Extension 8: Measuring Airborne Particles

Airborne dust is Particulate Matter (PM), pollution. PM is made up of tiny solid particles or liquid droplets that float in the air. They are very small, but sometimes you can see a haze - formed when a great deal of the suspended particles obscure sunlight. However, the composition of particles varies a great deal, which makes determining the effects of particle pollution on health difficult. In addition, behaviour of particles depends upon size – larger particles settle near to the source, whereas smaller particles can be carried long distance.

The small particles can pass through the nose and travel to the lungs where they can cause damage to health. People especially at risk from breathing particle pollution are children, the elderly, those with respiratory disease and even those that regularly exercise outdoors. The pollution can be classified according to particle size.

Particulate matter (PM_{10}) pollution consists of very small particles – less than 10 microns in diameter (1 micron = 1 micrometre (1 μm) = 1×10^{-6} m). As a comparison, human hair has a diameter of 50-70 μm. This pollution is small enough to be inhaled deep into the lungs and it can aggravate bronchitis for example. PM_{10} can include smoke, dust, acids, salt and metals. It can come from both human and natural sources including: motor vehicles, open fires dust from building works, pollen, mold, waste burning and emissions from industry. It is thought that the smaller particles, in particular PM less than 2.5 μm in diameter ($PM_{2.5}$), are more closely associated with serious health effects than PM_{10} – they stay longer in the air and can penetrate more deeply into the lungs.

How do the particles move?

Particles become airborne when their source is disturbed. This could be by: wind, moving vehicles and the operation of machinery. Wind speed together with size of the particles influences the distance they move. Smaller particles remain suspended in the atmosphere longer than larger particles, which tend to settle sooner. The particle movement tends to follow the direction of the wind.

How do we monitor PM?

There is a variety of monitoring methods available for the measurement of mass of PM in air. These include both direct reading instruments and filter-based samplers that draw the air through a filter, where the particulate material collects. The filter is then weighed in a laboratory.

It is not useful to measure the amount of PM in moles – firstly, a mixture of different species is present and secondly, the numbers involved would be very small. Measurements are given in units of particulate mass per unit volume of air (typically μg m^{-3}). The temperature and pressure of the air must be specified. The same volume of air will have different concentrations as these properties change.

Limits

World Health Organisation (WHO) recommends the following for PM_{10}:

Annual mean: 20μg m^{-3}

24 hour mean: 50 μg m^{-3}

They estimate that reducing annual average particulate matter (PM_{10}) concentrations from levels of 70 μg m^{-3}, common in many cities, to the WHO guideline level of 20 μg m^{-3} could reduce air pollution-related deaths by around 15%. The UK Air Quality Strategy have introduced target values for $PM_{2.5}$, as $PM_{2.5}$ is understood to have no safe limit for health, it is beneficial to reduce levels at all locations. The new targets are therefore a 25μg m^{-3} 'cap' for hotspots and a 15% reduction in $PM_{2.5}$ levels in all urban locations by 2020. Scotland has set a target of 12μg m^{-3} by 2020.

Further reading:

https://www.gov.uk/government/publications/fine-particulate-matter-pm2-5-in-the-uk

https://uk-air.defra.gov.uk/assets/documents/reports/aqeg/ch5.pdf

Revision questions

1. How do you think that particles might naturally be removed from the atmosphere?

2. Apart from the harmful effect on the health of living things, how can a heavy concentration of particulates be a nuisance?

3. What is the upper size limit of $PM_{2.5}$ particles in metres?

4. "Black Carbon" is thought to contribute to climate change – its particles absorb sunlight. Where do you think it comes from?

5. How do you think we can cut down on air pollution?

Answers

1. Rain is useful in "cleaning up" the atmosphere.

2. Some examples are: it can cause deposits on cars, discolour washing and paintwork on houses; particles in the atmosphere can affect visibility and contribute to fog formation.

3. Less than 2.5×10^{-6} metres.

4. Some sources are: diesel engines, solid fuel heating and forest fires. However, unlike carbon dioxide which can stay in the atmosphere for hundreds of years, it returns to earth with rain or snow after days or weeks.

5. Some ideas: use cleaner fuels/alternative energy sources and trap pollutants before they are released.