Final Evaluation Report

We ask all grant recipients to complete a project evaluation that helps us to gauge the success of your project. This must be sent in **MS Word and not PDF format**. We understand that projects often do not follow the predicted course but knowledge of your experiences is valuable to us and others who may be undertaking similar work – remember that negative experiences are just as valuable as positive ones if they help others to learn from them.

Please DO NOT fill in and submit this form until the project has been completed.

Complete the form in English. Note that the information may be edited before posting on our website.

Please email this report to jane@rufford.org.

Your Details	
Full Name	Lina Marcela Mosquera Chaverra
Project Title	Plant species colonizing areas degraded by gold mining in the department of Chocó, Colombia: identification of candidates for phytoremediation of mercury.
Application ID	41948-1
Date of this Report	February 2026

1. Indicate the level of achievement of the project's original objectives and include any relevant comments on factors affecting this.

Objective	Not achieved	Partially achieved	Fully achieved	Comments
Select sampling sites				Seven sampling sites were selected across mining impacted areas with different periods since cessation of gold mining activity (from approximately 3 months to 7 years). We conducted four semi-structured interviews with local field guides in each municipality to support the selection of sampling sites and to better understand the mining dynamics in the study areas. The interviews provided information about the gold mining process, the tools and machinery commonly used, and the use of mercury in gold extraction.
Characterize water, soil, and sediment samples				Soil samples were collected at each site (seven in total). Where mining ponds/wetlands were present, water and sediment were also sampled for physicochemical analysis. In total, ten pools were selected and assessed.
Explore the abundance and distribution of plant species in contaminated areas				Species abundance was recorded in each site, and richness/diversity indices were estimated to compare vegetation patterns across areas with different disturbance histories.
Determine the mercury content in plants and environmental matrices				Plant tissues and rhizosphere soils were sampled to determine mercury and other heavy metals. Mercury was also quantified in water, soil, and sediment. A total of 99 plant species were identified during the study. For mercury analysis, plant samples were collected

				in triplicate, so each species was analysed 3 times, resulting in a total of 297 plant samples. From these, the 20 most representative species across the different study areas were selected for additional analysis of other heavy metals.
Calculate the efficiency of phytoremediation				Phytoremediation potential was estimated for the selected plant species using field and analytical data from contaminated matrices.

2. Describe the three most important outcomes of your project.

a. Baseline ecological inventory in mining-impacted landscapes

We identified and assessed seven sampling areas with different cessation times of gold-mining activity in Atrato and Lloró (Chocó, Colombia). Across all sites, we recorded 2,502 seedlings representing 53 species, 39 genera, and 20 families. Of these, 1,370 individuals were recorded in Lloró and 1,132 in Atrato.

b. Identification of frequent and adaptable species, with conservation relevance

Several species were recurrent across sites, suggesting broad ecological tolerance under post-mining conditions.

- Present in all seven areas: *Pityrogramma calomelanos* Link, *Tibouchina herbacea*, and *Clidemia capitellata* (Bonpl.) D.Don.
- Present in six areas: *Homolepis aturensis* Chase, *Cespedesia spathulata*
- Present in five areas: *Vismia baccifera* Planch. & Trianac, *Mimosa pudica*, and *Tonina fluviatilis* Aub.
- Present in four areas: *Scleria secans* Urb., *Fuirena robusta* Kunth, *Phyllanthus caroliniensis* Walter, and *Palhinhaea cernua* (L.).

Most of these frequent species are categorized as Least Concern (LC), while Cedrela odorata (one individual recorded) is Vulnerable (VU), consistent with pressures from timber extraction and habitat fragmentation.

c. Identification of contamination hotspots and priority phytoremediation candidates

High mercury contamination was detected in Atrato zone A1 and in select mining ponds (PA1, PA2 in Atrato; PLl3 in Lloró). Methylmercury was also detected in PLl3, together with elevated Cd, As, and Pb concentrations.

The most promising phytoremediation candidates were:

- Herbaceous species: *Pityrogramma calomelanos*, *Andropogon bicornis*, Erechtites hieracifolia, and *Cyperus odoratus*.
- Shrubs: *Miconia reducens*, *Clidemia sericea*, and *Clidemia capitellata*
- Trees: *Vismia macrophylla*, *Cecropia peltata*, and *Vismia baccifera*.

3. Explain any unforeseen difficulties that arose during the project and how these were tackled.

Fieldwork in rural Chocó presented two major unforeseen challenges: security-related mobility restrictions and recurrent flooding. Some visits had to be postponed due to temporary road access disruptions, and high water levels periodically limited access to sampling areas and mining ponds. In addition, at a few locations, our local guides advised against photographing for safety reasons.

To address these issues, we applied an adaptive fieldwork strategy: (i) flexible scheduling with rapid rescheduling windows, (ii) close coordination with local community leaders and guides before each visit, (iii) a strict safety-first protocol (no entry/no data collection under unsafe conditions), and (iv) alternative documentation (georeferenced field notes, sample coding, and chain of custody records) when photography was not possible. Although these constraints caused delays, they did not prevent completion of the core project objectives, and data quality was maintained.

4. Describe the involvement of local communities and how they have benefitted from the project.

Local communities were actively involved throughout the project, particularly during planning and fieldwork in Atrato and Lloró (Chocó, Colombia). Community leaders and local guides facilitated safe site access and helped identify former mining areas, including ponds and wetlands created by mining activities. They also shared valuable local ecological knowledge on vegetation recovery after mining cessation. Their participation was essential for adapting field schedules to changing on-the-ground conditions.

At the local level, the project generated clear benefits. It strengthened community capacity for basic environmental monitoring (site identification, sample traceability, and field documentation) and increased awareness of mercury and other heavy-metal risks in soil, sediment, and water. In addition, the identification of native and common species with potential for post-mining restoration highlighted practical local uses (e.g., medicinal and edible) and the importance of conserving these species. Overall, the project produced evidence that can support community-led restoration and local environmental management decisions.

5. Are there any plans to continue this work?

Yes. This project established a baseline of plant species with phytoremediation potential in mining-affected areas of Chocó. It represents one of the first systematic efforts in the region to identify native species for ecological restoration, reducing the need to introduce non-native plants. The next phase will focus on seasonal and long-term monitoring of contamination and vegetation recovery. Validation of priority phytoremediator species under both controlled and field conditions. Expansion to additional mining-impacted sites across Chocó, where artisanal and small-scale gold mining remains a dominant rural activity. Pilot restoration actions with local communities in Atrato and Lloró, using the most promising species identified by this project, and strengthening laboratory analyses for mercury and associated metals to support evidence-based restoration planning and risk reduction.

6. How do you plan to share the results of your work with others?

Results are being shared through both academic and outreach channels. First, we published a manuscript in *Environmental Science and Pollution Research* (Springer) entitled "Mercury accumulator plants with phytoremediation potential in a region of northwestern Colombia." In parallel, we produced an illustrated brochure featuring key plant species identified in the two study areas, with the aim of making the findings more accessible to local stakeholders and non-specialist audiences. In addition, a second manuscript is in preparation to report contamination levels in water, soil, and sediment matrices, while a third manuscript will focus on species with phytoremediation potential for other hazardous heavy metals, including arsenic, lead, cadmium, and chromium, for which several plants showed elevated concentrations. Finally, since this research is part of my doctoral work, all results will be integrated into my PhD thesis, which I plan to defend in June 2026 at the Universidad Tecnológica de Pereira (UTP).

7. Looking ahead, what do you feel are the important next steps?

Looking ahead, the most important next step is to secure funding to establish pilot restoration projects with local communities in areas where mining disturbance has ceased, using practical protocols for species selection and long-term monitoring. At the same time, it is essential to validate the phytoremediation performance of priority species under both field and controlled conditions, including uptake, retention, and metal-specific behavior. In parallel, ecological and contamination datasets should be integrated to define restoration priorities by site type, particularly distinguishing terrestrial soils from pond/wetland systems. Likewise, conservation criteria should be incorporated throughout restoration planning, particularly when vulnerable or low-frequency species are identified. Finally, continued dissemination through conferences, seminars, and peer-reviewed journals will be key to strengthening partnerships, increasing visibility, and scaling the long-term impact of this work in Chocó.

8. Did you use The Rufford Foundation logo in any materials produced in relation to this project? Did the Foundation receive any publicity during the course of your work?

Yes. The Rufford Foundation logo was included in the illustrated species booklet produced by the project. In addition, the Foundation's support was formally acknowledged in our article published in *Environmental Science and Pollution Research* (Springer), entitled "Mercury accumulator plants with phytoremediation potential in a region of northwestern Colombia." Rufford was also acknowledged during project dissemination activities, including a poster presentation entitled "Evaluation of promising species from mining sites in the department of Chocó for the phytoremediation of mercury-contaminated sites," organized by the Vice-Rector's Office for Research, Innovation, and Extension at the Universidad Tecnológica de Pereira (UTP). Furthermore, during community meetings in the study areas, the Foundation's role as project funder was explicitly recognized.

9. Provide a full list of all the members of your team and their role in the project.

The project team combined academic staff, students, and local community members from Atrato and Lloró. Team members and roles were as follows:

- Lina Marcela Mosquera Chaverra: Project Leader and Principal Investigator; responsible for field design, data integration, and project reporting.
- Juan David Córdoba Borja: Biology student (Research Assistant); supported the Principal Investigator and assisted in plant species identification.
- Yilmar Antonio Córdoba Cuesta: Biology student; supported plant collection for taxonomic identification and vegetation counts.
- Jhonier Javier Borja Rentería: Biologist, Botanist, M.Sc. in Biological Sciences; responsible for taxonomic identification of plant species.
- Edgar Andrés Lloreda: Environmental Engineering student; supported the collection of water, soil, and sediment samples.
- Abigail Córdoba: Field Coordinator (Atrato municipality); responsible for logistics, access planning to sampling sites, and team safety coordination.
- Luis Basilio Perea: Field Coordinator (Lloró municipality); responsible for logistics, access planning to sampling sites, and field safety coordination.

- Keiner Stiven Cuesta Mayoral: Local community member; supported plant collection and species count in Atrato.
- Luis Carlos Perea: Local community member; supported plant collection and species count in Atrato.
- Jaider Lemus Roa: Local community member; supported plant collection and species count in Lloró.
- Juan David Lemos Asprilla: Local community member; supported plant collection and species count in Lloró and assisted with water sampling in ponds and wetlands.
- Eufrosina Perea Quejada: Local community member and assistant to the local guide in Lloró; supported plant collection and species count.
- Leiver Londoño: Local community member (Atrato); responsible for sample chain-of-custody and secure transfer to the laboratory.
- Jaider Mosquera: Local community member (Lloró); responsible for sample chain-of-custody and secure transfer to the laboratory.
- Celene Quintero Osorio: Environmental Administrator; responsible for project data organization and review, and for coordinating laboratory sample shipment.
- Diana Cristina Ñustez: Environmental Engineer; responsible for implementing protocols for water, soil, and sediment samples.

10. Any other comments?

We are deeply grateful to The Rufford Foundation for supporting this research through a Rufford Small Grant in a highly biodiverse yet logistically complex region. Despite access and security constraints, the project achieved its main objectives and produced a solid baseline for contamination patterns, plant diversity, and candidate phytoremediator species in post-gold-mining sites where mercury had been used. This support has also strengthened local collaboration and laid the groundwork for the next phase: evidence-based ecological restoration linked to community participation and long-term environmental monitoring in Chocó, Colombia. We also thank Dr Alexandre Campos and Dr Pedro Carvalho for serving as referees, and our supervisors, Diego Paredes Cuervo and Ana María López, for their guidance throughout this research. In addition, we acknowledge the logistical support provided by the Technological University of Pereira and the Technological University of Chocó. Finally, we sincerely thank the entire project team, students, researchers, field guides, and community members, whose commitment made this work possible.

ANNEX – Financial Report

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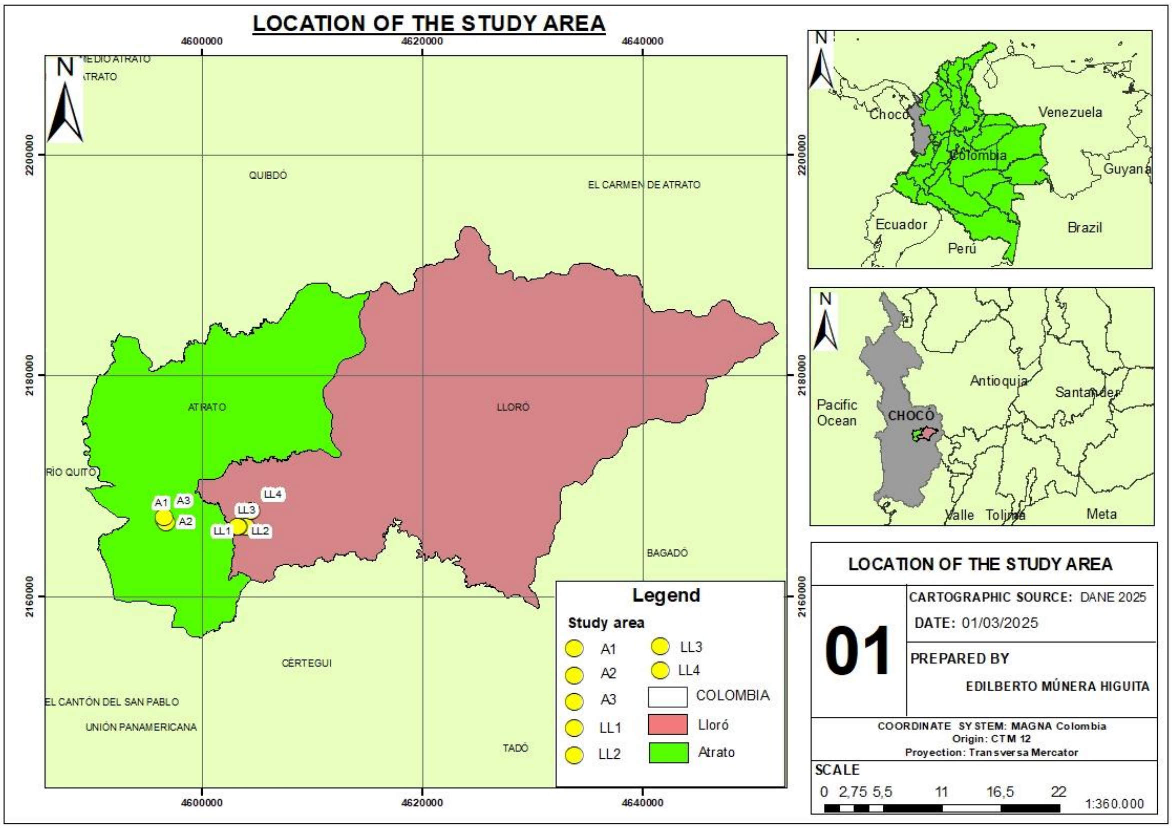
Appendix I. Study area and sampling environments



Location of the study area (Atrato and Lloró, Chocó, Colombia)

Sediment sampling in pond 3 in the municipality of Lloró. Local guide. **Photographer:** Juan David Córdoba Borja

Pond 4 in the municipality of Atrato. **Photographer:** Lina Marcela Mosquera

Sediment sampling in pond 3 in the municipality of Atrato was carried out by Juan David Córdoba. **Photographer:** Lina Mosquera

Field logistics before sampling at a mining-related pond/wetland in Lloró, Chocó (pond 5). The inflatable boat used to access water and sediment sampling points is shown. **Photographer:** Yilmar Córdoba

In situ measurement of water physicochemical parameters in a mining pond using a portable multiparameter instrument. **Photographer:** Juan David

Panoramic view of a mining-origin pond/wetland and the local field team during sampling. **Photographer**: Lina Mosquera

Mining ponds/wetlands selected for sampling

The following photographs show gold-mining-disturbed landscapes in Atrato and Lloró (Chocó, Colombia), characterized by a mosaic of post-mining environments. Coarse gravel and sand tailings, disturbed/compacted substrates, artificial channels and ponds, and forest-edge habitats are evident. Several sites exhibit early natural regeneration of pioneer herbaceous and shrub species, whereas others remain highly degraded, with sparse vegetation cover. This disturbance–recovery gradient informed the selection of sampling sites for analyses of soil, water, sediment, and vegetation.

Mining-disturbed slope with exposed gravel tailings, local erosion features, and adjacent forest-edge vegetation. **Photographer:** Juan David Córdoba

Post-mining channel and tailings deposits during site reconnaissance and sampling-point verification. **Photographer:** Juan David Córdoba.

Coarse gravel tailings with early colonization by pioneer species under natural regeneration (Lloró). **Photographer:** Jhonier Javier Borja Rentería.

Degraded post-mining area showing exposed substrate, sparse plant cover, and early-stage ecological recovery. **Photographer:** Jhonier Javier Borja Rentería.

Appendix II. Fieldwork activities and documentation

Local field team participation during fieldwork in mining-affected areas of Atrato and Lloró (Chocó, Colombia), including logistics coordination, access to sampling sites, plot delimitation, and support for plant and environmental sampling activities.

In situ measurement of water physicochemical parameters in a mining pond. In this photo, Lina Mosquera (project leader) and Andrés Lloreda (research student - Environmental Engineering). **Photographer:** Juan David Córdoba

Field verification and recording of multiparameter readings at the sampling point. In this photo, Yilmar Córdoba (research student – Biology) and Andrés Lloreda (research student - Environmental Engineering). **Photographer:** Lina Mosquera

Preservation step for water samples prior to transport to the laboratory. In this photo, Lina Mosquera (project leader) and Juan David Córdoba (research student - Biology. **Photographer:** Yilmar Córdoba

Sample handling, labelling, and field documentation. In this photo, Lina Mosquera (project leader). **Photographer:** Yilmar Córdoba

Local transport used during fieldwork (motorized tricycle) to mobilize personnel and equipment, including the inflatable boat, between access points and sampling sites in Atrato and Lloró (Chocó, Colombia). **Photographer:** Juan David Córdoba

Field assistant collecting a rhizosphere soil sample within a tape-delimited plot in a disturbed herbaceous area, as part of the plant inventory and mercury assessment protocol. **Photographer**: Andrés Lloreda

Field assistant collecting a rhizosphere soil sample within a tape-delimited plot in a disturbed herbaceous area, as part of the plant inventory and mercury assessment protocol. In this photo: Abigail Córdoba (field Coordinator - Atrato municipality) and Yilmar Córdoba (research student – Biology). **Photographer**: Andrés Lloreda

Species abundance assessment in a delimited plot: a field team member counts and records the number of individuals per plant species. In these photos, Juan David Córdoba (research student - Biology. **Photographer:** Yilmar Córdoba

Visible mercury contamination in soil at the sampling site, showing metallic mercury droplets accumulated on the wet surface.

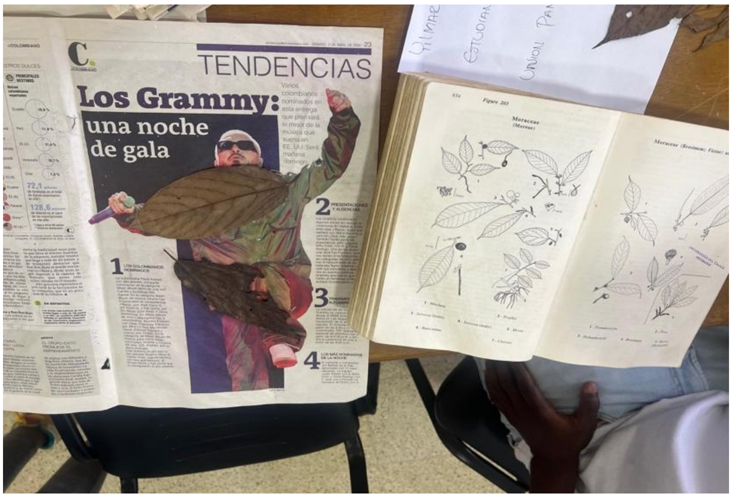
In situ measurement of atmospheric mercury using a portable analyzer (Lumex), reporting gaseous mercury concentration (ng m⁻³) at the study area.

A freshly collected plant specimen was arranged on newspaper over a plastic sheet in the field, with leaves and reproductive structures spread out to support preliminary morphological observation prior to taxonomic identification.

After collection, the plant material was wrapped in newspaper, tied into a labelled field package (including site/zone code and coordinates), preserved with alcohol, and prepared for transport to the herbarium for taxonomic confirmation.

Plant specimens collected in the field

Appendix III. Laboratory work

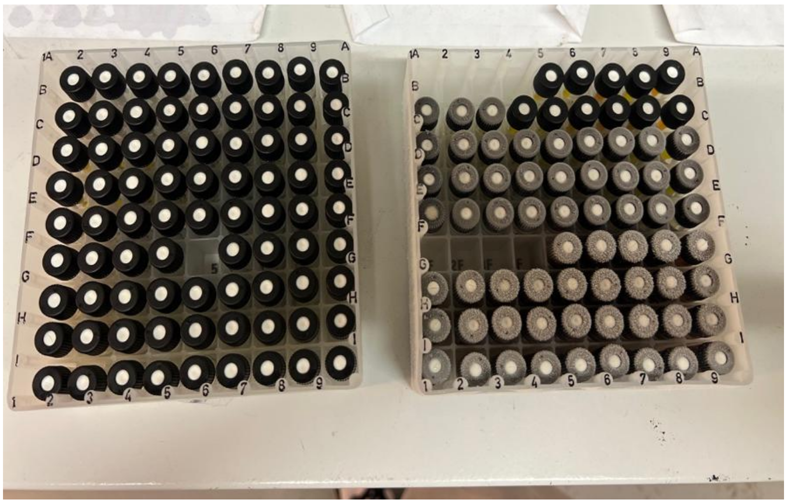


Freshly collected leaf specimens are placed on newspaper and compared with a botanical reference to evaluate diagnostic traits such as leaf shape, venation, and reproductive structures.

A team member organizes and prepares plant material for voucher preparation, labelling, and incorporation into the herbarium collection for long-term storage and future verification. In this photo, Yilmar Córdoba (research student – Biology).

Soil samples for physicochemical analysis, heavy metals, and mercury

Samples of plant species previously identified for mercury analysis



Laboratory work for processing and preparing soil and plant samples for mercury analysis.