Managing the Health Impacts of Aluminum Smelters

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Managing the Health Impacts of Aluminum Smelters

• Objectives
  – Present the major health issues associated with aluminum smelters in workers and communities in the vicinity of the smelters
  – Discuss strategies to prevent adverse health effects in workers and communities in the vicinity of smelters
Yale-Alcoa Partnership

- January 1997 – Agreement between Alcoa and Yale University
- Research & consultative services in environmental, health & safety
- Occupational & Environmental Health Advisory Council (OEHAC)
Worker vs. Community Health

• Worker’s Health
  • Healthy workforce, 17-65 yrs
  • Higher exposure to substances
  • More options for control within the plant
  • Employees can be monitored easily

• Community Health
  • Children, pregnant women, elderly
  • Much lower exposure to substances
  • Main control is to limit air emission, waste and water discharge
  • General public less easily monitored
Aluminum Production

Mining of bauxite

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Bauxite refining to produce Alumina

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Alumina smelting to produce Aluminum
Aluminum Smelting

- Alumina smelting to aluminum by Hall-Héroult process (1886)

- Smelting technology
  - Söderburg smelters uses anodes baked in pot
  - Pre-bake smelters uses anodes pre-baked in separate facility
Aluminum Smelting

- Alumina dissolved in molten cryolite (sodium aluminum fluoride) in large carbon lined steel pot
- Electric current flows between carbon anode made of petroleum coke & pitch and cathode formed by pot lining
- Molten aluminum deposited at the bottom of the pot & siphoned off for casting ingots.
Aluminum Smelting

Emissions
Fluorides from bath
Particulates, CO2, SOx, PAHs,

Heat Loss

Cathode Block
Alumina Hopper
Molten Aluminium
Gases
Fluoride Hopper
Anode
Electrolyte
Molten Aluminium
Cathode Block

YALE UNIVERSITY
SCHOOL OF MEDICINE
Primary Emissions from Aluminum Smelters

- Coal Tar Pitch Volatiles (PAHs)
- Fluorides
  - Gaseous fluorides
  - Particulate fluorides
- Sulfur dioxide (SO$_2$)
- Alumina dust
Coal Tar Pitch Volatiles

Health Effects
Coal Tar Pitch Volatiles (CTPV)

• Distillation product from coal
• Made up of chemicals called polycyclic aromatic hydrocarbons (PAHs)
• Sources in Aluminum industry
  – Carbon anode: Petroleum coke & pitch
  – Carbon or graphite pot lining
Polycyclic Aromatic Hydrocarbons: PAHs

• PAHs are formed from incomplete burning of almost any fuel

• Common Sources
  – Forest fires
  – Domestic heating
  – Vehicle exhaust
  – Waste incinerators

• Industrial activities
  – Aluminum, coke, gas, asphalt, iron & steel plants, transportation industry
  – Other activities using materials from organic matter like coke, coal tar, pitch, creosote, asphalt, diesel, heavy oil
Aluminum Workers & Cancer Risk

- Lung & bladder cancer reported in Canadian Söderberg Smelters workers (1950-1979) exposed to large levels of coal tar pitch volatiles over long periods.

- Similar observation reported in smelter workers in other countries. Other studies have also reported pancreas & kidney cancer.

- These studies have shown levels of exposure to CTPV that causes cancer & levels that did not cause cancer.
Cancer Risk

![Graph showing the increase in cancer rate with age.](image)

The graph illustrates the background risk of cancer over age, with a steep rise as age increases.
Cancer Risk

![Graph showing the relationship between age and cancer risk. The graph plots age (years) on the x-axis and cancer rate on the y-axis. Two curves are shown: one representing background risk and the other representing an increase in risk with age.](image)
Management of Cancer Risk

![Graph showing cancer rate against age with and without controls.](image-url)
Strategies to Prevent Cancer Risk in Workers

- Establish safe levels of exposure limits for workers
- Engineering control
  - Prebake (newer technology); anode made in separate facility with automated process & emission control
  - Cell hooding & ventilation in potroom
  - Automated cranes & equipment to minimize worker activity near cells
- Use of personal protective equipment for certain tasks
- Education and training of workers
- Medical surveillance of workers
## Cancer Risk From Studies of Aluminum Smelter Workers

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<th>Relative Risk</th>
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Range of exposures for workers in Armstrong study
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**Range of exposures expected for workers in modern Prebake smelter**

**Range of exposures for workers in Armstrong study**
Strategies to Prevent Cancer Risk in Workers

- More recent study following workers from Prebake smelters in Victoria, Australia (1984-present) with changes in technology and work practices have not shown increase risk of cancer.
Risk of Cancer in Communities in the Around Aluminum Smelters

- PAHs are widely distributed in environment
- Levels higher in urban vs. rural areas
- Söderberg smelters release more PAHs compared to Prebake smelters
- Levels of PAHs in communities around aluminum plants especially Söderberg smelters can be high
- Levels of PAHs at the boundary of smelters much lower compared to levels inside the plant
Risk of Cancer in Communities in the Around Aluminum Smelters

- Norwegian study of cancer in communities surrounding 4 aluminum smelters which had been operating for more than 30 years

- New cases of cancer diagnosed between 1960-1991 was compared to the expected numbers of cancer for the same population based on national averages

- Incidence of cancer was not different in the communities studied compared to the rest of the country
Risk of Cancer in Communities in the Around Aluminum Smelters

- Safe air limits for PAHs have been developed by regulatory agencies.
- If PAH emission is kept below the safe limits at the boundary of the facility, the community should be safe.
- This can be achieved by emission controls using appropriate technology within the plant.
Fluorides

Health Effects
Health Effects of Fluorides

- Ingestion of fluorides at low levels prevents dental cavities and useful for the treatment of osteoporosis

- Exposure to very high levels of fluoride through breathing or drinking water may cause fluorosis:
  - Teeth discoloration
  - Bone pain & decrease spine mobility

- Exposure to fluorides can also cause irritation of upper airway & asthma
Fluoride Exposure in Workplace: Fluorosis

- 1932 in cryolite workers in Denmark
- Also reported in aluminum and fertilizer workers
- Fluorosis occurs when exposure in the workplace is over 3.8 mg/m$^3$ of fluoride
- Workplace standards to prevent fluorosis was implemented many years ago
- Fluorosis has not been reported in smelter workers in over 30 years where fluoride exposure was controlled $\leq 2.5$ mg/m$^3$
Fluoride Exposure in Community: Fluorosis


- No similar reports from smelters in Western Europe, North America, Australia, South America

- Fluorosis unlikely to occur in the vicinity of a modern Prebake smelter
Fluoride Exposure in Workplace: Asthma

• There continues to be a modest increase risk of asthma among workers from exposure to lower levels of fluorides and other irritants in the workplace.

• Control measures that prevents fluorosis not adequate for prevention of asthma in workers.

• Lower exposure levels to prevent asthma 0.4-0.6 mg/m³ has been recommended and implemented by countries like Norway and some companies.
Fluoride Exposure to Community: Asthma

– No reports of increase incidence of respiratory diseases in residents of communities living in vicinity of Prebake smelters

– Asthma and other respiratory diseases can be prevented in the vicinity of a modern Prebake smelter by controlling fluoride, dust & SO$_2$ emissions using:
  – Low emission technology designed to capture and recycle most of the emissions
  – Adequate buffer zone
Conclusion

- Successful control of health hazards can be achieved in a properly run modern aluminum smelter by:
  
  - **Workplace**
    - Modern technology
    - Engineering
    - Personal protective equipment
    - Medical Surveillance
  
  - **Community**
    - Controlling emissions below established standards
    - Ongoing monitoring & audits of air, water and soil
• Questions?