HEALTH EFFECTS – INHALABLE COAL DUST

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Topics to be Covered

- Anatomy of the respiratory system
- Lung defences
- Particle size and deposition
- Inhalable, thoracic and respirable dust
- Health hazards of inhalable coal dust
- Summary
Respiratory Anatomy

• **Upper Respiratory Tract:**
  – Nose, nasopharynx
  – Pharynx
  – Larynx

• **Lower Respiratory Tract=Tracheobronchial Tree**
  – Bronchi, respiratory bronchioles, alveoli
Respiratory anatomy

• **Conducting airways**
  – Trachea, bronchi, bronchioles

• **Gas exchanging airways**
  – Respiratory bronchioles
  – Alveolar sacks
Lung Defence

• Three lines of defence of lung against foreign particles:
  1. Particle deposition in upper airways
  2. Fluids lining passages and muco-ciliary escalator; macrophage scavenger cells
  3. Specific immune defences
     Humoral and cell mediated immunity
Three Lines of Defence

• Particle deposition in upper airways:
  – By impaction, sedimentation, diffusional deposition

• Receptors can initiate sneezing, coughing to expel particles

• Receptors can initiate constriction of bronchial smooth muscle as a response to chemical or mechanical irritation
Ciliated Respiratory Epithelium

Figure 13.6  Ciliated tracheal epithelium from adult Fisher 344 rat (4,000×). (Courtesy of George Schifflersky, Brookhaven National Laboratory.)
Total deposition as a function of particle size

Figure 13.1 Total deposition (fraction inhaled) as a function of particle size (MMD, d<0.5 μm; MMAD, d>0.5 μm). (From Scheuch G, Stahlhofen W. Deposition and dispersion of aerosols: the airways of the human respiratory tract: the effect of particle size. Exp Lung Res. 1992;18:343–358 with permission.)
Tracheobronchial Deposition vs Particle Size

Figure 13.2 Tracheobronchial (TB) deposition, fraction of aerosol entering the trachea, as a function of particle size (MMD, d<0.5 μm; MMAD, d>0.5 μm). (From Scheuch G, Stahlofen W. Deposition and dispersion of aerosols in the airways of the human respiratory tract: the effect of particle size. Exp Lung Res. 1992;18:343–358 with permission.)
Figure 13.3  Alveolar (gas-exchanging region) deposition, fraction inhaled, as a function of particle size (MMD, d<0.5 μm; MMAD, d>0.5 μm). (From Scheuch G, Stahlhofen W. Deposition and dispersion of aerosols in the airways of the human respiratory tract: the effect of particle size. Exp Lung Res. 1992;18:343-358 with permission.)
Respiratory Disease in Coal Workers

• **Coal Workers Pneumoconiosis**
  – Basic lesion is the coal macule

• **Progressive Massive Fibrosis**
  – More severe form of CWP

• **COPD**
  – Chronic obstructive pulmonary disease
Respiratory Disease in Coal Workers

- **Silicosis**
  - Due to exposure to hard rock eg in drillers and blasters

- **Others**
  - Changes in lung function correlate with coal dust exposure over the years
    - Fall in FEV1
    - Fall in FVC
Summary so far

- The lung can be dividing into conducting airways and gas exchanging airways.
- There are mechanisms to protect all of the airways from inhaled particles.
- Particle size is important in penetration and deposition.
- Serious Diseases can result from the retention of hazardous dusts.
Inhalable fraction

- **Inhalable fraction:**
  - Is defined as the mass fraction of total airborne particles that are inhaled through the nose and/or mouth
  - Includes the thoracic and respirable fractions
Thoracic fraction

• The mass fraction that penetrates the respiratory system beyond the larynx
• Includes the respirable fraction
Respirable fraction

- Respirable fraction:
  - The mass fraction that penetrates to the unciliated airways of the lung
  - i.e., the alveolar region where the gas exchange takes place
Review of Health Effects due to Inhalable Coal Dust

• 2005 Report by Martin Jennings & Martyn Flahive
• Available on Coal Services website:
Jennings & Flahive: Research brief

• What are the adverse effects of inhalable coal dust?
• Are comparisons with other inhalable dusts useful?
• What is a suitable Workplace Exposure Standard for inhalable coal dust?
• What degree of protection does it provide for specific health outcomes?
Effects Examined

• Jennings & Flahive examined:

• Extra-thoracic effects:
  – Cancer of larynx, pharynx, buccal mucosa
  – Cancer of the stomach

• Thoracic effects:
  – Chronic bronchitis
  – COPD
Jennings & Flahive: findings

- Cancer – larynx, pharynx, buccal
  - Only limited no.s of reports examining this relationship
  - No significant research identified any relationship
Jennings & Flahive findings

• Gastric cancer-
  – More studies made on the relationship between coal dust and gastric cancer
  – No conclusive evidence of a dose-response relationship with either inhalable or respirable coal dust
  – A relationship is biologically plausible but can be explained by lifestyle & other confounding factors
Overall cancer findings:

• Insufficient evidence to classify coal dust as a carcinogen
Findings: Thoracic Effects

• Inhalable dust and Chronic Obstructive Pulmonary Disease:
  – No research found on this
  – Further research suggested:
    • Eg by monitoring NSW coal miners incidence and prevalence of CORD, and upper airways disease for correlation with inhalable dust levels
Findings:

- Correlation between inhalable and respirable dust fractions

- Unlike overseas studies, no relationship found under Australian conditions
Findings

- No comparisons between inhalable coal dust and other dusts can be made.
- Due to coal dusts unique physico-chemical properties.
- Difficult to suggest a health based standard for inhalable coal dust.
- Further work suggested.
Findings

- Proposed standard of 10mg/m$^3$
- Designed to reduce eye and nose irritation
- Designed to improve visibility
# Health effects of coal dust

<table>
<thead>
<tr>
<th>INHALABLE</th>
<th>RESPIRABLE</th>
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<tbody>
<tr>
<td>Reduced visibility</td>
<td>CWP</td>
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<tr>
<td>Irritation of eyes</td>
<td>PMF</td>
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<tr>
<td>Irritation of nose</td>
<td>Silicosis</td>
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<tr>
<td>Irritation of pre-existing conditions eg asthma</td>
<td>COPD</td>
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<tr>
<td>COPD- research lacking</td>
<td>Reduction in FEV1</td>
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<tr>
<td>Cancer- not established</td>
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Sampling Convention for Particle Size Fractions

Figure 1: Particle size fractions (i.e. inhalable, thoracic, respirable) for health-related sampling in workplaces that have been internationally agreed by CEN, ISO and ACGIH.