

Artisanal Small-scale Alluvial Gold Mining in Papua New Guinea: Meriyaka Alluvial Gold Mining – A Case Study.

Benny Mek

University of Goroka

mekb@uog.ac.pg / benny.mek@gmail.com

Abstract

Artisanal Small-scale Mining (ASM) has recently increased with increase in high gold prize. Populations of small-scale mining in PNG are rural bashed miners who use rudimentary sluice box and gold panning dish. The small-scale mining activities have increased due to very high gold prize, consequently environmental problem arises such mercury pollution and other safety hazard associated with mining and processing of alluvial gold. This paper presents the current grass roots alluvial mining practice with its associated environmental problem and suggestions of ways to minimize those hazards while increasing gold production. It also outlines mechanisms for sustainable development of model that to be in placed for continuous monitoring safe mercury use and efficient alluvial mining for improved recovery to sustain rural bashed population.

Keywords:

Artisanal Small-scale Mining, sluice box, mercury pollution, sustainable development model, Alluvial Mining Lease

Introduction

With increase in prize of gold by more than 400% in ten year period (US \$ 260 /oz in March 2001 to US \$ 1200/oz in July 2010) , ASM have increased throughout the country operating in both new and old deposits. More than 2500 registered alluvial miners under old mining Act, chapter 125, are operating in the country however the real figure can be double by now. Papua New Guinea alluvial mining population consists 90% of miners use rudimentary sluice box and gold panning dish with out mechanical aid. Less than 10 % use semi mechanize mining such as sluice box incorporated with 2-7 inch dredge or water pumps to run a jet pressure to wash gravel into sluice box while less than 1% use fully mechanized mining and processing equipment such as excavators and dozers incorporated with high capacity processing kits such as trammels and jigs. More than 60% of the above miners use mercury to capture fine gold and subsequently separate mercury from gold through heating. (Susapu & Crispin 2001)

Economic importance

ASM contribute about K180-K200 million per annum as revenue into country anticipated from both known amount of gold exported as well as illegal gold that are believed to be derived from Papua New Guinea. (Susapu & Crispin 2001).With the increasing gold prize coupled with new alluvial discoveries and effective mining/processing techniques, the production is expected to double to 8.0 tonne which should fetch more than K500 million per year. That should accounts for more than 4% of average gross domestic product of the country.

Comparing rural commodities, the prize the buyer pays for the gold to rural bashed alluvial miner is always more than 70-90% of the prize they would sell to world market where as other rural commodities are paid smaller percentage of ultimate consumer of the final product due to intermediate transport and processing cost.

Environmental Importance

Environmental destructions due to ASM practices have been considered to be minimal however particular attention was given to mercury pollution which has been main environmental concern for both human being and surrounding ecosystem. Apart from mercury pollution to environment cyanide is used sometimes prior to milling to dissolve and extract gold solvent in fact this process is rare in Papua New Guinea. Other environmental destructions from alluvial mining include siltation, sedimentation of river system, and pollution of drinking water, landscape degradation and erosion.

About 4.0 tones of mercury are polluted annually into environment due to mercury misuse by ASM activities in Papua New Guinea. Mercury in a vapour form poses higher health hazards since it can be easily inhaled than in liquid state. Mercury being part of platinum group metals form amalgam with gold. Nevertheless mercury vapour poses great health hazard to human being and environment than in liquid state. Most of the mercury released into environment is inorganic mercury which can have neurobehavioral effects, however mercury that is of concern is generated from mercury use in ASM is the toxic methyl mercury. The methyl mercury forms by methylation, a biogeochemical process in certain environmental condition attributed by methylating microbial population in the presence of mercuric ions. (La Beller and Hilliker, 2003)

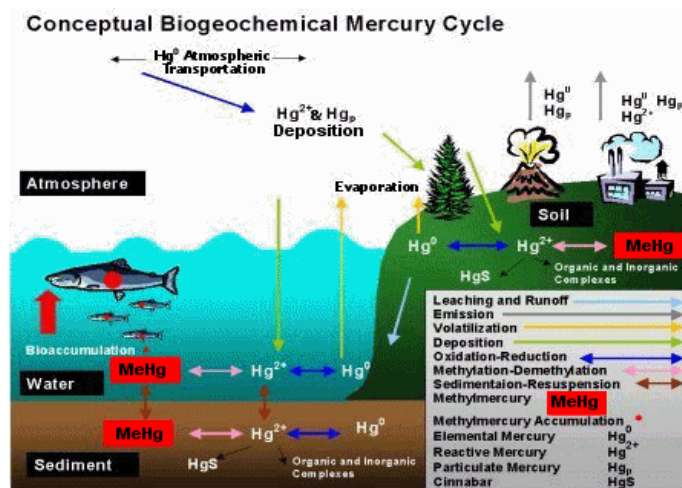


Figure 1. Mercury cycle. Source: La Beller and Hilliker, 2003

Policies and Regulation

Although ASM is not permitted in some parts of the world, it is legally recognized sector for the Government of PNG. The two main legislation governing the PNG mining sector are; 1992 Mining Act and Mining Safety Act. The Mining Act provides two tenements namely Alluvial Mining Lease (AML) and Mining Lease (ML) that are applicable for ASM.

The Government through Department of Mines (DoM) is constantly changing minor legislation to suit ASM activities to alleviate poverty and sustain their livelihood in the safer and environmentally friendly practice where possible. Alluvial Mining Lease (AML) is restricted to traditional land owners. ASM activity can be done without AML if it is undertaken using only non mechanized techniques provided that the miner is a customary landowner. AML is restricted to size of 5 ha and can only be taken 20 meters of river course. Thus AML is meant for traditional landowners and only non mechanized and semi-mechanized techniques are applicable. The Small-scale Mining Support (ASMS) section under Department of Mine (DoM) has established its support centre at various alluvial mining locations including Wau. Through this centre the government provides technical advice, training skills and continuous liaison for mining lease and tenements matters. ASMS also initiate,

proposes and recommends for donor agencies about projects identified being sustainable for small scale mining community. With remoteness and under staffing of ASMS, it cannot be able to keep in touch with certain alluvial mining locations.

Non Government Participation

International donor agencies recognition of this sector as a way of sustaining rural based population and therefore have strong commitment to ASM in PNG. European Union has funded 6.8 million Euros under Sysmin Project to Small-scale Mining Branch in 2001. The money was used to build there Alluvial Mining Training centre in Wau, Porgera and Wewak. Apart from small-scale Mining European Union has also funded various projects within the Department of Mine (DoM) including such as upgrading PNG geological data and building DoM headquarter in Port Moresby.

During 1999 to 2001 AusAid has funded the training of local staff and produced modules, brochures and videotapes aiming to educate small-scale miners on the efficiency of mining and the dangers and safe practice of mercury use.

Japanese Social Development Fund (JSDF) has funded training through Wau Ecology \$US 468300 have disbursed through consultancy and educational cost in protecting of selected endangered species due to pollution caused by mining and related. Metal Refinery Operation (MRO) has also sought considerable support by supplying small scale mining equipment at a competitive prize with free technical expertise on how to use equipment effectively as well as setting up safer gold buying location.

Donor agencies have helped much to train miners so that they could effectively increase production in the most environmentally sound manner. However ADB has proposed and financed Micro Finance scheme in Wau in 1991 to encourage business incentive within mining communities. The initially known

Wau Micro Bank which has now managed to become a Nationwide Micro Bank of Papua New Guinea which currently has more than 11 branches located at main centres of the country.

Definition of Artisanal and Small-scale Mining (ASM)

Wide ranges of definition have been given ASM around the world. According to small scale mining conference in 1988, Ankara, Turkey, the general criteria used to classify mining operation as ASM include production capacity, revenue generated, number of people employed and mine life.

In PNG ASM includes minimum investments of \$ US 0 to \$US 1,000,000 utilizing rudimentary sluicing and panning techniques to fully mechanized mining operation respectively. The middle range would fall within an investment about US \$3,000 where equipment such as portable dredge and water pumps are employed. (Lole .H, June 2005).

ASM Practice – A Case Study of Meriyaka Alluvial Mining

The Meriyaka alluvial deposit was discovered last year (2009) and is located approximately 6km north-west of Goroka town. It has the mining population more than 600 alluvial small-scale (ASM) miners who dwell with in the vicinity along the Meriyaka creek. While working along side with the miners for a week and a regular visit to the mining community within a period from January to June 2010, the experience was no different to other ASM miners in PNG who involved in unsafe mining practice driven by poverty and failed rural based agriculture commodity caused by seasonal change variation or climatic change. The mining population used rudimentary sluice box with digging and panning with shovels and panning dish respectively while 60% of miners used mercury in addition to panning and sluicing. Their working approached towards prospecting a working site, preparation, digging, sluicing, panning and mercury use

has been noted and briefly discussed in the following text.

Prospecting

Locating high grade spot requires a lot of time searching for promising site with physical observation on trail and error bases or with experience build on from working on it for years. Miners make random sampling using, panning dishes at certain spots and once they strike gold after two or three panning, that particular site is selected to be further worked on. The site selected is worked on for as long as it provides significant gold or otherwise it is abandoned and new search is done. Water source and its head pressure, available working equipment, manpower potential safety hazard are some important factors that has been considered when selecting a site.

Preparing & Working Equipment

Miners work in a group generally consisting of family members ranging from 4-10 miners depending on the nature of work. Among them have one or two experience miners who supervise and assign tasks to members in the group and assess potential safety hazards such boulder rolling, nearby river current and land slip before work is preceded. Preparation work can be done such as removing overburden, any boulders or bushes or any unwanted that is found near, around and on top of the selected deposit using bush knives, axes shovels or crowbar. The working groups are organized with assigning group member each task such as digging using crowbar and spade or shovels while others transport material to washing area where experience gold panning and sluicing operators are selected to do that job.

The particular working group consists of the following equipment on an average have 2- 3 shovels, 1 crowbar, 2 spade, 3 panning dish and 1 sluice box. Hardly any boots, water proof coats, overall or gloves. Mercury is assessable on an average two per three working group.

Digging & Sluicing and Panning

Digging, sluicing and panning has been traditional mining and processing practice for ASM small scale alluvial miners in PNG. The Meriyaka community is no exception and adopted that practice as a way of sustaining their livelihood who has gained those skills through experience miners from well informed mining community such as in Wau Bulolo and Kainantu.

Digging is done selectively on certain part of gravel, mud or soil within the selected working site after over burden is removed. Before the material dug is brought each time to be washed in the sluice box, the sluice box with mat for trapping finer gold is firmly set in a rigid inclined position and water is directed to run on the sluice from part of the stream that has been diverted trough channelling or through a pipe from upstream dam. Experience miners make good estimate by adjusting the flow that can effectively run number of shovel or dishes of gravel/mud drawn by sluice each time at a constant interval. The coarser heavy particles are settled on the mat inside the hairy loop that provides the turbulence while heavier particles washed over by water. Until such a time when it is noted that the mat in the sluiced box is loaded enough with courser material normally after an average of 5-10 run of dishes or shovel, the sluice box with mat is carefully removed from channelled

water. The courser material of high grade that were collected on the mat and sluice are carefully washed onto the panning dish and panning is done carefully by with experienced panning skilled miner until visible gold particle with black sand and other heavier fine particles identified as residue on the panning dish. Careful panning is continued until all visible smaller gold particles are collected by hand and carefully stored away while the remaining black and other course material is discarded as tailing if a particular group does not uses mercury.

Mercury use

After visible gold particles are picked after digging, sluicing and panning, mercury is put on that residue dish and careful and gentle shaking is done for mercury to get in contact with finer gold particles and eventually form an amalgam separating fine gold away from black sand and other course material The amalgam form was carefully stored in a container and later heated in empty tin or pot to separate mercury from gold.

The entire miners in the community has no access to mercury retort and all of the amalgam was heated on empty tin or panning bowl to collect gold while mercury vapour freely escapes in the open air. Two in every three group used mercury to collect mercury thus more than 60% of the mining population used mercury.

Mercury is one of the most fragile substances to handle by ASM miners in Papua New Guinea even when using retort. It is a liquid by nature at room temperature and when placed in the ripple compartment and on in panning dish to catch and trap gold to form amalgam extra care is required to prevent spilling of mercury.

Practically mercury placed in the compartment of ripple in the sluice box have 90 % more change of spill into a river system due to inconsistency in loading of gavel materials and water at the sluice box. Remember when it is spilled thus the liquid bond is broken by counteracting water particles and material fed into the sluice and those particles that washed over can't be collected back anyway .Therefore mercury placed in compartment of ripple tank of sluice box is unsafe practice. The only option that may be available for ASM to use mercury is the use it only when panning carefully together with a higher grade residue and must be transferred carefully with out spilling to a retort to heat, separate gold and collect mercury. In mercury catching fine gold to form amalgam have been inefficient especially when using together with water which the water lowers the temperate of mercury thus collision of gold particles to mercury to form amalgam is decrease. That was observed with some gold particles not forming amalgam and left alone in the panning dish even it in contact with the mercury.

Therefore heating amalgam in a pot or empty tin to release mercury vapour away and collect gold is most unsafe health hazardous practice for human being and the surrounding ecosystem. Example **Module 3** shows how simple mercury retorts that can be constructed and used in a safe manner. The estimated production of gold produced per day for the entire community is around 500g based on figures supplied by each group.

Developing a sustainable ASM policy

While various development have been made by organizations and department of mine to counteract mercury related problem, it was

highly noted that sustainable development is feasible when there is a continuous administered model in place targeting a particular ASM community for environmental protection while enhancing economic alluvial mining activities. Thus simple community based model can be implemented by direct interaction with miners through awareness and demonstration until the knowledge is fully grasped and practiced by particular alluvial mining population. A model can be discussed, innovated or implemented where applicable by government to create capacity building policies to support grassroots alluvial miners. An effective model can be derived from the following (i-vi) assessments tasks:

i) Identifying Alluvial Mining Communities

Various locations in Papua New Guinea that practice ARM are sparsely distributed throughout the country. While there are well informed mining population in Wau Bulolo, Kainantu, Porgera and Mt Kare who have increased mining activity with increasing gold price, most of the alluvial mining in PNG are yet to receive administrative assistance in a form of education on efficiency of mining and safer practice. Some deposits are not mined due to either lack of expertise and appropriate equipment or the local miner's population is too small and working on certain small portion of the deposit while some part of deposits left unexplored. While specialist staff from DOM has been sent to various ASM mining location however some locations are situated in the remotest parts of the country which are not easily accessed. Once the mining community is identified it will be assessed accordingly.

ii) Assessing the Nature of Deposit

Alluvial deposits vary due to the nature of deposits. Mining techniques

to be deployed depends on the nature of deposits, its topography, and availability of water and mining equipments. An experience geologist can be engaged to make a detailed assessment of the grade of alluvial deposit, particle size distribution and estimation mine life. Such information are useful to advice the type of mining to be employed as well as keeping future reference for mining lease and tenements. When the type of alluvial deposits is known, the local alluvial miner will be advised to set up set up a mining and processing technique accordingly.

iii) Assessing Current Mining and Processing Technologies

Studying the current practice used by local alluvial mining population can provide information that can be used to correct and improve the efficiency as well as to contain and prevent environmental pollution. Required information include the type of equipment used, the number of miners involved, approximate gold production per week and whether or not mercury and other chemical are used and why and how they are used. Unless the miner is fully aware of the art of alluvial mining, he will be spending a tireless hours in the river or creek without seeing a pieces of gold. Usually the local miners use panning dish and sluice box as trail and error initially and continue with it once they see they collect some gold some how without any idea on the nature of the deposit. Nevertheless sluice box and pan are cheaply available for ASM miners. Miners in a particular area learn from one or two who had prior experience in another well informed alluvial mining area such as Wau Bulolo or Kainantu. In Simbai miners search for nuggets only

in a along the rivers and collect them by hand or using gold panning dish.

v) Identifying Environmental Hazard

Determining the nature of environmental pollutions by ASM including the source and extend of pollution in the affected area require great deal of effort and scientific research. Among mercury pollution which is the major there are other environment concern generated by ASM such as sedimentation, destroying habitat of marine and aquatic life by continuous mining along the river, stream and lake.

The long term heavily exploited alluvial mining areas especially Wau Bulolo, Mt Kare, Porgera and Tolukuma are the location where environmental degradation including mercury pollution which is evident in a larger extend. Responsible government bodies are required to carefully assess the source and extend of pollution so as to recommend counteractive measures. Several research have been done by relevant government authority as well as other non government organization to determine extend of mercury pollution and other related pollution along heavily exploited ASM areas. A research done by Nema & Banda 2001 to determine the presence of heavy metal in the food chain along Agabanga river near Tolukuma mine where alluvial mining is done showed that the concentration of mercury in the Lobsters was significantly higher than the world health standard recommendation.

Determining the extend of direct mercury pollution on human being can not easily assessed however common major signs and symptoms

among others developed by human being due to mercury vapour exposure includes physiological disturbance, oral cavity disorders, gastrointestinal effects, systemic neurological effects such as frequent headaches and respiratory such as persistent cough.

vi) Assessing ASM community & Government relationship.

Relationship between the government and ASM communities to maintain peace and order is vital when land dispute arises over ownership of mining area. The ASM miners must be law abiding citizen with the effective presence of law enforcing bodies. The nature of mining community must be peaceful in order to participate in sustainable development model of ASM.

Implementation of a model

Bashed on report from assessment criteria (i-v), a corresponding model can be devised to increase gold production while practicing environmentally sound techniques. A sustainable implementation model involves basically setting up a committee within ASM area. The aim of committee must always be maintain thus to increase gold production while maintaining minimal or no environmental pollution. The committees are to be members of ASM population that continuously monitoring the ASM operation and reports to Small Scale Mining (SSM) branch from Department of Mining (DoM) upon the branch representative or other NGO officers field visits on a regular bases. A constant dialogue is vital to be maintained between the ASM committee and representative from SSM while implementation of model. Education and awareness on highlighted issues such as efficient mining techniques and minimizing mercury pollution through public forum or through production of pamphlets and brochures and modules have always been an effective, however it must be executed on a

continuous bases until the ASM community is fully adapted to the system

Some of the education and awareness projects that can be implemented based on recommendation from ASM committee in consultation with SSM representative and NGO officer could be the following as summarized in table 1. The number of projects that has been identified may vary from particular ASM community and again depends on recommendation from ASM committee and SSM representative.

Summary

Artisanal Small-scale Mining (ASM) activities in Papua New Guinea have increase with increase in gold price. More than 90% of ASM miners use rudimentary sluice box and panning dishes thus they operate in hazardous condition using environmentally unsafe mining and processing techniques. ASM is becoming a main source of income for rural based community in PNG that have alluvial deposit. As the ASM practice increases the environmental and health occupation problem also arises. The government has realized the importance of ASM sector as a way of economic contribution by unemployed rural based population and thus legislations have been formulated to support this sector.

With increasing ASM operation in PNG, there is a need for sustainable development model to combat increasing environmental problem while encouraging ASM population to operate effectively thus increasing production to sustain their livelihood. The model can be developed for the particular ASM population based on preliminary assessment on location, type deposit, and techniques of mining and processing deployed and environmental pollution.

Model is developed after a continuous consultancy by Small-scale Alluvial Mining representative from Department of Mine with an organized ASM community. The model can be implemented with cooperation and constant dialogue from both the ASM community and Small-scale Alluvial Mining representative. Education and awareness can a very good mode of interaction and communication through modules and brochures after a particular problem have been identified in a certain ASM community.

Concluding Remarks

Artisanal Small-scale Mining (ASM) in Papua New Guinea is projected to increase using inefficient mining practice as the prizes of gold increases steadily.

Although various international donor agencies have sought help to minimize mercury and related environmental pollution, the environmental problem is also expected to increase with increasing ASM activities.

Implementation and development of sustainable model to counteract mercury pollution and increase mining efficiency can be achieved if both ASM community and Department of Mine have a constant dialogue to address issues faced with ASM community.

Table 1.shows how module can be developed targeting particular issues ASM community.

Training Modules	Knowledge from community Practice	Knowledge from Academic disciplines
Module1 How Mercury Makes People Sick	Pathways of exposures :Mercury and methyl mercury ; vapour and skin ingestion	Environmental toxicology
Module 2 How to prevent mercury pollution	Careful handling and transporting of mercury	Health care
	Heating of amalgam in a retort rather than on a pot	Mineral Processing
Module 3 How to build and use mercury retort	Simple design and construction of retort using locally available materials	Mineral Processing Engineering, Fabricators
	Effective separating mercury and gold from amalgam by heating using retort	Mineral Processing
Module 4 How to effectively use mercury in sluicing and panning	Precaution measures in handling, storing. How best to use when panning and sluicing	Health Care, Mineral Processing
Module 5 How to recognize symptoms	Recognize symptoms	Health care
	Effects on children and women	Epidemiology; gender studies
Module 6 How to produce more gold	Alluvial Mining Methods: control of siltation , gravity concentration	Mining & Mineral Processing ,Watershed management
	Use of semi merchandise and merchandised gravity separators such as dredges and pumps.	
	Mine safety, ground stability, ventilation	Mining Engineering
	Conventional sluicing, panning & digging	Mineral Processing, Well trained certified ASM miner

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