EVALUATING HEALTH IMPACTS FROM LAND-BASED POLLUTION: DATA GAPS & NEEDS ASSESSMENT

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Inter-Organization Programme for the Sound Management of Chemicals (IOMC) Webinar on "Evaluating Health Impacts from Land-Based Pollution: Data Gaps & Proposed Framework and Economic Considerations"

November 18, 2021

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E RISKSCIENCES
ANALYSIS & TOOLS FOR DECISION-MAKING

Public Health Risks

Risk magnitude	Expect about one adverse event per	Examples: deaths in Britain per year from:
10 *(1 in 1)*	Person	-
9 *(1 in 10)*	Family	-
8 *(1 in 100)*	Street	Any cause
7 *(1 in 1 thousand)*	Village	Any cause, age 40
6 *(1 in 10 thousand)*	Small town	Road accidence
5 *(1 in 100 thousand)*	Large town	Murder
4 *(1 in 1 million)*	City	Oral contraceptives
3 *(1 in 10 million)*	Province/country	Lightning
2 *(1 in 100 million)*	Large country	Measles
1 *(1 in 1 billion)*	Continent	-
0 *(1 in 10 billion)*	World	-

Annual Deaths Worldwide

Heart Disease	8,750,000
Tuberculosis	1,270,000
Malaria	435,000
Land-based pollution	???

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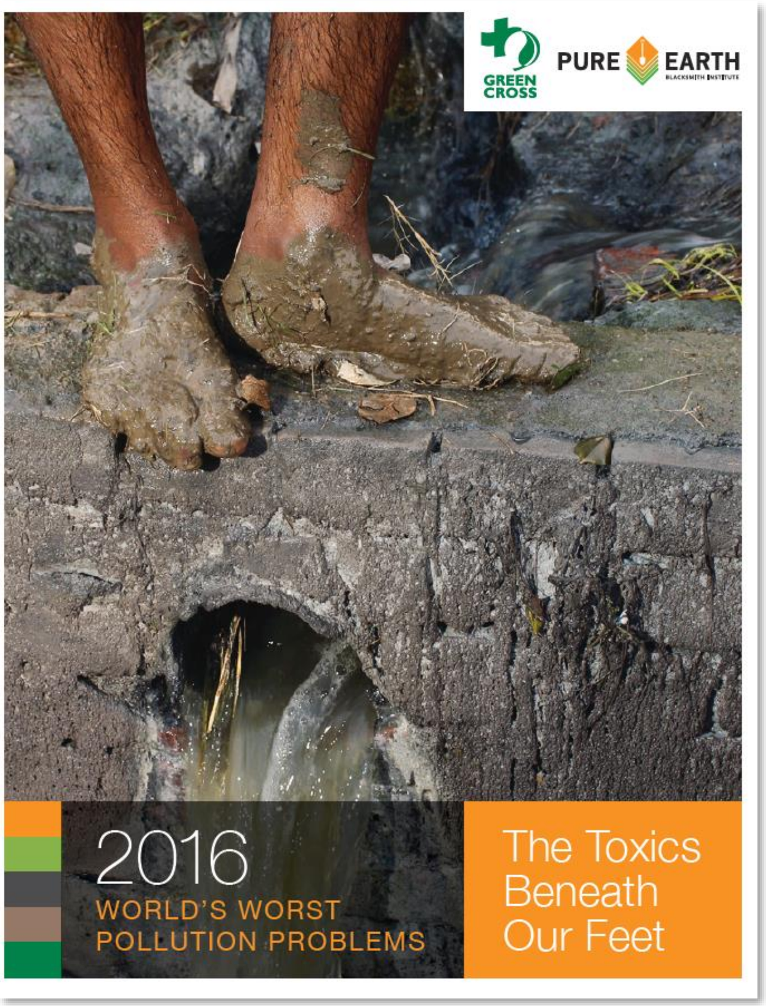
Land-Based Pollution in LMICs

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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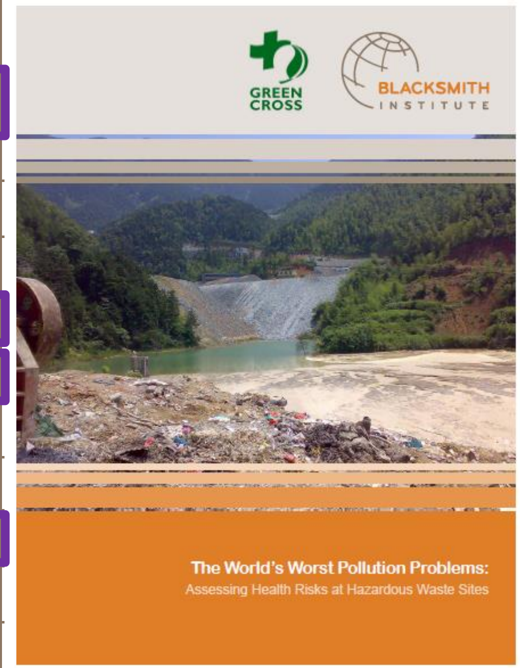
Top Pollutants & Industries

ESTIMATED DALYS

	LEAD	CHROMIUM	ASBESTOS	CADMIUM	MERCURY	INDUSTRY TOTAL
Lead Smelting	2,600,000	0	0	0	0	2,600,000
Industrial Estates	1,000,000	60,000	0	0	0	1,060,000
Product Manufacturing	550,000	236,000	0	0	0	786,000
Mining and Ore Processing	2,000,000	380,000	140,000	100	1,500	2,521,600
Battery Recycling	4,800,000	0	0	0	0	4,800,000
Tanneries	130,000	1,800,000	0	0	0	1,930,000
Industrial Dumpsites	1,200,000	34,000	0	0	0	1,234,000
Chemical Manufacturing	300,000	465,000	0	0	0	765,000
Artisanal Mining	1,000,000	9,000	0	0	12,000	1,021,000
Dye Industry	80,000	350,000	0	0	0	430,000
Subtotal	13,660,000	3,334,000	140,000	100	13,500	
TOTAL DALYS	17,147,600					



How Good Are These Estimates?

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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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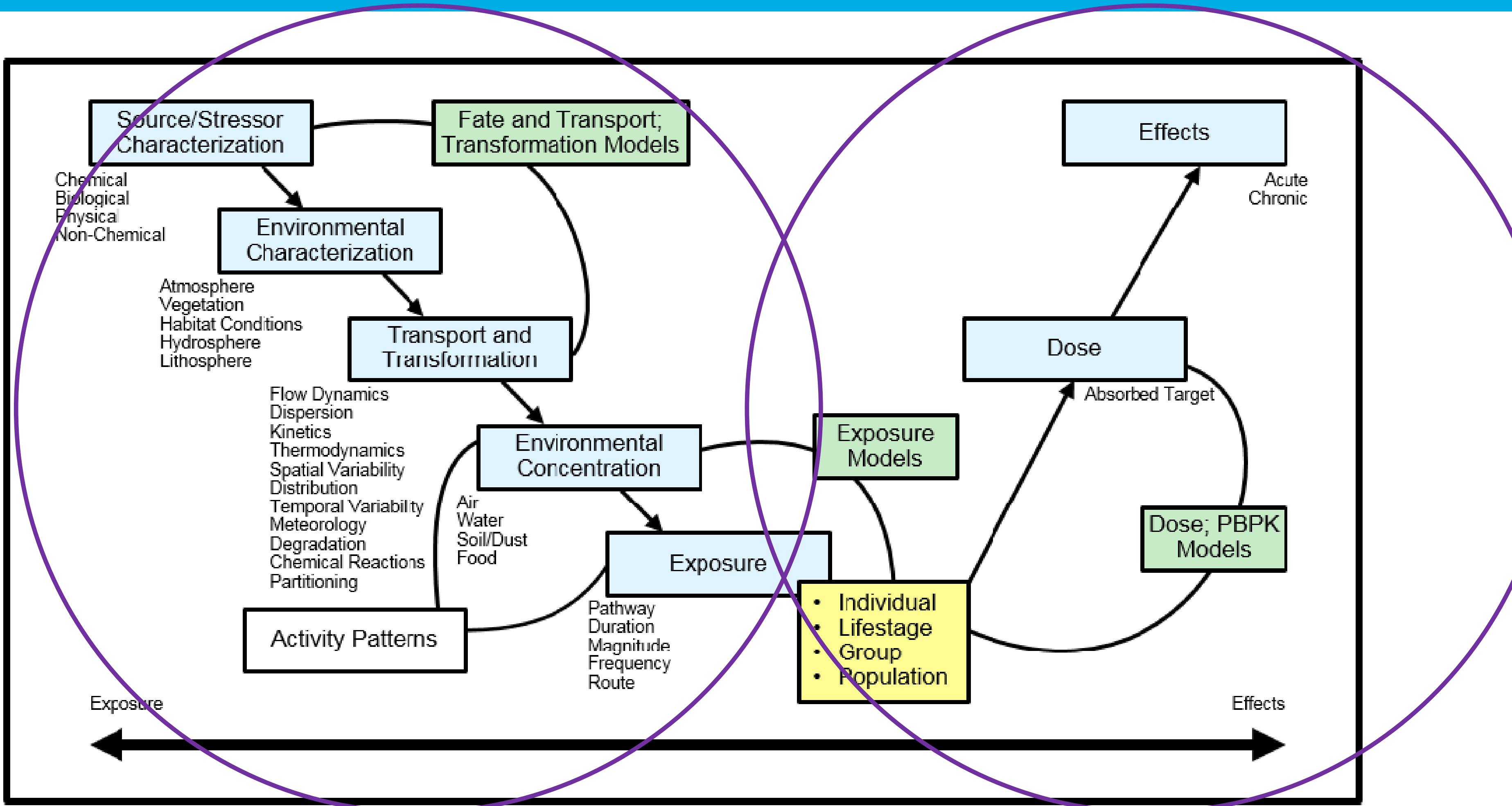
What Do We Need to Know?



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

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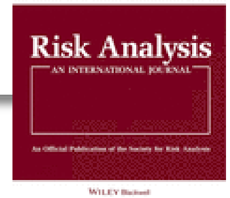
Key Findings (Williams et al.)



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.

Data Gaps:

- Representativeness
- Site contamination
- Pollutants and pathways
- Exposure factors
- Exposures and risks
- Biomonitoring data
- Health outcomes

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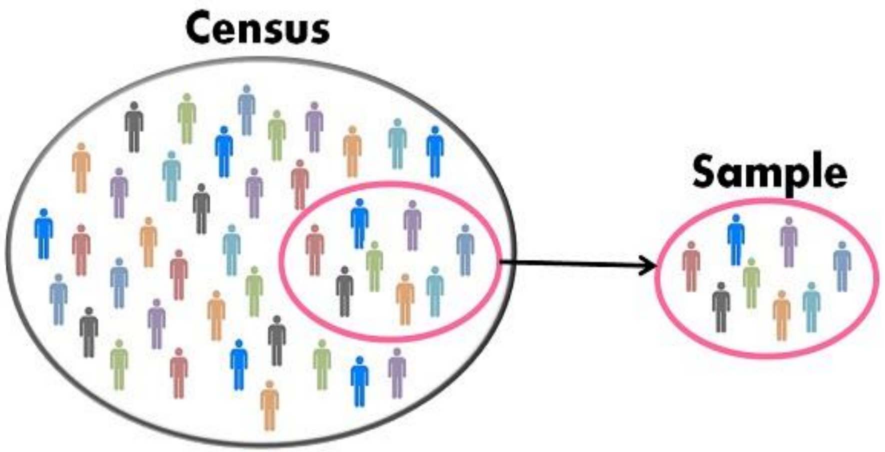
Representativeness of Population



Findings:

- Reliance on targeted or convenience samples
- Lack of robust census data at local level

J|H&P

Case Study

Assessment and Rem... Lead Contamination

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Group ID	Number Tested	Age Range	Range (µg/dL)	> 45 µg/dL	> 70 µg/dL
Siblings	32	7 mos-7 yrs	59.1 - 345.4	32	31
Mothers	23	20-44 yrs	32.5 - 98.8	14	5
Other Children	18	3 mos-19 yrs	39.8 - 613.9	15	10
Other Adults	8	20-64 yrs	37.7 - 81.0	5	2
Total # Tested	81	—	—	66	48

Table 1.2 — World Health Organization. June 2008

the deaths of at least 18 infants. A coalition of local community members, local and federal government agencies, and international non-governmental organizations was able to develop and implement a comprehensive assessment and remediation strategy specifically focused on minimizing future risks to the local population with minimal disruption. The implemented soil removal plan resulted in site remediation without population relocation, spanning just over two years, and being completed under the budget of USD 200,000.

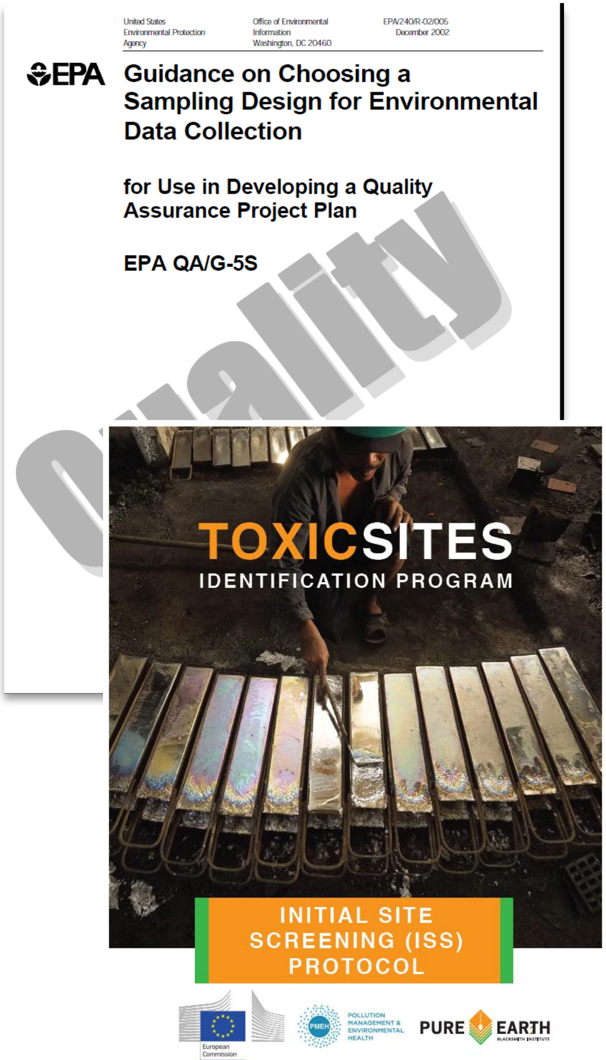
Competing Interests. The authors declare no competing financial interests.

Keywords. Senegal, lead, used lead-acid battery, ULAB, assessment
J Health Pollution 2:37-47 (2011)

Introduction

At least 18 children died from lead poisoning in the community of Thiaroye Sur Mer (TSM), Senegal, in late 2007 and early 2008.[1] The deaths occurred within months following a "lead rush" started by a battery recycler who paid top wages for the sifting

Extent of Site Contamination



Findings:

- Lack of systematic and random sampling
- Sampling near contamination source or to identify "hot spots"

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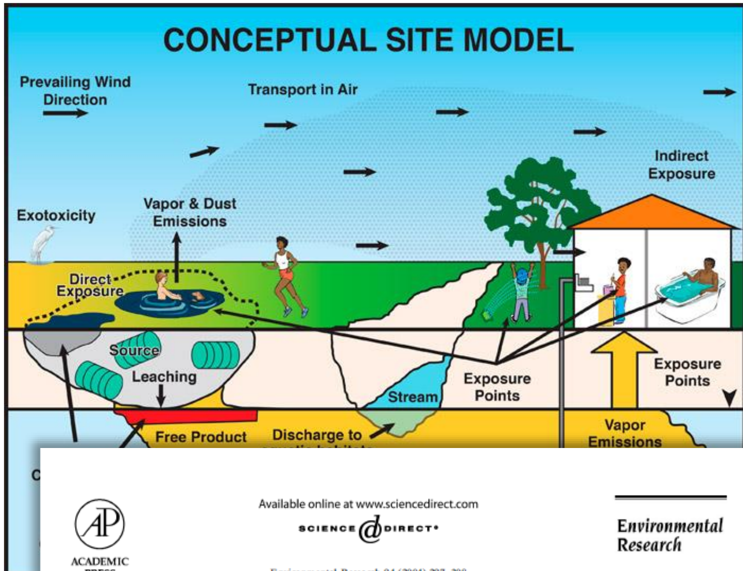
Multi-Pollutant and Pathways



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Environmental Research

Environmental Research 94 (2004) 297–308

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Lead in residential soil and dust in a mining and smelting district in northern Armenia: a pilot study☆,☆☆

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Abstract

This pilot study of sources of lead exposure in residential settings was conducted in a mining and smelting district in northern Armenia. Samples of exterior soil and dust and interior house dust were collected in and around apartment buildings in Alaverdi where the country's largest polymetallic smelter is located, and in nearby mining towns of Aghtala and Shamlugh. The NITON XL-723 Multi-Element XRF analyzer was used for lead testing. Lead levels in samples from Alaverdi were higher than those in Shamlugh and Aghtala. In all three towns, the highest lead levels were found in loose exterior dust samples, and lead concentrations in yard soil were higher than those in garden soil. Many soil samples (34%) and the majority of loose dust samples (77%) in Alaverdi exceeded the US Environmental Protection Agency standard of 400 mg/kg for bare soil in children's play areas. In addition, 36% of floor dust samples from apartments in Alaverdi exceeded the US Environmental Protection Agency standard of 40 μg/ft^2 for lead loading in residential floor dust. The Armenian Ministry of Health and other interested agencies are being informed about the findings of the study so that they can consider and develop educational and preventive programs including blood lead screening among sensitive populations.

Keywords: Armenia; Smelter; Lead; Residential soil and dust

Findings:

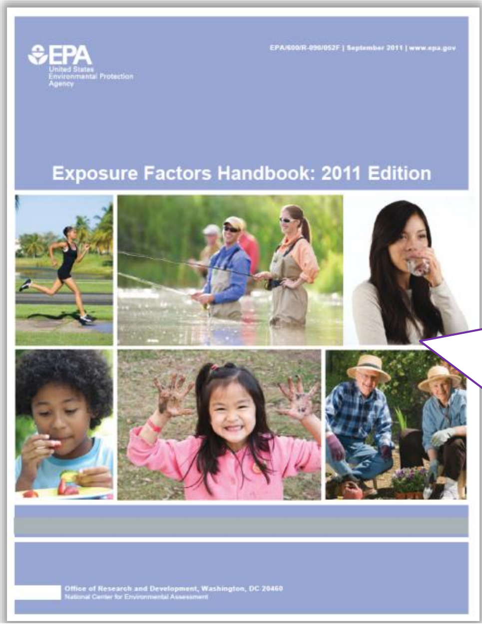
- Lack of conceptual site model (CSM)
- Limited sampling of pollutants, media, and exposure pathways

Table 5
Metals' Concentrations (mg/kg) in garden and yard soils, and exterior loose dust by study area

Metal	Alaverdi					
	Garden soil		Yard soil		Loose dust	
	n(N)[a]	Range (mg/kg)	n(N)	Range (mg/kg)	n(N)	Range (mg/kg)
As	16 (20)	17–184	17 (18)	17–448	26 (30)	25–490
Cr total	0 (20)	—	1 (18)	352	3 (30)	324–423
Co	3 (20)	292–392	6 (18)	275–828	8 (30)	305–636
Cu	18 (20)	201–3648	18 (18)	64–5930	30 (30)	147–6989
Fe	20 (20)	9357–48282	18 (18)	22195–82688	30 (30)	25088–100966
Hg	0 (20)	—	0 (18)	—	0 (30)	—
Mn	19 (20)	537–3299	17 (18)	592–1440	24 (30)	590–1779
Mo	15 (20)	14–38	16 (18)	14–183	28 (30)	15–219
Ni	0 (20)	—	2 (18)	157–158	6 (30)	170–337
Rb	8 (20)	11–24	7 (18)	10–27	3 (30)	13–18
Se	3 (20)	10–12	4 (18)	12–31	8 (30)	11–30
Sr	20 (20)	91–579	18 (18)	94–292	30 (30)	125–280
Zn	20 (20)	75–1160	18 (18)	95–1450	30 (30)	221–3709
Zr	20 (20)	26–77	18 (18)	47–73	30 (30)	34–73

[a] n, the number of samples with detectable levels of metals; N, the total number of samples collected.

Exposure Factors



"Exposure factors are factors related to human behavior and characteristics that help define an individual's exposure to an agent."

Findings:

- Little data on population-specific exposure factors
  - Intake rates (soil)
  - Activity patterns

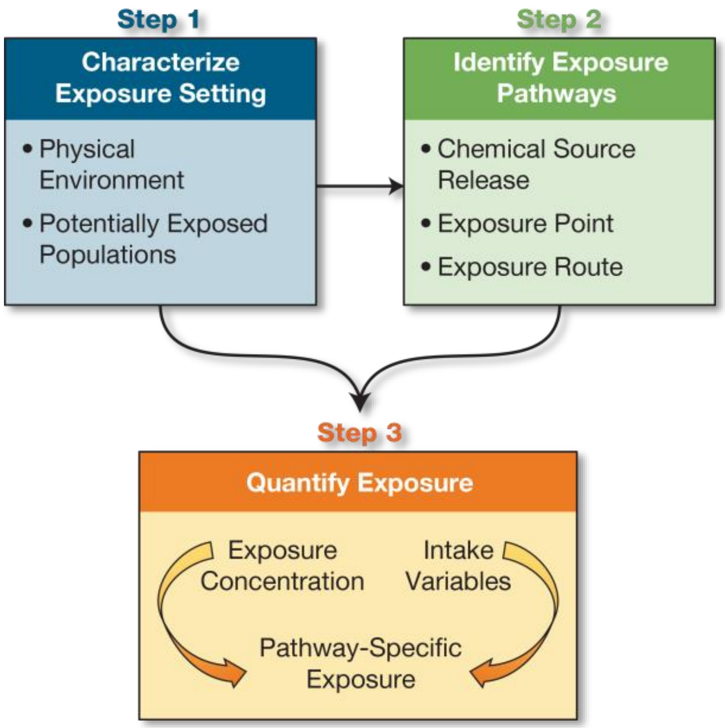
Environ Geochem Health
https://doi.org/10.1007/s10653-018-0185-x

ORIGINAL PAPER

The sources and chemical content of edible
in markets in Tanzania: a cross-sectional analytical study

Charisma U. Msoffe · Elias C. Nyanza · Deborah S. K. Thomas ·
Ola Jahanpour · Deborah Dewey

Estimating Exposures and Risks



Findings:

- Limited reliance on traditional exposure and risk estimation approaches
- Limited exposure modeling except lead uptake in children (EPA IEUBK model)

$$I = (C \times CR \times EFD) \div (BW \times AT)$$

Chemical-related variable (C)

Variables that describe the exposed population (exposure factors) (CR, EFD, BW)

Assessment-determined variable (AT)

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Estimating Exposures and Risks

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Human Exposure Pathways of Heavy Metals in a Lead-Zinc Mining Area, Jiangsu Province, China

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Abstract

Heavy metal pollution is becoming a serious issue in developing countries such as China, and the public is increasingly aware of its adverse health impacts in recent years. We assessed the potential health risks in a lead-zinc mining area and attempted to identify the key exposure pathways. We evaluated the spatial distributions of personal exposure using indigenous exposure factors and field monitoring results of water, soil, food, and indoor and outdoor air samples. The risks posed by 10 metals and the contribution of inhalation, ingestion and dermal contact pathways to these risks were estimated. Human hair samples were also analyzed to indicate the exposure level in the human body. Our results show that heavy metal pollution may pose high potential health risks to local residents, especially in the village closest to the mine (V1), mainly due to Pb, Cd and Hg. Correspondingly, the residents in V1 had higher Pb (8.14 mg/kg) levels in hair than those in the other two villages. Most of the estimated risks came from soil, the intake of self-produced vegetables and indoor air inhalation. This study highlights the importance of site-specific multipathway health risk assessments in studying heavy-metal exposures in China.

Citation: Qu C-S, Ma Z-W, Yang J, Liu Y, Bi J, et al. (2012) Human Exposure Pathways of Heavy Metals in a Lead-Zinc Mining Area, Jiangsu Province, China. PLoS ONE 7(11): e46793. doi:10.1371/journal.pone.0046793

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Competing Interests: One author (JY) is employed by a commercial company, SGS-CSTC Standards Technical Services (Shanghai) Co., Ltd. However, this study was not funded by the SGS company. SGS company is a cooperative partner in this study. The authors have cooperation agreement with SGS company. This does not alter the authors' adherence to all the PLOS ONE policies on sharing data and materials.

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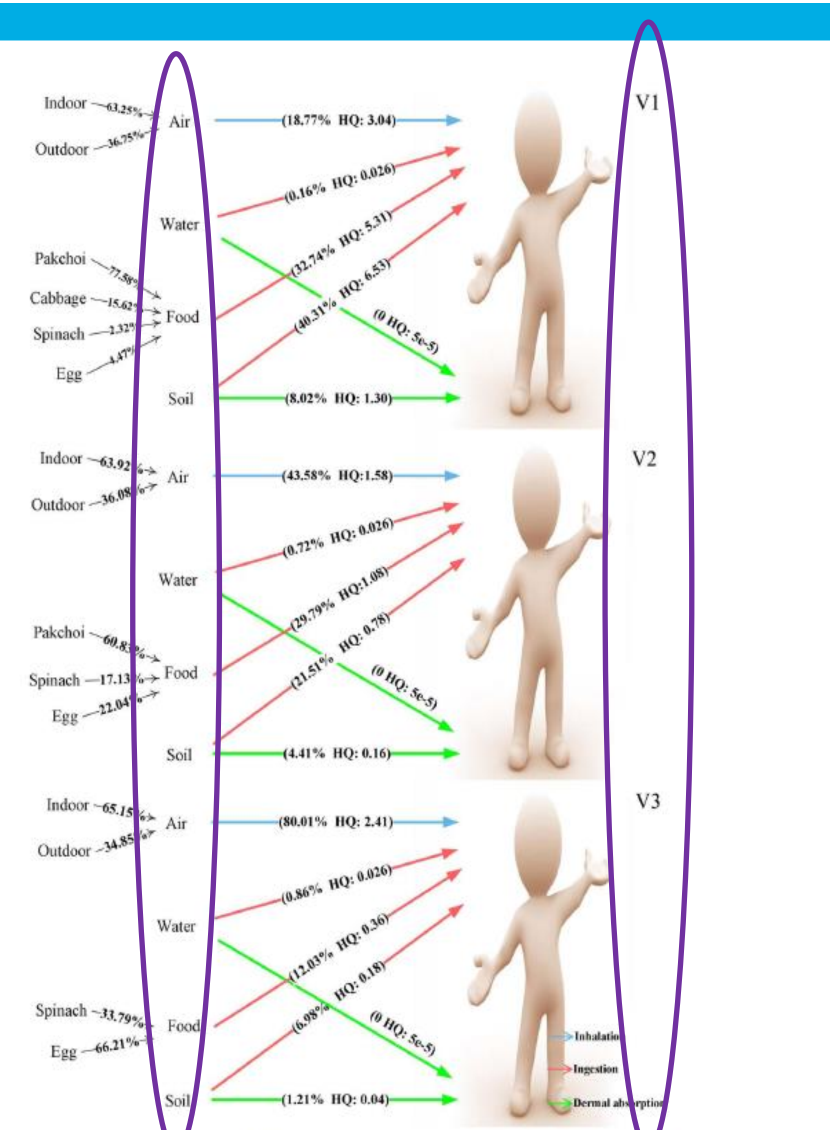
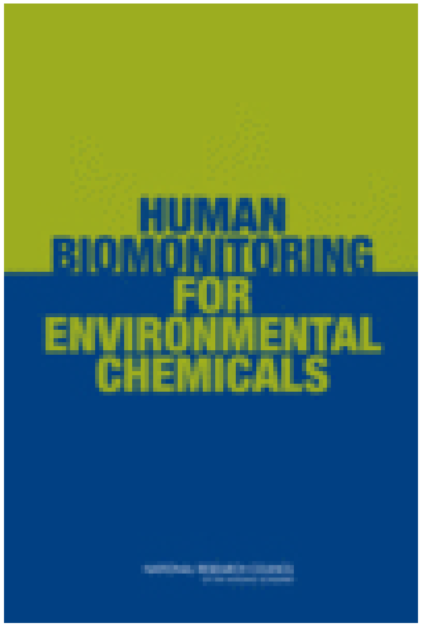
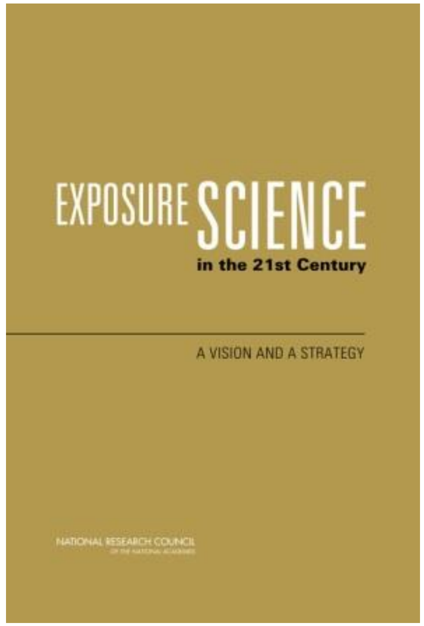


Figure 3. Multipathway analysis of HQ (Pb). Each pathway's contribution to total Pb exposure of local residents in the three studied villages was calculated based on average HQ values.

Biomonitoring Data





Findings:

- Limited use and interpretation of biomonitoring data
- Many differences in study design, data quality, health benchmarks, internal dose metrics, etc.

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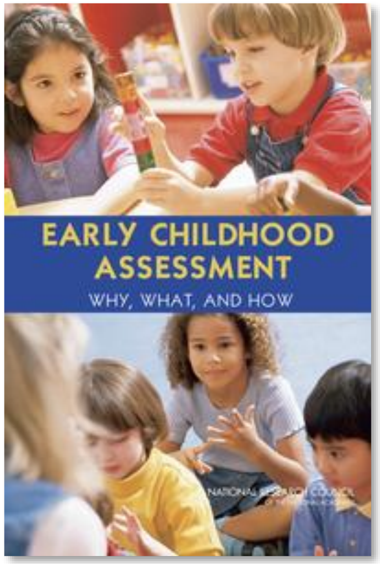
Measuring Health Outcomes



Health Outcome Measurements:

- Self-reported symptoms
- Clinical examinations
- Standardized tests/instruments
- Medical diagnoses

Findings:

- Insufficient data collected on health outcomes
- Use of different (unvalidated) measurement tools and diagnostic criteria

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Summary

- Many studies provide useful data on site contamination and public exposures, but study objectives and sampling strategies differ widely
- Unable to link environmental contamination from specific industrial sites or activities to population exposures and health outcomes
- Knowledge and data gaps hinder ability to quantify public health impacts from land-based pollution in LMICs

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Recommendations

- Develop systematic framework and uniform protocols for future data collection and sampling in LMICs
- Support greater use of traditional exposure and risk assessment methods and tools
- Explore use of risk analysis approaches to improve risk management decision-making in LMICs

Risk Analysis Approaches

- Precautionary Principal
- Human Health Risk Assessment
- Value-of-Information Analysis

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Perspective

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