Health risk assessment of arsenic dispersion from mining in Mount Isa

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ABSTRACT: The study identified that arsenic (As) exposure to the population of Mount Isa is of limited significance but surface tailings and fall out (city) may be higher risk because their % bioaccessibilities are higher than those of other sources. Total As concentrations ($\mu\text{g m}^{-2}$) in surface wipes indicate a need to clean surfaces where children regularly contact. Airborne particulate concentrations were not significant for the sampling period.

1 INTRODUCTION

The Lead Pathway Air Study (2007–2012) has also examined sources of arsenic (As) and provided an understanding of human exposure at Mount Isa from mining and processing activities (Noller *et al.*, 2017). If not properly managed, dispersion of metals and metalloids from mine activities may cause adverse effects on the environment and human health. The National Environment Protection Measures (NEPMs) guidelines for soil contamination in Australia (NEPC, 2013) identify a need to undertake further Tier II risk assessment of the site if the Health Investigation Levels (HIL) are exceeded. In the absence of site specific data, the NEPMs may not provide accurate close out criteria for mined land. The aim of this study is to use a risk assessment process to assess any potential health effects from As sources in Mount Isa city including from mining and mineral processing, natural and other sources of exposure to the local population.

2 METHODS/EXPERIMENTAL

Samples of ores and processed materials were collected from Mount Isa Mines, and soil and dust from the nearby city (Noller *et al.*, 2017). Samples initially sieved to <2 mm for measurement of total concentrations (aqua regia digest) were also sieved to <250 μm for bioaccessibility (gastro-intestinal tract simulation) measurement using the physiologically-based extraction test (Ng *et al.*, 2015; Ruby *et al.*, 1996). Air particulates and surface wipes were also collected (Noller *et al.*, 2017). Arsenic concentrations were

determined in digest solutions by ICP-MS. Particle size analysis was undertaken by Malvern Mastersizer (2000). Hazard assessment, exposure assessment and risk characterization of arsenic followed the Australian enHealth (2012) health risk assessment framework.

3 RESULTS AND DISCUSSION

Table 1 gives results for total As and bioaccessible-adjusted concentrations (mg kg^{-1}) in soil, minerals and dusts from Mount Isa and environs. Whilst some total As concentrations exceed NEPM HILs, only surface tailings and fall out (city) exceed HIL A for bioaccessibility adjusted As concentration (Table 1). Total As concentrations ($\mu\text{g m}^{-2}$) in surface wipes at Mount Isa city (Table 2) show that floor and carpet surfaces, based on an indicative guideline, have much lower concentrations than window sill and trough and external surfaces which are not cleaned in houses and regularly as floors and carpets. These data indicate a need to clean surfaces that children regularly contact. Table 3 gives airborne concentrations of As ($\mu\text{g m}^{-3}$) in outdoor and indoor air at the Mount Isa residential area and show that the As guideline for total suspended particulates was not exceeded for the period of sample collections. Bioaccessibility (% BAc, in-vitro) is generally a more conservative approach to estimate bioavailability of contaminated wastes such as from mining. Figure 1 shows the particle size distribution of samples from the mine site and residential area as cumulative (%). All samples have 50% of volume in the range 10–110 μm except for surface tailings with 50% of volume being 1 μm but bimodal. This data

Table 1. Total As concentrations and bioaccessible As in soil and dust samples from Mount Isa.

Sample	Total As (mg kg ⁻¹) Mean ± sd (n*)	Bioaccessibility (BAc) Mean ± sd (n*)	
		Adjusted (mg kg ⁻¹)	BAc %
Background geology			
Outcrops	31 ± 27 (13)	3 ± 2.1 (5)	9 ± 6 (5)
Mineralization	497 ± 197 (4)	7 (1)	1 (1)
Mining and mineral processing			
Mine site dust	1320 ± 4040 (72)	25 ± 23 (16)	8 ± 6 (16)
Haul road dust	291 ± 3 (9)	32 ± 27 (9)	11 ± 4 (9)
Tailings surface	361 ± 31 (7)	112 ± 96 (7)	31 ± 28 (7)
Smelter dust	375 ± 525 (16)	30 ± 42 (22)	8 ± 5 (22)
City residential area			
Garden soil ($<250\ \mu\text{m}$)	12 ± 9 (76)	2 ± 2 (76)	15 ± 8 (76)
Garden soil ($<10\ \mu\text{m}$)	39 ± 28 (74)	11 ± 11 (74)	28 ± 15 (74)
Footpath	9 ± 6 (14)	1.9 ± 0.9 (14)	27 ± 14 (14)
Fallout dust	291 ± 248 (15)	130 ± 90 (15)	47 ± 23 (15)
Roof gutter dust	1139 ± 1511 (18)	52 ± 54 (18)	11 ± 10 (18)
Carpet dust	46 ± 26 (6)	9 ± 7 (6)	22 ± 10 (6)
Australian soil contamination guidelines (NEPC 2013)			
HIL A (residential/ garden)	100	—	—
HIL C (public open space)	300	—	—

*n = number of samples.

Table 2. Total As concentrations (µg m⁻²) in surface wipes.

Sample	Total As (µg m ⁻²) mean ± sd (n*)
Floor wipe	17 ± 48 (176)
Carpet wipe	13 ± 4 (68)
Window sill	102 ± 235 (130)
Window trough	2163 ± 5140 (47)
Roof wipe	1247 ± 2834 (134)
Veranda wipe	146 ± 248 (84)
Guideline (Brookhaven National Laboratory 2014)	
Surface wipe for As	1500 µg m ⁻² *

*n = number of samples; Criteria type – Housekeeping – all.

supports that tailings surface material and city fall out may be higher risk because their % BAc's (Table 1) are 31 and 47, respectively.

4 CONCLUSIONS

The study identified that As exposure to the population of Mount Isa is low but surface tailings and fall out (city) may be higher risk because their % BAc's are higher than those of other sources. Total As concentrations (µg m⁻²) in surface wipes indicate a need to clean surfaces where children regularly contact.

Table 3. Airborne As concentrations (µg m⁻³) in Mount Isa.

Sample	Total As (µg m ⁻³) Mean ± sd (n*)
City outdoor	
(2009)	0.005 ± 0.008 (12)
(2010)	0.005 ± 0.008 (12)
(2011)	0.005 ± 0.008 (12)
City Indoor	
(2010)	0.004 ± 0.004 (12)
Guideline (NEPC 2002)	
As in total suspended particles ('TSP')*	0.006 µg m ⁻³ (1 year averaging period)

*n = number of samples.

Figure 1. Particle size distribution of samples from the mine site and residential area as cumulative (%).

Airborne particulate concentrations were not significant for the sampling period.

ACKNOWLEDGEMENTS

Glencore- Mount Isa Mines funded the study.

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