Eco Cities (2022) Volume 3 Issue 1, *11 pages*.
doi: 10.54517/ec.v3i1.1852

ORIGINAL RESEARCH ARTICLE

Causes and treatment of air pollution in modern Greater London

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ABSTRACT

Since the 19th century, the process of industrialization and urbanization in Britain has not only created huge material wealth but also had heavy negative effects on human society. Among them, air pollution is one of the costs and has become a major obstacle to the construction of an ecological city. London first analyzes and treats the causes of smoke and air pollution, and then treats the sulfur dioxide and lead pollution in automobile exhaust. Since the new century, it has focused on the monitoring and treatment of nitrogen dioxide and inhalable suspended particles. From air legislation to the mayor of Greater London's air quality strategy, from congestion fees to low emission areas, from green travel represented by bicycles to the treatment of dust on the construction site streets, it shows that the London municipal government's treatment of air pollution is becoming more and more in-depth and comprehensive, and the means to control air pollution are also innovating.

Keywords: Greater London; air pollution; fog city; ecological city

1. Introduction

The process of modern industrialization and urbanization since the 19th century has not only created huge material wealth but also brought heavy negative effects to human society, of which air pollution is one of the costs. So-called air pollution refers to the substances in the air that directly affect human health, happiness, and animal and plant life. Air quality is measured by the concentration of pollutants in the air we breathe[1]. Today, analyzing the treatment of smog pollution in fog capital London, the measures to deal with automobile exhaust pollution, and interpreting the footprints of London's eco city construction will not only help us understand London from a general historical process, but also have important value for us to understand the two sides of modern science and technology, and also provide a little warning for the development of modern and future cities, which undoubtedly has a strong reference significance for the construction of China's ecological city, which is in the rush of urbanization today.

ARTICLE INFO
Received: March 2, 2022 | Accepted: April 14, 2022 | Available online: April 30, 2022

CITATION
Yu Z, Lu W. Causes and treatment of air pollution in modern Greater London. Eco Cities 2022; 3(1): 11 pages.

2. Causes

From the 19th century to the middle and lower 20th centuries, the main source of air pollution in Britain was industry, and the pollutants were soot and flying dust. The air pollution represented by London fog has become the ID card of industrial Britain. In Britain in the 19th century, London fog was famous. Words such as "fog", "haze" and "dim" became common vocabulary and appeared from time to time in British literary works at that time. Charles Dickens, a master of British realism, vividly described London fog at the beginning of his novel Desolate Villa: "it is a kind of darkness penetrating into the hearts of the people and an overwhelming atmosphere." Impressionist master. Claude Monet exclaimed, "I love London more than the English countryside, and what I love most is the fog in London". His psychedelic oil painting of the Houses of Parliament in London, with the with the sun breaking through the fog, shows the gray and yellow sky of the British capital. It is said that from 1881 to 1885, "the bright sunshine in central London in December and January was less than one sixth of the sunshine enjoyed by four small towns such as Oxford, Cambridge, Marlborough, and geldeston[2]." This fog has been the symbol of London for more than a century, but it has not fundamentally changed. In the 20th century, London fog still raged. Mr. Lao She, who used to live in London as a guest, described the London fog as "black, muddy yellow, and crimson, so spicy and choking". So how did the air pollution marked by London fog come about?

Firstly, London fog is the product of a specific geographical location and specific climatic conditions and has a long history. London is located in the temperate marine climate zone, with a warm and humid climate and high air humidity, which makes it easy to produce fog. In autumn and winter, the warm water flow in the North Atlantic converges with the cold water flow on the land, and a large amount of warm air from the sea meets with the cold air mass over the island, which naturally forms a thick fog, which has become an important part of the British way of life. In France, on the other side of the English Channel, the "fog moon," named by the revolutionary calendar during the great revolution, reflects this climate characteristic.

Secondly, London fog is the product of the British industrial production mode in those years. Industrialization and urbanization have made air pollution a serious social problem. The large-scale production of factories starting with steam engines has greatly improved labor productivity and raised air pollution to a new level. Britain has changed from a beautiful rural society with pastoral songs to an urban society with chimneys. Factories and industries have created the "world factory", but the price is "soot has tortured Great Britain. For more than 100 years, cities using bituminous coal as fuel, including London, Manchester, Glasgow, etc., have suffered from decades of severe air pollution before they can find alternative fuels[3]."

Third, the British lifestyle has also increased air pollution to a certain extent. Historically, humans have used firewood for cooking and heating. Poetic cooking smoke actually pollutes the air. Later, coal became the main fuel. In the 19th century, household coal was one of the sources of air pollution in London. The coal burned by cooking and heating in the fireplace released a large amount of soot. With the rapid development of the economy and society since the mid-19th century and the general improvement of residents' living conditions, the use of fireplaces for heating is becoming more common, and various household coal-fired coal produces a large amount of smoke, which also makes more and more smoke and dust in the air of London and the air more and more turbid. Especially in autumn and winter, when the climate is cold, Londoners must burn more coal for heating. Therefore, more smoke and dust are produced, which aggravates the degree of air pollution in London.

In short, the natural fog and the smoke generated by the combustion of domestic coal and industrial coal obscured most of the light in the town. A thick layer of smoke often covered the city sky like a blanket, and even the air became gray. This thick

smoke was romantically called “pea soup”. A thick fog as thick as peas, and obtained the new word smog (a compound of smoke and fog), which means “smoke”. At the end of the 19th century, fog days in London lasted for three months. In the 1950s, fog days still lasted about 50 days.

The ferocious face of London fog in the winter of 1952 finally woke up the world. The dense fog has been suspended over London for five days, and the amount of smoke in the air around the city center has almost increased tenfold! According to the measurement at that time, the sulfur dioxide in the atmosphere per cubic meter reached 3.8 mg, and the smoke and dust reached 4.5 mg. More than 4,000 people died in a few days[4]. Recent research estimated that the number of victims could be as high as 12,000! This London fog is named murder fog! The control of air pollution caused by soot has been put on the agenda.

London adjusts the layout of the manufacturing industry and uses legislation to improve monitoring standards to improve air quality. In terms of industrial pollution, adjust the industrial layout and reduce soot pollution at the source. In 1956, the British government promulgated the Clean Air Act for the first time. Move large soot polluters such as power plants and heavy industry to the suburbs, set up smoke-free areas in the urban area, and prohibit the use of smoke-producing fuels. One of the most famous modern art museums in Europe today. Displaying the works of Matisse and Picasso, Tate Modern, formerly known as the Bankside Power Station on the Thames, the factories left in the city shall not burn coal, and the chimney shall not be less than 200 m. If the chimney of any factory emits black smoke, heavy punishment and relocation will be carried out at the same time. In 1968, the Clean Air Act was promulgated, requiring industrial enterprises to build tall chimneys to evacuate air pollutants. The Air Pollution Control Act of 1974 stipulates the upper limit of sulfur in industrial fuels. Regulations such as the workplace health and safety law stipulate that polluting industries must take measures to avoid discharging harmful gases into the atmosphere; otherwise, they will face severe punishment. Subsequently, a series of more detailed clean air acts further set strict standards for pollution emissions from industrial enterprises. At the civil level, the traditional stoves of urban residents will be transformed on a large scale to reduce the consumption of coal and gradually realize the natural gasification of residents’ lives. Change the heating mode of residents, change the use of coal to gas or electricity, and gradually replace the traditional winter heating mode of each household with a central heating mode. These measures are very effective and greatly reduce the smoke, dust, and sulfur dioxide pollution caused by coal combustion.

By adjusting the layout of polluting industries, controlling pollution sources by legislative means, and changing residents’ lifestyles, smoky air pollution in London has been gradually and effectively improved. In 1975, the foggy days in London were reduced from dozens of days a year to 15 days, and in 1980, they rose and fell to 5 days. London has largely solved the emission of soot pollution and basically removed the hat of “fog city”.

3. Measures

Since the 1980s, London’s air pollution has taken on new forms, and automobile exhaust has become the “culprit” of air pollution. At that time, the traditional soot and dust were basically solved, and the pollution caused by road traffic became a new problem. With the improvement of living standards and technological progress, cars have become the main means of transportation for European and American people and the necessities of daily life. Therefore, automobile exhaust has become the main pollutant in London’s air instead of soot. The exhaust gas emitted after the combustion of gasoline and diesel motor vehicles contains a large number of harmful substances, including carbon monoxide, hydrocarbons, nitrogen oxides, sulfur dioxide, nitrogen dioxide, soot particles, etc. According to the research (**Table 1**), every thousand cars emits about 3,000 kg of carbon monoxide, 200–400 kg of hydrocarbons, and 50–150 kg of nitrogen

oxides every day.

Aiming at various new pollutants and their indepth understanding of pollution, people are urged to take more measures to deal with them.

Table 1. Pollution index (daily average value) of inhalable particulate matter in UK air and corresponding pollution concentration limite[5]

Index	Index	PM_{10} mg/m^3	Impact on health
Low	1–3	<63	People who know they are sensitive to air pollution are unlikely to feel it.
In	4–6	63–94	The consequences are slight, and the susceptible people may feel it, which can basically be ignored.
High	7–9	95–127	Susceptible people may feel obvious. In order to reduce or avoid the consequences of pollution, measures may be necessary (such as reducing the outdoor stay time) A sthmatic patients may feel increased lung pollution when using “palliative” inhalers.
Very high	10	≥128	The feeling of susceptible people in this high degree of pollution may be aggravated.

First, deal with the problems of lead pollution and carbon dioxide emissions in tail gas. In the late 1980s and early 1990s, people began to deal with other pollutants emitted by vehicles, such as nitrogen oxides, carbon monoxide, unstable organic compounds, and “photochemical smog”. Since January 1993, all new cars sold in the UK must be equipped with catalysts to reduce nitrogen oxide pollution. In 1995, the UK passed the Environmental Law, which requiresthe UK to formulate a national strategy for pollution control, determine the quantitative objectives of relevant pollution control, and reduce the emission of eight common pollutants such as carbon monoxide, nitrogen ooxide, and sulfur dioxide. Since the same year, the UK has formulated the national air quality strategy, which stipulates that all cities should carry out air quality evaluation and review. For places that fail to meet the national standards, the local government must delimit the air quality management area and formulate corresponding measures to meet the standards within the specified period. Fixed monitoring stations are set beside the roads with large traffic fflowsin London. For example, Croydon has set up 14 comprehensive monitoring stations to monitor nitric oxide, nitrogen dioxide, carbon monoxide, sulfur oxide, inhalable particulate matter, oozone, and other substances continuously for 24 hours, and focus on the remediation of areas that cannot meet the national standards. In addition, 14 monitoring points are set up specifically for nitrogen dioxide. Since the end of the 20th century, the content of carbon monoxide in the air has decreased sharply and has been relatively stable since 2002. After recognizing the harm of leaded gasoline, unleaded gasoline has been pgivenmore and more attention, and lead emissions have been gradually reduced. Sulfur dioxide and lead, which used to be a historical problem in London, have been maintained at a level that does not affect human health. London also conducted a thorough investigation on carbon dioxide emissions and identified key areas of carbon dioxide emissions. It is considered that three-quarters of London’s carbon emissions come from buildings, including 38% from residential areas, 33% from commercial buildings and government office buildings, and the other one-quarter from transportation and a small amount of industrial emissions. At the end of February 2007, London Mayor Ken Livingston (in office from 2000 to 2008) announced a comprehensive environmental protection plan, which plans to reduce London’s carbon dioxide emissions by 60% within 20 years and build London into the world’s most environmentally friendly city.

The second is to levy a traffic congestion charge to reduce the traffic flow in the city center so as to reduce exhaust emissions. On February 17, 2003, London began to levy a vehicle entry fee, aiming to reduce urban traffic flow and improve traffic congestion. The system stipulates that for the emission of vehicles driving for 1,000 meters under the ideal state, the low emission is class A, which is less than 100 grams of carbon dioxide per kilometer, and the highest class G carbon dioxide emission is more than 225 grams per kilometer, so as to determine the category of specific vehicles. Class A reduces or even does not charge, while class G

charges £25 a day, while zero-emission electric vehicles are free. From Monday to Friday, from 7:00 to 18:30, cars, lorries, and vans must pay £5 (later to £8) to drive in the city center (in some areas), and the fee will be used to improve the bus system. Since then, the charging area has continued to expand, and the charging standard has also been raised to £8. A total of 800 cameras have been installed to monitor vehicles entering the central area.

The third is to set up the world's first Low Emission Zone (LEZ), covering almost the whole city, to reduce the exhaust emissions of diesel-powered commercial vehicles in London through a traffic pollution charging system. The low emission zone policy restricts vehicles with excessive exhaust emissions from entering the Greater London area, improving London's air quality and at the same time reducing the flow of motor vehicles entering Greater London to a certain extent. London's LEZ charges are available year-round, 24 hours a day, 7 days a week, including weekends and holidays. Geographically, it covers most of Greater London. The levy is for those older diesel engine trucks, buses, coaches, large vans (with an empty weight of more than 1.205 tons), and vans (under 5 tons, with more than 8 seats). And cars, electric vehicles, and small vans (with an unladen weight of less than 1.205 tons) are not subject to the low-emission zone policy. The specific operation procedures are: when the vehicle enters the low-emission area, the nearby cameras will automatically identify the vehicle's license plate number and check against the vehicle database to check whether the vehicle meets the corresponding exhaust emission standards; whether it enjoys a daily fee waiver or has registered to enjoy a 100% discount; and whether the toll has been paid in advance. Once the vehicle license plate matches the data in the database of "Transport for London", it means that the vehicle either meets the emission standards, has paid enough fees, has obtained the corresponding fee waiver, or is registered to enjoy 100% great discounts, so no fees are charged and stored vehicle photos are automatically deleted. All vehicles that do not meet low emission standards or are not eligible for exemptions or 100% discounts must pay the daily fee. The specific emission standards and schedule are as follows: From February 4, 2008, heavier trucks, light trucks, buses, and long-distance buses will be implemented in accordance with the European Phase III particle emission standards. Since January 3, 2012, the above-mentioned vehicle emission standards have been upgraded to Euro IV particle emission standards. In addition, including large vans, from October 4, 2010, began to implement the European Phase III particle emission standards. In the charging standard, only those vehicles that meet the European 3-particle emission standard can drive for free in the low-emission charging area. The amount charged depends on the vehicle size and total vehicle weight. The charge for heavy vehicles is £200 a day, and the charge for light vehicles is halved. The charging execution time is from midnight to midnight the next day. The penalty is quite strict. If the car owner does not pay the fee on time, he will face a penalty several times the normal charging standard. If the fine is not paid within 14 days, the fine will be 250 pounds or 500 pounds, depending on the size of the vehicle. If the fine is not paid within 28 days, the fine will increase. to £750 or £1,500. For those affected vehicles, measures can be taken to reduce emissions, such as updating the vehicle, rebuilding the engine, installing a "micro trap" or "filter", or converting the vehicle to natural gas power.

The fourth is to deal with the problem of dust, which will be caused by road traffic and construction sites in London. Therefore, effective control of construction dust is also an important measure to control air pollution in Greater London. In November 2006, the British government and the City Council of London jointly formulated the guidance on the control of dust and pollutant gas emissions from construction sites (hereinafter referred to as the guidance) to reduce the air pollutants produced by construction sites[6]. The guidance stipulates that all construction sites in Greater London must take general measures to control air pollution and meet the basic requirements of "green construction". Open fire is strictly prohibited in construction sites; minimize the construction scope that is easy to cause

dust as far as possible; all working vehicles shall turn off the engine during non-working hours; and all goods entering and leaving the construction site must be covered. It is strictly prohibited to discharge sewage, sludge, and other pollutants to areas outside the construction site; encourage the construction site to suppress dust by means of water mist spraying. The guidance also divides construction sites in Greater London into three pollution threat levels: high, medium, and low.

Through these measures, the exhaust pollution in London has been controlled to a certain extent. The concentration of PM_{10} decreased significantly in the 1990s, although the rate of reduction slowed down in the early 20th century[1]. Among the seven pollutants involved in the air quality regulations—benzene, butane, carbon monoxide, lead, carbon dioxide, sulfur dioxide, and suspended particles—five of them have been controlled. In particular, the concentration of sulfur dioxide and lead, which used to be a difficult problem in London, has no longer affected people's health. 8 curves of sulfur dioxide and fog pollutants in the air of London[1]. From 1950 to 2000 (annual average) $\mu g/m^3$)[7] tells us the downward trend of traditional pollutants such as sulfur dioxide and fog in London. The congestion charge policy has achieved certain results. The London Transport Authority said that the number of vehicles entering the congestion charge area every day was reduced by 60,000 and the exhaust emissions were reduced by 12%. More and more people stop driving to work and choose to take the bus or subway. Mayor Livingstone also takes the subway to work. Later, efforts were intensified, from raising the charging standard to expanding the charging range, with the goal of alleviating the traffic congestion in the central area. There are 70,000 fewer vehicles entering. Central London every day, while the number of passengers taking public transport during the charging period has increased by 6%. After the expansion of the West London area, the toll for cyclists entering the West London area has decreased by 120,000 percent since 2007[8].

4. Research

Since the 21st century, London has taken a sereis of measures to improve air quality. According to the report of Environment Committee of the London Parliament in 2009, carbon monoxide and sulfur dioxide in London have reached the EU limit standards, but nitrogen dioxide, suspended particles, and ozone pollutants have not[9]. Like big cities in Europe, London is still heavily polluted (**Table 2**).

Table 2. Environmental management measures for construction sites with different pollution threat levels

Type	Site area and building quantity	Environmental management measures
Low pollution threat area	Construction sites with an area of less than 1,000 m^2 and less than 10	Fence around the construction site or at least in the main construction area; All vehicles must be brushed and cleaned before leaving the construction site
Moderate pollution threat area	Construction site with an area of 1,000 m^2–15,000 m^2 and 150–210 blocks	Fences must be set around the construction site; Ensure that the road surface of common transportation routes in the construction site is intact and cleaned on time; The speed limit of vehicles driving in the construction site shall be limited; The vehicle must be cleaned before leaving the construction site, with emphasis on cleaning the tire parts; All materials stored on the construction site must be sealed or at least covered; Appoint environmental supervision personnel and ensure to stay on site during the construction period; The crusher and concrete batching machine on the construction site must have the operation qualification certificate issued by relevant departments
High pollution threat area	More than 150 key construction sites with an area of more than 15,000m^2 established by the Greater London joint authority and local self-government	A strong barrier fence must be set around the construction site to ensure that the construction site is completely isolated from the outside world; Dust pollution real-time monitoring device must be set in the construction site; The road surface on the construction site must be intact and flat to meet the standard of dust suppression; Minimize the driving times of vehicles in the construction site, specify the driving route and speed limit; All vehicles must be cleaned before leaving the construction site; Special parts such as tires shall be cleaned and wiped additionally; The road surface must be kept wet when vehicles leave the construction site;

Table 2. Continued.

Type	Site area and building quantity	Environmental management measures
		All building materials and materials in the material storage area of the construction site must be covered, or at least fences and other barriers must be set up; All personnel on the construction site must receive strict training and have job qualification; The person in charge of the on-site environment must be specially trained to ensure that he is resident on the site during construction time Supervise and inspect various environmental problems that may be caused by construction activities at any time, and record the work log; The crusher and concrete batching machine on the construction site must have the operation qualification certificate issued by relevant departments

Until 2005, the content of inhalable particulate matter and nitrogen oxides in London's atmosphere was still higher than the maximum content specified in the EU air quality target. In 2007, TFL estimated that 1,000 people die early and 1,000 are hospitalized every year due to air pollution[10]. In 2008, the mayor announced that more than 4,267 people in London die early every year due to long-term exposure to air pollution. In the spring of 2012, various official monitoring stations in the capital showed that various particles, including nitrogen dioxide, sulfur dioxide, and other pollutants, had reached a high concentration that had not been recorded since the introduction of the new strict measurement method in 2008[11]. London faces the threat of huge fines.

PM_{10}, which had fallen steadily, also rebounded. The emission of PM_{10} and nitrogen dioxide in London in 2003 is shown in **Table 3**[12].

According to the newly implemented suspended particulate matter treatment standard (PM_{10}) in Europe, after investigating the air pollution control measures of 17 major cities in Europe from 2005 to 2010, a committee believes that the air quality level of London is lower than the average value of European countries and is one of the most unhealthy major cities in Europe[13].

Since December 2008, various air quality monitoring stations in London have detected $PM_{2.5}$, that is, particles with a diameter of less than 2.5 microns, which are easier to enter the blood than PM_{10} particles, causing respiratory tract damage, asthma, cardiovascular disease, lung cancer, and premature death (**Figure 1**). They have the greatest impact on children's weak lung function. Children are closer to the exhaust outlets of vehicles than adults. An independent survey commissioned by the Select Committee on Environmental Audit of the House of Commons showed that air pollution increased the risk of asthma in children by 15–30%, and the risk of chronic obstructive pulmonary disease and coronary heart disease in the elderly over 65 increased by a similar proportion.

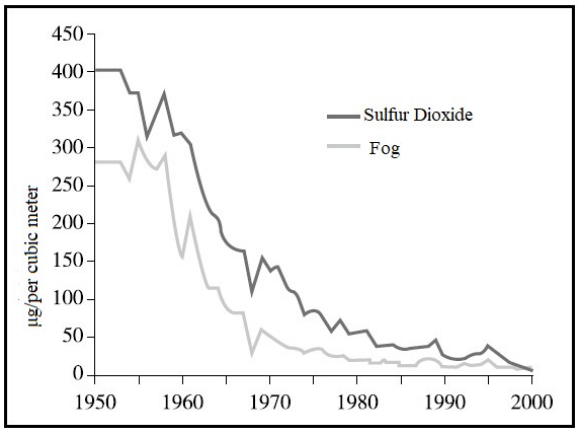

Figure 1. Pollutant levels in London's air.

Facts have proved that the ten places with the densest suspended particles in London are close to traffic arteries, including Marylebone high street, London City, Hyde Park and King's cross road (**Table 3**). However, due to the low-density living here, the number of premature deaths here is lower than that in other areas with low air pollution but high-density living. The two most polluted places are Bryanston and Dorset squares in Westminster.

Table 3. PM_{10} and nitrogen dioxide emissions in London in 2003

	Road traffic	Coal gas	Industrial production	Railway	Aviation	Agriculture	Architecture	Other
PM_{10} emission%	67	12	9	4	4	2	1	1
Nitrogen dioxide emissions%	41	39	8	5	6	-	-	1

According to $PM_{2.5}$ provided by the campaign for clean air in London on June 30, 2010 (**Tables 4-6)**. According to the data on average aggregation degree, among the London boroughs, the most serious suspended particle pollution is in the cities of London, Westminster, Camden, Kensington, Chelsea, and Islington, while the boroughs outside London rank last: nitrogen dioxide cannot meet the standard for a long time. From the perspective of nitrogen dioxide pollution in London, the annual average value of some sections is very high, and the time when the value exceeds 200 mg/m^3 is also very long. Among them, Brixton Road in Lambath has 2,563 hours—that is, more than 100 days.

Table 4. London suspended particulate $PM_{2.5}$ the top ten most dense sections (unit: microgram/cubic meter)

Name	$PM_{2.5}$ quantity	Name	$PM_{2.5}$ quantity
Brienston and Dorset square	17.71	St James's	17.35
Marylebone high street	17.69	Hyde Park	17.28
City of London	17.59	King's Cross	17.19
Bloomsbury, Bloomsbury	17.54	Holborn and Covent Garden	17.18
West end, west end, London	17.41	Brompton Brompton	16.78

Table 5. The top ten London municipalities with the largest concentration of particles

Name of municipality	Total population	$PM_{2.5}$	Died of $PM_{2.5}$ number of people contaminated
City of London	9,155	17.590	4
Westminster	214,750	16.561	96
Camden	207,198	16.188	107
Kensington and Chelsea	169,015	16.169	75
Tower hanlets	231,664	16.024	102
Islington	195,114	15.921	100
Waltham Forest	226,706	15.920	129
Southwark	276,838	15.804	136
Hannersmith and Fulham	178,656	15.794	86
Hackney	223,357	15.702	96

Table 6. Road sections with the highest level of nitrogen dioxide pollution in London in 2010

Name	Average annual value (mg/m^3)	Over 200 hours
Lambeth Brixton road in lambath	173	2,563 hours
Wardsworthputney high street in Woodworth	166	2,602 hours
Walbrook Wharf in London	116	570 hours
Kensington and Chelsea's Earls Court Road	109	436 hours

If we analyze the source composition of the main pollutants, we can better understand the air pollution in London. First, look at the inhalable suspended particles. The composition of PM_{10} in the center of London is as follows: in 2008, road traffic accounted for 79%, cars accounted for 23%, taxis accounted for 25%, transporters accounted for 10–15%, and buses accounted for less than 10%. Tire and brake wear account for 35%. Until 2012, Greater London became the only city in the UK that was required to delay meeting the PM_{10} standard (of course, PM_{10} in 25 of the 27 EU Member States also exceeded the standard). Suspended particulate $PM_{2.5}$ became the largest industrial and commercial road in London, accounting for 20% in 2008. 20% of transporters, cars, and taxis, 5% of buses, and 25% of tires and brakes are worn.

Look at the sources of nitrogen oxide pollution in Greater London. In 2008, road traffic accounted for 46%, household gas 22%, commerce, industry, aviation, and railways 7–8%, cars 35%, transporters 30%, and buses 21%. Nitrogen oxide emissions vary

greatly in different regions of London. Domestic gas emissions in Inner London and outer London are becoming more and more important, but they account for less than 10% in the center of London; more gas emissions in workplaces account for 30%; aviation and railway emissions in the center of London each account for less than 1%; and road traffic emissions in Inner London (60%) are much more than those in outer London. Industrial and domestic gas, aviation, and railway emissions here are relatively low. In central London, buses have become the main source of nitrogen oxide pollution. In 2008, 40% of cars accounted for 20%, heavy transport vehicles accounted for 20%, and taxis and vans accounted for 10%, respectively[1].

It is not difficult to understand why poor air quality is still regarded as one of the biggest public health issues in Britain. The main source of these pollutants is still traffic emissions, especially the inhalable suspended particles, and nitrogen dioxide cannot meet the requirements. Respirable suspended particles mainly come from combustion, including transportation, household, and industrial sources. Residents living in inner-city areas breathe the most polluted air. According to the analysis of the mayor's air quality strategy in 2010, road traffic pollution in central London accounted for about 80% of the air pollution in 2008, including 20% caused by old black taxis, 35% by cars, 30% by transporters, and 21% by buses. Therefore, at present, the most important content of ecological improvement in London is to reduce emissions from road traffic and household and commercial heating systems.

Therefore, clean air: the mayor's air quality strategy, published on December 14, 2010, is committed to reducing the emission of pollutants from London's transportation, homes, and workplaces, especially focusing on reducing the accumulation of suspended particles and nitrogen dioxide and seeking to control nitrogen dioxide within the annual average limit. Boris Johnson, mayor of London (since 2008), said in his introduction: "In my mind, London is a high-quality life that enjoys the beautiful, safe, and clean environment of small cities and the advantages of big cities in the world[1]."

First, in order to promote the use of newer and cleaner taxis, the mayor put forward age restrictions on taxis and privately employed cars. This is the first time that there have been age restrictions on taxis in London. From January 1, 2012, black taxis over 15 years old will not be able to obtain a driving permit, so as to ensure that the oldest and most polluting vehicles will no longer appear on London streets. Accordingly, about 1,200 black taxis will withdraw due to being over 15 years of age. The mayor and the transport bureau also announced that £1 million will be used to encourage taxi owners to upgrade their vehicles and replace them with black electric taxis. The upgraded owners of these vehicles can use the funds to replace the cleanest vehicles. All black taxis must be inspected twice a year by the Ministry of Transport instead of the original annual inspection. The new taxi drivers will attend environmental driving courses to teach efficient driving so as to reduce costs and emissions. Since 2012, any new taxi needs to meet the EU 5 emission standard[1].

Second, launch new, clean cars. Since taxis are the major source of energy consumption and emissions in urban transportation, the London municipal government cooperates with taxi enterprises to produce cleaner taxis, such as electric hybrid vehicles, to reduce exhaust emissions. Lotus has developed a fuel cell driving device for electric taxis. As a substitute for a diesel engine, it can run all day without adding fuel in the middle, and there is no pollutant emission except water. It is expected to produce affordable, zero-emission black taxis by 2020. At present, more than 21,000 electric taxis are in operation in London. The original diesel cars will cause serious traffic pollution, and the emissions include carbon dioxide, nitrogen oxides, lead, and micromaterials. Transforming them into zero-emission vehicles will be of great benefit to reducing the level of air pollution in London. Since the spring of 2013, Londoners have been able to sign up to participate in a new electric vehicle membership project in London, making driving electric vehicles

an easy choice. A 100% discount on low-emission vehicles is also implemented so that Londoners can have a real financial incentive to drive the cleanest vehicles. In addition, the new buses that began service in London in 2012 use the latest hybrid technology, which improves efficiency by 40% compared with the original vehicles and 15% compared with the existing London hybrid fuel buses. London will also encourage residents to buy cars with low exhaust volumes, promote efficient and clean engine technology, and use low-pollution cars using natural gas, electricity, or fuel cells.

Third, it is the first time in the UK to use a dust suppression machine to eliminate road dust. London Mayor Johnson discovered the "innovative dust suppression technology" to control microdust by using a calcium-based adhesive on the streets to control air pollution. International cases show that taking such measures in the target area has a beneficial impact, which can reduce 10–20% of suspended particle PM_{10}[1]. In the autumn of 2010, London first conducted experiments on Marylebone Road and Upper. Since the spring of 2012, 900,000 pounds have been invested. Some specially modified vehicles spray this adhesive on the roads in the busiest traffic areas in London in the middle of the night. This adhesive is similar to glue, which is used to absorb the inhalable particulate matter PM in the air and fix it on the ground to avoid entering the air circulation again. According to the monitoring results, the particles in the dust removal area have decreased by 14%.

Fourth, change the travel mode and advocate "green transportation". In the 21st century, green transportation has sprung up in London. Improve buses to make them cleaner and build the famous "London Double Deck red bus" to the extent of cobwebs. At the same time, it advocates the research, development, and operation of zero-emission electric vehicles. In particular, green transportation, marked by bicycles, is deeply rooted in the hearts of the people. In 2007, Livingstone, then mayor of London, launched a bicycle rental service. Boris. Johnson, the current mayor, took the lead as a model for bicycle promotion. At present, more and more Londoners choose bicycles as a means of transportation. There are more than 350, 1,000-mile bicycle routes in London, and 85% of Londoners use public transport at work. All these have reduced road pollution to a certain extent.

5. Revelations

Analyzing the sources and manifestations of air pollution in London in recent decades, studying different treatment measures for air pollution in London, and exploring London's efforts to build an ecological city with clean air have given us deep enlightenment.

First of all, the London municipal government pays more and more attention to the treatment of air pollution. If the city of London did not do much to control the smog before the "murder fog" in 1952, Since the second half of the 20th century, the municipal government has raised the problem of air pollution in London to an unprecedented level, from the relevant air legislation to the adjustment of London's industrial layout, and then to the mayor's air quality strategy in the 21st century. The first air quality strategy was issued in Britain in 1997; the first mayor's air quality strategy was issued in 2002; and inhalable suspended particulates were included in the national legislation in 2010. It can be said that the air quality in London has become one of the top priorities of the mayor of London.

Secondly, air pollution is a historical phenomenon and presents different forms with the progress of technology. In the process of industrialization in the 19th century, the large-scale production of machines led to coal smoke industrial pollution and smoke air pollution known as the fog city. Since the second half of the 20th century, automobile exhaust has become a new type of pollution with major pollutants. If the smog pollution of foggy London is visible and audible pollution, the air pollution represented by automobile exhaust is almost invisible and unheard pollution. Even if London has solved the most urgent pollution

problem of nitrogen dioxide and suspended inhalable particles, social progress may cause new pollutants or find new pollutants that deserve more attention and solutions.

Third, technological progress, a double-edged sword, not only brings new pollution but also provides means to control pollution. The discovery of suspended particles since the turn of the century is an obvious example of technological progress. From suspended inhalable particles PM_{10} to inhalable suspended particles $PM_{2.5}$. It can only be detected by means of science and technology, which is far beyond the scope of human sensory perception. At the same time, it is only through scientific research that these inhalable particles may have an impact on human health. The air quality inspection points in London provide people with the concentration of pollutants in time, so as to help people avoid or reduce the possibility of pollution to a certain extent.

Finally, the means of air pollution control are also innovating. The treatment of the pollution caused by road traffic includes solving the problem of lead pollution in tail gas through unleaded gasoline and trying to reduce emissions through the development of new electric vehicles or hybrid vehicles. Through the congestion tax levied since 2003 and the low-emission area set up since 2007, we try to reduce the number of travel vehicles in London and scrap the old cars with high pollution. Providing green bicycle travel and developing clean buses provide a channel to reduce pollution. Promoting intelligent driving and reducing dust production on the construction site will reduce the generation of various particles. The new technology was just adopted to suppress. Street ash raising once again shows the new wisdom of mankind. Historical experience tells us that air pollution is an extremely complex problem, and there is a long way to go to control air pollution. The construction of an ecological city is a long process and presents different characteristics and requirements with the development of the times.

Conflict of interest

The authors declare no conflict of interest.

References

1. Greater London Authority [Internet]. Clearing the air: The mayor's air quality strategy; 2010 Dec. Available from: www.london.gov.uk.
2. Clapp BW. An environmental history of Britain since the industrial revolution. New York: Longman Publishing; 1994. p. 14.
3. Stradling D, Thorsheim P. The smoke of great cities, British and American efforts to control air pollution, 1860–1914. Environmental History 1999; 4(1): 8.
4. Goldsmith JR. Urban air conservation. Bulletin of the Atomic Scientists 1961; 17(9): 376–386.
5. London air [Internet]. UK: Environmental Research Group (ERG). Available from: http://www.londonair.org.uk
6. Best Practice Guidance. The control of dust and emissions from construction and demolition. Available from: http://legacy.london.gov.uk/mayor/environment/air_quality/docs/construction-dust-bpg.pdf
7. Wang D. Comparison of air pollution index between China and Britain. Clean and Air Conditioning Technology 2012; (1): 44–46.
8. Transport for London [Internet]. London: Greater London Authority. Available from: http://www.tfl.gov.uk/roadusers/congestioncharging/6723.aspx
9. London Assembly Enviornment Committee. Every breath you take: An investigation into air quality in London. London: Greater London Authority; 2009. Available from: www.london.gov.uk
10. Millward D. School minibuses to be hit by pollution charge. The Daily Telegraph (Telegraph News and Media), 2007 May 11. Available from: http://www.telegraph.co.uk/earth/main.jhtml?xml=/earth/2007/11/05/eabuses105.xml.
11. Air pollution leads to premature deaths of more than 4,000 Londoners a year [Internet]. London: The Guardian [updated 2010 Jun 30]. Available from: http://www.guardian.co.uk/environment/2010/jun/30/london-air-quality-premature-deaths.
12. Simon B. 'Invisible' air pollution is the second biggest public health risk. London: Barbican Association; 2012. p. 47.
13. Moorcroft S, Marner B. Review of the air quality monitoring network in London. London: Air Quality Consultants; 2011.