Mitigating Mercury Usage & Environmental Contamination: A Multi-Scalar, Mixed-Methods Approach to Artisanal and Small-Scale Gold Mining

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Introduction, Motivation, and Objectives

Motivation: Eliminate Emissions

Offer recommendations for future actions needed to improve estimates and illustrate limitations and opportunities of current estimation approaches.

Case study based on existing best practices

Analyze data and estimates used to develop baseline HG estimates

Reduce targets

Gold production estimates

Hg:Au ratio development

Extrapolation to national levels

Reduction targets

NAP Mercury Estimation Methods

1. Analyze data and estimates used to develop baseline HG estimates

   - Gold production estimates
   - Hg:Au ratio development
   - Extrapolation to national levels
   - Reduction targets

   - 25% reduction by 2021; 50% reduction by 2022; 75% reduction by 2023

2. Compare data and estimates from 25 NAPs using statistical methods

3. Case study based on existing best practices

4. Suggested ways ahead based on best practices and emission estimates from other fields of study

Methodology

Mapping stakeholders based on interest and influence over mercury contamination

- The methodology revealed valuable local knowledge about contamination pathways
- Participants included miners, coffee farmers, ASGM processing plant managers, and community members
- River networks are a central mechanism for mercury contamination (highlighted in red)
- Connection to the physical environment influences perceptions of mercury contamination and behaviors associated with reducing contamination

Conflicting Priorities: Quantifying perceived risk

Conceptual Site Model of Perceived Environmental and Health Risk

- Mining-related hazards relate to other environmental hazards in the case study location
- Priorities and risk perception vary based on demographic characteristics (i.e., primary sector of work)
- Hazards due to ASGM activities received the highest ratings regardless of sector of work or education level. For those individuals who believed mercury amalgamation still occurs in Andes, Colombia, they consistently ranked mercury amalgamation as the most hazardous activity to the environment

Case Study – Emission Estimate Comparison

Error propagation in uncertainty calculations higher than target reductions (25% reduction by 2021; 50% reduction by 2022; 75% reduction by 2023)

- Reduction targets alone are insufficient for gauging the success of emission reductions
- Need for measurement-informed inventories

Recommendations

1. Purely quantitative analysis creates limitations that potentially inhibit NAP policy and mercury remediation interventions – potential far-reaching due to mercury interventions

2. Account for uncertainty in the emission estimates when evaluating policies against target reductions

3. Urgent need for emission factors (i.e., global averages) based on data-driven approaches

4. Guidance on measurement informed inventories

   a) Data and estimate transparency and documentation

   b) Include qualitative analysis in the approach

   c) Approach informed by successes in other fields of study (GHG emissions)

Acknowledgments

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References


Mercury Emissions – Synthesis

Baseline mercury estimation methods and data sources used vary widely:

- Gold production estimates
- Extrapolation to National Levels
- Extrapolation with Satellite Imagery
- Not Extrapolation
- Not Explained

Use of global average Hg:Au produces estimates ~ 15% lower than data-driven approaches

Uncertainty 40-52%
Mitigating mercury usage & environmental contamination: A multi-scalar, mixed methods approach for artisanal and small-scale gold mining

Minamata Convention on Mercury, COP-5

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Motivation

Objectives

Overall Approach

Findings

Way Ahead

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Why Artisanal and Small-Scale Gold Mining (ASGM)?

» Large contributor to world’s gold supply (20%)

» Gold in many things we hold dear: jewelry, retirement funds, electronics, national treasuries

» Main source of anthropogenic Mercury pollution (37% of global mercury pollution (more than any other sector); 2,000 tons HG emissions to air, land and water per year)

» Yet it also finances violent conflict and facilitates money laundering
Who mines the gold?

Graphic 6: The 80:20 rule in gold mining*

Graphic 7: Value of illegal gold production*

Main problems associated with ASGM

• Environmental:
  • Mercury and heavy metal pollution
  • Deforestation
  • Water basin destruction

• Social:
  • Financing organized crime
  • Forced labor, child labor, human trafficking, sex slavery
  • Land grabbing and displacement
  • Violent conflict

• Economic:
  • Poverty
  • Tax evasion
  • Money laundering
Analyses and proposed solutions for different problems along ASGM supply chain have been either technical or social

- Technical: technical fix to reduce use of Hg
- Social: new legal regulations for ASGM miners

Limited success at best (if not outright failures)
Research Question:

How do the social, environmental, and technical dynamics of ASGM systems in intersect and influence one another, posing both risks and opportunities for miners, communities, and environments?
Integrating Environmental Contamination Perceptions of Artisanal and Small-Scale Mining into Environmental Responses across Spatial Scales

• How do environmental perceptions of ASGM contamination at varying spatial scales shape and inform environmental responses?

• Using ASGM National Action Plans (NAPs) and baseline reports from 25 countries, synthesize methods and data used in emission estimates

• Illustrate limitations and opportunities of current estimation approaches

• Offer recommendations for future actions needed to improve estimates and provide realistic emission reduction targets
Ethnographic field methods

Environmental remediation tools

Environmental remediation

Technical solutions

Social concerns

Participatory action research

Mixed Methods (Quantitative and Qualitative)

Acknowledgments

Motivation

Objectives

Overall Approach

Findings

Way Ahead

Integrated, interdisciplinary, community-centered approach

Site-specific studies (mapping, sampling, and analyses)

Literature reviews (peer and gray)
The methodology revealed valuable local knowledge about contamination pathways.

Mining-related hazards relate to other environmental hazards in the case study location.

Connection to the physical environment influences perceptions of mercury contamination and behaviors associated with reducing contamination.
1. Analyze data and estimates used to develop baseline HG estimates [1,2]

- Gold production estimates
- \( \text{Hg: Au ratio development} \)
- Extrapolation to national levels
- Reduction targets

2. Compare data/estimates from 25 NAPs using statistical methods
3. Case study based on existing best practices
4. Suggested ways ahead based on best practices & emission estimates from other fields of study

\[ \text{Hg Emissions and Releases} = \frac{\text{Gold Production}}{\text{Hg: Au Ratio}} \]

- 25% reduction by 2021; 50% reduction by 2022; 75% reduction by 2023

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Mercury Emissions Synthesis

Baseline mercury estimation methods and data sources used vary widely

Gold Production Estimates

- 60% of NAPs only use one method
- Use of different data sources results in widely different estimates (next slide)
- Only 2 countries showed the variability of estimated gold production (and therefore Hg emissions) using different data sources
- Best practice: use multiple sources to estimate gold production due to the lack of data in any one source

Mercury Emissions Synthesis

Baseline mercury estimation methods and data sources used vary widely

Hg:Au Ratio Estimates

Use of global average Hg:Au produces estimates ~ 15 – 20% lower than data-driven approaches

➢ Best practice: use multiple methods to include Global average and data driven approaches; report # of sites and uncertainty in the measurements
Mercury Emissions Synthesis

Baseline mercury estimation methods and data sources used vary widely

Extrapolation to National Levels

- Extrapolation methods to scale local and regional estimates to national levels vary
- Best practices include (1) using multiple methods and (2) satellite imagery and protocols that develop a system to identify ASGM sites not listed on official records
Case Study – Emission Estimate Comparison

Error propagation in uncertainty calculations can create a % uncertainty higher than target reductions

![Graph showing annual mercury loss with weighted and unweighted averages](image)

- Error propagation in uncertainty calculations higher than **target reductions** (25% reduction by 2021; 50% reduction by 2022; 75% reduction by 2023)
  - Reduction targets insufficient for gaging success of emission reductions
  - Need for measurement-informed inventories

Recommendations

• Account for uncertainty in the emission estimates when evaluating policy against target reductions

• Urgent need for emission factors (i.e., global averages) based on data-driven approaches

• Guidance on measurement informed inventories
  • Data and estimate transparency and documentation
  • Include qualitative analysis in the approach
  • Approach informed by successes in other fields of study (GHG emissions)

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Thank you

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