What do we know about health impact of road dust?

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Global impact of risk factors on premature death

Global burden of disease from pollution in 2015:

9 mill premature death
16% of all deaths
3 times more than AIDS, malaria and tuberculosis combined
15 times more than all wars and other forms of violence

*Figure 5: Global estimated deaths by major risk factor and cause, 2015*
*Using data from the GBD Study, 2016.*
Majority of impact due to air pollution

Air pollution cause 6.4 million premature deaths annually

Outdoor air pollution: 4.2 million

Global burden of disease from air pollution in 2015:
19% of all cardiovascular deaths
23% of all lung cancer deaths

Estimated 6-9 million annual deaths by 2060 - if not aggressively controlled

Figure 4: Global estimated deaths (millions) by pollution risk factor, 2005-15
Using data from the GBD study and WHO. IHME = Institute for Health Metrics and Evaluation.
Health impact of air pollution in Norway - 2015

Disease burden in Norway 2015 (Folkehelseinstituttet, 2017):

Air pollution 8th most important cause of premature death

Comparable to low physical activity
Health effects from pollution – tip of the iceberg

The impact of pollution on global health is based on established pollution–disease pairs, for which there are robust estimates of their contributions to the global burden of disease.

Quantifiable: (9 mill deaths)

Non-quantifiable (Majority of pollutants and associated health outcomes)

“The health effects of pollution that are currently recognised and quantified could thus be the tip of a much larger iceberg”

– Lancet Commission on pollution and health
Health effects from air pollution

Burden of disease estimates for air pollution are based on pulmonary and cardiovascular deaths.

By now air pollution has also been associated with:

- Asthma and COPD
- Increased risk of respiratory infections
- Neurodegenerative diseases in elderly (dementia and Alzheimer’s)
- Neurodevelopmental disorders in children (ADHD, autism and cognitive effects)
- Preterm birth and birth weight
- Metabolic syndromes (obesity and type 2 diabetes)
Risk factors for adverse effects of air pollution:

- Age (elderly and infants more susceptible)
- Existing diseases
  - Pulmonary disease (asthma, COPD)
  - Cardiovascular disease
  - Diabetes and obesity
- Genetic predisposition (certain polymorphisms in antioxidant genes)
The majority of health impact from air pollution is due to inhalable particulate matter (PM)

Traffic is considered one of the dominating sources
Trimodal size distribution of ambient air PM

Size distribution generation mechanisms of PM in ambient air.

PM < 1 μm and PM > 1 μm are typically generated through combustion (exhaust) and mechanical processes (abrasion/wear), respectively.

Agglomerates of combustion PM may exceed 1 μm.

(Adapted from WHO 2006)
Traffic air pollution

Mixture of gases and particulate matter (PM) from exhaust and wear of road pavement, tires and brakes.

From a regulatory view, the main pollution issues related to vehicle traffic in Nordic countries are high levels of coarse mineral-rich wear PM from abrasion due to use of studded tires in the winter, and nitrogen oxides (NOx) and exhaust PM from diesel vehicles.

Mineral particles
Combustion particles (Diesel exhaust)
Health effects of PM
- Central questions to solve

Which PM sources contributes the most to adverse health effects?
• Toxicity of PM of different sources and composition varies

How do PM of from different sources interact to produce biological effects?
• What is the combined effects of road abrasion and vehicle exhaust?

How does low dose PM-exposure affect health?
• Most studies are from cities with higher PM-concentrations than found in Nordic countries
PM size-fraction specific effects

Coarse PM (PM10-2.5) mainly associated with pulmonary effects

Fine/ultrafine PM (PM2.5/PM0.1) also associated with effects beyond the lung
  • Cardiovascular disease
  • Metabolic syndrome
  • Neurological effects
PM size-fraction specific effects

Size specific effects most likely linked to:

• Size-dependent deposition in the airways

• Difference in physico-chemical characteristics of PM from different sources
Size dependent deposition of particles and aerosols

NOPL: Nose, Pharynx, Larynx (nose, mouth, throat)
TB: Trachea/Bronchi;
P: Peripheral region (alveoli)

\[ \text{PM}_{0.1} \quad \text{PM}_{2.5} \quad \text{PM}_{10} \]

- > 10 μm little penetration into lower airways
- 5-10 μm deposits mostly in upper airways, trachea and bronchi
- 0.01-5 μm may reach bronchioles and alveoli
- < 0.01 μm deposits mostly in upper airways due to diffusion
Coarse PM but not fine or ultrafine PM affect pulmonary responsiveness

Fine and ultrafine PM, but not coarse PM, affect cardiovascular outcomes

NRC/FRC = near road/ far from road coarse PM; NRF/FRF = near road/ far from road fine PM; NRU/FRU = near road/ far from road ultrafine PM
Mineral particles

Health effects:
- Pulmonary inflammation
- Chronic bronchitis
- Fibrosis
- Lung cancer
- Increased susceptibility towards pulmonary infections (tuberculosis)

Fibrosis:
- increased fibrotic tissue
- thickening/destruction of alveolar walls
- reduced lung surface
- reduced $O_2/CO_2$ exchange

![Normal lung and alveoli](image1)

![Alveoli in pulmonary fibrosis](image2)

- Irregular, abnormal air spaces
- Large areas of scarring (fibrosis)
- Irregular, thickening of tissue between alveoli
Mineral composition affects toxicity

Schwarze et al. (2007) Inhal. Toxicol. 19 Suppl 1, 17
Combustion particles

Complex composition with thousands of different compounds adhered to surface
- 10-60% of mass may be organic chemicals (majority unidentified)
- Effect largely due to soluble components (particle act as carrier)

Diesel exhaust particles

Diesel exhaust particles has been found in animal studies to cause or exacerbate, cardiovascular, neurological, and metabolic effects
Fuel composition and exhaust cleansing technologies

50% biodiesel blend increase toxicity

Diesel particle filter (PDF) reduce the mass of emitted DEP

...but increase the inflammatory potential of the particles.

Gerlofs-Nijland et al. (2013)
Environ Sci Technol 47, 5931
How can we improve urban air quality and reduce the health impact from air pollutant in the most efficient way?

Current measures to improve air quality mainly focus on mass reductions. They do not discriminate between toxicity/health effects of emissions from different sources.

- Suitable for defined pollutants such as gases
- Particulate matter (PM) represent variable entities with highly source-dependent properties
- PM from different sources have different reactivity and represents different health hazards
We need to figure out what sources contributes the most to the adverse health effects.

Current evidence suggest that coarse road dust PM10-2.5 may predominately affect the airways.

Fine and ultrafine PM dominated by combustion particles may be more important for effects beyond the lung.

However more knowledge is needed in order to conclude on these matters.