Environmental Studies
FACT SHEET
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The Health Effects of Particulates

This Factsheet:

- Describes the nature and sources of particulates
- Summarises the evidence linking particulates to the incidence of heart and respiratory disease
- Reviews typical exam questions on this topic

Introduction

Particulates are made up of a complex mixture of soot (carbon), sulphate particles, metals and inorganic salts such as sea salt.

PM10s are particles which are smaller than or equal to 10 microns diameter (10 microns = one hundredth of a millimetre). PM10s are one of the eight substances for which the UK government has established an air quality standard as part of its national Air Quality Strategy. The air quality standard - which should not be exceeded as a running 24 hour mean - has been set at 50 microgrammes per cubic metre (ug / m^3).

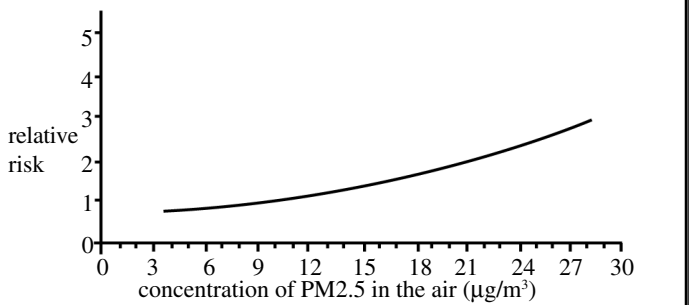
PM2.5 mainly originates from road traffic emissions and, specifically, from diesel-powered vehicles. Scientists, particularly in the US, are focussing a lot of research on PM2.5s because these very fine particles appear to be linked to a range of respiratory and cardiac diseases.

Typical Exam Question

Scientists investigated whether women's exposure to tiny particulates (PM2.5s) increased their likelihood of developing cardiovascular disease.

They studied nearly 65 000 women, all aged over 60 for 6 years. The graph shows their relative risk of death from cardiovascular disease at different PM2.5 concentrations.

Fig 1. Relative risk of death from cardiovascular disease



(a) Explain whether the scientists were able to conclude " There is a linear relationship between exposure to PM2.5 and the women's relative risk of developing cardiovascular disease" (2)

(b) What concentration of PM2.5 in the air has been set as the standard? (1)

Markscheme

(a) No;
Relationship is positive but curvilinear not linear;

(b) 11 ìg/m³;

In order to investigate the effects of particulates further the scientists exposed groups of genetically identical mice to air containing different concentrations of particulates. The mice were exposed to the polluted air for 80 hours and were then humanely killed. Their blood vessels were then examined for signs of injury. The results are shown in Table 1.

Table 1. The effect of inhaling different size air particles on mice blood vessels

Particles in the air	No. of mice in sample	Number of particles/cm^3	Relative damage to blood vessels
Almost none	15	< 5000	1
PM2.5	16	450,000	1.23
<PM2.5 ultrafine particles (UFPs)	14	390,000	1.55

Clearly, exposure to such high concentrations of PM2.5 and especially the UFPs increased damage to the mice' blood vessels.

Typical Exam Question

(a) Suggest two ways in which the scientists have tried to control variables other than the concentration of particulates (2)

(b) Identify one limitation of this research for our understanding of the effects of particulates on humans (1).

Markscheme

(a) genetically identical mice;
all groups exposed for same time;

(b) mice may respond differently than humans to particulates;
prolonged exposure by humans to such high concentrations unlikely;
investigation provides no evidence on long term effects;

Particulates in the UK

Most monitors in the IK measure only the larger particles - PM10. Air quality standards suggest an annual mean concentration of 25 ìg/m^3 for PM2.5 but this is only a recommendation, not a requirement. There are no standards at all for UFPs and no way of monitoring their concentration on a routine basis!

Air – quality campaigners want more research carried out on the effects of UFPs and mandatory maxima for PM2.5.

Research in Europe has indicated that prolonged exposure of commuters to raised levels of PM2.5 increases their chances of developing cardio - and cerebrovascular disease and that raised levels result in increased hospital admissions for myocardial infarction (heart attack) and stroke (leaking of blood vessels in the brain).

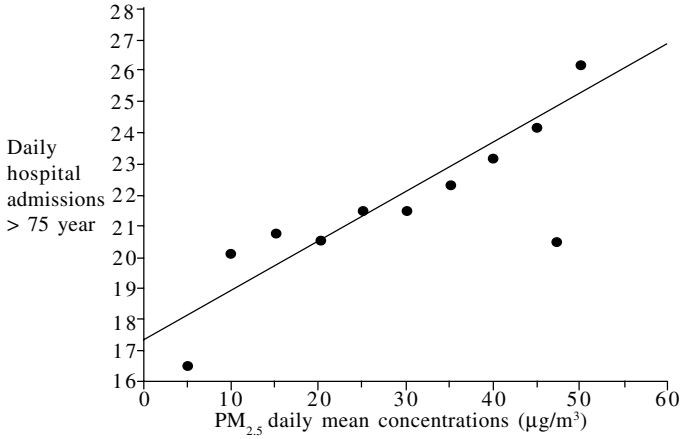
Case Study: PM2.5 levels and hospital admissions in Madrid

Recently, 70% of particulate matter readings taken at air-quality monitoring and control stations in Spain exceeded the daily maximum limit value.

The major cause of this is believed to be the dramatically increasing number of diesel vehicles in the country. In 1997, there were 2,800,000 diesel vehicles but by 2005 this had increased to 8,400,000.

Scientists investigated the relationship between daily mean PM2.5 concentrations and hospital admissions of people aged over 75. The investigation was carried out in Madrid, a city with a high and increasing traffic density. The results are shown in Fig. 2

Fig. 2 The effect of PM2.5 on hospital admissions of people aged over 75, Madrid



Source: Linares, C. Diaz, J (2009)

The scientists found a linear relationship between PM2.5 concentrations and hospital admissions. The next part of their work will attempt to estimate the financial cost of these admissions and thus make an economic argument for tighter emissions of these particulates.

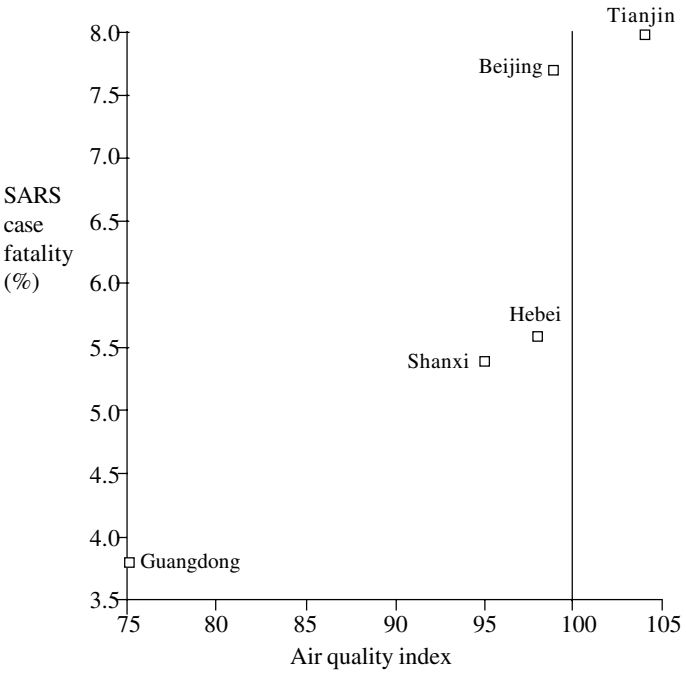
References:

Linares, C. Diaz, J (2009) Short-term effect of concentrations of fine particulate matter on hospital admissions due to cardiovascular and respiratory causes among the over-75 age group in Madrid, Spain. Public Health

Severe Acute Respiratory Syndrome (SARS)

In 2003, scientists in China investigated the link between deaths from Severe Acute Respiratory Syndrome (SARS) and air quality in five Chinese provinces. The air quality index incorporates five major pollutants, including particulates. An index of below 100 is considered healthy for the general population. Fig. 3 shows their results

Fig 3. SARS cases and air quality



Typical Exam Question

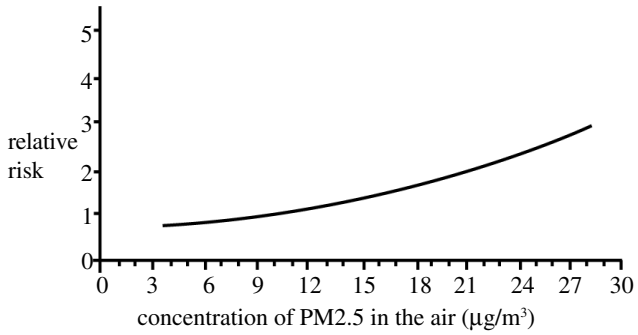
Describe the data shown (3)

Markscheme

Air quality index of the 5 provinces ranges from 75 to104;
4 provinces experience air quality that would be considered healthy;
Tianjin experiences a value above that which is considered safe for the general population;
3 provinces out of 5 are just below the safe level;
Positive correlation between declining air quality and death from SARS/ Fatalities from SARS increases as air quality decreases;

Practice Question

The graph shows the relative risk of death from cardiovascular disease



The risk at 11 ìg/m^3 of PM2.5 has been set as the standard.

(a) Estimate the risk of death at a concentration of 21 ìg/m^3 relative to this standard (1)

(b) The death rate from cardiovascular disease for people living at a concentration of PM2.5 of 11 ìg/m^3 is 4.45 per 1000. Predict the rate for those living at a concentration of 24 ìg/m^3.

Markscheme

(a) 1.7-1.9/ approximately double;

(b) $4.45 \times 2.2/2.3; = 9.79 - 10.23;$

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