



**Ministry of Environment  
and Gender Equality**  
Environmental  
Protection Agency

# **Final Report for “Demonstration project for remediating & eliminating mercury in small-scale gold mining in Honduras” MUDP-project**

MUDP Report

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# Miljøteknologisk Udviklings- og Demonstrationsprogram

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MUDP investerer i udvikling af fremtidens miljøteknologi til gavn for klima og miljø i Danmark og globalt, samtidig med at dansk vækst og beskæftigelse styrkes. Programmet understøtter dels den bredere miljødagsorden, herunder rent vand, ren luft og sikker kemi, men understøtter også regeringens målsætninger inden for klima, biodiversitet og cirkulær økonomi.

Det er MUDP's bestyrelse, som beslutter, hvilke projekter der skal modtage tilskud. Bestyrelsen betjenes af MUDP-sekretariatet i Miljøstyrelsen.

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*Denne slutrapport er godkendt af MUDP, men det er alene rapportens forfatter/projektlederen, som er ansvarlige for indholdet. Rapporten må citeres med kildeangivelse.*

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**Key Institutions:**

Honduran Institute of Geology & Mines (INHGEOMIN)  
Secretariat of Environment and Natural Resources (SERNA)  
Center for Control of Hazardous Wastes (CESCCO)  
Danish Ministry of Environment Program for the Development of Environmental Technology (MUDP) and the Secretariat of Eco-innovation

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# Abbreviations

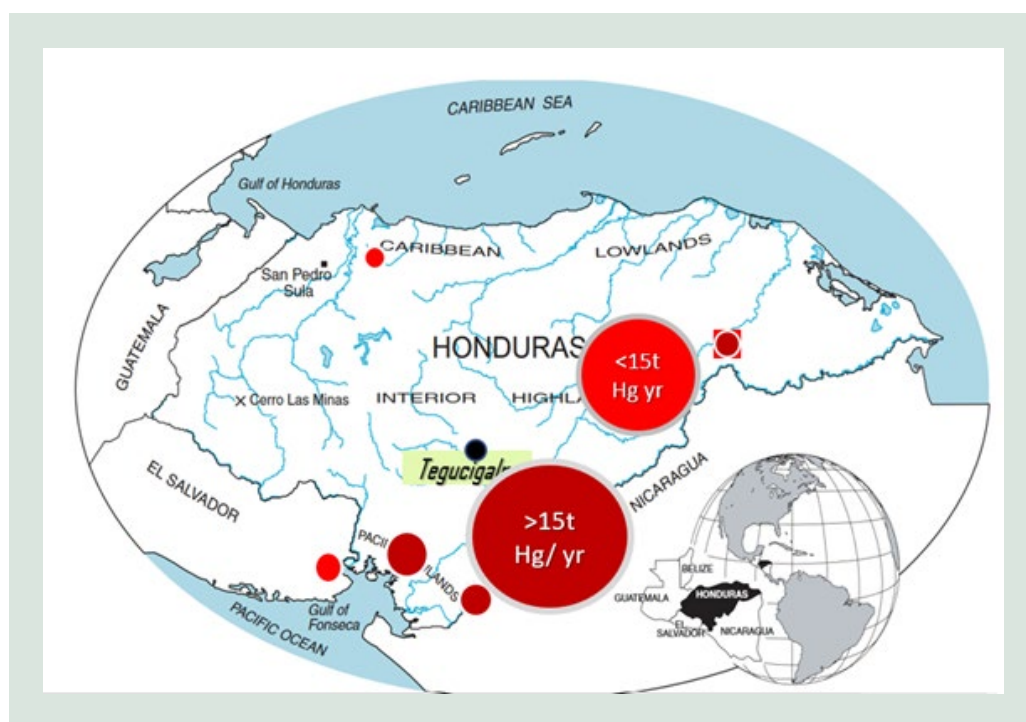
**TABLE 1.** Abbreviations.

<b>AAS</b>	<i>Atomic Absorption Spectrophotometry</i>
<b>Au</b>	<i>Silver</i>
<b>ASGM</b>	<i>Artisanal <u>and</u> Small-scale gold mining</i>
<b>Cu</b>	<i>Copper</i>
<b>dm<sup>3</sup></b>	<i>Cubic decimeter</i>
<b>FAM</b>	<i>Finite Assessment Model</i>
<b>g</b>	<i>Grams</i>
<b>Hg</b>	<i>Mercury</i>
<b>INHGEOMIN</b>	<i>Honduran Institute of Geology and Mines</i>
<b>Kg</b>	<i>Kilograms</i>
<b>kHz</b>	<i>Kilohertz</i>
<b>PPM</b>	<i>Parts per Million</i>
<b>SSGM</b>	<i>Small scale Gold mining</i>
<b>MS</b>	<i>Mass spectrometry</i>
<b>SO</b>	<i>Specific Objective</i>
<b>SERNA</b>	<i>Secretariat of the Natural Resources and the Environment (SERNA)</i>
<b>MUDP</b>	<i>Danish Eco-Innovation Fund for Environmental Technology</i>
<b>ml</b>	<i>Milliliters</i>

# 1. Introduction

The amount of mercury released to the planet by human activities is staggering and it is estimated that artisanal and small-scale gold mining (ASGM) alone releases up to 3,000 tons of mercury per year, representing around 37% of global air pollution. Much of this pollution evaporates into the atmosphere, but the rest is carried downstream by rivers and reaches estuaries and oceans, and to humans who handle this neurotoxin without using any protection. ASGM-associated mercury also enters food webs and bioaccumulates in fish, shrimp, crabs, and mammals, as well as in agricultural crops that are contaminated by polluted runoff feeding watersheds and irrigation canals. Unless immediate steps are taken to reduce and eliminate the widespread use of ASGM-produced gold, the continued uncontrolled release of mercury to the planet and its inhabitants will likely result in serious and persistent impacts on ecosystems and the human health.

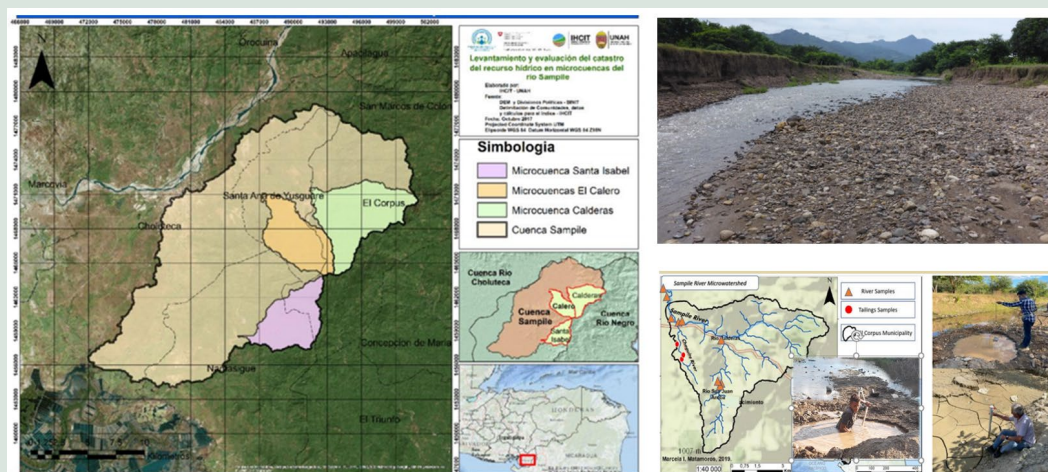
Small-scale gold mining using mercury has been carried out for centuries in Nicaragua and Honduras (FIGURE 1) and El Corpus Municipality is the site of one of the oldest gold mining areas in Central America and this has resulted in the chronic release of mercury into the air, soil surface and groundwater water in the surrounding hydrological network).



**FIGURE 1.** Map of Honduras and the project area showing the relative amount of annual mercury discharges in Honduras and Nicaragua.

## 1.1 Historical & Present Background of the Project Area

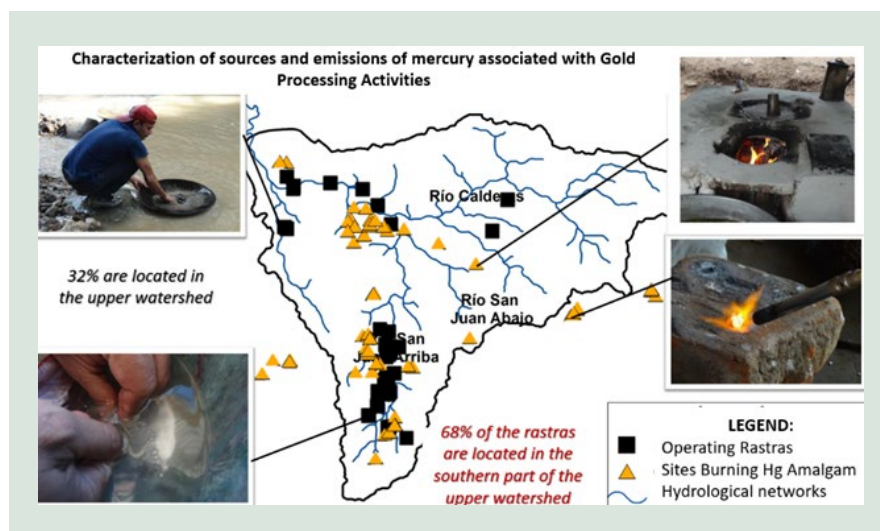
The small-scale gold mining activities from the most heavily mercury-polluted area release suspended sediments and mercury from over 100 processing plants in hydrological networks that drain the hills and lowlands within the El Corpus Municipality where they are transported to Calderas and Sampile rivers and carried to wetlands adjacent to the Gulf of Fonseca on Honduras' Caribbean coast (FIGURE 2).



**FIGURE 2.** Map showing the El Corpus Municipality boundaries and the Sampile River watershed (beige shading) and its tributaries, including the Calderas microwatersheds receiving mercury from mining areas and the location of baseline studies of river sediments, groundwater and tailing lagoons.

## 1.2 Characterization of total mercury in water, sediments, tailings and humans

When the project commenced, the Elplatek team met with Planet Gold, government institutions responsible for mining and pollution and informed that a recent MSc thesis, funded by Planet Gold, documented high levels of mercury in river sediments throughout the watershed originating from multiple sources (FIGURE 3).

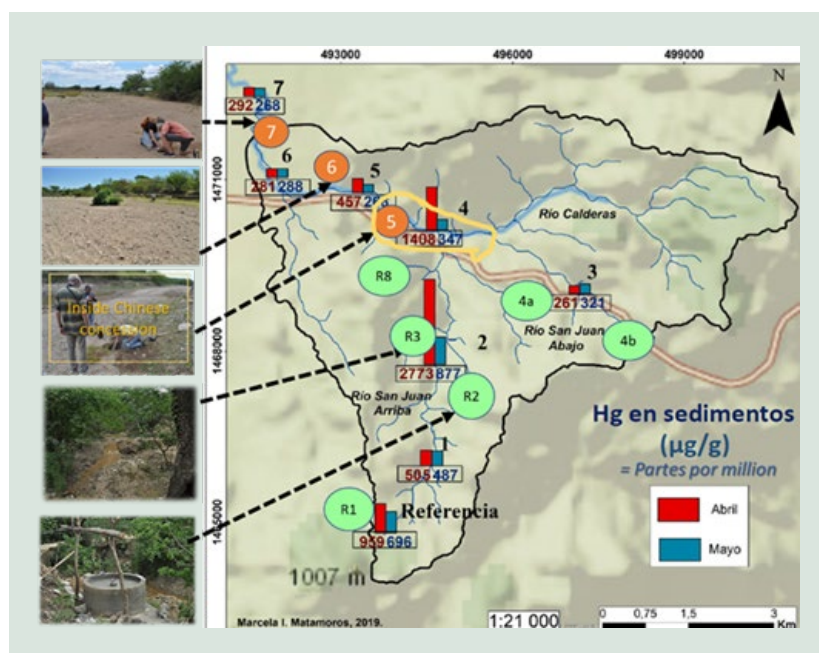


**FIGURE 3.** Sources of mercury emissions in the Municipality (Matamoros 2017).

Based on the available data from this and other studies indicating dangerously high mercury concentrations in river sediments, the Elplatek team conducted a wet and dry season sampling campaign to establish baselines in the river sediments and tailing lagoons (FIGURE 4) before committing to a specific design for cleaning mercury from the river bottoms.



However, the results from the baseline survey indicated that Total Mercury in river –bottom sediments, tailing lagoons and groundwater did not support the existing scientific hypotheses by Honduran universities that river sediments contain high Hg concentrations. Instead, it sharpened our focus on tailing ponds which 10x higher Hg concentrations than river sediments.



**FIGURE 4.** Location of Elplatek's total Hg baseline sites.

This unexpected finding that the highest concentrations are in the tailing lagoons rather than in river sediments led to the project team to *shift its focus from remediating river bottoms to tailings and potentially saved the project tens of thousands of dollars* by erroneously focusing on the wrong mercury-containing compartments.



**FIGURE 5.** Photos of mercury used by teen to extract gold, mercury contaminated tailings lagoon and river.

This led to the Elplatek team carrying out an inventory of contaminated tailing lagoons and prioritizing them according to the immediate needs for remediation. The project also funded a MSc study for determining the concentrations of mercury in groundwater, which found traces

of mercury on several wells, as well as high fecal coliform concentrations. the Elplatek Team sampled numerous tailing lagoons like those shown in the adjacent photos and found mercury concentrations that ranged from 10-45 parts per million. Lagoons were ranked according to the Hg pollution index and prioritized for remediation according to the highest to lowest Hg concentrations.



**FIGURE 6.** Examples of tailing lagoons sampled by Elplatek team

A recent study by Planet Gold found that over half of the miners and one quarter of their female partners have high levels of mercury in their bodies. Of more than 150 people tested, 70% had values of concern or beyond safe levels (20%). This presents serious concerns about neurotoxicity that results in the observed tremors in some miners and problem that presents the most serious risks to pregnant women and developing children, and it is something that has been ignored by previous governments for decades.

Mercury in Urine			
Range/Who	Miners	Non-Miners	Total
<5 (low; Safe)	14 (16%)	41 (43%)	55 (30%)
>5 - <20 (Alert)	51 (59%)	40 (42%)	91 (50%)
>20 (exceeds safe exposure limits)	22 (25%)	15 (16%)	37 (20%)

**FIGURE 7.** Study by Planet Gold showing levels of mercury in bodies of examined study participant.

### 1.3 The Baseline findings and the need for a major readjustment of the approach to remediate mercury

Based on a request from Elplatek of Denmark, Alta Research S.A. was contracted to manufacture two distinct prototypes – one for cleaning mercury using ultrasonic amalgamation with rotating, electroplated silver plates to capture mercury from processed mine tailings, which also contain significant concentrations of gold flakes, (up to 60% of the gold is lost in the inefficient rastra milling process).



**FIGURE 8.** Mercury remediation prototype.

The other processes gold ores and extracts gold using gravimetric methods without using mercury. Both prototypes were installed in the mining area located within the El Corpus municipality. These two prototypes are significant improvements on earlier models developed prior to this project and they are in line with the guidelines of the Danish MUDP Eco-technological Innovation approach. Given that they are significantly different from the original mercury remediation proposal by Appel Global, the preliminary results **clearly** indicate that these improved prototypes provide a more efficient and effective approach, not only to remediate significant amounts of mercury (up to 85%) from mine tailings, but also to extract considerable amounts (up to 90%) gold flakes that are lost by the inefficient rastra milling process used throughout Latin America.

## 2. Objectives

The original project objective presented to MUDP's Eco-innovation Fund aimed to develop, test and demonstrate a project to assist a country committed to meeting its obligations under the Minamata Convention to reduce the risks of contamination by highly toxic mercury to the planet and the well-being of its citizens and their environments. The beneficiaries are artisanal and small-scale gold miners (ASGM) and the environment.

While the project has been operating for the past 2 ½ years, multiple delays, unexpected findings that came out of an intensive field sampling program to collect baseline data in the micro-watersheds receiving runoff containing mercury and multiple challenges that were outside the project's control<sup>1</sup> required some major adjustments in the project's original specific objectives (SO). Nonetheless, the Elplatek team worked continuously on testing, providing on-the-job learning for interested miners, women and government officials who accompanied the project throughout implementation. When the new government took over in 2022, an inter-institutional project coordinating committee made frequent site visits to the Demonstration area and convened semi-annual meetings to learn about the project's progress. Adapting to the lessons and unforeseen findings from the baseline surveys in river bottom sediments and tailing lagoons, the project modified the SOs as follows:

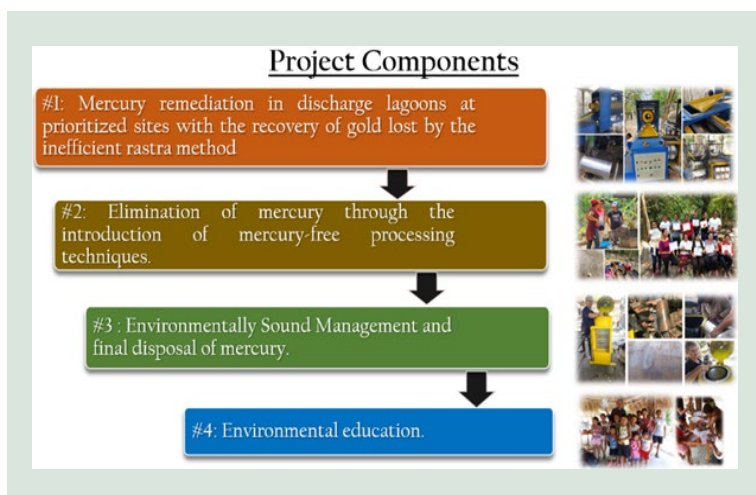
1. **Develop, test and demonstrate innovative and evolving Danish technology to remediate mercury from ASGM tailings in a demonstration area and safely dispose of it using internationally accepted protocols** by recovering gold and mercury lost to the tailing from the inefficient rastra milling method that uses large amounts of mercury and it loses c. 60% of the gold.
2. **Develop, test and demonstrate evolving innovative Danish technology to apply mercury-free gravimetric methods in a demonstration area** and improve the efficiency and effectiveness of artisanal gold mining to improve gold recovery, increase revenue and reduce risks to the community, miners' health and gold-ore processors and the environment.

### 2.1 Project Components

The project developed activities within 4 components to help achieve these objectives, as shown in the adjacent figure. It is imperative that these actions be implemented together because until mercury use in gold processing is stopped, governments will always be forced to clean mercury continually from tailings and rivers. This will continue to put its people and environment at risk from exposure to this potent neurotoxin. As a result, this two-pronged approach will reduce health risks to the surrounding population, many of whom have been found to have high mercury concentrations in their bodies, including women, whose partners' mercury-saturated clothing and bodies are exposing their families to this neurotoxin. Pregnant women and their fetuses are especially at risk.

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<sup>1</sup> Delays up to 8 months forced the project to stop due to the COVID pandemic; Challenges included efforts to introduce a new method to a heavily male-dominated small-scale gold mining and processing culture that dates back for more than one century. Regarding findings, the original project contemplated cleaning up mercury-contaminated river sediments based on a study by one Honduran university that was falsely misleading with its data. Instead, the highest risks come from polluted tailing ponds polluted with mercury.



**FIGURE 9.** Presentation of project components.

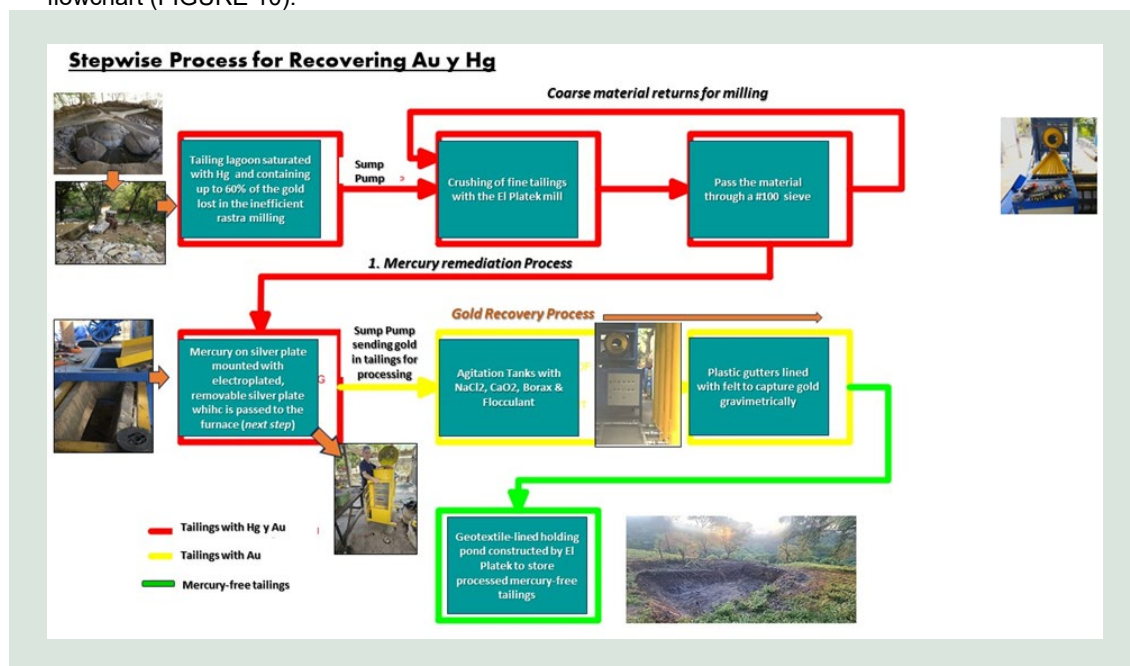


### 3. Conceptual and Operational Approach

Elplatek and its team in Honduras collaboratively designed a system with Alta Research to improve upon an earlier version carried out by Appel Global under separate MUDP funding. It was concluded that this previous mercury remediation method using copper plates amalgamated with mercury to recover mercury from tailings was judged not to be a viable one for many reasons that were discovered when trying to replicate it. This forced the team to abandon that method and develop a new approach using safer and more efficient silver plates to recover gold using passive gravimetric methods.

The significantly modified prototype concluded that rather than using laminar gravimetric flow to channel mercury across a silver plate, a prototype that employed at included the use of a rotating and vibrating drum to produce sinusoidal capture of mercury on removable, electroplated plate with 2 ounces of silver on each side. The variable-speed motor and vibration unit allows for controlling the rotation speed and vibration frequency to generated a standing wave (ultrasonic vibration up to 40 kHz) of a mercury slurry that passes over its surface. This results in the tailing particles to hit the silver plate repeatedly and this substantially increases the probability that free mercury would amalgamate with the plaque. This was further improved by engraving a cavity with channels in the rotating silver plate to enhance the capture of mercury. The idea of using ultrasonic vibration to increase the proportion of mercury captured by the silver plate can be justified by understanding the physics of standing waves. Although it is a well-known process, its use in this application is novel.

Work done with electroplated plates confirmed that this process could be used with vibration to further increase mercury capture (see 'Promoting the recovery and responsible management of mercury in tailings'). Choosing an optimal treatment for the recovery of gold and mercury from tailings requires a series of sequential steps that are summarized in the following flowchart (FIGURE 10).



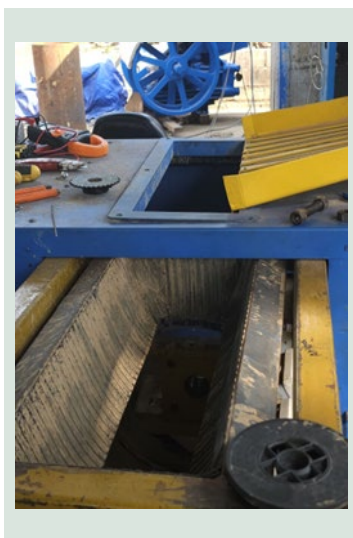
**FIGURE 10.** Diagram showing the different steps of the processing of tailings containing mercury and gold from tailing ponds throughout the mining area.

### 3.1 Component 1: The Capture of mercury on rotating silver plates

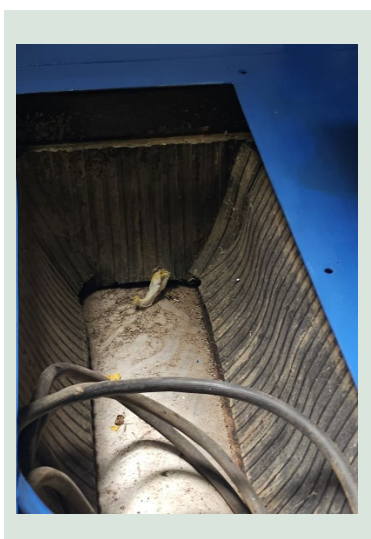
The new mercury remediation prototype (FIGURES 11-13) introduces several innovative techniques to improve the recovery of mercury and gold flakes by: i) introducing a 100% mercury-free technique; ii) a motor with variable speed controls to slow rotation if the tailings have low mercury concentrations, or speed them up if they have high mercury concentrations; iii) vibrational frequency control to increase or decrease the frequency to achieve a standing wave in the tailings, while the silver cylinder rotates against the flow. While testing the proper combination of speed and vibration has been a time-consuming effort and has resulted in a delay of over 6 weeks, it is imperative to have evidence of the proper combination before installing the machines so they can be adjusted accordingly. This was necessary in the workshop, where tools are readily available, rather than in the field with limited technical working conditions. Annex 1 describes this process of amalgamation of mercury with silver.



**FIGURE 11.** Assembling the silver plate to install it on the rotating drum with vibrator (controls in the foreground).



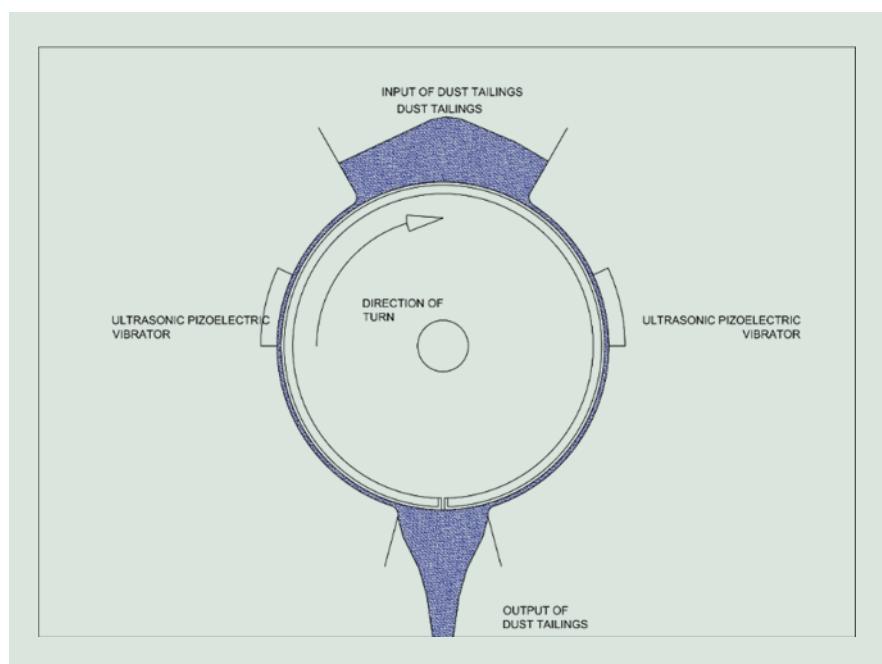
**FIGURE 12.** Compartment into which the silver plate attached to the rotating drum is inserted.



**FIGURE 13.** Silver plate mounted with mercury mounted on the inner compartment of the drum.

The FMA (finite modelling analysis) model applied during the design phase showed that approximately 85-90% of the free mercury would amalgamate on the plate with a 1-centimeter-wide channel when a frequency of 40 kHz was applied rotating in a rotating drum (FIGURE 14). Not that these are theoretical calculations and *in situ* tests will be held once the prototype is installed in the mining area.





**FIGURE 14.** Diagram showing the rotating cylinder and the silver plate mounted onto of it.

For the initial testing of the mercury capture system, we used mercury-saturated tailings to verify that the system performed as expected. One of the problems that arose was the limitation on the number of 50 kg bags of tailings that we could take to our workshop because we had to comply with hygiene and safety standards, as well as the environmental regulations of Nicaragua<sup>2</sup>. It is illegal to transport tailings from mining sites and anyone who violates this rule is subject to strong penalties.

Based on the above, we determined that we could use a maximum of 2.5 tons of tailings for testing, as long as they were visually saturated with mercury. During this process we found that some artisanal miners mistakenly believed that they could obtain more gold by using more mercury. In the samples we bought, we estimated that there were up to 10 grams per ton.

This was based on the fact that artisanal miners recovered 10 grams of mercury after having distilled it from gold in a retort, and originally poured 50 grams of mercury into the 4 tons that were ground in the fine tailings. Mercury was clearly visible in the tailings we used to test extraction efficiency in the prototype.

Tests show that upon reaching harmonic resonance, tailings that accumulated in a given unit area (cm<sup>2</sup>) in the channel on the silver plates can exceed recovery efficiencies >90%. We are awaiting results of further testing from the EUROFINS laboratory in Seattle, which is now applying mass spectrometry (MS) analyses, which are more sensitive than cold vapor atomic absorption spectrophotometry (AAS), which is expected It will be ready in mid-November.

### 3.1.1 Chemicals used for the remediation process

The amounts of chemicals applied to the system may vary with the composition of the tailings, but generally the values indicated below will be acceptable for typical tailings:

<sup>2</sup> Tailings had to be brought from the Nicaraguan gold mines to test the prototype regularly while it was being tested at the Alta Research Laboratory in Managua.

- I. Sodium chloride 100g per tank (tailings with 50% water weight 800Kg)
- II. Calcium oxide 100g per tank (tailings with 50% water weight 800Kg)
- III. Borax 50g per tank (tailings with 50% water weight 800Kg)
- IV. Flocculant 25g per tank (tailings with 50% water weight 800Kg)
- V. Detergent 25g per tank (tailings with 50% water weight 800Kg)

The quantities listed above are for each 471-liter tank considering tailings with a specific weight of 1.7 kg/dm<sup>3</sup>.

### 3.1.2 Useful life expectancy of a silver plate

This prototype for mercury extraction is a new method developed by our company for which some parameters require a long useful life. It uses electroplated lacquers with silver on both sides. We only calculate values, since the machine has obviously not been running for a long time. Silver plate life is one of the parameters for which we have no real data, as we have only used the machine for a few hundred hours (approximately 180 hours).

We calculate that, with 2 ounces of silver on the surface of the plate, abrasion can eliminate the silver when 1.7 million liters are passed if the tailings have a granulometry less than 100 Mesh, this is 3 months of operation at an approximate flow of 340 ml/sec. Granulometric particle sizes greater than 100Mesh can exponentially increase the wear of the plate. That is why it is very important to have a selector cone with a #100 mesh at the exit of the mill. FIGURE 15 demonstrates the plate with amalgamated mercury on the surface.



**FIGURE 15.** A used silver plate with mercury amalgamated to it and recovered mercury.

### 3.1.3 The oven designed to capture mercury form the silver plates

An oven (FIGURES 16-18) was designed and built to be able to heat the silver plate used in the mercury contaminated tailings remediation process, which can be easily inserted into the oven and heated to 380°C+. The galvanized silver plate for recovering mercury was placed in the oven and activated. The program used to operate the oven raises the temperature to 350°C, and the reverse air circulation flow (from top to bottom) is activated. Normal ice was

used in performance tests, but thanks to the redesign of the ice containment tank, it did not cause problems with water evaporation (which originally produced steam). As the temperature increases, the mercury is volatilized, and an aspirator creates a constant flow of air that carries the mercury to a cooling ice bath. Two tests were carried out by placing a silver plate containing mercury in the oven, using common ice, since when ice melts it begins to produce water vapor.



**FIGURE 16.** Oven with heating coils.



**FIGURE 17.** Complete view of the oven.



**FIGURE 18.** Top view of the oven.

After initial tests, we found that it was preferable to use dry ice at  $-78^{\circ}\text{C}$  because ice oxidizes the silver plate (FIGURES 19 and 20). Therefore, a lesson learned is that it is necessary to use dry ice to obtain a flow of  $\text{CO}_2$  gas that would reduce the oxidation of the plate at  $350^{\circ}\text{C}$  because this will freeze the gases by condensation in a container with dry ice. This will also help increase the number of cycles in which the furnace will operate, because it allows all of the mercury to be extracted with a single load of dry ice.

In the first test, after reaching  $350^{\circ}\text{C}$ , the automatic system performed 10 air flow cycles of 6 minutes each. The test stopped when the ice melted, and the water began to produce steam. The containment tank was opened, and it was verified that there was a small amount of mercury at the bottom, 0.39 English ounces (not troy ounces), which is equivalent to 11.05 grams (FIGURE 21). For the second test, ice was loaded again, and the machine was cycled again at  $350^{\circ}\text{C}$  for 10 cycles. It was verified that there were 0.32 ounces or 9.07 grams. A third test was carried out, but it was found that there was no longer mercury on the plate.



**FIGURE 19.** Ice bath to cool the Hg vapor.



**FIGURE 20.** Oxidized Electro-plated silver plate after going through the oven and ice bath.



**FIGURE 21.** Mercury samples captured by the furnace.

During these tests of the mercury extraction system, we were able to verify that the plate amalgamated mercury by approximately 80%. This analysis was based on the amount of mercury in the 2.5 tons of mercury-contaminated tailings (see theoretical framework above) where there was an estimated 10 grams per ton. These tests allowed us to determine that the best option is to heat the entire plate at 350°C for 3 hours with 10 cycles per hour of CO<sub>2</sub>, in the oven with 5 kilos of dry ice inside.

### 3.2 Capturing residual gold from Hg-contaminated tailings

One of the problems with capturing mercury by ultrasonic amalgamation is that this system would not capture gold, the most important element for miners and buyers of it. This presents a problem, as artisanal miners do not have an incentive to capture mercury, since by handing over the mercury, they will not receive any profit. For this reason, the prototype has been mod-



ified to capture mercury within a containerized system for gravimetric gold extraction (see FIGURES 22-24), with the objective of recovering up to 60% of the gold that is lost in tailings ponds or discharged directly into microwatersheds due to the inefficiency of the inefficient ras-tra method for extracting gold with mercury.



**FIGURE 22.** Concrete container for housing the equipment for remediating the Hg and recovering gold from tailings.



**FIGURE 23.** Tanks used to process Hg and Au tailings.



**FIGURE 24.** Mill for processing. Fine tailings (rear) and tanks for capturing Hg and Au.

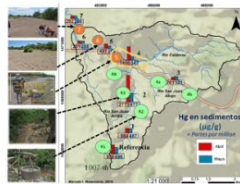
Consequently, the tailings have an enormous economic value and for that reason, buyers send young men to collect the tailings (without any type of protection), load them into bags that are transported to a site where the remaining gold is extracted, with cyanide. If a buyer (almost all of them are not Honduran) buys 50 tons of tailings from the tailings ponds of a hauler owner, the price is less than \$2000. The amount of gold in that volume of tailings can be worth up to \$65,000. Consequently, the profits go directly to the buyer, taxes are not collected by the central government or the municipalities.

It should be noted that, according to our preliminary tests, between 70% and 80% can be recovered using gravimetry, through channels. Efficiency is maximized by using the chemicals listed in the next subsection of this report. However, if only detergent is used in the agitators, this will limit the gold recovery efficiency to 70%. This can be done in locations that require environmental impact studies for other chemicals, making the initial cost of serial operation very high.

FIGURE 25 summarizes the entire process for remediating mercury from tailings, as well as capturing the residual gold flakes that are lost to the tailing lagoons from the inefficient rastra and mercury-intensive method.

## Achievements: REMEDIATION of Hg in TAILINGS

Baseline established for Total Mercury in river – bottom sediments, tailing lagoons and groundwater  
– Relatively low Hg in river sediments required a change in focus to tailings.



Design of a unique Hg Remediation prototype to clean Hg in tailings AND recover gold lost as waste to tailings from inefficient milling



Prioritization Hg Hotspots among 150 Tailing Lagoon Sites Requiring Remediation.



Furnace for safely volatilizing mercury captured on rotating silver plates.



Installation and Testing of Prototype in Mining area



- Avg. of 11g of Gold recovered per 3 Tons of Tailings
- Avg. of 1 Kg Mercury recovered per 5 Tons of Tailings

**FIGURE 25.** Diagram summarizing the entire mercury and gold recovery process used to clean tailings.



## 4. Component #3: Introduction of a technique for processing mercury-free gold ores

### 4.1 The urgency of going beyond remediation mercury in tailings

While Component #1 of this project aims to remediate mercury in tailing ponds in the mining area, unless miners have a more economically attractive alternative, they will continue to use mercury, which will always threaten human and environmental health of the people exposed to in groundwater, atmospheric fallout and mercury-tainted seafood in the adjacent Gulf of Fonseca nursery area.

**Consequently, following the logic of the MUDP Innovation Fund, the Elplatek Team recognized an important opportunity to add further value to the project by introducing a technique for extracting nearly 2 times more gold without using mercury.** The demonstration exercise was carried out using gravimetric methods and a modified Filipino mill that Appel Global has successfully tested in over 20 countries.

### 4.2 The Modified mercury-free gold extraction method

The modification of the mill is focused on an automated process, which eliminates the risks associated with the manual operation of individual mills and allows them to have greater gold recovery, compared to a process that is not automated. The performances associated with the modification of the mill are detailed below:

**TABLE 2.** Processing yields associated with the modified Filipino mill.

Mill Capacity	Time	Weight
6 sacks	3 hours	300 kg

If gold ores are processed daily, in a 12-hour shift, the theoretical yield would be 1.2 tons. Similarly, for 24-hour shifts, the benefit of 2.4 tons per day would be expected.

In this pilot, the women recovered 1.7 times more gold than was captured by the harrowing where the men applied the mercury.

Furthermore, the modified Filipino mill crushed nearly 3 times more gold ores, it is fully automated and uses an efficient electrical motor, rather than diesel. It is also self-contained and there are no moving parts that could injure the operators.

### 4.3 Demonstration of the mill operation and maintenance for gold-ore processing

The launch of stage two, of project component #2, a demonstrative course on plant operation (FIGURE 26) was carried out, focused on the target group and the technical operator of the plant, who will be hired by the project, while the planned activities of stage two are carried out.

This course was taught by the general manager of the Alta Research company in Nicaragua, who was in charge of modifying the processing plant.

This plant represents an unprecedented benefit for the municipality of El Corpus, also for the target group, since it is the first technology for the benefit of gold without the use of mercury, in an organized group made up of women from communities in the municipality of The Corpus. This provides the opportunity to replicate the pilot approach of this project in other municipalities where Small Mining and Artisanal Mining activities are carried out in Honduras, El Salvador, Nicaragua and Guatemala.



**FIGURE 26.** Demonstration of the mill to women by Alta Research.

#### **4.4 The modified Filipino mill as a process for overcoming male-dominated cultural norms among miners**

There is a significant cultural barrier that the project had to overcome to introduce an alternative technique for gold processing, since male miners consider that the recovery yields in the inefficient mercury extraction method are higher than those obtained by gravimetric processes. This was further complicated by a pervasive macho culture where men believe that they are too strong to be affected by mercury and have nothing to fear, despite the team observing numerous cases of men with neurological tremors.

While there is no correlation that unusually common birth defects of children in the mining area are linked to Minamata disease, a recent medical study found that 60% of males associated with mining had excessive levels of mercury in hair and blood samples, while 40% of women who washed the men's clothes had high levels of mercury.

Although men were reluctant to participate in a comparative test of the mercury free versus traditional rastra /mercury technique, women jumped at the opportunity and clearly showed the economic and efficiency values of using the modified Filipino mill developed with MUDP Funds. This has already started to cause an important paradigm to shift in the male-dominated mining culture and men are now becoming increasingly interested in the method.

#### **4.5 Economic empowerment of women in a male-dominated mining culture**

Consequently, the demonstration sessions consisted of members of the organized women's group "Joyas Cuculmeca". In that sense, the demonstration was carried out entirely with the members of this group.

Seventeen women were certified as operators by the technical team of Filipino miners of Appel Global, a member of the Elplatek Consortium. In the demonstration program, a cultural barrier

was experienced by the male members of the target group. Annex 3 presents additional information and data related to this component. They continue processing and extracting gold and an additional 40 women from different mining areas throughout the country have request that they be included in these certifications.

#### **4.6 Connecting with mercury free gold markets in Europe**

This new approach will provide mercury-free ore processing technology to the organized group and will allow them direct insertion into the gold value chain and sell mercury free gold to markets in Europe, thanks to an agreement established with the German Cooperation.

The members of the organized group, for the most part, are single mothers with no economic income, inhabitants of areas of extreme poverty. This technology transfer could provide them with a permanent job. This represents a paradigm shift for male miners, since, in previous decades, women were relegated from involvement in the gold value chain; They only participated in economic activities related to the sale of food, fuel and washing clothes.

#### **4.7 Construction of concrete foundation for operating the modified Filipino mill for processing mercury-free gold**

Annex 3 shows the process used to build solid concrete foundations for the two Prototypes in their respective locations.

## 5. Environmental Education

Unfortunately, the delays and limited funding for Component 4 forced the team to look for other sources of funding. Fortunately, the Rotary Club of Key Biscayne Florida pledged an initial grant of \$2000 to develop an environmental education program for primary school children and this will include the production of coloring books highlighting ways to care for the environment, watersheds and especially, the benefits of with mercury-free milling and gold recovery.

## 6. Process to formalize agreements with the government target groups of EI Corpus

The Project presents a strict approach of testing, rehearsing and demonstrating Danish technology, in order to improve the gold recovery process for miners, as well as decontaminate prioritized sites, through a pilot approach. In order to be able to transfer technologies, it is necessary that the target groups have their respective Mining Rights and Environmental Licenses. Annex 4 presents additional information for this process.

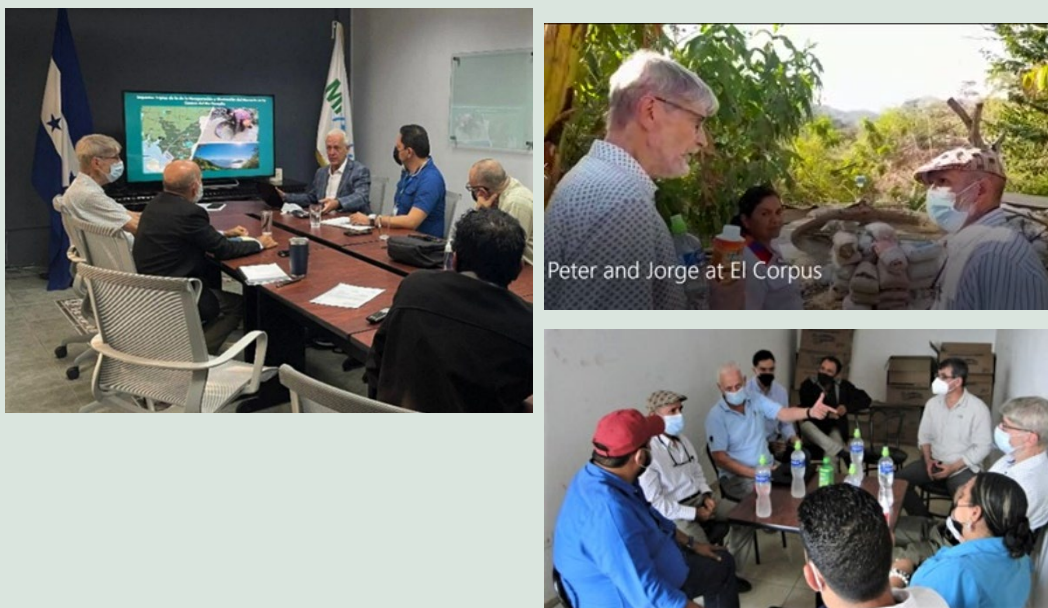
### 6.1 Agreement between The Government of Honduras and the Danish consortium

In March 2022, the Danish team meet with the new Vice Minister of Environment to explain the project (see Figures below) and to inform him that the Consortium has a signed Memorandum of Understanding<sup>3</sup> between the Honduran Institute of Geology and Mines (INHGEOMIN), signed by Joe Ryan the Consortium's legal representative in-January 2022. The Consortium formally requested that the Ministry of Environment sign an Inter-institutional Agreement to ensure full cooperation throughout the implementation of the pilot project. Important highlights of the memorandum include:

- Permission to work in mining areas.
- Permission to import work equipment.
- Permission to export soils, metals and most importantly mercury for stabilization and deposition.
- Assistance with safety- and customs related issues.

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<sup>3</sup> has been developed with the assistance from conservationist Rafael Sambula, La Ceiba, Honduras, who is a member of the Danish team.



**FIGURE 27.** Presentation to the 2 MiAmbiente Vice Minsiters and the UNDP GEF Gold Coordinator; Peter Appel explaining the mercury-free technique to Vice Minsiter Salaverri and Francisca, the coordinator of the Women's Directorate for the El Corpus Municipality in the Gold mining area; Joe Ryan explaining the project to the El Corpus Mayor, the Mi Ambiente Vice Minsiter, the Municipality Lawyer and Technical assistant in El Corpus, March 2022.

In addition to the MoU itself the Honduran government has required a translated and certified (legalization by the Danish Ministry of Foreign Affairs) copy of a) A signed, written assignment giving legal representation power to Joseph D. Ryan (Annex 3), b) The financing agreement and project approval by the Danish Ministry of Environment (Annex 4), c) Company constitution of Elplatek (Annex 5). The MoU has been discussed with high levels of the new Ministry of Environment advisors, who assumed office as of January 27, 2022. As of July 2022, the Consortium is working closely with the Honduran Ministry of Foreign Affairs to ensure that the MoU with MiAmbiente follows all legal requirements.

## 6.2 Reactivation of Environmental Licensing with the Ministry of Environment and Natural Resources (SERNA)

In order to promote the operation of the target groups under a formal scheme, which legalizes the entire gold value chain, a request was made to form a SINEIA, approved on July 6 and carried out on July 13. A field inspection was carried out, with representatives from the Ministry of Environment and Natural Resources (SERNA), the Honduran Institute of Geology and Mines (INHGEOMIN), the Municipal Environmental Unit of El Corpus (UMA) and the Miners Association of El Corpus.

The objective of this SINEIA was to reactivate the Environmental Licensing process, which led to obtaining the Operating License, issued on November 11, 2021. The process subsequent to this is obtaining the Operating License, but for this a field inspection was necessary. Once the Operating License is obtained, it is intended to make an addendum to the Environmental License, in order to include in the PMA what is related to the processing process of tailings contaminated with mercury and litter.

### **6.3 Follow up of the process of obtaining Mining Rights with INHGEOMIN**

On Monday, September 18, a meeting of the Technical Project Committee was held, made up of representatives of: INHGEOMIN, CESCO-SERNA and the global PlanetGOLD project. The objective of this meeting was to share progress, opportunities and lessons learned by project component. Likewise, know the status of past applications from the Miners Association of El Corpus Dos de Julio, and the need to have a Benefit Concession; in case you cannot have a Small Mining permit.

Taking these uncertainties into account, an agreement was reached to generate a call for a meeting with the Executive Director of INHGEOMIN and the units competent on the subject.

### **6.4 Meeting to generate a roadmap for legalization of target groups of El Corpus miners**

In follow-up to the process of legalization of mining activity, a meeting was held on October 16 that was attended by:

- Director of the Institute of Geology and Mines, Eng. Carlos Maradiaga.
- Head of ASM Unit: Eng. Josiela Sánchez.
- Head of Training Unit: Eng. David Alcántara
- National PlanetGOLD Project Coordinator: Eng. Pablo Rodríguez.

At this meeting, the need to formalize the mining activity of the municipality of El Corpus was explained, taking into account that this is necessary to carry out both mercury remediation activities and its elimination; in the beneficiation of the mineral. Given which, it was requested to carry out a review of PCM-018-2016 with the objective of making a modification to it, which would allow the viability of requesting a Mining Right, to carry out exploitation under the figure of Small Mining and Artisanal Mining. .

There was an institutional agreement to carry out a review of the Executive Decree, and provide a technical-legal opinion, about the viability of making a modification to it, or finding a legal figure that would allow exploitation under a Small Mining figure in area.

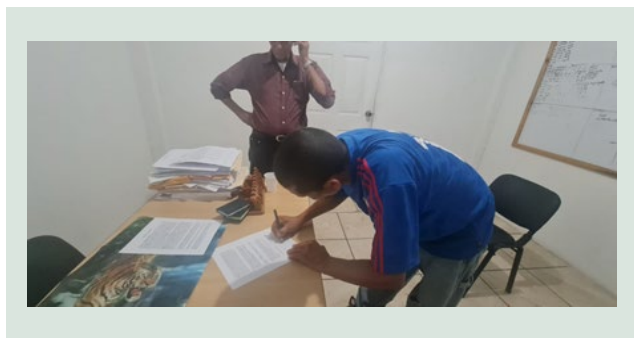
Demonstrating the Institutional commitment of INHGEOMIN to support community mining, the Institute issued a memorandum, on November 3, 2023, that sets out the determination to request a Mining Right on Small Mining, by the miners of the communities of El Corpus is viable and in accordance with the law, as long as they are subject to the provisions established by Executive Decree PCM-018-2016 and the Understanding Agreement form for exploration or exploitation of Materials in Special Areas, form 8 of the DUPAI-CEAE-FL -01.

This represents an opportunity to legalize the value chain regarding Mining Rights and Environmental Licensing, for which a mapping of the interests and needs of the target groups will be carried out, to provide support in the request for the corresponding Mining Rights.

### **6.5 Signing of the Loan Agreement and Cooperation Agreement for the loan of land between Elplatek and Jewels of Cuculmeca.**

With the objective to ensure that all of the Elplatek-MUDP project requirements are followed regarding the inclusion of the tailings owners of the prioritized sites, generate a sustainability strategy through the creation of an economic fund that will be used when the project ends, strictly avoid the manipulation of the recovered mercury, and ensure a site that allow miners to process tailings and mercury-free gold.

Demonstration participants to be able to carry out the remediation process in a safe way that does not compromise the recovery of the odor; On September 6, 2023, the signing of an agreement to loan the land for the project and a Cooperation Agreement took place, between the owner of the land of the piling site and the President of the El Corpus Miners Association: José Edas Rivera Salinas.



**FIGURE 28.** Signing of the Agreements with the July 2 artisanal Miner Association.



## 7. Conclusions

The MUDP Innovation Fund project has now concluded and has achieved its general and specific objectives through the development, testing and demonstration of an innovative mercury remediation prototype and the mercury-free milling process to extract gold for small-scale gold miners in Honduras. However, because of delays and especially the lack of full commitment promised from the outset by the Miner Association, the project fell short of its expected outcomes in terms of the amount of mercury and gold that was expected to be captured.

While the two mercury and gold recovery machines with the silver plates are extremely effective and an excellent way to recover mercury, the aspect of human operation in terms of handling the machine and making adjustments when something goes wrong, proved to be an important lesson and barrier from expediting mercury extraction. This problem was overcome late in the final stages of the project when the Elplatek team engaged a group of committed women who not only learned to operate the mercury-free milling prototype using a gravimetric gold capturing method, but also to operate the mercury remediation process to clean over 20 tons of tailings. In 2 weeks, the women recovered an average of 11grams of Gold recovered from 3 Tons of Tailings and 0.5 Kg Mercury recovered per 5 Tons of Tailings. In total 2.2 Kg of mercury was recovered from this initial serial run of the prototype machines. The goal of the project was to ship the mercury to Switzerland for safe disposal, unfortunately the project ran out of time and the relatively low mercury yield made little sense to pay the high disposal fee. Therefore, the 2.2 Kg of mercury was donated to the local university as they needed it to run laboratory tests.

The women will continue operating both prototypes thanks to investments by the Rotary Club of Miami, the Elplatek Team Leader and Alta Research, as well as pro bono support by the latter two, until the women are able to auto finance the purchase of gold ores on the one-hand, and tailings on the other. This is expected to be completed by June 2024.

The entire project will increasingly benefit small-scale artisanal gold miners to recover larger volumes of gold without using mercury and recover and reduce health risks to miners, their families and other people affected by mercury in areas of direct impacts and indirect effects of mining and mineral processing. The project not only offers an excellent mercury-free gold processing area in other mining areas of Honduras, but also to connect with gold processing value chains in Germany and other European countries. It also offers the opportunity for further testing in other countries in Latin America, Asia and Africa that have banned ASM and/or have no methods to meet their obligations under the Minamata Convention to reduce and/or eliminate mercury. ***The approach also provides an economic-legal, technical and circular model for the Honduran government and others to legalize hitherto illegal ASM, demonstrating how Danish technology can significantly reduce impacts on human and ecosystem health.***

Finally, it is highlighted that unless techniques are developed to capture gold without using mercury, the remediation process will never end, and people and their environment will continue to have adverse impacts on their bodies and their surrounding ecosystems. For that reason, a separate component of the innovation fund was developed to modify traditional Philippine rotating mills using mercury-free gravimetric methods.

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## **Final Report for “Demonstration project for remediating & eliminating mercury in small-scale gold mining in Honduras”**

This report presents findings on reducing mercury use in small-scale gold mining in Honduras. High levels of mercury contamination in river sediments, tailing lagoons, and groundwater necessitated the project. The project had four components:

- 1) Mercury remediation in discharge lagoons at prioritized sites with the recovery of gold lost by the inefficient rastra method.
- 2) Elimination of mercury through the introduction of mercury-free processing techniques.
- 3) Environmentally sound management and final disposal of mercury.
- 4) Environmental education.

Despite challenges like delays and changing government policies, the project successfully demonstrated an innovative technology to remediate mercury from mining tailings, introduced mercury-free gold extraction methods, and initiated an environmental education program. The project also contributed to legalizing small-scale gold mining in Honduras using Danish technology to reduce impacts on human and ecosystem health.



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