Management of Mercury and Mercury-Containing Waste

Mercury Analysis and Results of Chile

Mercury Waste Project Final Workshop
June 2010
Milestone

- Prepare Terms of Reference (Sept, 15, 2009)
- Adjudgment to Fundación Chile (Oct, 24, 2009)
- Contract Sign (Oct, 29, 2009)
- Inception Workshop (Nov, 2 y 3, 2009)
- Meeting with Fundación Chile (nov 9-Dic 10)
- Preliminary Report (Dic 2009)
- Final report (Jan, 2010)
- Final Workshop (March, 19, 2010)
- Final report delivered to UNEP (May, 13, 2010)
Specific Objectives

1. Review of environmentally sound management (ESM) guidelines determine its applicability at national level
2. Evaluation of the capacity of national laboratories for analysis of Mercury.
3. Develop an Preliminary Risk Assessment of a selected site
4. Remediation options and preliminary cost estimates associated.
1. Review ESM Guideline


2. General observations were made of the guidance and specific comments for each chapter.

3. This review was conducted by two professionals of Fundación Chile, and its international advisory Dr. Andreas Zimmermann.
2. Evaluation of the capacity of national laboratories for analysis of Mercury.

1. It generated a record audit in order to recognize the national laboratories carrying out analysis of mercury in environmental matrix.

2. Clinical laboratories were considered most important environmental and national level.

3. Telephone interviews were conducted with managers of these laboratories and in some cases the information was sent audit for review and response.

4. We conducted a database with the results of the surveys.
3. Develop an Preliminary Risk Assessment of a selected site

Model of an Environmental Risk Assessment (U. S. EPA, 1989)

- Problem
- Site Characterization
- Valuation of Exposure
- Valuation of Toxicity
- Risk Characterization
- Communication
4. Remediation options and preliminary cost estimates associated.

1. Analysis results delivered

2. Determine remedial measures for site 1.

3. This review and proposal for remediation was carried out by Fundación Chile professionals and Dr. Andreas Zimmermann.
Methodology
Risk assessment is a quantitative and qualitative process, which determines the probability that they produce effects on the health of people who are exposed to environmental hazards.
Risk Assessment

- Ecology
- Engineering
- Toxicology
- Geology
- Biology
- Statistics

Multidisciplinary Analysis
Environmental Risk Assessment

Methodology

Characterization Area

- Water Quality
- Air Quality
- Climatology
- Flora y Fauna
- Geology and soil
- Demographic Variables

Characterización del área
Environmental Risk Assessment Methodology

Identification Problem

Recognized Area

Identify the problem

As is planned to characterize this
Environmental Risk Assessment Methodology

**Site Characterization**
Identification of the existence of hazardous substances

**Nature**
- Source
- Contaminated environmental component selection

**Extension**
- Involved Area
- Affected population

**Concentración**
- Sampling Plan
- Chemical Analysis
Environmental Risk Assessment Methodology

Characterization Site

Coordination with analytical laboratory

The quantitative chemical analysis were carried out by the National Environment Centre (CENMA), an organization with quality control and analytical capacity of environmental samples.
Environmental Risk Assessment Methodology

Characterization Site

- Analytical Results
- Data Analysis
- Selection of Contaminants of Potential Risk
- Reference Criteria (Benchmarks)
Environmental Risk Assessment Methodology

Exposure Assessment

- Using algorithms to estimate absorbed doses
- Recognize exposure routes
- Define receptors
- Develop conceptual model of the problem

To estimate the type and magnitude of exposures to chemicals on the site and are of concern
Environmental Risk Assessment Methodology

**Receptors**

**Exposure Assessment**

- **Scenario 1:** Adults and children living next to the site.
- **Scenario 2:** Working adults who are developing their work at 20 meters from the site.
- **Scenario 3:** Visitors to both adults and children who visit the area on holidays or other instances.
- **Scenario 4:** Potential Workers at the site remediation activities.
Environmental Risk Assessment Methodology

Calculation of exposure dose

- Ingestion
- Specific algorithms
- Inhalation of particles
- Skin Contact
# Environmental Risk Assessment Methodology

## Conceptual Model

<table>
<thead>
<tr>
<th>Source</th>
<th>Mechanism of transport</th>
<th>Source</th>
<th>Mechanism of transport</th>
<th>Exposure Medium</th>
<th>Receptors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary</td>
<td></td>
<td>Secondary</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Erosion by wind</td>
<td>Particles suspended</td>
<td>Infiltration and percolation</td>
<td>Ground water</td>
<td>Superficial water</td>
<td>Skin, Oral, Inhalation</td>
</tr>
</tbody>
</table>

### Receptors
- Residential
  - Adult
  - Child
- Worker
  - Adult
  - Child
- Visitor
  - Adult
  - Child

### Assumptions
- Not considered
- Considered
Environmental Risk Assessment
Methodology

Toxicity Assessment

- Definite substances of concern
- Toxicological review
- Toxicological profiles generated
- Toxicity values are defined for each pollutant

Toxicity values defined

They are used in risk characterization stage
Environmental Risk Assessment Methodology

Risk Communication

- Obtained results
- These should be communicated to those responsible for risk management
- Management measures
Reviewing ESM Guideline

**Strengths**
- Relevant information regarding sources, uses, process and toxicology profile for mercury, taking international recognized sources
- Extensive international literature review about the mercury problem

**Weaknesses**
- Is recommended to be translated into other languages
- It requires more detail or more specific guidelines in relation to the gold mining activities
### Laboratory Survey

#### North Zone
- Analyze Mercury: 6
- No analyze Mercury: 51
- No answer: 16
- Total laboratories: 73

#### Metropolitan Zone
- Analyze Mercury: 18
- No analyze Mercury: 29
- No answer: 20
- Total laboratories: 67

#### Zona Sur
- Analyze Mercury: 6
- No analyze Mercury: 59
- No answer: 9
- Total laboratories: 74

Of a total of 214 laboratories surveyed, 30 laboratories carrying out analysis of mercury, they are mainly concentrated in the metropolitan area, with 60% of the laboratories that perform this type of determination in different environmental matrices.
Main Outcomes

Characterization Area

- Andacollo
  - 10,288 inhabitants
  - 5,140 women
  - 5,148 men
  - 91.2% is urban population and 8.8% are rural
Main Outcomes

- Mining 36%
- Construction 16%
- Trade 14%
- Agriculture and livestock 13%
- Other activities represent 27% of economic participation
Main Outcomes

Hydrology and Hydrogeology

- Andacollo basin contains a watershed of about 43 km²

- Its natural discharge is in the northeast corner of it, by the gorge of Andacollo.

- The drainage of the watershed is dendritic type, this drainage is formed by many tributaries, which are dry most of the year.
Main Outcomes

Ground Water

- Different type of quality in the basin.
- Areas high "good quality."
- Lower area of the watershed "High contents of metals and low pH."

Air

On Monday April 6, 2009, the town of Andacollo and surrounding areas saturated zone was declared as respirable particulate matter, PM 10, as the concentration of 24 hours annually.

The statement is based on the results of official monitoring PM10.
Main Outcomes

Andacollo mining activities

- Today in Andacollo operate two major mining projects, which correspond to the activities of Dayton Mining Company which extracts gold and Carmen de Andacollo Mining Company which draws copper mainly.

- In relation to small-scale mining and artisanal mining that takes place in the commune of Andacollo, these activities use extraction and processing of crude ore, which include the use of the “trapiche”.

Carmen de Andacollo Mining Company

Dayton Mining Company
Main Outcomes

Environmental Problems Andacollo

- The process of extraction and recovery of metals from a mine, it generates a massive amount of waste. Which is classified into two types, waste from the metal recovery process (tailings, slag and rubble), and discard material from the mine that has not entered a beneficial process, as are the “sterile” (Universidad de Chile, 2006). These waste generate a series of problems and environmental risks to human populations and for other ecological receptors (OECD, 2005).
Main Outcomes

Problem
Main Outcomes

Site Selection Study

Sitio 1
Main Outcomes

Site Features

- Tailings deposit type “torta”
- Area: 4500 m²
- Maximum Height: 20 m
- 71,000 m³
- 60° slope
- Nearby towns
### Main Outcomes

#### Site 1 characterization

<table>
<thead>
<tr>
<th>Site’s name</th>
<th>Whittle Plant</th>
</tr>
</thead>
<tbody>
<tr>
<td>Owner</td>
<td>Whittle Cortes Sanfrancisco</td>
</tr>
<tr>
<td>Actual State</td>
<td>Abandoned</td>
</tr>
<tr>
<td>Area (m²)</td>
<td>4500 m²</td>
</tr>
<tr>
<td>Maximum Height</td>
<td>15 – 20 m</td>
</tr>
<tr>
<td>Average slope downstream slope</td>
<td>60°</td>
</tr>
<tr>
<td>Access</td>
<td>Free, with minor restrictions</td>
</tr>
<tr>
<td>Active years</td>
<td>Approximately 30 years</td>
</tr>
<tr>
<td>Origin of waste</td>
<td>Different mining sites</td>
</tr>
<tr>
<td>Mining Process</td>
<td>Gold and cupper</td>
</tr>
</tbody>
</table>
Main Outcomes

Sampling and Analysis
- F. Chile
- CENMA

International Laboratory
- Abberden University
- Delivered Result on June 18, 2010
Main Outcomes

Exposure Assessment

In this project only assessed the potential risk to human populations Site 1.

Primary source of contamination, the tailings material that is disposed at Site 1.

The main routes of exposure are respiratory tract, ingestion and dermal contact.
Conclusions

Risk Assessment:
- Principal route of exposure: inhalation of particles.
- Main Contaminants: mercury, copper and molybdenum.

Identified Risks

- Mobilization of tailings by wind (inhalation, dermal contact).
- Development activities in the area of the site (inhalation, accidental ingestion or skin contact).
- People falling slope
- Failures in the slope of the tailings deposit
- Leachate infiltration.
Conclusions

Mitigation Measures

Access Closed

- Discourage entry by the deposit of tailings and thus minimize the risk of accidents for people and direct exposure to the tailings, it is proposed fencing off the deposit in its entirety through a gate.

Windbreak mesh installation

- Reduce the effect of wind erosion and emission of particulate material and tailings into the atmosphere.
## Conclusions

**Remediation Measures**

<table>
<thead>
<tr>
<th>In-Situ Measures</th>
<th>Ex-Situ Measures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coverage permeable</td>
<td>Remobilization and disposal</td>
</tr>
<tr>
<td>Impervious coverage</td>
<td>Remobilization and recovered</td>
</tr>
</tbody>
</table>
Recommendations

Remediation Actions
- Implementation of measures to control risk

Complementary Studies
- Survey and preliminary characterization of PAMs in Andacollo Commune.
- Study of the legal status of PAMs
- Detailed risk assessment (cumulative effect).
- Design Study of Risk Management for Andacollo Commune
- Communication Strategy and Risk Management
## Recommendations

<table>
<thead>
<tr>
<th>Category</th>
<th>Items</th>
</tr>
</thead>
<tbody>
<tr>
<td>Survey liabilities</td>
<td>Location, Tailings cubing</td>
</tr>
<tr>
<td>Liabilities preliminary Characterization</td>
<td>Sampling, Chemical Analysis</td>
</tr>
<tr>
<td>Risk Assessment</td>
<td>Specific Site, Basin level</td>
</tr>
<tr>
<td>Legal Study</td>
<td>Legal Statum of liabilities, Owner Identification</td>
</tr>
<tr>
<td>Communication strategy and risk management</td>
<td>Risk Communication to habitant and authorities, Strategy to institutional risk management (founds, etc.)</td>
</tr>
</tbody>
</table>