Mining and Environmental Health in Armenia

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Outline

- Background information
- Toxic Site Identification Program in Armenia

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Mining in Armenia

- State Inventory of Mineral Resources - 670 mines of construction sand/stone and metals
  - 270 inactive mines including 8 metal mines
  - 400 active mines including 22 metal mines
- Among 30 metal mines:
  - 7 copper-molybdenum mines
  - 4 copper mines
  - 14 gold and gold - polymetallic mines
  - 2 polymetallic mines
  - 2 iron ore mines
  - 1 aluminum mine
- 15 tailing ponds

Sources: *Mining Industry in Armenia, 2011. Armenian Development Agency; RA Ministry of Energy and Natural Resources*

Impact of Mining/Processing on Environmental and Public Health

- Changing purpose of land use
- Soil erosion
- Soil, water, and air contamination
  - Mining waste mainly in **tailing ponds** leading to **heavy metal** contamination
- Loss of biodiversity
- Population displacement
- Occupational diseases and injuries
- Impaired health of communities
  - Heavy metals, silica dust, and noise

Mining and Heavy Metals

- **Arsenic** - smelting of copper and lead concentrates, gold recovery
- **Cadmium** - byproduct of refining zinc metal from sulfide ore concentrates, refining lead ores or complex copper-zinc ores
- **Lead -** from recovering gold and silver from refining processes of base metals such as copper and lead, gold recovery
- **Mercury -** gold recovery
- **Chromium –** tanneries or leather processing, dye and chemical manufacturing, contaminated landfills, cement dust

Source: US Environmental Protection Agency

Heavy Metals - Carcinogens

International Agency for Research on Cancer (World Health Organization)

- Group 1: Carcinogenic to humans
- Group 2A: Probably carcinogenic to humans
- Group 2B: Possibly carcinogenic to humans
- Group 3: Unclassifiable as to carcinogenicity in humans
- Group 4: Probably not carcinogenic to humans

Source: International Agency for Research on Cancer, WHO. http://monographs.iarc.fr/ENG/Classification/

Health Effects of Arsenic

- **Human carcinogen** - skin, liver, bladder and lungs cancer
- Disorders of nervous and circulatory systems
- Can cross the placenta into fetuses and can be transported from mother to child through breast milk
- Chronic exposure associated with birth defects, still births, and miscarriage

Source: US Agency for Toxic Substances and Disease Registry

Health Effects of Cadmium

- **Human carcinogen -** lung cancer
- Kidney, lung, and intestinal damage
- Reproductive problems in humans including low birth weight and reduced sperm count
- In animals, during pregnancy - negative effects on behavior and learning, abnormal fetal metabolism, low fetal weight and skeletal deformations

Source: US Agency for Toxic Substances and Disease Registry

Health Effects of Lead

- **Probably carcinogenic to humans**
- Children
  - Permanent damage to the brain and nervous system, behavior and learning problems, lower IQ, and hearing problems, slow growth, and anemia
- Adults
  - Nervous system effects
  - Cardiovascular effects, increased blood pressure and incidence of hypertension
  - Decreased kidney function
  - Reproductive problems (in men and women)
  - Miscarriage
  - Reduced growth of the fetus and premature birth

Source: US Environmental Protection Agency; US Agency for Toxic Substances and Disease Registry

Health Effects of Chromium

- **Human carcinogen (**hexavalent**) –** lung cancer
- Asthma, cough, shortness of breath, or wheezing
- Skin ulcers, swelling, and allergic reactions
- Sperm damage and damage to the male reproductive system in laboratory animals exposed to chromium(hexavalent)

Source: US Agency for Toxic Substances and Disease Registry

Environmental Impact of the Copper Smelter in Alaverdi, 2001

Lead exceeding the US EPA action level 400mg/kg:

- 25% of all 20 garden soil samples
- 44% of all 18 yard samples including playgrounds
- 77% of all 30 loose soil s. front of building entrance

Arsenic:

- 87% of 68 soil samples exceeding the *international maximum concentration of 12mg/kg*
- exceeding E-K soil remediation criterion of 80mg/kg (Visser 1994)
  - 45% of all garden soil samples
  - 50% of all yard soil samples
  - 70% of all loose dust samples

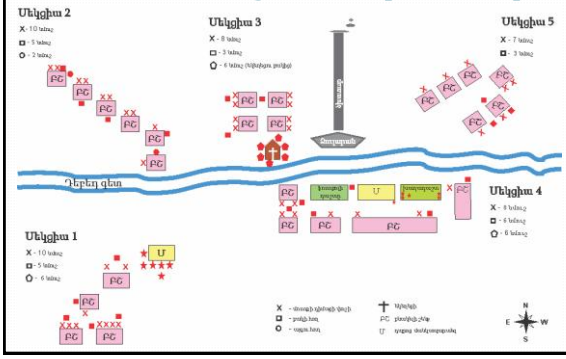
Source: Petrosyan V. et all. Lead in residential soil and dust in a mining and smelting district in northern Armenia: a pilot study. *Environmental Research, 94 (2004), 297 – 308. NITON XL-723 Multi-element XRF analyzer*

Alaverdi, 2013 (Hazard Identification)

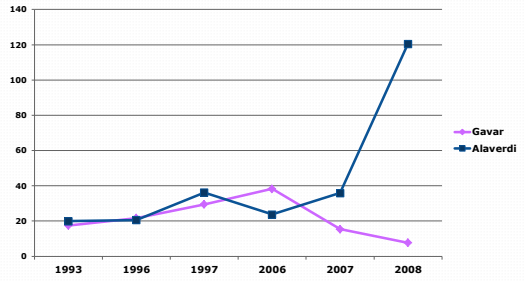
- **Arsenic above IMC**
  - 100% (11/11) composite samples of residential soil
  - 100% (2/2) composite samples of kindergarten soil
  - 100% (1/1) composite sample of garden soil
- **Chromium above IMC**
  - 72.7% (8/11) residential soil
  - 100% (1/1) garden soil
- **Lead above IMC**
  - 9.1% (1/11) residential soil
- **Cadmium above IMC**
  - 100% (1/1) garden soil

Source: AUA School of Public Health. *Inductively coupled plasma-mass spectrometry (ICP-MS).*

Alaverdi - Arsenic Samples Exceeding IMC (in red)



Lung Cancer Rates per 100000 Pop. in Alaverdi and Gavar Cities



Source: *G. Nazaryan, Geo Alaverdi. Environment and Urban Development , Yerevan, 2009.* THE GLOBAL ENVIRONMENTAL OUTLOOK FOR CITIES PROGRAM BY THE UNEP/GRID-ARENDAL AND OSCE YEREVAN OFFICE

Burden of Diseases in Alaverdi: Absolute Numbers

	2004	2008
Tumors	70	110
Respiratory diseases	31	86
Neurological diseases	211	446
Blood circulation diseases	1127	1398
Dermatological diseases	132	515

Source: *G. Nazaryan, Geo Alaverdi. Environment and Urban Development , Yerevan, 2009.* THE GLOBAL ENVIRONMENTAL OUTLOOK FOR CITIES PROGRAM BY THE UNEP/GRID-ARENDAL AND OSCE YEREVAN OFFICE

Copper Mining in Akhtala, 2001

Lead exceeding the US EPA action level 400mg/kg:

- 11% of all 9 yard samples including playgrounds
- 17% of all 12 loose soil s. front of building entrance

Arsenic:

- 58% of soil samples exceeded the *international maximum concentration of 12mg/kg*

Source: Petrosyan V. et all. Lead in residential soil and dust in a mining and smelting district in northern Armenia: a pilot study. *Environmental Research, 94 (2004), 297 – 308.* *NITON XL-723 Multi-element XRF analyzer*

Copper Mining in Akhtala, 2013 (Hazard Identification)

- **Arsenic above International Maximum Concentration (IMC)**
  - 100% (4/4) composite samples of residential soil
  - 100% (1/1) composite samples of kindergarten soil
  - 100% (2/2) composite samples of garden soil
- **Chromium above IMC**
  - 50% (2/4) residential soil
  - 100% (1/1) kindergarten soil
- **Cadmium above IMC**
  - 25% (1/4) residential soil
  - 100% (2/2) garden soil
- **Lead above IMC**
  - 25% (1/4) residential soil
  - 50% (1/2) garden soil

Source: AUA School of Public Health. *Inductively coupled plasma-mass spectrometry (ICP-MS)*

Yard Soil of the Church in Akhtala, 2013

- **Arsenic above International Maximum Concentration (IMC)**
  - 12 times higher
- **Lead above IMC**
  - 11 times higher
- **Cadmium above IMC**
  - 1.1 times higher

Toxic Site Identification Program - Armenia

School of Public Health

Acopian Center for the Environment

Blacksmith Institute

Objectives of the Study

- Toxic site identification project (TSI) - a joint effort by the Blacksmith Institute, World Bank, European Commission and other partners to develop a comprehensive database of toxic contamination locations in low/middle-income countries
- Blacksmith's Initial Site Assessment (ISA) protocol to evaluate sites where toxic pollution may impact human health
- Eligible sites
  - Located in Armenia
  - from "point-sources" (fixed locations, not cars/trucks)
  - where there is a migration pathway for the pollution source to people
  - a potential human health impact

Methods

- Site observation and description
- Rapid stakeholder analysis with community members, local authorities (medical staff and mayors office), representatives from some NGOs
  - 115 participants
- Water and soil sampling
  - Tested using inductively coupled plasma-mass spectrometry (ICP-MS), total dissolution performed prior to analysis

Toxic Sites and Collected Samples

- Investigated 19 communities in 6 marzes impacted by
  - 10 mines
  - 15 active or abandoned tailing ponds and 1 open tailing pipe
  - 1 active and 1 abandoned smelter
- Collected 112 samples
  - 20 water (18%)
  - 92 composite soil (82%)

Environmental Sampling

Soil – 92 samples

- Agricultural 29 samples
  - private gardens near housing, pastures, cultivated areas far from housing
- Residential 40 samples
  - yards, streets, playing areas in front of housing
- School/kindergarten 23 samples
  - play grounds

Water -20 samples

- Irrigation 16 samples
  - from water reservoirs and rivers using for both irrigation and fishing
- Drinking 4 samples

Soil Sample Analysis

Source for IMC: Blacksmith Institute	*Residential soil international maximum concentration Mg/kg*	% of residential soil samples above IMC n/N	% of school/ kindergarten playground soil samples above IMC n/N	*Agricultural soil international maximum concentration Mg/kg*	% of agricultural soil samples above IMC n/N
Chromium	*64*	**65.0** 26/40	**39.1** 9/23	*64*	**51.7** 15/29
Cadmium	*14*	**5.0** 2/40	**0.0** 0/23	*1.4*	**3.4** 1/29
Arsenic	*12*	**52.5** 21/40	**39.1** 9/23	*12*	**34.5** 10/29
Lead	*400*	**5.0** 2/40	**0.0** 0/23	*400*	**6.9** 2/29

Observations
Interviews
Discussions

Impact of Toxic Waste Sites on the Environment and Health - Observations

- Neglected state of tailing ponds
  - Lack of proper fencing and warning signs
  - Some abandoned tailing ponds used as pasture sites or gardens
- No systematic and adequate monitoring of tailing ponds
- Multiple accidents, breaks, and leakages from tailing ponds or tailing pipes affecting communities
- Located near residential areas or have a migration pathway to people through rivers, pastures and cultivated lands
- In some places tailings were used as construction material by community residents
- Children exposed to heavy metals mainly through contaminated soil in their yards and playgrounds

Specific Negative Impacts – Stakeholder Reports

- ***Flora*** – reduced fertility and quality of some vegetables and fruits
- ***Fauna*** – some species of animals disappearing (e.g., frogs and fish) in polluted rivers
- ***Human*** – increased number of myocardial infarction and stroke, hypertension, gastrointestinal diseases, fatigue, malignant tumors, allergies, birth defects, infertility, respiratory diseases, headaches, and diabetes

Mining Wastes Near the Communities

Mining wastes in the river flowing through residential areas

Mining waste in the school yard source of exposure for children

Leakage from the tailing pond to the community road

Socio-Economic Impact of Mining on Communities – Stakeholder Reports

- Residents often forced to sell property to mining companies without proper compensation
- Low salaries of community members working in mines
- No medical insurance for mining workers or community
- Fear of residents to raise concerns, particularly those who have family members working in mines
- Lack of trust towards policy and decision makers to resolve mining related socio-economic and health issues
- Damage to housing because of explosions and vibration
- Dust, noise, vibration and smell disturbing residents
- Agricultural products from polluted areas not competitive in the market because of being considered contaminated

Strengths and Limitations

Strengths

- First large scale risk assessment in Armenia
- Samples tested in a laboratory certified by a European reference laboratory

Limitations

- No extra quality control measures taken by the research team (i.e., absence of standard or duplicate samples)
- Initial assessment / hazard identification - limited scope: low number of environmental samples

Recommendations

- Thorough environmental and health risk assessment in communities where hazards identified
- Educate communities on prevention of heavy metal exposure
- National Action Plan - Immediate clean up of certain sites, particularly school and kindergarten playgrounds
- Immediate upgrading of ore processing and smelting plants and adequate storage of tailings in line with international norms and standards to reduce the damage to the health of people and environment
- Systematic environmental and health monitoring of active and abandoned tailing ponds, mining and smelting sites and nearby communities
- Appropriate health protection and coverage of mining workers and affected communities