

School of Mining Engineering



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**TOWARDS IMPROVING ENVIRONMENTAL LEGISLATION
IN ARTISANAL AND SMALL-SCALE MINING: A CASE
STUDY OF OTTER MINE IN TANZANIA**

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I declare that this research report is my own unaided work. It is being submitted for the degree of Master of Science at the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination to any other university.

Johannesburg, 2025

DECLARATION

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17th day of September 2025

“It always seems impossible until it’s done”

Nelson Mandela

ABSTRACT

This research focuses on improving environmental legislation in artisanal and small-scale mining (ASM) in Tanzania. While economically important, ASM operations often result in severe environmental degradation due to inadequate regulatory frameworks and knowledge. This research, based on a case study around Otter Mine, identifies gaps in current legislation and proposes measures to mitigate environmental impacts. The research was conducted through a combination of legislative review, interviews with local operators, as well as environmental and operational assessments. The findings highlight the need for stricter environmental controls and government intervention to standardise mining practices and rehabilitate affected areas, ensuring the long-term viability of both the environment and the mining sector.

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LIST OF ABBREVIATIONS AND SYMBOLS

Abbreviation	Description
AMD	Acid Mine Drainage
ASM	Artisanal and Small-Scale Mining
CSR	Corporate Social Responsibility
EIA	Environmental Impact Assessment
EMA	Environmental Management Act
LSM	Large-Scale Mining
NEMC	National Environmental Management Council
NGO	Non-Governmental Organisation
MSCP	Multi-Stakeholder Community Partnership
PML	Primary Mining License
TSF	Tailings Storage Facilities
UNDP	United Nations Development Programme
WHO	World Health Organisation

Symbol	Description
Hg	Mercury
Fe	Iron
Pb	Lead
Cu	Copper
NO ₃ ⁻	Nitrate
NO ₂ ⁻	Nitrite
HCN	Cyanide

1 INTRODUCTION

1.1 Research Background and Context

Tanzania is rich in mineral resources, including gold, diamonds, iron, coal, nickel, tanzanite, uranium, and natural gas. Some of these commodities are extracted through both large-scale and small-scale mining operations. However, at the artisanal and small-scale mining (ASM) level, many practices are carried out without proper environmental considerations. This negligence often leads to air, water, and land pollution, as well as land disturbances. Consequences include the creation of artificial hills and gullies, deforestation, land degradation, and poor vegetation growth (Machasek, 2019).

Mining can provide significant benefits to society when conducted responsibly. However, inadequate planning and poor management practices in the industry have often led to environmental damage and harm to ecosystems (Singh & Gurdeep, 2013). This can only be rectified through all stakeholders upholding high standards in mining and rehabilitation. Responsible authorities must ensure that the legislation and enforcement processes are inclusive of all scales of mining operations, and that all operations adhere to these standards.

Communities are concerned about the negative impacts of ongoing mining activities, such as siltation, abandoned open shafts, livestock fatalities, and contamination of water and land from mine effluent. The effluent consists of chemicals, mainly mercury and cyanide, used in ore processing, along with oils and improperly disposed of wastewater. Unfortunately, this contamination affects livestock, aquatic life, and humans reliant on these water streams. Additionally, streams are being silted by soil erosion from mine sites due to inadequate stockpiling. Studies conducted in areas of Tanzania where ASM occurs have identified levels of cyanide and metals exceeding safety limits, posing a threat to both the environment and the surrounding communities (Gomezulu et al., 2018).

Due to the influence of foreign direct investments, the government appears to prioritise large-scale mines, overlooking the inclusion of ASM in the legislation. Mwalyosi (2004) elaborated that for (large-scale) mining to be sustainable in

Tanzania, mine development plans must address environmental and social concerns. According to The United Republic of Tanzania (2004), as documented in the Environmental Management Act of 2004, section 81, an Environmental Impact Assessment (EIA) is mandatory for (large-scale) mining operations. The act prohibits projects that result in unmitigated environmental damage (Skuta et al., 2017).

In Tanzania, a large-scale mine requires an EIA before operation, followed by regular environmental audits. This is different from ASM operations which require registration but typically do not require an EIA. In comparison with some other African countries:

- In 2016, the Government of Kenya introduced the Mining and Minerals Act to formalise ASM operations (Tax Justice Network Africa, 2023). However, the implementation of this legislation has faced delays due to ambiguities regarding the registration process. Consequently, many ASM operators continue to engage in mining activities without the requisite registration in Kenya.
- In Zimbabwe, ASM operators are required to complete an EIA, which is assessed by the Ministry of Mines and Mining Development, before being authorised to operate (Mapuranga, 2024). However, illegal ASM operators (locally known as '*Makorokoza*') generally operate without the EIA.
- In South Africa, ASM operators are licensed and governed by law, although many illegal ASMs (colloquially named '*Zama Zamas*') operate without licenses. In an effort to address unlicensed operations, the President of South Africa, Cyril Ramaphosa, sanctioned an operation deploying 3,300 army personnel to intercept illegal mining activities in November 2023 (Panchia, 2023). However, this solution is not sustainable as it fails to address underlying socio-economic issues, particularly unemployment, which often drives individuals to engage in illegal mining, a trend observed across several African nations.

According to Fritz et al., (2018), there were 40.5 million individuals engaged in ASM operations worldwide in 2017. This figure represents an increase from 30 million in 2014, 13 million in 1999, and 6 million in 1993. The number in Africa grew from 2 million in 1999 to 10 million in 2014 and 13 million in 2018. Table 1 identifies the

ASM numbers in Africa, with the Democratic Republic of Congo and Tanzania being the top two.

Table 1: Number of ASM operators per country

Country	Number of ASM Operators	Number of Dependents	Main Mineral Mined by ASM
Democratic Republic of Congo	2,000,000	1,200,000	Diamond, gold, Coltan
Tanzania	1,500,000	9,000,000	Gold
Ethiopia	500,000	3,000,000	Gold
Nigeria	500,000	2,500,000	Gold
Zimbabwe	500,000	3,000,000	Gold, diamonds, gemstones
Niger	450,000	2,700,000	Gold
Central Africa Republic	400,000	2,400,000	Gold, diamonds
Eritrea	400,000	2,400,000	Gold
Mali	400,000	2,400,000	Gold
Sierra Leone	300,000	1,800,000	Gold
Ghana	1,100,000	4,400,000	Gold, diamond, sand
Burkina Faso	200,000	1,000,000	Gold
Mozambique	100,000	1,200,000	Gemstones, gold
South Sudan	200,000	1,200,000	Gold
Uganda	150,000	900,000	Gold
Angola	150,000	900,000	Diamonds
South Africa	20,000	-	Gold
Malawi	40,000	-	Gemstones, gold
Cote D'Ivoire	100,000	600,000	Gold, diamonds
Guinea	300,000	1,500,000	Gold, diamonds
Liberia	100,000	600,000	Gold, diamonds
Chad	100,000	600,000	Gold
Madagascar	500,000	2,500,000	Gemstones, Gold

(Source: Fritz et al., 2018)

1.2 Problem Statement

In 2016, Tanzania had an estimated 1.5 million ASM operators, supporting an estimated 9 million family and extended family members (Hilson, 2016). Numbers are increasing yearly, with many people joining ASM primarily because of shortages of formal employment opportunities. Most of these operations are conducted haphazardly, stemming primarily from a lack of relevant environmental regulations specific to this sector. This is a serious concern, as such operations can adversely affect the environment and local communities' livelihoods in the long term.

Given this situation, the question being addressed by this Research is

- How does the Tanzanian environmental legislation need to change to properly benefit the ASM community, at the same time as protecting the environment?

1.3 Justification for Research

ASM activities are vital to the economy and offer valuable employment opportunities, especially for young people. As the number of individuals participating in ASM increases, it becomes essential to implement regulations and ensure compliance to promote sustainable and ethical mining practices. Given the vital role that ASM plays in Tanzanian communities, it is essential for this research to be conducted to provide proposals for regulating the ASM sector.

1.3.1 The role of ASM in the economy

ASM is a significant global producer of minerals and metals, contributing approximately 20% of the world's gold supply and about 80% of sapphire production (Fritz et al., 2018). This sector is particularly important in developing regions, where it provides livelihoods to millions of people (Tang & Qin, 2024). Additionally, ASM is an important part of Tanzania's economy. The government benefits from this sector through taxes and fees (Pederson, et al., 2021b), which all contribute to the Gross Domestic Product (Muganyizi, 2012).

The ASM sector has emerged as a rapidly growing employment industry, providing income primarily to marginalised communities. This phenomenon is not limited to Tanzania but extends throughout Africa (and elsewhere in the Developing World). With the region's scarcity of job opportunities, many individuals unable to find work elsewhere turn to the ASM sector to earn a living (Pederson et al., 2021a). As a result, families have improved their living conditions and can now send their children to school. Women actively participate in various ASM activities, such as mineral processing, and some even own mining licenses. Some of these women are represented by associations such as the Tanzanian Women Miners Association (TAWOMA).

1.3.2 The environmental impacts

Mining activities in the ASM sector have resulted in significant negative environmental impacts, including degradation and pollution of both land and water (Chacha, 2017). These issues have adversely affected farmland, vegetation, animals, aquatic life, and human health.

The rudimentary mining methods used by ASMs have led to significant land degradation in countries where such activities occur. According to Ofosu et al. (2020), in Zimbabwe, ASM competes with agriculture, causing damage that negatively impacts farming. Individuals whose land has been harmed by ASM activities are compelled to resort to mining for survival.

As poverty often outweighs the need for sustainable practices, miners focus on survival and appear to care little about the environment (Osei et al., 2022). In ASM areas, rehabilitation efforts are typically minimal to non-existent, resulting in the continued accumulation of improperly disposed waste materials, including slimes (tailings). Consequently, the land becomes unsuitable for agriculture as the soil loses its capacity to sustain microorganisms. Further, hazardous substances such as cyanide and mercury infiltrate river systems and surrounding lands, posing substantial risks to the ecosystem.

If the mined-out shafts and pits are not rehabilitated and/or fenced off, they can become death traps for animals. Besides posing a danger to animals, these shafts

also contribute to mosquito breeding, which can lead to malaria outbreaks. East Africa is one of the regions with the highest malaria rates (Paton et al., 2021).

The failure to rehabilitate land after ASM activities leads to erosion of the exposed land, which ultimately results in land degradation (Mhangara et al., 2020). The eroded material silts up rivers, adversely impacting aquatic life and water quality.

Additionally, the surrounding vegetation suffers due to uncontrolled dust from mining operations and dry mineral processing. This dust also poses serious health risks, causing respiratory diseases, particularly silicosis and tuberculosis, among ASM operators who are often exposed without proper personal protective equipment. Research by Howlett et al., (2023) in Tanzania, Zimbabwe, China, and Nigeria has revealed that many ASM workers are developing silicosis and tuberculosis due to high dust exposure.

As the world shifts towards renewable energy sources, ASMs remain reliant on outdated power generation methods. The generators and crushing plants produce excessive noise levels, which can impair hearing and cause some species to migrate away from the affected areas. There is a lack of awareness regarding the environmental impacts of the smoke from the generators and the noise from the crushers, with decisions primarily driven by affordability.

1.3.3 The failure of government regulations

As identified by the Tanzanian Minerals Policy (The United Republic of Tanzania, 2009), there was limited consideration of environmental policies when the government put effort into formalising ASM. In addition to acknowledging the environmental problems associated with ASM, the Government of Tanzania has agreed that the lack of monitoring and regulation of the many ASMs is due to financial and logistical challenges (Kinyondo & Huggins, 2021a). Without regulations governing mining practices, operators within the ASM sector manage their mines as they see fit. Therefore, government intervention is imperative to ensure sustainable mining practices and to prevent irreversible environmental damage.

Tanzania's National Environmental Management Council (NEMC) is responsible for environmental policy formulation, education, and enforcement. The NEMC does not have a national-level policy guiding the ASM sector. Instead, the current environmental policies give clear guidance for large-scale mining activities only. This has left the ASM activities largely unmonitored by the authorities and facing several challenges, including inadequate environmental, health, and safety practices, as well as significant social issues.

1.4 Research Objectives

This research aims to identify gaps in the existing environmental legislation that do not adequately address ASM issues. The study looks at the ASM-induced environmental damages around Otter Mine as a basis to propose mitigation measures that incorporate relevant legislation. The specific objectives of this research are as follows:

- To identify and understand the key environmental impacts of ASM operations.
- To review existing legislation to identify gaps associated with ASM operations.
- To propose evidence-based recommendations for improving environmental legislation and regulatory enforcement in the ASM sector in Tanzania. Going forward, the revised environmental legislation is expected to be a valuable tool for directing all ASM work and rehabilitating parts of the affected environment.

1.5 Research Methods

This study includes both qualitative and quantitative research methods. Qualitative research is essential in acquiring knowledge that complements and is validated by a quantitative approach. Combining both methods provides a more comprehensive understanding of the findings.

1.5.1 Qualitative research

When conducting research, qualitative methods can offer valuable insights into the social effects of the problem by exploring the underlying reasons and motivations.

This has been done through questionnaires and interviews. The in-depth interviews provide a synopsis of the practices that result from not applying environmental regulation.

1.5.2 Quantitative research

By contrast, quantitative methods involve collecting and analysing numerical data, providing precise and measurable information to further understand the issue at hand. Quantitative research provides objective and numerical results for data analysis. The results identify trends, patterns and correlations, which help make informed decisions. In this research, physical observation, data collection, and analysis have been used to verify and quantify the presence of toxic contaminants and environmental damage.

1.6 Sources of Data

Interviews and questionnaires were utilised, and the author anonymised the collected data. In addition, samples were collected from rivers, tailings, mine effluent, vat leaching sites and tailings storage facilities (TSF). Site observations consist of photographs and notes of current and old ASM sites and documenting environmental impacts.

1.7 Research Validation

In this study, the validity of the research was ensured through the utilisation of triangulated data collection methods, which included stakeholder interviews, ASM site observations, and sampling, to accurately reflect the environmental practices and challenges associated with Tanzanian ASM. This approach provides a solid foundation for legislative improvement.

This research compared its findings with those of previous studies on environmental impacts in the ASM sector in Tanzania. The comparison revealed a high level of consistency, with many of the impacts identified in earlier studies also emerging in the present study. While this consistency alone does not prove the validity of the methods used, it provides supportive evidence that the approach and

findings are in line with existing knowledge in the field. The evidence contributes to the validation of the research.

1.8 Structure of the Research Report

This research report consists of six chapters, namely:

- **Chapter one** serves as the introduction and presents the background to the research topic, the problem statement, the justification for the research, and the research objectives. It outlines the research methodologies employed in this study and identifies the sources of information used. Additionally, the chapter discusses research validation to ensure research findings are credible, reliable, and scientifically sound.
- **Chapter two** provides a literature review that establishes a foundational understanding of the gaps in ASM legislation. It includes studies on the environmental impacts and regulations associated with mining and the socio-economic effects and health concerns in the broader academic context. The chapter highlights how the absence of effective policies and knowledge in ASM has negatively affected the environment.
- **Chapter three** outlines the research approach. Both qualitative and quantitative methods were utilised for data collection to understand the impacts of ASM on the environment and social dynamics. The qualitative approach employed questionnaires, interviews, and on-site observation as sources of information, while the quantitative approach focused on collecting numerical data to provide precise and measurable insights.
- **Chapter four** presents the data for the study, including results obtained from interviews, field observations, and laboratory tests. These results cover the legislation, environmental impacts, causes, and the concentrations of cyanide, mercury, and other metals in the field samples.
- **Chapter five** constitutes an analysis of the data presented in Chapter four. The results discuss alarming environmental and health risks associated with substandard ASM practices, driven by limited resources, inadequate awareness, and insufficient regulation.
- **Chapter six** presents the conclusions and recommendations. Potential solutions are proposed to address the concerns raised and to improve the

well-being of both humans and animals. This chapter also addresses research limitations, and suggestions for future research.

2 LITERATURE REVIEW

2.1 Introduction

This chapter examines the current landscape of environmental legislation in Tanzania and the environmental impacts associated with ASM. It highlights the limitations of existing mining regulations, which often fail to adequately address the unique challenges posed by ASM activities. The chapter also delved into both local and international mining practices, across ASM and LSM, and their respective environmental consequences. This comparative analysis contributes to a deeper understanding of the issue and informs potential solutions. Further, a review of historical and contemporary data on the environmental and social implications of ASM, alongside an evaluation of ASM policy frameworks implemented in other countries, provides a foundation for identifying regulatory gaps, shaping the research direction and developing a theoretical framework.

2.2 Key Concepts and Context

Key areas for reducing the environmental impacts of ASM include strengthening the regulatory framework and enhancing community awareness and training. These efforts support proper chemical and waste disposal, promote mercury-free gold processing, control deforestation, improve waste management, and rehabilitate mined-out areas. Environmental regulation serves as a guide to achieving the aforementioned sustainable mining practices. However, various concepts and theories must be understood to develop an effective ASM policy for managing environmental impacts.

2.2.1 Overview of the ASM policy in Tanzania

As stated in the Tanzanian Mining Act Chapter 123 (The United Republic of Tanzania, 2019), the holder of a mining license, or their representative, must comply with the environmental principles outlined in the Environmental Management Act (EMA) (The United Republic of Tanzania, 2004) when conducting mining operations.

As stipulated by the EMA (The United Republic of Tanzania, 2004), individuals or organisations planning a project are mandated to conduct an EIA at their own cost. This assessment must be carried out before the project commences. Moreover, the assessors conducting the evaluation must be registered with the NEMC. The Council considers various issues when deciding whether to issue an EIA, including:

- The nature of the project and how it is likely to meet environmental standards,
- Evaluating the short-term socio-economic benefits of mining against the projected damage to the environment,
- Mitigation measures for addressing environmental threats, and
- Comments received during public review and any other review criteria.

The EMA, sections 100 and 101 (The United Republic of Tanzania, 2004) emphasises the need for environmental monitoring and audits throughout the project's lifecycle, which comes after the acquisition of an EIA. An environmental inspector must carry out these monitoring activities to ensure compliance. If the holder of the EIA certificate is found to be non-compliant, they may face fines or legal action.

In addition, section 105 of the EMA mandates EIAs for (large-scale) mining operations (The United Republic of Tanzania, 2004). However, while registration is necessary for ASM operations, they do not require an EIA. In reality, most ASM conduct mining activities without even registering their operations (Rwiza et al., 2023).

The NEMC, in consultation with the Commission, has the authority to grant a license for the management, transportation, storage, treatment, or disposal of waste resulting from mining operations to an entity contracted by a license holder. The terms and conditions for this license are specified, and mining activities can only commence after the license is issued by the Minister responsible for the environment. Failure to obtain this license may lead to imprisonment or a fine for the individual responsible for managing the mining processes.

Further, the EMA, section 110 (The United Republic of Tanzania, 2004) strictly prohibits the discharge of hazardous substances, oil, chemicals, poisons, or any

polluting liquids into the water or the environment without adhering to the prescribed containment protocols. Violating these standards can lead to environmental pollution, including noise, discharge of contaminants, and emissions that adversely affect human health and the environment. These substances should be properly contained to prevent potential harm to humans and the ecosystem.

The EMA further states that it is against the law to conduct construction or mining work near riverbanks without prior authorisation from the Minister of the NEMC. Legal action is available to obtain compensation for pollution damage caused by mining operations' discharge, both on land and in rivers.

LSMs generally abide by the regulations to protect their multi-million dollar investments. This is not, however, true of ASMs. As noted by Mwakaje (2012), despite the availability of legislation, the ASM sector has typically remained non-compliant.

ASM teams typically set up their mine sites wherever there is a mineral rush for commodities such as gold and gemstones, even within river systems, disregarding the inevitable damage that such operations may cause. They ignore, not only environmental hazards, but also safety risks, as mining in rivers can result in geotechnical failures from water infiltration and fractured rock (Zhu et al., 2022).

Although the EMA (sections 81, 105 and 171) promotes environmental management broadly, it refers only to the Environmental Protection Plan that is required by small-scale miners, and which is not relevant to artisanals. When mining (typically LSM) is mentioned, the associated environmental aspects must be included in the EIA report. Management controls are also required to highlight the preservation of the environment during mining operations.

The EMA, section 105, stipulates that the Ministry responsible for mining, energy, and water must do an environmental assessment (The United Republic of Tanzania, 2004). The Minister is also required to comply with the recommendations by the NEMC Minister. This suggests that if NEMC had legislation targeting the ASM, the Ministry of Mining, Energy, or Water would be responsible for enforcing compliance in the ASM. While this responsibility to

preserve the environment starts with the miners, they are currently not held accountable, as the legislation does not cover them. Therefore, the ASM teams continue to operate without clear guidelines, resulting in severe environmental impacts.

As a result of ongoing discussions between the government and leaders of the Federation of Miners Association of Tanzania, the government is considering (but has not yet implemented) a strategy aimed at supporting small-scale miners (TanzaniaInvest, 2025). Such a strategy would include a proposal to support ASMs by providing access to affordable financing, modern technology, and advanced mining equipment. If implemented, this initiative would have the potential to facilitate the transition of small-scale miners into large-scale operations, thereby reinforcing the economy.

Implications of the existing laws on the ASMs

Between 1997 and 2009, the government made efforts to transition artisanal mining into small-scale mining. According to the Africa Mining Development Centre (2025), the distinctions between artisanal mining and small-scale mining primarily lie in the areas of licensing and start-up capital. Artisanal mining operations often operate without formal licenses and rely on basic tools and techniques, whereas small-scale miners typically possess legal licenses and may utilise more advanced tools and equipment than their artisanal counterparts. **Figure 1** illustrates the degree to which the artisanal process is manual and labour-intensive.



Figure 1: Typical artisanal mining in Tanzania

(Source: Masegese, 2023)

As part of the policy statement in section 5.6 of the Mineral Policy of (The United Republic of Tanzania, 2009), the State asserted that it supports small-scale miners in accessing the mineral market, providing technical and financial assistance, as well as offering geological information. Nevertheless, financial assistance encountered challenges, as articulated in section 5.1 of the Mineral Policy, where it is noted that local financial institutions disregard the economic potential of small-scale mining and seldom offer supportive financial schemes, thereby hindering investment and sector growth.

In the Mining Act of 2019, The United Republic of Tanzania (2019) committed to supporting the LSM and small-scale miners with geo-scientific services offered by the Geological Survey of Tanzania. Additionally, in support of the ASM sector, the Government of Tanzania offers training programs at the Matundasi Demo Mine Training Centre located in Chunya District, Mbeya Region (Masanja, 2012). While the intention of these programmes is positive, TanzaniaInvest (2025) noted that they have not yet been fully or sustainably implemented.

In addition to section 5.6 of the Mineral Policy, the government also states that it will ensure that these small-scale miners preserve the environment. However, this commitment was not addressed in the EMA (The United Republic of Tanzania, 2004), leaving the ASMs without guidelines on how their operations can protect the environment.

Further, as noted by Kinyondo & Huggins (2021b), the government lacks the capacity to monitor the effectiveness of ASMs. This results in the ASMs doing as they please since there is neither legislation to guide them nor oversight from the government. The lack of guidance leads, *inter alia*, to a lack of sustainable development in operations.

The current ASM legislation needs to be guided by specific policies to enhance work safety, security of investment, and promote environmentally sustainable practices. These policies should encompass, but not be limited to, the necessity of formalising operations, the protection of the environment, the safe disposal of mining and chemical waste, the training and technical support for miners, and site inspections conducted by state officials. In addition, the legislation needs to address potential access to technical and financial support, as well as partnerships with legitimate companies.

Complimentary studies

Mwakaje (2012) emphasised that to achieve economic growth and environmental protection in Tanzania, it is essential to establish a suitable institutional framework for ASM that considers the miners' needs. This indicates that legislation concerning ASM has been long overdue, as evidenced by various scholarly studies. Mwakaje (2012) also highlighted the miners' failure to rehabilitate mined-out areas while opening multiple pits and shafts, posing risks to the environment, humans, and wildlife. Additionally, the use of mercury, inadequate disposal methods, and the burning of amalgam in the presence of people expose them to dangerous vapours.

Previous studies within the Lupa goldfield demonstrated high concentrations of cyanide. For example, research conducted by Jonsson et al., (2013) in the Makongolosi area, located approximately 20 km from Otter Mine, also revealed elevated mercury exposure levels and detrimental environmental effects. A second

study conducted cyanide tests at the Ifumbo mining location, about 70 kilometres southeast of Otter Mine (Mnali, 2001). The samples revealed high cyanide concentrations (from the improper disposal of leached tailings and wastewater runoff) exceeding 26 ppm (Mbare et al., 2023). This figure is significant when considering that, elsewhere in first-world mining jurisdictions, 0.2 ppm is considered safe (Government of Canada, 2008; The United Republic of Tanzania, 2007).

Tanzania's action on ASM

The Government of Tanzania has not yet fully addressed the environmental issues caused by ASM activities, but it benefits from ASM mineral sales taxes. ASMs are legally entitled to dispose of their gold (or other mineral commodities) using either government agents at formal trade centres or private brokers/dealers.

The formal mineral (gold) markets (or trade centres) were established by the government in 2019 as gold trading points, primarily for ASMs lacking proper market access (Further Africa, 2019). These government-run markets were set up for revenue collection and to bring transparency to the gold trading environment among brokers, dealers, and miners. According to Pederson et al., (2021a), the purchase of ASM gold has increased the government's monthly gold revenue collection from over US\$700,000 to \$3,000,000 between May 2019 and June 2020. Of the 53.53 tonnes of gold produced in the same year, 15.33 tonnes were from the ASM sector.

According to Pederson et al., (2021a), government agents transparently purchase minerals from ASM operators, deducting a 7.3% tax from the revenue. They supervise the process using global and market prices of minerals accessible to everyone via the Internet. The Mining Commission of Tanzania (2020) reports that as of 2020, some 31 mineral market centres had been established throughout the country. The latest report by The Mining Commission of Tanzania (2024) states that the number of market centres has tripled by July 2024, reaching 96 to accommodate the increasing number of mines.

The trade centres operate under a dealer's license for the trading of minerals. The dealer license allows the export of minerals and must be renewed annually (The

Mining Commission of Tanzania 2020). All brokerage and dealership activities are regulated by the Mining Commission of Tanzania in the Mining Act, Chapter 123.

Despite the availability of government trade centres, many ASMs sell their gold to private dealers and brokers who operate from nearby villages or mine sites. Private traders/brokers are holders of a broker's license, which is valid for 12 months and which allows them to buy minerals from specific buying stations such as mine sites. As further noted by The Mining Commission of Tanzania (2020), the traders/brokers are allowed to sell the minerals to established trade centres but cannot export them. When the private traders sell their gold to the government trading houses, they are required to pay the 7.3% tax on their sales. As a result, they purchase the gold from the artisans at lower prices so as to increase their profit margins (Pederson, et al., 2021b).

According to Kombe (2024), it would be beneficial if the private traders could assist ASMs by supplying machinery and other inputs required for improved production. This is expected to reduce mine operators' reliance on rudimentary tools.

The author also proposes that private traders might also serve as micro-financiers by supplying miners with capital, equipment, and modern technology within formal agreements linked to production delivery. This approach would replace exploitative informal credit, promote safer and more efficient mining, and ensure a consistent mineral supply through increased production. Further, trade centres could also serve as hubs for training, registration, finance, and equipment supply. Furthermore, the centres could provide office space for streamlined ASM registration.

Since the State runs the trade centres, it is expected that they could assist by streamlining and accelerating PML processes, including mobile registration, eventually expanding to strengthening ASM technology, productivity and livelihoods. As stated by Lui & Natai (2025), such a system is expected to enhance the technical support regulation, which was enacted in April 2025 to assist licensed miners. The recently enacted section 8(3) of the Mining Act, from Cap. 123 of 2010 (the Mining Act) facilitates mineral exploration, extraction, and processing, as well as expertise. If implemented well, ASM will be able to plan their operation guided

by geological exploration outcomes, adopt cleaner technologies, and acquire mining skills through training. According to Mutagwaba et al. (2018), 58% of ASM in Tanzania focus on gold mining. The remaining 42% mine other minerals, including gemstones such as diamonds, tsavorite, tanzanite, zircon, rubies, sapphires, natronite, spinel, alexandrite, rhodolite, spessartite, tourmaline, purple yoderite, and garnet. Some ASMs also extract industrial minerals and building materials, including limestone, salt, quarry materials, sand, gypsum, and dolomite. Figure 2 represents the estimated percentages of some of the minerals being mined by ASMs in Tanzania

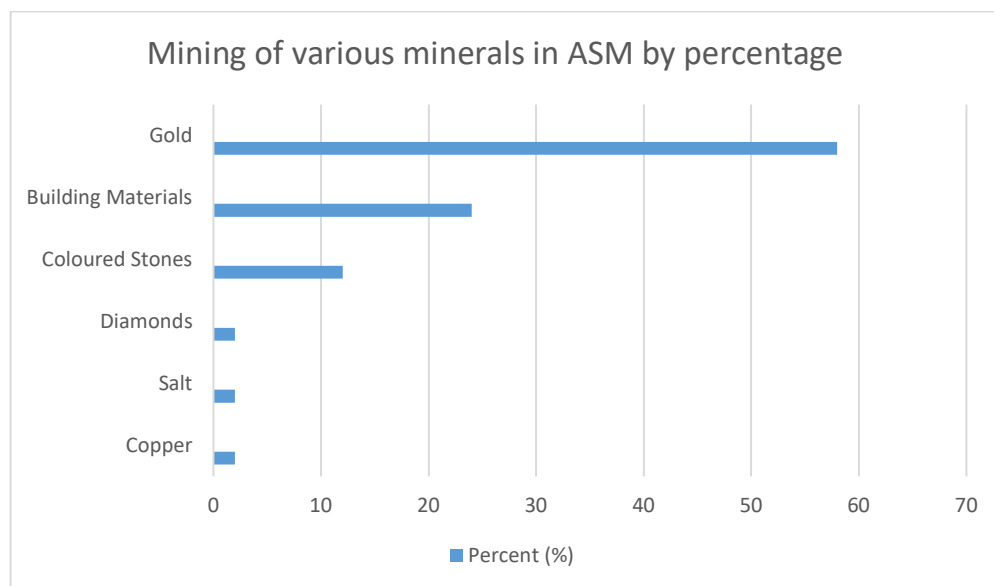


Figure 2: Mining of various minerals in ASM by percentage

(Source: Report of Tanzania Baseline Survey on Artisanal and Small-Scale Mining, MEM, 2012).

In recent years, the Tanzanian government has improved regulations and policies, including the registration of primary mining licenses (Kinyondo & Huggins, 2021b). Despite this government effort, a lack of follow-up, application, and implementation of ASM-specific policies remains.

2.2.2 Global context

Large-scale mining in Tanzania and around the world operates with a focus on environmental responsibility. Companies' duty to take care of the surroundings is a legal requirement deeply embedded in the corporate social responsibility

(Jenkins & Yakovleva, 2006). They demonstrate sound environmental stewardship by properly managing chemicals, mining waste, and rehabilitating mined-out areas. These larger established companies have come to terms with the technical and economic benefits of adopting environmental policies (Hilson & Nayee, 2002). Benefits include the protection of biodiversity, the promotion of sustainable industries, the assurance of food and water security, the enhancement of environmental productivity, and the support of natural processes. These factors also enable the long-term availability of resources for future generations.

Besides environmental protection, safety is prioritised through accident prevention, which involves both safety engineering and promoting a culture of behavioural safety (Ismail et al., 2021). This involves improving safety and production mechanisms, as well as gaining the trust and cooperation of miners in working safely. The same safety mechanisms and the safety culture deeply rooted in workers also make a positive impact on the environment.

Though significant environmental damage has been caused historically by large mining companies, there are ongoing efforts to minimise future impacts. For example, in South Africa, Sibanye Stillwater has an integrated approach to monitor programs for waste, chemicals, and water quality. At their Marikana operation, the company separates clean water and contaminated water, which then gets treated and recycled for re-use (Sibanye Stillwater, 2019). Further, all environmental incidents are reported, investigated, and effectively managed.

In Australia, the Government of Western Australian Department of Mines, Industry Regulation and Safety (1978) enforces seven golden rules for ASMs prospecting under a Prospecting Lease. The first six rules prioritise safety and the necessity of carrying proper supplies and communication tools, along with requirements for prospecting, including legal access rules and respecting other land users and cultural sites. Rule seven, which is also directly applicable to this research, requires that all holes dug should be filled and repaired.

ASM operations typically raise significant environmental, health, and safety concerns. Miners in ASM often work in hazardous conditions without proper personal protective gear, exposing themselves to harmful substances and

increasing their risk in hazardous work environments. Environmental issues stemming from ASM include land degradation, leading to loss of agricultural production, as well as pollution from chemicals, metals, mine waste, dust, and effluent (Fritz et al., 2018).

While limited (or even absent) environmental legislation in the ASM sector has led to significant environmental damage worldwide, several countries have developed and implemented effective policies. Zimbabwe, South Africa, and Ghana serve as positive examples (Mapuranga, 2024; Department of Mineral Resources and Energy, 2021; Republic of Ghana, 2006).

In South Africa, the legislation stipulates that ASM operators must hold an applicable Mining Permit, whether it be Artisanal or Small-Scale (Department of Mineral Resources and Energy, 2021). The type of ore mined, the technical and financial resources of the applicant, and the related potential environmental impacts determine the conditions of the permits. Training and skills development are essential priorities considered in the criteria for permit issuance. Furthermore, Environmental Assessment Practitioners must be engaged to assist with applications for water licences, environmental management, and the determination of rehabilitation costs.

Ghana's government recognises small-scale miners, who must hold a valid small-scale mining license issued by the Minister for Mines (Republic of Ghana, 2006). One primary aspect of the license is section 94, which requires miners to employ effective and efficient mining practices. Furthermore, production should adhere to proper standards and procedures while also observing health and safety regulations, as well as environmental preservation practices. Despite the existence of policies and the government's appeal to miners in Ghana to prioritise environmental protection, Fagariba et al. (2024) observed that ASM continues to inflict harm on the environment. Even licensed ASM operators frequently fail to adhere to the standards mandated by these policies. Further, due to inadequate follow-up by the responsible authorities, operators persist in their noncompliance. These authors also emphasised the importance of strict compliance with mining regulations and the necessity of training miners, thus promoting environmental stewardship and adherence to established standards. Additionally, Mwachukwu

(2025) emphasised the necessity of establishing a system where miners must receive training and their cooperatives attain official status. They further noted, however, that implementing such a system would require substantial investment in the ASM industry.

Notwithstanding operational issues, ASM enhances villagers' livelihoods. For example, in the Migori gold-mining district of Kenya, families have built decent houses and invested in other income-generating activities such as shops and hotels. The author witnessed how this has allowed the villagers access to local basic facilities and comfortable lives. Economic contributions are also made at the district and local levels in Tanzania, where tariffs are collected by the village government and used for local development projects (Mutagwaba et al., 2018).

In addition to African countries, Brazil exhibits cooperation among ASM, LSM, and medium-scale mining (MSM) to enhance responsible gold production and promote sustainable mining practices (Ribeiro-Duthie & Castilhos, 2016). The goal is to minimise human health and environmental impacts. The LSM operators confirm that they support the formalisation and regularisation of the ASM sector, which is intended to reduce the risks associated with mining. This initiative is commendable, particularly given that Brazil ranks among the countries with the highest numbers of ASM in Latin America, alongside Peru and Colombia (Fritz et al., 2018).

According to Newbold (2006), another South American country, Chile, also provides a good example of the government and companies playing a crucial role in responsibly managing natural resources and practicing environmental care. This occurs across all economic sectors, including mining, fishing, and agriculture. Companies conduct environmental audits and generate reports based on the audits.

The mandatory EIA requirement during the ASM licensing process in both Zimbabwe and South Africa is a step forward in ensuring environmental protection by addressing environmental concerns during mining (Mapuranga, 2024; Department of Mineral Resources and Energy, 2021). In these countries, the EIA broadly applies to all ASM activities. In Tanzania, however, the Environmental Protection Plan is only required as part of the small-scale mining licensing process,

which means that artisanal miners fall outside this licensing framework (The United Republic of Tanzania, 2004). This creates a policy gap where environmental protection applies to small-scale mining groups but excludes artisanal miners. As a result, overall environmental oversight in the ASM sector is limited.

Unlike Tanzania, the South African ASM also considers skills development, and the engagement of an environmental assessment practitioner for issues related to water, environment, and rehabilitation. Further, according to The Republic of Ghana (2006), regulations in Ghana require that ASM production comply with health, safety, and environmental standards while employing effective and efficient mining practices. The same applies to Brazil, where various stakeholders, including LSMs, set goals to minimise safety and environmental impacts (Ribeiro-Duthie & Castilhos, 2016). This contrasts sharply with the ASM situation in Tanzania, where enforcement of environmental practices, safety, health, and operational standards is largely absent, exposing a regulatory slack and governance weakness that undermines effective environmental and occupational management in the sector (Kinyondo & Huggins, 2021b).

Notwithstanding the implementation of these measures to varying degrees, illegal ASM persists as a challenge in Tanzania, Ghana, Zimbabwe, and South Africa. These unlawful activities are unregistered, lacking EIA, and do not conform to responsible mining practices. As a result, ASMs often disregard responsible mining practices, contributing to environmental degradation and unsafe working conditions.

Legal ASMs apply the legislation, but illegal zama zamas do not – this is the same in every country. Every country tries to bring illegals into the fold but fails because of underlying issues of affordability (poverty), bureaucratic and administrative difficulties, and lack of trust in the system.

2.2.3 Artisanal and small-scale (ASM) versus large-scale mining (LSM)

Unlike ASMs, most large-scale mining operations adhere to standard mining practices regarding safety, health, and environmental requirements. These mines are mechanised, can expand operations, and can access loans that enable them to meet the obligations imposed by the government. Safety issues such as the

detection of mine collapses can be anticipated in advance through the utilisation of seismic monitoring technology (Brijraj et al., 2024). This method is utilised in over 300 underground mines globally and offers significant safety and production advantages.

At the other end of the mining spectrum, most ASM teams lack adequate environmental knowledge; however, some do have some knowledge but are reluctant to implement. An example of this is the release of heavy metals into the environment from tailings without worrying about the effects (Budianta, 2020). Arable land is degraded, and water and air are polluted because of ASM operators' reckless mining operations. The quality of soil, crops, and food is affected by the toxic chemicals that form part of the mining processes (Sana et al., 2017). Additionally, plant and animal life cannot thrive in areas where soil and rock are dumped during uncontrolled mining operations.

Large-scale mining allocates capital to its operations and strategically plans for future growth, employing professionals who drive the company forward. By contrast, a lack of capacity is apparent in the mining methods employed by ASMs. This lack impacts, inter alia, their production rates and environmental management abilities. According to Hilson & Ackah-Baidoo (2011), while some organisations may be willing to help ASMs finance their operations, there is still hesitancy because they are unsure if the miners will ever be able to repay the loans. This uncertainty stems from the lack of defined Mineral Reserves on these operations.

Mineral Reserves are the economically mineable portions of Mineral Resources, as defined through a prefeasibility or feasibility study. The scope of these studies is defined in all the international mineral resource reporting codes, for example, the South African Code for the reporting of Exploration Results, Mineral Resources and Mineral Reserves (SAMREC Code, 2016)). Compliance with such codes is generally necessary for international investors to assist ASMs with funding. However, it is common for ASMs to operate without Code compliance, primarily due to a lack of expertise and financial resources.

2.2.4 Environmental impacts of ASM operations

The impacts of ASM operations on the environment are numerous and include pollution from the mining process and contamination of toxic metals and chemicals resulting from unsafe processing methods. These effects are exacerbated by poor land management and rehabilitation practices.

Pollution from mining processes employed by ASMs

In most mining operations, equipment is powered by generators due to the lack of access to the main electric power supply in remote areas. Using generators leads to the emission of exhaust fumes from fuel combustion, contributing to air pollution. Additionally, airborne emissions occur during drilling, blasting, ore transport, and ore processing (Gisore & Matina, 2015). Mining processes release air pollutants such as particulate matter, heavy metals, sulphur dioxide, carbon monoxide, and nitrogen oxides.

Notably, mercury is burnt by ASMs to extract gold from amalgam; the vaporised mercury poses environmental pollution risks to the ozone layer and health hazards to both humans and animals upon inhalation (Jonsson et al., 2013). Most of the miners have limited awareness of the dangers posed by mercury but only know about it as the cheapest and most commonly available gold processing method.

According to Veiga et al., (2006), an estimated 800 to 1,000 tonnes of mercury are released into the global environment annually, assuming one gram of mercury is used per gram of gold processed. Countries have varying ASM mercury emissions rates, with China having the highest. Table 2 shows annual ASM mercury emissions by country. Although Tanzania is not mentioned by Veiga et al. (2006), an earlier report from Straaten (2000) indicates that an estimated 3-4 tonnes of mercury is released by the Lake Victoria Goldfields. However, a recent report in the Daily News Reporter (2024) states that mercury dispersion throughout Tanzania may be around 20-25 tonnes of mercury.

Table 2: Annual ASM mercury emissions by country

Country	Annual ASM Mercury Emission (tonnes)
China	200-250
Indonesia	100-150
Brazil	10-30
Bolivia	10-30
Colombia	10-30
Peru	10-30
Philippines	10-30
Venezuela	10-30
Zimbabwe	10-30
<i>Tanzania (total)[#]</i>	<i>20-25</i>
<i>Tanzania (Lake Victoria Goldfields)[*]</i>	<i>4-5</i>

Sources: Veiga et al. (2006), [#] Daily News Reporter (2024), ^{*} Straaten (2000),

Most ASMs use chemicals to process gold. Apart from gold, most minerals in ASM operations are separated by gravitational sorting and other simple processes, without the use of chemicals. In the gemstone mining industry, for example, the majority of operations employ rotary pan plants or simple sieves to recover their stones.

For decades, mercury and cyanide have been the primary chemicals used in gold processing for both ASM and LSM. While no longer in use in LSM operations, mercury is utilised by ASMs in the process of amalgamation. Veiga et al. (2006) note that due to the density of both gold and mercury, they both gravitate to the bottom of the panning dish during processing. The mercury is then absorbed into

the surface of the gold particles, while lighter gangue materials remain floating. The mercury-gold amalgam is then burnt to recover the gold and some of the mercury remains in the tailings. These tailings are generally stored inadequately, typically deposited in loose piles on uncompacted ground and lack retaining walls.

Cyanide is primarily used by ASM operations that leach tailings, which, in most cases, were originally processed using mercury. The recovery rate of cyanide is much higher than that of mercury processing, but the handling and disposal of cyanide pose a similar danger as mercury. If not managed well, cyanide solution is discharged into the ecosystem (Eisler & Wiemeyer, 2004).

Water and land pollution

Heavy metals from mining sites are carried by water and deposited into the land and rivers. According to Budianta (2020), copper, zinc, lead, and cadmium exhibit high concentrations in stream sediments near the mining sites, which decrease further downstream. Additionally, acid mine drainage, resulting from the oxidation of sulphide minerals, is a significant water pollutant from active or abandoned mines. The affected water is typically rich in dissolved ferrous or non-ferrous metal sulphates, which are harmful to plants, humans, aquatic life, and wildlife (Simate & Ndlovu, 2014). Apart from heavy metals, cyanide is one of the more toxic chemicals deposited into land and water streams. Most of it is carried by flowing water from rain or by releasing cyanide-containing effluent from areas such as vat leaching sites or TSFs.

ASMs have limited control over how they dispose of mine effluent and mineral processing water. Often, these mines pump contaminated water into nearby streams. This water contains residual chemicals from explosives used in blasting. The polluted water also poses a risk to the domestic water supply used by local communities.

Soil contamination in ASM operations also occurs from mishandling oils from equipment due to a lack of standard disposal practices. Some of the equipment used is not in good working order, causing oil leaks that pollute the environment.

In addition to the detrimental effects of cyanide and mercury on the environment, one of the most severe environmental threats is acid mine drainage (AMD), which contaminates soil, groundwater, and surface water. Hogsden & Harding (2012) assert that streams affected by AMD present a significant threat to aquatic life, as the lifespan of impacted species is diminished and biodiversity is adversely affected.

According to Akcil & Koldas (2006), the formation of AMD is attributed to the exposure of sulphide-bearing material to water and oxygen. Water and oxygen enable the oxidation of the sulphide-bearing material, and the AMD usually emerges as low-pH water. The sulphide-bearing material originates from mine waste rock and mine tailings. Kaur et al., (2018) said that chemical weathering of metal sulphide-rich rocks produces acidic fluids with high metal concentrations. Pyrite (FeS_2) is usually the dominant sulphide mineral, and metals like gold (Au), silver (Ag), copper (Cu), zinc (Zn), and lead (Pb) are extracted from these deposits as contaminants. Mining activities expose these metals to air and water, thereby enhancing AMD processes. **Figure 3** depicts events that lead to AMD.

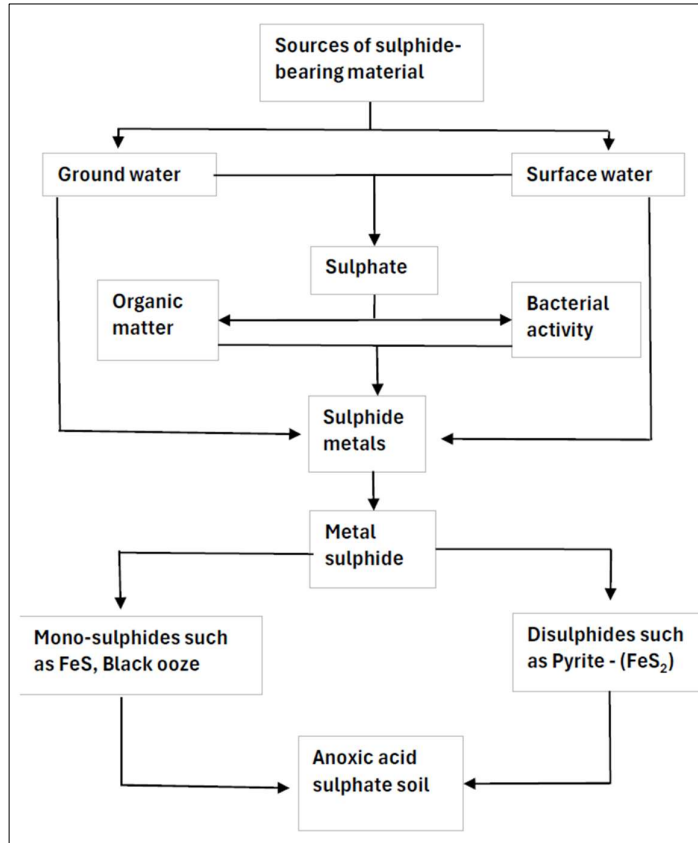


Figure 3: Pollutants from mining activities

(Redrawn from Kaur et al., 2018)

Although there is no standardised method for measuring and managing AMD, Akcil & Koldas (2006) emphasised the necessity for mining teams to possess an understanding of AMD and the appropriate tools to manage it effectively. It is essential to first comprehend the characteristics of AMD before determining treatment factors such as water quantity, sludge quality, and local climatic conditions. The neutralisation process required to mitigate AMD is complex, not solely for the ASMs but also for the stakeholders involved in LSM.

As observed by Kaur et al. (2018), an active treatment method for AMD involves increasing the pH of the affected water by adding specific chemicals. These chemicals encompass limestone, ammonia, caustic soda, hydrated lime, quicklime, and steel slag. The injection of ammonia gas into the water body to elevate the pH is regarded as one of the more cost-effective treatment methods.

Lack of rehabilitation, stockpiling and tailings management

Following the completion of mining operations by ASM operators, land that could otherwise have been utilised for farming remains covered in waste rock. Repurposing the same land for farming or infrastructure without extensive rehabilitation becomes unfeasible. This leads to the loss of wildlife and other species' habitats and food sources, ultimately resulting in either loss of life or migration to more sustainable environments (Gisore & Matina, 2015). According to Clashon et al., (2018), most ASM operators lack the capacity and knowledge to properly rehabilitate and backfill mined-out pits and shafts.

Dong et al., (2020) highlight that many companies (large and small) pay little attention to TSFs, citing a lack of direct economic value, without understanding the significant industrial and environmental effects that poor TSF management can have. Poor design can lead to the leaching of heavy metals into the ground and possible collapse, as seen with the Brumadinho tailings dam failure in Brazil in 2019, which resulted in the deaths of 250 people and affected forest and agricultural areas (Rotta et al., 2020).

The TSFs in ASM are typically small and do not usually pose a risk of collapse. Irrespective, the overall design still needs to contain all the tailings without allowing chemicals to seep into the ground or spread beyond the designated area. Using an impermeable concrete floor and a retaining wall can effectively prevent the spread of tailings. TSF design is typically done by professional geotechnical engineers. However, due primarily to cost considerations, ASMs generally do not consider professionally designed TSFs necessary.

Deforestation and land degradation

Mining activities typically begin with the clearing of vegetation. As a result of this disturbance, many animals are killed while others are forced to seek new habitats. This displacement also affects humans, who must find new homes and adjust to changes in their livelihoods when their land is repurposed. Musa & Jiya (2011) highlight some environmental and economic implications of deforestation resulting from vegetation clearing, including soil erosion due to increased infiltration, reduced biological diversity, land degradation, topographic changes, and the rapid

extinction of fauna and flora. Erosion also contributes to siltation, adversely affecting river streams and aquatic ecosystems.

Vegetation is a crucial source of oxygen for humans and other living organisms. Oxygen is released during photosynthesis, while the plants take in carbon dioxide (Ramanan et al., 2021). Carbon dioxide is released from various sources, including human and animal respiration, the decomposition of organic waste, ocean release, and the burning of fuels. Therefore, excessive deforestation leads to an imbalance in oxygen levels, contributing to global warming.

Developments in rehabilitated mining sites

Rehabilitated mining sites can be repurposed for various developments such as infrastructure, hotels, forests, or tourist attractions. According to Schulz & Wiegleb (2020), Lower Lusatia in Brandenburg, Germany, underwent reforestation and nature development after mining ceased in 2000. The process involved restoring nutrients in the soil to support agriculture. The landscapes were rapidly transformed into a new lake and forest. This transformation demonstrates that mine sites can be repurposed to be useful and productive after mining has been completed, and multiple benefits can accrue to the communities surrounding the former mine site.

2.3 Key Debates and Controversies

Various perspectives exist on ASM activities in Tanzania and other countries, considering historical context, current events, and future expectations. In general, the goal is to promote responsible mining, focusing on formalising ASM, addressing environmental concerns, resource management, expertise, and other important issues aimed at making a positive impact on communities and the environment. Notwithstanding, numerous controversies still surround ASMs, ranging from issues on the formalisation of ASMs, resource nationalism, and access to equipment and expertise.

In accordance with the Mining Act Chapter 123 (The United Republic of Tanzania, 2019), it is mandated that the holder of a mining license or their representative comply with the environmental principles delineated in the Environmental

Management Act while engaging in mining activities. Regarding environmental principles, the United Republic of Tanzania (2004) addresses the need for companies to conduct EIAs, periodic site audits, and follow directions related to environmental issues. The address is assumed to be directed to the LSMs, but the Act remains silent about the ASMs. This ASM group must be treated differently since they operate differently from the LSMs. In this regard, Rwiza et al., (2023) noted that environmental health education remains challenging in Tanzania, and no clear national policies support proper mining practices.

While environmental legislation in Tanzania does not specifically address ASM, it is concerning that environmental damages continue to occur, sometimes without the government's awareness of ASM activities in certain areas. Immediate action is necessary to address this situation. Additionally, safety and health are significant concerns due to the miners' irresponsible behaviour, risking their lives for minimal gains, often driven by poverty, negligence, or lack of knowledge.

Formalisation of ASM

As identified in the Mineral Policy of Tanzania (The United Republic of Tanzania, 2009), the government has given some consideration to environmental policies while formalising ASM efforts. On this matter, Rwiza et al., (2023) state that the aim of the Tanzania Mining Policy of 2009 was to preserve the environment by enhancing mining and processing methods as well as to promote sustainable development in ASM operations.

Fritz et al., (2018) proposed formalisation of ASM by introducing a formal governance framework. The ASM formalisation framework aimed to integrate mining activities within a cohesive legal, regulatory, and policy framework, which would also include the power to enforce such regulations. The positive effects of formalisation would result in access to technical and financial support and licensing as long as the operators work within the confines of the law.

By contrast, Kinyondo & Huggins (2020) suggested that job losses would result from mechanisation after formalisation and access to technical and financial support. This was expected to impact women more due to their lower representation in mining activities. Another potential issue with the proposed

formalisation was highlighted by Fisher (2018) and surrounding concerns over the difficulty (cost) of purchasing licences, leading to individuals not being able to manage the formalisation process.

Resource nationalism

Resource nationalism is concerned with how governments take charge of the natural resources within their borders for various strategic, economic, or political reasons. This trend often leads to policies that prioritise local needs and state oversight of resource industries, which can sometimes pose challenges for foreign or private stakeholders. The policies designed for resource nationalism are usually politically or economically aligned (Caramento et al., 2023).

Kinyondo & Huggins (2019) point out that African governments have introduced mining laws that promote resource nationalism, increasing royalty rates and/or requiring companies to use local resources. While this approach may be effective for large-scale mining, it generally has adverse implications for ASM, as these operators often struggle to sustain their operations, which are typically hand-to-mouth. Local resources are often too costly for ASMs to procure, with many ASMs opting to invest in more affordable Chinese equipment. The ASMs do not oppose the nationalism policy but attribute their inability to comply to resource scarcity and production challenges.

Pederson et al., (2019) argued that there have been ongoing ASM and LSM debates in the mining sector for decades but emphasise that the ASM issue has become politicised. Similarly, the researcher's experience indicates that there are occasions when political leaders employ resource nationalism as a strategy to mobilise support for their political ideologies and advance their campaigns. Additionally, there is often a tendency to create politically aligned policies for the sole benefit of politicians and their supporters. The politicisation of ASM means that regulations are likely to change with shifts in government and leadership, which is common in African countries where policies change with a change of government (Van De Walle, 2001).

Access to equipment and expertise

Weldegiorgis & Buxton (2017) mentioned that the state proposed establishing centres of excellence for technical training, geology and exploration expertise, and mineral processing. The government also planned to fund geological exploration to provide data and guidance before the start of mining. However, a report by Kinyondo & Huggins (2020) stated that although the idea of these centres had been around for decades, there have been no noticeable benefits since their completion. The ASM sector still lacks the technical knowledge necessary for environmental care, safety, health, and productivity. In addition, some components of the centres were later changed due to budgetary constraints, and the continued lack of funds was negatively impacting the purpose of these centres.

Many ASMs enter the mining industry without sufficient knowledge or experience. Although it is usually a low-cost investment, miners often invest without conducting geological exploration beforehand. Unlike LSMs, who are able to conduct extensive exploration, ASMs often rely on extrapolation from neighbouring mines. As a result, they may invest in a mining operation only to find that there is no high-grade ore. This not only represents a loss of investment but also a missed opportunity for the sector. In addition, ASMs may lack essential mining knowledge and often remove safety pillars from underground operations, risking their lives and their investment. In some cases, they may leave behind high-grade ore because of a lack of geological knowledge.

2.4 Chapter Summary

The review of the prevailing literature identifies many of the environmental challenges associated with ASM activities and highlights the necessity for stronger legislation and enforcement to address these issues. The review also compares the regulatory frameworks of ASM in different countries and notes the varying levels of enforcement and compliance.

The Tanzanian environmental policy promotes ecological processes by ensuring the protection and management of water bodies, forests, wildlife, and cultural heritage, as well as overseeing hazardous materials and procedures. Nevertheless, the effectiveness of these measures is constrained by the lack of

inclusion of issues specific to the ASM sector, whose operations continue to cause significant harm to the environment.

3 RESEARCH APPROACH

The research approach was designed to evaluate environmental legislation by gathering and analysing qualitative and quantitative data. This encompassed conducting field observations, interviews, sampling, and laboratory tests. Subsequently, the collected data underwent validation and analysis to inform potential improvements to the current environmental legislation.

3.1 Research Design

The research seeks to assist in improving environmental legislation in the ASM sector in Tanzania. Such improvements are proposed to contribute to correcting and minimising environmental impacts during and after mining and mineral processing.

The research design encompassed systematic data collection, measurement techniques, tests, validation processes, and analysis. The information was gathered through semi-structured interviews with relevant stakeholders, field observations, and sample tests.

In order to propose upgrades to environmental legislation, the causes and effects of environmental underperformance at ASM operations associated with Otter Mine were used as a case study. Understanding these issues is critical for addressing environmental concerns related to ASM operations across Tanzania.

Otter Mining Limited is a United Kingdom-owned company with various mining operations in Tanzania, including Otter Mine. Figure 4 shows the location of Otter Mine in the Mawoga area of the Chunya district (Lupa gold field in the Mbeya Region, southwestern Tanzania), which is the subject of this research. The company had been processing low-grade (gold) tailings during the period from January 2019 to December 2020, when it stopped because of operational losses caused by deteriorating grades. However, recently (January 2023), mining of primary ore has commenced, and mineral processing started again in late 2024.



Figure 4: Otter Mine site location in Mawoga area, Tanzania

(Source: Travel Dream Diary, 2024)

Otter Mine holds an approved EIA. However, substandard mining operations by local ASMs have been ongoing since they encroached on the company's land before the gold rush of 2020. Most of the ASMs come from the surrounding community, including former landowners and previous employees of Otter Mine. Following the ASM gold rush in 2020, Otter Mine did not expel the ASMs. Some community members allege that the company feared that the entire community might rally against them if they did. Due to the company's inaction and inadequate government oversight, environmental violations on and around the Otter Mine site abound.

Otter Mine was selected specifically because ASM activities are present both inside and outside of the mine boundary. Access to the ASM operations could be facilitated through the mine as a result of the author having worked there as an

engineering consultant. Additionally, due to the author's personal connection to the mine and the community, the author was confident that the ASMs and the community would be willing to engage in open dialogue to freely discuss their issues.

Further, the mine site and its surroundings serve as a microcosm of the environmental and social issues typical of ASM operations. It also represents an opportunity to demonstrate how larger and smaller mines could operate together for their mutual benefit.

Understanding the environmental impacts related to ASM activities at Otter Mine is essential for identifying measures to prevent these damages from recurring throughout Tanzania. The interviews, on-site observations, and tests provided valuable insights into the specific impacts and potential mitigation strategies. Moreover, knowledge of existing legislative gaps was essential for crafting effective and enforceable policies to address ASM-related environmental concerns nationwide.

3.2 Data Collection Process

The data collection process employed both quantitative and qualitative methods. The approach included conducting in-depth interviews with various stakeholders, making detailed observations of the mining operations and surrounding areas, administering carefully designed surveys, and analysing pre-existing secondary data sources such as research studies published in online journals. The majority of the selection consisted of journals sourced through Google Scholar, which is recognised as a reliable database. Additional reputable sources included government entities, university libraries, international journals, and various research institutions.

3.3 The Quantitative Approach

The quantitative approach involved sampling to detect cyanide and mercury in water, tailings, effluent, and soil. Cyanide and mercury are the main elements investigated in this research since they are most commonly used in the ASM

sector; all ASMs in gold extraction use mercury for amalgamation, while cyanide is utilised for the gold leaching process.

Water, tailings, and soil samples were collected and tested on-site, with duplicate samples dispatched to Nesch Mintech Laboratory in Mwanza for analysis. On-site assessments focused on mercury, while laboratory analysis targeted both mercury and cyanide. Supplementary elements tested for in the laboratory include copper, lead, silver, and iron.

3.4 The Qualitative Approach

The qualitative approach involved conducting interviews (both initial and follow-up) with local ASMs and community members, as well as key personnel from Otter Mine, and documenting on-site observations through detailed notes and photographic evidence. The on-site observations encompassed assessing abandoned shafts, soil stockpiles, tailings and waste rock stocks, vegetation, gullies, and pollution of land, air, water, and noise.

3.4.1 On-site observations

The observations conducted aimed to analyse the effects of mining activities and the associated marks left on the environment. Further, recording observations allowed the researcher to quantify aspects such as the number of abandoned shafts without rehabilitation, the composition of waste and tailings stockpiles, and the density of tree cover.

Stockpiles

Investigations focused on tailings, overburdened soil, and rock stockpiles in order to assess the degree to which these materials have been managed in accordance with environmentally responsible practices. As stated by Schoenberger (2016), geotechnical stability is critical, and tailings construction should be done in stages rather than haphazardly as mining progresses. The following areas were investigated as part of the physical examinations of the stockpiles:

- Retaining walls and impermeable floors on tailings,
- The possibility of seepage and washing away during rainfall,
- Possibility of cyanide and heavy metals spreading into unintended zones,

- Measures taken to neutralise cyanide on the tailings,
- Possibility of utilising the land for purposes other than stockpiles, and
- Topsoil loss from poor soil stockpiling.

Abandoned shafts and pits

Several abandoned shafts and pits were examined; a few were partially blocked, while the rest were just left open, posing a risk for animals to fall into. As noted by Mhlongo et al., (2019), people are exposed to the high risk posed by abandoned shafts, and there is a need to address this issue.

The following were observed during the exercise to ascertain environmental issues associated with abandoned shafts and pits:

- Whether the shafts and pits were rehabilitated or not.
- Approximate shaft depth measured using a Leica laser distance measurer.
The deepest shafts pose the greatest danger to animals, humans, and the environment.
- Remains of animals in the shafts,
- Risk faced by humans and animals on each shaft and pit,
- Risk of collapses over time, leading to additional environmental damage,
- Water accumulations, and
- Erosion emanating from the shafts and pits, especially from rainwater.

Pollution

ASM-related activities generate noise, as well as pollution in land, water, and air. During mining, many ASMs fail to follow standards, and they release toxic material into the environment (Mwakaje, 2012). The study encompassed inspection of ASM activities such as:

- Oil spills from machines and poor material handling,
- Dust deposited on trees and other vegetation,
- Dust emission from mining and crushing,
- Machinery and general waste dumping,
- Siltation in the water streams,
- Water pollution caused by effluent,
- Exhaust emission and burning of mercury amalgamation, and
- Excessive noise from crushing, milling, generators, drilling and blasting.

Land degradation and vegetation loss

Land degradation was identified through the assessment of soil erosion resulting from unstable terrain associated with ground disturbances and deforestation from mining operations. Further, several gullies have been documented, many of which appear to have originated from mining shafts and pits. This examination involved the following:

- Topsoil management, especially for open pit mining,
- Counting the number of trees taller than 4m per 0.1 km² in the ASM sites versus non-mining zones, and
- Identifying the source of gullies that caused land degradation.

3.4.2 Face to face interviews

Semi-structured initial interviews and more informal follow-up discussions were conducted to gain insight into the environmental issues within the ASM sector and the community. In the first instance, the questions were designed to address the research objectives. Participants were then asked preset questions using questionnaires. All participants were given the participant information sheet, and their details were filled out on the consent forms before the interviews. The communication was conducted in the main language, Swahili and the researcher completed the consent forms. Each interview gathered adequate data suitable for each group of interviewees, and additional paper sheets were used for excess data. Since it was a semi-structured interview, much of the discussion from community members and fishers centred on comments and open-ended questions included in the questionnaire, where the researcher encouraged open dialogue.

The researcher utilised semi-structured interviews to engage different participant groups with diverse roles. This method combined structured, pre-prepared questions with flexibility, enabling the discussion of open-ended questions. This approach facilitated a dialogue between the interviewer and participants, as opposed to adhering to a rigid question-and-answer format. The method encouraged participants to articulate their detailed thoughts and experiences on various topics. As noted by Barriball & While (1993), one advantage of the semi-structured interview is that it allows for discussions on various topics with multiple themes, stimulating new questions and ideas.

Ethics, confidentiality, and consent were prioritised during the interviews as fundamental principles of the research process. Participants signed consent forms acknowledging their voluntary participation in the interviews, confirming that their data would be kept confidential and anonymous. As agreed, the anonymised data was stored on a password-protected laptop and is used exclusively for this research project. The participants' rights to review or withdraw their data were also respected.

The researcher had previously undertaken consulting work in the Mawoga area, during which time he became familiar with the local residents and the ASM committees. Meetings with ASM operators and community members were arranged in advance, and the interviews were conducted at the respective workstations of the participants which also offered an opportunity for site observations and sample collection. Community members and fishers were approached at their homesteads. Staff members of the Otter mine were met at the company premises.

While the respondents were divided into groups designated ASMs, community members, fishers and Otter Mine staff, most community members and fishers had also been involved in mining at some stage in their lives. Further, the interviewer considered that, regardless of age and gender, most participants had engaged in nearly all categories of activities except Otter Mine employment.

The questionnaires evaluated the adverse impacts of ASM activities in the community and measured people's knowledge of environmental conservation. Additionally, the mining and mineral processing methods were examined. Community members shared their perspectives on ASM processes and their concerns. The questionnaires can be found in Appendix 9.1. Due to the high illiteracy level, the researcher assisted in filling out the questionnaires while translating the questions into Swahili. However, individuals who could read Swahili were given the forms to independently read and respond to verbally while the researcher completed the English questionnaire.

3.4.3 Sample size and representivity

Sample size and representativeness are important to encompass a diverse array of perspectives pertinent to the research question. To achieve this, it is necessary to establish a saturation level, at a point where no new themes emerge (Guest et al., 2006). To reach a saturation level, it is important to do purposive sampling, where participants with specific knowledge or expertise are chosen.

Various authors (for example, Hennink et al., 2016) recommend that 16 – 24 people represent a meaningful saturation point for a group or multi-study group. This closely aligns with the findings reported by Bekele & Ago (2022), which suggest that a sample size ranging from 20 to 60 is generally considered adequate. However, the authors emphasised several determining factors, including the research focus, type, available time and resources, characteristics of the interviewed group, and the institutional obligations. Other studies, including Boddie (2025) and Statistics How To (2025), suggest a practical guideline for the sample size, which is approximately 10% of the population. However, the 10% condition is not universally applicable; it is especially relevant in specific statistical contexts.

This research interviewed 38 participants, of whom 20 represented ASM operators out of an estimated 350 individuals directly engaged in ASM activities within the research area. The sample was purposively selected to ensure diversity as it considered various roles, genders, and ages. The number of participants was considered sufficient to capture a wide range of perspectives, experiences, and practices within the ASM community.

The sample of participants included various primary job categories, represented by both men and women in each age group. This diversity ensured a broad representation of the ASM community and varying perspectives. Table 3 indicates the number and groups of people.

Table 3: Interview groups, gender and ages

Group	Females	Males	Age 18-30	Age 31-50	Age 50+
Individuals involved in physical mining / excavating activities	4	8	4	5	3
Individuals involved in mineral processing	4	4	3	3	2
Community members (non-mining)	4	5	2	4	3
Fishermen and women	3	3	2	2	2
Otter Mine management	1	2	1	1	1
Sub-Total	16	22	12	15	11

The researcher conducted the interviews by travelling around the Otter Mine site to meet with stakeholders at convenient venues. As the interviews progressed, additional questions emerged based on the initial responses, and some participants willingly provided further valuable unsolicited information. Additional questions were not predetermined but emerged from the conversations as informal discussions, where most people were open to discussing topics outside the questionnaire list, rather than responding only with a yes or no. Examples of such additional informal discussion questions are:

- Do you think waste rock could be more useful in road construction, swampy areas, bridges and building? What other uses can you think of??
- As you mentioned, you have an understanding of environmental regulations; what would be necessary for you to comply with these in conducting your mining activities?
- What do you think can be done to manage waste tailings?
- Why do you need to dry the tailings, as you mentioned?
- Do you believe government assistance and standards are necessary for maintaining a strong environmental record?
- What part would you want the state to play in order to address problems in ASM?

- What is your take on mine formalisation, training, and financial assistance as a way of empowering ASMs?
- As a community, do you think that government involvement in ASM can help address the problems you are currently facing from ASM operations? In what way can the state be involved?
- What could be causing changes in water taste to be unnoticed, yet it is evident that cyanide and elements are seeping into the ground around water channels?
- What are your thoughts about deforestation from mining?

After the initial interviews, follow-up interviews were conducted. The follow-up interviews were conducted to elaborate on some of the earlier responses. Some questions included:

- When you suggested implementing regulations as guidance for ASM, what areas do you believe should be included?
- Do you concede that education, governmental support, and standardised mining practices are essential for fostering an exemplary environmental legacy?
- What additional efforts are necessary to ensure a favourable environmental outcome?
- What is your perspective regarding the site inspections conducted by government officials?

3.4.4 Sampling and sample testing

Sample collection

A total of 20 samples were collected from ASM sites: four from leached tailings (TSFs), four from stream water, four from mine effluent, four from the land surrounding TSFs, and four from silt in the streams. The 20 samples adequately represent the different types of ASM sites. The selected sites also reflect typical conditions and practices associated with chemical usage in ASM gold extraction and ore processing, making the findings broadly relevant for assessing

environmental risks in similar contexts. **Table 4** and Figure 5 identify the location of the samples collected.

Table 4: Sample collection details

Material sampled	Coordinates (Latitude/longitude)	Distance from ASM activities	Samples source
Mercury and cyanide	8°23'43"S 33°05'35"E	Active site	Tailings, land and effluent
Mercury and cyanide	8°24'26"S 33°05'01"E	Active site	Tailings, land and effluent
Mercury and cyanide	8°24'05"S 33°05'04"E	300m down-gradient	Water
Mercury and cyanide	8°24'03"S 33°05'02"E	350m Down-gradient	Silt
Mercury and cyanide	8°24'18"S 33°04'28"E	800m Down-gradient	Water
Mercury and cyanide	8°24'19"S 33°04'27"E	850m Down-gradient	Silt

(Source: Adapted coordinates from Google Maps, 2025)



Figure 5: Sample collection locations

Sample locations were selected based on mining activities, observable environmental impacts, and water and effluent flow patterns to ensure spatial representation. All samples were collected, preserved, and transported using the sampling procedures described below.

In hindsight, it was noted that the samples were taken during the wet season; some of the samples had been collected a day after rainfall had occurred. These samples included those from ASM sites and from rivers some 300m downstream of an ASM site. It was realised that, because of the rain, many of the deleterious elements and chemicals may have been washed downstream or, at the very least, been heavily diluted.

Dominy et al., (2018) noted that grab sampling is susceptible to bias arising from the selective sampling of specific particle sizes. However, in this research, measures were implemented to mitigate this bias where fine (<1mm) material was consistently sampled. This is because all the tailings from ASMs are pulverised by milling before retrieving the gold.

The 20 samples collected were taken from various ASM workplaces and analysed for cyanide and mercury. Table 5 shows the number and location of samples analysed.

Table 5: Number of samples and sources

Source of the samples	Number of samples	Analysis
Water from two streams	4	Mercury in the field Mercury and Cyanide at the laboratory
The land surrounding TSF	4	
ASM leached tailings	4	
Effluent from leaching sites	4	
Silt in water streams	4	
Total samples	20	

Grab and auger samples were collected from various locations within the leached tailings, both at the surface and at deeper depths. In line with Holmes' (2010) guidance, an auger was used to collect samples from the bottom of the leached tailings stockpile. The utilisation of an auger facilitated the extraction of complete vertical sample columns from various locations within each stockpile. The aim was to sample all strata where leached chemicals might accumulate. A narrow spacing of 3.5 m (approximately 1 sample every 23 m³) between sample points was implemented due to the limited size and irregular shape of the ASM stockpiles. (NSW Environment Protection Authority, 2022).

To ensure that the results reflected conditions across a broad area rather than from isolated points, the four water samples from the two streams were blended to form

a single sample; likewise, each of the four samples from the land surrounding the TSF and the four samples from the ASM leached tailings areas were blended to form single samples. Each of these blended samples was subsequently divided into four equal aliquots.

Additionally, samples were taken from the land surrounding the tailings stockpiles to determine if cyanide and mercury had contaminated the area. This assessment aimed to evaluate the potential spread of elements from the tailings to the surrounding land by wind or rainwater.

All solid samples from each source were combined on a clean sampling sheet, thoroughly mixed using a hand shovel, and divided into four parts. Equal portions were taken from each quarter to create 2kg samples, divided into two 1kg aliquots, and then packed into labelled plastic sample bags. All the sample-containing bags were placed in a black opaque carrier bag to shield them from light, which can affect cyanide in the samples and result in altered findings. One of each of the two aliquots was tested for metals on-site, and the other was sent to the laboratory.

All samples were placed in opaque bags due to cyanide's volatility and sensitivity to light. To preserve sample integrity, cyanide samples were analysed in the laboratory within 24 to 48 hours, as recommended by the Australian Water Quality Centre (2025). Further, to prevent any mistakes, each sample was carefully labelled detailing the sample number, source, date, and time of collection.

Water sampling followed the ultra-clean, free-metal standard to minimise external contamination (Donkor et al., 2006). This standard is utilised in trace metals analysis, such as mercury and lead. To meet this standard, acid-washed, non-metallic equipment was used, along with strict handling procedures, including the use of clean gloves. Samples were also collected from the base of water bodies downstream from contamination sources. Moreover, water samples intended for cyanide testing were collected in sterile glass containers to ensure the absence of contamination. Furthermore, the cyanide samples were collected from the water body, downstream of the suspected source of contamination. The bottles were filled to avoid air space, which could lead to cyanide volatilisation (Australian Water Quality Centre, 2025).

The auger technique was utilised to collect silt samples from the rivers. However, some portions of the silt tended to detach from the auger, necessitating the excavation of pits and the collection of samples throughout the depth of the pit until the natural soil layers were reached.

All of the above samples were tested for the presence of cyanide and mercury. Test strips were used on-site to test the presence of mercury, while duplicate samples were tested in the laboratory for both mercury and cyanide. The strip tests provided some indication, but the laboratory's metal detection method (see details below) offered detailed results for environmental analysis. The laboratory results were then matched with the results from the test strips, analysed and validated.

Personal protective equipment was critical during the sampling and testing process. Protective gear used during sampling included a work suit to protect against contaminants and hazardous materials, waterproof gumboots to keep feet dry and secure, polyvinyl chloride (PVC) gloves to shield the hands, a hard hat for head protection, earplugs for hearing protection, a respirator to safeguard against inhaling harmful substances, and safety goggles to protect the eyes from any potential hazards.

Sample testing

The on-site testing involved using the Chinese-sourced, DNX 16-in-1 rapid test paper strips (Figure 6) to detect the presence of mercury. The main goal was to indicate any mercury before waiting for detailed laboratory results. In addition to the primary element of interest, the presence of Iron (Fe), Lead (Pb), Copper (Cu), Nitrate (NO_3^-), and Nitrite (NO_2) was also assessed. These substances are among the toxic metals that are frequently released into the environment due to ASM activities at the mine sites.



Figure 6: DNX 16-in-1 full panel strips water quality testing

(Source: Homedoc, 2024)

The test kit consists of a test tube, a labelled tin, and paper strips that change colour when they react with the metal solution. These test kits are effective for testing metals in slurry and water. To create the slurry, tailings were mixed with distilled water and placed into 15 ml test tubes. The test strip was then dipped into the slurry, left to react for a few seconds, and then removed to observe any colour changes. These colour changes were then compared to the corresponding values on the container scale illustrated in Figure 6. Each chemical element displayed a different colour, indicating its concentration. Two samples from each source were tested using the test strips.

At the laboratory, the duplicate samples were washed with water to extract the cyanide. The water was subsequently filtered to remove the cyanide. After filtration, the filtrate was titrated in a silver nitrate solution to form a silver cyanide precipitate. The residue from the filtration was analysed for the presence of cyanide (CN) using Atomic Absorption Spectrophotometry (AAS), which is shown in Figure 7. After the cyanide was removed, the samples were prepared for mercury testing. Each sample was carefully air-dried, crushed and then digested in a mixture of nitric acid

and hydrochloric acid. Subsequently, flocculant, Aliquat 336 and Diisobutyl Ketone were added to assist with AAS analysis.

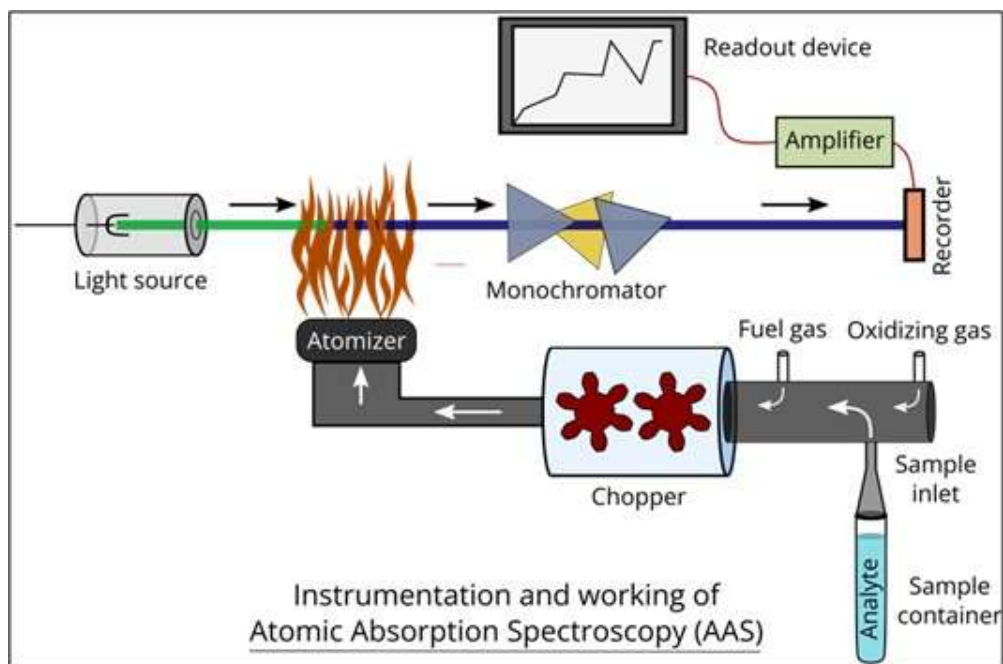


Figure 7: Simplified diagram of the Atomic Absorption Spectroscopy process

(Source: Junaid, 2022, cited in Sharma, 2023)

3.5 Data Validation Process

Data validation is essential for demonstrating the quality of research data. This process ensures the production of accurate, reliable, and relevant data. In order to ensure accurate results, the researcher employed appropriate sampling techniques. The process involves collecting water samples directly from the water bodies. Sampling occurred at various depths and lateral points of the piles, using clean containers to prevent contamination. All samples were processed, preserved, and transported as described above.

The cyanide levels from the research were compared to results from prior research conducted at adjacent areas in Ifumbo and Makongolosi by Mbare et al., (2023) and Jonsson et al., (2013), respectively. In both these studies and the current research, patterns in cyanide levels across multiple sources resulted in the

identification of consistent trends, including areas of elevated concentrations near active processing zones. These observed similarities provided an additional layer of validation for the author's findings, reinforcing the reliability of the sampling and analysis process. The convergence of results across different studies not only strengthened the credibility of the current research but also demonstrated a broader pattern of cyanide contamination typical in ASM environments. This cross-referencing of data contributed to a more comprehensive understanding of cyanide distribution and potential environmental impacts within the study area.

The analysis was validated through a triangulation of data sources. This combination of qualitative and quantitative validation methods enhanced the reliability and depth of the study, ensuring that the conclusions drawn were well-founded and reflective of the actual conditions. The data sources included participants' comments, laboratory sample test results, and the researcher's direct observations at multiple ASM sites:

- Participants' insights provided context-specific knowledge and firsthand accounts of mining practices, chemical use, and perceived environmental impacts, which were instrumental in interpreting the technical findings.
- Laboratory results offered objective, quantifiable data on contaminants such as mercury and cyanide, serving as a scientific basis for confirming the narratives shared by participants.
- The researcher's field observations, which include deforestation, the condition of water bodies, the presence of disorganised tailings, as well as the mining and processing techniques employed, contributed to corroborating both the verbal and analytical data.

3.6 Data Analysis

The information gathered from stakeholder interviews was organised to understand their beliefs and actions regarding mining and its environmental impact. The interview responses provided new insights, prompting the researcher to observe specific areas in more detail and to understand the reasons behind the environmental challenges prevailing in the ASM sector.

3.6.1 Data coding and categorisation

In analysing the large amount of data collected during interviews, the completed questionnaires were categorised to identify themes, which were matched using coding in Excel. In the categories of responses, words and sentences were labelled with short phrases to summarise the contents. This made the data easier to understand, identifying patterns in the matched responses and enabling more effective data interpretation and analysis.

The responses to open-ended questions and comments, especially those directly pertaining to mining operations, were also coded using open-ended response coding. Based on the colour matching from the coding, relationships were established, which led to conclusions in each category

3.7 Chapter Summary

The data collection method involved assessing environmental and operational factors, sampling, and conducting interviews with stakeholders in the mining industry, including ASMs and local community members. This approach incorporated numerical data and an evaluation of environmental and social challenges. Analysing the findings was a crucial step in developing comprehensive guidelines for sustainable ASM practices aimed at protecting ecosystems. The analysed data was securely stored on a laptop to maintain confidentiality.

4 RESULTS

This section presents the findings derived from the researcher's field observations, along with an analysis of the responses gathered from the survey questionnaires. In addition, it includes the results obtained from the sample analysis, highlighting toxic levels of elements and compounds. A discussion and synthesis of these findings is elaborated upon in Chapter 5, where implications and interpretations are addressed in greater detail.

The principal legal framework governing mining operations in Tanzania is established by the Mining Act of 2010 and its various amendments. While strict conditions concerning license type, duration and renewal are legislated, these are generally applicable to LSM. Among these conditions are the presentation of an EIA and adherence to environmental compliance. Additionally, community development obligations must be established prior to issuing a mining license. While special ASM licences exist, their requirements and the legislation backing them are not well-defined or cognisant of the difficulties faced by ASM operators.

With the above legislative background (expanded upon in greater detail in the Literature Review), Chapter 4 presents key findings from three main data sources (field observations, interviews, and site-specific sample tests collected at multiple sites) to highlight the challenges faced by ASM operators. Observational data provided insights into visible environmental conditions and mining practices. Interviews with miners and the community revealed perceptions of environmental and health risks, chemical use practices, and socio-economic dynamics affecting ASM. Complementing these qualitative findings, laboratory analysis of samples confirmed varying contamination levels and the presence of hazardous substances across the study area.

4.1.1 Results of the field observations

Based on the observations made at the various mining sites, ASM activities have led to significant environmental impacts. These include waste dumps, substandard tailings storage facilities, land deformation, loss of vegetation, pollution, and open shafts and pits. **Table 6** summarises the on-site activities and the resultant environmental impacts.

Table 6: ASM activities and the resultant environmental effects

Sphere of Activities	Effects
Land clearing for mining.	Deforestation, landscape and soil profile disturbance, and erosion.
Ore extraction and waste stockpiling / poor mining practices.	Loss of productive land and vegetation, and soil erosion during rainfall.
Drilling and blasting.	Smoke, gasses, noise and dust emission, ground vibration, subsidence, and oil and chemical spills.
Mining and processing machinery operation.	Smoke, noise, and dust emitted, and oil spills
Ore processing – crushing, milling, amalgamation and vat leaching.	Mercury and cyanide release, mercury gas, effluent, dust, noise, tailings mismanagement, and chemical and metal seepage.
Mining in rivers – primary and secondary deposits.	Mercury release, riverbank damage, loss of aquatic life, and water pollution.
Poor tailings storage design.	Tailings eroded into nearby land and river streams, chemical release, and chemical and metal seepage.
Lack of fencing and rehabilitation.	Unauthorised access, entrapment and poisoning of animals and humans.

Deforestation

Vast lands have been cleared for ASM work, leading to deforestation. Miners dig shallow shafts along the outcropping reef, sometimes as close as four metres apart. Their mining methods involve sinking vertical shafts without creating horizontal tunnels, and that requires clearing large vegetation areas to accommodate all these shafts. Additionally, a series of ball mills is installed to process the mined ore. Each ball mill has a processing capacity of only 90 kilograms of rocks per hour. Consequently, the operation requires the utilisation of multiple ball mills to effectively manage all shafts, which in turn leads to the clearing of additional land.

Activities within the ASM areas have led to permanent landscape and soil profile disturbances. The loosened soil is more susceptible to erosion, resulting in widespread erosion, loss of productive land, formation of large gullies, and siltation. Many rivers that used to be significantly larger have been reduced to mere trickles because of the amount of silt. Figure 8 depicts deforestation, topsoil and landscape disturbance, and siltation during mining activities.



Figure 8: Deforestation, topsoil and landscape disturbance, and siltation of rivers.

Photo credit: H Muchanyangi (author), 2024

To determine the effects of deforestation, the number of trees taller than 4m high per 0.1 km² (100 m x 1,000 m) were counted in areas under ASM control as opposed to the natural environment. Although vegetation densities vary naturally,

Figure 9 demonstrates excessive deforestation in ASM zones as compared to non-mining zones. Figure 10 depicts the map of where the counting was done.

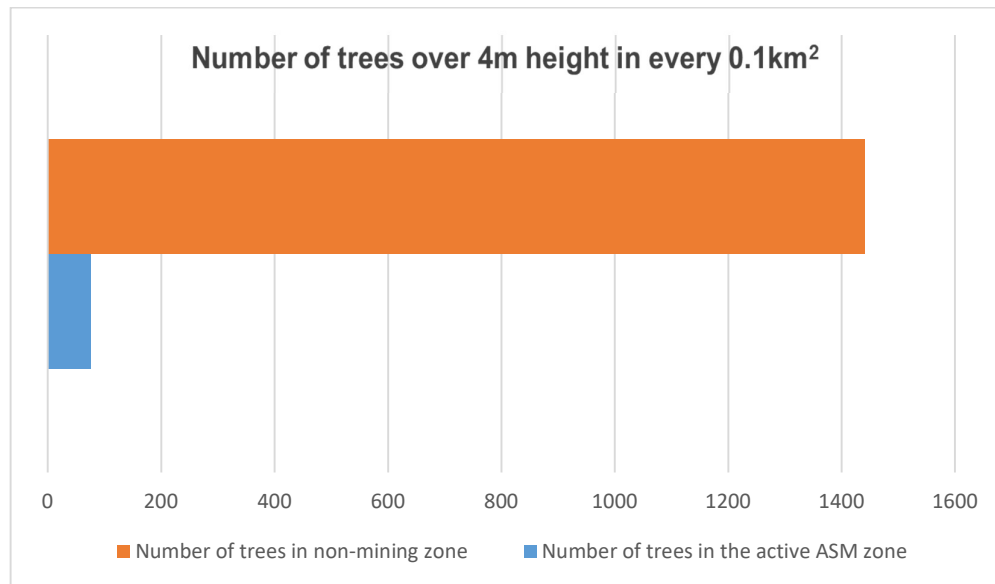


Figure 9: Number of trees present in ASM zone versus non-mining zones

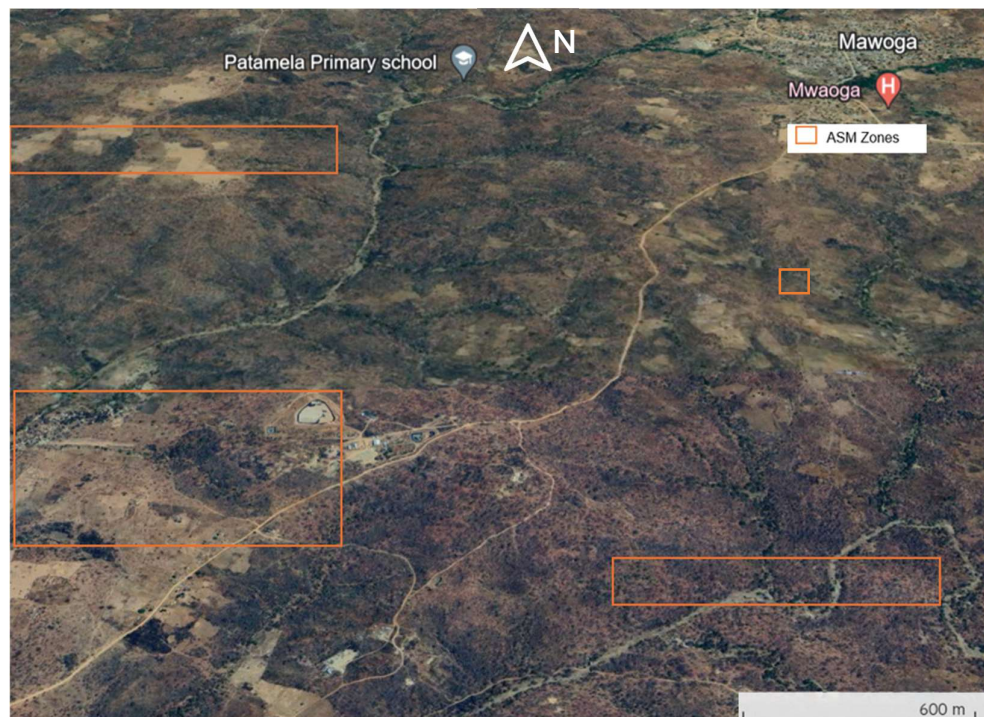


Figure 10: Zones where tree counting was done

(Source: Adapted from Google Maps, 2025)

Mining in rivers

Mining activities are being carried out in rivers, leading to significant environmental impacts. Such activities include alluvial mining within the rivers and shafts dug near the riverbanks wherever there is mineralisation. Due to the lack of pumps, ASMs use river water to process the ore directly in the rivers. Because the process involves mercury, some is released into the rivers, causing an environmental threat.

ASM operations conducted within the rivers have caused significant damage to riverbeds, disrupting the aquatic ecosystem, water quality, biodiversity, and siltation. The impact of these activities has led to the drying up of numerous rivers due to the accumulation of mining waste and subsequent riverbank collapses. Figure 11 indicates some of the effects of riverbank mining.



Figure 11: Mining on the riverbanks, pollution and siltation

Photo credit: H Muchanyangi (author), 2024.

Drilling and blasting

The ASM operations include drilling and blasting activities conducted underground and on the surface. Dry drilling and blasting generate a large amount of dust and gases, which are released into the environment, leading to air pollution and the deterioration of plant life. The resultant dust settles on vegetation, adversely impacting both fauna and flora. These activities also generate noise and vibration, contributing to noise pollution and ground subsidence, respectively, due to the absence of control measures. The inadequate execution of blasting practices by unskilled operators commonly results in the destruction of infrastructure. Additionally, the disturbances caused by the noise and vibration prompt the migration of many animals away from the mining sites.

During mining, explosive components become entrapped within blasted rocks and transported by water, leading to their deposition in water streams. These components, which include ammonium nitrate solution, fuel oil, and emulsifiers, are contaminants within these water systems.

Pollution by mining and processing equipment

ASM operators lack proper funding and therefore resort to substandard equipment, which produces excessive noise, smoke, and oil spills. Some sites use noisy ball mills without dust suppression and smoky generators. Further, much of their equipment has oil leaks. As observed by the author, these concerns are not deemed critical by ASM operators, who prioritise survival over environmental and safety considerations.

Ore processing – crushing, milling, amalgamation and vat leaching

The processing of gold involves several steps. First, the mined rocks containing gold are dried and manually broken into pieces smaller than 20mm. These broken rocks are then loaded into local ball mills and pulverised into fine powder (typically <1mm). Each milling cycle takes about an hour for every 90kg of rocks. The rock powder is then mixed with water and agitated by hand in a basin to allow the gold to settle through gravity separation. Mercury is added to the resulting concentrate to form a mercury-gold amalgam. The final step involves burning the amalgam to evaporate the mercury, leaving the gold behind as illustrated in Figure 12. This

process recovers less than 30% of the gold in the ore, with the remaining gold reporting to the tailings (Veiga et al., 2009).

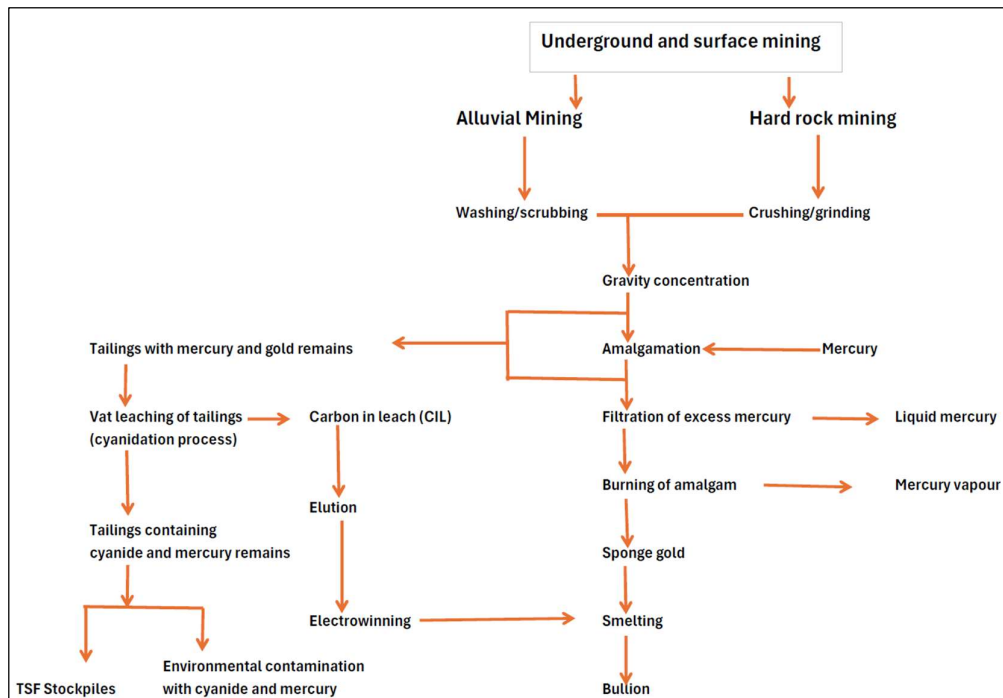


Figure 12: Processes involved in ASM gold processing

Source: Adapted from Amankwah et al., (2017)

The tailings are collected from various miners and sold to a few individuals. These individuals use vat leaching with cyanide to recover around 75-90% of the gold remaining in the tailings (cyanidation process).

Mercury and cyanide are frequently used improperly by ASMs. While some operators know the dangers of mercury spills into the tailings, they do not understand that burning the amalgam leads to mercury vapour emissions. Additionally, the cyanide used for cyanidation poses a danger to the environment when it is released together with the tailings. Some of the cyanide-containing tailings are carried by rainwater and spread into rivers, further damaging the ecosystem. Figure 13 shows one of the vat leaching sites where cyanide release is rampant, ore preparation for milling, land pollution from ore processing, and the milled ore being off-loaded from the ball mill.



Figure 13: Vat leaching plant, ore preparation for milling, and other ore processing activities.

Photo credit: H Muchanyangi (author), 2024

Poor mining practices

ASM is conducted without a skilled workforce that understands environmental care and proper occupational health and safety practices. This has resulted in environmental harm, including deforestation. Operators primarily use indigenous trees and only purchase gum trees when local supplies are depleted. In addition to the loss of vegetation and productive land due to poor practices, gullies are also formed, as illustrated in Figure 14. The amount of waste is even more significant in areas with multiple shafts occupying large areas of land.



Figure 14: Poor rock stockpiling and massive land disturbance.

Photo credit: H Muchanyangi (author), 2024

Poor tailings storage design.

ASMs are reluctant to invest in proper TSF design and often settle for substandard facilities. As a result, TSFs without retaining walls and compacted floors allow tailings containing chemicals and dissolved heavy metals to spread and seep into the ground.

The unregulated practices contribute to extremely high and deadly levels of cyanide in the tailings. The absence of retaining walls can result in catastrophic floods of tailings which are not detoxicated to the required limit. The cyanide limit in Tanzania is set at a concentration of 50 ppm as established by the International Cyanide Management Institute in 2021. This regulation is in place because Tanzanian mines are part of the International Cyanide Code (The International Cyanide Management Institute, 2024). If high cyanide concentrations enter water sources, chlorination processes cannot effectively remove the cyanide. Figure 15 illustrates some tailings prone to eroding into rivers, along with a silted river where the tailings and cyanide are deposited.



Figure 15: Tailings erosion and siltation of rivers.

Photo credit: H Muchanyangi (author), 2024

Lack of fencing and rehabilitation

After mining operations are completed, ASMs generally do not commit to restoring and rehabilitating sites. The failure to rehabilitate waste rock, tailings, and other waste materials results in land pollution, contamination, and the consumption of land that could otherwise be used for agricultural purposes. Further, rainwater accumulates in some of the shafts and pits, creating breeding grounds for mosquitoes and contributing to malaria outbreaks in the community. Villagers often collect contaminated water from old shafts and pits for domestic use, as can be seen in Figure 16.



Figure 16: Abandoned pit with dirty water used by villagers

Photo credit: H Muchanyangi (author), 2024

Many mine sites are not fenced, resulting in injuries and deaths for both animals and humans. Additionally, animals seeking drinking water gain access to vat leaching sites and become poisoned by the cyanide and mercury in the water. Figure 17 shows some of the shafts left open while Figure 18 contains records of abandoned shaft fencing, rehabilitation, and the risk posed to wildlife.



Figure 17: Open and unfenced shafts

Photo credit: H Muchanyangi (author), 2024

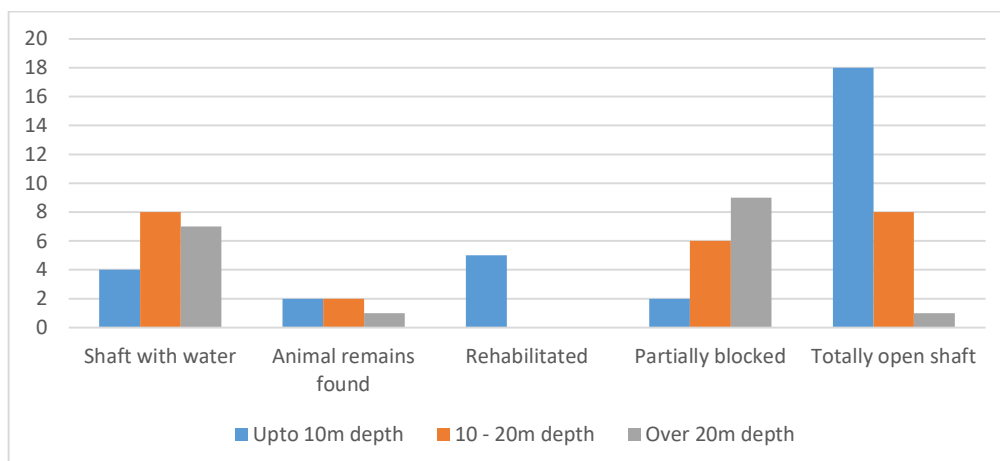


Figure 18: Abandoned shaft observation data

4.1.2 Results of interviews

Various responses were captured from the several groups interviewed. The responses below are categorised into comments from artisanal miners, community members, and Otter Mine staff.

Artisanal Miners

All ASM operators confirmed using mercury to extract the gold from the ore and then burning the amalgam to recover the gold. While the amount of mercury that spills into the tailings may be considered minimal, the most significant dangers are associated with burning the mercury amalgam. Table 7 summarises responses from the ASMs. Due to the nature of semi-structured interviews, these comments include supplementary insights gathered from discussions with the participants.

Table 7: Artisanal and small-scale miners' comments

Discussion Points	Comments from the ASM community
Having a basic understanding of environmental regulation.	Less than 57% indicated they have a basic knowledge of the environmental legislation and appropriate waste disposal techniques.
Knowledge of the dangers posed by using mercury and cyanide.	The majority (90%) indicated that they understand that mercury and cyanide cause water pollution and are toxic to both humans and animals.
The need for survival outweighs environmental care.	Only 50% care about the environment. The other 50% indicated that their survival was of far more importance to them.
Preparing a good environmental legacy for future generations.	All the interviewees (100%) accept that education, government assistance, and standard mining practices are required to prepare an excellent environmental legacy.
Witnessing water pollution from mining sites.	Some 89% of respondents agree that water pollution is occurring
Witnessing the mass death of aquatic life.	19% have occasionally seen the mass death of fish.
Animals cyanide poisoning and falling in shafts	Everyone (100%) has witnessed animal death from ASM activities involving shafts and cyanide.
Plant deterioration near ASM sites.	The majority (76%) have seen vegetation being affected.
Change in drinking water near ASM sites.	Only 19% indicated that they noticed changes in drinking water quality.
Possible utilisation of waste rock in the community.	Most participants (some 76%), said waste rock is useful for building roads, houses, and bridges and filling swampy areas.
Witnessing any erosion initiated from ASM sites.	This was acknowledged by 76% of participants.
Suggestions for the ASMs	60% suggested the need for environmental care, mining responsibly, following the law, and involving the community to address concerns. 20% said that they wanted the environment to be preserved but felt that any such legislation would interfere with the profitability of their operations. 10% suggested that the state assume full responsibility of rehabilitation. A further 10% were concerned only with mining profitably as long as possible.

Some ASM operators demonstrated some awareness of the mining regulations. The participants generally possessed a basic knowledge; however, they were unfamiliar with the specific regulations. In addition, the operators were aware of the need to address environmental threats and manage mining waste, as outlined in the Environmental Management Act. However, most ASMs seem to believe they only apply to LSMs and not to their own ASM activities.

The ASM operators demonstrated awareness of the hazardous nature of cyanide and mercury, expressing a keen interest in environmental preservation and the necessity of compliance with prospective government regulations governing ASM operations, albeit with a need for support. All interviewees shared a commitment to establishing a positive environmental legacy, notwithstanding the acknowledgment that poverty is one of the drivers of adverse impacts in their mining operations. Figure 19 highlights responses from ASM groups.

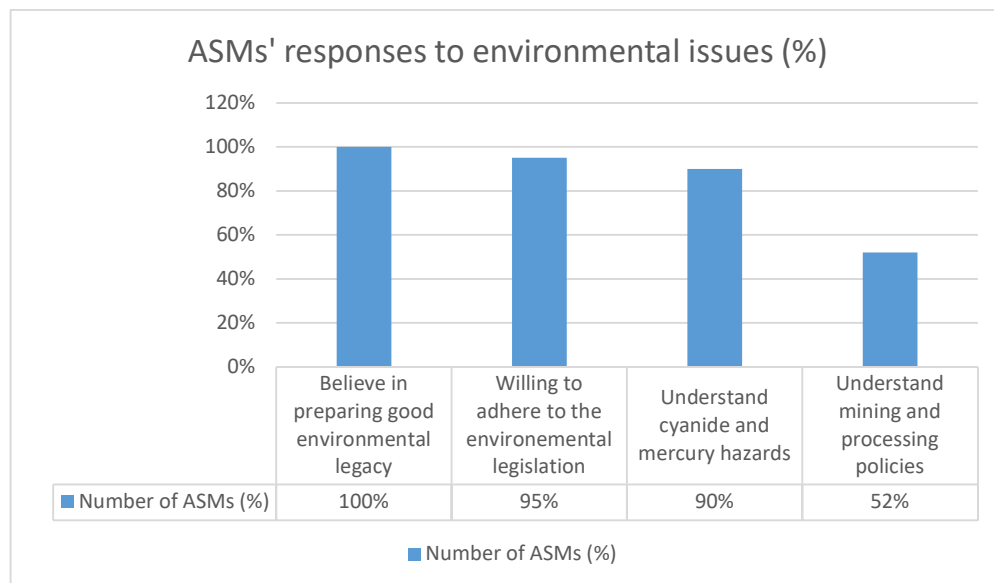


Figure 19: ASMs' understanding and beliefs on environmental issues

ASM participants acknowledged witnessing the crippling effects of their mining activities on the environment. These include deterioration of vegetation, water, land, noise, and air pollution, animal deaths due to cyanide poisoning, and entrapment in pits and shafts. They also acknowledged that the declining vegetation was due to the cutting down of trees and the slashing of grass to pave the way for mining, as well as ground disturbance.

Community Comments

When asked about various aspects of mining and its environmental impact, the community members (including fishermen and women) acknowledged the crucial role that mining plays in uplifting their livelihoods. However, they expressed numerous comments regarding the following environmental issues resulting from mining activities, as detailed in Table 8.

Table 8: Areas addressed by the communities

Area addressed	Community Comments
Deforestation	• Trees are cut down in gold-rush areas, and no one is willing to replace them. • Government intervention is required to replace the lost vegetation.
Waste and tailings management	• Education is required in ASM. • Fencing and TSFs are critical. • Drying tailings soon after vat leaching to evaporate cyanide. • Use of environmentally safe ways. • Other land uses to be considered.
The best way to protect the environment in a mining zone	• Involve professionals to educate ASMs and enforce the law. • Minimise ASM and promote LSM. • Rehabilitation, follow the law. • Neutralise and contain chemicals • Proper stockpiling of rock waste and tailings.
Disposing of tailings and water containing cyanide	• Strict enforcement is required since some of the sumps leak cyanide into the environment. • NEMC inspects vat leaching sites.
Possible uses of waste rock in the community	• Roads and house construction. • Backfilling of shafts and pits.
Preparing a good environmental legacy	• Government to assist in funding environmental protection. • Follow-up by government officials is required. • Officials need to stop corruption.
Participants take on ASMs and the environment	• ASM should mine responsibly while considering the ecosystem. • Fine ASMs who do not abide by the standards and rules. • ASMs need to seek knowledge about mining and processing. • Funding is required for ASMs to thrive in environmental care.
The Environmental Law	• It seems to address LSM only. • It needs to be clear as to where it applies. • Many ASMs do not know it well.

Otter Mine Staff

Otter Mine's staff have a better understanding of environmental legislation and have effectively aligned their operations with the required standards. In LSM, aligning mining operations with regulations is straightforward when the staff understands the necessary work procedures. However, issues with ASM activities in the licensed area challenge the company's control.

One such example can be seen in 2020, when there was an ASM gold rush some 30 metres from the company offices that resulted in an estimated 7 kg of gold being mined in a very short time. Because the company is committed to fostering a positive relationship with the community, no action was taken to enforce ASM compliance. Since then, it has become increasingly challenging for Otter Mining to manage and remove the local miners from the land parcel.

All the staff acknowledged witnessing water pollution, plant deterioration, and animals dying from cyanide poisoning and falling into shafts in the vicinity of the mine. Table 9 contains a list of management's responses and suggestions regarding ASM.

Table 9: Concerns raised by Otter Mining staff

Area of concern	Responses
Safety and training	• While it is accepted that life is difficult for the ASMs, safety and environmental care are paramount. • Training mine operators and involving professionals can drastically improve understanding and work practices.
Government involvement in preserving the environment	• Government financial assistance is very useful in ensuring ASM operations are done to standard. • Arresting or fining of ASMs who breach the environmental and safety regulations. • Authorities' follow-up on ASM work is crucial in ensuring standard work practices and environmental protection
Standards and regulations	• The importance of detoxifying dangerous chemicals before disposing of tailings and mine effluent. • Investing in properly designed and fenced TSFs that contain tailings without endangering the ecosystem. • Need for regulating vat leaching, which has severe direct impacts.

4.1.3 Sample test results

Testing of the water and soil samples was conducted using test strips, as well as through laboratory analysis. The test strips yielded rapid results on-site, while the laboratory approach required a longer processing time for result delivery. Both testing methods exhibited certain advantages and disadvantages; however, each proved beneficial for the task at hand.

Field testing

Table 10 shows the results from the onsite strip testing. Though the focus was on mercury, other elements/chemicals were also tested in the field, namely Iron (Fe), Lead (Pb), Copper (Cu), Nitrate (NO₃⁻), and Nitrite (NO₂⁻).

The rest of the results presented reveal concerning concentrations of lead, recognised as one of the most toxic elements, recorded at 5 ppm in comparison to a safe limit of 0.015 ppm. These samples were obtained from sources with a high potential for environmental contamination. This concerning situation is similarly observed with other elements, such as nitrate, which is measured at 100 ppm against a safe limit of 10 ppm; nitrite, which registers at 40 ppm while the safe limit is 1 ppm; and copper, which shows a level of 470 ppm as opposed to a safe limit of 1.3 ppm. Only iron demonstrated results that fell below the safe threshold limits.

Table 10: On-site strip test results

Source of samples	Analysis	Result (ppm)
Waste TSF (after cyanidation processes)	Mercury	0
	Iron	3
	Lead	5
	Copper	5
	Nitrate	100
	Nitrite	40
Land surrounding TSF	Mercury	0
	Iron	0.3
	Lead	0
	Copper	5
	Nitrate	25
	Nitrite	5
Stream water	Mercury	0
	Iron	0
	Lead	0
	Copper	2.5
	Nitrate	0
	Nitrite	0
Effluent (waste water from mineral processing facilities)	Mercury	0
	Iron	0
	Lead	5
	Copper	2.5
	Nitrate	0
	Nitrite	0
Silt	Mercury	0
	Iron	0
	Lead	0
	Copper	5
	Nitrate	0
	Nitrite	0

The results of the strip tests revealed no detectable traces of mercury. This was highly surprising, given the amount of mercury in the system and the fact that it has been detected in considerable quantities in other studies (Jonsson et al., 2013; Spiegel, 2009). Factors such as the concentration and distribution of mercury in the matrix and the limitations of the strip test method itself are thought to contribute to the non-detection.

The results from the test strips are not always accurate, being affected by low sample volume, low resolution and precision of the test strip, as well as exposure to unfavourable temperatures. However, it was essential to use them (test strips) to get quick results on-site and demonstrate that such tests could be easily managed by ASM operators. Strip testing also managed some elements that the laboratory could not test for, such as nitrite and nitrate.

Laboratory test results

The Nesch Mintech laboratory, is a SADCAS accredited laboratory in Tanzania. SADCAS (The Southern African Development Community Accreditation Services) is a multi-economy accreditation body established in terms of Article 15 B of the Technical Barriers to Trade (TBT) Annex to the SADC Protocol on Trade with the primary purpose of ensuring that conformity assessment service providers (calibration/testing/medical laboratories, certification and inspection bodies) operating in those SADC Member States which do not have national accreditation bodies are subject to an oversight by an authoritative body). It is also the only accredited laboratory in East Africa.

Nesch Mintech, however, is only equipped to process solids and slurry effluent samples and is unable to process liquid samples. Therefore, water samples from the river were not tested for mercury and cyanide. For Nesch Mintech laboratory to test the water-based samples, they would have to send them abroad, which would be more costly and time-consuming. In addition, using multiple laboratories would have also introduced inconsistencies in both methodologies and results. To uphold data integrity and adhere to the research project's time and budget constraints, the focus was placed on soil samples, which continued to provide a more reliable basis for evaluating contamination.

The World Health Organisation (WHO) and the International Finance Corporation (IFC) standards were used for sample results comparison (The United Republic of Tanzania, 2007; World Health Organisation, 2018; International Finance Corporation, 2007). In this study, the author compared sample findings to drinking water quality standards rather than the stricter effluent discharge limits designed for large-scale mines. Large-scale mining regulations are structured to protect the environment and control the discharge of effluent (chemical), whereas ASM-induced contamination frequently enters rivers and groundwater without mitigation. Therefore, applying drinking water standards (both IFC and Tanzanian/WHO benchmarks) served to establish a precautionary, realistic, and scientifically relevant assessment.

Table 11 displays the results of the laboratory tests in comparison to those of the WHO and IFC. Once again, the mercury tests were inconclusive. Mercury does not distribute evenly (and, as a result, requires significantly more and/or larger samples). During processing by the ASMs, the entire 90kg is processed using panning, and the heavy fraction (estimated at some 5kg) is extracted using mercury. The mercury sinks to the bottom of the panning dish and creates discrete globules. While the ASMs try to recover as much mercury as possible, some unquantifiable amounts remain in the tailings as discrete globules. This “nugget effect” reduces the likelihood of finding mercury when grab sampling the tailings.

Table 11: Laboratory test results for mercury and other elements

Source	Sample serial number	Sample ID	Hg (ppm)	Other metals results (ppm)				
				Pb	Cu	Ag	Fe	Cr
Land around TSF	S24/61680/01	1	<0.001	4.01	23.25	1.11	0.85	66.89
Leached tailings A	S24/61680/02	5	<0.001	31.36	459.44	1.05	2.16	138.60
Leached tailings B	S24/61680/03	6	<0.001	32.84	469.63	1.21	2.22	148.04
Silt	S24/61680/04	11	<0.001	5.79	32.53	0.56	1.27	99.23
Tanzanian, WHO, and IFC Water Quality Limits (ppm)								
Tanzania			0.001	0.1	3.0	-	1.0	0.05
WHO			0.007	0.1	3.0	-	-	0.5
IFC			0.002	0.2	0.3	-	2.0	0.1

(Source: Adapted water quality limits from The United Republic of Tanzania, 2007; World Health Organisation, 2018; International Finance Corporation, 2007)

The cyanide test results are shown in Table 12. Using the Tanzanian standard, less than 0.2 ppm free cyanide (HCN and CN-) is considered acceptable (The United Republic of Tanzania, 2007). However, in the test samples, it can be seen that all of the samples showed unacceptably high levels of cyanide. These results have been compared with the Tanzanian and WHO water quality limits to the IFC mine effluent standard (The United Republic of Tanzania, 2007; World Health Organisation, 2018; International Finance Corporation, 2007)

Table 12: Laboratory cyanide test results

Source	Sample matrix	Sample serial number	Sample ID	Cyanide test results (ppm)
Land surrounding TSF	Solution	S24/61680/005	001	30
Effluent A	Solution	S24/61680/006	004	210
Leached tailings A	Solution	S24/61680/007	005	60
Leached tailings B	Solution	S24/61680/008	006	30
River silt	Solution	S24/61680/009	009	10
Tanzania and WHO drinking water quality limits, and IFC Mine Effluent limit (ppm)				
Tanzania				0.2
WHO				0.6
IFC				0.1

(Source: Adapted water quality limits from The United Republic of Tanzania, 2007; World Health Organisation, 2018; International Finance Corporation, 2007)

Tanzania's drinking water standard for cyanide is 0.2 ppm as defined under the sixth schedule of the Environmental Management (Water Quality Standards) Regulations (The United Republic of Tanzania, 2007). Canada also applies the same threshold of 0.2 ppm (Government of Canada, 2008). In this study, however, both guidelines were adopted as reference points representing an internationally recognised benchmark and aligning with precautionary approaches to chemical safety. These choices broadened the knowledge and standards in chemical safety.

Effluent A is derived from the vat-leaching tanks. This muddy material gets mixed with water from other sources and freely flows until it converges with river sources. It is disastrous to have 210 ppm of cyanide spreading into the environment.

Leached tailings A were obtained from the active vat leaching site and tested positive for 60 ppm cyanide. The tailings were sampled while wet during the offloading from the leaching tanks. The stockpiling of the tailings did not meet

standard procedures, and when it rains, the tailings are washed away into the environment, thereby spreading the cyanide.

The **leached tailings B** were partially dried tailings that had been leached a month earlier and were exposed to the sun, which caused some of the cyanide to evaporate. The tailings contained a 30 ppm concentration of cyanide. There were signs that rain had washed away some of the tailings, possibly when they were still wet and had higher cyanide concentrations.

The presence of 10 ppm of cyanide in the **river silt** indicates the impacts of cyanide from the vat leaching sites. This highlights the magnitude of cyanide effects before settling in the silt.

The results reveal concerning relationships between high levels of cyanide and metals. Despite some reduction through evaporation and rainwater dilution, river silt samples reveal cyanide levels of 10 ppm, posing a threat to aquatic life. Proper safety protocols, monitoring, and remediation are crucial in order to minimise exposure. Additionally, animal deaths from cyanide poisoning are mainly associated with leaks or overflows from the vat leaching process.

4.2 Chapter Summary

The site observations, interviews, and sampling results have revealed severe environmental impacts from ASM activities that fall significantly short of standards and regulations. While the ASM operators are eager to advocate for a positive environmental legacy, they call on government assistance as they cannot afford to mitigate the risks without external assistance.

The community recognises the significant role of mining in enhancing the well-being of families. However, they express apprehension regarding the direct repercussions on local animals and the broader environment, a concern that extends to Otter Mining. The company's staff is mindful of these concerns and notices the need for governmental support to provide ASMs with training, financial assistance, and ongoing guidance.

The analysis of the samples indicated elevated levels of cyanide and other toxic elements. The absence of mercury in the samples was noted and highlighted as a factor that requires additional attention.

Discrepancies were noted between the strip test results and the corresponding laboratory results for copper and iron. Several factors can lead to these discrepancies. Strip tests typically exhibit lower sensitivity and are more susceptible to interference from environmental conditions, including pH, turbidity, and the presence of other ions or oxidising agents (Rice et al., 2017). Laboratory-based analytical methods, such as AAS, provide higher precision and accuracy, as they involve standardised procedures for sample digestion, calibration, and quantification (Llaver et al., 2021). The laboratory possesses the capability to detect exceedingly low concentrations, whereas strip tests may only register values exceeding a certain threshold. Additionally, human error is a contributing factor, as strip test interpretation depends on subjective visual colour comparison, in contrast to laboratory results, which are derived from quantitative measurements and are consequently more objective. As a result, laboratory tests were preferred for their reliability and accuracy, while strip tests were also valuable for quick indications.

5 ANALYSIS AND FINDINGS

5.1 Analysis

The results of the physical observations, interviews and sample analysis identified in Chapter 4 reveal common themes of substandard practices, poverty, limited knowledge and resources, as well as environmental damage caused by improper waste disposal and subsequent high levels of toxic elements and chemicals above the safety limits.

5.1.1 Degradation of the environment

Typically, ASM mining processes, such as land clearing, ore extraction, amalgamation, vat leaching, and stockpiling, do not adhere to mining standards. The operators often work without oversight, disregarding the resulting environmental damage. Testing of samples has shown that significant amounts of cyanide and heavy metals are being released into the environment due to non-compliance with approved mining standards. Some effects are gradual, while others are rapid.

From interviews, 19% of individuals reported noticing changes in their drinking water. The unexpectedly low number is attributed to the fact that changes may occur gradually, causing people to adapt to the new taste without realising it. Further, many individuals do not pay attention to changes in water taste; however, as contamination becomes more severe, it becomes impossible to ignore. ASMs also frequently relocate to different mining locations, which means they may not be aware of whether the well water has retained its original taste or if contamination has occurred.

Similarly, regarding the deaths of fish and other aquatic life, which few people have witnessed directly but have observed through diminishing numbers and species. Very few individuals engage in fishing, which means that fish may die and become food for wild birds before anyone notices. Fish deaths are inevitable, considering that the cyanide test revealed a concentration of 10 ppm in the wet river silt, significantly higher than the lethal limit of 0.2 ppm. Additionally, nitrite was also present in the samples at levels harmful to fish, with the highest concentration

being 40 ppm in the tailings, compared to a safe limit of 1 ppm. Although AMD was not tested, it was also a suspect in the deaths of fish due to its severe environmental damage by contaminating water with acidity and heavy metals, harming aquatic life (Hogsden & Harding, 2012). As noted by the Office of Research and Development (1977), nitrite oxidises with haemoglobin, producing excessive methaemoglobin. This methaemoglobin enters the fish's bloodstream, reducing oxygen levels because it cannot facilitate oxygen transport. Though nitrobacters (bacteria that play an important role in the nitrogen cycle in soil and marine systems (Spieck & Bock, 2004) can convert nitrite into the less toxic nitrate, nitrate can still harm fish at concentrations above 80 ppm. One sample tested at 100 ppm nitrate, indicating a severe risk to fish populations.

Test results indicate that most samples exceed the safe limits for cyanide and various metals in drinking water, as noted by Torrent Laboratory (2024). The findings highlight significant exposure levels for both animals and humans, as well as associated environmental implications. Table 13 presents the highest metal test results (from this study) versus the safe limits, while Table 14 indicates the laboratory test results for cyanide compared to the safe limit.

Table 13: Highest metal test results versus the safe limit

<i>Element type</i>	<i>Highest test results (ppm)</i>	<i>Safe limit (ppm)</i>	<i>Variance from safe limit (ppm)</i>
<i>Cu</i>	469.63	1.3	+468.33
<i>Ag</i>	1.21	1.1	+0.11
<i>Fe</i>	2.22	10	-7.78
<i>Cr</i>	148.04	0.1	+147.94
<i>Pb</i>	32.84	0.015	+32.83
<i>NO₃</i>	100	10	+90
<i>NO₂</i>	40	1	+39

(Source of allowable limits: Torrent Laboratory, 2024)

Table 14: Laboratory test results for cyanide compared to the safe limit.

<i>Source</i>	<i>Cyanide concentration (ppm)</i>	<i>Safe limit (ppm)</i>	<i>Variance from safe limit (ppm)</i>
Land surrounding TSF	30	0.2	+29.8
Effluent A	210	0.2	+209.8
Leached tailings A	60	0.2	+59.8
Leached tailings B	30	0.2	+29.8
River silt	10	0.2	+9.8

(Source of allowable limits: Torrent Laboratory, 2024)

Concerning **cyanide**, Jaszczak et al., (2017) elaborated that although it is a highly toxic substance, it does not persist in the environment for long periods. Cyanide breaks down into less toxic forms, potentially reducing long-term effects. Evaporation of cyanide reduces its concentration in tailings (Halim & Naidu, 2024). Additionally, cyanide becomes diluted when it comes into contact with water. However, cyanide exposure can cause environmental damage and animal poisoning before it (cyanide) is fully evaporated or diluted. According to Halim & Naidu (2024), exposure can occur through inhalation, ingestion, or skin contact, and the pathways are water and soil. Therefore, this highlights the importance of safeguarding tailings and all discharges, especially from vat-leaching plants, to avoid human and animal exposure and dissemination.

In contrast to cyanide, **mercury** typically has a long-lasting presence in the environment. Mercury is known to be used in all gold processing activities, and it has been directly observed by the researcher that ASM operators lose mercury in the tailings during gold processing. Despite these observations, testing in this investigation has shown no traces of mercury.

Undetected mercury test results do not necessarily affirm the absence of mercury; instead, they suggest that either the sampling process was faulty or that the concentration of mercury was below the sensitivity threshold of the testing apparatus. Such results can arise from various factors such as mercury

evaporation, sampling inaccuracies, non-representative samples, or the presence of mercury in discrete globules that may have been missed during the sample collection (the “nugget effect”).

As noted by (Hellmann et al., 2018; International Labmate Limited, 2025; Suvarapu et al., 2013), mercury often remains in tailings as discrete globules, which are small, dense droplets of elemental mercury. This presents a significant challenge during sample collection and analysis. These globules tend to settle quickly and become embedded in the coarser, heavier fractions of the tailings or sink deep into sediment layers, making them less likely to be captured during surface or random sampling. Additionally, because elemental mercury is not uniformly distributed throughout the tailings matrix, standard grab or composite sampling techniques may inadvertently miss these concentrated pockets. This non-homogeneous distribution, coupled with mercury's physical properties such as high density and immiscibility with water, contributes to underrepresentation in laboratory samples. Moreover, as adapted from (Devasena & Nambi, 2010), mercury may leach away over time, particularly in wet or porous environments, resulting in lower detectable concentrations in the solid phase.

As a result, mercury present in the environment may go undetected or be significantly underestimated unless sampling protocols are specifically adapted to capture the heavier fractions where these globules are likely to accumulate. These factors, when combined, contribute to the challenge of consistently detecting mercury in tailings samples, despite its observed use in ASM processes.

The presence of mercury in ASM operations has been identified in studies by the United Nations around Rwamagasa, Geita (northern Tanzania), as reported by Spiegel (2009). Here, mercury concentrations in drainage sediments varied between 0.02 to 3.02 ppm. Additionally, Spiegel (2009) also notes that Türkiye rejected over 16 tonnes of fish fillets from Tanzania after analyses indicated the presence of mercury.

Iron in limited quantities can benefit the ecosystem, particularly for aquatic animals that receive iron-rich effluents during the cold season, which supports overall growth (Asad et al., 2023). Additionally, iron promotes algae growth in the water,

as observed by the researcher on-site, where there were visibly high iron concentrations. However, when iron levels are excessive, they become toxic and reduce bioavailability. Another negative aspect of excessive iron is its potential to cause rusting and subsequent weakening of metals.

One of the samples tested was found to contain excessive amounts of **silver**. As elaborated by Drake & Hazelwood (2005), high concentrations of silver have toxic effects on humans, including kidney and liver damage, as well as changes in blood cells. While a few cases of kidney and liver failure have been reported in the community, these cannot be directly linked to silver exposure, as there are also other primary causes for such illnesses.

Most of the **copper** released from mining contaminates the soil and water. Aquatic organisms can be affected even at low concentrations of copper. The elevated copper levels indicated by sample test results explain why plants have struggled to grow in low-lying areas where metals are deposited by rainwater. According to Rehman et al., (2019), the release of copper into the soil damages carbohydrates, lipids, proteins, and DNA. This leads to the deterioration of plants, hindering their ability to meet the nutritional needs of animals and humans. Observations on the ground confirm that large areas have been degraded by the presence of metals, with copper sample results showing levels of 468 ppm, which exceed safe limits.

High levels of **chromium** have also been recorded, posing risks to both water and soil. Prolonged exposure to these metals can accumulate to harmful levels in human and animal tissues, leading to toxic health effects (Agency for Toxic Substances and Disease Registry, 2024). Contaminated soil also experiences poor production due to reduced plant growth, which is a common issue in many of the ASM community lands in Tanzania.

The test results for **lead** in the tested samples were alarmingly high, posing serious risks to humans and animals consuming water from channels connected to mining areas. The WHO classifies lead as one of the most hazardous environmental toxins (Jarvis & Fawell, 2021). Unfortunately, the community and the miners are unaware of the hazardous lead entering their water sources, which gradually affects their health. While the maximum allowable limit is 0.015 ppm, any detectable level of

lead in water is deemed unsafe and damages the liver, kidney, bones and brain (Torrent Laboratory, 2024).

To ensure the consumption of lead-free water, Strandberg (2022) noted that quality monitoring and surveillance for all water sources are some of the WHO's crucial requirements. However, Otter Mine sites, along with numerous other ASM sites in Tanzania, are located in remote areas where quality water monitoring is lacking. Many countries in Africa also lack the necessary resources to fulfil these monitoring requirements. The severity of the matter is evident in the field samples, which recorded lead concentrations of 32.84 ppm, significantly exceeding the acceptable limit of 0.015 ppm. Table 15 summarises the human health impacts associated with exposure to the elements and substances.

Table 15: Laboratory results and associated health impacts on humans

Elements and substances	Highest concentration (ppm) detected in this study	WHO drinking water limits (ppm)	Potential health impacts
Cyanide	210	0.05	Extremely toxic, causing headache, dizziness, respiratory failure, seizures, coma, and death with acute exposure.
Lead	32.84	0.01	Severe neurotoxicity, developmental delay in children, kidney and cardiovascular damage in adults.
Copper	469	2	Acute gastrointestinal toxicity (nausea, vomiting, diarrhea); risk of liver/kidney damage at prolonged exposure.
Silver	1.21	~0.1	Risk of argyria (skin pigmentation); long-term tissue accumulation.
Iron	2.22	0.3	High levels may aggravate liver disorders.
Chromium	148	0.05	This is highly toxic/carcinogenic (Cr(VI)), causing acute poisoning, gastrointestinal bleeding, kidney/liver damage, and increased cancer risk

(Source: Adapted from World Health Organisation, 1988; World Health Organisation, 2009)

5.1.2 Issues of poverty

Some operators earn just enough to provide daily meals for their families and so require financial assistance to protect the environment. A few miners that the researcher spoke to say that they do care, but claim they are too poor to comply with environmental regulations. A similar situation is noted in Zimbabwe, where ASM operators argue that the need for survival outweighs environmental concerns (Macheka et al., 2020). This message clearly indicates the ASM belief that the priority is poverty alleviation over environmental protection.

From comments made by the ASMs, many operations are non-compliant because they lack funding for proper environmental assessments. In addition, ASM operators lack skills, use basic tools, and cannot afford mechanisation to improve production. As a result, their standards are low and mine production fails to reach commercial levels.

5.1.3 Lack of knowledge.

Despite having some awareness of the environmental damage caused by mining processes, there appears to be limited concern for environmental conservation. This attitude may be, in part, attributed to the relaxed application of existing environmental laws and the belief that they apply only to LSMs, as this is all that's referenced in the EMA.

ASMs also often lack a deeper understanding of certain issues. One example is the burning of amalgam, which releases mercury vapor into the environment. The consequences of excessive mercury exposure can be severe. According to Kazantzis, (2002), mercury poisoning can harm the brain, nerves, lungs, kidneys, skin, eyes, and the digestive and immune systems of humans and animals. In humans, poisoning can occur from eating mercury-contaminated food and touching one's skin with mercury-contaminated hands.

5.1.4 The current legislation is insufficient

Current legislation inadequately addresses environmental protection and occupational health and safety concerns related to ASM. For instance, cyanide and mercury use in ASM gold extraction remains unregulated. Although a broad legislative framework exists, including the Mining Act of 2010 and its amendments,

enforcing these regulations locally is often obstructed by insufficient state resources and rampant corruption, allowing unlicensed and/or poorly regulated operations to persist.

Many ASM operators engage in informal or illegal practices due to the complex and costly licensing process. As a result, a large portion of the sector operates outside legal protections, which in turn, generally precludes them from accessing financial assistance. Additionally, mechanisms to provide ASM operators with essential technical knowledge are insufficient. Without this support, many continue unsafe and environmentally harmful practices.

There is, further, an absence of CSR within ASM. ASM operators frequently fail to engage in consultations with local communities, traditional authorities, and fellow miners. The prevailing attitude is one of self-preservation, even to the detriment of others in the community.

5.2 Chapter Summary

The analysis reveals several themes emanating from the comments of the interviewees. The most obvious is the severe environmental and potential health issues resulting from substandard ASM practices, driven by a lack of resources, limited awareness, and weak regulatory enforcement. Improper waste and chemical disposal have led to widespread contamination, with sample test results showing cyanide and heavy metal levels far exceeding safe limits.

Significant amounts of cyanide and heavy metals are released into the environment, causing both gradual and rapid impacts. An example was fish deaths linked to toxic concentrations of cyanide, nitrite and suspected AMD. While mercury was not detected in samples, its known use in gold processing remains a concern to animals and humans. Elevated concentrations of copper, chromium, and lead, particularly dangerously high lead levels, pose significant risks to human and ecological health.

The ASM sector is further burdened by inadequate legislation, weak enforcement, and limited state capacity. The findings underscore the urgent need for targeted environmental and occupational safety reforms, enhanced regulatory oversight,

and financial and technical support tailored to ASM operations to promote responsible and sustainable mining practices.

6 CONCLUSIONS AND RECOMMENDATIONS

There are an estimated 10 million ASMs in Africa, with approximately 1.5 million in Tanzania and about 350 of these operate around Otter Mine. As the number of ASMs rises, their environmental impact grows daily. This research investigated the causes and extent of the damage caused by these activities. The impacts were identified through interviews, sampling, testing, and site observations. The data collection and analysis revealed that a lack of legislative guidance has resulted in substandard practices. Based on the findings, solutions to address these issues are proposed.

6.1 Summary of Chapters

This section presents the key overview of the research chapters. The report comprises six chapters that cover the following areas:

- Chapter 1 provides background information on the significance of the research project, detailing the research methods, the role of ASM in supporting livelihoods, and how ASM functions while posing threats to environmental stability in Tanzania. In addition to its environmental impacts, the chapter highlights how ASM operations affect local communities. The legislation surrounding ASM in African countries is assessed, with a specific emphasis on Tanzania.
- Chapter 2 is the literature review which examined key aspects of ASM, focusing on environmental impacts, regulatory frameworks, comparative analysis, socio-economic effects, health and safety concerns, and a global perspective. It highlighted that poor management in ASM leads to land degradation, pollution, and deforestation, negatively affecting humans and wildlife. The review noted the lack of regulation in ASM, resulting in harmful practices.
- A comparative analysis explored different countries' strategies for addressing ASM issues, while the socio-economic section emphasised its importance to local communities. Health and safety concerns included exposure to dust and other hazardous conditions. Finally, the global perspective discussed mining and the policies in various countries, and the African Mining Vision, which aims to enhance livelihoods and promote

sustainable development in the ASM sector. This overview stresses the urgent need for regulatory measures to ensure environmentally sustainable mining practices.

- Chapter 3 described the research approach, which employed both qualitative and quantitative approaches. The qualitative approach was essential for understanding how the environment and people's social functioning are affected by ASM activities. This includes using questionnaires and interviews to gather in-depth insights into the effects of a lack of expertise and the failure to apply environmental protection standards. In contrast, the quantitative approach focused on collecting and analysing numerical data, delivering precise and measurable information to enhance understanding of the issues at hand.
- Chapter 4 comprises the results for the study, which were derived from questionnaires, field observations, and laboratory tests to evaluate the environmental impacts and propose solutions. It also assessed the understanding of ASM operators regarding relevant standards and regulations and their awareness of the harm caused to the environment, animals, and human health. The study also highlighted the community's perspective on mining activities and how they (activities) affect them (the community).
- Chapter 5 outlines the analysis and findings, highlighting the key environmental impacts of ASM activities. The results indicate severe ecological damage and health risks for the miners and the local community. These damages and risks are often overlooked because operators prioritise poverty reduction over other critical areas. Consequently, there is a call for a comprehensive approach that includes legislation, education and training, government intervention, and community engagement.
- Chapter 6 summarises the previous chapters, research observations, limitations, contributions, and proposed solutions. The limitations addressed the challenges faced by the researcher, particularly during data collection in marginalised communities. A key component of this chapter is the contributions and recommendations section, which suggests solutions to the identified problems. The issues encompass environmental impacts resulting from ASM operations, while the main solution emphasises establishing a policy that regulates these operations. These

recommendations aim to reduce the environmental impacts of ASM while promoting sustainable and ethical mining practices. If implemented, these recommendations could have a positive impact on the environment, economy, and communities, as well as benefit the operators involved.

6.2 Research Conclusions

Poverty serves as the primary catalyst driving numerous individuals toward ASM, even though they do not possess the necessary knowledge or resources to engage in these activities safely and effectively. For many, the pressing need to survive and provide for their families outweighs the risks associated with mining. In many communities, the improvements in livelihood that ASM has brought about are widely recognised and celebrated. Families who previously struggled are now experiencing better economic conditions, which fosters an atmosphere of hope and ambition. This perceived success has inspired more individuals to pursue mining to enhance their financial stability. However, they still require coaching on standards and environmental protection in their quest for survival.

Environmental legislation is one way of ensuring the successful and sustainable implementation of ASM operations. This research has identified several gaps that should be addressed in ASM legislation in Tanzania. Some of these gaps are highlighted in Table 16 and expanded upon below.

Table 16: Identified gaps in the ASM legislation and proposed amendments

Gaps identified	Proposed amendments: A responsibility of the state
Regulatory and formalisation challenges in ASM operations The current legislation is directed primarily towards large-scale mining operations and does not explicitly address ASM issues. Without the necessary legislative guidance, the ASM communities operate in disorganised informal groups, resulting in unsystematic operations and poor mining practices that give rise to detrimental outcomes, particularly for the environment and local communities. Additionally, a lack of guiding policies for ASM	Establish a regulation dedicated to the ASM operations. Specific proposals include: 1. Involving miners in policy discussions. Their inclusion fosters ownership and accountability. Involving ASM miners in policy discussions makes legislation more practical, accepted, and supportive of safer, more sustainable mining for all stakeholders.

makes it challenging for miners to access supportive initiatives, such as professional assistance or financial resources.	2. Formalise ASM operations through legal recognition and a simplified licensing process. Relaxing conditions, such as costs for ASM licences, and encouraging registration as community groups or mining cooperatives to spread the cost burden. 3. Decentralising of licensing to district community offices instead of only the zonal mining offices at Mbeya, Mwanza, Kilimanjaro, Dodoma, Dar es Salaam and Kilimanjaro.
Environmental, health and safety challenges It was noted that many of the ASM operators appeared to be unaware of the dangers of burning the mercury. Less than 15% of the ASM acknowledged that they have knowledge of applicable legislation and waste disposal techniques. Many unknowingly expose themselves to hazards, such as burning mercury and inhaling the released vapours. Sometimes, teams know the risks but fail to take the necessary precautions. Such negligence can also occur when handling cyanide, despite established best practices. These oversights can lead to fatalities and harm to the ecosystem.	Establish a national policy framework that promotes safe, healthy, and environmentally responsible mining practices among ASM operators specifically. Specific proposals include: 1. Integrate minimum environmental, health, and safety standards into ASM licenses, enforce regular compliance reporting, and establish local EHS monitoring committees involving communities and local authorities. 2. Insist on mercury-free practices such as gravity concentration
Failure to follow up on ASM work and corruption by state officials	Strengthen the powers of anti-corruption measures in the EMA and Mining Acts.
Lack of areas with easily accessible orebodies One of the most persistent barriers for ASMs in Tanzania is the lack of access to areas with viable and easily accessible ore bodies. Many high-potential areas are either unlicensed, underexplored, or locked under large-scale concessions that are inactive. This forces ASMs to operate informally or in geologically poor areas, leading to low productivity, environmental damage, and conflicts.	Provide specific land/data access to ASM operators 1. Legislate ASM zones based on national geological data and ensure open access to basic mineral information through government platforms and local offices
Deficiencies in skills, technical knowledge and productivity.	<i>While not technically a proposed amendment to the legislation, the government could</i>

Numerous operators enter the mining sector without the essential skills or training, often following other untrained individuals. With that lack of knowledge, their work typically entails excavating for minerals without critically considering geology, rock mechanics, environmental impacts, safety protocols, pollution management, and the appropriate use and disposal of chemicals and waste. Such neglect can culminate in severe environmental and safety repercussions.	<i>consider setting up state-funded training centres for ASM miners to improve their productivity, self-sufficiency, and technical skills</i>
Access to finance and equipment Reputable organisations prefer to work with registered and regulated operations that operate responsibly. However, in trying to get equipment loans, many miners face challenges at the due diligence stage due to a lack of responsible mining practices (The Impact Facility, 2024). Being a registered and regulated miner carries responsibilities that institutions or potential investors carefully consider before partnering.	According to the current legislation (section 5.6 by the United Republic of Tanzania, 2009), the government will strive to formalise artisanal mining into small-scale mining and, subsequently, collaborate with stakeholders to support access to markets, geological data, technical assistance, and financial services. It is recommended that this provision be expanded to support ASMs with low-interest loans, equipment financing, and grants.

To strengthen ASM legislation in Tanzania, policy efforts should focus on establishing a clear legal framework and promoting decentralised governance. Additionally, priorities should include environmental protection, financial and technical support, formalisation incentives, and improved institutional coordination to support training and ensure sustainable, safe, and inclusive mining practices.

There is a need for the development and enforcement of tailored environmental and occupational safety regulations specifically for ASM, including the safe handling and disposal of toxic elements and chemicals, including mercury and cyanide, as well as small-scale waste management practices. To effectively implement the policies, training for the ASM needs to be included to equip them with the necessary knowledge and skills. Not only miners, but also local mining officials, need to be equipped with field monitoring skills.

Simplified licensing procedures, reduced fees, decentralising authority to local offices and the provision of state support services in navigating the formalisation

process would ease the burden to ASMs. Digitalisation, such as mobile phone applications (“apps”), could be considered as they would be easily accessible to many.

In addition to the legislative changes, the results of this research indicate that many socioeconomic challenges need to be addressed before the problems associated with ASM operations can be solved. Without addressing fundamental issues like financial insecurity and a lack of a progressive mindset, regulatory interventions alone are unlikely to yield sustainable outcomes. Therefore, any strategy to enhance ASM must include social development initiatives that empower communities and promote inclusive economic opportunities alongside regulation enforcement. Table 17 identifies some of these issues that need the input of a multi-stakeholder community partnership (MSCP) process. Such a joint venture might be led by the government but requires the cooperation of non-governmental organisations (NGOs), communities, media outlets, educators, and other private organisations willing and able to contribute their assistance.

Table 17: Non-legislative issues

Issues identified	Proposed corrective action by MSCP
Short-term thinking	The MCSP needs to hold workshops on a variety of topics, including, but not restricted to: • encouraging ASMs to think beyond putting food on the table, but to mine for business • financial literacy, long-term business planning, safety, and environmental responsibility to foster sustainable mining practices. • Behavioural change programs in mining communities and collaborate with media to promote positive, consistent messaging on sustainability.
Attitudes toward safety and the environment	MSCP through radio and television stations should consistently advocate for safety, environmental responsibility, and forward-thinking initiatives to transform public perceptions regarding mining communities, making ASM operators believe that accidents and injuries are

	not part of mining and can be prevented
Resistance to formalisation Even with successful mining operations, many individuals fail to improve safety and environmental standards due to a deep-rooted poverty mentality. Although financial and professional assistance can be beneficial, ASMs still struggle to operate responsibly without direct regulations and close supervision from government agencies, such as the NEMC. Additionally, the ASMs with whom the researcher spoke to on the ground expressed their fear of failing to comply with the rules and regulations if the ASM is formalised. They stated that any new mining regulations might require financing and special skills that they (miners) lack.	Oversight by bodies such as the NEMC is crucial to ensure compliance with relevant legislation. The MSCP community needs to educate miners regarding the benefits of formalisation.
Access to finance and equipment While most people require technical and financial assistance, they are worried that this may result in them having to surrender a portion of their production to the State.	The MSCP should be encouraged to promote and support the formation of ASM cooperatives as a strategy to enhance miners' access to credit, financial services, and technical support, thereby improving operational capacity, legal compliance, and environmental performance. Provide group lending schemes through local loan cooperatives or community banks. Promote public-private and donor support for ASM by linking financial access to formalisation and partnering with NGOs and mining associations to deliver related services.

The policy recommendation for ASM reform in Tanzania underscores the need for a coordinated, multi-stakeholder approach by the state and the MSCP so as to formalise and enhance the sustainability of ASM. Given the substantial financial and structural demands of such reform, the proposed strategy would likely involve

establishing a National ASM Development Fund to support regulatory implementation, capacity-building programs, formalisation processes, environmental management, and technological advancement within the ASM sector. Such funding might be made possible by mobilising resources from the government, development partners such as the United Nations Development Programme (UNDP) and the World Bank, the African Union or the African Development Bank, mining companies through CSR initiatives, as well as international donors. Other options that might be investigated include encouraging established mining companies to partner with ASMs, perhaps through schemes that include tax deductions or other incentives.

Following the establishment of funding mechanisms, further emphasis should be placed on incentivising regulatory compliance, strengthening the capacity of local institutions, and aligning ASM initiatives with national development objectives. Collectively, these measures aim to ensure that ASM reform is both economically viable and socially inclusive through strategic resource coordination and stakeholder collaboration.

6.3 Recommendations

The recommendations address key issues regarding legislation, training, funding, and innovative alternatives in ASM operations. Implementing these strategies can improve safety standards and promote sustainable practices within this sector. In this respect, a national dialogue is crucial for developing reforms and policies. Such dialogue should include community members, ASM operators, mining license holders, academia, ASM associations, the government, media, civil organisations, and other relevant groups. ASMs and community consultation workshops would lead to healthier working conditions for miners and more responsible resource management, benefiting both local communities and ecosystems in the long run.

Introduction and enforcement of ASM-specific legislation in the EMA and Mining Acts can be pivotal in managing the industry. This legislation should address numerous areas, including registration processes, environmental protection, afforestation, chemical usage and disposal, mine closure plans and rehabilitation, TSF design, and pollution control. Additionally, anti-corruption safeguards should

be established to combat corruption and promote accountability and transparency in ASM operations.

For the policy to be effective, however, training is essential. Training equips mine operators to understand safe mining practices, including environmental care, resulting in enhanced eligibility for external funding opportunities and/or joint ventures with larger companies. It is, further, recommended that the State invest in field monitoring training for local mining officers.

The State might also encourage and perhaps facilitate partnerships with non-governmental organisations (NGOs) or academic institutions to support capacity-building. Government-backed credit schemes, technical extension services, and access to shared processing centres with clean technology (e.g., mercury-free gold processing systems) might also be created in the same way that the government invested in gold market centres.

A number of specific proposals could include:

- The government of Tanzania has set a limit of 50 ppm cyanide for mines. This limit is more applicable to LSM, where TSFs are adequately fenced and designed to prevent contamination of the surrounding environment and water sources. However, due to the proximity of local communities and ASMs' lack of site protection, a safer limit for ASM might be closer to the international limit of 0.2 ppm (Government of Canada, 2008; The United Republic of Tanzania, 2007).
- Like many large-scale mining operations, particularly in developed countries, post-mining activities can benefit surrounding communities (Worlanyo & Jiangfeng, 2021). This includes rehabilitating and repurposing the land for uses other than mining and enabling people to engage in various non-mining activities. ASMs cannot manage to rehabilitate due to financial challenges. However, the government collects 7.3% taxation from ASM gold sales, and part of this tax could be ringfenced for rehabilitating mined-out areas and making them useful again, for example, for farming. This can improve food security in these communities. Moreover, plantations might be established on rehabilitated land, benefiting the local community with employment and services, and serving the timber industry.

Additionally, if deemed safe, shallow pits could be converted into fish farms, which have proved successful as opportunity-driven ventures in East Africa and other regions (Rutaisire et al., 2009; Obiero, et al., 2019; Oirere, 2019).

- Detection of cyanide, mercury and other toxic elements in the tailings and the effluent is usually accomplished by testing samples in a laboratory. Selective fluorescent sensors are commonly used to detect mercury ions (Wei et al., 2014). According to Wang et al., (2016), anion-intercalated layered double hydroxides modified test strips check the presence of metal ions by change of colour when metal ion solution is dropped on the strips (Erdemir & Malkondu, 2020). These and other simple, low-cost, on-site test strips and solutions might be promoted within the ASM community to keep a constant check on their levels of cyanide. If cyanide is detected in water, hydrogen peroxide can be used to neutralise it (Kepa et al., 2008).
- Mercury-free processing methods, such as gravimetric techniques, can also be promoted (or legislated) as a primary solution that is less harmful to the environment and human health. These include panning, sluice boxes, and shaking tables, although they can be less effective, costly, and require training. While it can be challenging to eliminate the common traditional mercury-based processing methods, a secondary solution involves using retorts and fume hoods to recover mercury during the burning of amalgam. While this approach may be costly, it is highly effective in reducing mercury vapor emissions. According to Amankwah et al., (2017), retorts can recover up to 99% of mercury vapours. With the help of Tanzanian-based foreign organisations such as Planet Gold and TIF, implementation of these mercury-free methods may be promoted within the ASM communities, especially if there is associated financial assistance.
- Due to increased fears about the environmental toxicity of cyanide in gold leaching, potentially ecologically safe gold leaching methods such as the Chinese-made gold dressing agent, GDA, have been introduced in Tanzania. The GDA is less toxic than cyanide and is touted as environmentally friendly (Yantai Xinhai Materials Technology Company Ltd., 2019). Another Chinese supplier, Nanning Baiyi Trading Co. Ltd (2024), emphasised that the GDA is environmentally friendly, cost-effective, versatile, easy to apply, and has an acceptable gold recovery rate. As per supplier information, the GDA leaching might be suitable for

ASMs, considering financial constraints and the lack of professional knowledge in processing and environmental care in this sector.

- Besides the manufacturer's information, there are also independently verified scholarly reports, such as Beyuo et al., (2016), which point to the effectiveness and the safety of the GDA. These authors describe the chemical compounds of GDA as thiourea $\text{SC}(\text{NH}_2)_2$, sodium silicate (NaSiO_3), sodium hydroxide (NaOH), and sodium hexametaphosphate (NaPO_3)₆. They note that it is more environmentally acceptable since it does not contain cyanide. They further confirm its ease of use and applicability to ASM operations.
- Several ASMs are testing the GDA for leaching gold, and reports from Tanzanian ASMs suggest that it (GDA) is working effectively, although it is currently in short supply. If supplied in large quantities, the GDA has the potential to mitigate the environmental impacts caused by improper handling of cyanide. This method may positively impact the ASM sector if implemented effectively.
- Poor mining practices in ASM operations have led to siltation caused by erosion from ground disturbances, waste soil, waste rock and tailings. Desilting of rivers and other watercourses has been identified as a viable method for enhancing water quality and quantity (Bhatia, 2022). While ASM operations are not likely to be able to afford to desilt, such operations could be subcontracted to individuals and organisations engaged in commercial silt removal.

6.4 Research Limitations

The study identified several limitations related to sampling and testing, which impacted the qualitative sampling results:

- Mercury was not identified in any of the samples, despite its known presence in the tailings. This was likely related to the limited number and size of the samples. This highlights the importance of using targeted sampling and pre-analysis homogenisation methods when assessing mercury contamination in ASM tailings. Additionally, this non-detectable outcome is most likely attributable to recent rainfall events, which may have

facilitated surface runoff and dilution, thereby reducing the mercury concentrations at the sampling sites to below detectable limits.

- The Nesch Mintech Laboratory in Mwanza had significant limitations with regard to testing water-based samples. Although the laboratory was accredited, it could not test for cyanide, mercury, and other heavy metals in water. This affected the analysis of water samples taken from the river, preventing the researcher from determining the amounts of mercury and cyanide in the water based on laboratory tests. Only the strip tests were able to detect metals in water-based samples.
- Acid-base accounting tests were not conducted as these could not be done in Tanzania. Local laboratories confirmed that they would have had to send the samples to international laboratories. This would have resulted in incurring significant costs that the author could not carry and was not able to obtain sponsorship for.

Access to remote areas encountered challenges because of an inadequate road network. This limitation delayed access to various ASM sites, hindering timely operations and research efforts. Upon arrival at Otter Mine, it was discovered that several ASM sites were subject to access restrictions. These limitations affected the ability to gather essential data. Transport issues and access restrictions ultimately made collecting data from all planned sites difficult.

This research collected samples from ASM operations surrounding Otter Mine. Therefore, the results may not be entirely representative of ASM operations throughout Tanzania since the concentration levels of elements and compounds are expected to vary with bedrock geology and geomorphological complexities.

6.5 Recommendations for Future Research

Further research is recommended to address environmental issues related to ASM. These studies can contribute to developing sustainable mining practices, the development of new mining techniques, exploring innovative approaches, and promoting behaviour change.

- More research is needed in the estimation of contaminants, specifically mercury and cyanide, but also including other applicable toxic

metals/chemicals from ASM operations further afield in Tanzania, as well as elsewhere, regionally and globally. Moreover, because higher concentrations of mercury and cyanide are more likely to occur during the dry season, when rainfall-driven dilution does not occur, sampling during this period would provide a more accurate assessment of contaminant levels

- Such research should also include acid-base accounting. This knowledge can contribute to formulating a clear policy that establishes safe limits for such metals/chemicals and aids in developing alternative methods for gold recovery options.
- With regard to testing, research should be conducted into finding simple, low-cost methods that can easily be conducted by ASMs as part of their day-to-day operations. These methods should target mercury and cyanide specifically.

Researching social attitudes toward change among ASM operators is a further recommended area for future study. While ASM provides a significant source of income for millions, it also poses environmental risks and is linked to unsafe practices. Some of the proposals recommended in this research to increase regulatory control and improve environmental management come at a cost to the ASM community. It is suspected that the additional costs will be a significant burden to the ASMs, and they may resist them, either due to genuine financial need or simply due to negative attitudes and resistance to change.

A further field of study that should be investigated is how the proposals made above might be financed. Potential assistance from the government, development partners such as the UNDP and the World Bank, international donors, and mining companies operating in Tanzania should be investigated.

6.6 Concluding Comment

This research proposes solutions to address the current issues surrounding ASM in Tanzania. The collected and analysed data have provided an understanding of environmental issues caused by the ASM, which in turn is crucial for developing effective strategies, including legislation, training, technology, and access to

finance. The proposed solutions specifically target the most affected sections, such as the use and disposal of cyanide and mercury, mine waste management, mine development and rehabilitation, pollution control, and vegetation protection.

While the Tanzanian government talks commitment to overseeing and regulating the ASM sector (Kinyondo & Huggins, 2021b), the regularisation process faces challenges. Such challenges include uncertainty as to what exactly is required and the high costs associated with it.

This research has made several proposals as to how the legislation could be improved. These proposals are based on research into the environmental impacts identified at Otter Mine and discussions held with the local ASM community. The research focuses on regulatory framework, skills training, and funding as catalysts to reduce environmental impact while boosting mining production and revenue.

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8 APPENDICES Appendix A: Questionnaire

Research Questionnaire – Otter Mining				
Participant Role:				
Miner	Yes / No			
Community member	Yes / No			
Mineral processor	Yes / No			
Fisher	Yes / No			
Otter Mine Management	Yes / No			
Other.....				
Male / Female..... Age.....				
Date..... /...../2024				
Questions	Yes	Maybe	No	Comments
Do you have basic understanding of the environmental legislation?				
Do you know of any environmental policies that you follow when mining or processing?				
Have you ever witnessed any water pollution near the mining sites?				
Have you ever witnessed mass death of fish or any aquatic life in the rivers?				
Have you ever witnessed incidents of animals falling in the shafts or dying of cyanide poisoning?				
Have ever noticed plant growth deteriorating near ASM sites?				
Have you ever noticed any changes in the drinking water fetched from the protected wells near mining sites?				
Have you ever used cyanide for mineral processing?				
Have you ever used mercury to recover gold?				

Do you understand the dangers posed by the use and inappropriate disposal of both cyanide and mercury?				
Is there any erosion initiated from the mine sites?				
Can the waste rock stockpiles find use within the community?				
How do you dispose of tailings and water containing cyanide?				
How do you dispose of mercury to recover gold from amalgam – do you burn it with fire?				
How best can tailings be stockpiled and how can chemical danger be minimized?				
What are your thoughts on waste and tailings management, and land rehabilitation?				
What could be done to improve waste storage and tailings disposal?				
In your opinion, does the need for survival outweigh the concern for the environment?				
What adjustments could be made to the environmental legislation in order to include ASM?				
Do you know of any government procedures to follow before you start ASM mining processes?				
Will you adhere to the environmental legislation if the government puts enforcement measures? How?				
What can you suggest or special message to the ASM teams?				
What steps can Otter Mining take to ensure that ASM activities are done responsibly in its Mining License area?				
Do you believe in preparing a good environmental legacy for future generations, and how is it possible?				
In your opinion, how best can the environment be protected during and after mining processes?				
Open questions/ Any other contributions				

Appendix B: Laboratory test results

LF2/LP12



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TEST-5 0029

ORGANIZATIONAL MEMBER

Plot 27 Block E Butimba Mkuyuni Mwanza Tanzania. Email: info@neschmintec.com, Website: www.neschmintec.com, 0755360446, 0745282968

ANALYSIS REPORT			S/N° NESCH24/1506
Client Name:	Happison Muchanyangi	Contact Person:	Happison Muchanyangi
Contact Details	0742215921		
Batch No.	S24/61680	Number of Sample:	4
Date Received:	2024-08-23	Date Analyzed:	2024-08-27
		Date Issued:	2024-08-27

RESULT

Sample Matrix	Sample S/N	Sample Name	LM-01 Ag ppm	LM-01 Al ppm	LM-01 As ppm	LM-01 B ppm	LM-01 Ba ppm	LM-01 Be ppm	LM-01 Bi ppm	LM-01 Ca ppm
Soil	S24/61680/01	1	1.11	7357.26	1.15	33.18	25.52	0.65	0.31	408.92
Soil	S24/61680/02	5	1.05	3862.37	24.46	0.46	115.30	1.29	24.17	5406.18
Soil	S24/61680/03	6	1.21	4246.94	23.11	0.54	117.25	1.38	25.88	5253.05
Soil	S24/61680/04	11	0.56	5150.62	8.81	0.35	66.60	0.61	1.00	9389.98

Sample Matrix	Sample S/N	Sample Name	LM-01 Cd ppm	*LM-01 Co ppm	LM-01 Cr ppm	*LM-01 Cu ppm	LM-01 Fe %	LM-01 Hg ppm	LM-01 K ppm	LM-01 La ppm
Soil	S24/61680/01	1	0.45	0.24	66.89	23.25	0.85	<0.001	395.40	8.99
Soil	S24/61680/02	5	1.53	4.47	138.60	459.44	2.16	<0.001	203.65	3.33
Soil	S24/61680/03	6	1.60	4.68	148.04	469.63	2.22	<0.001	220.48	3.54
Soil	S24/61680/04	11	0.80	7.37	99.23	32.53	1.27	<0.001	208.6	6.14

RESULTS

Location of performance: Mwanza	Technical Signatory
Approved by: Lab Manager-NESCH	
 Prosper Munemo	 Alfonsin Ngoni Vambe

Detection level: {<0.01-less than 0.01ppm/< 10-less than 10ppm/> 100-greater than 100ppm/>10000-greater than 10000ppm}

***Accredited Methods:** NesochMintecLM-01 (Aqua Regia Digestion for Gold with AAS Finish); LM-02 (Fire Assay for Gold with AAS finish); LM-01/03 (Base metal trace level with AAS or MPAES finish); LM-01/5 (Ore Grade base metal with AAS or MPAES finish); LM-01/7 (Ore grade Nickel analysis with AAS or MPAES finish); Carbon & Sulphur analysis-LM-05; LM-09/7 (Determination of Anions with UV-vis finish)

Non-Accredited Methods: Carbon Ashing-LM-03; Carbon Activity-LM-04; Solution AAS Finish-LM-06; Telescopic Analysis-LM-07; Bottle Roll & Leach Profile Test-LM-08; Environmental Water Analysis-LM-09; Environmental Soil Analysis-LM-10; Industrial mineral Test-LM-11; XRF analysis- LM 12

Disclaimer: Results in this report refer to the samples submitted to Nesoch Mintec laboratory only. The report shall not be reproduced except in full without approval of Nesoch Mintec laboratory. The client is referred to the "Limitation of liability" on our website terms and conditions accessible at <http://www.neschmintec.com/terms-conditions/>.



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TEST-5 0029



ORGANIZATIONAL MEMBER

Plot 27 Block E Butimba Mkuyuni Mwanza Tanzania. Email: info@neschmintec.com, Website: www.neschmintec.com, 0755360446, 0745282968

ANALYSIS REPORT			S/N° NESCH24/1480
Client Name:	Happison Muchanyangi Otter Mining	Contact Person:	Happison Muchanyangi Otter Mining
Contact Details	0742215921		
Batch No.	S24/61680	Number of Sample:	5
Date Received:	2024-08-23	Date Analyzed:	2024-08-23
		Date Issued:	2024-08-23

RESULT

Sample Matrix	Sample S/N	Sample Name	LM-09 Cyanide (CN) ppm
Solution	S24/61680/005	001	30
Solution	S24/61680/006	004	210
Solution	S24/61680/007	005	60
Solution	S24/61680/008	006	30
Solution	S24/61680/009	009	10

Location of performance: Mwanza	Technical Signatory
Approved by: Lab Manager-NESCH	
Prosper Munemo	Alfonsin Ngoni Vambe

Detection level: {<0.01-less than 0.01ppm/< 10-less than 10ppm/ > 100-greater than 100ppm/>10000-greater than 10000ppm}

***Accredited Methods:** Neschemintec/LM-01 (Aqua Regia Digestion for Gold with AAS Finish); LM-02 (Fire Assay for Gold with AAS finish); LM-01/03 (Base metal trace level with AAS or MPAES finish); LM-01/5 (Ore Grade base metal with AAS or MPAES finish); LM-01/7 (Ore grade Nickel analysis with AAS or MPAES finish); Carbon & Sulphur analysis-LM-05; LM-09/7 (Determination of Anions with UV-vis finish)

Non-Accredited Methods: Carbon Ashing-LM-03; Carbon Activity-LM-04; Solution AAS Finish-LM-06; Telescopic Analysis-LM-07; Bottle Roll & Leach Profile Test-LM-08; Environmental Water Analysis-LM-09; Environmental Soil Analysis-LM-10; Industrial mineral Test-LM-11; XRF analysis- LM 12

Disclaimer: Results in this report refer to the samples submitted to Neschemintec laboratory only. The report shall not be reproduced except in full without approval of Neschemintec laboratory. The client is referred to the "Limitation of liability" on our website terms and conditions accessible at <http://www.neschmintec.com/terms-conditions/>.

Appendix C: Ethics clearance certificate



HUMAN RESEARCH ETHICS COMMITTEE (NON-MEDICAL)

Registration number: REC-101114-044

SCHOOL OF MINING ENGINEERING ETHICS COMMITTEE

Ethics clearance/waiver number: EMINN/2024/114

24 July 2024

Re: **Happison Muchanyangi (981712)**

To whom it may concern,

Happison Muchanyangi (981712) is currently registered as a ECA00 MSc Masters by Course work 50/50 student at the School of Mining Engineering, University of the Witwatersrand, Johannesburg. This letter is to confirm that, at the time of writing, **Happison Muchanyangi** does need ethical clearance for his/her study entitled '*TOWARDS IMPROVING ENVIRONMENTAL LEGISLATION IN ARTISANAL AND SMALL-SCALE MINING: A CASE STUDY OF OTTER MINING IN TANZANIA*'. This decision has been reached based upon a description of the project supplied by **Happison Muchanyangi** to the School of Mining Engineering Ethics Committee, constituted as a subcommittee of the University Human Research Ethics Committee (Non-Medical), which has been evaluated by the subcommittee chair. This decision has then been ratified by the University Human Research Ethics Committee (Non-Medical). If, however, **Happison Muchanyangi** changes the methods of data collection and analysis for this project, this decision may no longer be valid. If such changes take place, this should be communicated to the School of Mining Engineering Ethics Committee.

Please feel free to contact me should you require any further information.

Thank you.

Yours sincerely,

A handwritten signature in black ink, appearing to read 'Bekir Genc'.

Prof Bekir Genc
Ethics Chairperson

Shaun Schoeman (Senior Administrative Officer)
Solomon Mahlangu House, 10th Floor, Room 10004, Jorissen Street, Braamfontein, Johannesburg
Private Bag 3, Wits 2050
T + 27(0)11 717 1408 | E Shaun.Schoeman@wits.ac.za | hrecnon-medical@wits.ac.za
www.wits.ac.za/research/about-our-research/ethics-and-research-integrity/

Appendix D: Questionnaire responses

Research Questionnaire – Otter Mining

Participant Role:

Miner Yes / No

Community member ☒ Yes / No

Mineral processor ☒ Yes / No

Fisher Yes / No

Otter Mine Management Yes / No

Other.....

Male ☒ Female..... Age.. 24

Date.. 10 / 06 / 2024

Questions	Yes	Maybe	No	Comments
Do you have basic understanding of the environmental legislation?	☒			not everything
Do you know of any environmental policies that you follow when mining or processing?	☒			knowledge of chemical handling
Have you ever witnessed any water pollution near the mining sites?	☒			
Have you ever witnessed mass death of fish or any aquatic life in the rivers?			☒	
Have you ever witnessed incidents of animals falling in the shafts or dying of cyanide poisoning?	☒			spillage from TSE killed cattle
Have ever noticed plant growth deteriorating near ASM sites?	☒			Trees are cut in gold rush areas
Have you ever noticed any changes in the drinking water fetched from the protected wells near mining sites?	☒			
Have you ever used cyanide for mineral processing?	☒			leaching of tailings
Have you ever used mercury to recover gold?	☒			

Do you understand the dangers posed by the use and inappropriate disposal of both cyanide and mercury?	✓			Mercury fumes affect lungs
Is there any erosion initiated from the mine sites?				
Can the waste rock stockpiles find use within the community?	✓			road construction
How do you dispose of tailings and water containing cyanide?				Standard TSF
How do you dispose of mercury to recover gold from amalgam – do you burn it with fire?	✓			Burning in an open space
How best can tailings be stockpiled and how can chemical danger be minimized?				Putting a liner on the floor before loading tailings
What are your thoughts on waste and tailings management, and land rehabilitation?				Educating ASMs
What could be done to improve waste storage and tailings disposal?				-Learn more about disposing according to Environmental laws
In your opinion, does the need for survival outweigh the concern for the environment?			✓	Humans depend on the environment
What adjustments could be made to the environmental legislation in order to include ASM?				Educating ASM
Do you know of any government procedures to follow before you start ASM mining processes?	✓			Mining license
Will you adhere to the environmental legislation if the government puts enforcement measures? How?				Following laws from the Ministry
What can you suggest or special message to the ASM teams?				Seminars to educate about the environment
What steps can Otter Mining take to ensure that ASM activities are done responsibly in its Mining License area?				Following environmental laws in all the licensed area
Do you believe in preparing a good environmental legacy for future generations, and how is it possible?				Following procedures to tailings Mgt.
In your opinion, how best can the environment be protected during and after mining processes?				Educating & informing the ASM to follow proper standards

Research Questionnaire – Otter Mining

Participant Role:

Miner Yes / No

Community member Yes / No

Mineral processor ☒ Yes / No

Fisher Yes / No

Otter Mine Management Yes / No

Other.....

Male ☒ Female..... Age 30

Date 07 / 06 / 2024

Questions	Yes	Maybe	No	Comments
Do you have basic understanding of the environmental legislation?	☒			
Do you know of any environmental policies that you follow when mining or processing?			☒	
Have you ever witnessed any water pollution near the mining sites?	☒			
Have you ever witnessed mass death of fish or any aquatic life in the rivers?	☒			
Have you ever witnessed incidents of animals falling in the shafts or dying of cyanide poisoning?	☒			
Have ever noticed plant growth deteriorating near ASM sites?			☒	
Have you ever noticed any changes in the drinking water fetched from the protected wells near mining sites?			☒	
Have you ever used cyanide for mineral processing?	☒			
Have you ever used mercury to recover gold?	☒			

Do you understand the dangers posed by the use and inappropriate disposal of both cyanide and mercury?	✓			
Is there any erosion initiated from the mine sites?			✓	
Can the waste rock stockpiles find use within the community?	✓			
How do you dispose of tailings and water containing cyanide?				establish designated dumping areas
How do you dispose of mercury to recover gold from amalgam – do you burn it with fire?	✓			
How best can tailings be stockpiled and how can chemical danger be minimized?				fencing TSFs & all stockpiles
What are your thoughts on waste and tailings management, and land rehabilitation?				Reduce cyanide concentration
What could be done to improve waste storage and tailings disposal?				Keep concentration low
In your opinion, does the need for survival outweigh the concern for the environment?	✓			
What adjustments could be made to the environmental legislation in order to include ASM?				Teach ASMs about envr legislation
Do you know of any government procedures to follow before you start ASM mining processes?			✓	
Will you adhere to the environmental legislation if the government puts enforcement measures? How?				Yes, all the laws
What can you suggest or special message to the ASM teams?				Move villages to safe places/areas
What steps can Otter Mining take to ensure that ASM activities are done responsibly in its Mining License area?				Follow up for compliance check
Do you believe in preparing a good environmental legacy for future generations, and how is it possible?	✓			think of the Env. when mining
In your opinion, how best can the environment be protected during and after mining processes?				Proper disposal of effluent

Research Questionnaire – Otter Mining

Participant Role:

Miner Yes / No

Community member ☒ Yes ☐ No

Mineral processor Yes / No

Fisher Yes / No

Otter Mine Management ☒ Yes ☐ No

Other.....

Male ☒ Female..... Age 26

Date 07/08/2024

Questions	Yes	Maybe	No	Comments
Do you have basic understanding of the environmental legislation?	☒			large scale Mining legislation
Do you know of any environmental policies that you follow when mining or processing?	☒			
Have you ever witnessed any water pollution near the mining sites?				N/A
Have you ever witnessed mass death of fish or any aquatic life in the rivers?			☒	
Have you ever witnessed incidents of animals falling in the shafts or dying of cyanide poisoning?	☒			
Have ever noticed plant growth deteriorating near ASM sites?	☒			
Have you ever noticed any changes in the drinking water fetched from the protected wells near mining sites?			☒	
Have you ever used cyanide for mineral processing?	☒			At Otter Mine
Have you ever used mercury to recover gold?	☒			Outside of the Mine (Personal work)

Do you understand the dangers posed by the use and inappropriate disposal of both cyanide and mercury?	✓			- Cyanide is very toxic - Mercury gas is harmful when inhaled
Is there any erosion initiated from the mine sites?	✓			
Can the waste rock stockpiles find use within the community?	✓			Road construction
How do you dispose of tailings and water containing cyanide?				T.S.F
How do you dispose of mercury to recover gold from amalgam – do you burn it with fire?	✓			
How best can tailings be stockpiled and how can chemical danger be minimized?				- good handling of chemical - minimise concentration on disposed
What are your thoughts on waste and tailings management, and land rehabilitation?				N/A
What could be done to improve waste storage and tailings disposal?				- Getting rid of toxic chemicals before disposal
In your opinion, does the need for survival outweigh the concern for the environment?		✓		- we don't want to kill what we depend on
What adjustments could be made to the environmental legislation in order to include ASM?				-
Do you know of any government procedures to follow before you start ASM mining processes?				Mining and processing license
Will you adhere to the environmental legislation if the government puts enforcement measures? How?				N/A
What can you suggest or special message to the ASM teams?				- Protect the environment when mining
What steps can Otter Mining take to ensure that ASM activities are done responsibly in its Mining License area?				- legal regulations & punishment to the offenders
Do you believe in preparing a good environmental legacy for future generations, and how is it possible?	✓			Govt assistance is required on this
In your opinion, how best can the environment be protected during and after mining processes?				- Mining laws - proper waste disposal

Research Questionnaire – Otter Mining

Participant Role:

Miner ☒ Yes ☐ No

Community member ☐ Yes ☐ No

Mineral processor ☒ Yes ☐ No

Fisher ☐ Yes ☐ No

Otter Mine Management ☐ Yes ☐ No

Other.....

Male ☒ Female ☐ Age 27

Date...../...../2024

Questions	Yes	Maybe	No	Comments
Do you have basic understanding of the environmental legislation?			☒	
Do you know of any environmental policies that you follow when mining or processing?			☒	
Have you ever witnessed any water pollution near the mining sites?	☒			
Have you ever witnessed mass death of fish or any aquatic life in the rivers?			☒	
Have you ever witnessed incidents of animals falling in the shafts or dying of cyanide poisoning?	☒			
Have ever noticed plant growth deteriorating near ASM sites?	☒			
Have you ever noticed any changes in the drinking water fetched from the protected wells near mining sites?			☒	
Have you ever used cyanide for mineral processing?			☒	
Have you ever used mercury to recover gold?	☒			

Do you understand the dangers posed by the use and inappropriate disposal of both cyanide and mercury?	✓			
Is there any erosion initiated from the mine sites?	✓			
Can the waste rock stockpiles find use within the community?	✓			
How do you dispose of tailings and water containing cyanide?				—
How do you dispose of mercury to recover gold from amalgam – do you burn it with fire?	✓			
How best can tailings be stockpiled and how can chemical danger be minimized?				—
What are your thoughts on waste and tailings management, and land rehabilitation?				—
What could be done to improve waste storage and tailings disposal?				Sharing knowledge with ASMs
In your opinion, does the need for survival outweigh the concern for the environment?	✓			
What adjustments could be made to the environmental legislation in order to include ASM?				—
Do you know of any government procedures to follow before you start ASM mining processes?			✓	
Will you adhere to the environmental legislation if the government puts enforcement measures? How?	✓			Following the law if Govt publishes.
What can you suggest or special message to the ASM teams?				—
What steps can Otter Mining take to ensure that ASM activities are done responsibly in its Mining License area?				Educating Asm on responsible mining
Do you believe in preparing a good environmental legacy for future generations, and how is it possible?	✓			
In your opinion, how best can the environment be protected during and after mining processes?				—

Research Questionnaire – Otter Mining

Participant Role:

Miner

☒ Yes / No

Community member

Yes / No

Mineral processor

☒ Yes / No

Fisher

Yes / No

Otter Mine Management

Yes / No

Other.....

Male ☒ Female..... Age 22

Date 09 / 06 / 2024

Questions	Yes	Maybe	No	Comments
Do you have basic understanding of the environmental legislation?		☒		Have not heard about it.
Do you know of any environmental policies that you follow when mining or processing?			☒	
Have you ever witnessed any water pollution near the mining sites?			☒	
Have you ever witnessed mass death of fish or any aquatic life in the rivers?			☒	
Have you ever witnessed incidents of animals falling in the shafts or dying of cyanide poisoning?	☒			cyanide.
Have ever noticed plant growth deteriorating near ASM sites?			☒	
Have you ever noticed any changes in the drinking water fetched from the protected wells near mining sites?			☒	
Have you ever used cyanide for mineral processing?			☒	
Have you ever used mercury to recover gold?	☒			

Do you understand the dangers posed by the use and inappropriate disposal of both cyanide and mercury?	✓			Animal deaths
Is there any erosion initiated from the mine sites?		✓		
Can the waste rock stockpiles find use within the community?			✓	Backfilling gullies
How do you dispose of tailings and water containing cyanide?				N/A
How do you dispose of mercury to recover gold from amalgam – do you burn it with fire?	✓			
How best can tailings be stockpiled and how can chemical danger be minimized?				N/A
What are your thoughts on waste and tailings management, and land rehabilitation?				Important for keeping the env, good
What could be done to improve waste storage and tailings disposal?				Setting up ASM countries to enforce
In your opinion, does the need for survival outweigh the concern for the environment?			✓	
What adjustments could be made to the environmental legislation in order to include ASM?		N/A		Find cheaper ways affordable to common people.
Do you know of any government procedures to follow before you start ASM mining processes?			✓	
Will you adhere to the environmental legislation if the government puts enforcement measures? How?	✓			costly though - need govt assistance
What can you suggest or special message to the ASM teams?				N/A
What steps can Otter Mining take to ensure that ASM activities are done responsibly in its Mining License area?				N/A
Do you believe in preparing a good environmental legacy for future generations, and how is it possible?	✓			
In your opinion, how best can the environment be protected during and after mining processes?				Environment legislation that can be enforced

Research Questionnaire – Otter Mining

Participant Role:

Miner

☒ Yes / No

Community member

Yes / No

Mineral processor

☒ Yes / No

Fisher

Yes / No

Otter Mine Management

Yes / No

Other.....

Male / ☒ Female..... Age..... 24

Date..... 07...../08...../2024

Questions	Yes	Maybe	No	Comments
Do you have basic understanding of the environmental legislation?			☒	
Do you know of any environmental policies that you follow when mining or processing?			☒	
Have you ever witnessed any water pollution near the mining sites?	☒			
Have you ever witnessed mass death of fish or any aquatic life in the rivers?			☒	
Have you ever witnessed incidents of animals falling in the shafts or dying of cyanide poisoning?	☒			Cyanide & shafts
Have ever noticed plant growth deteriorating near ASM sites?	☒			Trees are cut and grow poorly
Have you ever noticed any changes in the drinking water fetched from the protected wells near mining sites?	☒			
Have you ever used cyanide for mineral processing?			☒	used for leaching
Have you ever used mercury to recover gold?	☒			

Do you understand the dangers posed by the use and inappropriate disposal of both cyanide and mercury?			✓	
Is there any erosion initiated from the mine sites?	✓			
Can the waste rock stockpiles find use within the community?	✓			Road construction
How do you dispose of tailings and water containing cyanide?				Anywhere
How do you dispose of mercury to recover gold from amalgam – do you burn it with fire?	✓			Burning
How best can tailings be stockpiled and how can chemical danger be minimized?				No idea
What are your thoughts on waste and tailings management, and land rehabilitation?				No idea
What could be done to improve waste storage and tailings disposal?				Piling in one place
In your opinion, does the need for survival outweigh the concern for the environment?	✓			
What adjustments could be made to the environmental legislation in order to include ASM?				No idea
Do you know of any government procedures to follow before you start ASM mining processes?			✓	
Will you adhere to the environmental legislation if the government puts enforcement measures? How?		✓		- Could be complex - Too costly
What can you suggest or special message to the ASM teams?				N/A
What steps can Otter Mining take to ensure that ASM activities are done responsibly in its Mining License area?				Support ASM with resources
Do you believe in preparing a good environmental legacy for future generations, and how is it possible?	✓			Mining responsibly
In your opinion, how best can the environment be protected during and after mining processes?				N/A

Research Questionnaire – Otter Mining

Participant Role:

Miner Yes / No

Community member Yes / No

Mineral processor Yes / No

Fisher ☒ Yes ☐ No

Otter Mine Management Yes / No

Other.....

☒ Male ☐ Female..... Age... 19

Date 07/06/2024

Questions	Yes	Maybe	No	Comments
Do you have basic understanding of the environmental legislation?			☒	
Do you know of any environmental policies that you follow when mining or processing?			☒	
Have you ever witnessed any water pollution near the mining sites?	☒			
Have you ever witnessed mass death of fish or any aquatic life in the rivers?			☒	
Have you ever witnessed incidents of animals falling in the shafts or dying of cyanide poisoning?			☒	
Have ever noticed plant growth deteriorating near ASM sites?				—
Have you ever noticed any changes in the drinking water fetched from the protected wells near mining sites?			☒	
Have you ever used cyanide for mineral processing?			☒	
Have you ever used mercury to recover gold?			☒	

Do you understand the dangers posed by the use and inappropriate disposal of both cyanide and mercury?	✓			
Is there any erosion initiated from the mine sites?			✓	
Can the waste rock stockpiles find use within the community?	✓			
How do you dispose of tailings and water containing cyanide?				Tailings dam
How do you dispose of mercury to recover gold from amalgam – do you burn it with fire?	✓			
How best can tailings be stockpiled and how can chemical danger be minimized?				- Planting trees on tailings - This reduces running water eroding the land
What are your thoughts on waste and tailings management, and land rehabilitation?				- Preserve the env. for future generations
What could be done to improve waste storage and tailings disposal?				Training should be done to know
In your opinion, does the need for survival outweigh the concern for the environment?			✓	
What adjustments could be made to the environmental legislation in order to include ASM?				Introduce regulations to the ASM
Do you know of any government procedures to follow before you start ASM mining processes?			✓	
Will you adhere to the environmental legislation if the government puts enforcement measures? How?				—
What can you suggest or special message to the ASM teams?				—
What steps can Otter Mining take to ensure that ASM activities are done responsibly in its Mining License area?				—
Do you believe in preparing a good environmental legacy for future generations, and how is it possible?	✓			
In your opinion, how best can the environment be protected during and after mining processes?				Afforestation

Research Questionnaire – Otter Mining

Participant Role:

Miner Yes / No

Community member ☒ Yes/ No

Mineral processor ☒ Yes/ No

Fisher ☒ Yes / No

Otter Mine Management Yes / No

Other.....

☒ Male/ Female..... Age 24

Date 08/06/2024

Questions	Yes	Maybe	No	Comments
Do you have basic understanding of the environmental legislation?			☒	
Do you know of any environmental policies that you follow when mining or processing?			☒	
Have you ever witnessed any water pollution near the mining sites?	☒			
Have you ever witnessed mass death of fish or any aquatic life in the rivers?				—
Have you ever witnessed incidents of animals falling in the shafts or dying of cyanide poisoning?	☒			
Have ever noticed plant growth deteriorating near ASM sites?	☒			
Have you ever noticed any changes in the drinking water fetched from the protected wells near mining sites?			☒	
Have you ever used cyanide for mineral processing?			☒	
Have you ever used mercury to recover gold?	☒			—

Do you understand the dangers posed by the use and inappropriate disposal of both cyanide and mercury?	✓			
Is there any erosion initiated from the mine sites?	✓			
Can the waste rock stockpiles find use within the community?	✓			we have witnessed roads fixed using waste rocks in other places
How do you dispose of tailings and water containing cyanide?				—
How do you dispose of mercury to recover gold from amalgam – do you burn it with fire?				—
How best can tailings be stockpiled and how can chemical danger be minimized?				—
What are your thoughts on waste and tailings management, and land rehabilitation?				—
What could be done to improve waste storage and tailings disposal?				—
In your opinion, does the need for survival outweigh the concern for the environment?			✓	
What adjustments could be made to the environmental legislation in order to include ASM?				—
Do you know of any government procedures to follow before you start ASM mining processes?			✓	
Will you adhere to the environmental legislation if the government puts enforcement measures? How?				Report all env breaches
What can you suggest or special message to the ASM teams?				To be aware of other people, animals & ecosystem living in the same environment that they are destroying
What steps can Otter Mining take to ensure that ASM activities are done responsibly in its Mining License area?				—
Do you believe in preparing a good environmental legacy for future generations, and how is it possible?				Agmt to set aside funds for environmental protection
In your opinion, how best can the environment be protected during and after mining processes?				—

Research Questionnaire – Otter Mining

Participant Role:

Miner Yes / No

Community member Yes / No

Mineral processor ☒ Yes / No

Fisher Yes / No

Otter Mine Management Yes / No

Other.....

☒ Male / Female..... Age 23

Date 09/08/2024

Questions	Yes	Maybe	No	Comments
Do you have basic understanding of the environmental legislation?	☒			
Do you know of any environmental policies that you follow when mining or processing?	☒			
Have you ever witnessed any water pollution near the mining sites?			☒	
Have you ever witnessed mass death of fish or any aquatic life in the rivers?			☒	
Have you ever witnessed incidents of animals falling in the shafts or dying of cyanide poisoning?	☒			
Have ever noticed plant growth deteriorating near ASM sites?	☒			
Have you ever noticed any changes in the drinking water fetched from the protected wells near mining sites?			☒	
Have you ever used cyanide for mineral processing?			☒	
Have you ever used mercury to recover gold?	☒			

Do you understand the dangers posed by the use and inappropriate disposal of both cyanide and mercury?	✓			
Is there any erosion initiated from the mine sites?			✓	
Can the waste rock stockpiles find use within the community?	✓			
How do you dispose of tailings and water containing cyanide?				TSF & recycling
How do you dispose of mercury to recover gold from amalgam – do you burn it with fire?	✓			
How best can tailings be stockpiled and how can chemical danger be minimized?				Design storage dams - PPE
What are your thoughts on waste and tailings management, and land rehabilitation?				TSF to be at least 100m from sites for safety
What could be done to improve waste storage and tailings disposal?				Education & enforcing ENV. laws
In your opinion, does the need for survival outweigh the concern for the environment?				
What adjustments could be made to the environmental legislation in order to include ASM?				Providing policies
Do you know of any government procedures to follow before you start ASM mining processes?	✓			
Will you adhere to the environmental legislation if the government puts enforcement measures? How?				Following policies
What can you suggest or special message to the ASM teams?				Involve professionals in the work
What steps can Otter Mining take to ensure that ASM activities are done responsibly in its Mining License area?				-
Do you believe in preparing a good environmental legacy for future generations, and how is it possible?	✓			
In your opinion, how best can the environment be protected during and after mining processes?				Follow up during & after mining -

Research Questionnaire – Otter Mining

Participant Role:

Miner ☒ Yes / No

Community member ☒ Yes / No

Mineral processor ☒ Yes / No

Fisher Yes / No

Otter Mine Management Yes / No

Other.....

☒ Male / Female..... Age 28

Date 08/06/2024

Questions	Yes	Maybe	No	Comments
Do you have basic understanding of the environmental legislation?			☒	
Do you know of any environmental policies that you follow when mining or processing?	☒			
Have you ever witnessed any water pollution near the mining sites?	☒			
Have you ever witnessed mass death of fish or any aquatic life in the rivers?	☒			
Have you ever witnessed incidents of animals falling in the shafts or dying of cyanide poisoning?	☒			
Have ever noticed plant growth deteriorating near ASM sites?			☒	
Have you ever noticed any changes in the drinking water fetched from the protected wells near mining sites?			☒	
Have you ever used cyanide for mineral processing?	☒			
Have you ever used mercury to recover gold?	☒			

Do you understand the dangers posed by the use and inappropriate disposal of both cyanide and mercury?	✓		
Is there any erosion initiated from the mine sites?			✓
Can the waste rock stockpiles find use within the community?	✓		
How do you dispose of tailings and water containing cyanide?			TSF
How do you dispose of mercury to recover gold from amalgam – do you burn it with fire?	✓		
How best can tailings be stockpiled and how can chemical danger be minimized?			-fencing -dry stacking
What are your thoughts on waste and tailings management, and land rehabilitation?			proper storage to avoid effects to the ecosystem
What could be done to improve waste storage and tailings disposal?			-keeping tailings dry
In your opinion, does the need for survival outweigh the concern for the environment?			life depends on the environment
What adjustments could be made to the environmental legislation in order to include ASM?			—
Do you know of any government procedures to follow before you start ASM mining processes?	✓		Secure licenses
Will you adhere to the environmental legislation if the government puts enforcement measures? How?			Follow laws
What can you suggest or special message to the ASM teams?			Follow environmental policy
What steps can Otter Mining take to ensure that ASM activities are done responsibly in its Mining License area?			—
Do you believe in preparing a good environmental legacy for future generations, and how is it possible?			-Education -Afforestation
In your opinion, how best can the environment be protected during and after mining processes?			-minimise ASM & promote LSM

Research Questionnaire – Otter Mining

Participant Role:

Miner ☒ Yes / No

Community member Yes / No

Mineral processor ☒ Yes / No

Fisher Yes / No

Otter Mine Management Yes / No

Other.....

☒ Male / Female..... Age 26

Date 10 / 06 / 2024

Questions	Yes	Maybe	No	Comments
Do you have basic understanding of the environmental legislation?	☒			
Do you know of any environmental policies that you follow when mining or processing?	☒			
Have you ever witnessed any water pollution near the mining sites?	☒			
Have you ever witnessed mass death of fish or any aquatic life in the rivers?	☒			
Have you ever witnessed incidents of animals falling in the shafts or dying of cyanide poisoning?	☒			
Have ever noticed plant growth deteriorating near ASM sites?			☒	
Have you ever noticed any changes in the drinking water fetched from the protected wells near mining sites?	☒			
Have you ever used cyanide for mineral processing?	☒			
Have you ever used mercury to recover gold?	☒			

Do you understand the dangers posed by the use and inappropriate disposal of both cyanide and mercury?	✓			
Is there any erosion initiated from the mine sites?	✓			
Can the waste rock stockpiles find use within the community?			✓	
How do you dispose of tailings and water containing cyanide?				Tsf
How do you dispose of mercury to recover gold from amalgam – do you burn it with fire?				Tsf
How best can tailings be stockpiled and how can chemical danger be minimized?	✓			
What are your thoughts on waste and tailings management, and land rehabilitation?				They should be done in a way that does not harm the env.
What could be done to improve waste storage and tailings disposal?				—Have designated areas to stockpiling of TSFs
In your opinion, does the need for survival outweigh the concern for the environment?	✓			
What adjustments could be made to the environmental legislation in order to include ASM?				—
Do you know of any government procedures to follow before you start ASM mining processes?	✓			
Will you adhere to the environmental legislation if the government puts enforcement measures? How?	✓			Complying to the legislation fully
What can you suggest or special message to the ASM teams?				To mine responsibly and consider the environment
What steps can Otter Mining take to ensure that ASM activities are done responsibly in its Mining License area?				Supporting the local miners with env. education & guidance.
Do you believe in preparing a good environmental legacy for future generations, and how is it possible?	✓			
In your opinion, how best can the environment be protected during and after mining processes?				set a good plan ahead.

Research Questionnaire – Otter Mining

Participant Role:

Miner Yes / No

Community member ☒ Yes / No

Mineral processor Yes / No

Fisher ☒ Yes / No

Otter Mine Management Yes / No

Other.....

☒ Male / Female..... Age... 35

Date... 07.06/2024

Questions	Yes	Maybe	No	Comments
Do you have basic understanding of the environmental legislation?			☒	
Do you know of any environmental policies that you follow when mining or processing?			☒	
Have you ever witnessed any water pollution near the mining sites?	☒			
Have you ever witnessed mass death of fish or any aquatic life in the rivers?			☒	But sometimes water is dirty from effluent
Have you ever witnessed incidents of animals falling in the shafts or dying of cyanide poisoning?	☒			
Have ever noticed plant growth deteriorating near ASM sites?	☒			
Have you ever noticed any changes in the drinking water fetched from the protected wells near mining sites?		☒		It differs with seasons
Have you ever used cyanide for mineral processing?			☒	
Have you ever used mercury to recover gold?			☒	

Do you understand the dangers posed by the use and inappropriate disposal of both cyanide and mercury?	.	✓		Have an idea
Is there any erosion initiated from the mine sites?	✓			
Can the waste rock stockpiles find use within the community?	✓			
How do you dispose of tailings and water containing cyanide?				—
How do you dispose of mercury to recover gold from amalgam – do you burn it with fire?				—
How best can tailings be stockpiled and how can chemical danger be minimized?				—
What are your thoughts on waste and tailings management, and land rehabilitation?				It should allow land to be used again
What could be done to improve waste storage and tailings disposal?				—
In your opinion, does the need for survival outweigh the concern for the environment?			✓	
What adjustments could be made to the environmental legislation in order to include ASM?				Include the community's decisions to mining issues.
Do you know of any government procedures to follow before you start ASM mining processes?				—
Will you adhere to the environmental legislation if the government puts enforcement measures? How?				—
What can you suggest or special message to the ASM teams?				—
What steps can Otter Mining take to ensure that ASM activities are done responsibly in its Mining License area?				Enforce compliance
Do you believe in preparing a good environmental legacy for future generations, and how is it possible?	✓			
In your opinion, how best can the environment be protected during and after mining processes?				—

Research Questionnaire – Otter Mining

Participant Role:

Miner ☒ Yes / No

Community member ☒ Yes / No

Mineral processor ☒ Yes / No

Fisher Yes / No

Otter Mine Management Yes / No

Other.....

☒ Male / ☐ Female..... Age 44

Date 09 / 06 / 2024

Questions	Yes	Maybe	No	Comments
Do you have basic understanding of the environmental legislation?			☒	
Do you know of any environmental policies that you follow when mining or processing?			☒	
Have you ever witnessed any water pollution near the mining sites?	☒			
Have you ever witnessed mass death of fish or any aquatic life in the rivers?			☒	
Have you ever witnessed incidents of animals falling in the shafts or dying of cyanide poisoning?	☒			
Have ever noticed plant growth deteriorating near ASM sites?	☒			
Have you ever noticed any changes in the drinking water fetched from the protected wells near mining sites?			☒	
Have you ever used cyanide for mineral processing?			☒	
Have you ever used mercury to recover gold?	☒			

Do you understand the dangers posed by the use and inappropriate disposal of both cyanide and mercury?	✓			
Is there any erosion initiated from the mine sites?	✓			
Can the waste rock stockpiles find use within the community?		✓		Road especially in swampy areas
How do you dispose of tailings and water containing cyanide?				TSF
How do you dispose of mercury to recover gold from amalgam – do you burn it with fire?	✓			
How best can tailings be stockpiled and how can chemical danger be minimized?				-TSF -Drying tailings
What are your thoughts on waste and tailings management, and land rehabilitation?				Good for other land uses
What could be done to improve waste storage and tailings disposal?				Set aside enough land for that
In your opinion, does the need for survival outweigh the concern for the environment?	✓			People are living in poverty now.
What adjustments could be made to the environmental legislation in order to include ASM?				Be specific as to where it applies
Do you know of any government procedures to follow before you start ASM mining processes?			✓	
Will you adhere to the environmental legislation if the government puts enforcement measures? How?		✓		Govt funding required because miners are poor.
What can you suggest or special message to the ASM teams?				To be responsible
What steps can Otter Mining take to ensure that ASM activities are done responsibly in its Mining License area?				Involve police or govt to enforce standards
Do you believe in preparing a good environmental legacy for future generations, and how is it possible?	✓			
In your opinion, how best can the environment be protected during and after mining processes?				Proper mining ways

Research Questionnaire – Otter Mining

Participant Role:

Miner

☒ Yes / No

Community member

Yes / No

Mineral processor

☒ Yes / No

Fisher

Yes / No

Otter Mine Management

Yes / No

Other.....

☒ Male / Female..... Age 32

Date 10 / 06 / 2024

Questions	Yes	Maybe	No	Comments
Do you have basic understanding of the environmental legislation?	☒			
Do you know of any environmental policies that you follow when mining or processing?	☐			Yes but not following
Have you ever witnessed any water pollution near the mining sites?	☒			It is normal at mine sites
Have you ever witnessed mass death of fish or any aquatic life in the rivers?			☒	
Have you ever witnessed incidents of animals falling in the shafts or dying of cyanide poisoning?	☒			
Have ever noticed plant growth deteriorating near ASM sites?	☒			
Have you ever noticed any changes in the drinking water fetched from the protected wells near mining sites?			☒	
Have you ever used cyanide for mineral processing?	☒			
Have you ever used mercury to recover gold?	☒			

Do you understand the dangers posed by the use and inappropriate disposal of both cyanide and mercury?	✓			
Is there any erosion initiated from the mine sites?	✓			
Can the waste rock stockpiles find use within the community?	✓			Bridges construction
How do you dispose of tailings and water containing cyanide?				Tanks in fenced area
How do you dispose of mercury to recover gold from amalgam – do you burn it with fire?	✓			
How best can tailings be stockpiled and how can chemical danger be minimized?				TsF and fencing
What are your thoughts on waste and tailings management, and land rehabilitation?				Good to land utilization for farming
What could be done to improve waste storage and tailings disposal?				Education
In your opinion, does the need for survival outweigh the concern for the environment?			✓	
What adjustments could be made to the environmental legislation in order to include ASM?				The law to be clear to every part
Do you know of any government procedures to follow before you start ASM mining processes?			✓	
Will you adhere to the environmental legislation if the government puts enforcement measures? How?	✓			Implementing the Law & Standards
What can you suggest or special message to the ASM teams?				—
What steps can Otter Mining take to ensure that ASM activities are done responsibly in its Mining License area?				—
Do you believe in preparing a good environmental legacy for future generations, and how is it possible?	✓			
In your opinion, how best can the environment be protected during and after mining processes?				Govt to fund environmental protection

Research Questionnaire – Otter Mining

Participant Role:

Miner Yes / No

Community member ☒ Yes / No

Mineral processor Yes / No

Fisher Yes / No

Otter Mine Management Yes / No

Other.....

☒ Male / ☐ Female..... Age 32

Date 10/06/2024

Questions	Yes	Maybe	No	Comments
Do you have basic understanding of the environmental legislation?			☒	
Do you know of any environmental policies that you follow when mining or processing?			☒	
Have you ever witnessed any water pollution near the mining sites?			☒	
Have you ever witnessed mass death of fish or any aquatic life in the rivers?			☒	
Have you ever witnessed incidents of animals falling in the shafts or dying of cyanide poisoning?	☒			
Have ever noticed plant growth deteriorating near ASM sites?	☒			
Have you ever noticed any changes in the drinking water fetched from the protected wells near mining sites?			☒	
Have you ever used cyanide for mineral processing?			☒	
Have you ever used mercury to recover gold?			☒	

Do you understand the dangers posed by the use and inappropriate disposal of both cyanide and mercury?			✓	
Is there any erosion initiated from the mine sites?	✓			
Can the waste rock stockpiles find use within the community?	✓			
How do you dispose of tailings and water containing cyanide?				Road repairs
How do you dispose of mercury to recover gold from amalgam – do you burn it with fire?				—
How best can tailings be stockpiled and how can chemical danger be minimized?				—
What are your thoughts on waste and tailings management, and land rehabilitation?				should be contained within the mine area
What could be done to improve waste storage and tailings disposal?				Education about the handling procedures
In your opinion, does the need for survival outweigh the concern for the environment?	✓		✓	
What adjustments could be made to the environmental legislation in order to include ASM?				—
Do you know of any government procedures to follow before you start ASM mining processes?				—
Will you adhere to the environmental legislation if the government puts enforcement measures? How?				Following the laws
What can you suggest or special message to the ASM teams?				Continue mining without affecting the community
What steps can Otter Mining take to ensure that ASM activities are done responsibly in its Mining License area?				—
Do you believe in preparing a good environmental legacy for future generations, and how is it possible?	✓			
In your opinion, how best can the environment be protected during and after mining processes?				Following Ministry laws & procedures (mines & Environment)

Research Questionnaire – Otter Mining

Participant Role:

Miner ☒ Yes / No

Community member Yes / No

Mineral processor ☒ Yes / No

Fisher Yes / No

Otter Mine Management Yes / No

Other.....

☒ Male / Female..... Age...42

Date...10/06/2024

Questions	Yes	Maybe	No	Comments
Do you have basic understanding of the environmental legislation?			☒	
Do you know of any environmental policies that you follow when mining or processing?			☒	
Have you ever witnessed any water pollution near the mining sites?	☒			
Have you ever witnessed mass death of fish or any aquatic life in the rivers?			☒	
Have you ever witnessed incidents of animals falling in the shafts or dying of cyanide poisoning?	☒			
Have ever noticed plant growth deteriorating near ASM sites?	☒			
Have you ever noticed any changes in the drinking water fetched from the protected wells near mining sites?			☒	Wells are protected using concrete slabs
Have you ever used cyanide for mineral processing?	☒			
Have you ever used mercury to recover gold?	☒			

Do you understand the dangers posed by the use and inappropriate disposal of both cyanide and mercury?	✓			
Is there any erosion initiated from the mine sites?	✓			
Can the waste rock stockpiles find use within the community?		✓		
How do you dispose of tailings and water containing cyanide?				T SFs & - Tanks
How do you dispose of mercury to recover gold from amalgam – do you burn it with fire?	✓			
How best can tailings be stockpiled and how can chemical danger be minimized?				—
What are your thoughts on waste and tailings management, and land rehabilitation?				It reduces envr damage. Rehab,
What could be done to improve waste storage and tailings disposal?				Educational seminars by Govt
In your opinion, does the need for survival outweigh the concern for the environment?	✓			
What adjustments could be made to the environmental legislation in order to include ASM?				Cheaper ways by the Govt
Do you know of any government procedures to follow before you start ASM mining processes?			✓	
Will you adhere to the environmental legislation if the government puts enforcement measures? How?				Implementing the laws
What can you suggest or special message to the ASM teams?				Strict laws Implementation
What steps can Otter Mining take to ensure that ASM activities are done responsibly in its Mining License area?				—
Do you believe in preparing a good environmental legacy for future generations, and how is it possible?	✓			
In your opinion, how best can the environment be protected during and after mining processes?				Enforcing best practices

Research Questionnaire – Otter Mining

Participant Role:

Miner Yes / No

Community member Yes / No

Mineral processor Yes / No

Fisher Yes / No

Otter Mine Management ☒ Yes / No

Other.....

☒ Male / Female..... Age 34

Date 09/06 /2024

Questions	Yes	Maybe	No	Comments
Do you have basic understanding of the environmental legislation?	☒			
Do you know of any environmental policies that you follow when mining or processing?	☒			
Have you ever witnessed any water pollution near the mining sites?	☒			
Have you ever witnessed mass death of fish or any aquatic life in the rivers?			☒	
Have you ever witnessed incidents of animals falling in the shafts or dying of cyanide poisoning?	☒			
Have ever noticed plant growth deteriorating near ASM sites?	☒			
Have you ever noticed any changes in the drinking water fetched from the protected wells near mining sites?			☒	
Have you ever used cyanide for mineral processing?	☒			company - VAT leaching
Have you ever used mercury to recover gold?	☒			

Do you understand the dangers posed by the use and inappropriate disposal of both cyanide and mercury?	✓			
Is there any erosion initiated from the mine sites?	✓			
Can the waste rock stockpiles find use within the community?	✓			
How do you dispose of tailings and water containing cyanide?				In places designated for that but people do shortcuts
How do you dispose of mercury to recover gold from amalgam – do you burn it with fire?	✓			
How best can tailings be stockpiled and how can chemical danger be minimized?				Away from animals and people
What are your thoughts on waste and tailings management, and land rehabilitation?				- Establishing places for disposal of tailings & waste.
What could be done to improve waste storage and tailings disposal?			✓	
In your opinion, does the need for survival outweigh the concern for the environment?			✓	
What adjustments could be made to the environmental legislation in order to include ASM?			✓	
Do you know of any government procedures to follow before you start ASM mining processes?				N/A
Will you adhere to the environmental legislation if the government puts enforcement measures? How?	✓			Understanding the requirements of the regulation
What can you suggest or special message to the ASM teams?				Hurry but be safe and follow environment laws.
What steps can Otter Mining take to ensure that ASM activities are done responsibly in its Mining License area?				- Following the laws from the Govt
Do you believe in preparing a good environmental legacy for future generations, and how is it possible?	✓			- Blocky shafts - Afforestation - Rehabilitation
In your opinion, how best can the environment be protected during and after mining processes?				- Disposing off poisonous chemical properly in fenced areas

Research Questionnaire – Otter Mining

Participant Role:

Miner ☒ Yes / No

Community member Yes / No

Mineral processor Yes / No

Fisher Yes / No

Otter Mine Management ☒ Yes / No

Other.....

☒ Male / ☐ Female..... Age 41.....

Date 07 / 06 / 2024

Questions	Yes	Maybe	No	Comments
Do you have basic understanding of the environmental legislation?	☒			
Do you know of any environmental policies that you follow when mining or processing?	☒			
Have you ever witnessed any water pollution near the mining sites?	☒			
Have you ever witnessed mass death of fish or any aquatic life in the rivers?			☒	
Have you ever witnessed incidents of animals falling in the shafts or dying of cyanide poisoning?	☒			
Have ever noticed plant growth deteriorating near ASM sites?	☒			
Have you ever noticed any changes in the drinking water fetched from the protected wells near mining sites?			☒	
Have you ever used cyanide for mineral processing?	☒			
Have you ever used mercury to recover gold?	☒			

Do you understand the dangers posed by the use and inappropriate disposal of both cyanide and mercury?	✓			
Is there any erosion initiated from the mine sites?	✓			
Can the waste rock stockpiles find use within the community?	✓			
How do you dispose of tailings and water containing cyanide?				Pumped to TFS
How do you dispose of mercury to recover gold from amalgam – do you burn it with fire?				N/A
How best can tailings be stockpiled and how can chemical danger be minimized?				Pump all Mine effluent to TFS
What are your thoughts on waste and tailings management, and land rehabilitation?				N/A
What could be done to improve waste storage and tailings disposal?				Employing more professional who know the dangers of these.
In your opinion, does the need for survival outweigh the concern for the environment?	✓			
What adjustments could be made to the environmental legislation in order to include ASM?				N/A
Do you know of any government procedures to follow before you start ASM mining processes?	✓			
Will you adhere to the environmental legislation if the government puts enforcement measures? How?				Following all required standards of Laws
What can you suggest or special message to the ASM teams?				Continue mining but mind on protecting the environment
What steps can Otter Mining take to ensure that ASM activities are done responsibly in its Mining License area?				Fine the ASM who do not adhere to the regulations
Do you believe in preparing a good environmental legacy for future generations, and how is it possible?	✓			Thorough follow up from the authorities
In your opinion, how best can the environment be protected during and after mining processes?				N/A

Research Questionnaire – Otter Mining

Participant Role:

Miner ☒ Yes / No

Community member ☐ Yes / No

Mineral processor ☒ Yes / No

Fisher ☒ Yes / No

Otter Mine Management ☐ Yes / No

Other.....

☒ Male / Female..... Age 40

Date...../...../2024

Questions	Yes	Maybe	No	Comments
Do you have basic understanding of the environmental legislation?	☒	☐	☒	
Do you know of any environmental policies that you follow when mining or processing?	☐	☐	☒	
Have you ever witnessed any water pollution near the mining sites?	☒	☐	☐	
Have you ever witnessed mass death of fish or any aquatic life in the rivers?	☐	☐	☒	
Have you ever witnessed incidents of animals falling in the shafts or dying of cyanide poisoning?	☒	☐	☐	
Have ever noticed plant growth deteriorating near ASM sites?	☒	☐	☐	
Have you ever noticed any changes in the drinking water fetched from the protected wells near mining sites?	☐	☐	☒	
Have you ever used cyanide for mineral processing?	☐	☐	☒	
Have you ever used mercury to recover gold?	☒	☐	☐	

Do you understand the dangers posed by the use and inappropriate disposal of both cyanide and mercury?	✓			
Is there any erosion initiated from the mine sites?	✓			
Can the waste rock stockpiles find use within the community?	✓			Build houses
How do you dispose of tailings and water containing cyanide?				—
How do you dispose of mercury to recover gold from amalgam – do you burn it with fire?				—
How best can tailings be stockpiled and how can chemical danger be minimized?				Enclose the chemicals to avoid spreading
What are your thoughts on waste and tailings management, and land rehabilitation?				To protect the environment
What could be done to improve waste storage and tailings disposal?				Emphasizing on GVT follow without taking bribes
In your opinion, does the need for survival outweigh the concern for the environment?			✓	
What adjustments could be made to the environmental legislation in order to include ASM?				—
Do you know of any government procedures to follow before you start ASM mining processes?				—
Will you adhere to the environmental legislation if the government puts enforcement measures? How?				Following the legislation
What can you suggest or special message to the ASM teams?				To seek knowledge about mining & processing
What steps can Otter Mining take to ensure that ASM activities are done responsibly in its Mining License area?				—
Do you believe in preparing a good environmental legacy for future generations, and how is it possible?	✓			
In your opinion, how best can the environment be protected during and after mining processes?				Ensure toxic chemicals do not spread into the environment even after mining

Research Questionnaire – Otter Mining

Participant Role:

Miner Yes / No

Community member ☒ Yes / No

Mineral processor Yes / No

Fisher Yes / No

Otter Mine Management Yes / No

Other.....

☒ Male / Female..... Age 35

Date 09/06/2024

Questions	Yes	Maybe	No	Comments
Do you have basic understanding of the environmental legislation?			☒	
Do you know of any environmental policies that you follow when mining or processing?			☒	
Have you ever witnessed any water pollution near the mining sites?	☒			
Have you ever witnessed mass death of fish or any aquatic life in the rivers?			☒	
Have you ever witnessed incidents of animals falling in the shafts or dying of cyanide poisoning?	☒			
Have ever noticed plant growth deteriorating near ASM sites?	☒			
Have you ever noticed any changes in the drinking water fetched from the protected wells near mining sites?	☒			
Have you ever used cyanide for mineral processing?			☒	
Have you ever used mercury to recover gold?			☒	

Do you understand the dangers posed by the use and inappropriate disposal of both cyanide and mercury?	✓			Cyanide is very toxic
Is there any erosion initiated from the mine sites?	✓			
Can the waste rock stockpiles find use within the community?				—
How do you dispose of tailings and water containing cyanide?				Avoid spreading of cyanide into water & land
How do you dispose of mercury to recover gold from amalgam – do you burn it with fire?				—
How best can tailings be stockpiled and how can chemical danger be minimized?				—
What are your thoughts on waste and tailings management, and land rehabilitation?				Govt follow up & enforcement
What could be done to improve waste storage and tailings disposal?				Mining dept to enforce disposal standards
In your opinion, does the need for survival outweigh the concern for the environment?		✓		Effects of survival affect humans now & in the future
What adjustments could be made to the environmental legislation in order to include ASM?				—
Do you know of any government procedures to follow before you start ASM mining processes?		✓		
Will you adhere to the environmental legislation if the government puts enforcement measures? How?				Reporting all environmental breach
What can you suggest or special message to the ASM teams?				Follow standards
What steps can Otter Mining take to ensure that ASM activities are done responsibly in its Mining License area?				—
Do you believe in preparing a good environmental legacy for future generations, and how is it possible?	✓			Govt to assist on this
In your opinion, how best can the environment be protected during and after mining processes?				—

Research Questionnaire – Otter Mining

Participant Role:

Miner Yes / No

Community member ☒ Yes / ☐ No

Mineral processor Yes / No

Fisher Yes / No

Otter Mine Management Yes / No

Other.....

Male ☒ Female ☐ Age 48

Date 09 / 06 / 2024

Questions	Yes	Maybe	No	Comments
Do you have basic understanding of the environmental legislation?		✓		
Do you know of any environmental policies that you follow when mining or processing?			✓	
Have you ever witnessed any water pollution near the mining sites?	✓			
Have you ever witnessed mass death of fish or any aquatic life in the rivers?	✓			Cyanide poisoning when livestock go for water
Have you ever witnessed incidents of animals falling in the shafts or dying of cyanide poisoning?	✓			livestock fall in pits time & again
Have ever noticed plant growth deteriorating near ASM sites?			✓	
Have you ever noticed any changes in the drinking water fetched from the protected wells near mining sites?			✓	
Have you ever used cyanide for mineral processing?			✓	
Have you ever used mercury to recover gold?			✓	

Do you understand the dangers posed by the use and inappropriate disposal of both cyanide and mercury?	✓			Poisonous Cyanide
Is there any erosion initiated from the mine sites?	✓			
Can the waste rock stockpiles find use within the community?	✓			
How do you dispose of tailings and water containing cyanide?				Within the mining site, not outside
How do you dispose of mercury to recover gold from amalgam – do you burn it with fire?				In fenced areas away from animals & humans
How best can tailings be stockpiled and how can chemical danger be minimized?				In such a way that land can be utilized again
What are your thoughts on waste and tailings management, and land rehabilitation?				Best done in a way that land can be used again esp for farming
What could be done to improve waste storage and tailings disposal?				Following govt guidance
In your opinion, does the need for survival outweigh the concern for the environment?			✓	
What adjustments could be made to the environmental legislation in order to include ASM?				Following the legislation
Do you know of any government procedures to follow before you start ASM mining processes?				—
Will you adhere to the environmental legislation if the government puts enforcement measures? How?				—
What can you suggest or special message to the ASM teams?				Health, Safety & environmental responsibility
What steps can Otter Mining take to ensure that ASM activities are done responsibly in its Mining License area?				Following up ASMs & ensure their mining doesn't affect the community & the env.
Do you believe in preparing a good environmental legacy for future generations, and how is it possible?	✓			
In your opinion, how best can the environment be protected during and after mining processes?				Govt follow up without corruption

Research Questionnaire – Otter Mining

Participant Role:

Miner Yes / No

Community member ☒ Yes ☐ No

Mineral processor ☒ Yes ☐ No

Fisher Yes / No

Otter Mine Management Yes / No

Other.....

Male ☒ Female..... Age 40

Date 09 / 06 / 2024

Questions	Yes	Maybe	No	Comments
Do you have basic understanding of the environmental legislation?	☒			
Do you know of any environmental policies that you follow when mining or processing?	☒			
Have you ever witnessed any water pollution near the mining sites?			☒	
Have you ever witnessed mass death of fish or any aquatic life in the rivers?			☒	
Have you ever witnessed incidents of animals falling in the shafts or dying of cyanide poisoning?	☒			
Have ever noticed plant growth deteriorating near ASM sites?	☒			
Have you ever noticed any changes in the drinking water fetched from the protected wells near mining sites?			☒	
Have you ever used cyanide for mineral processing?	☒			
Have you ever used mercury to recover gold?	☒			

Do you understand the dangers posed by the use and inappropriate disposal of both cyanide and mercury?	✓			
Is there any erosion initiated from the mine sites?	✓			
Can the waste rock stockpiles find use within the community?	✓			
How do you dispose of tailings and water containing cyanide?				—
How do you dispose of mercury to recover gold from amalgam – do you burn it with fire?	✓			
How best can tailings be stockpiled and how can chemical danger be minimized?				— Tailings dam
What are your thoughts on waste and tailings management, and land rehabilitation?				—
What could be done to improve waste storage and tailings disposal?				proper design of T&F
In your opinion, does the need for survival outweigh the concern for the environment?			✓	
What adjustments could be made to the environmental legislation in order to include ASM?				—
Do you know of any government procedures to follow before you start ASM mining processes?				Mining license
Will you adhere to the environmental legislation if the government puts enforcement measures? How?	✓			Self accountability
What can you suggest or special message to the ASM teams?				Each ASM member to be responsible with their material
What steps can Otter Mining take to ensure that ASM activities are done responsibly in its Mining License area?				Community engagement in education on environmental mgt
Do you believe in preparing a good environmental legacy for future generations, and how is it possible?	✓			
In your opinion, how best can the environment be protected during and after mining processes?				Backfilling & Afforestation

Research Questionnaire – Otter Mining

Participant Role:

Miner

☒ Yes / No

Community member

Yes / No

Mineral processor

☒ Yes / No

Fisher

Yes / No

Otter Mine Management

Yes / No

Other.....

Male / ☒ Female..... Age 37

Date 09 / 08 / 2024

Questions	Yes	Maybe	No	Comments
Do you have basic understanding of the environmental legislation?	☒			
Do you know of any environmental policies that you follow when mining or processing?	☒			Cyanide, mercury and explosives to be handled with care
Have you ever witnessed any water pollution near the mining sites?	☒			
Have you ever witnessed mass death of fish or any aquatic life in the rivers?			☒	
Have you ever witnessed incidents of animals falling in the shafts or dying of cyanide poisoning?	☒			Cyanide
Have ever noticed plant growth deteriorating near ASM sites?	☒			- areas where cyanide and chemicals/ acids spill
Have you ever noticed any changes in the drinking water fetched from the protected wells near mining sites?			☒	
Have you ever used cyanide for mineral processing?			☒	
Have you ever used mercury to recover gold?	☒			- Always

Do you understand the dangers posed by the use and inappropriate disposal of both cyanide and mercury?	✓			Cyanide is poisonous to animals, humans and the environment
Is there any erosion initiated from the mine sites?	✓			
Can the waste rock stockpiles find use within the community?	✓			Back-filling old shafts
How do you dispose of tailings and water containing cyanide?				Construction of tailings dams
How do you dispose of mercury to recover gold from amalgam – do you burn it with fire?	✓			
How best can tailings be stockpiled and how can chemical danger be minimized?				Stockpiling way that do not allow leaching down
What are your thoughts on waste and tailings management, and land rehabilitation?				Environmental safe ways to be used
What could be done to improve waste storage and tailings disposal?				Alternative mining ways that do not harm the environment
In your opinion, does the need for survival outweigh the concern for the environment?		✓		
What adjustments could be made to the environmental legislation in order to include ASM?				N/A
Do you know of any government procedures to follow before you start ASM mining processes?	✓			- Mining license - Cyanide license for use & transportation
Will you adhere to the environmental legislation if the government puts enforcement measures? How?	✓			- following required laws
What can you suggest or special message to the ASM teams?	-			To think of the future.
What steps can Otter Mining take to ensure that ASM activities are done responsibly in its Mining License area?				N/A
Do you believe in preparing a good environmental legacy for future generations, and how is it possible?	✓			Educating ASM the importance of environmental practices
In your opinion, how best can the environment be protected during and after mining processes?				Engaging professionals

Research Questionnaire – Otter Mining

Participant Role:

Miner Yes / No

Community member ☒ Yes ☐ No

Mineral processor ☒ Yes ☐ No

Fisher Yes / No

Otter Mine Management Yes / No

Other.....

Male / Female..... Age 38

Date 08/06/2024

Questions	Yes	Maybe	No	Comments
Do you have basic understanding of the environmental legislation?	☒			
Do you know of any environmental policies that you follow when mining or processing?	☒			
Have you ever witnessed any water pollution near the mining sites?	☒			
Have you ever witnessed mass death of fish or any aquatic life in the rivers?			☒	
Have you ever witnessed incidents of animals falling in the shafts or dying of cyanide poisoning?	☒			
Have ever noticed plant growth deteriorating near ASM sites?			☒	
Have you ever noticed any changes in the drinking water fetched from the protected wells near mining sites?				
Have you ever used cyanide for mineral processing?	☒			
Have you ever used mercury to recover gold?	☒			

Do you understand the dangers posed by the use and inappropriate disposal of both cyanide and mercury?	✓			
Is there any erosion initiated from the mine sites?			✓	
Can the waste rock stockpiles find use within the community?	✓			
How do you dispose of tailings and water containing cyanide?				+Drying in a pile - Use of TSF
How do you dispose of mercury to recover gold from amalgam – do you burn it with fire?	✓			
How best can tailings be stockpiled and how can chemical danger be minimized?				- Stones in a pile - Using TSF - Use of oxidizing agent to oxidise
What are your thoughts on waste and tailings management, and land rehabilitation?				- plant trees around leaching plants - Avoid producing more waste
What could be done to improve waste storage and tailings disposal?				- Share knowledge - Use less toxic ways
In your opinion, does the need for survival outweigh the concern for the environment?			✓	Environment is needed for life.
What adjustments could be made to the environmental legislation in order to include ASM?				-
Do you know of any government procedures to follow before you start ASM mining processes?				- Get gov licenses - Permission from land owner
Will you adhere to the environmental legislation if the government puts enforcement measures? How?				- workers to consider environmental sustainability
What can you suggest or special message to the ASM teams?				Follow up by gov officials
What steps can Otter Mining take to ensure that ASM activities are done responsibly in its Mining License area?				Demarkating working areas
Do you believe in preparing a good environmental legacy for future generations, and how is it possible?				- Law enforcement - Afforestation - Avoid a lot of waste
In your opinion, how best can the environment be protected during and after mining processes?				- minimise land disturbance - Afforestation - Use of better techniques with less impacts

Research Questionnaire – Otter Mining

Participant Role:

Miner Yes / No

Community member ☒ Yes ☐ No

Mineral processor Yes / No

Fisher ☒ Yes ☐ No

Otter Mine Management Yes / No

Other.....

Male ☒ Female ☐ Age 32

Date 08 / 06 / 2024

Questions	Yes	Maybe	No	Comments
Do you have basic understanding of the environmental legislation?			☒	
Do you know of any environmental policies that you follow when mining or processing?			☒	
Have you ever witnessed any water pollution near the mining sites?	☒			
Have you ever witnessed mass death of fish or any aquatic life in the rivers?			☒	Few fish die one in a while.
Have you ever witnessed incidents of animals falling in the shafts or dying of cyanide poisoning?	☒			
Have ever noticed plant growth deteriorating near ASM sites?	☒			
Have you ever noticed any changes in the drinking water fetched from the protected wells near mining sites?			☒	
Have you ever used cyanide for mineral processing?			☒	
Have you ever used mercury to recover gold?			☒	

Do you understand the dangers posed by the use and inappropriate disposal of both cyanide and mercury?	✓			
Is there any erosion initiated from the mine sites?	✓			
Can the waste rock stockpiles find use within the community?	✓			
How do you dispose of tailings and water containing cyanide?				N/A
How do you dispose of mercury to recover gold from amalgam – do you burn it with fire?				N/A
How best can tailings be stockpiled and how can chemical danger be minimized?				Containing all toxic substances in protected area
What are your thoughts on waste and tailings management, and land rehabilitation?				N/A
What could be done to improve waste storage and tailings disposal?				Using less toxic chemicals
In your opinion, does the need for survival outweigh the concern for the environment?			✓	The environment carries everything & every one's life
What adjustments could be made to the environmental legislation in order to include ASM?				N/A
Do you know of any government procedures to follow before you start ASM mining processes?			✓	
Will you adhere to the environmental legislation if the government puts enforcement measures? How?				N/A
What can you suggest or special message to the ASM teams?				Conserve environment for future generation
What steps can Otter Mining take to ensure that ASM activities are done responsibly in its Mining License area?				N/A
Do you believe in preparing a good environmental legacy for future generations, and how is it possible?				- Planting trees - Avoid bush fires
In your opinion, how best can the environment be protected during and after mining processes?				- Avoid mining activities from polluting the environment

Research Questionnaire – Otter Mining

Participant Role:

Miner

☒ Yes / No

Community member

Yes / No

Mineral processor

Yes / No

Fisher

☒ Yes / No

Otter Mine Management

Yes / No

Other.....

☒ Male / Female..... Age 55

Date 08/06/2024

Questions	Yes	Maybe	No	Comments
Do you have basic understanding of the environmental legislation?	☒			
Do you know of any environmental policies that you follow when mining or processing?	☒			
Have you ever witnessed any water pollution near the mining sites?	☒			
Have you ever witnessed mass death of fish or any aquatic life in the rivers?			☒	Few fish death
Have you ever witnessed incidents of animals falling in the shafts or dying of cyanide poisoning?	☒			It happens time and again.
Have ever noticed plant growth deteriorating near ASM sites?	☒			
Have you ever noticed any changes in the drinking water fetched from the protected wells near mining sites?			☒	
Have you ever used cyanide for mineral processing?			☒	I do not touch cyanide, its toxic
Have you ever used mercury to recover gold?	☒			

Do you understand the dangers posed by the use and inappropriate disposal of both cyanide and mercury?	✓			
Is there any erosion initiated from the mine sites?	✓			
Can the waste rock stockpiles find use within the community?	✓			Many uses
How do you dispose of tailings and water containing cyanide?				Fenced areas away from rivers
How do you dispose of mercury to recover gold from amalgam – do you burn it with fire?	✓			
How best can tailings be stockpiled and how can chemical danger be minimized?				TSF
What are your thoughts on waste and tailings management, and land rehabilitation?				Agricultural land use
What could be done to improve waste storage and tailings disposal?				—
In your opinion, does the need for survival outweigh the concern for the environment?			✓	
What adjustments could be made to the environmental legislation in order to include ASM?				To be specific
Do you know of any government procedures to follow before you start ASM mining processes?				License to mine
Will you adhere to the environmental legislation if the government puts enforcement measures? How?	✓			Govt funding required
What can you suggest or special message to the ASM teams?				—
What steps can Otter Mining take to ensure that ASM activities are done responsibly in its Mining License area?				—
Do you believe in preparing a good environmental legacy for future generations, and how is it possible?	✓			
In your opinion, how best can the environment be protected during and after mining processes?				Education

Research Questionnaire – Otter Mining

Participant Role:

Miner ☒ Yes / No

Community member Yes / No

Mineral processor ☒ Yes / No

Fisher Yes / No

Otter Mine Management Yes / No

Other.....

Male / Female..... Age 61.....

Date 10/06/2024

Questions	Yes	Maybe	No	Comments
Do you have basic understanding of the environmental legislation?	☒			
Do you know of any environmental policies that you follow when mining or processing?	☒			
Have you ever witnessed any water pollution near the mining sites?	☒			
Have you ever witnessed mass death of fish or any aquatic life in the rivers?			☒	
Have you ever witnessed incidents of animals falling in the shafts or dying of cyanide poisoning?	☒			
Have ever noticed plant growth deteriorating near ASM sites?	☒			
Have you ever noticed any changes in the drinking water fetched from the protected wells near mining sites?	☒			
Have you ever used cyanide for mineral processing?		☒		
Have you ever used mercury to recover gold?	☒			

Do you understand the dangers posed by the use and inappropriate disposal of both cyanide and mercury?			✓	
Is there any erosion initiated from the mine sites?	✓			
Can the waste rock stockpiles find use within the community?	✓			crush for concrete
How do you dispose of tailings and water containing cyanide?				In fenced T.S.F
How do you dispose of mercury to recover gold from amalgam – do you burn it with fire?	✓			
How best can tailings be stockpiled and how can chemical danger be minimized?				Lay polythen on the floor
What are your thoughts on waste and tailings management, and land rehabilitation?				—
What could be done to improve waste storage and tailings disposal?				—
In your opinion, does the need for survival outweigh the concern for the environment?			✓	
What adjustments could be made to the environmental legislation in order to include ASM?				—
Do you know of any government procedures to follow before you start ASM mining processes?				—
Will you adhere to the environmental legislation if the government puts enforcement measures? How?	✓		✓	
What can you suggest or special message to the ASM teams?				—
What steps can Otter Mining take to ensure that ASM activities are done responsibly in its Mining License area?				—
Do you believe in preparing a good environmental legacy for future generations, and how is it possible?	✓			
In your opinion, how best can the environment be protected during and after mining processes?				

Research Questionnaire – Otter Mining

Participant Role:

Miner ☒ Yes / No

Community member Yes / No

Mineral processor Yes / No

Fisher Yes / No

Otter Mine Management Yes / No

Other.....

☒ Male / Female..... Age 58

Date 10 / 08 / 2024

Questions	Yes	Maybe	No	Comments
Do you have basic understanding of the environmental legislation?	✓			
Do you know of any environmental policies that you follow when mining or processing?	✓			
Have you ever witnessed any water pollution near the mining sites?	✓			
Have you ever witnessed mass death of fish or any aquatic life in the rivers?			✓	
Have you ever witnessed incidents of animals falling in the shafts or dying of cyanide poisoning?	✓			
Have ever noticed plant growth deteriorating near ASM sites?	✓			
Have you ever noticed any changes in the drinking water fetched from the protected wells near mining sites?			✓	
Have you ever used cyanide for mineral processing?			✓	
Have you ever used mercury to recover gold?	✓			

Do you understand the dangers posed by the use and inappropriate disposal of both cyanide and mercury?	✓			
Is there any erosion initiated from the mine sites?	✓			
Can the waste rock stockpiles find use within the community?	✓			
How do you dispose of tailings and water containing cyanide?				Fenced areas
How do you dispose of mercury to recover gold from amalgam – do you burn it with fire?	✓			
How best can tailings be stockpiled and how can chemical danger be minimized?				—
What are your thoughts on waste and tailings management, and land rehabilitation?				—
What could be done to improve waste storage and tailings disposal?				Teaching ASM
In your opinion, does the need for survival outweigh the concern for the environment?			✓	
What adjustments could be made to the environmental legislation in order to include ASM?				—
Do you know of any government procedures to follow before you start ASM mining processes?				—
Will you adhere to the environmental legislation if the government puts enforcement measures? How?	✓			
What can you suggest or special message to the ASM teams?				Mine responsibly
What steps can Otter Mining take to ensure that ASM activities are done responsibly in its Mining License area?				—
Do you believe in preparing a good environmental legacy for future generations, and how is it possible?	✓			
In your opinion, how best can the environment be protected during and after mining processes?				Educating each other

Research Questionnaire – Otter Mining

Participant Role:

Miner ☒ Yes / No

Community member ☒ Yes / No

Mineral processor ☒ Yes / No

Fisher Yes / No

Otter Mine Management Yes / No

Other.....

Male ☒ Female..... Age 74

Date...../...../2024

Questions	Yes	Maybe	No	Comments
Do you have basic understanding of the environmental legislation?			☒	
Do you know of any environmental policies that you follow when mining or processing?			☒	
Have you ever witnessed any water pollution near the mining sites?	☒			
Have you ever witnessed mass death of fish or any aquatic life in the rivers?			☒	
Have you ever witnessed incidents of animals falling in the shafts or dying of cyanide poisoning?	☒			
Have ever noticed plant growth deteriorating near ASM sites?	☒			
Have you ever noticed any changes in the drinking water fetched from the protected wells near mining sites?			☒	
Have you ever used cyanide for mineral processing?	☒			
Have you ever used mercury to recover gold?	☒			

Do you understand the dangers posed by the use and inappropriate disposal of both cyanide and mercury?	✓			
Is there any erosion initiated from the mine sites?	✓			
Can the waste rock stockpiles find use within the community?	✓			
How do you dispose of tailings and water containing cyanide?				Dams
How do you dispose of mercury to recover gold from amalgam – do you burn it with fire?	✓			
How best can tailings be stockpiled and how can chemical danger be minimized?				—
What are your thoughts on waste and tailings management, and land rehabilitation?				Some land will be relieved to other duties
What could be done to improve waste storage and tailings disposal?				—
In your opinion, does the need for survival outweigh the concern for the environment?			✓	
What adjustments could be made to the environmental legislation in order to include ASM?				—
Do you know of any government procedures to follow before you start ASM mining processes?			✓	
Will you adhere to the environmental legislation if the government puts enforcement measures? How?	✓			
What can you suggest or special message to the ASM teams?				Take care of the environment
What steps can Otter Mining take to ensure that ASM activities are done responsibly in its Mining License area?				~
Do you believe in preparing a good environmental legacy for future generations, and how is it possible?	✓			
In your opinion, how best can the environment be protected during and after mining processes?				Education

Research Questionnaire – Otter Mining

Participant Role:

Miner Yes / No

Community member ☒ Yes / No

Mineral processor ☒ Yes / No

Fisher Yes / No

Otter Mine Management Yes / No

Other.....

☒ Male ☐ Female..... Age 85

Date 09/06/2024

Questions	Yes	Maybe	No	Comments
Do you have basic understanding of the environmental legislation?			☒	
Do you know of any environmental policies that you follow when mining or processing?			☒	
Have you ever witnessed any water pollution near the mining sites?	☒			
Have you ever witnessed mass death of fish or any aquatic life in the rivers?			☒	
Have you ever witnessed incidents of animals falling in the shafts or dying of cyanide poisoning?	☒			
Have ever noticed plant growth deteriorating near ASM sites?	☒			
Have you ever noticed any changes in the drinking water fetched from the protected wells near mining sites?	☒			Change in seasons
Have you ever used cyanide for mineral processing?			☒	
Have you ever used mercury to recover gold?	☒			

Do you understand the dangers posed by the use and inappropriate disposal of both cyanide and mercury?	✓			Animal deaths
Is there any erosion initiated from the mine sites?	✓			
Can the waste rock stockpiles find use within the community?	✓			A lot of uses if carried to people
How do you dispose of tailings and water containing cyanide?				Build a dam
How do you dispose of mercury to recover gold from amalgam – do you burn it with fire?	✓			
How best can tailings be stockpiled and how can chemical danger be minimized?				TSF
What are your thoughts on waste and tailings management, and land rehabilitation?				Good for community land,
What could be done to improve waste storage and tailings disposal?				—
In your opinion, does the need for survival outweigh the concern for the environment?			✓	
What adjustments could be made to the environmental legislation in order to include ASM?				—
Do you know of any government procedures to follow before you start ASM mining processes?				—
Will you adhere to the environmental legislation if the government puts enforcement measures? How?	✓			
What can you suggest or special message to the ASM teams?				Mine responsibly
What steps can Otter Mining take to ensure that ASM activities are done responsibly in its Mining License area?				—
Do you believe in preparing a good environmental legacy for future generations, and how is it possible?	✓			
In your opinion, how best can the environment be protected during and after mining processes?				Reduce chemical use.

Research Questionnaire – Otter Mining

Participant Role:

Miner

☒ Yes / No Also do gold leaching

Community member

Yes / No

Mineral processor

Yes / No

Fisher

Yes / No

Otter Mine Management

Yes / No

Other.....

☒ Male / ☐ Female..... Age 51.....

Date 08/06/2024

Questions	Yes	Maybe	No	Comments
Do you have basic understanding of the environmental legislation?			☒	
Do you know of any environmental policies that you follow when mining or processing?			☒	
Have you ever witnessed any water pollution near the mining sites?	☒			
Have you ever witnessed mass death of fish or any aquatic life in the rivers?			☒	
Have you ever witnessed incidents of animals falling in the shafts or dying of cyanide poisoning?	☒			Shafts
Have ever noticed plant growth deteriorating near ASM sites?			☒	
Have you ever noticed any changes in the drinking water fetched from the protected wells near mining sites?			☒	
Have you ever used cyanide for mineral processing?			☒	
Have you ever used mercury to recover gold?	☒			

Do you understand the dangers posed by the use and inappropriate disposal of both cyanide and mercury?	✓			
Is there any erosion initiated from the mine sites?	✓			
Can the waste rock stockpiles find use within the community?	✓			Building houses
How do you dispose of tailings and water containing cyanide?				unrestricted stock piling
How do you dispose of mercury to recover gold from amalgam – do you burn it with fire?			✓	Burning
How best can tailings be stockpiled and how can chemical danger be minimized?				—
What are your thoughts on waste and tailings management, and land rehabilitation?				Very costly and unaffordable
What could be done to improve waste storage and tailings disposal?				Educating ASM on best methods
In your opinion, does the need for survival outweigh the concern for the environment?	✓			
What adjustments could be made to the environmental legislation in order to include ASM?				Setting up teams to learn the environmental legislation
Do you know of any government procedures to follow before you start ASM mining processes?			✓	
Will you adhere to the environmental legislation if the government puts enforcement measures? How?	✓			Following the required steps
What can you suggest or special message to the ASM teams?				—
What steps can Otter Mining take to ensure that ASM activities are done responsibly in its Mining License area?				Regular follow-ups to see if mining is done responsibly
Do you believe in preparing a good environmental legacy for future generations, and how is it possible?	✓			
In your opinion, how best can the environment be protected during and after mining processes?				- Standard mining practices - Afforestation

Research Questionnaire – Otter Mining

Participant Role:

Miner

☒ Yes / No

Community member

☒ Yes / No

Mineral processor

☒ Yes / No

Fisher

Yes / No

Otter Mine Management

Yes / No

Other.....

☒ Male / Female..... Age 56

Date 08/06/2024

Questions	Yes	Maybe	No	Comments
Do you have basic understanding of the environmental legislation?			☒	
Do you know of any environmental policies that you follow when mining or processing?			☒	
Have you ever witnessed any water pollution near the mining sites?	☒			
Have you ever witnessed mass death of fish or any aquatic life in the rivers?			☒	
Have you ever witnessed incidents of animals falling in the shafts or dying of cyanide poisoning?	☒			<i>cyanide & shafts</i>
Have ever noticed plant growth deteriorating near ASM sites?	☒			
Have you ever noticed any changes in the drinking water fetched from the protected wells near mining sites?			☒	
Have you ever used cyanide for mineral processing?	☒			
Have you ever used mercury to recover gold?	☒			

Do you understand the dangers posed by the use and inappropriate disposal of both cyanide and mercury?	✓			Water pollution, kills plants & animals - Ozone layer
Is there any erosion initiated from the mine sites?	✓			
Can the waste rock stockpiles find use within the community?	✓			Building houses
How do you dispose of tailings and water containing cyanide?				- In tanks for VAT leaching
How do you dispose of mercury to recover gold from amalgam – do you burn it with fire?	✓			
How best can tailings be stockpiled and how can chemical danger be minimized?				—
What are your thoughts on waste and tailings management, and land rehabilitation?				—
What could be done to improve waste storage and tailings disposal?				Education
In your opinion, does the need for survival outweigh the concern for the environment?			✓	
What adjustments could be made to the environmental legislation in order to include ASM?				—
Do you know of any government procedures to follow before you start ASM mining processes?		✓		- Mining license
Will you adhere to the environmental legislation if the government puts enforcement measures? How?	✓			
What can you suggest or special message to the ASM teams?				Following the Law
What steps can Otter Mining take to ensure that ASM activities are done responsibly in its Mining License area?				—
Do you believe in preparing a good environmental legacy for future generations, and how is it possible?	✓			
In your opinion, how best can the environment be protected during and after mining processes?				char rehab & Afforestation

Research Questionnaire – Otter Mining

Participant Role:

Miner

☒ Yes / No

Community member

Yes / No

Mineral processor

☒ Yes / No

Fisher

☒ Yes / No

Otter Mine Management

Yes / No

Other.....

☒ Male / ☐ Female..... Age 55

Date 08/09/2024

Questions	Yes	Maybe	No	Comments
Do you have basic understanding of the environmental legislation?			☒	
Do you know of any environmental policies that you follow when mining or processing?			☒	
Have you ever witnessed any water pollution near the mining sites?	☒			
Have you ever witnessed mass death of fish or any aquatic life in the rivers?			☒	
Have you ever witnessed incidents of animals falling in the shafts or dying of cyanide poisoning?	☒			
Have ever noticed plant growth deteriorating near ASM sites?	☒			
Have you ever noticed any changes in the drinking water fetched from the protected wells near mining sites?			☒	
Have you ever used cyanide for mineral processing?	☒			
Have you ever used mercury to recover gold?	☒			

Do you understand the dangers posed by the use and inappropriate disposal of both cyanide and mercury?	✓			Cyanide kills animals
Is there any erosion initiated from the mine sites?	✓			
Can the waste rock stockpiles find use within the community?	✓			Road repairs & houses foundation
How do you dispose of tailings and water containing cyanide?				In VAT teaching, fencing is required
How do you dispose of mercury to recover gold from amalgam – do you burn it with fire?	✓			
How best can tailings be stockpiled and how can chemical danger be minimized?				Digging trenches to contain all tailings & effluent.
What are your thoughts on waste and tailings management, and land rehabilitation?				—
What could be done to improve waste storage and tailings disposal?				Education
In your opinion, does the need for survival outweigh the concern for the environment?	✓			
What adjustments could be made to the environmental legislation in order to include ASM?				—
Do you know of any government procedures to follow before you start ASM mining processes?			✓	
Will you adhere to the environmental legislation if the government puts enforcement measures? How?	✓			Follow Govt Laws if available
What can you suggest or special message to the ASM teams?				—
What steps can Otter Mining take to ensure that ASM activities are done responsibly in its Mining License area?				—
Do you believe in preparing a good environmental legacy for future generations, and how is it possible?	✓			
In your opinion, how best can the environment be protected during and after mining processes?				Backfilling shafts — Education

Research Questionnaire – Otter Mining

Participant Role:

Miner Yes / No

Community member ☒ Yes ☐ No

Mineral processor Yes / No

Fisher Yes / No

Otter Mine Management Yes / No

Other.....

Male ☒ Female ☐ Age 65

Date 10 / 06 / 2024

Questions	Yes	Maybe	No	Comments
Do you have basic understanding of the environmental legislation?			☒	
Do you know of any environmental policies that you follow when mining or processing?			☒	
Have you ever witnessed any water pollution near the mining sites?	☒			-It is a big concern to the community
Have you ever witnessed mass death of fish or any aquatic life in the rivers?				-Not mass death but fish shortage maybe due to mining chemicals
Have you ever witnessed incidents of animals falling in the shafts or dying of cyanide poisoning?	☒			It often happens
Have ever noticed plant growth deteriorating near ASM sites?	☒			
Have you ever noticed any changes in the drinking water fetched from the protected wells near mining sites?			☒	-difficult to notice.
Have you ever used cyanide for mineral processing?			☒	N/A
Have you ever used mercury to recover gold?			☒	N/A

Do you understand the dangers posed by the use and inappropriate disposal of both cyanide and mercury?		✓		Environmental issues, Health issues
Is there any erosion initiated from the mine sites?	✓			
Can the waste rock stockpiles find use within the community?	✓			Building of roads construction
How do you dispose of tailings and water containing cyanide?				N/A
How do you dispose of mercury to recover gold from amalgam – do you burn it with fire?				N/A
How best can tailings be stockpiled and how can chemical danger be minimized?				- Mining responsibly
What are your thoughts on waste and tailings management, and land rehabilitation?				- It is important for the land to be used again
What could be done to improve waste storage and tailings disposal?				- Having one designated storage place/site.
In your opinion, does the need for survival outweigh the concern for the environment?			✓	
What adjustments could be made to the environmental legislation in order to include ASM?				Community should have a say. It is our land.
Do you know of any government procedures to follow before you start ASM mining processes?	✓			Registration
Will you adhere to the environmental legislation if the government puts enforcement measures? How?				N/A
What can you suggest or special message to the ASM teams?				To work hand in hand with community and the govt.
What steps can Otter Mining take to ensure that ASM activities are done responsibly in its Mining License area?				Involving community in all decisions & actions
Do you believe in preparing a good environmental legacy for future generations, and how is it possible?	✓			
In your opinion, how best can the environment be protected during and after mining processes?				- Following standards - Involving community - Rehabilitation

Mining is helpful to our community and the youths but govt should assist to make things happen in a proper way.

Research Questionnaire – Otter Mining

Participant Role:

Miner Yes / No

Community member ☒ Yes / No

Mineral processor Yes / No

Fisher ☒ Yes / No

Otter Mine Management Yes / No

Other.....

☒ Male ☐ Female..... Age: 52

Date: 08/06 / 06 / 2024

Questions	Yes	Maybe	No	Comments
Do you have basic understanding of the environmental legislation?	☒			
Do you know of any environmental policies that you follow when mining or processing?	☒			Not to dispose waste & chemical into water bodies for environment
Have you ever witnessed any water pollution near the mining sites?	☒			
Have you ever witnessed mass death of fish or any aquatic life in the rivers?	☒			
Have you ever witnessed incidents of animals falling in the shafts or dying of cyanide poisoning?	☒			
Have ever noticed plant growth deteriorating near ASM sites?	☒			
Have you ever noticed any changes in the drinking water fetched from the protected wells near mining sites?			☒	
Have you ever used cyanide for mineral processing?			☒	
Have you ever used mercury to recover gold?			☒	

Do you understand the dangers posed by the use and inappropriate disposal of both cyanide and mercury?	✓			They poison fish in water bodies
Is there any erosion initiated from the mine sites?	✓			
Can the waste rock stockpiles find use within the community?	✓			
How do you dispose of tailings and water containing cyanide?				—
How do you dispose of mercury to recover gold from amalgam – do you burn it with fire?				—
How best can tailings be stockpiled and how can chemical danger be minimized?				—
What are your thoughts on waste and tailings management, and land rehabilitation?				To be stored without affecting the environment
What could be done to improve waste storage and tailings disposal?				Govt checks on ASM activities
In your opinion, does the need for survival outweigh the concern for the environment?		✓		
What adjustments could be made to the environmental legislation in order to include ASM?				—
Do you know of any government procedures to follow before you start ASM mining processes?	✓			
Will you adhere to the environmental legislation if the government puts enforcement measures? How?				Reporting any deviation in the environmental law
What can you suggest or special message to the ASM teams?				Consider other humans & animals when mining.
What steps can Otter Mining take to ensure that ASM activities are done responsibly in its Mining License area?				—
Do you believe in preparing a good environmental legacy for future generations, and how is it possible?	✓			Strict environmental laws
In your opinion, how best can the environment be protected during and after mining processes?				—

Follow up Interview

Research Questionnaire – Otter Mining

Participant Role:

Miner Yes / No

Community member Yes / No

Mineral processor ☒ Yes / No

Fisher Yes / No

Otter Mine Management Yes / No

Other.....

☒ Male ☐ Female..... Age 54

Date 12 / 06 / 2024

Questions	Yes	Maybe	No	Comments
Do you have basic understanding of the environmental legislation?	☒			
Do you know of any environmental policies that you follow when mining or processing?	☒			As set when constructing leaching plant.
Have you ever witnessed any water pollution near the mining sites?	☒			
Have you ever witnessed mass death of fish or any aquatic life in the rivers?			☒	
Have you ever witnessed incidents of animals falling in the shafts or dying of cyanide poisoning?	☒			
Have ever noticed plant growth deteriorating near ASM sites?	☒			
Have you ever noticed any changes in the drinking water fetched from the protected wells near mining sites?			☒	
Have you ever used cyanide for mineral processing?	☒			Always in VAT leaching
Have you ever used mercury to recover gold?	☒			

- Environmental department checks on VAT leaching sites for compliance. Bribery is common.
- Sumps used for cyanide water storage are sometimes leaking (poor design)
- The environmental law needs to be clear, specific and be preached to everyone.

Do you understand the dangers posed by the use and inappropriate disposal of both cyanide and mercury?	✓			
Is there any erosion initiated from the mine sites?	✓			
Can the waste rock stockpiles find use within the community?		✓		
How do you dispose of tailings and water containing cyanide?				In the Sumps in fenced areas.
How do you dispose of mercury to recover gold from amalgam – do you burn it with fire?	✓			
How best can tailings be stockpiled and how can chemical danger be minimized?				-Drying tailings to evaporate cyanide -TSF
What are your thoughts on waste and tailings management, and land rehabilitation?				-TSF to be designed well -land rehab helps to use the land again
What could be done to improve waste storage and tailings disposal?				-Experts help -Govt support -Complying to the law
In your opinion, does the need for survival outweigh the concern for the environment?			✓	
What adjustments could be made to the environmental legislation in order to include ASM?				To be specific and preached to everyone
Do you know of any government procedures to follow before you start ASM mining processes?		✓		Licensing
Will you adhere to the environmental legislation if the government puts enforcement measures? How?	✓			The environment keeps us alive
What can you suggest or special message to the ASM teams?				-Try environmental friendly ways of mining & processing -mine responsibly
What steps can Other Mining take to ensure that ASM activities are done responsibly in its Mining License area?				Assist ASM to thrive but monitor how they mine.
Do you believe in preparing a good environmental legacy for future generations, and how is it possible?	✓			Environmental care
In your opinion, how best can the environment be protected during and after mining processes?				-Mine responsibly -Establish the law & follow up by Govt. -Government funding

Follow up Interview

Research Questionnaire – Otter Mining

Participant Role:

Miner ☒ Yes ☐ No

Community member Yes / No

Mineral processor Yes / No

Fisher Yes / No

Otter Mine Management Yes / No

Other.....

☒ Male ☐ Female..... Age 29.....

Date 12 / 06 / 2024

Questions	Yes	Maybe	No	Comments
Do you have basic understanding of the environmental legislation?	☒			I think it is for LSM but not ASM
Do you know of any environmental policies that you follow when mining or processing?	☒			
Have you ever witnessed any water pollution near the mining sites?	☒			It is very common due to negligence of miners
Have you ever witnessed mass death of fish or any aquatic life in the rivers?	☒			In another region when the cyanide water leaked into the river
Have you ever witnessed incidents of animals falling in the shafts or dying of cyanide poisoning?	☒			People also fall in pits Very common cases
Have ever noticed plant growth deteriorating near ASM sites?	☒			Due to deforestation and so much activity
Have you ever noticed any changes in the drinking water fetched from the protected wells near mining sites?			☒	
Have you ever used cyanide for mineral processing?			☒	
Have you ever used mercury to recover gold?	☒			Always

- The government (Govt) has to come out clear about ASM laws. For now it is not clear but applies to LSM
- Many ASM are struggling financially and would require Govt support to mine and process to standard.

Do you understand the dangers posed by the use and inappropriate disposal of both cyanide and mercury?	✓			Affects humans, animals and plants
Is there any erosion initiated from the mine sites?	✓			It is very serious in active mining sites
Can the waste rock stockpiles find use within the community?	✓			
How do you dispose of tailings and water containing cyanide?				It should be in fenced areas but people are negligent
How do you dispose of mercury to recover gold from amalgam – do you burn it with fire?	✓			
How best can tailings be stockpiled and how can chemical danger be minimized?				TSF with ridges around to contain the tailings inside
What are your thoughts on waste and tailings management, and land rehabilitation?				- Saves animal life - Creates land for other uses
What could be done to improve waste storage and tailings disposal?				- Education and have designated areas for that - Govt assistance
In your opinion, does the need for survival outweigh the concern for the environment?			✓	Environment keeps everyone alive
What adjustments could be made to the environmental legislation in order to include ASM?				It has to be specific about ASM
Do you know of any government procedures to follow before you start ASM mining processes?				- Licensing but many ASM operate without licenses
Will you adhere to the environmental legislation if the government puts enforcement measures? How?	✓			Following the law. Tanzanians are prepared but Govt support is needed
What can you suggest or special message to the ASM teams?				consider the environment
What steps can Otter Mining take to ensure that ASM activities are done responsibly in its Mining License area?				They should ensure mining in their area is done to standard.
Do you believe in preparing a good environmental legacy for future generations, and how is it possible?	✓			Only if we mine responsibly and take care of the environment
In your opinion, how best can the environment be protected during and after mining processes?				- Rehabilitation - Neutralize and contain chemicals - Follow the law

Follow up Interview

Research Questionnaire – Otter Mining

Participant Role:

Miner Yes / No

Community member ☒ Yes / No

Mineral processor Yes / No

Fisher Yes / No

Otter Mine Management Yes / No

Other.....

Male / ☒ Female..... Age 37

Date 12/06/2024

Questions	Yes	Maybe	No	Comments
Do you have basic understanding of the environmental legislation?	☒			
Do you know of any environmental policies that you follow when mining or processing?				N/A
Have you ever witnessed any water pollution near the mining sites?	☒			The community is not happy about it
Have you ever witnessed mass death of fish or any aquatic life in the rivers?			☒	Have heard about from other communities
Have you ever witnessed incidents of animals falling in the shafts or dying of cyanide poisoning?	☒			Drunk people & kids sometimes fall in the pits & shafts
Have ever noticed plant growth deteriorating near ASM sites?	☒			
Have you ever noticed any changes in the drinking water fetched from the protected wells near mining sites?			☒	So difficult to notice. It may take decades (maybe)
Have you ever used cyanide for mineral processing?				N/A
Have you ever used mercury to recover gold?				N/A

- ASM does not rehabilitate or restore after mining.
- The community would want the land to be useful again after mining. Only possible if rehabilitated but it is not happening

Do you understand the dangers posed by the use and inappropriate disposal of both cyanide and mercury?	✓			
Is there any erosion initiated from the mine sites?	✓			
Can the waste rock stockpiles find use within the community?	✓			Very useful in the villages if transported & cleaned. We're afraid about chemicals
How do you dispose of tailings and water containing cyanide?				N/A
How do you dispose of mercury to recover gold from amalgam – do you burn it with fire?				ASM people burn mercury
How best can tailings be stockpiled and how can chemical danger be minimized?				By fencing the sites and neutralise chemical
What are your thoughts on waste and tailings management, and land rehabilitation?				ASM to consider use of the same land after mining
What could be done to improve waste storage and tailings disposal?				Involve experts
In your opinion, does the need for survival outweigh the concern for the environment?			✓	
What adjustments could be made to the environmental legislation in order to include ASM?				The law must be strict to ASM
Do you know of any government procedures to follow before you start ASM mining processes?		✓		License and environmental check
Will you adhere to the environmental legislation if the government puts enforcement measures? How?	✓			For the sake of the environment & future generation
What can you suggest or special message to the ASM teams?				Mine responsibly and rehabilitate
What steps can Otter Mining take to ensure that ASM activities are done responsibly in its Mining License area?				Following up on ASM activities.
Do you believe in preparing a good environmental legacy for future generations, and how is it possible?	✓			
In your opinion, how best can the environment be protected during and after mining processes?				- restore land - Afforestation

Additional Responses

- Government assistance is required in regards to speeding up and simplifying ASM registration process. Currently the process is too complex and costly that ordinary ASMs cannot manage it.
- The state can also help by funding equipment loans, fulfilling training requirements and implement environmental protection measures
- As a community, government involvement assists in putting environmental control measures that reduce pollution, deforestation, erosion, and loss of community animals and land.
- Currently there are no site inspections carried out by state/departament officials. Some areas with ASM activities acknowledge seeing the officials once in a while.
- Education/training can positively impact environmental safety in ASM and this would be enabled by involving various stakeholders
- Many ASMs would welcome the legislation but are afraid that the implementation can be costly and will affect the profitability of their operations.