DATA GAPS & RESEARCH NEEDS TO SUPPORT HEALTH IMPACT ANALYSES

Pamela R.D. Williams, MS, ScD, CIH

World Bank-UNITAR side-event at Minamata Convention COP

Evaluating Health Impacts from Land-based Pollution: Data Gaps & Proposed Framework

March 7, 2022

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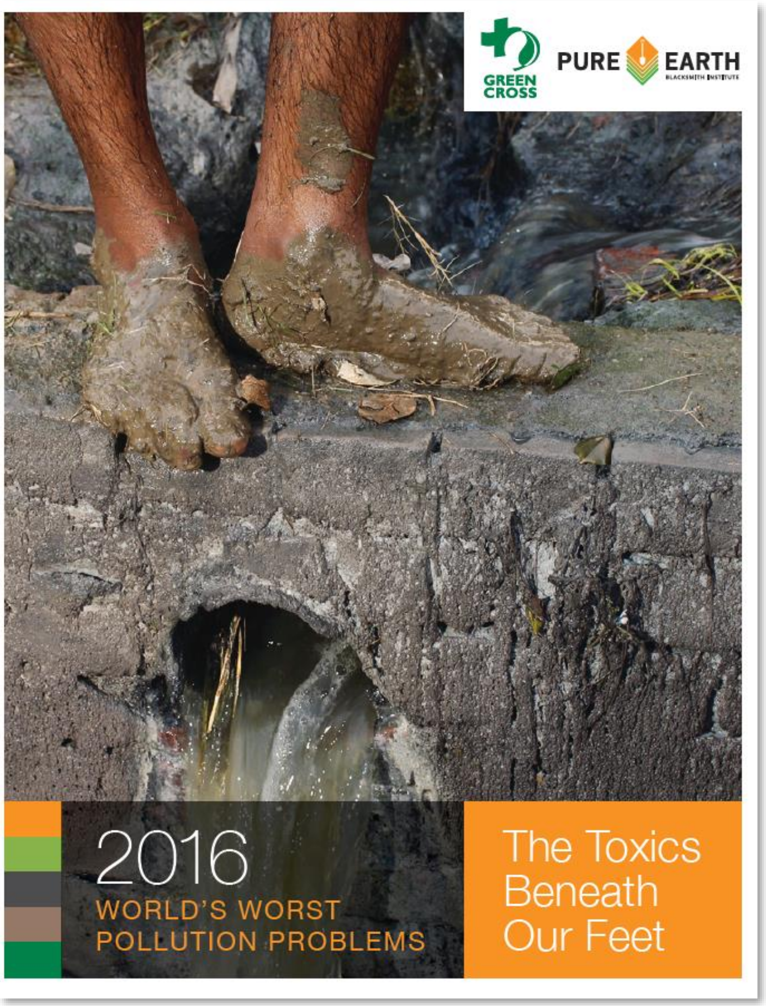
E RISKSCIENCES
ANALYSIS & TOOLS FOR DECISION-MAKING

Land-Based Pollution in LMICs

Burden of Disease in LMICs

- 200 million people at risk from industrial site pollution across 50 LMICs
- 17 million DALYs attributed to land-based pollution
- Disease burden is similar to other widespread diseases (TB, malaria)



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Objectives

1. Determine whether sufficient information to quantify public health impacts from land-based pollution in LMICs
   - Can specific health impacts be attributed to specific industries and activities?
2. Identify primary knowledge and data gaps and make recommendations to obtain better information
   - Can risk analysis methods and tools help?

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Key Findings (Williams et al.)

Risk Analysis, Vol. 0, No. 0, 2021

Perspective

Risk Analysis Approaches to Evaluating Health Impacts from Land-Based Pollution in Low- and Middle-Income Countries

Pamela R. D. Williams,[1,*] Katherine von Stackelberg,[2] Mayra Gabriela Guerra Lopez,[3] and Ernesto Sanchez-Triana[3]

Risk analysis offers a useful framework for evaluating and managing environmental health risks across different settings. In this Perspective, we question whether the principles and practice of risk analysis could be beneficial in the context of land-based pollution in low- and middle-income countries (LMICs) to better support risk-based decision making. Specifically, potential health and economic impacts from land-based pollution in LMICs has become an increasing issue of concern due to widespread environmental contamination from active and legacy operations, particularly informal activities that are becoming increasingly dispersed throughout communities, such as used lead acid battery recycling, artisanal and small-scale gold mining, and small-scale tanneries. However, the overall magnitude and scale of the public health problem arising from these sources remains highly uncertain and poorly characterized and cannot be compared to land-based pollution in high-income countries due to unique factors. This lack of knowledge has negatively affected the political priority and level of funding for risk mitigation actions targeting land-based pollution in these countries. Our primary objective is to raise further awareness of this emerging issue among risk analysts and decisionmakers and to advocate for more robust and focused research. Here, we highlight the types of industries and activities contributing to land-based pollution in LMICs and describe key findings and knowledge and data gaps that have hindered a fuller understanding of this issue. We also discuss how several risk assessment and risk management approaches might be useful in this resource-constrained context. We conclude that a combination of risk analysis approaches may be worthwhile, but more work is needed to determine which methods or tools will be most informative, technically feasible, and cost-effective for identifying, prioritizing, and mitigating land-based pollution in LMICs. Affected researchers, funding agencies, and local or national governments will need to work together to develop improved study designs and risk mitigation strategies.

- Many studies provide useful data on site contamination and community exposures
- But study objectives, sampling strategies, and methods differ widely
- Unable to link specific activities to human exposures and health outcomes

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Data Gaps

- Reliance on targeted or convenience samples; lack of robust census data at local level
- Lack of systematic and random sampling; sampling near sources or to identify “hot spots”
- Lack of conceptual site model (CSM); limited sampling of pollutants, media, and pathways
- Little data on population-specific exposure factors
- Limited reliance on traditional exposure and risk estimation approaches and exposure models
- Limited use and interpretation of biomonitoring data; differences in study design and data quality
- Insufficient data on health outcomes; use of different (unvalidated) measurement tools and diagnostic criteria

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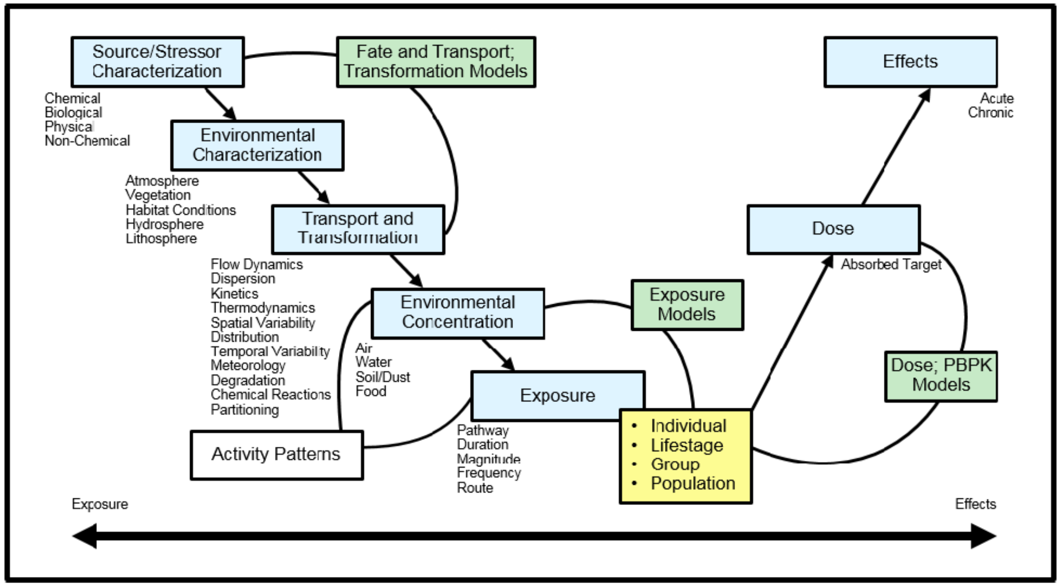
Recommendation

- Develop systematic framework and uniform protocols for future data collection and sampling in LMICs to support health-impact analyses



Note: PBPK = physiologically based pharmacokinetic
Adapted from NRC (1983); NRC (1997)

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PROTOCOL FOR ASSESSMENT OF ENVIRONMENTAL HEALTH IMPACTS OF SMALL-SCALE ARTISANAL GOLD MINING

Katherine von Stackelberg
Pamela R.D. Williams

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March 7, 2022

However, within the country there exists wide variation in the types of communities and ecosystems in which mines are situated (e.g., the South of Ghana is more tropical and economically developed than the North, and cultural differences abound across the country). While a majority of health risk factors (e.g., mercury use, poor sanitation) are ubiquitous across sites, some risks may be site-specific (e.g., content of lead or arsenic in the mined ore; local cultures and behaviours; health care services). For the purposes of this assessment we maintain broad generalizations as the focus is on developing countrywide response options.

The lack of detailed exposure assessment information for any ASGM site limits the ability to perform meaningful risk assessments and establish causal linkages. While a number of biomarker studies have been performed, as well as survey-based interviews, a rigorous and detailed exposure assessment that links source, fate, and exposure (ultimately linked to adverse health outcomes) is lacking.

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Review

Integrated Assessment of Artisanal and Small-Scale Gold Mining in Ghana—Part 1: Human Health Review

Niladri Basu [1,*], Edith Clarke [2], Allyson Green [3], Benedict Calys-Tagoe [4], Laurie Chan [5], Mawuli Dzodzomenyo [6], Julius Fobil [6], Rachel N. Long [3], Richard L. Neitzel [3], Samuel Obiri [7], Eric Odei [2], Lauretta Ovadje [3], Reginald Quansah [6,8], Mozhgon Rajaee [3] and Mark L. Wilson [9]

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Table 6 Demographic factors and levels of heavy metals in whole blood of resident adults from the study areas

Demographic factors	Concentration in µg/L													
	Mining area—TNMA/PHVD ($n = 200$)							Non-mining area—CCMA ($n = 100$)						
	As	Cd	Hg	Cu	Mn	Pb	Zn	As	Cd	Hg	Cu	Mn	Pb	Zn
Sex:														
Male (M)	20	221	34	2044	113	16	764	0.019	0.037	0.63	64	0.92	1.38	1.79
Female (F)	18	82	29	1258	79	11	643	0.013	0.013	0.47	36	0.58	1.02	1.12
No. of years of staying in the study areas:														
5–20 years	32	166	48	1300	110	5.78	967	0.020	0.031	0.721	63	0.99	0.780	1.63
21–36 years	4.80	100	15	371	55	13.0	302	0.005	0.008	0.365	23	0.17	0.048	0.70
>36 years	1.00	38	–	1602	–	9.32	136	0.007	0.012	–	14	0.35	1.572	0.58
Use of earthenware cooking materials:														
Yes	33.2	269.6	44.7	79	165	20	1246	0.021	0.032	0.22	0.125	1.280	2.280	0.410
No	4.80	33	18.5	3221	30	8.10	159	0.011	0.018	0.88	0.875	0.220	0.120	2.500
Type of drinking water:														
Streams/rivers	21.5	194	48.2	1238	134	15.5	668	0.020	0.030	0.770	3.452	1.010	1.193	1.193
Boreholes	13.8	98	9.45	975	45	3.550	168	0.008	0.015	0.220	3.983	0.330	0.634	0.960
Tap water	2.67	10	5.35	252	16	8.960	342	0.004	0.006	0.110	56.7	0.170	0.236	0.701

Environ Sci Pollut Res (2016) 23:16589–16597
DOI 10.1007/s11356-016-6537-0

RESEARCH ARTICLE

Levels of arsenic, mercury, cadmium, copper, lead, zinc and manganese in serum and whole blood of resident adults from mining and non-mining communities in Ghana

Samuel Obiri[1,2] · Philip O. Yeboah[1] · Shiloh Osae[1] · Sam Adu-Kumi[3]

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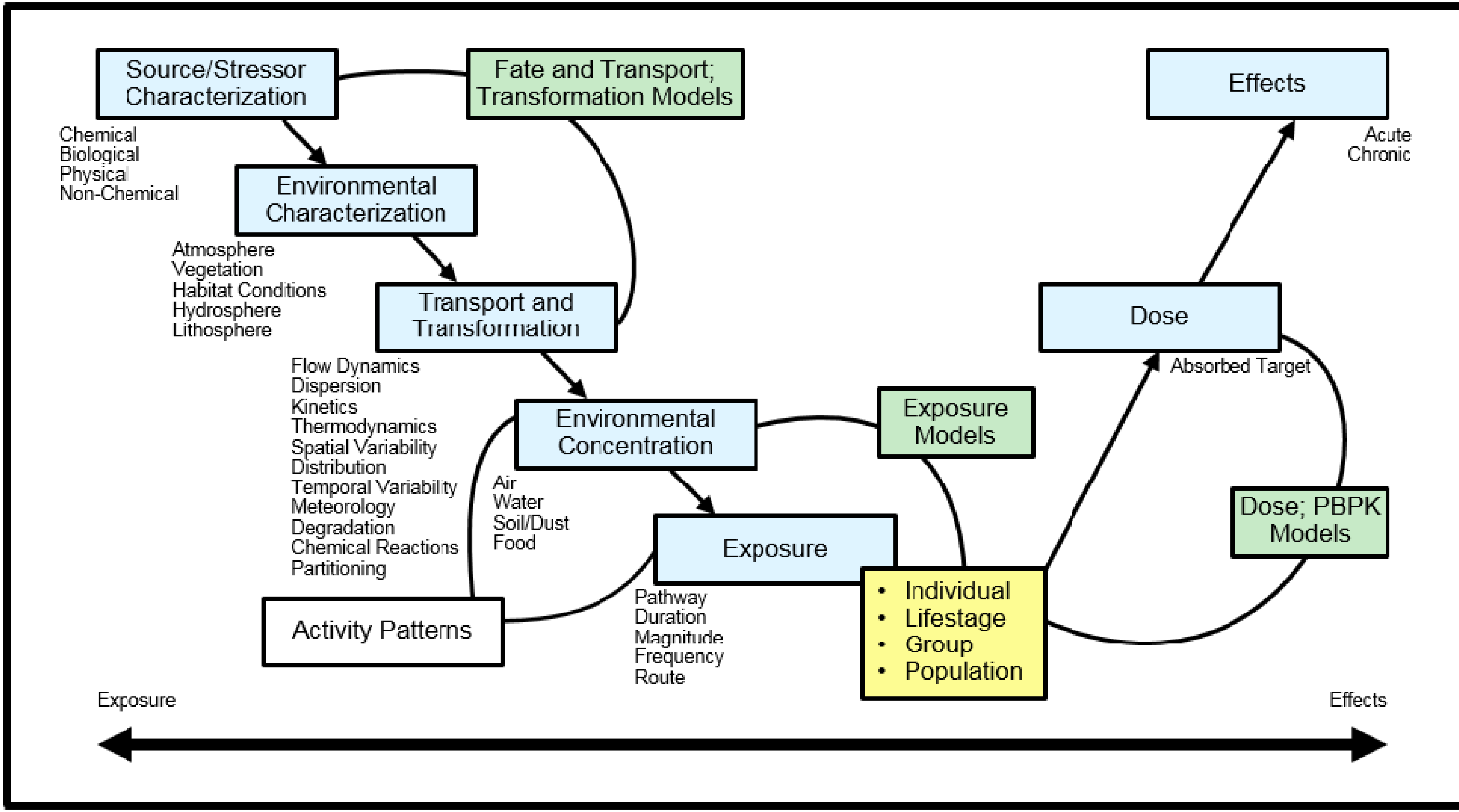

Note: PBPK = physiologically based pharmacokinetic
Adapted from NRC (1983); NRC (1997)

International Journal of
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Article

A Systematic Framework for Collecting Site-Specific Sampling and Survey Data to Support Analyses of Health Impacts from Land-Based Pollution in Low- and Middle-Income Countries

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Abstract: The rise of small-scale and localized economic activities in low- and middle-income countries (LMICs) has led to increased exposures to contaminants associated with these processes and the potential for resulting adverse health effects in exposed communities. Risk assessment is the process of building models to predict the probability of adverse outcomes based on concentration-response functions and exposure scenarios for individual contaminants, while epidemiology uses statistical methods to explore associations between potential exposures and observed health outcomes. Neither approach by itself is practical or sufficient for evaluating the magnitude of exposures and health impacts associated with land-based pollution in LMICs. Here we propose a more pragmatic framework for designing representative studies, including uniform sampling guidelines and household surveys, that draws from both methodologies to better support community health impact analyses associated with land-based pollution sources in LMICs. Our primary goal is to explicitly link environmental contamination from land-based pollution associated with specific localized economic activities to community exposures and health outcomes at the household level. The proposed framework was applied to the following three types of industries that are now widespread in many LMICs: artisanal scale gold mining (ASGM), used lead-acid battery recycling (ULAB), and small tanning facilities. For each activity, we develop a generalized conceptual site model (CSM) that describes qualitative linkages from chemical releases or discharges, environmental fate and transport mechanisms, exposure pathways and routes, populations at risk, and health outcomes. This upfront information, which is often overlooked, is essential for delineating the contaminant zone of influence in a community and identifying relevant households for study. We also recommend cost-effective methods for use in LMICs related to environmental sampling, biological monitoring, survey questionnaires, and health outcome measurements at contaminated and unexposed reference sites. Future study designs based on this framework will facilitate consistent, comparable, and standardized community exposure, risk, and health impact assessments for land-based pollution in LMICs. The results of these studies can also support economic burden analyses and risk management decision-making around site cleanup, risk mitigation, and public health education.

Keywords: risk assessment; burden of disease; low- and middle-income countries; biomonitoring

check for updates

Citation: von Stackelberg, K.; Williams, P.R.D.; Sánchez-Triana, E. A Systematic Framework for Collecting Site-Specific Sampling and Survey Data to Support Analyses of Health Impacts from Land-Based Pollution in Low- and Middle-Income Countries. *Int. J. Environ. Res. Public Health* 2021, *18*, 4676. https://doi.org/10.3390/ijerph18094676

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Develop a Consistent Format Across Guidelines

Exposure Factors

- Population behaviors, activity patterns, and contact rates
- Section 2: *Study Sampling Design* and Annex 2: Home Survey Questionnaire

Exposure Point Concentration

- Chemical concentrations in environmental media
- Section 3: *General Guidelines for Environmental Sampling*

Internal Dose

- Chemical concentrations in biological matrices – biomarkers of exposure and effect
- Section 4: *General Guidelines for Biological Sampling*

Health Outcomes

- Symptoms, intermediate health outcomes, and health effects
- Section 5: *Guidelines for Medical Survey, Exams, and Diagnostic Testing: Health Outcomes*

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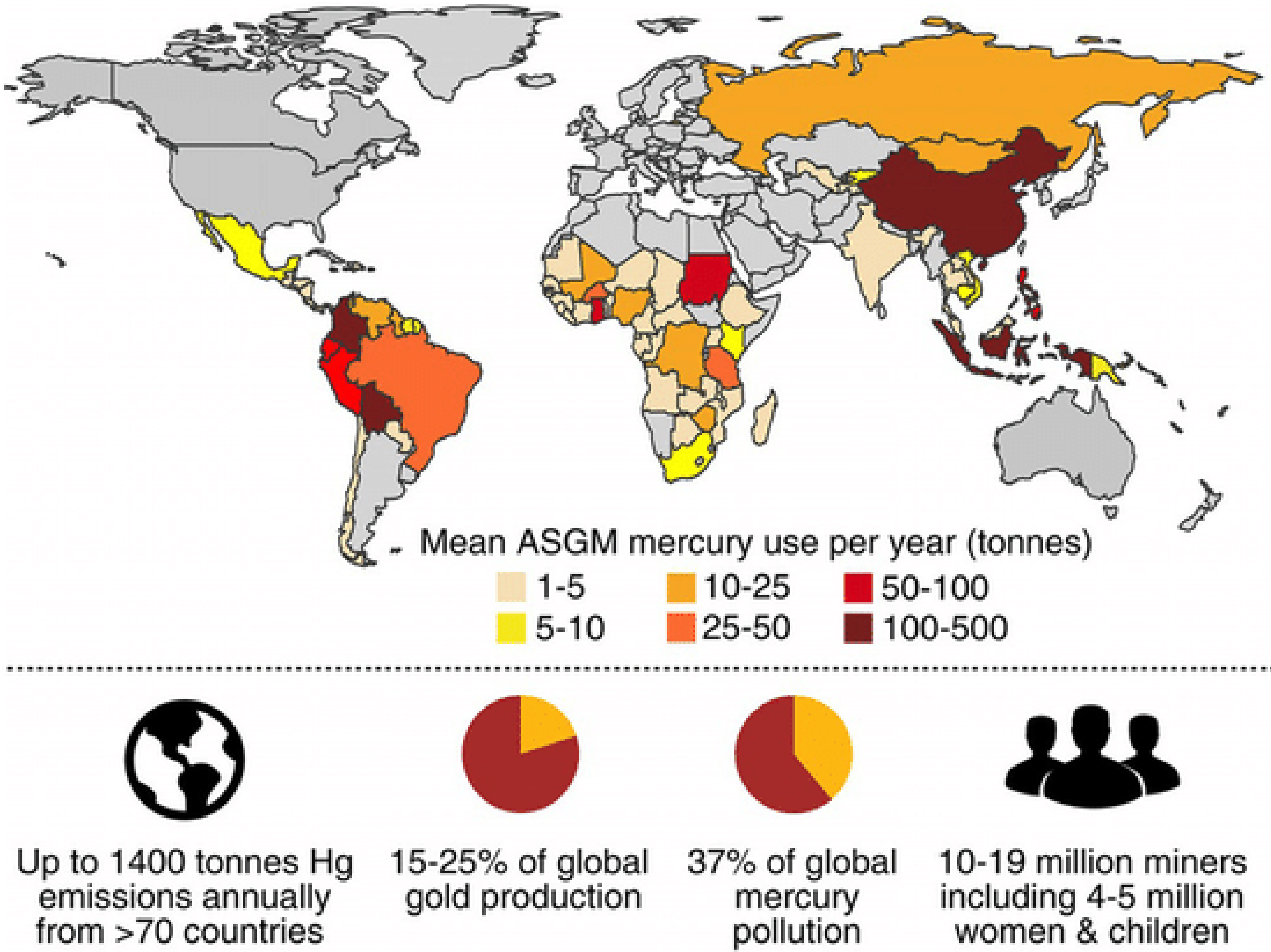

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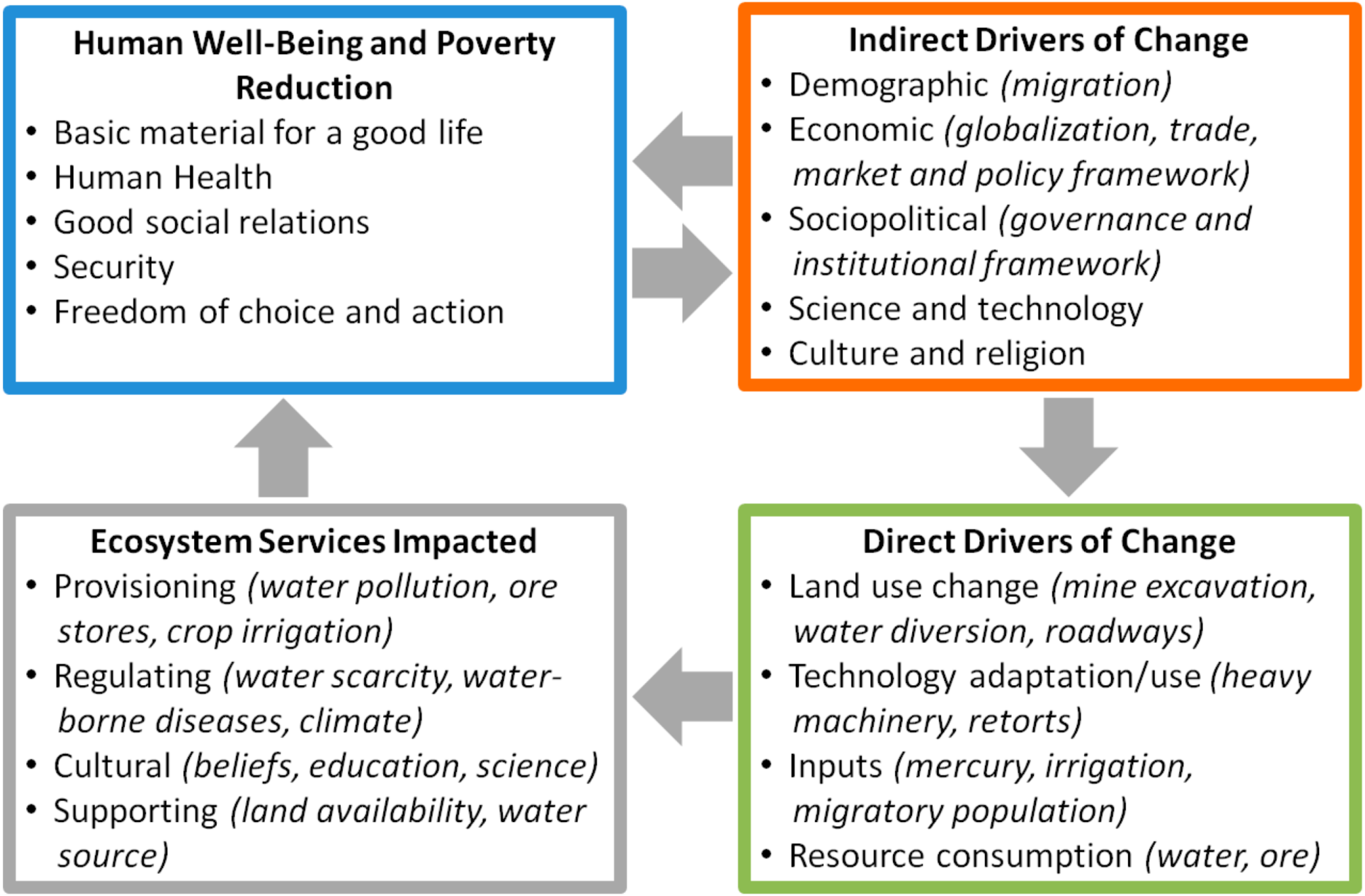

Source: Rajaee M, Obiri S, Green A, Long R, Cobbina SJ, Nartey V, Buck D, Antwi E, Basu N. Integrated assessment of artisanal and small-scale gold mining in Ghana—Part 2: Natural sciences review. International Journal of Environmental Research and Public Health. 2015 Aug;12(8):8971-9011.

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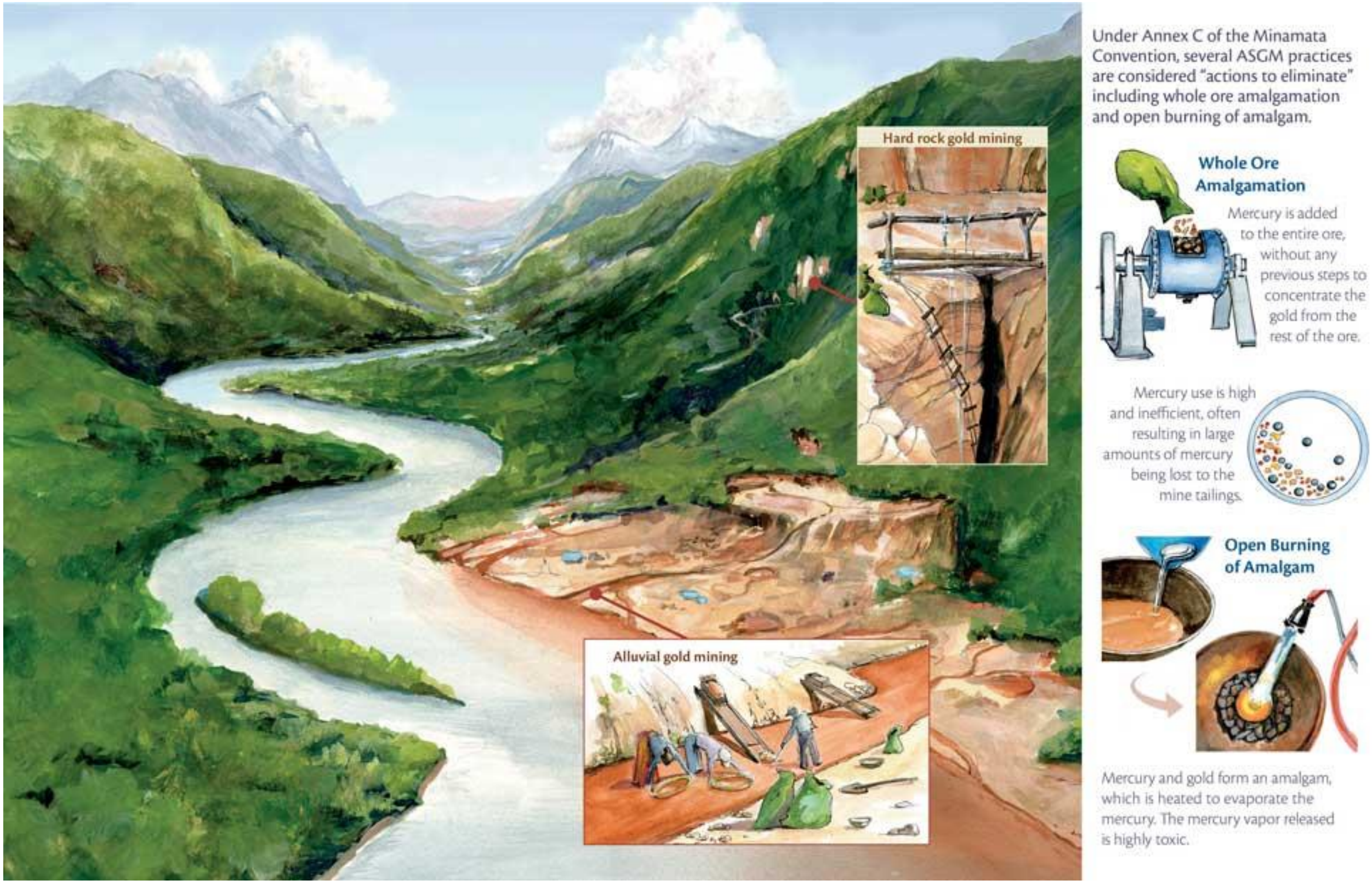
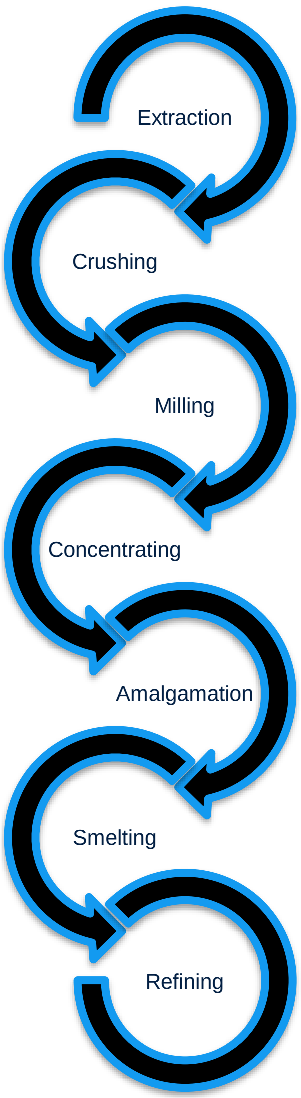
Artisanal Gold Mining - ASGM



Process Leading to Environmental Releases



Underground mining; sediment pumping from riverbed

Typically done by hand; may be offsite from primary area

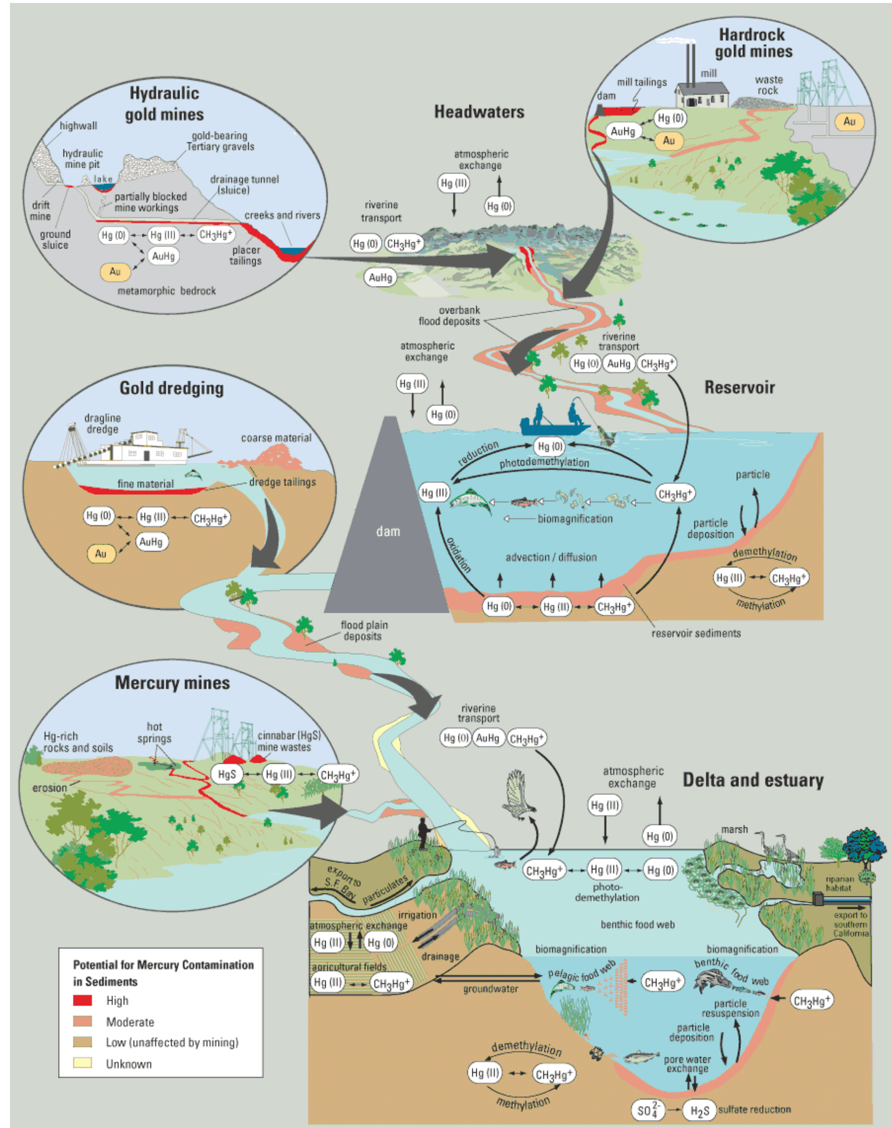
Use of ball mills or other grinding to obtain mineral powder

Hg added to form Hg-gold amalgam

Excess Hg is removed, often by squeezing through cloth with bare hands resulting in 60% gold

Amalgam burned in open pans (fast and easy) or retorts (less Hg vapor)

Gold is heated to vaporize residual Hg. Often done indoors



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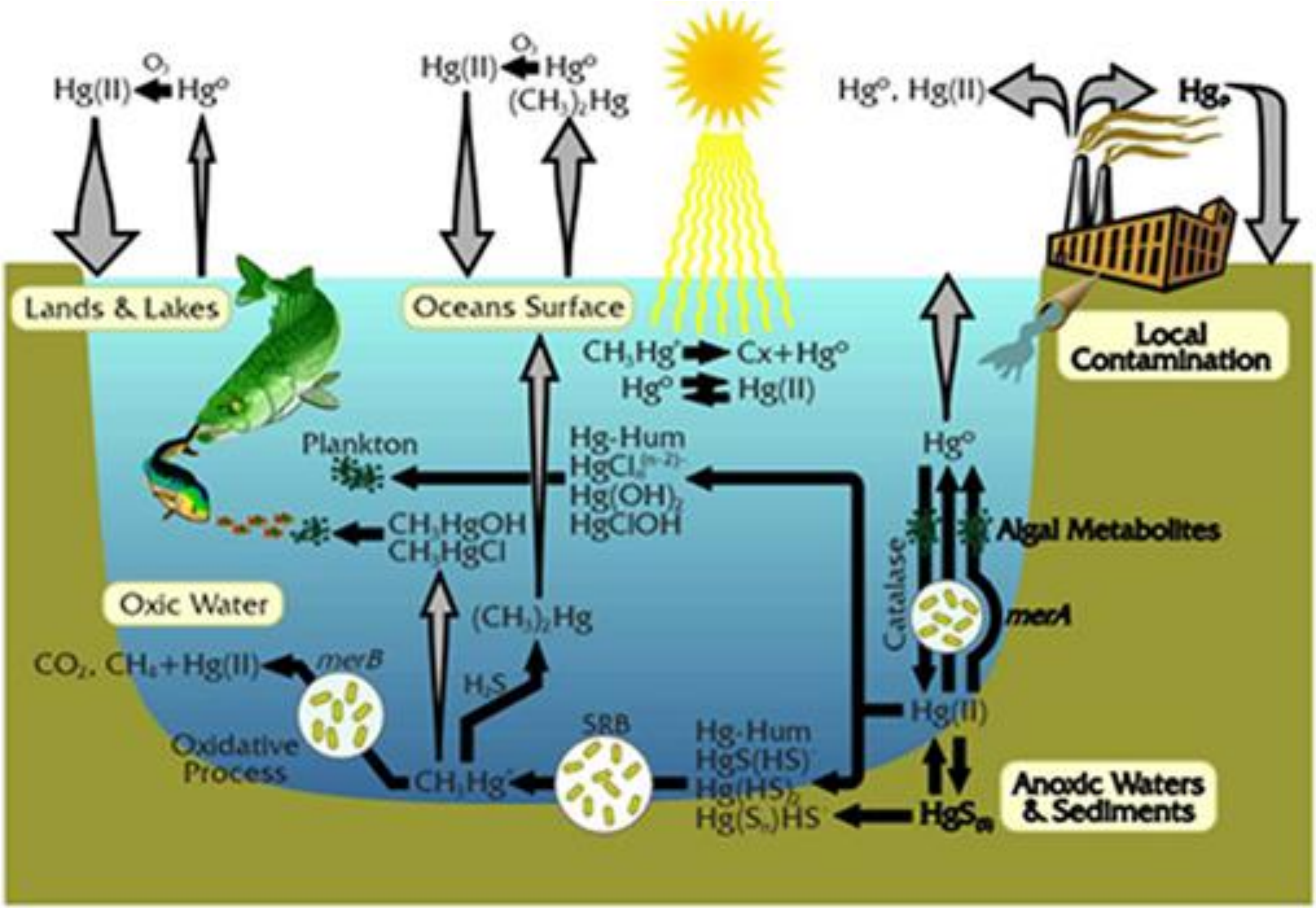
Exposures at ASGM Sites

Exposure Route	Environmental Media		
	Air	Soil/Dust	Water
Inhalation	Inhalation of Hg vapors and Hg, Pb, As particles in outdoor air due to releases to air during entire process or during crushing and milling of ore	Inhalation of Hg soil vapors and Hg, Pb, As particles or dust in outdoor air due to releases to soil during entire process or during crushing and milling of ore or from mine tailing or wastewater discharges to water	Inhalation of Hg or Pb vapors released from tap, surface, or ground water (e.g., bathing, showering, washing, swimming) due to mine tailing or wastewater discharges to water
	Inhalation of Hg vapors and Hg, Pb, As particles in indoor air due to releases to air during entire process or during crushing and milling of ore	Inhalation of Hg soil vapors and Hg, Pb, As particles or dust in indoor air due to releases to soil during entire process or during crushing and milling of ore or from mine tailing or wastewater discharges to water	
Ingestion	Ingestion of agricultural products contaminated with Hg, Pb, As due to deposition of vapors or particles (e.g., fruits, vegetables, grains)	Incidental ingestion of Hg, Pb, As in soil or dust (indoors or outdoors) due to releases to soil during entire process or during crushing and milling of ore and from mine tailing or wastewater discharges to soil	Ingestion of Hg, Pb, As in tap, surface, or ground water due to mine tailing or wastewater discharges to water
	Ingestion of agricultural products contaminated with Hg, Pb, As due to transfer of contaminants from air to animals or plants to animals (e.g., meat, milk, eggs)	Ingestion of agricultural products contaminated with Hg, Pb, As by transfer of contaminants from soil to plants, animals, or plants to animals	Ingestion of Hg, Pb, As in agricultural products due to being irrigated with contaminated water
			Ingestion of Hg, Pb, or As in agricultural products due to transfer of contaminants from water to animals
			Ingestion of MeHg in fish/shellfish due to deposition of Hg and methylation to MeHg in sediments
Dermal contact	Dermal contact with Hg vapors and Hg, Pb, As particles due to releases to air during entire process or during crushing and milling of ore	Dermal contact with Hg, Pb, As in soil or dust (indoors or outdoors) due to releases to soil during entire process or during crushing and milling of ore and from mine tailing or wastewater discharges to soil	Dermal contact with Hg, Pb, As in tap, surface, or ground water due to mine tailing or wastewater discharges to water



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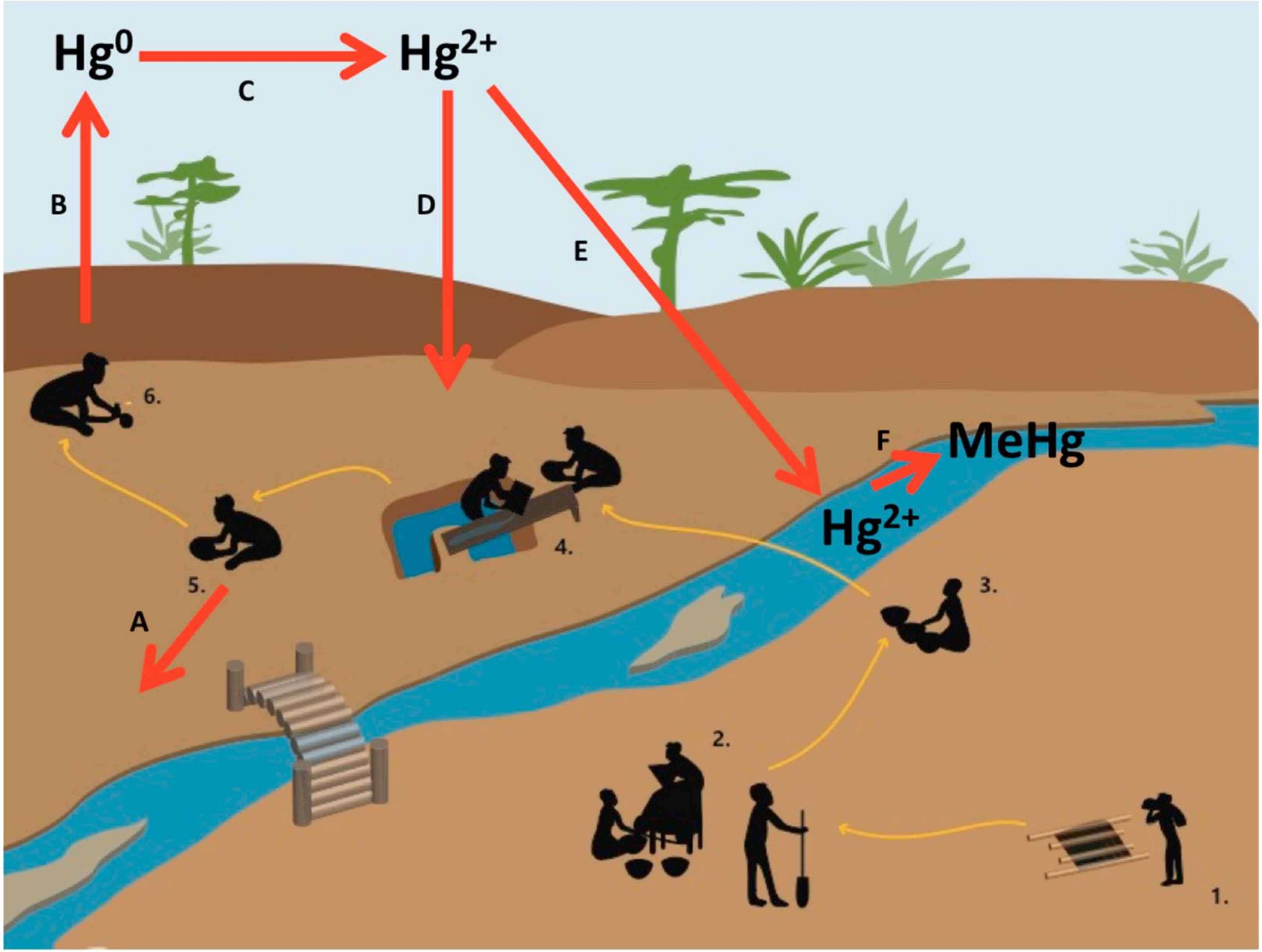

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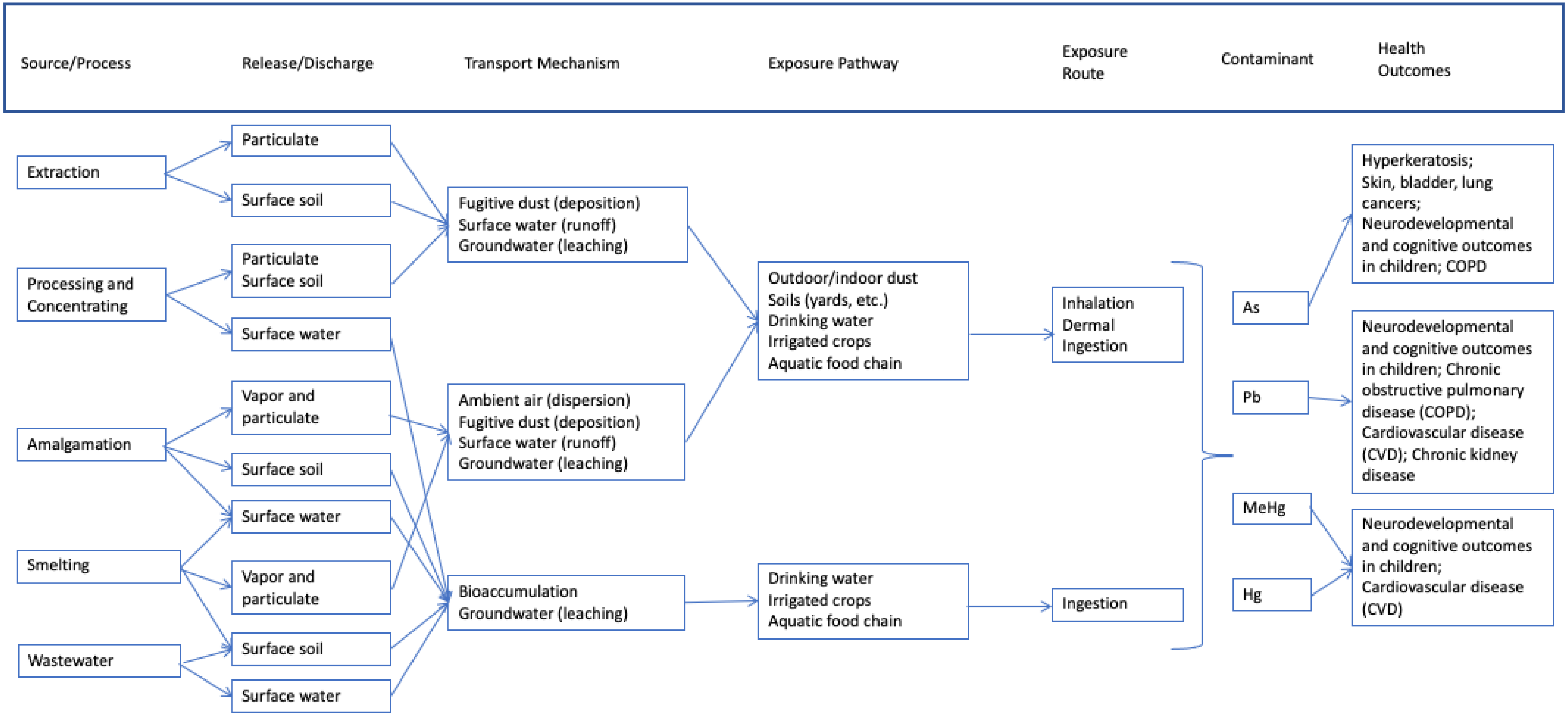
Generalized Conceptual Model for ASGM Sites



Generalized Conceptual Site Models (CSMs)

Series of questions as a checklist to make the CSMs site-specific

Community exposures

Environmental setting combined with behaviors and activities

- Fate and transport of contaminants
- Where and how people spend their time
- Vulnerable subpopulations

Process for identifying participating households

- Must be a direct connection between environmental exposures, biomonitoring data, and health outcome data

Focus is on metals but recognize there are many different contaminants (e.g., solvents, pesticides, organics)

Primary contaminant – identifying signal in the noise

Iterative not linear process – may benefit from household survey input

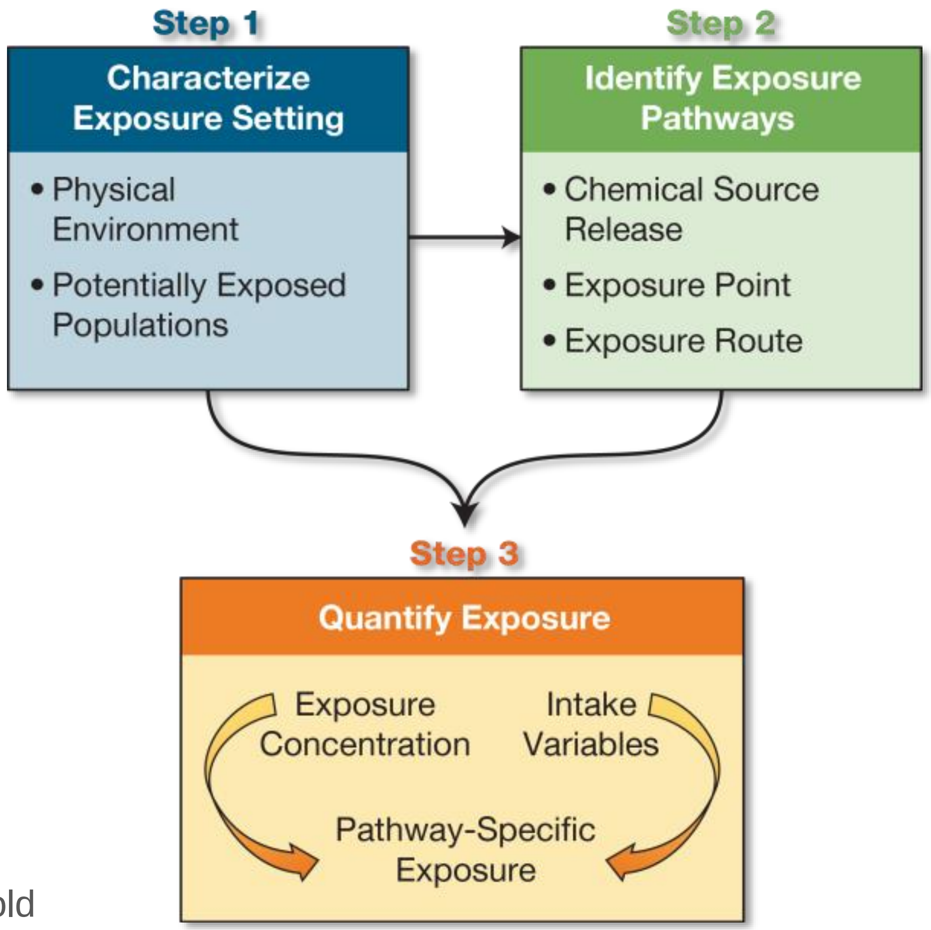


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Table 1. Overview of sector-specific guiding questions.

ASGM	ULAB	Tanning
• Locate ASGM activities in the context of local populations, noting where different aspects of the process may occur. In some areas, grinding and milling occurs in local homes. • Identify locations of all surface waters, including ditches, creeks, streams, rivers, and lakes. • Identify what is known about ground water, depth to the water table and aquifers in the study area. • Identify the prevailing wind direction, particularly relative to residential areas, local waterbodies, and small- or large-scale agricultural activities within several km of primary site activities, particularly amalgamation. • Identify water bodies within a depositional area of ASGM activities, or impacted by wastewaters or soil runoff. • Identify agricultural areas, community gardens, and the potential for backyard gardening. • Locate sources of irrigation water that might be impacted by ASGM discharges, including direct or indirect surface water discharges or releases to soils that can runoff or erode. Establish whether ground water is used for irrigation and whether there is a leaching pathway. • Identify locations where animals or animal products (e.g., milk, eggs) are raised for consumption.	• Locate ULAB activities in the context of local populations, noting where different aspects of the process may occur. In some areas, battery breaking may occur in separate areas from primary smelting and refining. • Identify locations of all surface waters, including ditches, creeks, streams, rivers, and lakes. • Identify what is known about ground water, depth to the water table and aquifers in the study area. • Identify the prevailing wind direction, particularly relative to residential areas, local waterbodies, and small- or large-scale agricultural activities. Dispersion and deposition of lead dust and other metals is likely to be significant, and can occur over large areas. • Identify water bodies within a depositional area of ULAB activities, or impacted by wastewaters or soil runoff, both of which are likely to contain lead and other metals. • Identify agricultural areas, community gardens, and the potential for backyard gardening. • Locate sources of irrigation water that might be impacted by ULAB wastewater discharges, including direct or indirect surface water discharges or releases to soils that can runoff or erode. Establish whether ground water is used for irrigation and whether there is a leaching pathway. • Identify locations where animals or animal products (e.g., milk, eggs) are raised for consumption.	• Locate small-scale tanning activities in the context of local populations. • Note whether process activities are dispersed in different areas, for example, curing and soaking occurring in one location while fleshing and liming occurring elsewhere. In some cases, specific activities will be clustered within smaller neighborhoods. • Identify locations of all surface waters, including ditches, creeks, streams, rivers, and lakes. • Identify what is known about ground water, depth to the water table and aquifers in the study area. • Identify the prevailing wind direction, particularly relative to residential areas, local waterbodies, and small- or large-scale agricultural activities. • Identify agricultural areas, community gardens, and the potential for backyard gardening. • Locate sources of irrigation water that might be impacted by tanning discharges, including direct or indirect surface water discharges or releases to soils that can runoff or erode. Establish whether ground water is used for irrigation and whether there is leaching pathway. • Identify locations where animals or animal products (e.g., milk, eggs) are raised for consumption. Organic wastes from tanning, including residual scrap hides, protein, hair and fur, dung, fatty material, and other organic solid wastes, including chemicals from the tanning process, are often repurposed as either livestock feed or fertilizer. Identify and locate these activities on a map.

Determining the Zone of Influence

Link back to specific objectives (assumes primary objective is linking environmental sampling to biomonitoring data to community health outcomes)

Develop site map based on local land use

Characterize environmental setting

- Detailed checklist
- Individual vs. shared drinking water
- Agricultural products
- Schools, community centers, public gathering

General demographics

- Relative to environmental setting
- Vulnerable populations
- Places where people spend time

Refine the general CSM to finalize site-specific CSM

Collect field data

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Identifying Participating Households

Sample sizes and power calculations

- Highly dependent on specific hypotheses, expected variance
- Multiple contaminants, exposure pathways, health outcomes
- Provide recommendations for how to calculate given specific objectives
- In general – 200-300 households as a working strawman

Overlay a grid on site map

- Recommendations for grid density

Need for targeted sampling

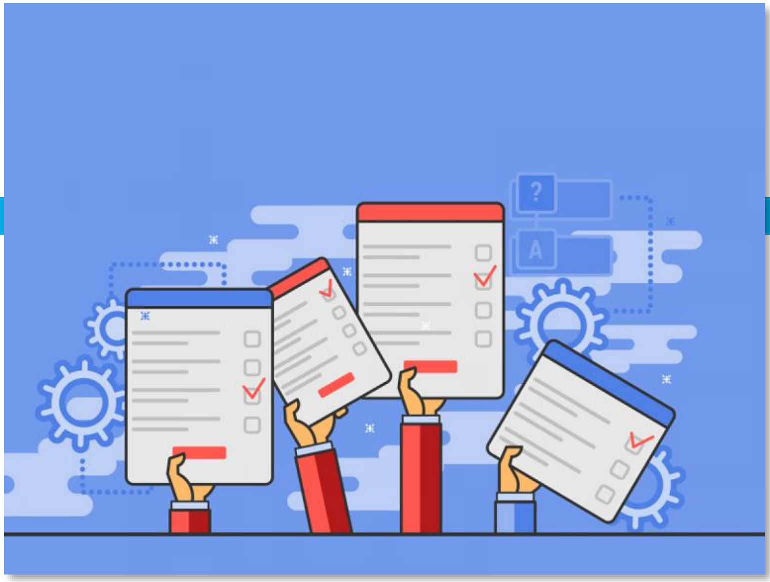
- May require additional input following results of household surveys

Children and youth generally the target population

- But also include adults – renal effects, cancer

Data from Household Surveys

- Stakeholder engagement!!!!!
- Important data source
- Field implementation
- Demographics
- Economics – facilitate later linkages
- Behavior and time-activity patterns: exposure factors
- Self-reported health outcomes
- Limited observations on health outcomes (e.g., skin or other obvious responses)
- Recommend doing this early in the process – may change/augment the CSM, sampling plan and program
- Sets the stage for later (concurrent) environmental sampling, more detailed health outcome data collection, biomonitoring



Environmental Sampling

Media- and contaminant-specific

Emphasize use of in-field XRF

- 25% confirmatory samples sent to a laboratory – local laboratory
- Subset of samples for focused analyses, such as bioavailability of As, Pb
- Hg vs MeHg in environmental samples

Recommendations related to site-specific CSM development

- Agricultural products
- Fish and fish consumption
- If site-specific study objectives call for understanding bioaccumulation, then water, sediment and fish sampling should occur

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Biomonitoring Data

Contaminant	Recommendations
As	Gold standard is metabolite monomethylarsonic acid (%MMA) obtained from a speciated creatinine-adjusted urine sample
Hg	In-field XRF (toenails) together with blood
MeHg	Hair and in-field XRF
Pb	Venous blood is the gold standard but dried capillary blood spot also used, which allows in-field LeadCare analyzer

Health Outcomes

Metals	Measurable Health Outcomes
Hg	Developmental and cognitive deficits in children Neurotoxicity (e.g., tremors, ataxia) in children and adults Renal health outcomes in children and adults
MeHg	Developmental and cognitive deficits in children
Pb	Developmental health outcomes in children (e.g., reduction in IQ, cognitive deficits) Cardiovascular health outcomes in adults Renal health outcomes in children and adults
As	Skin rashes and lesions and hyperkeratosis, possible precursors to skin cancer Developmental and cognitive deficits in children Lung cancer in adults Bladder cancer in adults

Measuring Health Outcomes

Category	Utility and Examples
Formal medical diagnosis or clinical testing	Related to direct or measurable clinical outcomes known to be associated with exposure • bladder cancer or hyperkeratosis associated with As exposures • cognitive deficits as measured by age-specific standardized testing instruments associated with exposures to MeHg, Pb, and As
Intermediate, non-specific observation or measurement	Associated with the health outcome of interest • increased blood pressure associated with cardiovascular outcomes that may be related to exposure to Pb, MeHg, Cd
Intermediate biochemical measurement or biomarker of effect	Laboratory or in-field analysis of a biological matrix • diagnosis of anemia based on hematocrit level in blood that may be related to Pb exposures • micronucleus formation in blood that may be associated with genotoxic effects of As

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Contaminant-Specific Recommendations

CoC	Biomonitoring (Exposure)	Health Outcomes
As	Gold standard is metabolite monomethylarsonic acid (%MMA) obtained from a speciated creatinine-adjusted urine sample	• Conduct age-specific, culturally-relevant cognitive testing for each child • Conduct in-field screening for keratosis on the soles of the feet as part of the household survey or as part of a more formal medical examination • If keratosis is observed, consider a carcinogenic biomarker such as DNA adduct assay or micronucleus formation assay • Measure C-reactive protein as a non-specific biomarker of intermediate effects on the renal and cardiovascular systems
Hg	In-field XRF together with hair	• Administer the CIMI as presented in Table 5-2 to each participant (can be done in-field with appropriately trained personnel or as part of a more formal clinical assessment) • Measure proteinurea (e.g., albumin)
MeHg	Hair	• Conduct age-specific, culturally-relevant cognitive testing for each child
Pb	Venous blood is the gold standard; dried capillary blood spot also used, allows in-field LeadCare Analyzer	• Measure blood pressure in adults in the field or as part of a medical examination • Measure specific biomarkers including proteinuria (e.g., albumin), anemia status (e.g., hematocrit), cardiovascular risk (e.g., C-reactive protein) • Conduct age-specific, culturally-relevant cognitive testing for each child

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Conclusions

Guidelines geared toward a specific objective: understanding potential health outcomes at the community level as a function of specific land-based pollution sources

- Maximize likelihood of discerning signal from noise

But can be used to achieve multiple and varying sub-objectives

- Biomonitoring data – measurement and repository
- Comprehensive environmental characterization and setting
- Expanding local capability – laboratory analysis to conducting surveys to health outcome measurement
- Database of exposure factors

Depending on emphasis, need to carefully think through power and sample size calculations

- Guidelines do not address statistical methods and analyses
- Linkages to economic data

Moving Toward Solutions

Consistent data collection will improve understanding and implications of land-based pollution

There should be a plan / consensus on anonymized data repositories

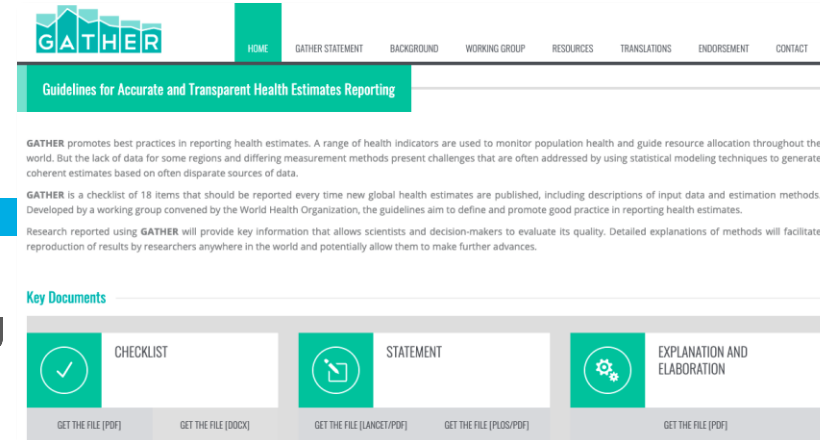
Exposure Factors Handbook

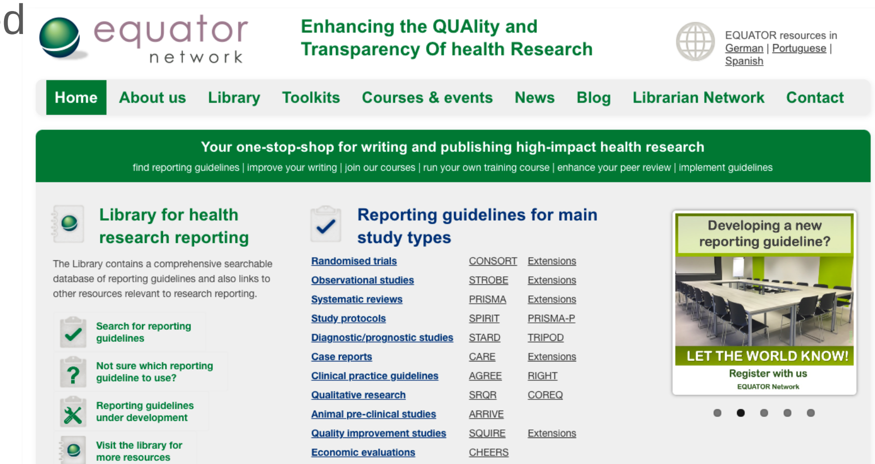
How “big” is the problem

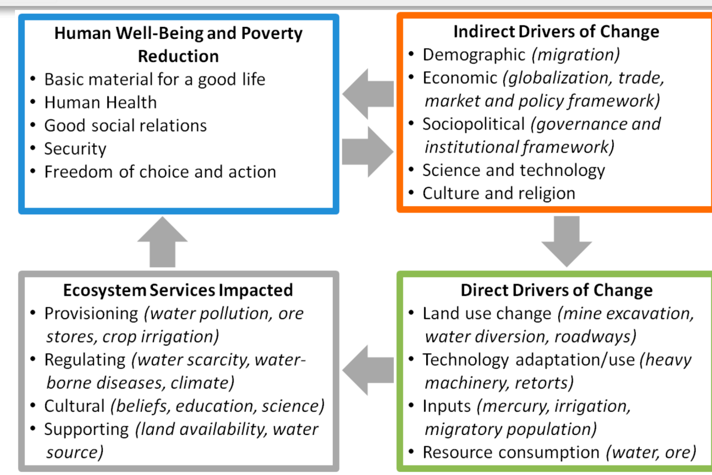
Can use the process to engage community and strengthen understanding of issues

Elicit community preferences

Support systems-based management approaches: Ecosystem services, climate change, transformation







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Data Gathering for ASGM Baseline Estimates

World Bank-UNITAR side-event at Minamata Convention COP

Eric Neglic

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CHEMICALS & WASTE MANAGEMENT PROGRAM

OVERVIEW

- Baseline ASGM Inventory Methodology
- Collecting Field Data

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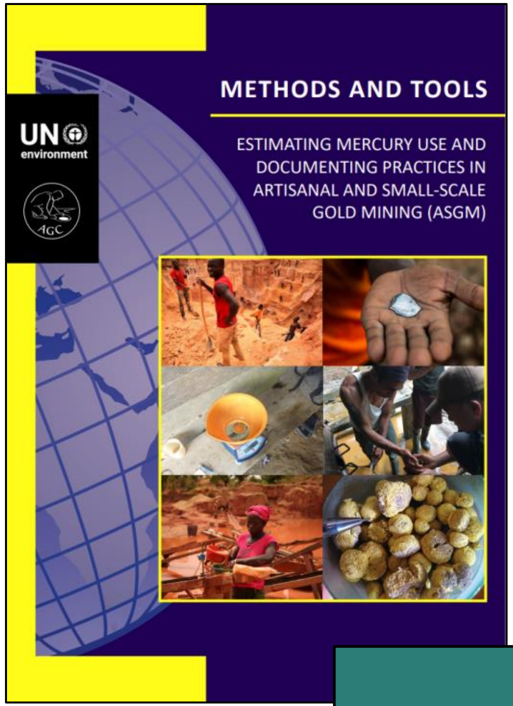
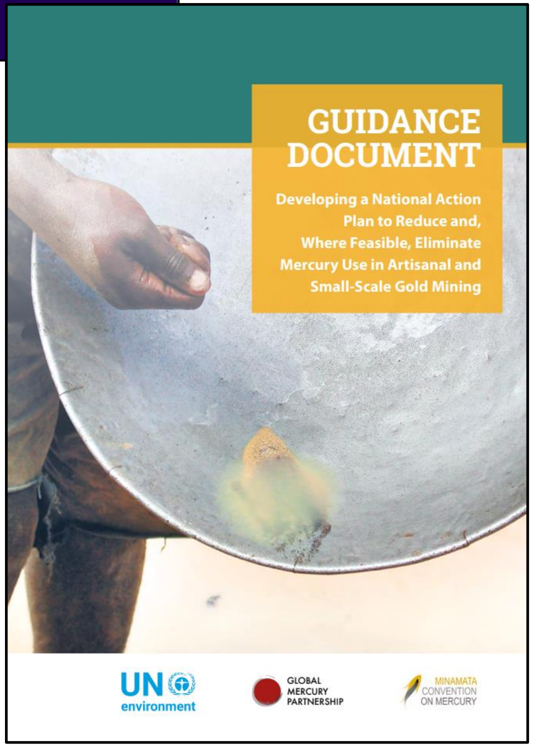
Photo: ARTISANAL GOLD COUNCIL

Developing Baseline ASGM Inventories:
AGC/UNEP Methodology

- Identify existing information and information gaps
- Select inventory approaches
- Develop field plans
- Collect, compile and analyze field data
- Cross-check and triangulate inventory information to improve estimate confidence
- Produce local, regional and national inventory estimates and sector summaries





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ASGM Baseline Information

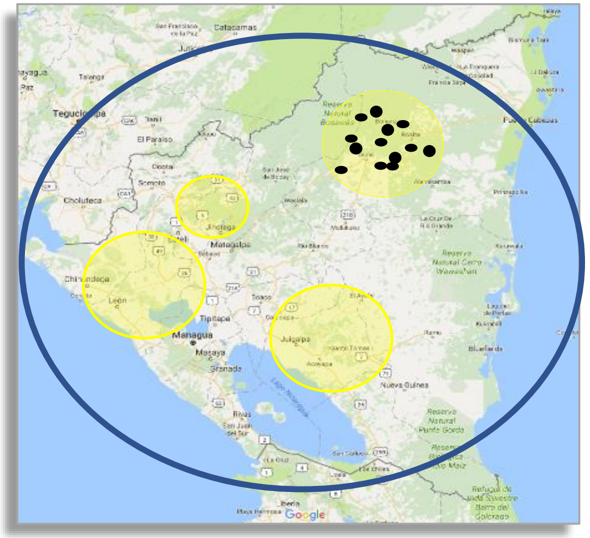
Photos: ARTISANAL GOLD COUNCIL

Mercury Use

Gold Production

Workforce

Develop General Understanding of ASGM Sector and Practices:
- Local
- Regional
- National



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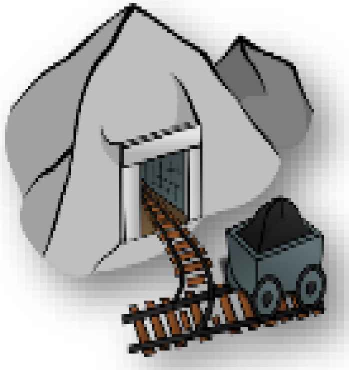
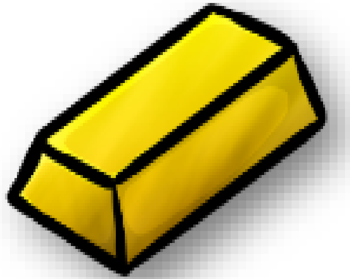
Approaches to Developing Baseline Estimates

Extraction based estimates



Triangulate results

Processing based estimates



Earnings based estimates

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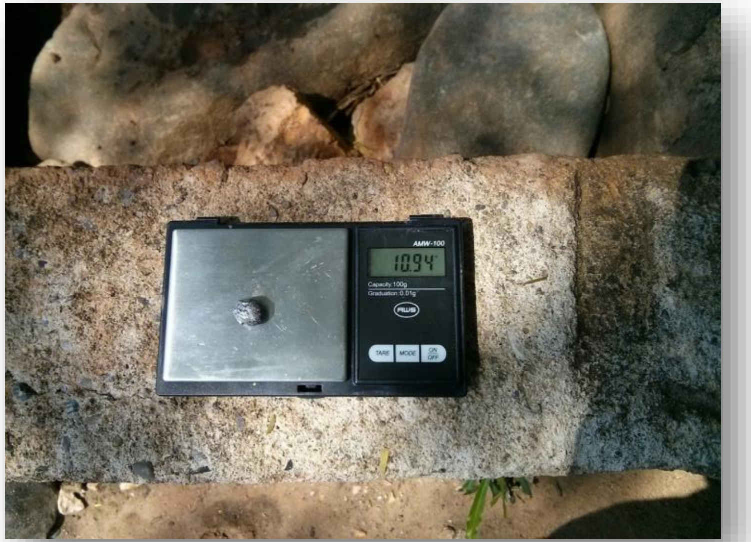
Collecting Field Data

Interviews

Observations

Physical Measurements



- Understand chosen inventory approach
- develop a standardized process to obtain the information needed to produce baseline estimates

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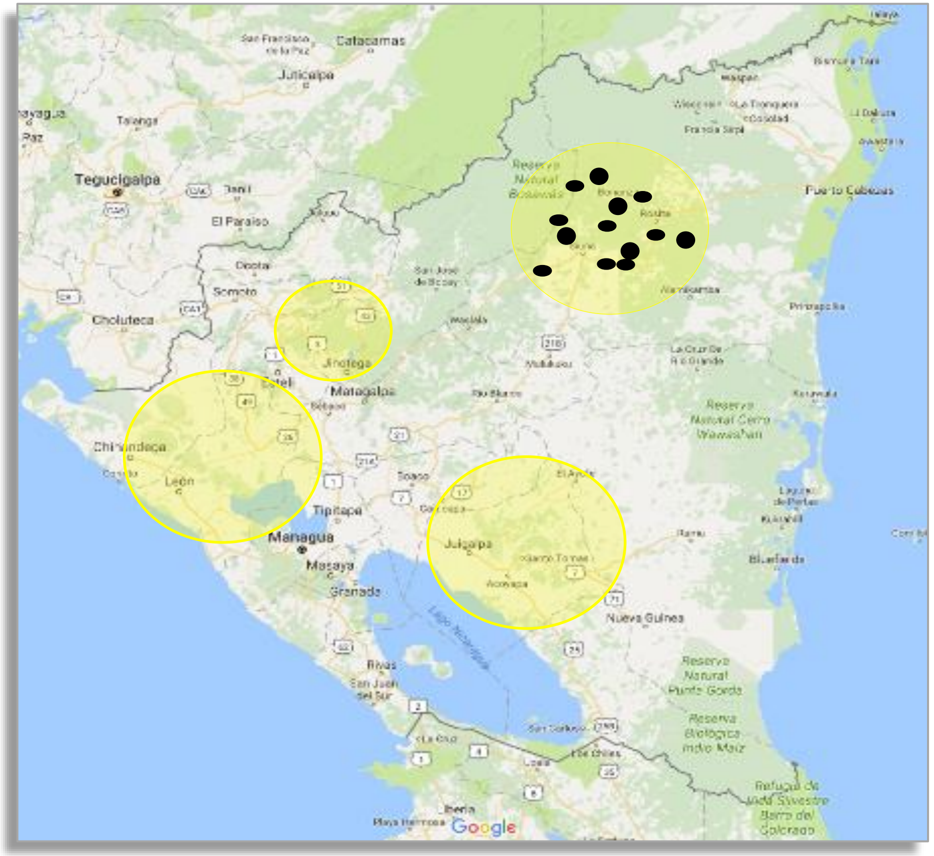
Field Data Collection: Mercury use at a Rastra



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Field Data Collection: Mercury use at a Rastra

Goal:

- Measure Hg use and Au production from a rastra

Approach:

Observe entire processing cycle and observe/measure:

Ore:

- Weight of or bags
- Total number of ore bags processed

Mercury:

- Total Hg added
- Total Hg Recovered
- Record time and weight of each addition of Hg to the rastra

Gold:

- Measure sponge gold weight
- Determine karatage of gold through acid test at gold shop

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Field Data Collection: Mercury use at a Rastra

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Mercury:
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Gold:
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Field Data Collection: Mercury use at a Rastra

Calculate:

Total daily ore throughput of a rastra
- (= Ore bag weight x # ore bags per day)

Total mercury lost per day per rastra
- (= mercury added – mercury recovered)

Total Au produced per day per rastra
- (= Au produced corrected for purity)

Ore Grade
- (= Total daily ore throughput / Au recovered)

Hg:Au ratio
- (= Total daily Hg loss / Au produced)

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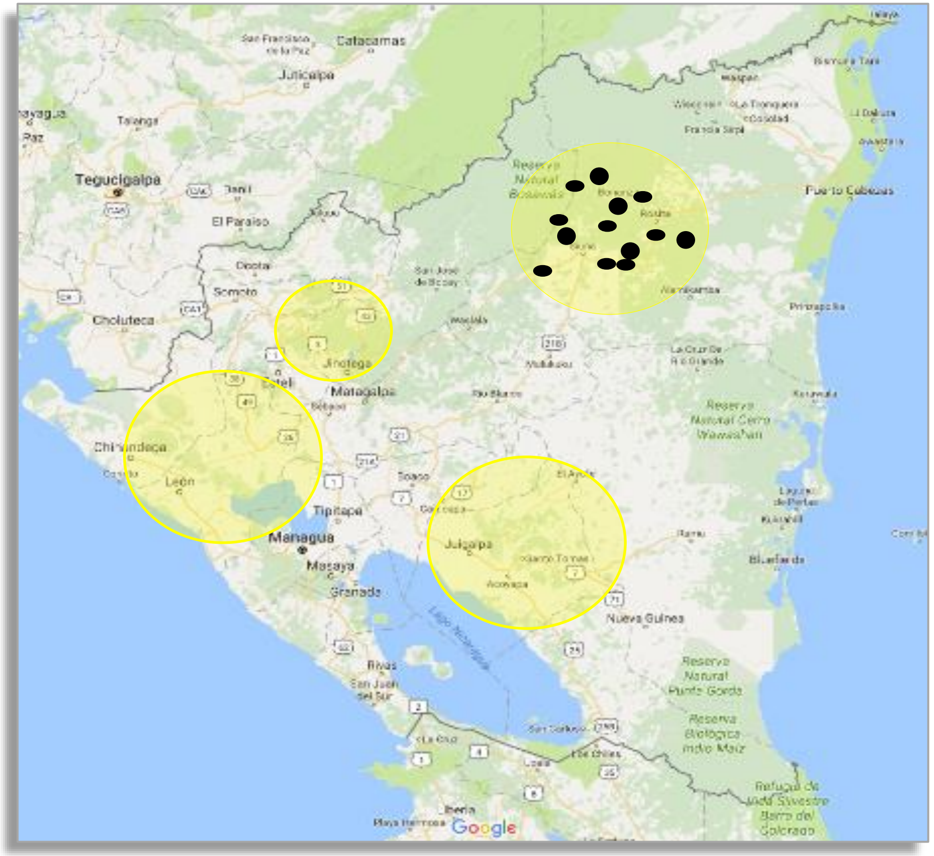
Field Data Collection: Extrapolating Data

Apply local data to produce regional estimates:

- Produce averages using data from various sites
- Identify regional knowns
- Combine averages with regional knowns to produce regional estimates

Identify:
- Major Au producing and Hg emitting regions
- Areas of worst practices
- Regional variations in practices



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SUMMARY

- Field data is key to increasing ASGM baseline estimate confidence
- Standardizing ASGM baseline data acquisition is difficult
- Standardized tools, approaches, information requirements and templates can provide increased consistency
- ASGM baseline studies provide snapshots of ASGM sectors and can inform selection of sites and regions for further work

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THANK YOU!

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