TOXIC ENVIRONMENTS & TOXIC BODIES

Mercury in the South African Environment

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Introduction

- Mercury in South African Environment
- Mercury human health risk
- Summary
- Way Forward

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Toxic Environments - Mercury

- Mercury, also known as quick silver, is ubiquitous in the environment
- Uses
  - Medical: medicines, thermometers, dental amalgam, etc.
  - Manufacturing industry: batteries, gold mining, chlorine production, cement production, etc.
  - Personal care products: make up, e.g. mascara, skin lighteners, anti-aging products, etc.

Toxic Environments - Mercury

- Sources
  - Natural degassing of the earth
  - Fossil fuel combustion process – e.g. coal based electricity generation
  - Biomass burning
  - Industrial discharges and wastes, e.g. medical waste streams
  - Incineration & crematories
- Hg is found in all environmental compartments
  - air, water, soil/sediment, and biota
- Inorganic and organic mercury
  - Elemental Hg Divalent Hg Methylmercury

$Hg^0 \longrightarrow Hg^{2+} \longrightarrow CH_3Hg^+$

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Mercury in the South African Environment

- Emissions
  - Coal combustion
    - 82.6 tonnes Hg p.a. → Stationery sources (2000)
      - 50.4 tonnes Hg p.a. → Coal fired power plants
      - Per capita emissions → 1.24 g Hg per person^{-1} y^{-1} R^{-1}
    - 9.8 tonnes Hg p.a. → Coal fired power plants (2004)
      - Per capita emissions → 0.24 g Hg per person^{-1} y^{-1} R^{-1}
  - Gold mining
    - Gold extraction & refining processes → 706 tonnes p.a. → 193 Hg kg yr^{-1}
    - Decline gold production → 204.9 tonnes p.a. (2009) → lower emissions
    - No estimates for artisanal gold mining

Dabrowski et al., 2008; Pacyna et al., 2006; Schroeder et al., 1982; Chamber of Mines 2009 (http://www.bullion.org.za/)

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Mercury in the South African Environment

- Air concentrations
  - Cape Point Global Atmospheric Watch Station
    - Total gaseous mercury (TGM)
      - 1.2 - 1.4 ng/m^3 (1995 -1999)
    - Gaseous elemental mercury (GEM)
      - below detection limit (0.05 ng/m^3) – 5.88 ng/m^3 (2007-2008)
  - TGM: 1.5 ng/m^3 - biomass burning episode in the Cape Peninsula
  - Coal fired power plants
    - $Hg^0 \rightarrow$ 0.25 ng/m^3; $Hg^{2+} \rightarrow$ 0.19 ng/m^3; $Hg^P \rightarrow$ 0.04 ng/m^3

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Baker et al., 2002; Carter, W. 2009; Brunke et al., 2010

Mercury in the South African Environment

- Surface Water
  - Rivers: Eerste/Kuils, Silvermine, Liesbeeck, Black (Western Cape) and Steenkoolspruit (Mpumalanga)
    - MeHg → 0.1 – 0.9 ng/L
  - Water Management Areas: Inkomati, Olifants and Upper Vaal
    - T-Hg > global average (5 ng/L) in 38% of samples
    - MeHg → below detection limit (0.02 ng/L) to 2.73 ng/L
- Concentrations below SA target value 1 µg/L

Learner et al., 2009; Williams et al., 2010

Mercury in the South African Environment

Freshwater Fish		Marine Fish	
WMA	**THg (µg/g)**	**Site**	**THg (µg/g)**
Inkomati	0.065 – 0.425	Durban Harbour	0.040 – 0.252
Upper Vaal	0.010 – 0.034	False Bay	0.036 – 0.402
uMvoti/ uMzimkhulu	0.014 – 0.038	West Coast	0.021 – 0.405

Human Health Risks – Hg poisoning

Place	Year	Cases
Minamata	1953-60	1 000
Nigata	1964-65	646
Guatemala	1963-65	45
Ghana	1967	144
Pakistan	1969	100
Iraq	1956	100
Iraq	1960	1 002
Iraq	1971	40 000

Mercury – Health Effects

- Blindness – deafness
- Cerebral Palsy – seizures
- Abnormal reflexes and muscle tone
- Retarded/delayed motor development
- Visual and auditory deficits
- Impaired mental development

Human Health Risks

- Dose-response
- Risk = Hazard * Exposure
- Individual susceptibility
- Scenario development
  - Scenario 1: 1 fish meal every day of the week
  - Scenario 3: 1 fish meal per week
  - Fish meal – 227 g/day
  - Adult: >18 yrs
  - Child: 10 yrs

Mercury Health Risks – Freshwater Fish

Health risks from air and water were negligible

WMA	Species	Hazard Quotient	
		Adult	Child
Berg	Silverfish, Catfish; Yellowfish	1.44 – 2.34 (0.03 – 0.35)	1.27 – 13.67 (1.20 – 1.95)
Upper Vaal	Yellow fish Banded Tilapia	0.16 – 0.53 (0.01 – 0.10)	0.89 - 2.98 (0.13 – 0.43)
Inkomati	Largemouth bass	6.68 (0.95)	37.40 (5.33)
uMvoti/ Umzimkhulu	Banded tilapia; Yellowfish Red breast tilapia	1.15 - 4.44 (0.04 – 0.63)	1.47 – 24.87 (0.21 – 0.92)

Adult = >18 yrs; Child = 10 yrs ; S1 – Scenario 1; S3 = Scenario 3

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Mercury Health Risks – Marine Fish

Sites	Species	HQ Adult	Child
Durban	Red roman Mullet	1.21 – 7.59 (0.58 – 1.13)	3.58 – 21.26 (0.50 – 5.04)
False bay	Red roman Yellowtail	3.50 – 12.12 (1.56 – 5.40)	9.79 – 33.92 (1.45 – 5.04)
Kalk Bay	Hottentot seabream Blueskin seabream	1.42 - 1.87 (0.63 – 0.83)	3.97 – 5.23 (0.59 – 0.78)
West Coast	Kob, Red panga; Silversfish, White stumpnose	3.16 – 12.21 (1.41 – 5.44)	3.95 – 15.23 (1.55 – 5.08)

Adult = >18 yrs; Child = 10 yrs ; S1 – Scenario 1; S3 = Scenario 3

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Mercury Health Risks

- Artisanal gold mining community's Hg exposure
  - T-Hg below the target value for South Africa (1 µg/L)
  - T-Hg in fish was 0.34 µg/g
  - 20% of respondents used coal for cooking
  - 57.1% of the urine sample levels were at or above the guideline of 5 µg/g creatinine
  - 21% of the blood sample levels were at or above the guideline of 10 µg/L
  - The maximum levels detected in the urine and blood were above the occupational Biological Exposure Index (BEI) for South Africa, which is 35 µg/g creatinine for urine and 15 µg/L for blood.

Oozthuizen et al., 2010

Human Health Risks

- Hg and Selenium (Se)
- Hg exposure and potential to cause adverse effects is mediated by selenium. Therefore, there may be cases where Hg exposure is elevated but the impacts are minimal.
- Suggests that Hg risk assessments need to account for Se antagonistic role in the developing Hg associated adverse effects

Summary

- Hg emissions increasing globally
  - South Africa is a significant contributor to total global Hg emissions
  - Source contributions from other sources not clearly known
- Ambient air and surface water concentrations very low. Exposure from these media unlikely to pose a health risk to the exposed.
- Fish tissue concentration indicate bioaccumulation and biomagnification – predatory fish – exposure potentially high for sensitive consumers – adverse effects more likely.
- South Africa has vulnerability issues which enhance people's susceptibility to environmental exposures.

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Way Forward

- A better understanding of other source emissions, e.g. biomass burning, cement production, etc.
- Improved monitoring systems for sensitive ecosystems, e.g. wetlands, to establish trends
- A better understanding of concentrations in fish species and other food types.
- A better understanding of South African fish consumption patterns
- Characterisation of adverse health impacts particularly for people with high fish consumption levels

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Thank you

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