Description of Service	Technical Training “Construction of Micro-Scale Mercury-Free Gold Processing Equipment”
Location of Training	Anggai Village, Obi Sub-District, South Halmahera
Names of Trainers	1. Asep Nurohmat, S.Si., M.Sc. (BRIN) 2. Nicko Widiatmoko, S.Si., M.Si (BRIN) 3. Yeni Novitasari, S.T. (BRIN) 4. Mifa Nurul Azmi, S.T.(BRIN) 5. Rahmadhani Triastomo, S.T (BRIN) 6. Mujianto (BRIN)
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Glossary of Terms and Abbreviations

3M	: Mask wearing, handwashing with soap, and physical distancing
BRIN	: National Research and Innovation Agency
DLH	: Environmental Agency
GOLD-ISMIA	: Global Opportunities for Long–term Development - Integrated Sound Management of Mercury in Indonesia's ASGM
K3	: Occupational Health and Safety
KESDM	: Ministry of Energy and Mineral Resources
KLHK	: Ministry of Environment and Forestry
PB3	:Hazardous and Toxic Material Management
Minerba	: Minerals and coal
PESK	: Artisanal and Small-Scale Gold Miningl
PMU	: Project Management Unit
UGM	: Gajah Mada University
UNDP	: United Nations Development Programme
FF	: Field Facilitator
SMBS	: Sodium Metabisulfite
DO	: Dissolved Oxygen
pH	: Power of Hydrogen (Acidity Level)
CN	: Cyanide
NaCN	: Sodium Cyanide
$AgNO_3$	: Silver Nitrate
$CuSO_4$	: Copper Sulfate

1. Introduction

1.1. Background

The United Nations Development Program (UNDP) in collaboration with the Ministry of Environment and Forestry (KLHK) and the Agency of National Research and Innovation (BRIN) are in a five-year partnership (2018 – 2023) to address relevant issues in the Artisanal and Small-Scale Gold Mining (ASGM) sector through the implementation of the Global Opportunities for Long-term Development of Artisanal and Small-Scale Gold Mining (GOLD-ISMIA) Project. Six (6) districts in 6 provinces have been selected as pilot locations for the GOLD-ISMIA Project, including South Halmahera District, North Maluku Province, specifically the Anggai Village, Obi Sub-District.

The main objective of the GOLD ISMIA project is to reduce and eliminate the use of mercury in the ASGM sector in Indonesia through the following 4 (four) components:

- Component 1: Strengthening institutions and policies for the mercury-free ASGM sector
- Component 2: Establishment of a financial mechanism in order to provide loans for the procurement of mercury-free gold processing equipment/machinery
- Component 3: Capacity building for mercury-free ASGM through provision of technical assistance, technology transfer and formalization support (licensing)
- Component 4: Monitoring and evaluation, raising awareness, sharing of experiences, lessons-learned and best practices

Pursuant to capacity building efforts to create a mercury-free ASGM sector in Anggai Village, Obi Sub-District, South Halmahera District, the GOLD-ISMIA Project supports technology transfer to ASGM miners with limited capital. In this regard, the GOLD-ISMIA Project conducted a technical training on the installation of micro-scale mercury-free gold processing equipment to the management and members of local mining cooperatives and mining groups.

Through this training, the miners were equipped with effective and efficient techniques on the non-mercury gold processing and tailing management with an ultimate goal to increase their gold recovery. Furthermore, the micro-scale mercury-free gold processing equipment is expected to be another option of technology to be pursued by the miners in Anggai, particularly those with limited investment.

1.2. Objectives

a. Introduce micro-scale mercury-free gold processing technology and the proper handling of tailings resulted from the process;

b. Equip the miners with know-how in the installation micro-scale mercury-free gold processing equipment; and,

c. Raise awareness among the mining community regarding the economic, health and environmental disadvantages of gold processing using mercury.

1.3. Participants

The training participants are:

No.	Institution		Total
1	BRIN - BPPT	Trainer	6 persons
2	PB3 Directorate - KLHK	Resource Person	1 person
3	North Maluku Provincial Office of Energy and Mineral Resources (Mining Inspector)	Resource Person	1 person
4	North Maluku Provincial Environment and Forestry Office	Focal Point	1 person
5	South Halmahera District Environmental Office	Focal Point	2 person
6	UNDP GOLD-ISMIA PMU	Jakarta Team	1 person
		Field Facilitator	1 person
7	Head of Obi Sub-District	Local Government Representative	1 person
8	Head of Anggai Village		1 person
9	Head of Obi Police Agency		1 person
10	Management and Members of the Anggai Tambang Raya Cooperative	Trainee	8 persons
11	Management and Members of the Bina Usaha Maju Jaya Cooperative	Trainee	8 persons
12	Management and Members of the Gugun Pratama Akerica Cooperative	Trainee	8 persons
13	Management and Members of the Rawa Jaya Emas Cooperative	Trainee	8 persons
14	Management and Members of the Permata Obi Raya Cooperative Producers / Consumers	Trainee	8 persons
		Total	**56 persons (40 trainees; xx are females)**

To comply with the COVID-19 Health Protocols, the training was conducted simultaneously in 2 batches with each batch took place in different classes.

1.4. Methodology

The adult learning approach was used in this training because the participants already have knowledge and experience in ASGM practices, especially gold processing using cyanide.

The training materials were delivered in various methods, such as presentations, group discussions, simulations, demonstrations, actions, and questions and answer sessions. A competitive atmosphere was also created to help lighthen the participants' mood.

2. Observation

2.1. Presentation of Theory

Theoretical materials presented in this training were aimed to serve as a technical guide in processing primary ore gold and managing its waste. The materials covered

5 main topics, namely: (1) Introduction to mercury-free gold processing (2) Cyanided gold processing; (3) Cyanidation waste treatment; (4) K3 in the cyanidation process; (5) Introduction to individual-scale gold processing equipment.

These materials were printed and distributed to the participants prior to the training and this arrangement helped encourage the participants' active roles during the activity. The printed materials can also become the reference documents in application of good and correct mining practices, particularly in primary gold ore processing and waste management.

2.2. Installation of Micro-Scale Mercury-Free Gold Processing Equipment

During the practical sessions, each batch of participants was learning on how to install 1 set of the micro-scale mercury-free gold processing equipment; a total of 2 sets of equipment was installed in the end of the training.

The installment techniques were delivered in such a way that is easy to follow and the practical session run smoothly, as per BRIN's guidance. Meanwhile, there were some techniques that need to be refined so that the installment process can be conducted more effectively and efficiently in future. There were also tools that were not identified during the preparation leading to the trainers took sometime needed to find these during the training session.

The installment techniques delivered were expected to be well understood by the miners so that they can replicateand assemble their own micro-scale mercury-free gold equipment.

2.3. Micro-Scale Mercury-Free Gold Processing Practices

The micro-scale mercury-free gold processing uses a volume of 200 liters of water with 90 kg of ore is added into each equipment. Five hundred (500) grams of lime is dissolved and added little by little to the apparatus until the pH level of the mixture reached 10.5. Then 700 grams of Sodium Cyanide (NaCN) is added to obtain the concentration of 1200 ppm of cyanide (CN-) in the tank and after 6 hours, seven (7) kg of carbon is added. This gold dissolution process takes 48 hours.

During the process, the miners were learning on how to determine the pH and Dissolved Oxygen levels and the amount of free cyanide using the titration method. This is done so that miners can determine the pH, Dissolved Oxygen, and free cyanide levels. The parameters of this process should be

determined in the first 6 hours before the carbon is added to determine whether the process has been performed well. Table 1 reflectes the process parameters established during the training.

Table 1. Parameters

Time	First Tank			Second Tank		
	CN- (ppm)	pH	DO (ppm)	CN- (ppm)	pH	DO (ppm)
0th Hour	1192	10.65	7.1	1192	10.68	6.8
1st Hour	1139	10.61	7	1126	10.65	7.2
2nd Hour	1086	10.56	6.8	1099	10.61	7.1
3rd Hour	1060	10.54	7.1	980	10.55	6.8
6th Hour	1060	10.40	6.9	954	10.41	7.0
24th Hour	795	10.20	6.8	821	10.18	6.7
28th Hour	768	10.50	6.8	795	10.47	6.8

After 48 hours, the carbon is removed and washed. This collected carbon will be burned and smelted elsewhere because it is difficult to move the smelting equipment to the training location. The final product is 1.14 gram of mercury-free gold.

2.4. Gold Processing Waste Treatment Practices

The gold processing produces a high concentration of cyanide waste which is prohibited to be disposed directly of into the environment for which the cyanide waste must be treated.

In this training, into each tank, 50 grams of copper sulfate is added as a detoxification catalyst and 5 kg of sodium metabisulfite (SMBS) is used as a detoxification agent. After 3 hours, the free cyanide was measured using a spectrometer, showing 1.4 ppm level of free cyanide. It was estimated that after 6 hours of detoxification process, the level of free cyanied could reach 0.5 ppm which is a threshold value of free cyanide released to environment, as per the government regulation.

The proper handling of waste from cyanidation is a new topic for the miners; they commonly dispose the waste immediately without carrying out detoxification leading to pollution and endangering the health of the surrounding community.

2.5. Training Methodology

The main topics of the training include procedures for processing mercury-free gold and waste management with the following subs (1) Assembly of micro-scale mercury-free gold processing equipment; (2) Carbon Dissolution and Sequestration; (3) Carbon Washing and Burning; (4) Carbon Ash Smelting; (5) Waste Treatment; (6) Measurement of Free Cyanide Levels. Material on the mentioned subjects was delivered through presentations, discussions, case studies, simulations, demonstrations, hands-on practice and question and answer sessions.

This technical training is the first time conducted in Anggai and it was observed that the participants showed positives response and enthusiasm througout the event. The training is very important for them to understand the procedure of gold processing without using mercury and waste management. The training materials that consist of 6 topics received a positive feedback, which could be seen from the participants' body language and expressions when the materials were presented and discussed.

3. Evaluation

3.1. Pre- and Post-Test

The results of the pre- and post-test shows an improvement in the level of knowledge in most of the participants (30 out of 37 participants) who participated from the beginning to the end of the training. The average score increased from 30.95 to 46.35; so that the average percentage increase is 49.78%. This figure indicates that the training materials were delivered effectively and the participants were able to receive the information presented well.

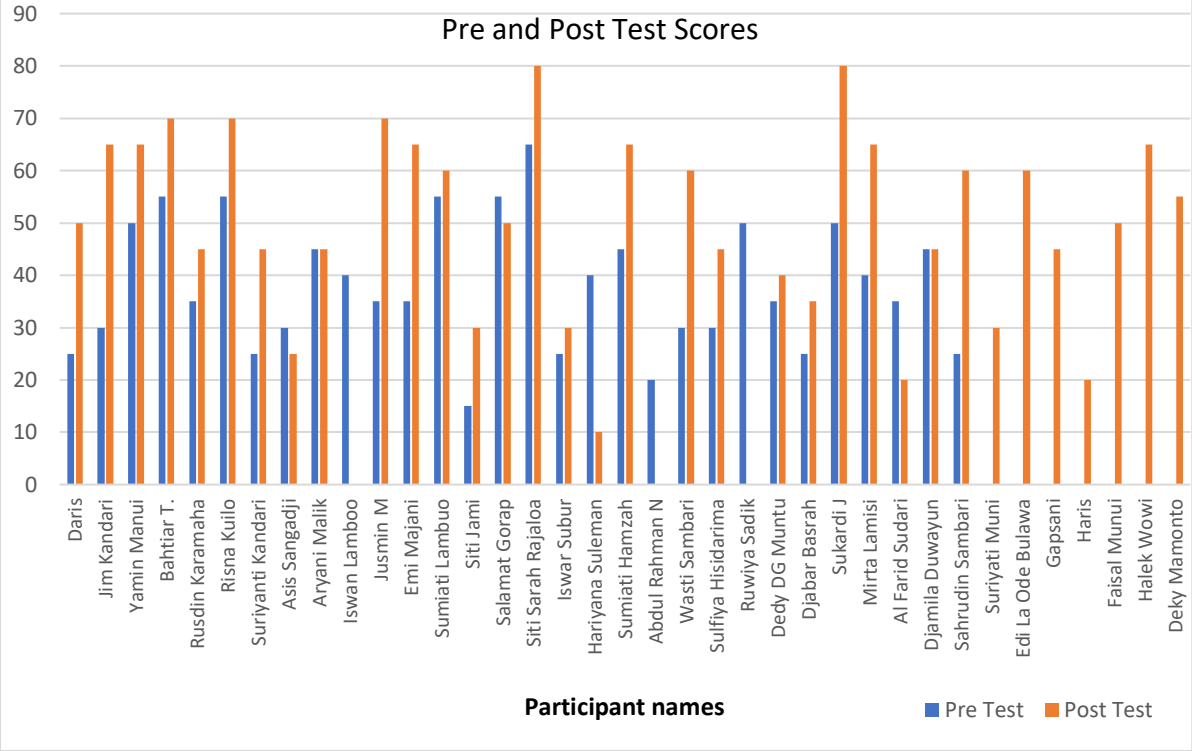

Figure 3.1 Pre-Test and Post-Test Results of Training Participants for Construction of Micro-Scale Mercury-Free Gold Processing Equipment

3.2. Participant Feedback

The results of participant feedback showed that participants were very enthusiastic in the learning sessions. All participants were active in discussions, case studies, calculation simulations, demonstrations, hands-on practice and question and answer sessions.

3.3. Participant Satisfaction Level

The results of the evaluation on the level of participant showed that all participants were satisfied with the training. Participants suggested modifications to the equipment in order to increase the performance of the machine and to process the ore more effectively.

3.4. General Technical Evaluation

NO.	ASPECT	COMMENTS
1	**Health Protocols**	• Despite repetitive reminders made by the trainers and UNDP personnel, some participants were not consistent in observing the COVID-19 Protocols, specifically in wearing face masks (e.g. wearing a mask on the chin, wearing a mask that only covers the mouth). • For similar conduct, it is suggested that the Organizing Committee play a video on safety induction and health protocols before the event starts and replay this during the breaks,
5	**Individual-Scale Mercury Free Gold Processing Facilitator and Trial**	• In general, the information conveyed to the participants was in accordance to the objectives of the event. • The miners already had an understanding of the importance of HSE in gold processing using cyanide, so they were active in using safety tools such as rubber gloves. • The time allocated was sufficient to complete the processing, combustion and smelting processes. However, due to technical difficulties in transporting the smelting equipments owned by the miners, the burning and smelting process cannot be demonstrated directly to the participants at the training venue. • The field trials of individual-scale mercury-free gold processing were carried out with 2 tanks with the same operating conditions and the same ore. The pH parameter in both tanks tended to be the same of around 10.5 and DO as expected at around 7 ppm and dissolved cyanide measuring close to 1200 ppm. The challenge in this trial was that the pH tended to be stable and did not go down; while in general the pH level will decrease due to the chemical reaction of gold with cyanide. Furthermore, the dissolved cyanide did not decrease significantly. Whereas in general, the amount of dissolved cyanide will decrease as an indication of the cyanide reacting with the gold. In this case, additional cyanide was not added from the start and lime was only added twice from the start. • The above peculiarities were perhaps caused by the presence of deposits/sediments at the bottom of the tank leading to the unwell reaction of the gold and cyanide. These sediments which was approximately 2 cm were formed within the inclined part of the tank due to the ineffective movement of stirring pump. Further modification needs to be carried out to solve this part. • Refinement on the techniques and methods wre also needed to smoothen the removal process of carbon from the tank.

7	**Documentation**	• The conduct of the training was well documentd. Nevertheless, a pilot drone is receommended for future use to obtain aerial view documentation.

4. Results

4.1. Conclusion

The training on the Construction of Micro-Scale Mercury-Free Gold Processing Equipment in Anggai Village, Obi Sub-District, South Halmahera went smoothly. This training was attended by 40 ASGM miners from 4 gold mining cooperatives spread across Anggai Village.

Participants responded positively to the material provided. Participants were active in the groups and were able to follow each session well. Participants were very enthusiastic in the discussions, simulations, demonstrations, hands-on practice and question and answer sessions.

Participants gained knowledge during the training on mercury-free primary gold ore processing and waste management. Their knowledge on mercury-free gold processing increased significantly, with an increase of 49.78 % in post-test scores.

4.2. Recommendations

The trainers should also pay attention to the current capacity of the miners. In term of ore preparation, for example, the miners were unable to grind the ore up to 200 mesh, so it is necessary to design the equipment to accommodate this.

The gold processing tank should be tested intensely and should be able to mix completely before moved to the training site. This is because during training, deposits were found at the bottom of the sloping part of the tank which affects the effectiveness of the reaction between the gold and cyanide. The movement of the stirring pump in the tank is not effective in stirring the ore so that the ore just sits at the bottom.

Apart from the substance of the training, the Organizing Committee and the UNDP GOLD-ISMIA PMU had carried out maximum efforts in preventing the COVID-19 transmission. This was done, among others, by limiting the number of invitees, grouping of the participants, reminders as stated in the invitation to practice 3M, routine cleaning and disinfection of meeting rooms, as well as the provision of masks, face shields, and hand sanitizers for all invitees.

4.3. Follow-up Actions

The equipment will be modified based on the ore size below 200 mesh which is required with 2 additional pumps to help with the stirring or stirring blades (stirrer)can be used like the one used by miners to mix the ore effectively.

The miners through the mining cooperative will modify the existing micro-scale processing equipments based on the recommendations.

5. Appendix

5.1. Photo Gallery

Figure 1. Checking tools and materials before the technical training

Figure 2. Opening of the event by UNDP Focal Point and local stakeholders

Figure 3. Pre-Test taken by miners

Figure 4. Presentation of material by Trainer (1)

Figure 5. Presentation of material by Trainer (2)

Figure 6. Instructions from Trainer for assembly of equipment(1)

Figure 7. Instructions from Trainer for assembly of equipment (2)

Figure8. Assembly of equipment by miners (1)

Figure 9. Assembly of equipment by miners (1)

Figure 10. Assembly of equipment by miners (2)

Figure 11. Assembly of equipment by miners (3)

Figure 12. Assembly of equipment by miners (4)

Figure 13. Assembly of equipment by miners (5)

Figure 14. Equipment that has been assembled

Figure 15. Process of adding the ore into the equipment

Figure 16. Weighing of chemicals

Figure 17. Process of adding the lime

Figure 18. Instructions from the Trainer in using the Multimeter

Figure 19. Use of multimeter by miners (1)

Figure 20.Use of multimeter by miners (2)

Figure 21. Process of adding cyanide

Figure 22. Presentation of technical material by Trainer to determine free cyanide levels (1)

Figure 23.Presentation of technical material by Trainer to determine free cyanide levels (2)

Figure 24.Determining free cyanide level by miner

Figure 25.Preparation of adding carbon

Figure 26. Adding carbon into the equipment

Figure 27. Removing carbon from the equipment (1)

Figure 28.Removing carbon from the equipment (2)

Figure 29. Carbon that is ready to burn

Figure 30.Addition of copper sulfate as a waste detoxification catalyst

Figure 31.Addition of SMBS to reduce free cyanide

Figure 32.Removal of detoxified cyanide waste

Figure 33.Carbon burning equipment

Figure 34.Carbon smelting equipment

Figure 35.Carbon smelting

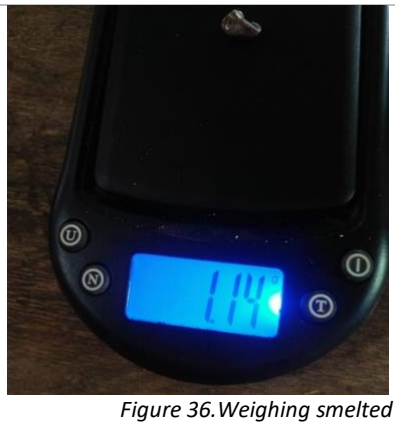

Figure 36.Weighing smelted gold

Figure 37.Gold produced from training

Figure 38.Photo-taking of all participants in attendance (1)

Figure 39.Photo-taking of all participants in attendance (2)

Figure 40.Photo-taking of all participants in attendance (3)