Environmental Studies
FACT SHEET
www.curriculum-press.co.uk
Number 168

Diesel fumes, asthma and cancer on Oxford St

Defra – the department for environment, food and rural affairs estimate that air pollution reduces life expectancy in the UK by an average of six months. The most important air pollutant causing damage to health is particulate matter (PM) – particles mostly emitted from vehicle exhausts and chimneys or formed in the air from reactions between other pollutants. The World Health Organization (WHO) states that there is no safe exposure level to PM.

This Factsheet:

- Summarises the causes and health effect of PMs and diesel fumes
- Summarises the results of an investigation into particulates and exhaust fumes in central London
- Provides examples of the type of exam questions that have come up recently on this topic

Diesel engines emit less CO_2 than petrol engines but more NOx and particulates. In fact diesel exhausts contain a wide range of pollutants such as carbon monoxide, hydrocarbons, oxides of sulfur, ammonia, cyanide, benzene and PAHs.

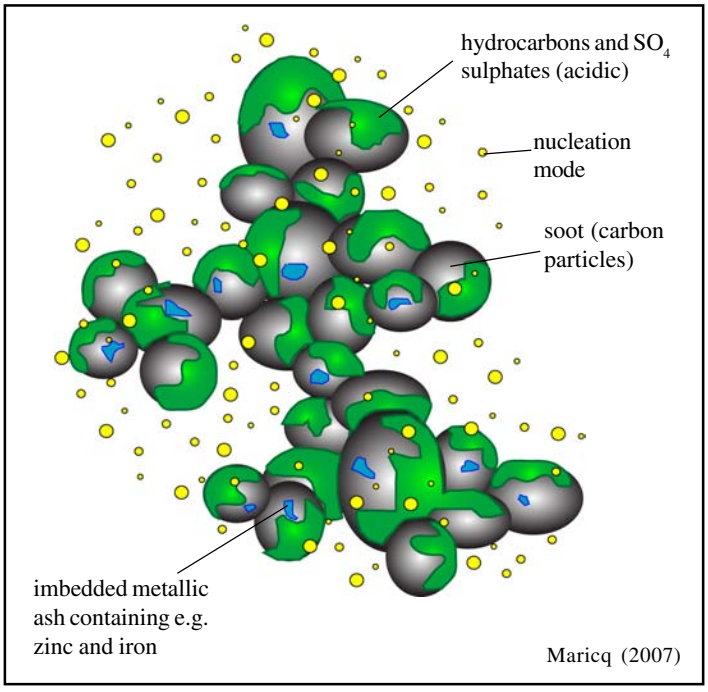
Vehicle emissions from diesel engines are the major source of fine particulate matter (PM2.5 i.e. PM with a diameter > 2.5 nm) in urban areas such as London.

Diesel particulate matter (DPM) is a complex mix of solid and liquid pollutant particles suspended in a gas. Diesel exhaust gases contains about 20 000 different chemical compounds and the precise composition of DPM varies because of factors such as the:

- type of diesel used
- amount of moisture in the air
- amount of other pollutants in the air
- engine temperature and fuel injection speed
- presence/absence/condition of diesel particle filters

Figure 1 shows the physical and chemical composition and structure of DPM.

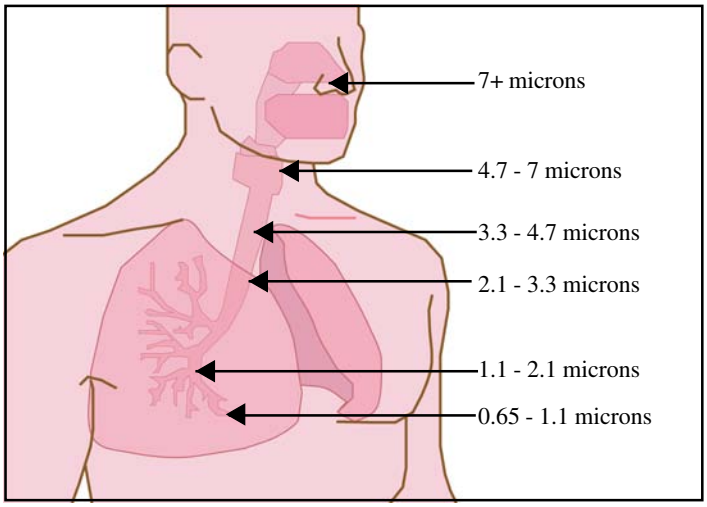
Fig 1. Physical and chemical structure of DPM



Health effects of DPM

Many scientific studies have shown that as PM levels increase in cities, the risk of developing respiratory problems such as asthma, lung inflammation and lung cancer also increases. The most dangerous particles are the smallest ones because they can penetrate deep into the alveoli of the lungs (Fig .2)

Fig 2. Penetration of particles into sensitive tissues – the smaller the particle, the deeper they get



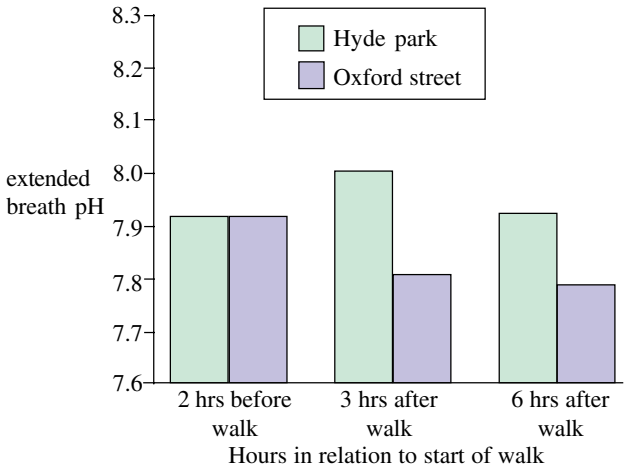
The risk of harmful effects increases the longer the particles remain in the lungs so children are particularly at risk from DPM. Worryingly, studies in the United States have shown that the concentration of DPM inside school buses may be up to ten times higher than those outside the bus – the particles are entering the bus through cracks from the engine and cannot then escape and so are likely to be inhaled.

Case Study: DPM's link to asthma in London

Scientists investigated the effect of exposure to roadside traffic on 60 people with asthma in London. Each participant first walked for two hours through Hyde Park, which is a large green, traffic-free area and then, on a separate day they were asked to walk Oxford Street, one of the busiest streets in London and one where only diesel-fuelled buses and taxis are allowed.

The scientists measured the pH of the participants' exhaled breath 2 hours before each walk and then 3 hours and 6 hours after the start of each walk. Fig. 3 shows the results.

Fig 3. pH of the participants' exhaled breath 2 hours before each walk and then 3 hours and 6 hours after the start of each walk.



Source: McCreanor,J Cullinan,P Nieuwenhuijsen, MJ et al (2007)

Typical Exam Question

Describe the changes in the pH of the participants' exhaled breath caused by walking in the two locations (3)

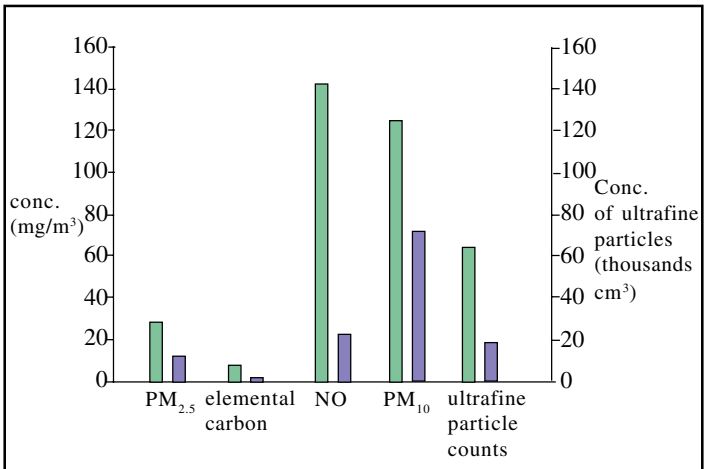
Look carefully at the graph. Two hours before the walks the pH of the participants' exhaled breath was just above 7.9. After walking through leafy Hyde park the pH of the participants' breath increased and even after 6 hours remained slightly higher than before the walk began. Walking along Oxford St resulted in a fall in the pH of exhaled breath.

Q. Why might walking along Oxford St cause the breath of people with asthma to become more acidic?

- Walking increases cell respiration, which produces more CO_2
- CO_2 is an acidic gas
- DPM also contain acidic substances e.g. sulphates
- Walking along the polluted street results in the tubes leading to the lungs (the bronchioles) to constrict – they become narrower
- Breathing out becomes more difficult and there is a build-up of CO_2 in the lungs which leads to more acidic breath

The scientists measured the lung functions of all the participants before and after the walks. The walks along Oxford St resulted in reduced lung efficiencies that were statistically significant. They also measured the concentrations of several pollutants at each site. Fig 4 shows some of the results.

Fig 4. Air pollutants in Hyde Park and along Oxford St



Source: McCreanor,J Cullinan,P Nieuwenhuijsen, MJ et al (2007)

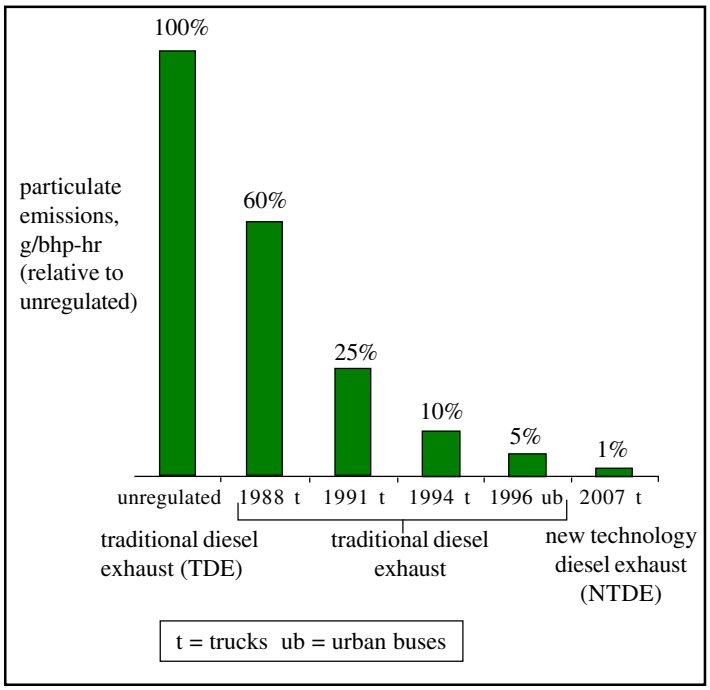
Some participants reported more symptoms of asthma after walking along Oxford St. So, is this study proof that it is DPM from buses and taxis that caused these reports of worsening symptoms?

No. In fact science never **proves** anything. It merely provides evidence in support of or against a particular hypothesis. There are many other factors that might be partially responsible for the worsening symptoms – the higher levels of nitrogen dioxide, dust, allergens, pollen, stress, cold temperatures etc. But there have now been literally hundreds of scientific investigations that positively link DPM and other PM to respiratory problems. So whilst the Oxford St investigation isn't proof, it adds to a growing body of evidence that we really need to start reducing our emissions of these substances.

Reducing DPM

Efforts to reduce DPM emitted in exhaust fumes have been successful in countries such as the United States (Fig.5).

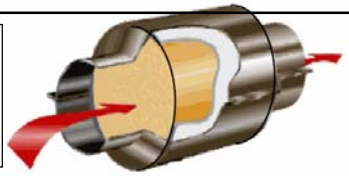
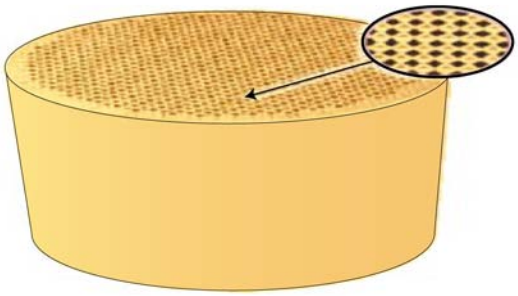
Fig 5. Decrease in permitted emissions of DPM by the EPA in the US



The EPA – Environmental Protection Agency have seriously tightened up what is allowed to be emitted from individual vehicles but, worldwide, the use of diesel engines is increasing, not least because they emit less CO_2 than petrol engines.

Table 2 summarises two of the main techniques for reducing emissions of DPM.

Table 2 Control techniques

Technique		Principles
Diesel oxidation catalysts	carbon SOF NO_x CO HC  CO_2 NO_x water — DOC control capabilities; DPM 20 to 40% reduction; CO > 40%; HCs > 50%	Uses metals e.g. platinum and palladium to oxidise hydrocarbons (HC), carbon monoxide (CO) and the volatile organic fraction (VOF) of particulate matter (DPM).
Diesel particulate filters		A honeycomb of silicon carbide traps the particles and separates them from the other gases

References

Maricq MM. (2007) Chemical characterization of particulate emissions from diesel engines: a review. *J. Aerosol Sci*; **38**: p1079–118.

McCreanor,J Cullinan,P Nieuwenhuijsen, MJ et al (2007) Respiratory effects of exposure to diesel traffic in persons with asthma *The New England Journal Of Medicine* 357, 23

Prasad,R Vanketeswara, RB (2010) A Review on diesel soot emission, its effects and control *Bulletin of Chemical Reaction Engineering & Catalysis* 5 (2) p69-86

Practice Question

The table provides data on fuel efficiency and carbon dioxide emissions per litre of fuel for a petrol engine and a diesel engine.

	Petrol engine	Diesel engine
Fuel efficiency / litres per 100 km	11.5	9.5
CO_2 emitted per litre of fuel/ kg	2.4	2.6

(a) Which engine releases less carbon dioxide when travelling 100 kilometres? Show your working (3).

(b) Some cities are considering replacing diesel-fuelled buses with electric trams. The trams are powered by electricity generated in power stations and transmitted along overhead power cables.

(i) Suggest three advantages of this change (3)

(ii) Suggest three disadvantages of this change (3)

Markscheme

(a) Petrol: CO_2 emitted = 11.5 x 2.4 = 27.6 kg;
Diesel: CO_2 emitted = 9.5 x 2.6 = 24.7 kg;
Diesel releases less CO_2;

(b) (i) Less particulates on the street;
Less noise;
Power station may be more efficient than diesel engine;
Trams more efficient than buses as they don't have to carry fuel;
Regenerative braking feeds electricity back into the system;

(ii) Quiet trams more of a danger to pedestrians/cyclists;
Danger from overhead electrical cables;
Visual pollution of cables;
Fitting tram lines expensive;
Tram lines impractical in some areas;

Acknowledgments: This Factsheet was researched and written by Kevin Byrne
Curriculum Press, Bank House, 105 King Street, Wellington, Shropshire, TF1 1NU
 ISSN 1351-5136