Mercury Monitoring in the Global Environment: New Initiatives

David Evers, PhD
Biodiversity Research Institute

Side Event for the Minamata Convention on Mercury under COP 4.2
10 March 2022
Overarching global model to understand interactions of Ecosystem Sensitivity, anthropogenic Hg Input (e.g., Risk), and Threats

Factors included in Sensitivity Modeling:
1. Multiple Land Cover Types;
2. Habitat Characteristics;
3. Forest Integrity;
4. Soil Organic Carbon;
5. Water Quality;
6. Climate Change Disturbance;
7. Naturally occurring mercury

Factors included in Anthropogenic Influence (e.g., Risk)
1. ASGM;
2. Power Generation;
3. Industrial Sources;
4. Intentional Use and Product Waste;
5. Human-Induced Ecological Disturbance:
6. Deforestation;
7. Fire Management;
8. Hydrologic Alteration;
9. Sedimentation

Threat = Sensitivity + Risk
Ecosystem Sensitivity
Risk of Mercury Contamination
Sensitivity + Risk = Threat
Global Atmospheric Network

Nicola Pirrone, CNR, Italy
Alexandra Steffen, Environment and Climate Change Canada

Pre-COP4 Side Event:
Mercury monitoring in the global environment: New initiatives

10 March 2022
Objectives

✓ To support the implementation of the MC and the development of a globally-coordinated monitoring system for measuring mercury levels in air and deposition samples.

✓ To enhance / promote the coordination of existing monitoring networks and programmes to ensure globally comparable air monitoring data.

✓ To develop a Knowledge Hub for mercury designed to make available monitoring data and tools for supporting decision making.

✓ To promote intercomparison exercises among existing QA/QC systems, PASs and analytical procedures

✓ To contribute to the preparation of SOPs for Hg monitoring and Effectiveness Evaluation.
How does monitoring data help with international treaties and conventions?

Global treaty to protect humans and the environment from adverse effects of mercury

- **Two treaty articles monitoring related**
  - **Article 22**: Effectiveness Evaluation
  - **Article 19**: Research, Development and Monitoring

- **Monitoring Guidance**
  - Air is a chosen media / chapter on monitoring
  - Tiered approach
    ✓ Mostly air concentration
    ✓ Trend attribution
    ✓ Process understanding

10 March 2022
Global Observation System for Mercury
- a GEO Flagship -

**Focus**: Integration of existing monitoring networks measuring Hg levels in the global environment and support the policy process by providing a Knowledge Hub (from Observational Data to Knowledge) designed for end-users.

**URL**: [www.gos4m.org](http://www.gos4m.org)
A field intercomparison of three passive air samplers for gaseous mercury in ambient air


1 CNR-Institute of Atmospheric Pollution Research, University of Rome, UNICAL, Palermo, Italy
2 CNR-Institute of Atmospheric Pollution Research, Research Area of Rome 1, Via Salaria km 26.800, 00016 Montecatini, Italy
3 IVL Swedish Environmental Research Institute, Stockholm SE-11433, Sweden
4 Air Quality Process Research Unit, Environment and Climate Change Canada, Toronto, ON, M5B 2W1, Canada
5 Department of Physical and Environmental Sciences, University of Toronto Scarborough, Toronto, M1C 1A4, Canada
6 Fresenius Environmental Corporation, 350 Northumberland Boulevard, Toronto, Ontario, M1R 3W1, Canada

Correspondence: Antillo Nucciarone (antillo.nucciarone@ivl.no) and Frank Wania (frank.wania@fresenius.ca)

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Abstract. Passive air samplers (PASs), which provide time-averaged concentrations of gaseous mercury over the internarrative period of months, are promising for filling a gap in the monitoring of atmospheric mercury worldwide. Their usefulness will depend on their ease of use and readiness under field conditions, their availability and affordability, and most notably, their ability to provide results of acceptable precision and accuracy. Here we describe a comprehensive evaluation of three PASs with respect to their ability to precisely and accurately record atmospheric background mercury concentrations at sites both in southern Italy and northern Ontario, Canada. The study includes the CRES PAS with gold nanoparticles on a sorbent, developed by the Italian National Research Council, the IVL-PAS using an activated carbon-coated disk developed by the Swedish Environmental Research Institute, and the MERPTM PAS using a sulfur-impregnated activated carbon sorbent, developed at the University of Toronto and commercialized by Thermo. Detection limits are calculated from the variability in the amount of mercury recovered in more than 20 field blank samples for each PAS. Analytical and sampling precision is quantified through 22 replicate deployments for each PAS, ranging in duration from 2 to 12 weeks. Accuracy and bias are assessed through comparison with gaseous elemental mercury concentrations recorded by Thermo 2317 automated mercury analyzers operating alongside the PASs at both locations. The performance of the PASs was significantly better in Italy, with all of their providing concentrations that are not significantly different from the average concentrations of the Thermo 2317 instruments. In Canada, where weather conditions were much more variable and more variable during the February through April deployment period, there are differences among the PASs. At both sites, the MerPAS is currently the most sensitive, precise, and accurate among the three PASs. A key reason for this is the larger size and the radial configuration of the MerPAS, which results in lower blank levels relative to the sequential amount of mercury when compared to the other two PASs, which rely on axial diffusion properties. Since black carbon loading in the environment relatively smaller with larger deployments, performance tends to be closer among the PASs during deployments of 8 or 12 weeks.

Published by Copernicus Publications on behalf of the European Communities Union.
> 80 sites operating across > 30 countries
Planned Activities

- **Continue** the integration of monitoring data into the GOS4M Knowledge Hub.

- **Promote** intercomparison exercises for QA/QC and PAS devises including analytical procedures aiming to prepare SOPs to be adopted at all sites.

- **Testing new monitoring devises** for monitoring Hg levels in air, deposition and top soil/ice-snow samples

- **Organise a workshop** as part of the GOS4M activities
Thanks....
Mercury Monitoring in the Caribbean Region

The Antigua & Barbuda SIP Experience

Linroy Christian
Director of Analytical Services
Minamata Convention Focal Point
The Caribbean Region Mercury Monitoring Network (CRMMN)

Establishing an integrated network

- Improve mercury data sets in the region
- Improve analytical capacity and engage in technology transfer
- Benefits derived from shared experiences and capacity
- Improved implementation of the Minamata Convention
- A stepping stone to greater collaboration

Antigua and Barbuda as Admin Coordinator and Central Lab

- Based on SIP goal to establish network
- Sustainability of the network
Scope of the Network
Central Laboratory Functions

- Coordination of Sample Collection
- Handling of Shipping Logistics
- Dissemination of Information and Data
- Procurement of Standards
- Procurement of Certified Reference Material (CRM)
- Coordination of Interlaboratory Comparison
- Engage Laboratories on Comparable Test Methods
Human Biomonitoring Data

MeHg/ppm

0.58 ppm Recommended Safe Threshold

1 ppm Threshold

29%

56%
Fish Biomonitoring Data
Regional Areas of Interest

- **Air** - PAS Sites (ECCC, Tekran)
- **Fish** (Tuna, Barracuda, Red Snapper, Mahi Mahi)
- **Hair** (Ethical clearance required)
- **Cosmetics** (Expanded database)
- **Frigate Bird Study Barbuda** (BRI)
SIP Expected Outcomes

Q1: Coordinate a network of labs

Q2: Enhance analytical capacity

Q3: Develop SOPs of interest

Q4: Collect biotic samples and certify labs
Develop a regional Hg monitoring program

Q5: Develop a biomonitoring plan
Conduct biomonitoring with country-specific interests
Disseminate biomonitoring mercury findings at a regional workshop.

Q6: Develop outreach materials (e.g., videos)
Develop country-specific fish cards

Q7: Conclude Hg Monitoring and Evaluation Report

Q8: Department of Analytical Services

Quality Science for Applied Solutions
Relevance of Monitoring

**Regional Context**
- Technical capacity enhancement
- Technical cooperation

**National Context**
- Surveillance programmes
- Scientific publications
- Trade and Economy

**Convention Articles**
- 12 - Verification of contaminated sites
- 16 - Health aspects
- 19 - Research, development and monitoring
- 22 - Effectiveness evaluation

**Awareness**
- General health concerns
- Consumer empowerment
- Policy level awareness
Thank You!
Facilitating capacity-building with technology assistance and technology transfer for monitoring and managing mercury in Central Africa

Jean Hervé Mve Beh, Clotaire SIKA, Guylène NKOANE NDOUTOUME
Central Africa Regional Mercury Monitoring Hub

• **Goal:** Launch a regional mercury monitoring hub in Central Africa by establishing a laboratory for mercury analyses and other environmental assessments.

• **Purpose:** Provide a forum for communication, networking and collaboration of laboratory directors/managers, field personnel responsible for collecting samples, and policymakers.
Situated at the center of Africa’s west coast; straddles the equator, and bordered by Equatorial Guinea and Cameroon to the north, and the Republic of Congo to the east and south:

Gabon is a forested country. 80% of the territory is under forest cover, representing 15% of the Congo Basin region forests

- 268,670 km² (104,000 sq miles)
- 4575 $ GDP per capita
- 1.5 - 2 M habitants (50% in Libreville)
- 10,000 km² of interior waters (3,900 sq miles)
- 258,670 km² land surface (100,000 sq miles)
- 800 km of coast-line (500 miles)
- Tropical humid climate (+ 2m rainfall/yr and 80-90% humidity)
Five Central Africa SIP Countries
1. **Initiate and coordinate an integrated approach to establishing a centralized laboratory as a regional analytical hub for the Central Africa Region.**
   - *Enhance the analytical capacity in Gabon in coordinating the regional hub laboratory.*
   - *Develop a Laboratory SOPs for tissues of interest.*
   - *Collect biotic samples of interest and certify the regional lab.*

2. **Develop a biomonitoring plan for the Central Africa Region.**
   - *Conduct biomonitoring with country-specific interests.*

3. **Disseminate biomonitoring mercury findings at a regional workshop.**

4. **Initiate dialogue about mercury concentrations in biota and air in each country.**

5. **Raise awareness at 15th ICMGP in Cape Town, South Africa in 2022 and again at the 16th ICMGP in 2024.**
Gabon National Fish Survey – 2019

Relatively small freshwater fish size and low abundance of average freshwater fish catch

Typical day’s catch for sale in the market

Identifying the fish caught on this survey
Many fish species groups in Gabon have more mercury than other areas in Africa.
Some areas may have higher levels of mercury in fish than others, but more sampling is needed.
Low levels of mercury in abiotic samples suggest high ecosystem sensitivity to mercury methylation that gets expressed in fish.

1 This hair data is from a U.S. vegetarian with very low levels initially ($t_{ini} = 0.1$ ppm) who consumed local Gabonese fish for the 2-week field campaign, and levels increased substantially ($t_{2-weeks} = 1.7$ ppm).
Gabon National Fish Survey – 2019

National Fish Survey Conclusions:

1. Gabon’s fish are already broadly, consistently, and highly contaminated with mercury.

2. Gabon’s ecosystems are sensitive to any further inputs of mercury arising from human activities.

3. Increased environmental monitoring and evaluation efforts are needed to protect human health and identify changes in ASGM activity as prioritized in the National Action Plan.
Next steps –

1) Gather more data on mercury in people and the environment.

2) Relate fish mercury levels and threat levels to better understand risks to people and nature.

3) Conduct more research to determine where the mercury is coming from and what can be done to reduce its impact.
Questions?
Mercury Monitoring Initiatives in Indonesia

Yuyun Ismawati MSc, Nexus3 Foundation
Dave Evers PhD, Biodiversity Research Institute
Tim Tear PhD, Biodiversity Research Institute
Minamata Convention and monitoring priorities (ongoing discussions during COP4.2)
Policy Framework on Mercury Management in Indonesia

- Health sector: Hg-devices phase out by 2020
- ASGM sector: all sites Hg-free by 2025
- Energy sector: reduce Hg emission 33.2% by 2030
- Manufacture sector: reduce Hg batteries 50% by 2030

Key sectors to reduce and eliminate mercury in Indonesia based on Presidential Decree No. 21/2019
Distribution of ASGM in Indonesia 2019

- >1,200,000 gold miners
- 10,000,000 population at risk
- 3,500 T Hg/year
- 175 T Au/year
- 30 Provinces out of 34 (88%)
- 190 Regencies/Cities out of 514 (37%)
- 15 National Parks/Grand Forest/Protect Areas
- + 125,000 Hectares degraded land (open access)
Potential mercury contamination sites

- Heavily polluted, >10 years
- Mildly polluted, between 5-10 year, some areas still active
- Low pollution, <5 years, most hotspots still active
- Hg used approx. 1000-3000 ton per year

Source: BaliFokus, 2018
Non-invasive human biomarkers can provide important information.

**Monitoring Human Exposure to Mercury at ASGM Sites**

**Occupational**
- Humans are exposed to elemental mercury through ASGM processes (skin and lungs)

**Dietary**
- Humans consume food contaminated with methylmercury such as fish or rice

**Biomarkers for Hg**
- Urine sampling
- Hair sampling
ASGM is by far the largest contributor to Indonesia’s Hg emissions, enough to have a visible global signature.
All three major compartments are well above mercury safety thresholds.
Large portions of Indonesian society both directly and indirectly related to ASGM activities are contaminated above safe thresholds.
Indonesia has one of the highest relative percentages of mercury* in human hair collected that are above the human health safety threshold of 1 ppm (measured as total Hg)

*Samples collected from Indonesian people associated with ASGM activities (this WB study where links to ASGM were documented) are compared with a global dataset (Trasande et al. 2016) presented by continent or region (Oceana = countries within the Pacific Ocean).
Some fish species are more at risk of contamination than others – the true risk is not yet known for Indonesia

Small sample sizes = much more monitoring is needed to support public health guidance on fish consumption
(Note: green = freshwater, blue=marine)
CHIME Program
Children’s Health Intervention in Mercury-polluted Environment

CHIME is an initiative to protect and improve children's health in mercury-polluted environment

Rapid Participatory Assessment
Medical interventions
Capacity building
Rehabilitation
Next Steps: Hg biomonitoring

**U.S. State Department Project**
- More Hg biomonitoring (especially with fish) is necessary because of the high risk to ecohealth and human health.
- Need to build from the existing World Bank and other datasets.
- Need to work closely with the Indonesian government and their new Hg lab to build capacity and structure for potential long-term standard monitoring needs.

**Terre des Hommes Germany Project**
- Monitoring children’s health in mercury hotspots using Rapid Participatory Assessment toolkits.
- Awareness raising to advocate the ecological child rights and the rights to live in a healthy environment.
Thank you

Resources:
Indonesia ASGM related resources from the U.S. State Department Project
www.briwildlife.org/hgcenter/artisanal-small-scale-gold-mining/asgm-projects-indonesia/

BRI’s contribution to the Minamata Convention related to Hg monitoring
https://briwildlife.org/minamata-cop4/

Contact:
david.evers@briwildlife.org
yuyun@nexus3foundation.org
Mercury Monitoring Effort in the Peruvian Amazon

Claudia M. Vega
Mercury Program Coordinator
Centro de Innovación Científica Amazónica, Wake Forest University
MADRE DE DIOS
“Capital de la Biodiversidad”
Phase 1: Gather initial information on the potential mercury use in ASGM.
Deforestation due to ASGM
Madre de Dios: 1985-2017

Artisanal Gold Mining
In Madre de Dios

Deforested: 115,000 ha
160,000 soccer field

Source: CINCIA 2018 y MAAP 2018
Mercury release profile defined by an ASGM Hydroscape
Phase 2: Define the scope, goals, and priorities of the monitoring action.
Artisanal Gold Mining
In Madre de Dios

releases
182 tons of mercury per year

source: Artisanal Gold Council 2018
La Pampa, Madre de Dios - Perú
Mining ponds and lakes presented methylation rates 5-7 greater than rivers.  

Gerson et al. 2020
There is life in the mining ponds!!

Fish from Mining Ponds
Assessing Mercury Distribution in Madre de Dios
Phase 3: Develop a stakeholder engagement plan that includes relevant local communities to create effective communications channels for information exchange.

Phase 4: Identify and secure initial resources needed for field monitoring programs.
LAMQA | Laboratorio de Mercurio y Quimica Ambiental

First mercury lab in the Peruvian Amazon and was implemented in alliance with IIAP
Phase 5: Design a field sample collection and sample analysis plans that fit time, logistical and budget constraints.

Phase 6: Conduct field sample collection, sample analysis and interpretation of the results to develop basic knowledge of mercury levels in target sites
Assessing Hg in Aquatic ecosystems
Mercury level in bottom sediment

In 2017 and 2018, we collected 131 sediment samples from 44 oxbow lakes and 87 mining ponds.
In 2017 and 2018, we collected 1148 fish from 79 species
Assessing Hg in Terrestrial Ecosystems

In 2019 we sample Birds and bats from 4 Mining ponds and 1 Oxbow lake
Mercury in Birds’ feathers

364 Birds from 121 species
Mercury levels in bats’ fur

289 bats from 32 species
Evaluando mercurio en el aire con Muestreador Pasivo

 Passive Mercury Air Sampler

- No need of electrical power
- Low cost
- Easy to use
- We analyze it in LAMQA
Sampling Hg in de mercurio en aire en Puerto Maldonado (PEM)
Air Mercury Levels in Puerto Maldonado
Air Mercury Levels in the Interoceanic Highway (IOC)
Air Mercury levels in IOC PEM/Laberinto/Mazuko

Limite 2000ng/m3, solo 1 punto sobrepaso con más de 5000 ng/m3
Amazon forests capture high levels of atmospheric mercury pollution from artisanal gold mining


Nature Communications 13, Article number: 559 (2022) | Cite this article

Metrics
Mercury Deposition in soils

Adapted from Gerson et al. 2022
Mercury levels in Soils

Soil sampling in a Mining concession
Mercury levels in Soils

(M.G. Velásquez Ramírez et al. 2021)
Phase 7: Communicate results to stakeholders and interested parties
Deforestation and Forest Degradation Due to Gold Mining in the Peruvian Amazon: A 34-Year Perspective

Jorge Catalán Espinoza 1, Max Monteagudo 1,2, Francisco tenorio-Dulce Mayan 1,2, Cesar Acosta 3, Luis E. Fernández 1,2 and Milé Pick 1

1 Centro de Innovación Científica Amazónica (CINCA) y Capurro Calle 28, San Martín, Junín, Perú. 
2 Centro de Amazonia, Universidad Nacional Abierta y a Distancia, Perú. 
3 Centro de Innovación Científica Amazónica (CINCA)

Abstract: While deforestation rates decline globally they are rising in the Western Amazon. Artisanal-scale gold mining (ASGM) is a large cause of this deforestation and brings with it extensive environmental, social, governance, and public health impacts, including large carbon emissions and mercury pollution. Underlying ASGM is a broad network of factors that influence its growth, distribution, and practices, such as poverty, threat of legal and illegal armed conflict, deforestation, and global economic trends. Despite its central role in land use and land cover change in the Western Amazon and the severity of its social and environmental impacts, it is relatively poorly studied. While ASGM in Southeastern Peru has been quantified previously, doing so is difficult due to the heterogeneity of the resulting landscape. Using a novel approach to classify mining that relies on a fusion of CLC2016 and the Global Forest Change dataset, two Landsat-based deforestation detection tools, we weighted to quantify ASGM caused deforestation in the period 1990–2017 in the southern Peruvian Amazon and examine trends in the geography, methods, and impacts of ASGM across that time. We identify nearly 156,000 ha of deforestation due to ASGM in the 34-year study period, an increase of 25% compared to previous estimates. Further, we find that 15% of that deforestation occurred in 2017, the highest annual amount of deforestation in the study period, with 15% occurring since 2015. Finally, we demonstrate that not all mining is created equal by examining key patterns and changes in ASGM activity and techniques through time and space. We discuss their connections with, and impacts on, socio-economic factors, such as land tenure, infrastructure, institutional markets, governance efforts, and social and environmental impacts.

Keywords: Landscape, artisanal-scale gold mining, infrastructure, protected areas, commodity

1. Introduction

Deforestation currently accounts for approximately 6-15% of global carbon emissions [1-2] and, while forest cover has increased globally in the past 30 years, forest loss is ongoing in the tropics [3-4]. While much of this land is cleared for agriculture, subsistence, and cattle ranching, small and often difficult-to-detect activities, such as selective logging, tree farming, and artisanal scale gold mining (ASGM), are responsible for a large fraction of forest loss and disturbances in the Western Amazon [5]. ASGM is unique among these activities of deforestation in the severity of its impacts, forming a highly altered landscape. It has the lowest residual forest carbon of any land use in the region, and leads to loss of ecosystem services, removal of fine sediments, deforestation, severely impaired water quality, and mercury contamination of soil, water, and air [6-7]. Indeed, ASGM is the largest single contributor...
CENTRO DE INNOVACIÓN CIENTÍFICA AMAZÓNICA | cinciaEDUCACION
Cartoons and Videos

SOMOS LO QUE COMEMOS

Nos han dicho que los peces tienen mercurio, que es malo, pero no sabemos qué es.

El mercurio es el único metal líquido que existe en la naturaleza y puede ser malo para la salud.

Cuando está en el suelo no causa daño...

PESCADO SEGUNDO Y ALIMENTACIÓN VARIADA

Entonces... comer pescado me hace mal?

No, sólo tienes que comer el pescado que tiene menos mercurio y es más seguro.

Ahora que voy a tener un hermano, tienes que evitar comer pescado dorado, doncella, pirána, bagre, o los peces que comimos primero porque tienen más mercurio.


CINCIA - ACIERTA, es una alianza entre la Universidad de Wake Forest y USAID.

Este es un trabajo conjunto con:
For more information:

- Caribbean Region Mercury Monitoring Network
  - www.briwildlife.org/hgcenter/crmmn
- CINCIA
  - https://cincia.wfu.edu/en
- Ecosystem Sensitivity Mapping
  - www.briwildlife.org/minamata-cop4
- Mercury monitoring in Indonesia
  - www.briwildlife.org/hgcenter/artisanal-small-scale-gold-mining/asgm-projects-Indonesia
- NEXUS3 Foundation
  - www.nexus3foundation.org