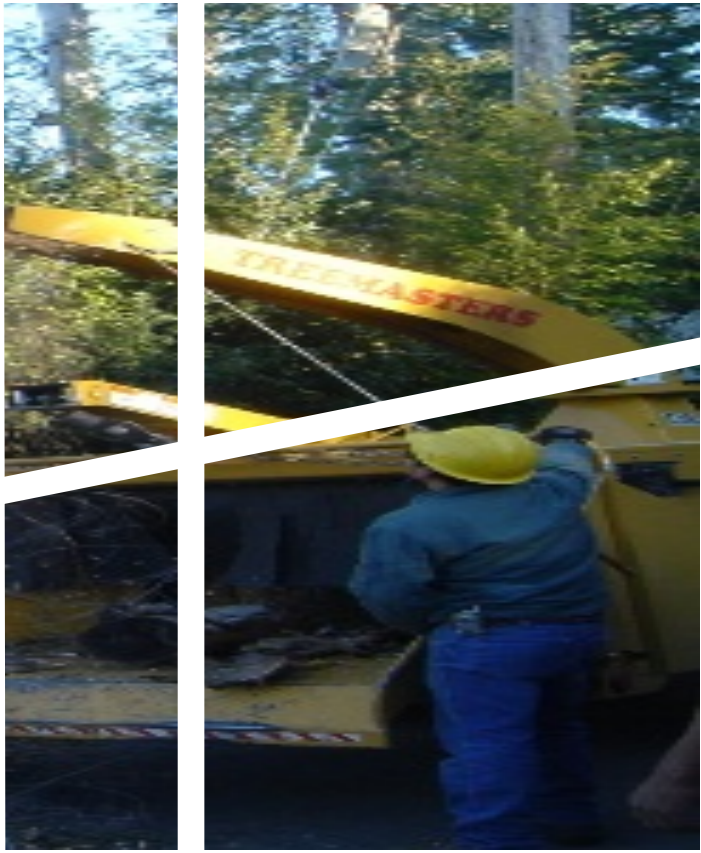
Dusts and bioaerosols in the production and handling of waste and biomass derived fuels

Sources, hazards and mitigation



Pat Wheeler, Task 36 UK representative

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What are bioaerosols?

Bioaerosols include all biological particulates suspended in air, as both viable and non-viable microbes and or their constituent elements such as: whole bacterial and fungal cells, parasites, spores, moulds, pollens and algae, as well as cell fractions and submicron elements such as biopolymers, mycotoxins, endotoxins, viruses and other organic material.

American Conference of Governmental Industrial Hygienists 1999.

- Or simply, organic dust that is
  - Suspended in the air
  - bacteria alive or dead
  - Fungal cells and spores
  - Pollen etc.
  - parts of cells and organic material
  - “active” biological compounds e.g. endotoxins, glucans etc.
- Endemic in the environment and not a health hazard under normal conditions

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How do bioaerosols affect health

- Three mechanisms which bioaerosols can cause health effects
  - Physical
    - Where the physical interaction of the particle with the respiratory tract generates health impacts, e.g. mucus membrane irritation
  - Irritant/ allergenic
    - Where the biological particle generates an immunological response from the biological nature in the host such that adverse health effects are experienced, e.g. ODTS, asthma, rhinitis, hay fever
  - Pathogenic
    - Where a viable organism is inhaled and the organism propagates and infects the host causing disease, e.g. legionella, aspergillosis

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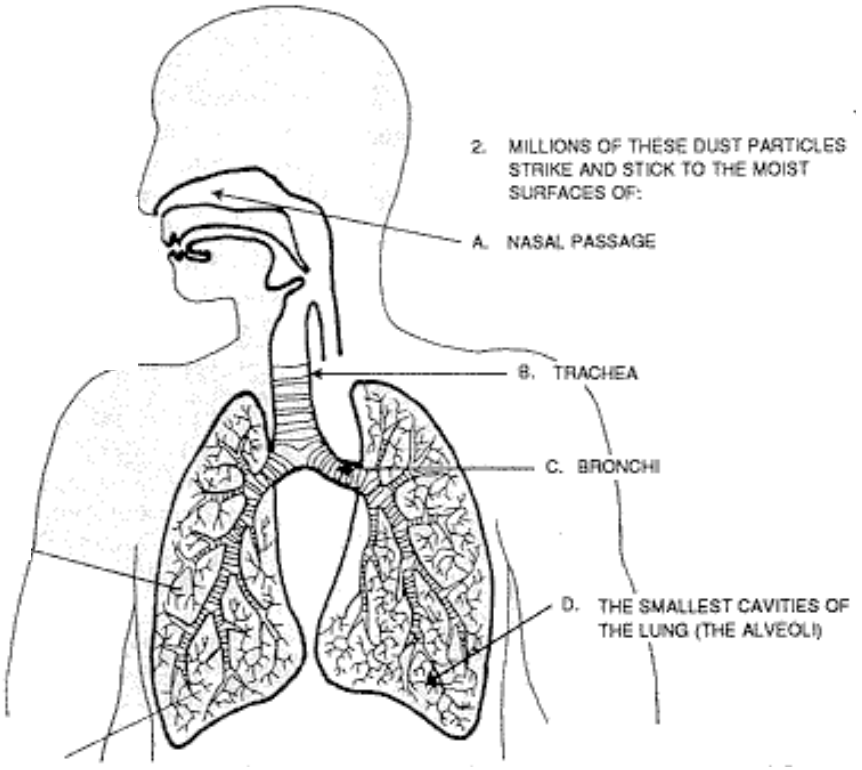
Size is important!

- The effect of particles on the body is determined by their size as this a how far they enter the lung
  - Inhalable Dust <100 µm
    - Captured in upper respiratory
  - Thoracic Dust <10 µm
    - Captured in bronchi.
  - Respirable Dust <5 µm
    - Penetrate to alveoli.

Lower

Hazard

Higher



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Health effects - Physical

Dust level limits exist for generalised dust levels both at occupational levels and air quality levels limits for total dust, PM_{10} and increasingly $PM_{2.5}$

- Occupational limits
  - ~10 mg/m^3 total
  - 1-3 mg/m^3 for respirable fractions
- Air quality limits
  - PM_{10} 150-18 $\mu g/m^3$ depending on averaging time and country
  - $PM_{2.5}$ 35-8 $\mu g/m^3$ depending on averaging time and country
- Some specific dust compositions have alternative limits due to additional risk factors e.g. asbestos, silica, mineral etc.

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Health effects - Irritant/allergic

- **Allergic response**
  - Immune system reacts to a specific agent and host becomes sensitised with repeated exposure
  - Impacts vary from mild irritation and breathing discomfort and coughing (e.g. hay fever and similar conditions) to more significant impairment and breathing difficulty e.g. asthma
  - Individual responses vary considerably
- **ODTS**
  - Organic Dust Toxic Syndrome
  - Generally an acute condition with an immune system response **without** sensitisation, as a result of high exposure but without long term effect
  - Symptoms include fever, chills, shortness of breath and influenza type symptoms etc.

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Health effects - Pathogenic

- Organism entering the host and then propagating within the host to cause disease
  - Most likely to be fungi and bacteria
    - Legionella and A. Fumigatus cases have been reported in waste and compost related cases
  - Could occur within respiratory tract or gastrointestinal tract
    - Very unlikely to get infection via dust inhalation and only where other conditions suppress immune system
    - Other infection routes are significant e.g. poor personal hygiene regarding eating and smoking as dose from these likely to be is much higher
  - However if infection occurs then impacts can be serious if not treated

How are they formed

- Contamination of feedstock with active biological matter
- Fines dusts from processing,
  - Shredding/cutting
  - Moving by pneumatic systems
  - Transfer points
  - Loading/unloading
- Degradation and mould formation and spore formation
  - Moist, warm conditions
  - Lack of ventilation
  - Some waste processing option use this as part of the process e.g. composting, biodrying, MBT therefore control regimes are necessarily inherent in the process design

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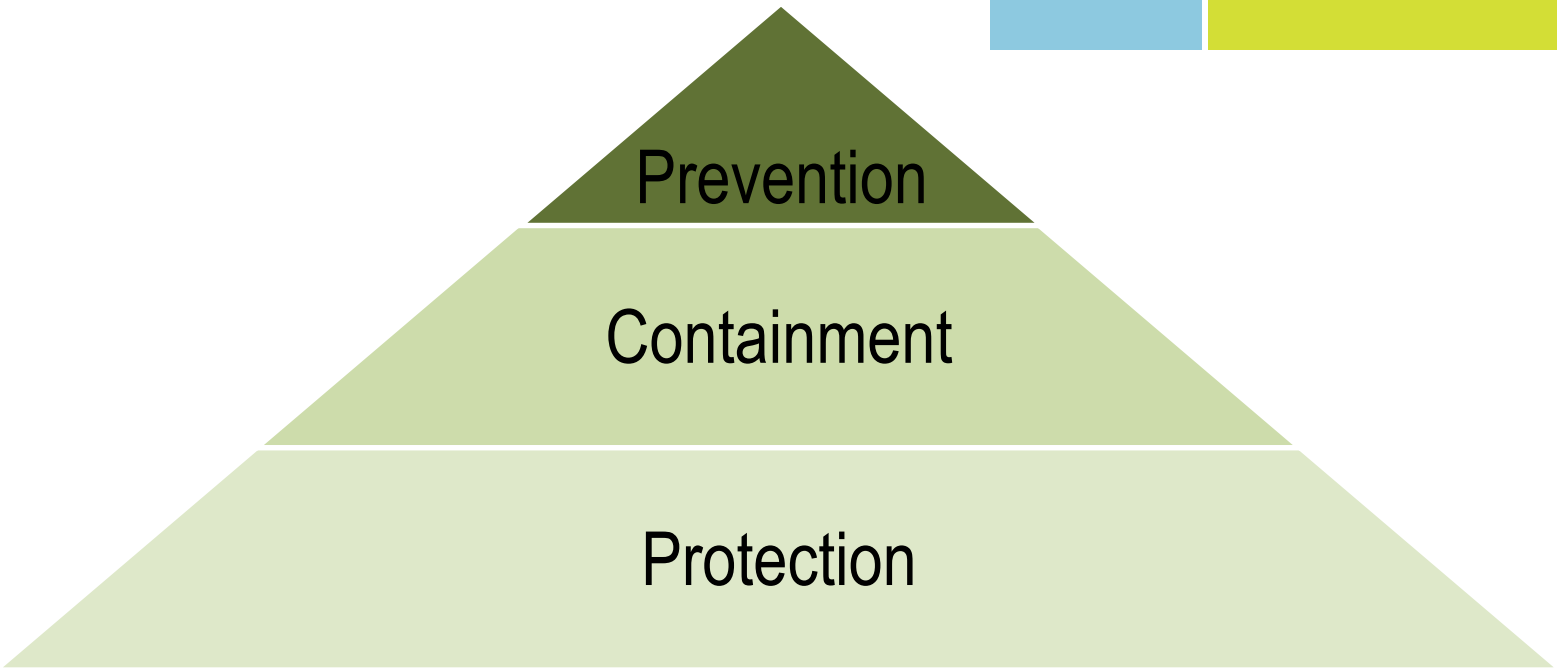
Sources

- Waste industry
  - SRF /RDF production
    - Raw fuels will be active and pose higher risks
    - Dried and heat treated fuel, lower risk but more dusty
- Biomass
  - Forestry and agricultural processes exposure typically during harvesting
  - Conversion of fuel to chips, sawmills, pellets, briquettes, etc.
- Transport, delivery and handling
  - All the fuel s need to be supplied and

How do we avoid problems



- Action needed as often the problematic finest particles are not visible
- if considered at the design stage of a project, the simple measures may be sufficient to control and mitigate the risks

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Reducing production

- Selection of size reduction equipment
  - cutting rather than impact
- Maintaining moisture content at levels where dusts do not become airborne
- Avoiding conditions for mould formation
  - Good ventilation in storage
  - Reduced moisture content
- Providing sanitisation as part of the process to reduce the viability and number of micro-organisms
- Agglomeration - pelletisation, briquetting
- Controlling agitation in the process
  - Control of falling material
  - Loading and stockpile control

Containment

- Controlling generated bioaerosols so that they are contained so that exposure is limited
- Normally installed in production processes as normal dust extraction and ventilation and covered by regulation
  - Ideal to have point source ventilation to capture dusts as they are generated
  - Need to consider dealing with capture dust in a safe way
- Transport and unloading can lead to dust release especially pneumatic systems unless air vent positioning carefully planned
- Smaller and mobile facilities may need extra care as these can be unregulated

Protection

- Protection of operatives and use of personal protective equipment is the last resort, and all attempts to reduce production and contain generated dusts should be made first.
- Simple measures such as ensuring vehicle cabs are closed and have appropriate measures to encourage drivers to keep the windows closed (air conditioning, etc.)
- Variety of breathing protection exist to suit risk; dust masks are the most likely solution but correct specification is needed to collect fine particles
- Education and training is the most important element. Operatives do have to protective equipment along with good operational practice to achieve effective control. Ensuring a good approach and attitude to health and safety is central to avoiding problems.

Conclusion

- Bioaerosols are ubiquitous in the environment and the hazards in biofuel production are derived from high concentration exposure of workers , customers and the public
- Generation from waste fuel production will tend to be higher but agricultural and biomass fuel systems do pose risks from dusts and regrowth of fungi if incorrectly processed or stored
- Health effects are mostly minor impairments but there can be serious health implications in individuals who have compromised immune systems or are exposed to specific viable microorganisms
- The impacts come from both viable microorganisms as well as “dead” organic matter
- Particle size is important and the smallest particles cause the most problems
- Good design of the production , handling and storage systems with consideration of dust will mostly address the exposure.
- The hierarchy of prevention, containment protection should be followed in the approach to addressing the risk

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