation of copper concentrates which contain arsenic, a toxic chemical element that causes cancer if exposed to humans in uncontrolled quantities brought an outcry in the country from the public.

2.4.1 Public Outcry over KCM's Importation of Copper Concentrate

KCM was challenged by the Mineworkers Union of Zambia (MUZ) for importing copper concentrate from South America. The Union argued that the company should have focused on boosting local production (Wange,

2015a) instead of importing concentrates. It was the Union's fear that the decision by KCM might lead to the company slowing down on ore production and concentrate on importing copper concentrate thereby reducing job opportunities in the country on the mining side [12]. The Union further argued that the safety of the employees was at risk considering that concentrate had elements of arsenic content. In a related reaction, a Member of Parliament (also a mining engineer,) in the same locality also argued that there was a lot of copper ore to mine both in Zambia and at KCM and therefore there was no justification for KCM to import copper ore from Chile [13]. As tension increased, non-governmental organisations from within the region also questioned the move taken by KCM. The Southern Africa Resource Watch (SARW) [14] appealed to the Government of Zambia to stop KCM's importation of toxic copper concentrate from Chile, a far-flung country. The Government was implored not to neglect its obligations of protecting the lives and the interests of Zambians in the mines. SARW also stressed that Zambia still had huge deposits of copper.

As regards, capacity building of inter-actors in the mining industry, intense public outcry could have been avoided had KCM engaged the different stakeholders on the environmental remedial measures before the undertaking to import the copper concentrate from Chile.

2.4.2 The justification for the importation of Copper Concentrate by KCM

Despite the public outcry as a result of KCM's importation of the copper concentrates from Chile, the company had its own reasons for the undertaking. The mining firm argued that it needed to operate its smelter as close to design capacity as possible to achieve maximum efficiency [15]. It was further explained that the design criteria of KCM's Nchanga smelter required high grade concentrate feed to function efficiently. The required feed was not available in sufficient quantities in Zambia while several new mines ramp up to full capacity. The company argued that it had to look further afield because of the limited availability of suitable concentrates in the region.

As regards mine waste management, the company explained that it was committed to international best practice of mine waste management practices. It was stated by KCM that it prioritised the health and safety of its employees, the surrounding communities and the environment very seriously. In its quest to ensure the employees' health was safeguard from the danger of the copper contained arsenic concentrates, the company started engaging in extensive consultations with stakeholders which included the Mineworkers Union of Zambia, National Union of Mining and Allied Workers (NUMAW) and the United Mineworkers Union of Zambia (UMUZ). On the side of the company's adherence to environmental legislation of the country, KCM also started to engage with the Zambia Environmental Management Agency and Mine Safety Department (MSD) in devising appropriate procedures to protect employees, communities and the environment. The company further stated that it would not process the 5,000 tonnes of copper concentrate imported from Chile, until all parties were satisfied that there would be no adverse impact.

2.4.3 Zambian Government Demand for KCM Toxic Report

As the stakeholders continued to press Government to take punitive measures against KCM, the Government directed the Zambia Environment Management Agency (ZEMA) to investigate how copper concentrates with

arsenic content had found themselves into [16] the country and provide a report.

2.4.4 KCM ordered to return the Concentrates to Chile

After assessment of the matter and consultations with stakeholders and government agencies, KCM was directed by the Ministry of Lands, Natural Resources and Environmental Protection not to proceed with the processing of the 2,000 tonnes of copper concentrates that were imported from Chile. This was because of abnormal toxic levels of arsenic mineral that were found in the concentrate. It was announced by the Ministry of Lands, Natural Resources and Environmental Protection [17] that the copper concentrates posed serious safety, health and environmental risks because it had four percent (4%) of arsenic. This level of arsenic was seven (7) times more than that found in most Zambian copper concentrates which averaged around 0.5%. The danger posed with arsenic substances could not only result in damage to the environment where it is being processed but could also lead to an increased risk of lung cancer once inhaled. As the assessment by the Zambian Government showed a high risk of the substance if processed within the country, KCM was instructed to make necessary arrangements to return the consignment to the country of origin. The company was further instructed to ensure the exercise was done in compliance with the existing legal framework of the Republic of Zambia. As a way to ensure compliance, ZEMA was tasked by the Zambian Government to closely monitor the situation. This was done to ensure that the Zambian citizens as well as the environment were protected from all environmental risks associated with mining. As a way to prevent any occurrence of similar activities in future, all mining companies were instructed to ensure adherence to operations within the framework of their mining licenses and adherence to the Zambian laws as regards the importation of any goods that were toxic in nature.

3. Discussion

Although there are underpinning principles, leading practice [6] is as much about approach and attitude as it is about a fixed set of practices or a particular technology. It involves the concept of *"adaptive management"*, a process of constant review and "learning by doing" through applying the best of scientific principles.

From the study, the following have been established:

(i) Design of TSFs in the Zambian mining industry conforms to leading practices in the management of mine waste.
(ii) MCM had a coordinated interaction with both the regulators (i.e. CEP) and the AMCO community.
- This resulted in a sustainable relocation and disposal of uranium tailings even though the company's competencies in the Zambian mining industry were in cooper tailings and not uranium.

(iii) FQM lacked a coordinated interaction with all stakeholders from the start.
- The result was that the construction of the Chisola dam was delayed.

(iv) KCM did not engage its stakeholders before the importation of the concentrates. The company only engaged the stakeholders after a public outcry. Thus the company could not adapt to a new situation as leadings practice around the world may demand. Instead, KCM suffered huge costs of exporting the toxic copper concentrates from Chingola to Taiwan (Fig. 11).

Figure 11: KCM Copper concentrates with arsenic loaded on trucks to port of exit en route to Taiwan [18]

Taking leaf from leading practices in sustainable mine waste management in the world, KCM could have ceased the opportunity to learn from Yerranderie mine site [8]. The Yerranderie project was undertaken to rehabilitate the Yerranderie mine site, which had arsenic contamination. The levels of arsenic at this mine site were potentially hazardous to human health and the surrounding environment. The undertaking of the project successfully managed reducing risks to the surrounding environment and Sydney's water supply and improving safety for visitors and tourists. The success of the project was not only hinged on the chemical fixation and immobilisation technique [8] but it was coupled with engagement of safety personnel, the surrounding community and New South Wales Department of Environment and Climate Change.

In view of the above, it's been found out that, although mining companies in Zambia could have excelled in the design of tailings storage facilities, a coordinated community and/or stakeholders' engagement needed to be addressed and there should also be flexible and innovative leading practices in mine waste management.

4. Conclusion

The success of a mine plan is not only dependent on a good design but also the engagement of the community and other stakeholders. Challenges in the achievement of sustainable mine waste management practices shall remain in the limelight for as long as the engagement of stakeholders involved remains uncoordinated. As there will continue to be an emergence of new challenges and development of new solutions, it should be understood that leading practice in mine waste management should be flexible and innovative in developing solutions that match site-specific requirements. It's been found out from the study that, although mining companies in Zambia have excelled in the design of tailings storage facilities, community and/or stakeholders' engagement needed to be addressed. Thus, the study concludes on the note that, building capacity in the Zambian minerals industry requires a coordinated interaction of all stakeholders as key to achieving a sustainable mine waste management practice.

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