Nov | 16

Outcomes, Origins & The Future of Air Pollution in London

Daisy Wain

A working document

Deliver Change Ltd.

1. Introduction

Air pollution has become a major problem in the UK and especially in cities such as London. It is damaging every aspect of the environment including human health, vegetation, animals, water resources and properties and these problems set to continue. Action has been taken to curb toxic emissions, but it is a complex process involving many stakeholders and industries, and more needs to be done.

This document provides a simple and easy to understand detail of the basic science behind air pollution, how that links to London, and what the Government is currently doing about it.

Deliver Change launched AirSensa under our London initiative Change London, and this document will also cover why we need large scale, continuous monitoring in cities as part of the package for healthy, productive and smart cities in the future.

1.1 What is air pollution?

Generally any substance that is introduced into the atmosphere that has damaging effects on living things or the environment is considered air pollution[1]. The substances that are responsible for air pollution are known as air pollutants. Air pollutants can be gaseous, liquid or solid in form, and can come from natural as well as human sources:

The main air pollutants that are emitted are:

- Sulphur oxides/sulphur dioxide
- Nitrogen oxides/nitrogen dioxide
- Carbon monoxide
- Carbon dioxide
- Volatile organic compounds
- Particulate matter
- Ammonia
- Lead
- Persistent organic pollutants
- Ozone

1.2 Origins

It is commonly understood that anthropogenic pollution is a by-product of all economic and societal activates[2]. Previously manmade air pollution came from coal fires, power plants and heavy industry but with clean fuels, filtration of gases, improvements in process technologies and the export of most polluting industries to countries with lower wages and less pollution controls, as well as the emergence of new sources such as motor vehicle transport, pollution has a new face

globally[3].

Modern pollution is now less visible but more immediately irritating and long term damaging than it used to be, meaning that understanding and communicating the risks is now even more of challenge. Air pollution can also come from natural processes such as forest fires and volcanic activity.

Below is a table with all the main types of outdoor air pollution[4] [5]and their sources and these pollutants are categorised into two groups:

- Primary pollutants – come from human processes
- Secondary pollutants – interaction of primary pollutants with the atmosphere

Primary pollutants	**Source**
Sulphur oxides (SOx)/sulphur dioxide (SO_2)	Combustion of fuels containing sulphur, mostly coal and oil, and produced during metal smelting and other industrial processes
Nitrogen oxides (NOx) /nitrogen dioxide (NO_2)	Cars, trucks, electric power plants and other industrial processes
Carbon monoxide (CO)	From combustion processes low in oxygen, mainly motor vehicles, but also from burning wood, industrial processes and non-transportation fuel combustion
Carbon dioxide (CO2)	From volcanic activity and hot springs, combustion processes, cars, and power plants
Volatile organic compound	Evaporates from sources such as vehicle exhausts, cleaning agents, furniture polish and fabric softeners
Particulate matter (PM)	"Fine" particles (less than 2.5 micrometers in diameter, known as "PM 2.5") result from motor vehicles, coal-burning electric power plants, factories as well as from residential fireplaces and wood stoves. Larger "coarse" particles (PM 10) come largely from windblown dust, vehicles travelling on unpaved roads, and crushing and grinding operations.
Ammonia	Used to fertilise crops and emitted from this agricultural process and farm animals
Lead	Naturally occurring, produced by lead smelters, metal processing, contained in old paints and plumbing
Persistent organic pollutants (POPs)	Produced through industrial processes and waste incineration
Secondary pollutants	**Source**

Particulate matter (from sulphates and nitrates)	Particles that are either man made or natural (such as sulphates and nitrates) interact with other compounds in the air to form fine particular matter. These tiny bits of soot can travel hundreds of miles downwind of the original pollution sources
Ozone	Formed from a chemical reaction during sunlight

1.3 Outcomes

Below is a complete list of the potential effects of air pollution worldwide:

- Human health through direct exposure to air pollution or intake via air and food chain
- Acidification which can lead to a loss of flora and fauna
- Eutrophication and a decrease in biodiversity
- Damage to crops, forests, plants because of ground level ozone
- Impacts of heavy metals and organic pollution, which can lead to environmental toxicity and bioaccumulation
- Climate forcing
- Decrease in atmospheric visibility
- Damage to materials and cultural heritage

2. LONDON, THE CASE STUDY

Now the general nature of air pollution has been established, this information shall now be linked to situation in the UK and London

2.1 ORIGINS IN LONDON

Despite the lengthy list of potential sources of air pollution and pollutants themselves, as seen in Fig. 1, it is obvious that not all of them apply to the UK and more specifically London. In London the human activities and natural sources that actually affect air pollution are[6]:

- Road, air and rail transport
- Shipping
- Domestic and commercial heating
- Industry
- Power generation
- Natural: windblown sea salt, sand or soil

Of these, most of the pollution in London is caused by road transport and domestic and commercial heating systems[7] and the main focus pollutants are PM and NO_2. The reason for this focus is that they are:

- The major source of air pollution
- The pollutants most at risk of missing EU and UK air quality targets[8] (discussed later)

Now linking the source and the pollutants together:

- Vehicles account for 80% of PM emissions and ½ of NOx
- Of this 91% of PM2.5 and 95% NO2 comes from diesel vehicles[9]
- Making it the singularly worst source of air pollution in London[10]

A bit more detail...

Majority of PM10 in central London is from road transport, of this 1/3 to 1/2 comes from tyre and brake wear, road-surface wear and particles whipped up from the road by passing vehicles[11] [12]. In Central London, taxis are responsible for 30% of emissions from exhausts. One of the reasons for diesel vehicles being such a large source is that between 2000 and 2011, there were 360,000 more registered diesel cars in Greater London[13].

2.2 Outcomes in London

The primary issue and effect of air pollution in London is the impact on human health from exposure. These effects are widely accepted by the medical and scientific community[14] and these health effects have been estimated at costing the economy approximately £20 billion a year[15].

It has also been concluded that often the most vulnerable and deprived communities are those who suffer the worse effects of air pollution[16].

In terms of life expectancy, previously it was thought that particulate air pollution reduces life expectancy by 6 months[17], but new research has indicated that it may now be closer to 9 months in London, which is 50% higher than the national average[18].

Furthermore, it has been estimated that as much as 140,743 life-years were lost in 2010, equivalent to 9,416 premature deaths (assuming a 30% overlap between the effects of PM2.5 and NO2 and comparing with a zero concentration of NO2). Air pollution is therefore the second most significant factor impacting on public health in London, after smoking[19]. This potentially increases the estimated total mortality burden considerably, compared with both the previous IOM and PHE reports due to combining PM2.5 and NO2[20]. In addition data published by Public Health England (5th Nov 2013) stated that the percentage of deaths from PM2.5 rose in 15 boroughs (this is 2011 compared to 2010). In the remaining boroughs there was either a small decrease or no appreciable change[21].

Mortality is not the only air pollution related health effect – in 2010 PM2.5 and NO2 were associated with approximately 1990 and 420 respiratory hospital admissions respectively with an additional 740 cardiovascular hospital admissions associated with PM2.5[22].

As well as effects on life expectancy, research from across the globe has found that[23]:

- A moderate increase in air pollution (specifically PM) can increase:
  - Amount of cardiovascular deaths by 12%
  - Risk of lung cancer by 22%
- Effect the respiratory systems (especially children's)
- Interfere with foetal development
- Neurodevelopment and degeneration.

A bit more detail...

Research has proven that living near roads travelled by 10,000 or more vehicles per day, where PM occurs in high concentrations, could be responsible for 15-30% of all new cases of asthma in children, for chronic obstructive pulmonary disease and coronary heart disease in adults aged 65+[24]. This is a particular concern when you consider the fact that 320,000 children (including more than 180,000 under 11) attend schools in London within 150 metres of roads carrying more than 10,000 vehicles a day[25].

Even though the health effects are the most significant and immediately damaging, it does

not mean we should forget other potential effects.

Firstly it can be very damaging to the natural environment, causing destruction to ecosystems, flora, fauna and environments. The potential effects include[26]:

> Acid rain damage: caused by the combination of NOx and SOx with rainwater. It can damages trees, causes soils and waters to acidify therefore making it unsuitable for some wildlife and plant life, it also speeds up the decay of buildings, statues and sculptures.
> Eutrophication: high concentration of nutrients (e.g. nitrogen) can cause algal blooms that starve the water of oxygen and can destroy ecosystems and food webs.
> Haze: when the sunlight encounters tiny pollution particles in the air, a haze in formed, which can obscure clarity, colour, texture and form of what we see.
> Effects on wildlife: like humans, wildlife can experience health problems including birth defects, reproductive failure and disease.
> Crop and forest damage: ground level ozone can reduce growth and survivability, as well as increased susceptibility to disease, pests and other environmental stresses.

Secondly, it can affect and damage our built environment which poses a risk to not only property but also the large cultural heritage and history as found in London. In more detail[27], modern day air pollution has the potential to degrade organic coatings and polymers (great importance to modern structures). Also, increasing fine diesel soot spoils simple lines and smooth area characteristics of many modern buildings.

2.3 Government Legislation

European Law

In the UK we report our national emissions to the European Commission and the United Nations Economic Commission for Europe's Convention on Long Range Transboundary Air Pollution. This convention was agreed in the Gothenberg Protocol, which sets national emission reduction targets for air pollutants which needs to be achieved by 2020[28].

These targets are translated into the EU Ambient Air Quality Directives. They set exact limits and targets of concentrations of various pollutants in outdoor air for the protection of health and ecosystems. These have to be abided by by all EU member states, including the UK.

These directives include:

> Ambient Air Quality Directive (2008/50/EC) and Directive 2004/107/EC: limits for concentration of pollutants in outdoor air
> EU National Emissions Ceilings Directive (2001/81EC): limits on total annual emission of important air pollutants for all member states to help reduce transboundary air pollution

National Law

These EU directives are then translated into national legislation within each member state. In the UK, DEFRA has legal responsibility for improving air pollution, though many of the required

measures fall under control of other departments or local government to implement[29].

Also, for the UK is a devolved matter, so even though the UK government leads on international and European legislation, Scotland, Wales and Northern Ireland are responsible for their own air quality pollution and legislation[30].

The regulations for England are:

> Part IV of The Environmental Act: provisions for protecting air quality in the UK and local management
> Air Quality (standards) Regulations 2010: transpose into English Law on Ambient Air Quality Directive
> Air Quality (England) Regulations 2000: national objectives for local authority in England
> National Emission Ceilings Regulations 2002: transpose into UK legislation requirements of the EU National Emissions Ceilings Directive

These English regulations can then be taken further by looking at The Clean Air Act. This was introduced in 1956 in response the smogs of the 1950s, which was then updated in 1968 and 1993, and is now being revised under the Red Tape Challenge to:

> Help local authority to meet air quality challenge
> Reduce the burdens for business

From these UK regulations and acts, different areas of the UK can adopt their own strategy to meet the EU targets.

In the summer of 2016, Sadiq Khan was made London Major with a plan to 'create a City for all Londoners' and part of his manifesto was focused around a greener, cleaner London – including cleaning the air[31]. Since becoming Major, Major Khan launched his plan for the toughest crackdown on the most polluting vehicles by any major city around the world on the 60th anniversary of the Clean Air Act in July. Key proposals include[32]:

> Implementing a £10 Emissions Surcharge (dubbed the 'T-charge') on the most polluting vehicles entering central London from 2017. The charge would apply to all vehicles with pre-Euro 4 emission standards (broadly speaking those registered before 2005) and will cost an extra £10 per day on top of the existing Congestion Charge.
> Introducing the central London Ultra-Low Emission Zone one year earlier in 2019
> Extending the Ultra-Low Emission Zone ('ULEZ') beyond central London from 2020: for motorcycles, cars and vans, to the North and South Circular; and for lorries, buses and coaches London-wide
> Developing a detailed proposal for a national diesel scrappage scheme for Government to implement
> Bringing forward the requirement for all double–deck buses to be ULEZ-compliant in central London from 2020 to 2019
> Implementing clean bus corridors – tackling the worst pollution hotspots by delivering cleaner buses on the dirtiest routes

A bit more info: How successful has some London strategies been?

The Low Emissions Zone: introduced in 2008 with further phases starting from the 1st Jan 2012. The reports are that there has been an absence of clear changes in central London, which may reflect difference in the vehicle mix, with a smaller proportion of vehicles affected by the LEZ.

The Congestion Charge Scheme: introduced in Feb 2003 into Central London, but research has concluded that it was not possible to identify any relative changes in pollution concentrations in association with the introduction of the scheme[33].

3. Air pollution trends in London

But how successful has these measures been? There is a long history of air pollution in the UK and specifically London, in the 1950s the entire city was plagued by smogs which caused thousands of deaths, but also lead to legislative reform[34] (as previously discussed).

Since then there have been major improvements, but these long-term trends at improving air quality in London have slowed in recent years[35]. More specifically, particulate matter concentrations have not fallen greatly since 2004, with one resource quoting that it has remained stable since 2008[36], and some places remain above the EU and UK targets.

Nitrogen dioxide is similarly failing with many sights significantly above the limit value; this has resulted in London being deemed one of the most polluted cities in Europe, especially for NO2 pollution[37].

More recently, provisional results for 2011 indicate that the annual mean National Air Quality Strategy objective (which mirrors the EU limit value) found that NO2 levels was breached at the majority of locations close to roads and at 5 locations away from busy roads. For PM10, the limit value was breached at 2 kerbside, 3 roadside and 1 industrial monitoring site.

But what does this all mean? Failing to meet the EU regulations has resulted in legal action against the UK Government, which could result in a multi million pound fine[38].

The legal action has been spearheaded by Environmental Lawyers ClientEarth and began in May 2013 where the Supreme Court ruled that the UK was failing its legal duty to tackle air pollution after violating the EU NO2 limits five years in a row. The UK was ordered to publish an action plan to tackle the problem. A government plan was published in December 2015[39], but that plan was also found not to meet the law's requirement of cutting nitrogen dioxide (NO2) pollution to legal levels in the "shortest possible time"[40].

The government is being forced to deliver another, more effective plan to tackle the UK's air pollution crisis within eight months, after a high court judge rejected a longer timetable as "far too leisurely". A draft plan is due by 24 April 2017 and the final one by 31 July 2017[41].

A bit more detail...

In 2010 the monitoring site at Marylebone Road was the 4th worse of more than 2000 sites across Europe for NO2 pollution and the worst of any capital city[42]. The current NO2 levels are reportedly comparable to those suffered in Beijing before the pre Olympic and Paralympics games clean up[43]. A 2011 report by Soot Free Cities for the European Environmental Bureau, ranked London 14th of 17 major European Cities for its policies to tackle black carbon PM, giving it the lowest possible rating of F. 86% of the worst areas in the UK for NO2 and 87% for PM are in London. Furthermore, new figures show London exceeded its air pollution limits for the entire year in just eight days in 2016, according to a monitoring and research group[44].

4. The Future

In July 2016, the IPPR released a publication[45] covering the illegal levels of air pollution in London and their recommendations for tackling the problem, specifically looking at policy. Below is a summary of that information.

European policy changes

At the European level tighter emissions standards will be required, as well as bringing forward the 'real world' emissions testing regime (with conformity factor 1.5 or less) which is not currently being planned until 2021.

National policy changes

At the national level, the UK government will need to progressively reform vehicle excise duty (VED) to disincentivise diesel vehicles. If it is unwilling to go far enough at the national level to drive compliance in places with acute air pollution problems like London, the government could devolve VED rates to those cities that wish to go further. Finally, to increase the pace of transition towards a diesel-free car eet, the government could introduce a scrappage scheme for older diesel cars across the UK or in areas of non-compliance with air pollution laws.

Local policy changes

At the local level the new mayor of London has already indicated a willingness to take much more radical action than his predecessor. Policy measures that are likely to be needed in order to achieve compliance with legal air pollution limits include:

- Expansion of the new ultra low emissions zone (ULEZ) across the whole of inner London
- Progressive tightening of emissions standards within the low emissions zone (covering the whole of London) for lorries, vans, buses and taxis, with the aim of progressively phasing out diesel buses and taxis altogether
- Introduction of new policies to promote alternative forms of sustainable transport.

While these recommendations are undoubtedly essential, as an organisation – Deliver Change believes that you cannot properly manage what you do not sufficiently measure. It is for this reason that we are creating the AirSensa network.

Currently monitoring is either sparse & expensive (only 300 official stations in the UK), or temporally poor (historic averages only) resulting in spatial & temporal variability not being captured (e.g. 'hot spots'). Therefore parameters (e.g. personal pollution exposure) are unreliable or inaccurate. So what we need is better monitoring, featuring:

1. Granularity – thousands of monitors – because air quality varies greatly over short distances – even across a road
2. Continuous operation – because air quality also varies greatly from one minute to the next, driven mostly by weight of traffic

3. Real-time – if data isn't valid right now, you can't take appropriate action

But how does better measurement actually help?

It's the first step, without which you can't take the vital next steps:

> Avoidance – Reducing the impact on public health, by helping people avoid it – e.g. low-pollution route planning apps
> Mitigation – the data will show how and where to apply new technology, rules or policy

Why isn't the government doing it?

Lack of political pressure; air quality is where smoking was in the 60s – the public hasn't been aware. But that's changing:

> Campaigns – the Evening Standard and Sunday Times campaigns have informed people, and the demand for data grows
> Dieselgate – the VW scandal has focused attention clearly on air pollution

What can you do with better monitoring (examples)?

> Localised alerts to protect everyone especially vulnerable groups through apps and test messages
> Pollution avoidance route planning for pedestrians and cyclists through apps
> Using data to control air conditioning unit filters, to save energy
> Pollution hot spot reduction through traffic light phasing
> Using data to switch hybrid buses to electric operation when in pollution hot spots

5. REFERENCES

[1] Greater London Authority. (Undated). *Air Pollution in London .* Available: http://www.london.gov.uk/priorities/environment/vision-strategy/clearing-londons-air/air-pollution-london. Last accessed 02/12/13.

[2] European Environment Agency. (2012). *Air quality in Europe — 2012 report.* Available: http://www.eea.europa.eu/publications/air-quality-in-europe-2012. Last accessed 20/08/2013.

[3] European Respiratory Society. (2010). *Air quality and health.* Available: http://ersnet.org/images/stories/pdf/web-AQ2010-ENG.pdf. Last accessed 20/08/2013.

[4] WHO. (2011). *Tackling the global clean air challenge.* Available: http://www.who.int/mediacentre/news/releases/2011/air_pollution_20110926/en/. Last accessed 20/08/2013.

[5]European Lung Foundation. (Undated). *Types and sources of air pollutants.* Available: http://www.european-lung-foundation.org/16538-types-and-sources-of-air-pollutants.htm. Last accessed 20/08/2013

[6] DEFRA. (2013). *Air quality statistics in the UK, 1987 to 2012.* Available: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/192277/Air_Qual_Statistics_final_release2012v2.pdf. Last accessed 2nd Dec 2013

[7] Greater London Authority. (Undated). *Air Pollution in London .* Available: http://www.london.gov.uk/priorities/environment/vision-strategy/clearing-londons-air/air-pollution-london. Last accessed 02/12/13.

[8] London Assembly. (2012). *Air Pollution in London.* Available: http://www.london.gov.uk/sites/default/files/Air%20pollution%20issues%20paper%20pdf_0.pdf. Last accessed 02/12/13.

[9] Moore, S.. (2012). *Something in the Air The forgotten crisis of Britain's poor air quality.* Available: http://www.policyexchange.org.uk/images/publications/something%20in%20the%20air.pdf. Last accessed 02/12/13.

[10] Greater London Authority. (2013). *News from Jenny Jones AM: Deaths linked to vehicle emissions rise in half of London boroughs.* Available: http://www.london.gov.uk/media/assembly-member-press-releases/green-party/2013/11/news-from-jenny-jones-am-deaths-linked-to-vehicle-emissions-rise. Last accessed 02/12/13.

[11] RT. (2016). *London breaks EU air pollution limits for 2016 in 'just 8 days'.* Available: www.rt.com/uk/328456-london-pollution-eu-days/ . Last accessed 06/12/16.

[12] Greater London Authority. (2010). *Clearing the air: The Mayor's Air Quality Strategy.* Available: http://www.london.gov.uk/sites/default/files/Air_Quality_Strategy_v3.pdf. Last accessed 02/12/13.

[13] Greater London Authority. (2013). *News from Jenny Jones AM: Deaths linked to vehicle emissions rise in half of London boroughs.* Available: http://www.london.gov.uk/media/assembly-member-press-releases/green-party/2013/11/news-from-jenny-jones-am-deaths-linked-to-vehicle-emissions-rise. Last accessed 02/12/13.

[14] Miller, B. (2010). *Report on estimation of mortality impacts of particulate air pollution in London.* Available: http://www.london.gov.uk/sites/default/files/Health_Study_%20Report.pdf. Last accessed 02/12/13.

[15] London Assembly. (2012). *Air Pollution in London.* Available: http://www.london.gov.uk/sites/default/files/Air%20pollution%20issues%20paper%20pdf_0.pdf. Last accessed 02/12/13.

[16] Moore, S.. (2012). *Something in the Air The forgotten crisis of Britain's poor air quality.* Available: http://www.policyexchange.org.uk/images/publications/something%20in%20the%20air.pdf. Last accessed 02/12/13.

[17] DEFRA. (2013). *International, European and national standards for air quality.* Available: https://www.gov.uk/government/policies/protecting-and-enhancing-our-urban-and-natural-environment-to-improve-public-health-and-wellbeing/supporting-pages/international-european-and-national-standards-. Last accessed 02/12/13.

[18] Moore, S.. (2012). *Something in the Air The forgotten crisis of Britain's poor air quality.* Available: http://www.policyexchange.org.uk/images/publications/something%20in%20the%20air.pdf. Last accessed 02/12/13.

[19] Quilter-Pinner H and Laybourn-Langton L (2016) *Lethal and illegal: London's air pollution crisis*, IPPR. http://www.ippr.org/publications/lethal-and-illegal-londons-air-pollution-crisis

[20] Kings College London. (2015). *Understanding the Health Impacts of Air Pollution in London.* Available: files.datapress.com/london/dataset/understanding-health-impacts-of-air-pollution-in-london-/2015-09-29T13:18:57/HIAinLondon_KingsReport_14072015_final.pdf. Last accessed 06/12/16.

[21] Greater London Authority. (2013). *News from Jenny Jones AM: Deaths linked to vehicle emissions rise in half of London boroughs.* Available: http://www.london.gov.uk/media/assembly-

member-press-releases/green-party/2013/11/news-from-jenny-jones-am-deaths-linked-to-vehicle-emissions-rise. Last accessed 02/12/13.

[22] Kings College London. (2015). *Understanding the Health Impacts of Air Pollution in London.* Available: files.datapress.com/london/dataset/understanding-health-impacts-of-air-pollution-in-london-/2015-09-29T13:18:57/HIAinLondon_KingsReport_14072015_final.pdf. Last accessed 06/12/16.

[23] Wain, D. (2013). *Air Pollution and Human Health.*

[24] Greater London Authority. (2013). *News from Jenny Jones AM: Deaths linked to vehicle emissions rise in half of London boroughs.* Available: http://www.london.gov.uk/media/assembly-member-press-releases/green-party/2013/11/news-from-jenny-jones-am-deaths-linked-to-vehicle-emissions-rise. Last accessed 02/12/13.

[25] Moore, S.. (2012). *Something in the Air The forgotten crisis of Britain's poor air quality.* Available: http://www.policyexchange.org.uk/images/publications/something%20in%20the%20air.pdf. Last accessed 02/12/13.

[26] MassDEP. (Undated). *Health & Environmental Effects of Air Pollution.* Available: http://www.mass.gov/eea/docs/dep/air/aq/health-and-env-effects-air-pollutions.pdf. Last accessed 02/12/13.

[27] Brimblecombe, P (2003). *The Effects of Air Pollution on the Built Environment*. East Anglia

[28] DEFRA. (2013). *International, European and national standards for air quality.* Available: https://www.gov.uk/government/policies/protecting-and-enhancing-our-urban-and-natural-environment-to-improve-public-health-and-wellbeing/supporting-pages/international-european-and-national-standards-. Last accessed 02/12/13.

[29] Moore, S.. (2012). *Something in the Air The forgotten crisis of Britain's poor air quality.* Available: http://www.policyexchange.org.uk/images/publications/something%20in%20the%20air.pdf. Last accessed 02/12/13.

[30] DEFRA. (2013). *International, European and national standards for air quality.* Available: https://www.gov.uk/government/policies/protecting-and-enhancing-our-urban-and-natural-environment-to-improve-public-health-and-wellbeing/supporting-pages/international-european-and-national-standards-. Last accessed 02/12/13.

[31] Sadiq Khan for London. (2016). *Manifesto.* Available: www.sadiq.london/a_greener_cleaner_london . Last accessed 06/12/16.

[32] London Assembly. (2016). *Sadiq Khan unveils action plan to battle London's toxic air.* Available: www.london.gov.uk/press-releases/mayoral/mayor-unveils-action-plan-to-battle-toxic-air . Last accessed 06/12/16.

[33] Atkinson, R. W. et al. (2009). The impact of the congestion charging scheme on ambient air pollution concentrations in London. *Atmospheric Environment*. 43, pg 5493–5500.

[34] DEFRA. (2013). *International, European and national standards for air quality.* Available: https://www.gov.uk/government/policies/protecting-and-enhancing-our-urban-and-natural-environment-to-improve-public-health-and-wellbeing/supporting-pages/international-european-and-national-standards-. Last accessed 02/12/13.

[35] Greater London Authority. (Undated). *Air Pollution in London .* Available: http://www.london.gov.uk/priorities/environment/vision-strategy/clearing-londons-air/air-pollution-london. Last accessed 02/12/13.

[36] DEFRA. (2013). *Air quality statistics in the UK, 1987 to 2012.* Available: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/192277/Air_Qual_Statistics_final_release2012v2.pdf. Last accessed 2nd Dec 2013

[37] Greater London Authority. (Undated). *Air Pollution in London .* Available: http://www.london.gov.uk/priorities/environment/vision-strategy/clearing-londons-air/air-pollution-london. Last accessed 02/12/13.

[38] Date, W. (2013). *'Quick' action wanted over UK air quality breaches.* Available: http://www.airqualitynews.com/2013/07/17/supreme-court-wants-quick-action-over-air-quality-breaches/. Last accessed 02/12/13.

[39] RT. (2016). *London breaks EU air pollution limits for 2016 in 'just 8 days'.* Available: www.rt.com/uk/328456-london-pollution-eu-days/ . Last accessed 06/12/16.

[40] Carrington, D.. (2016). *High court gives ministers deadline for tougher air pollution plan.* Available: www.theguardian.com/environment/2016/nov/21/high-court-ministers-deadline-air-quality-pollution-plan . Last accessed 06/12/16.

[41] Carrington, D.. (2016). *High court gives ministers deadline for tougher air pollution plan.* Available: www.theguardian.com/environment/2016/nov/21/high-court-ministers-deadline-air-quality-pollution-plan . Last accessed 06/12/16.

[42] Moore, S.. (2012). *Something in the Air The forgotten crisis of Britain's poor air quality.* Available: http://www.policyexchange.org.uk/images/publications/something%20in%20the%20air.pdf. Last accessed 02/12/13.

[43] Greater London Authority. (Undated). *Air Pollution in London .* Available: http://www.london.gov.uk/priorities/environment/vision-strategy/clearing-londons-air/air-pollution-london. Last accessed 02/12/13.

[44] RT. (2016). *London breaks EU air pollution limits for 2016 in 'just 8 days'.* Available: www.rt.com/uk/328456-london-pollution-eu-days/ . Last accessed 06/12/16.

[45] Quilter-Pinner H and Laybourn-Langton L (2016) *Lethal and illegal: London's air pollution crisis*, IPPR. http://www.ippr.org/publications/lethal-and-illegal-londons-air-pollution-crisis