SquareCircle
INSIGHT FOR DEVELOPMENT

PROJECT FINAL REPORT

Demonstration Project for the Papua New Guinea-Australia Joint Research Partnership Towards Safe and Sustainable Artisanal and Small-Scalle Gold Mining (ASGM).

Prepared by Square Circle Global Development on behalf of the Australia-PNG Economic Partnership (APEP)

30 October 2023

About this Report

This report presents the findings of a technical demonstration project that was conducted as part of the Demonstration Project for the Papua New Guinea-Australia Joint Research Partnership towards safe and sustainable Artisanal and Small-Scale Gold Mining (ASGM) in Wau-Bulolo, Morobe Province, PNG.

Acknowledgements

Australian Government
Department of Foreign Affairs and Trade

PNGAus Partnership

Australia-Papua New Guinea Economic Partnership

Executive Summary

The '***Demonstration Project for the Papua New Guinea-Australia Joint Research Partnership towards safe and sustainable Artisanal and Small-scale Gold Mining (ASGM)***' (***the 'Demonstration Project'***) is a joint agency initiative to assess the feasibility of a potential mercury-replacement technology for ASGM in Papua New Guinea (***PNG***), with the longer-term aim of reducing mercury emissions and releases in PNG.

The Demonstration Project was delivered through a collaboration between PNG's Conservation and Environment Protection Authority (**CEPA**) and Mineral Resources Authority (**MRA**), and the Australian Government's Department of Climate Change, Energy, the Environment and Water (**DCCEEW**), the Department of Foreign Affairs and Trade (**DFAT**), and the Commonwealth Scientific and Industrial Research Organisation (**CSIRO**). Clean Mining and Square Circle were implementing partners. The focus of the project was the trial of a new, non-toxic processing technology that could contribute to reducing and eventually eliminating the use of mercury in Artisanal and Small-scale Gold Mining (**ASGM**), which supports PNG's policy objectives for the alluvial mining sector and Australia's broader initiatives to strengthen resource governance and inclusive development outcomes in PNG's resource sector as part of the Australian Papua New Guinea Economic Partnership (**APEP**). APEP is a multi-sectoral investment in PNG to support economic growth and stability in PNG, and to assist the government of PNG to achieve the priorities outlined in its Strategic Development Plan. Central to this plan is the ongoing development of a resilient and diverse economy

that can ensure **a high quality of life for all Papua New Guineans**.

Mercury is used widely in ASGM due to its ease of access and operation, low capital costs and its efficiency in extracting gold from ore. Mercury is a highly toxic heavy metal that poses a global threat to human health and the environment. The technical demonstration is one activity in **PNG's ongoing efforts to address the negative environmental and social impacts of mercury** use. In concert with these efforts, the project supports **PNG's policy objectives** for the alluvial mining sector and its goal to accede to the Minamata Convention. **The Minamata Convention is a multilateral treaty** with the objective of protecting human health and the environment from the harmful effects of mercury[1]. The convention recognises that the significant levels of mercury in the environment caused by human activities requires international action. Having completed a Minamata National Assessment, PNG is awaiting Parliamentary approval to accede to the **Minamata Convention** and is preparing its Instrument of Accession. Once PNG is a Party to the Minamata Convention, a National Action Plan for ASGM will be developed which will include, inter alia, actions to eliminate whole ore amalgamation and strategies for promoting the reduction of

emissions and releases of mercury in ASGM mining and processing.

The Technical Demonstration using an alternative technology was conducted at **Pine Top mine site**[2], a semi-mechanised formal mine site in Wau-Bulolo, Morobe Province. The alternative technology uses non-toxic reagents dissolved in water to dissolve the gold from the sluice concentrate material into the leach solution. Gold is recovered from the leach solution by precipitation and the precipitate collected by filtration. The recovered precipitated gold is then heated to produce a gold dore product that can be sold to gold buyers.

To understand how mercury replacement technologies may impact ASGM in Wau-Bulolo, the project also undertook a **Rapid Impact Assessment** focussing on community perceptions regarding the formal and informal use of mercury in mining activities. Whilst the scope of the Technical Demonstration was limited to miners holding a formal lease with MRA, the Rapid Impact Assessment recognises **informal miners as potential beneficiaries** of the alternative technology and as people who may be impacted by its introduction in both positive and negative ways. A literature review was also conducted to map the social and economic context of mercury use in small-scale mining in PNG, and to better understand the global context for alternative technologies for mercury-reduction.

1 United Nations Environment Programme. 2013. Minamata convention on mercury. Accessed at: https://wedocs.unep.org/20.500.11822/8541

2 The Pine Top site holds a lease for mining purposes through MRA.

Key Findings of the Rapid Impact Assessment

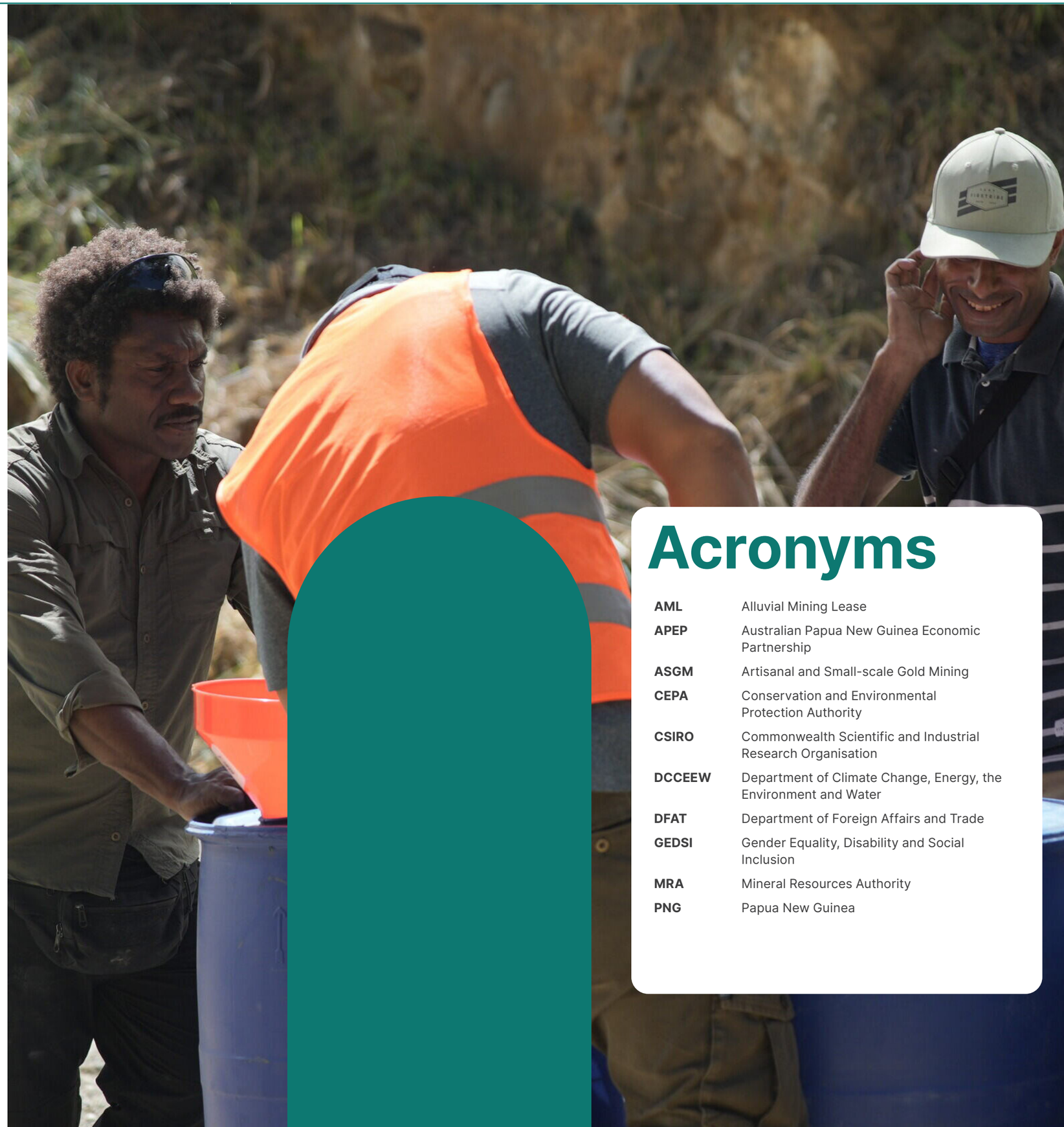
- Returns from mercury use in ASGM are immediate, and future technologies need to account for this.
- ASGM and mercury use play an important role in the local economy.
- 45% of people surveyed were not aware that mercury has negative health impacts. 59% were not aware that it has a negative impact on the environment. There is an extensive need for awareness raising regarding the health and environmental impacts of mercury use.
- The intergenerational nature of mercury use is deeply embedded in the Wau-Bulolo mining community. 63% of people surveyed who used mercury had done so for more than 20 years. Changing intergenerational behaviours around mercury use is a significant challenge for mercury reduction strategies.

Key Findings of the Technical Demonstration Feedback

Mercury-alternative research and technology development is a critical pathway to reducing mercury use in ASGM. The aim of the technical demonstration was to trial a minimal viable product that could offer a mercury alternative for small-scale gold miners, and in this way the demonstration contributed importantly to global efforts in research and technical innovation. With this in mind, the below findings, drawn from the feedback session with MRA Trainers indicate some areas to guide future research and technical development:

- The technology was understood by MRA Trainers and they are very receptive to alternate technologies.
- Improving the mercury-reduction potential of the alternative technology requires reorienting future development towards the resource and technical capabilities of small-scale and artisanal miners.
- Improving technology accessibility would entail scaling down the required equipment and process. There is a need for solutions to be market ready and affordable. Miners highlighted that the cost of materials and training required would limit uptake of the technology.
- The significant livelihood aspect of ASGM means that miners need to see that alternate technologies are fully operational and understand how these technologies could fit into existing practices.

Table of Contents



Acronyms

AML	Alluvial Mining Lease
APEP	Australian Papua New Guinea Economic Partnership
ASGM	Artisanal and Small-scale Gold Mining
CEPA	Conservation and Environmental Protection Authority
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DCCEEW	Department of Climate Change, Energy, the Environment and Water
DFAT	Department of Foreign Affairs and Trade
GEDSI	Gender Equality, Disability and Social Inclusion
MRA	Mineral Resources Authority
PNG	Papua New Guinea

Background

Mercury Use in PNG's ASGM Sector

Small-scale mining in PNG is a vital component of rural income generation. However, this economic contribution is complicated by the significant negative health and environmental impacts caused by the widespread use of mercury as a gold amalgamation technique. This is a global problem, and **the extensive support of key PNG Government agencies like CEPA and MRA provided throughout the demonstration project illustrates a strong national awareness of and commitment to reducing mercury use in ASGM**.

In PNG, small-scale gold mining is practiced across diverse geographical settings, where miners extract gold using a range of techniques based on the deposit environment, average ore grade and accessibility of the deposit.[3] In some of these processes, **mercury is used as an inexpensive reagent to extract gold from ore as an amalgam**. The amalgam is then heated, vaporizing the mercury and leaving behind the gold.[4] This process **releases mercury emissions into the atmosphere, which can cause severe environmental and health effects**. Methylmercury (CH3Hg), the most toxic form of mercury, is formed through the microbial conversion of elemental mercury in lakes, wetlands, oceans or soil.[5]

As a key regulator of the ASGM sector, MRA has supported multiple initiatives to help raise awareness of mercury's negative impacts among miners and has embedded important provisions in PNG's alluvial mining Policy to promote safe mining practices. However, a lack of information regarding how and where mercury is used, including the key supply chains that facilitate its use, and what local opportunities may exist for safer practices have in turn, constrained efforts to **harness the employment and poverty reduction capacity of the sector and to support the economic strategies of rural populations**.[6] A 2019 World Bank study[7] highlighted the pattern of data recycling in ASGM research, which has presented ASGM communities as static populations **despite significant shifts in mineral prices and changes to the economic and social environment of mining regions**.[8] Not only does this 'bury' the economic and social contributions of artisanal mining in national statistics, it overlooks the **unique technical, environmental and social forces that shape ASGM activities**.[9]

3 Moretti, Daniele, 'The Gender of the Gold: An Ethnographic and Historical Account of Women's Involvement in Artisanal and Small-Scale Mining in Mount Kaindi, Papua New Guinea' (2006) 76(2) Oceania 133, 134.

4 Torkaman, P, Veiga, M.M, de Andrada, L, Oliveira, L.A, Motta, J.S, Jesus, J.L, Lavkulich, L.M 'Leaching Gold with Cassava: An Option to Eliminate Mercury Use in Artisanal Gold Mining' (2021) 311 Journal of cleaner production 127531.

5 Wang, Jianxu, Xinbin Feng, Christopher W.N. Anderson, Ying Xing, and Lihai Shang. "Remediation of Mercury Contaminated Sites – A Review." Journal of Hazardous Materials 221-222 (2012).

6 Ghose, Ajoy K., and International Conference on Small-scale Mining. Small-Scale Mining : a Global Overview. Rotterdam: Balkema, 1994, 29-30.

7 World Bank. 2019 State of the Artisanal and Small-Scale Mining Sector. Washington, D.C.: World Bank. Accessed at: https://delvedatabase.org/resources/state-of-the-artisanal-and-small-scale-mining-sector, 2.

8 Portraying mechanised and artisanal mining as one activity also misrepresents small-scale mining as a sub-set industry of conventional, large-scale mining that navigates the same structural and industry challenges.

9 Carman, J. S. "The Contribution of Small-Scale Mining to World Mineral Production." Natural Resources Forum 9, no. 2 (1985): 119–24.

> **Salim gol, kisim moni.**
> *Sell gold, get money.*
>
> **- Research Participant**

In Papua New Guinea, alluvial and small-scale gold mining contributes significantly to the national economy, producing approximately K640 million or AUD$260.4 million in 2021.[10] Globally, the firmly established market value of gold means **small-scale alluvial mining provides significant economic opportunities for low-income communities, generating around three to five times more than the income of other available rural occupations**.[11] This is also the case in PNG and in Wau-Bulolo, where the livelihood strategies of most of the population are realised through artisanal and small-scale mining activities and supplementary subsistence agriculture, rather than through formal, wage-based labour.

10 Source: https://www.pngbusinessnews.com/articles/2022/4/alluvial-gold-mining-export-revenue-increases. Accessed 17/12/2022.

11 Siegel, Shefa, and Marcello M. Veiga. "Artisanal and Small-Scale Mining as an Extra-legal Economy: De Soto and the Redefinition of "formalization"." Resources Policy 34, no. 1 (2009): 51.

The Demonstration Project

The Demonstration Project was made up of two workstreams: the **Technical Demonstration** and the **Rapid Impact Assessment**. The Technical Demonstration tested the technical viability of the mercury-replacement technology in an ASGM context. The Rapid Impact Assessment wrapped around the Technical Demonstration to consider the environmental, social, economic and policy implications of the mercury replacement technology at the national (PNG) level and at the local (Wau-Bulolo) level through primary data collection methods. The assessment at the national level, was conducted through a desktop review of existing reports, data and information on the sector. The key findings of the desktop review are listed below:

- There is a lack of current and accurate information regarding mercury use in PNG's ASGM sector. This reveals an urgent, and global need for **more research to develop a solid baseline to understand mercury use** and emissions, in order to direct international collaboration on mercury reduction in ASGM.
- Sector formalisation has the potential to significantly **improve regulatory capacity, representative data on mercury use and good mining practices**.
- Mercury trade forms part of a **complex network of commodity transactions in global economic supply chains**, and is readily acquired through illicit networks.

The Demonstration Project took place over the course of three trips to the Wau-Bulolo region in Morobe Province. A site feasibility assessment was conducted between 8th - 11th of November 2022, to visit mining operation sites and assess their suitability for the demonstration project and to develop relationships with stakeholders. From this initial visit the Pine Top mine site was chosen. MRA representatives undertook a second trip to the Pine Top site on 18-19th May 2023, to raise awareness for local stakeholders, including the Pine Top Lease Holder and to assist with logistical planning requirements for the technical demonstration.[12] The technical demonstration trip took place in Wau-Bulolo, Morobe Province from 16th August – 2nd September 2023.

The Pine Top site is owned and operated by the local Leaseholder and is registered with **CEPA** and **MRA**. It is a mechanised mine with excavators for extraction and handling of ore. Pine Top produces 400-500 grams of gold per day as coarse gold particles along with some by amalgamation with mercury. The processing of ore at Pine Top is conducted 5 days per week with 2-3 shifts per day. Approximately 100-300 grams a day of mercury (Hg) is used in each amalgamation process to extract the gold. Despite the level of mechanisation at the Pine Top site, the mercury is volatilised (dispersed into the air), rather than recovered using a retort.

12 MRA Site Trip Report.

> **Mipla harim olsem sales blo Mercury bai stop na mipla wari nogut tru. Mipla save olsem time sales blo Mercury stop, wok moni blo mipla bai pinis wantaim.**
> *We heard that mercury sales would stop and we were so worried. We knew if mercury sales stop, our way of making money ends.*
>
> **- Research Participant**

ASGM in Wau Bulolo

Wau-Bulolo is made up of Wau and Bulolo, both of which are historically important and **key mining locations in PNG**, as an alluvial gold source for artisanal small-scale miners and for large scale gold mining projects. Gold was first identified at the Morobe goldfield in 1910. Alluvial dredging and hard rock mining of ore on or near the surface in Morobe reached peak production in the early 1940's when approximately 700 expatriate and 6000 local miners produced 404,000 ounces of gold.[13] Major dredging operations were later followed by small mining operations which expanded throughout Wau and Bulolo districts, utilising simple hydraulic pressure methods **which have continued generationally due to the high cost of modern and mechanized methods of mining**.[14] Rudimentary alluvial gold mining practices using panning and sluicing are also common and form the majority of gold mining practices. The extensive history of mining in Wau Bulolo means that historical deposits of mercury are often uncovered, posing potential harms to both people and environment.[15] This long history also means that small-scale mining techniques are **deeply embedded intergenerational practices**, adopted and passed on through mining families. The intergenerational nature of ASGM poses a significant implementation challenge for mercury-alternative technologies.

Typical of other places in PNG, a mix of gravity concentration and mercury amalgamation are the primary gold recovery techniques used in the Wau Bulolo ASGM community.[16] In this region, a study conducted in 2006 estimated that at least 75% of the population will participate in mining in their lifetime.[17] This contributes to the estimated **88, 000 – 175, 000 people nationally who participate in the small-scale mining sector and who produce 7 tonnes of gold annually.**[18] There are approximately 15–20,000 gold miners in Wau-Bulolo[19] who work either in small-scale operations (typically between 20 -100 persons) or in smaller 'artisanal' family mining groups. These family units carry out daily gold panning on their customary land without an Environment Permit or Alluvial Mining Lease (AML), using rudimentary methods to extract gold.[20] Approximately only 10% of alluvial miners secure the requisite Environment Permit or AML granted under the Environment Act 2000 and the Mining Act 1992. This is likely to be higher in Wau Bulolo due to the presence of more semi-mechanised and fully mechanised mine sites such as Pine Top.[21] However, even in districts that are characterised by more mechanised and semi-mechanised operations such as Wau Bulolo, the vast majority of miners using mercury in the region are small-scale, artisanal miners. This demonstrates that in Wau Bulolo, **small-scale gold mining is a vital component of livelihood strategies and is both an essential contributor to the local economy and assists communities to meet cultural and church obligations.**

13 Moretti, Daniele, 'The Gender of the Gold: An Ethnographic and Historical Account of Women's Involvement in Artisanal and Small-Scale Mining in Mount Kaindi, Papua New Guinea' (2006) 76(2) Oceania 133, 135.

14 Javia, Immaculate, Paulina Siop. "Paper on Challenges and Achievements on Small Scale Mining and Gender". Wau Small Scale Training Centre, 2010, 2.

15 When alluvial gold resources became depleted by the mid-1980s, focus turned to deposits discovered in the mid-1980s and large-scale modern mining commenced with The Hidden Valley gold-silver project which began production in 2009. Currently, Hidden Valley and Wafi-Golpu represent the two main large scale mining projects in the Morobe province along with other smaller ventures.

16 Ponyalou, Olive Kimale Lucas. "Gold Ore Characterisation, Mercury Use & Value Chains Analysis of the Artisanal & Small-Scale Gold Mining Sector of Wau, Morobe Province, Papua New Guinea." 2018.

17 Moretti, Daniele, 'The Gender of the Gold: An Ethnographic and Historical Account of Women's Involvement in Artisanal and Small-Scale Mining in Mount Kaindi, Papua New Guinea' (2006) 76(2) Oceania 133, 135.

18 Bainton, Nicholas, John R. Owen, Simon Kenema and John Burton, 'Land, Labour and Capital: Small and Large-Scale Miners in Papua New Guinea' (2020) 68 Resources policy 101805.

19 Updated data (October 2021) based on a presentation by Tongo and Crispin at the Geology, Exploration and Mining Conference in Port Moresby, June 2001.

20 "Landholders or natural citizens using sluice boxes and gold pans or such other rudimentary mining methods can undertake alluvial mining with or without an AML on their customary land; and anyone conducting an alluvial mining activity utilising any machinery that is powered by diesel, petrol or electricity must obtain an AML and the appropriate Environmental Permit" MRA. Alluvial Mining Policy, 2021, 5. MRA also categorises the small scale gold mining sector in the following way simple/semi mechanised/fully mechanised.

21 Moretti, Daniele, 'The Gender of the Gold: An Ethnographic and Historical Account of Women's Involvement in Artisanal and Small-Scale Mining in Mount Kaindi, Papua New Guinea' (2006) 76(2) Oceania 133, 135.

> **Sapos mipela nogat mining komuniti bai dai pinis.**
>
> *If we did not have gold mining the community would die.*
>
> **- Research Participant**

> **We used 200 kina worth of mercury, 2 bottles. And we got, 3000 plus.**
>
> **- Research Participant**

Rapid Impact Assessment

> **We do not really understand the situation about mercury use in PNG. This unknown presents one of the greatest challenges for us.**
>
> **- CEPA Representative**

Background and Sample

The Rapid Impact Assessment contributes to the growing body of knowledge addressing **current ASGM practices, perceptions of mercury use and the potential for and willingness of small-scale miners to adopt new technologies.**

The overall aim of the Rapid Impact Assessment was to understand the broader context in which the mercury technology replacement could be introduced. Specific aims were to assess:

1. The attitudes of ASGM miners to the technology itself and the potential ease of the alternative technology introduction; as well as the current health, social, economic, policy and environmental impacts of mercury that have been informed by the project desktop review.
2. Potential opportunities and barriers for uptake of the technology locally in Wau-Bulolo, and more broadly at the national level (through consultation with MRA).

To deepen the understanding of the alternative technology and where it sits in relation to questions such as "*What is the context for continued mercury use, how is it used and why?*", the team conducted surveys and semi-structured interviews with key participants, stakeholders and other institutional partners.

The analysis that follows gives shape to the **story of mercury use in Wau Bulolo's alluvial and artisanal mining sector**. The findings are also relevant for other locales in PNG where mercury use in ASGM is significant and help to support an integrated assessment of the social and livelihood dimensions of ASGM, in which poverty and poverty alleviation strategies are not viewed exclusively in economic terms, but which also consider the **overlapping social and cultural factors** that should inform government policy and development objectives.

Whilst based on a small study with a small sample of research participants, the findings from this Rapid Impact Assessment provide a 'snapshot' of mercury use in ASGM, and its impact in PNG and Wau Bulolo in particular. The assessment also provides important local context to understand **the potential impacts of the mercury-alternative technology in a location that has a long and continuing history of ASGM practices**.

Rapid Impact Assessment - Sample Characteristics

Site	Data Collection
Pine Top Mine Site	14 surveys (14 male)
Pine Top Market	5 surveys (5 female)
MRA Training Centre	2 semi-structured interviews (1 male, 1 female), 3 surveys (2 male, 1 female)
Total	**22 (6 female, 16 male)**

Data Collection and Analysis

Social Safeguards

In line with the principle of harm minimisation- that is, the activities undertaken should minimise harmful impacts to the community- social safeguards were an integral aspect of the Technical Demonstration and Rapid Impact Assessment, underpinned by DFAT's Environmental and Social Safeguard Policy.

Ethical Research

The research conducted as part of the Rapid Impact Assessment conforms to the principles set out in the Australian Code for the Responsible Conduct of Research (2018).

Informed Consent and Confidentiality

Research participants received information about the project in English and Tok Pisin. Information was provided to ensure participants understood the anonymous nature of the survey and the manner in which their identity and data would be protected. A signed consent form from each participant was obtained, communicating that the information was understood and that participants provided consent to be surveyed.

Sampling

The sampling strategy employed was a convenience cluster and snowball sample representing miners and the community in Wau-Bulolo, Papua New Guinea.[22]

Surveys

Surveys were conducted in Tok Pisin. A limited number of people watched the technical demonstration of the alternative technology. As a result, part three of the survey focussing on the alternative technology was not used. Feedback on the technical demonstration was therefore limited to semi-structured, in-depth interviews held with two participants. See Annex A for survey questions.

Semi-Structured In-Depth Interviews

Semi-structured in-depth interviews were audio recorded. Field team members also took notes and 'time stamps' which helped in the analysis of data. The analysis took an inductive approach. Audio recordings were analysed for emergent themes, otherwise known as 'open-coding'. Once consistent themes were identified, they were used as preliminary codes in which to code and analyse the remaining qualitative data. If other themes emerged through the analysis the themes and number of codes was expanded upon.

22 Some effects were revealed in the data analysis to have significance (p) values of greater than, however close to .05. In statistical methodology, this effect is known as 'trending towards significance', where it is likely that the effects become significant with a larger sample.

Data analysis

Data from the field were de-identified, entered manually into Microsoft excel and imported into the statistical data analysis program, R. From there, correlations and regression analyses were run to understand the relationship between age, gender, and mercury use. Descriptive statistics (averages, percentages, most common answers) were pulled out through a combination of Microsoft excel and R.

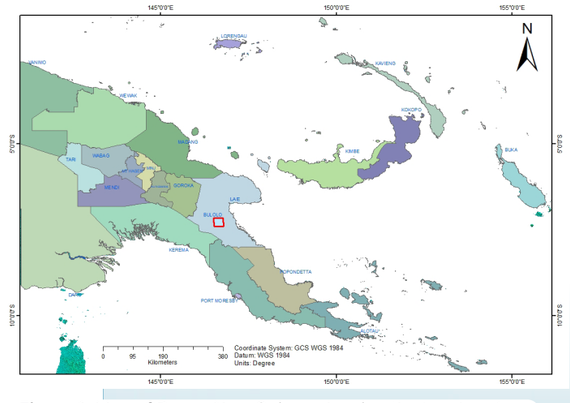


Figure 1: Map of Papua New Guinea showing the location of the Project site in Bulolo Morobe Province (red square).

Neim blo man blo mi em Eric. Mi wantem ol pikinini (blo mitupla) wok yet stap lo displa mining hap blo man blo mi. Eric ibin sik mo lo tripla mun na ibin lusim laif blo em. Ol han na lek blo em ibin go bilak tru. Taim mipla karim em igo lo Lae lo testim em, ol toksave lo mipla olsem em igat sik lo kidni blo em. Mipla bilip olsem ol pipol ibin bagarapim em. Eric ibin dai lo 2020.

My husband's name was Eric. My children and I still work on my husband's mining lease area. He was sick for over three months and then passed away. His arms and legs had turned black. When we took him for tests at Lae, we were told he had kidney problems. We believe people were jealous and did black magic on him. He died in 2020.

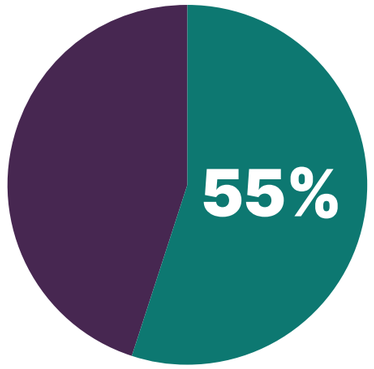
- Research Participant

100% of people said

> **Small scale gold mining is an important part of the local economy.**

Overwhelmingly, **participants thought small-scale gold mining was good for the local economy**. Basically, “gol em moni”/ gold means money; “salim gol kisim moni”/ sell gold, get money. These answers highlighted that the immediacy of the financial return facilitated by mercury means that people can start and complete the gold recovery process relatively efficiently and access cash funds to pay for their daily needs such as rice, tinned fish, batteries and soap. Survey responses that emphasised the economic contribution of small-scale mining dovetailed with the answers given for the question ‘why did you start gold mining?’, in that both sets of responses highlighted small-scale gold mining as enabling people to ‘get money’ and make a living in order for them to support their families, pay school fees and participate in cultural and church-based events.

Participants also mentioned that compared to gold mining, agriculture was difficult and a ‘struggle’. That is, people mentioned the time required to grow crops, the reliance on weather and the relatively high labour investment to monetary return ratio when compared to small-scale gold mining. Whilst some people still had gardens to help feed their families, **this was secondary in their livelihood strategies compared to small-scale gold mining.**



People who are aware that mercury can make them sick

A significant finding of the study was that **only 55% of people surveyed were aware that mercury can make them, or those around them sick**. This means that **45% of people were not aware of the severe health and environmental impacts of mercury**. That this finding was drawn from workers at a formalised mine operation suggests that mercury awareness levels in the informal and non-mechanised sector may be even lower.

While 55% of people said that mercury can make them or those around them sick, only 17% of people use some protection (mostly gloves) when handling mercury. Some people said that they wash their hands after using mercury and before they eat. This means that w**hile people may be aware that mercury can make them sick, they may not be concerned enough to take precautions**. Reasons for this could be that people do not recognise the symptoms of mercury poisoning or attribute symptoms to other causes such as sorcery and other illnesses.

Immediacy was an important theme that emerged from the qualitative data. Participants highlighted ‘turnaround time’ as a benefit of using mercury. That is, the capacity to get paid on the same day as finding and processing gold by using mercury in the amalgamation process. This immediacy, the lack of knowledge regarding mercury poisoning symptoms, and the delayed, future onset of health issues, means that **the positives of immediate financial return using mercury outweigh its negative health impacts for many miners**.

Findings

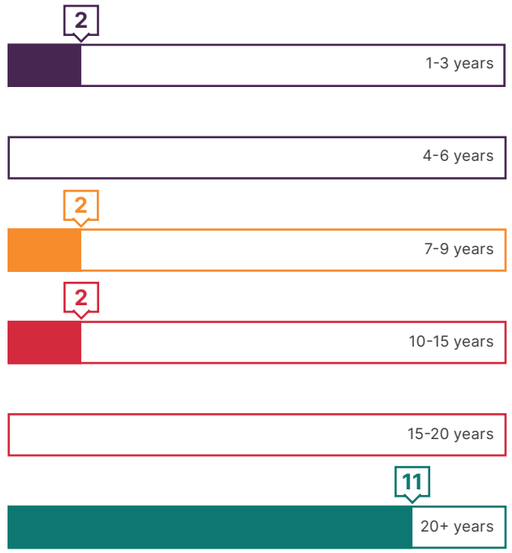
> **Yumi nonap igo lo bank/haus moni. ATM blo yumi em painim gol.**
>
> *We can’t just go to the bank so gold mining is like an ATM for us.*
>
> **- Research Participant**

83% of people use no protection when working with mercury.

17% of people use some protection when working with mercury.

Protection is primarily gloves and no respiratory protection (mask).

"How Long Have You Used Mercury?"



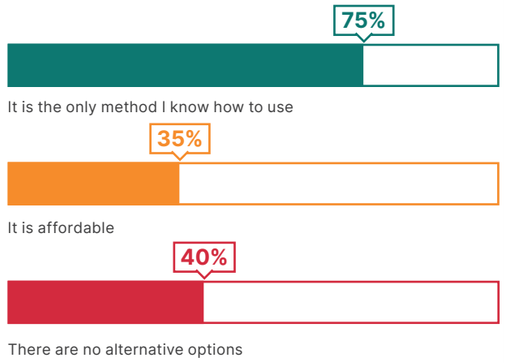
> **It's their real need- even if the price of mercury goes up, they still go for it. For them the thinking is that that is the only cheaper and fastest means of getting their gold.**
>
> **- MRA Representative**

The **intergenerational nature of ASGM was identified as a key factor in the continued use of mercury**, its connection to health issues and a general lack of protection used by miners. Miner's experience of witnessing family members using mercury for long periods of time without becoming ill, meant that they did not feel the need to use protection when using mercury themselves. In turn, the most common precaution taken when using mercury was to avoid inhaling the smoke during the amalgamation process, as there is a general awareness that the smoke can cause illness.

> **Simuk bai bagarapim yu sapos yu pulim win. Noken sanap klostu.**
>
> *The smoke buggers you up if you breathe it in. You can't stand too close.*
>
> **- Research Participant**

The most common (modal) answer for using mercury was two to three times per week. One quarter of people use mercury every day. However, the majority of participants being surveyed were on a mechanised mine site where not all workers used mercury in their jobs (i.e., machine operators). The numbers do indicate that outside of their work on the mine site, **some of the workers use mercury to find gold to supplement their formal mining incomes**. Supplementing income through small-scale gold mining is by no means confined to miners, some research participants suggested **it was also common for people in other forms of employment (i.e., teachers, forestry plantation workers) to turn to alluvial gold mining and use mercury when money was needed**. However, due to the limited sample size, no direct data between this supplementing by people outside the mine site and mercury use was taken.

"Why do you use mercury?"



> **[Small-scale mining] happens outside of accessible facilities [...] They employ high-risk behaviour in chasing for gold.**
>
> **- MRA Representative**

Compounding the perception of mercury's effectiveness, **mercury is also highly accessible in the Wau-Bulolo area**. Those who were surveyed knew where they could buy mercury (street stalls and gold dealers) and some people suggested mercury was easier to find now than it had been in the past. On this basis, important factors influencing miner's adoption of alternative technologies are **1.) an accessible price point and 2.) that technical processes are effective and efficient compared to mercury**. Suitable technologies would need to be demonstrated to miners with a transitional 'period of change' factored in, recognising that mercury use is deeply embedded in ASGM mining practices and mining communities. This means that change would not happen 'overnight.' **The transition away from using mercury and the associated awareness raising around its use should also factor in low literacy and education levels**. This is illustrated in study findings which demonstrated that people who use mercury more, spent less time at school.[23] This finding reflects the intergenerational dimension of small-scale gold mining, where miners 'learn the trade' as children to help out with family finances (i.e., help pay school fees).

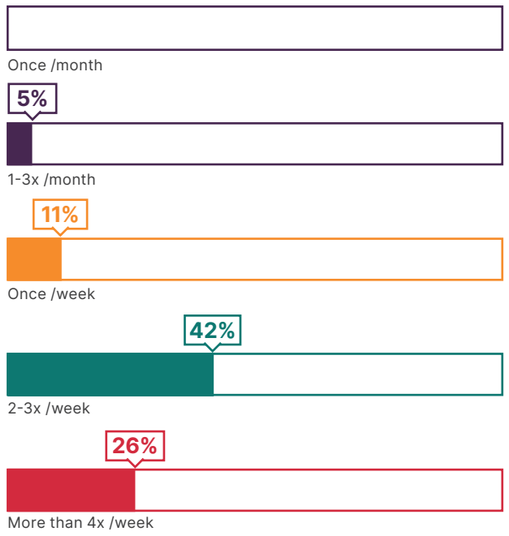
Most people use mercury because it is the only method they know how to use. The data also revealed the most common answer to the question '*Why do you use mercury?*' was "*It is the only method I know how to use* **and** *it is affordable*". This co-occurrence indicates that t**he use of mercury is deeply embedded in the small-scale gold mining sector and is seen to be effective by small-scale gold miners**. This effectiveness is complemented by its affordability.

The other site of significance in terms of data gathering was the Pine Top Market, which provided a 'less controlled' setting than the mechanised Pine Top mine site, and potentially more of a wider community viewpoint on the use of mercury. Whilst only women participating in informal non-mechanised gold mining were surveyed at the Pine Top Market, their frequency of use was higher,[24] indicating that community use may be higher than the figures reported from the mechanised Pine Top site. For instance, **one woman who was a mother of eight children reported using mercury daily, and that some of her children also used mercury to make ends meet**. This supports a finding in the literature review that women's participation in ASGM occurs primarily at the survival-oriented, informal end of the ASGM sector where women may face an increased exposure risk to the negative health impacts of mercury. Further consideration should also be given as it was suggested that a division of labour exists within family units undertaking small-scale mining, with men usually handling and working with mercury whilst the women undertake panning and sluicing. This may indicate with a larger sample size that 'community use' might be even higher, as this 'community sample' was limited to Pine Top Market and included only females.

23 r = -.62, p = .005; r represents a Pearson correlation coefficient, where a higher number represents a stronger relationship, with a maximum of 1. Significance is represented by the p value, where a value of less than .05 means that the relationship is statistically significant.

24 80% of people from the Pine Top Market site used mercury, where only 71% of people from the Pine Top Mine site used mercury; 80% of people from the Pine Top Market site used mercury, where only 71% of people from the Pine Top Mine site used mercury; Of the people who used mercury, men used it an average of one to three times per week, and women used it between 2 times and 'more than 4 times' per week. It is worth noting that the group means were not statistically significantly different, t = 2.031, p = .064, though this difference is again trending towards significance, suggesting that with a slightly larger sample, a significant (p < .05) difference would emerge.

"How often do you use mercury?"



> **Hem laif blo mi! Yu toktok long wanem?**
>
> *Mercury and gold mining is my life! What are you talking about?*
>
> **- MRA Trainer (on facing resistance when conducting mercury awareness at the community level).**

Participants also reported using mercury more frequently when they needed more money, for example, a wedding, funeral, church mission or if someone in their family became sick and needed medicine. Further, it was found that **individuals who had attended an MRA training course were more aware than those who had not that mercury has a negative impact on the environment**. This suggests that MRA play an important role in raising awareness of the impact of mercury in small-scale gold mining.

> **People who had attended an MRA training course were more likely to be aware that mercury has an impact on the environment.**

The 2021 Alluvial Mining Policy proposes the expansion of MRA Training Centres to other parts of PNG.[25] The expansion of these sites is potentially an important mechanism through which to further disseminate knowledge and awareness regarding mercury use in ASGM. However, it is important to note that the wider survey findings of a general lack of awareness of the health and environmental impacts of mercury, coupled with its economic importance, affordability and effectiveness, indicate that **more substantial awareness training needs to occur at the grassroots level**. Without targeted community awareness campaigns, the expansion of Training Centres alone would be ineffective in reducing mercury use.

It was also found that **the longer someone had been mining, the more mercury they used in a week**. However, analysis revealed that mercury use was actually explained by time spent in school, where people who had spent less time in school used more mercury. **This paints a picture of an older generation, who typically have less schooling, using ASGM (and mercury) to provide opportunities for the younger generation**.

25 Mineral Resources Authority, Papua New Guinea Alluvial Mining Policy 2021 (Policy, 2021) < https://mra.gov.pg/wp-content/uploads/2022/05/Alluvial-Mining-Policy.pdf>.

The study points forward to a need for more research and data to assist in global mercury reduction and elimination efforts. This is especially the case in PNG because there is **little accurate information available on how much mercury is used by ASGM miners in PNG**, including the levels of mercury miners are exposed to, and the full extent of mercury's environmental impact in PNG.

> **Yes em kain olsem, living blo mi em me usim mercury na me kisim moni na me kaikai. Na sapos yu stopim merury lo me nau, hau stret bai me salim pikini blo me go lo skul.**
>
> *So its like this, to sustain my way of living I use mercury to get money so I can sustain myself and eat. So if you prevent me from accessing mercury, how can I be able to send my child to school.*
>
> **- Research Participant**

Limitations

A limitation in the rapid impact assessment was that the evaluation addressed inclusion only in terms of gender, and not in terms of its broader dimensions (for example disability) because of the small sample size of available participants.

The gender sample size was also limited, due to the small number of women working at the Pine Top site, though this was offset to some degree by surveying women at the Pine Top Market. In this respect, the inclusion of pregnant women and children is an important focus for future projects, given this group's particular vulnerability to mercury exposure.[26]

Due to security concerns and in the interests of managing community expectations regarding the alternative technology, the sample size and community members included in the survey was relatively small. The sample size also dictated that the majority of research participants were formal small-scale gold miners working at a mechanised mine site.

The project scope limited analysis of the mercury supply chain to the desktop review. Supply chain analysis is an important focus area to inform mercury-reduction strategies and to understand the impact of these strategies on the existing value chain.

It is also worth mentioning that modifications were made to the survey to align with the desired outcomes of the project, resulting in a departure from Likert-style questions in favour of binary or categorical responses. This approach may have limited the breadth of analyses that could be run on the data.

Finally, feedback from the technical demonstration was limited as only four staff from the MRA Training Centre viewed the demonstration project and only two of this group participated in the semi-structured interviews which served as the feedback sessions on the technical demonstration.

26 Future projects and studies should focus more inclusively on the diverse groups involved in informal and formal mining, and particularly on communities living downstream from mining activities where mercury is used. As a study focus, this would demonstrate that harmful mercury exposure is not confined to the direct inhalation of mercury during mining amalgamation processes, but that non-mining communities are also exposed through the consumption of mercury-contaminated fish and water sources.

Summary

Overall, it was found that the ASGM miners who participated in the Rapid Impact Assessment were not fully aware of mercury's impact on health, the environment, and the specific exposure vulnerabilities of women and children. The most insightful relationship the analyses revealed was that there is a direct relationship between time spent in school and the amount of mercury a person uses in a week, where people who had spent more time in school used less mercury.

A number of other analyses were run, though they did not reveal any significant effects. It is worth noting that not finding effects does not mean that they do not exist in the wider population. For example, it was shown that individuals of the older generation used more mercury, and that mercury use is related to education. It was also found that overall, older individuals had lower levels of education. It would then follow that individuals in the older generation are less likely to be aware of mercury's impact, because of the relationship between age and education. This effect was identified in the analyses, though relationship did not reach significance.

The key findings from the assessment are as follows:

45% of people surveyed were not aware that mercury could make them sick.

ASGM and mercury use is often intergenerational.

Returns from mercury use in ASGM are immediate, and future technologies need to account for this.

The income from ASGM is essential to the local economy and a vital source of income for families to pay for school fees, food, and to meet cultural obligations.

Perceptions of the Technical Demonstration

The demonstration project was undertaken as a means of assessing the **technical, environmental, social and economic viability of the mercury alternative technology in an ASGM-context**.

A feedback session was held with two MRA trainers at the MRA Training Centre in Wau. The two MRA Trainers had completed a 'hands on' technical demonstration the previous day at the Pine Top Mine site. This session was conducted as a semi-structured group interview, the key points of which are presented below:

Overall Impressions

The trainers understood the technology and process and they welcome alternative technologies to reduce mercury use, while still supporting community livelihood strategies.

They suggested reducing and scaling down what they were shown in the demonstration. The reason provided was that they felt the technology could potentially be suitable at the current scale for fully and semi mechanised mine sites, but not for individual and smaller scale alluvial gold miners. Both trainers also raised the issue of miner literacy in relation to the technical process. They indicated that less literate miners may require assistance in mixing the solutions or require training as the current process is too technical.

Accessibility

3. Fewer barrels and containers and of a smaller size.
4. Make a 'ready-made kit' including pre-mixed solutions. This would reduce the time frame required to recover the gold. This would help to make the technology more comparable to the rapid recovery process and ease of using mercury.

Challenges

1. Cost of materials and the amount of materials required.
2. The training needed to complete the process (especially for individual miners or those not operating in semi or fully mechanised sites).
3. The time frame for the process is significantly longer than the mercury-assisted process. Current practices using mercury allow people to recover the gold *and* access money in a significantly shorter time frame to go and "buy their rice and tinned fish."
4. Storage would be an issue for smaller scale miners as they would not have the space required to store the necessary equipment. The equipment may also lead to unwanted attention from people, including thieves. Miners do not have security to guard the equipment.

Looking Forward

1. Who is the intended audience for the alternative technology? Is it designed for use only at mechanised and semi-mechanised sites?
2. The alternative technology could be situated within an awareness campaign that highlights the dangers associated with mercury use in ASGM.

Towards a Sustainable ASGM Future: Key Challenges and Priorities

Overall, people were receptive to the idea of alternative technologies to reduce the use of mercury in ASGM. This is a positive outlook for future projects and for the development of mercury-replacement technologies more broadly.

Reducing mercury use in ASGM requires further education and awareness raising of mercury's harmful impacts. Awareness raising and education should be done in partnership and collaboration with agencies such as CEPA and MRA in order to leverage existing community relations and industry networks on the ground.

Strategies to introduce alternative technologies need to address the intergenerational dimension of mercury use in ASGM. Incentivising miners to change mining techniques that have been practiced generationally is a significant, and national challenge facing mercury reduction in PNG. Further consultation with small-scale miners is needed in order to raise awareness of the benefits and potential practices of non-mercury techniques, identify gender 'gaps' in the sector, and to support the inclusive design and implementation of mercury-alternative technologies.

Returns from mercury use in ASGM are immediate, and future technologies need to account for this. The immediacy of ASGM as a livelihood strategy, to purchase food and pay for school fees emphasises that a competitive gold recovery time frame is a key determinant factor in the adoption of alternative technologies.

More data are needed to understand mercury use and its impacts in PNG. Current and accurate data related to mercury use in small-scale mining is needed to better understand the health and environmental impacts of mercury, the flow of mercury through local and international supply chains, and in order to continue to foster efforts towards formalisation in the ASGM sector. **Supply Chain analysis should form a key aspect of this future data**. Supply chain analysis may indicate how restrictions on formal supply chains could potentially deepen mercury trafficking networks and intensify labour marginalisation.[27]

27 Le Billon, Philippe and Samuel Spiegel, 'Cleaning Mineral Supply Chains? Political Economies of Exploitation and Hidden Costs of Technical Fixes' (2022) 29(3) Review of international political economy 768, 783.

Technical Demonstration

This section of the report has been provided by Clean Mining and CSIRO

PNG-Australia Joint Research Partnership towards safe and sustainable ASGM

DEMONSTRATION TECHNICAL REPORT

Demonstration undertaken 21st August – 1st September 2023 at the Pine Top gold mining operation near Bulolo in PNG.

This project is a collaboration between PNG's Conservation and Environment Protection Authority (CEPA), Mineral Resources Authority, the Australian Government's science agency CSIRO, the Department of Climate Change, Energy, the Environment and Water (DCCEEW) and the Department of Foreign Affairs and Trade (DFAT). The project aim was to demonstrate and assess the feasibility of a potential mercury-replacement technology (Clean Mining technology) as an alternative to mercury for gold recovery by Artisanal and Small-Scale Gold Mining (ASGM) in PNG, with the longer-term aim of reducing mercury emissions and releases in PNG.

Joint Agency Advisory Committee for the project

Sarah Douglass (Project Manager, DCCEEW)

Ruben Seaton (DFAT)

Theresa Gizoria (DFAT)

Simon Apte (CSIRO)

Paul Breuer (CSIRO)

Patricia Torea (CEPA)

Bobby Yavi (MRA)

Calvin Dusava (MRA)

Jeff McCulloch (Clean Mining)

David Toua (APEP)

Jonah Simet (APEP)

Summary

The Clean Mining process demonstrated at Pine Top used non-toxic reagents dissolved in water to leach (dissolve) the gold from the sluice concentrate material into the leach solution. The process was demonstrated with basic materials of drums, buckets and 12V water pump. The pump was powered by a 12V battery with a solar blanket used to recharge the battery. The gold was recovered from the leach solution by precipitation and the precipitate collected by decanting/filtration. The recovered precipitated gold was heated (smelted) to produce a gold dore product that can be traded.

The demonstration showed in a direct comparison test that the Clean Mining process (48 hour leach) could outperform mercury amalgamation with 3300 and 2500 g/t gold recovery respectively. The Clean Mining process was also demonstrated at longer leach times (4-6 days) to be able to leach and recover coarse gold when present.

Due to the non-toxic nature of the Clean Mining process, it provides the opportunity for miners to further increase their gold recovery by operating with higher mass pull to the concentrate which will increase the gravity gold recovery (reversing the gold losses in minimising the quantity of concentrate and mercury for mercury amalgamation).

Introduction

The initial site visit to Bulolo, PNG in November 2022 and satisfactory testing results for collected samples identified the Pine Top mine as a suitable site for the demonstration. The project developed a detailed demonstration plan which was undertaken in late August 2023. The schedule and roster for the demonstration is included in the Appendix.

Technical Activities

The Clean Mining leaching process was demonstrated with basic materials of drums, buckets and 12V water pump (Figure 1). The pump was powered by a 12V battery with a solar blanket used to recharge the battery.

Figure 1: Four samples undergoing leaching during the demonstration.

The gold containing leach solution was placed in a separate drum and the gold was recovered from the leach solution by precipitation. The precipitate was collected by decanting/filtration (Figure 2). The recovered precipitated gold was heated (smelted) to produce a gold dore product that can be traded.

Figure 2: Gold precipitate being recovered by decanting and filtration.

The demonstration planned to test several samples split to conduct parallel testing and provide a direct comparison of the Clean Mining process against mercury amalgamation. Unfortunately, the "spinner" used by the mine site to remove coarse gold from the sluice concentrate broke down a couple of weeks before arriving on-site for the demonstration. This meant there was limited samples available to conduct a direct comparison with mercury amalgamation. The demonstration was fortunately able to use samples of sluice concentrate containing coarse gold particles by adopting a longer leach time for these samples; a comparison with mercury amalgamation was not possible for this material as the coarse gold is not effectively recovered using mercury.

Five samples were processed during the demonstration:

- 2 sluice concentrate samples (from the hand sluice) with the coarse gold removed by the spinner [A1 & A2]: These samples were split and a direct comparison undertaken between the Clean Mining process and mercury amalgamation.
- 2 sluice concentrate samples (from the hand sluice) containing coarse gold (due to the spinner failure not allowing removal of the coarse gold) [C1 & C2]: The first sample was split into 3 separate leach tests, whilst the second sample was all leached in a single test. These samples were repulped and leached with fresh leach solution to hopefully provide sufficient leach time for the coarse gold contained in these samples.
- 1 sample of waste material from the hand sluice [B1]: This material was investigated to assess the opportunity to recover additional gold that is currently being lost in the Pine Top process. The representative nature of this material however is unknown. It was also assumed any gold in this material would be in the fines with only the fines in the tails weighed and assayed for residual gold.

Results/Outcomes

The summarised results from the demonstration are presented in the tables below based on the dore weight and analyses (tails and solution assays pending attainment and review). The gold dore composition for the Clean Mining tests is largely gold and silver (97-99 wt%) with the dore from mercury amalgamation being 95 and 91 wt% gold and silver (and 3.5 and 7.2 wt% mercury)

respectively for tests A1 and A2. The A1 Clean Mining test dore had significant gold lost into the slag during the smelting process, which was resolved for subsequent tests.

The direct comparison for sample A2, shows improved gold recovery by the Clean Mining process (3300 g/t gold) compared to mercury amalgamation (2500 g/t gold). The much higher gold recoveries from the C1 and C2 samples indicate with sufficient leach time coarse gold particles can also be leached and recovered by the Clean Mining process.

Clean Mining Tests

Sample	Sample weight (g)	Au dore		Extracted/Recovered (g/t)	
		(g)	(%Au)	Au dore	Au
A1	4813	7	61	1454	892
A2	3824	23	55	6015	3302
C1*	11992	156	56	13009	7315
C2	6748	56	62	8299	4689

* Combined result of the 3 sample splits that were separately treated.

Mercury Amalgamation Tests

Sample	Sample weight (g)	Au dore		Extracted/Recovered (g/t)	
		(g)	(%Au)	Au dore	Au
A1	3919	21	40	5359	2149
A2	3927	21	47	5347	2518

Results for sample B1 are pending leach solution analyses as there was insufficient precipitated gold to produce measurable gold dore (suggesting the gold grade of this sample was low). The quantity of gold though could be significant as there is a lot more of this material in comparison to the concentrate.

Figure 3 shows the gold dore products (after heating/smelting the gold precipitate) for some of the individual tests and the final combined gold dore product from all the Clean Mining tests.

Figure 3: Gold dore products – some individual test products on the left and final combined product on the right.

Conclusions and Recommendations

The demonstration showed in a direct comparison test that the Clean Mining process (48 hour leach) could outperform mercury amalgamation with 3300 and 2500 g/t gold recovery respectively. The Clean Mining process was also demonstrated at longer leach times (4-6 days) to be able to leach and recover coarse gold when present.

Due to the non-toxic nature of the Clean Mining process, it provides the opportunity for miners to further increase their gold recovery by operating with higher mass pull to the concentrate which will increase the gravity gold recovery (reversing the gold losses in minimising the quantity of concentrate and mercury for mercury amalgamation).

Appendix – Demonstration Schedule and Roster

	Task	**Required staff** ***(others to participate as-needed and subject to availability)***
Week 1 14 – 18 August	Project set up: • Ensure equipment is onsite and readily available for technical demonstration leads. • Finalise project logistics. • Stakeholder liaison and activities brief with Pine Top site managers and miners.	[DCCEEW, APEP, MRA, Square Circle] Sarah, Jonah, Bobby, Calvin and Michael **Tues 15th:** Logistics meetings in POM **Wed 16th:** Travel to Bulolo via Lae **Thurs 17th and Fri 18th:** Project readiness and stakeholder liaison
		Fri 18th: • Paul, Jeff and James fly Brisbane to POM. **Sat 19th:** • Patricia, Paul, Jeff and James to travel to Bulolo (via Lae if required). • Calvin to travel from Bulolo to POM.
Week 2 20-25 August (noting 26 August is a Saturday)	6-Day Demonstration: • Equipment set-up (1 day). • Process testing and refinement. • MRA training centre staff field trip to Pine Top site (23/8).	DCCEEW, APEP, CSIRO, MRA, Clean Mining, Square Circle On site in Bulolo for the week: Sarah, Jonah, Paul, Bobby, Jeff, Michael and James. Olive to be on site for 24/25. **Sun 20th:** Site & Equipment set up **Mon 21st:** Commence process testing; stakeholder liaison; filming.
		Tues 22nd – Fri 25th: Process testing and refinement; surveys; filming. Olive to begin testing with XRF gun on Thurs 24th. **Wed 23rd:** MRA field trip to Pine Top / Process testing and refinement; use blow torch to smelt the gold sample on site with the trainees; surveys; videography; Olive to continue testing with XRF gun. **Sat 26th:** Process testing and refinement at Pine Top.
Week 3 27 August – 1 September	6-Day Demonstration: • Process testing and refinement. • Project pack-down. • Site clean up and waste disposal. • Project debrief and final observations.	CSIRO, APEP, CEPA, MRA, Clean Mining On site in Bulolo for the week: Jonah, Paul, Bobby, Jeff, Simon and Patricia **Sun 27th – Thurs 31st:** Process testing and refinement; mapping out site clean up and disposal; surveys; On Wednesday: package up samples to supply to Fedex in Lae (Bobby to source export consent forms for dispatch from Lae direct to Australia – *need to know sample weight*). **Tues 29th:** Drivers to collect Simon from Lae airport for transport to Bulolo by early afternoon. **Fri 1st Sept:** Site clean up and waste disposal.

Appendix A

Rapid Impact Assessment Survey

Survey

Part One

1. Have you attended or are you attending school?

☐ Yes

☐ No

2. What age did you finish school? _____

3. When did you first start gold mining (insert year): _____

4. Why did you choose to start gold mining?

_____

_____

5. Have you ever wanted a different job? Please describe:

_____

6. Do you come from Wau-Bulolo?

☐ Yes

☐ No

If no, where does your family live? _____

7. Have you attended a training course at the MRA Training Centre in Wau?

☐ Yes

☐ No

8. Do you think small scale gold mining is an important part of the local economy?

☐ Yes

☐ No

Why? _____

9. How long have you been using mercury to mine gold? (tick one box):

☐ 1-3 years

☐ 4-6 years

☐ 7-9 years

☐ 10-15 years

☐ 15-20 years

☐ 20+ years

10. In a standard working week, how often do you use mercury? (tick one box):

☐ Less than once per month. Please describe: _____

☐ Once per month

☐ 1-3 times per month

☐ Once per week

☐ 2-3 times per week

☐ More than 4 times per week. Please describe: _____

11. When you use mercury, what safety precautions do you take? (please describe)

_____
_____

12. Why do you use mercury? (tick as many boxes as you wish):

- ☐ It is the only method I know how to use
- ☐ It is affordable
- ☐ There are no alterative options
- ☐ Other (please describe)_____

Part Two

13. Do you think that exposure to mercury can make you, or those around you, sick?

- ☐ Yes
- ☐ No

14. Did you know that mercury is more dangerous for pregnant women and children?

- ☐ Yes
- ☐ No

If yes, how did you know this? (please describe):_____

15. Do you think other miners in Bulolo understand that mercury is dangerous?

- ☐ Yes
- ☐ No

Please explain why: _____

16. Did you know that mercury use has environmental impacts?

- ☐ Yes
- ☐ No

If yes, what do you think it can have negative impacts on:

- ☐ Waterways and fishing
- ☐ Food gardens
- ☐ Forests
- ☐ Other (Please list)_____

Part 3

17. Do you think the new technology looks easy to use?

- ☐ Yes
- ☐ No

Please explain: _____

18. In the future, would you be interested in using the new technology instead of mercury?

- ☐ Yes
- ☐ No

Why? (Please explain): _____

19. Do you think there would be problems in using this new technology?

- ☐ Yes
- ☐ No

Why? (Please explain): _____

Part 4

20. How do you get mercury? For example, do you buy it at the market?

_____

_____

21. How much does it cost for approximately 5ml of mercury?

_____

22. Please provide any final comments you have about mercury use in your community or about the new technology:

_____

_____