

# **A Small Dose of Air Pollution or An Introduction to the Health Effects of Air Pollution**

Chapter 26

*A Small Dose of Toxicology - The Health Effects of Common Chemicals*

By

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Air pollution new and old

## Dossier

### Toxicology of Air Pollution

**Name:** Air Pollutants

**Definition of air pollution:** contamination of the indoor or outdoor environment by any chemical, physical or biological agent that modifies the natural characteristics of the atmosphere. Includes a wide range of chemicals and contaminants but six pollutants of noted concern are ozone, particulate matter, carbon monoxide, nitrogen oxides, sulfur dioxide, and lead

**Use:** Major pollutants do not have uses themselves but are byproducts of combustion and other processes in transportation, energy generation, etc.

**Recommended daily intake:** none (not essential)

**Absorption:** respiratory system (lungs)

**Sensitive individuals:** fetus and children, elderly, people with chronic respiratory problems

**Toxicity/symptoms:** irritation of the respiratory tract, dizziness, headache, neurological disorders, cancer, and reproductive effects

**Regulatory facts:** in the US the EPA sets some standards for air pollutants

**General facts:** emissions of billions of pounds of chemicals and particulate matter every year from a wide range of products and industries, and from combustion of fossil fuels such as coal and gasoline

**Environmental effects:** widely distributed in environment, linked with climate change and acid rain, and can affect wildlife and ecological health

**Recommendations:** minimize air pollution on a global scale, avoid exposure to children and other sensitive groups, expand research on toxicity and alternative sources of energy, adopt precautionary approach, reduce the use of fossil fuels, support international treaties

## Case Studies

"As soon as I had gotten out of the heavy air of Rome, and from the stink of the chimneys thereof, which being stirred, poured forth whatever pestilential vapors and soot they had enclosed in them, I felt an alteration to my disposition"

61 C.E., Seneca, Roman philosopher and noted essayist

### Donora Smog

The Donora Smog occurred in Donora, Pennsylvania, USA, starting on October 27, 1948 and lasting until it rained on October 31. The five days of severe air pollution caused the death of at least 20 people and respiratory illness (coughing and other signs of respiratory distress) in approximately 7000 people, half the population of Donora. Donora was a mill town on the Monongahela River, 24 miles southeast of



Pittsburgh, PA, built to take advantage of inexpensive Pennsylvania coal. US Steel's Donora Zinc Works and American Steel and Wire plant released hydrogen fluoride, sulfur dioxide, and other poisonous emissions, which winds typically diluted and dispersed. . This severe smog occurred when warmer air trapped a layer of colder air beneath it, concentrating the industrial pollutants and forming yellowish acid smog. The air was so dirty that emergency responders reported great difficulty in reaching sickened families. In addition, smog and other emissions killed much of the vegetation within a half-mile radius of the plants. There are reports that even ten years after this event, mortality rates in the community remained elevated. This event was a major stimulus for enactment of the US Clean Air Act and the creation of the Environmental Protection Agency. Devra Davis documented this event in her 2002 book *When Smoke Ran Like Water: Tales of Environmental Deception and the Battle Against Pollution* (see reference below).

### Great Smog of London

The great smog of London, also referred to as the Big Smoke, started on December 5, 1952, and lasted until December 9, 1952. Initial reports stated that 4,000 people died

prematurely due to the smog, but this toll was raised to as many as 12,000 people, with over 100,000 suffering a variety of illnesses. Many of the deaths were the result of respiratory infections, with the young and elderly being the most vulnerable. This event was the worst of a series of deadly smog events in London caused by the population growth and the Industrial Revolution. The Great Smog was caused by a cold spell that resulted in the increased burning of coal to keep warm as well as emissions from several coal burning power plants located in the city. The type of coal used, low-grade with high sulfurous content, increased the amount of sulfur dioxide in the smoke and contributed to the severity of the smog. In addition, diesel buses had replaced electric trams, adding to the air pollution. The word “smog” was derived by combining of the words smoke and fog. The yellow-black color of the London smog resulted from chimney smoke and particles of soot from the burning of coal. The large number of deaths and illnesses resulted in the passage of the Clean Air Act of 1956 by an Act of the Parliament of the United Kingdom. Overall this event was an significant impetus to the development of the modern environmental and human health movement.



London Smog 1952

## Diesel Exhaust

Diesel exhaust produced from a wide range of equipment including trucks, ships, trains, construction equipment, farm vehicles, and buses is a serious human health and environmental hazard. It is a very significant contributor to air pollution particularly in high population areas, especially when high-sulfur fuel is used. Air pollutants in diesel exhaust include nitrogen oxides and fine-particle material, sometimes referred to as diesel particulate matter (DPM). In addition, the unintended production of nanomaterials in diesel exhaust or soot (combustion-derived nanoparticles) can be a serious hazard to workers and others near the source of the exhaust, such as trucks, trains, or ships. The small size of these nanomaterials allows them to move deep into the lungs, resulting in acute effects such as asthma, or long-term damage. The nanoparticles can also carry chemical contaminants on their surface, such polycyclic aromatic hydrocarbons (PAHs), deep into the lungs (see nanotoxicology chapter). Diesel exhaust exposure can adversely affect health, resulting in increased asthma attacks, cardiopulmonary disease such as heart attack and stroke, respiratory disease such as pneumonia and lung cancer, adverse birth outcomes, and premature death.



### **Air Pollution Defined**

Air pollution is contamination of the indoor or outdoor environment by any chemical, physical or biological agent that modifies the natural characteristics of the atmosphere. (WHO - [http://www.who.int/topics/air\\_pollution/en/](http://www.who.int/topics/air_pollution/en/))

## **Introduction and History**

*"the smell of burning coal was disagreeable and troublesome".*  
Theophrastus (a student of Aristotle) Ancient Greece (3rd century BCE)

Air pollution is not new but the volume and concentration of contaminants has steadily increased with the development of modern civilization and can be very harmful to human health, even deadly. The Greeks and Romans noted the polluted air millennia ago, as documented in writings of Theophrastus and Seneca. The source of this foul air was stoves, home heating, and smelting of ore for lead and silver, and more generally from the growing population and concentration of people in cities. Evidence of the global distribution of lead air pollution from this period is found in the elevated lead concentrations preserved in Greenland ice sheets.

The unrestrained use of fossil fuels and subsequent air pollution was much worse in the Industrial Revolution. The use coal- and wood-burning stoves for heating and cooking, combined with industrial burning of fossil fuels, created massive air pollution events, especially when weather inversions occurred (see table of some notable events). One of the first people to take note of the air pollution in London was John Evelyn, who wrote the pamphlet *Fumifugium*, or, *The inconveniencie of the aer and smoak of London dissipated together with some remedies humbly proposed* in 1661. He recommended that polluting industries such as cement kilns and brewers be relocated outside the city. Part of the problem was that usage of high-sulfur sea coal increased as wood became scarce.

In 1663 Evelyn's pamphlet was summarized in stanza 23 of "Ballad of Gresham College," given here in modern English.

[...] shows that 'tis the sea-coal smoke  
That always London does environ,  
Which does our lungs and spirits choke,  
Our hanging spoil, and rust our iron.  
Let none at Fumifuge be scoffing  
Who heard at Church our Sunday's coughing.

As deadly air pollution events occurred with greater frequency in countries undergoing rapid industrialization, people became less tolerant and demanded that governments take action to improve air quality. In developed countries, changing fuel sources and installing pollution control devices have substantially improved air quality. However, developing countries such as India and China have struggled to balance rapid industrial growth with air pollution control. The use of coal-fired electric power plants with limited pollution control devices, often near cities, has created very serious air pollution problems. While there are ways to reduce air pollution from large point sources like power plants, non-point sources such as automobiles and trucks are increasing dramatically as economies develop. Ongoing research documents the serious health problems associated with air pollution, particularly for children.

Air pollutants can distribute widely in the environment and cause significant ecological harm. For example, toxaphene, a pesticide used in the corn belt of the United States, and flame retardants, used widely in industry and commercial products, can be found in the fatty tissues of animals in the Arctic, like the polar bear. Airborne nitrogen oxides deposited in water bodies cause increased algae growth, which depletes oxygen in the water and kills fish. Power plants emit sulfur dioxide, which is carried thousands of miles from the source and contributes to acid rain. Coal contains a wide range of contaminants such as mercury that are released as air pollution if not trapped during the combustion process. When the mercury falls out of the air into water, it is converted to methylmercury and bioaccumulates up the food chain, contaminating fish, an important food source for both people and wildlife.

### Notable Air Pollution Events

“Fly the city, shun its turbid air  
 Breathe not the chaos of eternal smoke”  
 British medical poet John Armstrong, *The Art of Preserving Health*, 1744

Date	Place	Description
500 BC - 300 AD	Greek and Roman empires	Mining and smelting of lead and silver caused pollution preserved in the Greenland Ice Sheets
300 BC	Athens	Theophrastus stated, “smell of burning coal was disagreeable and troublesome.”
61 AD	Rome	Seneca noted oppressive conditions of the Roman air

		Roman's used "beach houses" to escape city pollution and installed chimneys 8 meters tall to dissipate smoke.
1200	London	Middle ages – burning of oak wood and then "sea coal" (often high sulfur) in kilns for cement, heating, and brewing.
1285	London	Commission established to address severe air pollution.
1661	London	John Evelyn published one of the first pamphlets on air pollution.
1698	England / World	First crude steam engines, start of Industrial Revolution, centralized industrial manufacturing powered by coal.
1306	England	Edward I bans coal use in kilns, to no effect, sea coal use increases.
1869	Pittsburgh, PA	Burning of soft coal in locomotives in the city outlawed, but ban not enforced
1930	Meuse Valley, Belgium	Meuse Valley fog/smog from industrial air pollution and climatic conditions killed 60 people and sickened 1000s.
1948	Donora, Pennsylvania, USA	Five days of severe air pollution from coal-fired steel plants resulted in the death of at least 20 people and illness in 7000, half the population.
1952	London, England	The Big Smoke: smog from coal burning lasted four days; initial reports of 4,000 deaths, but toll was raised to as many as 12,000 people, with over 100,000 suffering a variety of illnesses
1962	Silent Spring	Rachel Carson's book Silent Spring published, credited with launching the global environmental movement.
1966	New York City	Elevated SO <sub>2</sub> levels during Thanksgiving (November 23-25) blamed for excess deaths
1970	Earth Day	Environmental teach-in called Earth Day was held for the first time on April 22, 1970.
1984	Bhopal, India	Accidental release of 40 metric tons of methyl isocyanate from a Union Carbide pesticide plant, approximately 15,000 people died and 150,000-600,000 injured
1986	Lake Nyos, Cameroon	Carbon dioxide released from the lake, suffocated 1800 people and livestock from nearby villages.

## Indoor Air Pollution / Air Quality

Indoor air quality is critically important because many people, particularly the young and the elderly, spend a great amount of time inside homes or schools. The workplace, either the office building or manufacturing facility, is also a potential setting for hazardous chemical exposure. The table below lists some sources of indoor air pollutants; inadequate ventilation of the indoor environment can cause chemicals released from consumer products to build up. Smoke from wood-burning stoves and fireplaces can also significantly contribute to outdoor air pollution in the local community.

The health effects from indoor air pollutants vary widely depending on the pollutants involved and the age and medical condition of those exposed. Children are vulnerable because they have small airways and respiration rates higher than adults'. Acute effects can include fatigue, headache, dizziness, sore throat, irritation of the eyes and nose, asthma, and anxiety. Chronic or repeated exposure can result in chronic obstructive respiratory disease (COPD), asthma, heart disease, and cancer. This cluster of health symptoms has been associated with "sick-building" syndrome, where poor building ventilation leads to adverse health effects.

It is estimated that 3 billion people, mostly in poor and developing countries, use wood, animal dung, crop waste, or coal for cooking and for heating their homes. This exposes men, women, and children to excessive levels of particulate matter, which increases the likelihood of COPD and pneumonia; children are particularly susceptible and premature death may result.

Table X – Sources of Indoor Air Pollutants

Combustion products	Wood-burning stove or fireplace, tobacco products (second-hand smoke), oil, gas, kerosene, coal, charcoal, cooking fuels
Building materials	Asbestos-containing insulation or tiles, lead based paint, new carpet (off gassing of glues/solvents), old carpet (mold, dust containing tracked-in contaminants), furniture or cabinetry containing pressed wood products (off gas formaldehyde), paint, sealants
Consumer products	Cleaning products, bathroom curtains, personal care products, glues and maintenance products, hobby materials, cars in attached garages, paints, art supplies, perfumes, air fresheners, dryer sheets (Read chapter on Toxics in the Home for more information.)
Other items	Radon, pesticides, lead, asbestos, carbon monoxide, pets, mold



## **Air Pollutants**

In the United States the first federal legislation addressing air pollution was the Air Pollution Control Act of 1955, which that primarily called for research. The first effort to control air pollution was the Clean Air Act of 1963. This act was significantly amended and strengthened in 1970, and established the National Ambient Air Quality Standards (NAAQS) for six priority pollutants. The Clean Air Act has since been amended several times, most recently in 1990 with the inclusion of actions to address acid rain. Concerns about the six air pollutants addressed by the National Ambient Air Quality Standards are briefly summarized below.

### **Ozone (O<sub>3</sub>)**

Ozone consists of three oxygen atoms and was first recognized by Christian Friedrich Schönbein in 1840 as part of the odor from lightning storms. It is beneficial in the upper layer of earth's atmosphere (stratosphere) as it blocks the sun's harmful ultraviolet rays, but in the breathing zone of the lower atmosphere (troposphere), ozone is a pervasive and harmful outdoor air pollutant. Ozone is created when sunlight reacts with pollutants such as volatile organic compounds (VOCs) and nitrogen oxides (NO<sub>x</sub>) that are released from the burning of fossil fuels by cars, trucks, electrical power plants, and chemical plants. While low levels of ozone occur naturally, exposure to elevated levels of ozone are harmful to the lungs. Acute exposure can cause difficulty breathing, coughing, pain while breathing, and asthma attacks, while chronic exposure can cause asthma and permanent damage to the lungs, aggravating chronic lung diseases like emphysema and bronchitis, generally reducing lung function, and increasing susceptibility to respiratory illness. Tangible efforts to reduce ozone levels, such as reducing the use of motor vehicles, have been taken for Olympic sporting events so the performance of athletes is not impaired. In the United States ground-level ozone is one of six major air pollutants regulated by National Ambient Air Quality Standards (NAAQS) under the US Clean Air Act.

### **Nitrogen Oxides (NO<sub>x</sub>)**

The two most significant sources of nitrogen oxides, particularly the highly reactive nitrogen dioxide (NO<sub>2</sub>), are motor vehicles and the burning of coal for electric power generation or industrial boilers. Additional sources include forest fires, the burning of wood for home heating and cooking, and tobacco smoke. Low levels of exposure to NO<sub>x</sub> cause respiratory tract irritation of the nose, throat and lungs, coughing, asthma attacks, and difficulty breathing; high levels of chronic exposure cause permanent damage to the tissues of the respiratory tract, resulting in emphysema and bronchitis. The health effects are of particular concern for people living near sources of NO<sub>2</sub> such as busy roadways. Nitrogen oxides also contribute to acid rain and interact with other pollutants and sunlight to catalyze the formation of ozone. In the United States nitrogen oxides are one of six

major air pollutants regulated by National Ambient Air Quality Standards (NAAQS) under the US Clean Air Act.

### **Sulfur Dioxide (SO<sub>2</sub>)**

The primary source of atmospheric sulfur dioxide is the burning of coal and oil to generate electricity or to facilitate other industrial process such as smelting for metallic ores. Burning high-sulfur fuels on trucks, locomotives, and ships is also a significant source. Sulfur dioxide is also an important precursor, along with nitrogen dioxide, to sulfuric acid or acid rain (H<sub>2</sub>SO<sub>4</sub>), and it reacts with other pollutants in the atmosphere to form small particulates. Most people are familiar with the strong rotten-egg odor of sulfur dioxide. Even low-level exposures can trigger a constriction of the bronchi, difficulty breathing, and an asthma attack. Long-term exposure can cause lung damage leading to emphysema, bronchitis, and cardiovascular disease. Technology is available to remove sulfur from coal-burning effluent and produce low-sulfur fuels. In the United States sulfur dioxide is regulated as an occupational hazard and is one of six major air pollutants regulated by National Ambient Air Quality Standards (NAAQS) under the U.S. Clean Air Act. Sulfur dioxide is useful in wine making, where it is used as an antimicrobial to control bacteria and natural yeasts and as an antioxidant to protect the wine from oxygen.

### **Particulate Matter**

Particulate matter is a mixture of liquid droplets and small particles including metals, organic chemicals, acids, dust, soil, and combustion byproducts. It is produced by the combustion of fossil fuels, wood, and almost anything that is burned. Regulatory agencies are particularly concerned with particles smaller than 10 micrometers (PM<sub>10</sub>) because they can move deep into the lungs and can carry a variety of chemicals. Particles less than 2.5 micrometers PM<sub>2.5</sub> are considered even more hazardous because they not only move deep into the lungs but also can cross into the bloodstream. Inhalation of particulate matter is associated with asthma attacks, heart attacks, stroke, respiratory disease, increased risk of cardiovascular disease, and premature death. In the United States both PM<sub>10</sub> and PM<sub>2.5</sub> are regulated as one of six major air pollutants under the National Ambient Air Quality Standards (NAAQS).

### **Carbon Monoxide (CO)**

Carbon monoxide poisoning is a distressingly common form of fatal air pollution. When combustion occurs in a low oxygen environment, carbon monoxide is formed instead of carbon dioxide. Aristotle (384–322 BCE) was one of the first to note that burning coals emanated toxic fumes; as a form of execution, criminals were shut in a bathing room with smoldering coals. It was not until 1800 that the structure of CO was identified. Carbon monoxide is colorless, odorless, and tasteless, and readily combines with hemoglobin, inhibiting its function of carrying oxygen to organs and tissues. Carbon monoxide poisoning can present as flu-like symptoms of headache, nausea, vomiting, dizziness, and fatigue, sometimes going unrecognized. A failing furnace or indoor use of charcoal fires or generators can lead to the production of CO and subsequent death. In the United States

carbon monoxide is regulated as one of six major air pollutants under the National Ambient Air Quality Standards (NAAQS).

### **Lead**

Lead air pollution was a global issue millenniums ago. Greenland ice sheets reveal a rise in airborne lead pollution due to the smelting and use of lead during Greek and Roman times from 500 BCE to 300 CE. The use of lead, and its worldwide distribution, increased dramatically during the Industrial Revolution. Perhaps the worst public health decision ever made was the addition of lead to motor fuel, which markedly increased the average child's blood lead level. After the US ban on leaded gasoline for motor vehicles, levels of lead in the air decreased by 94 percent between 1980 and 1999 and childhood blood lead levels declined significantly. Leaded gasoline for use in racecars was banned only recently, and leaded gasoline is still used in piston-driven airplanes. An ongoing concern, particularly for developing countries, is airborne lead contamination from ore smelting, battery recycling, and electronic waste. In the last few years, lead contamination from gold mining in Nigeria has killed over 400 children and harmed thousands. In addition, several developing countries continue to use leaded motor fuel.

### **Volatile Organic Compounds (VOCs)**

Volatile organic compounds are organic chemicals with a low boiling point that readily evaporate into the air. VOCs occur naturally but are generated by a wide variety of human activities and form a significant component of both indoor and outdoor air pollution. Common examples are formaldehyde, used in paints, glues, and pressed wood, and benzene, a solvent found in gasoline. Short-term exposure to VOCs can irritate the respiratory tract and eyes while long-term exposure can cause neurological disorders, cancer, and other effects. VOCs can also interact with nitrogen dioxide and sunlight to form ozone or particulate matter.

### **Asbestos**

Asbestos is the common name given to a group of six different naturally occurring fibrous minerals that can be separated into long fibers that can be spun and woven. The material is strong, flexible, resistant to heat and most solvents and acids, making it a very useful industrial product. Knowledge of asbestos goes back to the 2nd century B.C., but the first recorded use of the word asbestos was in the 1st century A.D. by Pliny the Elder.



The fire-resistant properties of asbestos were recognized early and contributed to its derivation from the Greek sbestos or "extinguishable," thus a-sbestos or inextinguishable. The Romans used asbestos to make cremation cloths and lamp wicks and in the Middle Ages, knights used asbestos to insulate their suits of armor. The use of asbestos increased with the Industrial Revolution and the need for a material to insulate steam boilers, such as those in locomotives. The first asbestos mine opened in 1879 in Quebec, Canada.

Canada continues to be the world's largest producer of asbestos, followed by Russia, China, Brazil and several other countries. In the United States, California produces a small amount but the majority of the asbestos used in the United States is imported from Canada.

Serious lung disease associated with asbestos inhalation was first described in the early 1900s in England. This disease became known as asbestosis and was fully described in British medical journals in 1924 as young workers died from asbestos exposure. By the early 1930s, dose-related injury, length of time exposed, and the latency of response were being well characterized in both Europe and the United States. By the mid and late 1930s the first associations with lung cancer were documented. In the 1960s the consequences of asbestos exposure for many workers in World War II started to become evident. Mesothelioma, a cancer of the lining of the lung, was found to be almost exclusively associated with asbestos exposure.



In the United States, regulation of asbestos exposure started in the early 1970s, with exposure limits rapidly decreasing as the serious and latent consequences of asbestos exposure became apparent. White asbestos or chrysotile was used in thousands of consumer products and is common in many older homes. The serious health effects of asbestos exposure have resulted in both regulatory and legal action, and many countries have instituted complete bans on asbestos use.

### **Phthalates**

Phthalates are a class of high-volume chemicals that are ubiquitous in the environment. They are plasticizers that, when added to plastics, impart a softening characteristic lending flexibility to the plastic. These water-insoluble, synthetic organic chemicals are usually added to polyvinyl chloride (PVC) plastics and have a wide expanse of uses, including in many common household items, cosmetics, and medical devices. As phthalates are not chemically bound to the plastics in which they are used, they can leach out into the environment.

Human exposure to phthalates begins in utero, and some levels of exposure are nearly unavoidable. Each year, more than 18 billion pounds of phthalates are used worldwide. Phthalates are used as plasticizing agents to make rigid plastics into flexible vinyl. They are ubiquitously found in the environment. They are also listed as "inert" ingredients in many sprays including pesticides, cosmetics, and wood finishes.

### **NAAQS standards**

National Ambient Air Quality Standards (NAAQS) are standards established by the United States Environmental Protection Agency under authority of the Clean Air Act as of October 2011 (see EPA - <http://www.epa.gov/air/criteria.html>)

Pollutant		Type	Standard	Averaging Time
Sulfur Dioxide	SO <sub>2</sub>	Primary <sup>1</sup>	0.075 ppm	1-hour
	SO <sub>2</sub>	Secondary <sup>2</sup>	0.5 ppm (1,300 µg/m <sup>3</sup> )	3-hour
Particle Pollution	PM <sub>10</sub>	Primary and Secondary	150 µg/m <sup>3</sup>	24-hour
	PM <sub>2.5</sub>	Primary	12 µg/m <sup>3</sup>	annual
	PM <sub>2.5</sub>	Secondary	15 µg/m <sup>3</sup>	annual
Carbon Monoxide	PM <sub>2.5</sub>	Primary and Secondary	35 µg/m <sup>3</sup>	24-hour
	CO	Primary	35 ppm (40 mg/m <sup>3</sup> )	1-hour
	CO	Primary	9 ppm (10 mg/m <sup>3</sup> )	8-hour
Ozone	O <sub>3</sub>	Primary and Secondary	0.075 ppm (150 µg/m <sup>3</sup> )	8-hour
Nitrogen Dioxide	NO <sub>2</sub>	Primary	0.100 ppm	1-hour
	NO <sub>2</sub>	Primary and Secondary	0.053 ppm (100 µg/m <sup>3</sup> )	annual
Lead	Pb	Primary and Secondary	0.15 µg/m <sup>3</sup>	Rolling 3 months

<sup>1</sup>**Primary standards** provide public health protection, including protecting the health of "sensitive" populations such as asthmatics, children, and the elderly.

<sup>2</sup>**Secondary standards** provide public welfare protection, including protection against decreased visibility and damage to animals, crops, vegetation, and buildings.

## Child Health and Air Pollution

Children are small but eat more, drink more, and breathe more than adults, based on body weight. Thus a small exposure is a big dose for a child because of their low body weight. Recent papers describing research on children and air pollution document the vulnerability of children to air pollution. Perera et al. (2007) describe how airborne polycyclic aromatic hydrocarbons (PAH) from fossil fuel burning adversely affects child behavior. Millman et al. (2008) describe the negative impact of air pollution related to coal burning in China on child development. Finally, Becerra et al. (2013) describe an association between air pollution from traffic in Los Angeles, California and childhood

autism. Taken together, these studies and other research clearly document the vulnerability of children to air pollution and the importance of clean air during development.

## Reducing Exposure

Reducing exposure to air pollution can be challenging, depending upon location and societal commitment. Indoor air pollution can be somewhat controlled by purchasing consumer products that emit fewer chemicals. Outdoor air pollution or work place exposures are far more difficult for individuals to control, but society can make improvements. Cars engines have been greatly improved to reduce air pollution and increase gas millage. Pollution from trucks and other diesel engines has also been greatly reduced through improved engine design and using low sulfur fuel. Individuals can make a difference by using mass transit, walking, or riding a bike. Some states are requiring more energy efficient appliances. In addition solar panels and other forms of alternative energy are becoming more practical and cost effective.

## Regulation of Air Pollution

Following incidents where people suffered from the harmful effects of air pollution, it was recognized that the regulation of air pollution was essential to the well-being of humans and ecosystems. Regulation started locally and gradually expanded to national and international efforts to control air pollution and reduce the worldwide distribution of harmful chemicals. It is important to note the possible overlaps between local and international issues: for example, contaminants from coal burned in the United States or China cause local air pollution but also contribute to international pollution. International treaties have successfully contributed to reducing specific air pollutants such as CFCs, but great effort will be necessary to control pollutants such as mercury and greenhouse gases, which contribute to global warming. Below are some of the notable regulatory events.

### Regulations Related to Air Pollution

Year	Name	Comment
1955	Air Pollution Control Act	Provided for research and declared that air pollution was a danger to public health and welfare, but preserved the "primary responsibilities and rights of the states and local government in controlling air pollution"
1963	Clean Air Act	Acknowledged that air pollution was a national problem that crossed state lines, published national air quality standards
1965	Motor Vehicle Air Pollution Control Act	Acknowledged that autos were a significant source of national air pollution, and national standards were needed

1970	National Environmental Policy Act (NEPA)	Stated that it was the duty of the U.S. government to “encourage productive and enjoyable harmony between man and his environment”, and established the Environmental Protection Agency (EPA), to take responsibility for environmental regulation and protection.
1970	Clean Air Act Amendments	Significantly strengthened the Clean Air Act, setting National Ambient Air Quality Standards (NAAQS) for six criteria pollutants
1986-1989	Montreal Protocol	Montreal Protocol on Substances that Deplete the Ozone Layer: international treaty to phase out chemicals like Chlorofluorocarbons, adopted 1986 and entered into force in 1989
1997-2005	Kyoto Protocol	United Nations Framework Convention on Climate Change (UNFCCC) - an international treaty to reduce emissions of greenhouse gases, adopted 1997 and entered into force in 2005

## Recommendation and Conclusions

Air pollution knows no boundaries and is thus a regional, national, and international issue. The unrestrained burning of fossil fuels such as coal, oil, and gasoline for electrical power generation, transportation, cement kilns, and chemical production are the major contributors of air pollution, greenhouse gases, and global warming. More research into alternative forms of energy and a reduction in the use of fossil fuels is essential to maintain a sustainable world and protect human health. Coal-burning power plants and boilers are significant point sources of air pollution and should have pollution control technology devices installed. The availability and use of mass transit and alternative forms of transportation must be developed to reduce the use of non-point sources of air pollution such as cars and trucks. Consumer products should be designed to reduce contributions to air pollution during manufacture and use. While outdoor air pollution is important, more attention must be given to the air quality indoors. As a global society we must work towards regulation that protects people locally as well as globally, preserving human and ecological health for current and future generations. We all, and especially our children, have a right to an environment in which we can reach and maintain our full potential, free of harmful air pollutants.

## More Information and References

### Slide Presentation

- A Small Dose of Air Pollution presentation material and references online: [www.asmalldoseoftoxicology.org](http://www.asmalldoseoftoxicology.org)  
Web site contains presentation material related to the health effects of Air Pollution.

### **European, Asian, and International Agencies**

- World Health Organization (WHO) Air pollution. Online at [http://www.who.int/topics/air\\_pollution/en/](http://www.who.int/topics/air_pollution/en/) (accessed: 28 October 2020)  
Overview of indoor and outdoor air pollution as well as health related information.
- World Health Organization (WHO) Household air pollution and health. Online: <https://www.who.int/en/news-room/fact-sheets/detail/household-air-pollution-and-health> (accessed: 28 October 2020)
- England – Department for Environment Food and Rural Affairs – Air Pollution. Online at <http://uk-air.defra.gov.uk> (accessed: 28 October 2020)
- England - Air Quality England. Online at <http://www.airqualityengland.co.uk> (accessed: 28 October 2020)  
“This website shows the latest near-real time air quality data for UK Government, local authorities and the private sector across England.”

### **North American Agencies**

- AIRNow – supported by U.S. EPA, NOAA, NPS, tribal, state, and local agencies  
Online at <http://airnow.gov/> (accessed: 19 October 2020)  
Provide U.S. national air quality information, daily AQI forecasts and real-time AQI conditions for over 300 cities across the U.S.
- Health Canada - Health Effects Of Air Pollution - Online  
<https://www.canada.ca/en/health-canada/services/air-quality/health-effects-indoor-air-pollution.html> (accessed: 19 October 2020)  
Overview of air pollution and health related issues.
- EPA Air Page – Online at <http://www2.epa.gov/learn-issues/air-resources#air-pollution> (accessed: 19 October 2020)  
EPA provides a wealth of information on air pollution regulations, air quality, emissions monitoring, and health and environmental impacts.



- US Clean Air Act – this page no longer exists  
EPA provides a brief introduction (in plain English) Guide to the 1990 Clean Air Act
- US EPA - Air Quality Criteria for Ozone and Related Photochemical Oxidants (2006 Final) – Online at <http://cfpub.epa.gov/ncea/cfm/recordisplay.cfm?deid=149923> (accessed: 19 October 2020)
- US EPA Indoor Air Pollution – Online at <http://www.epa.gov/iaq/index.html> (accessed: 19 October 2020).  
EPA provides excellent overview and references related to indoor air quality.
- US EPA – Sulfur Dioxide – Online at <http://www.epa.gov/airquality/sulfurdioxide/index.html> (accessed: 19 October 2020)
- US EPA – Nitrogen Oxides – Online at <http://www.epa.gov/airquality/nitrogenoxides/> (accessed: 19 October 2020)
- US EPA – Particulate matter – Online at <http://www.epa.gov/airquality/particlepollution/> (accessed: 19 October 2020)
- US EPA – Carbon monoxide – Online at <http://www.epa.gov/airquality/carbonmonoxide/> (accessed: 19 October 2020)
- US Occupational Safety & Health Administration - Indoor Air Quality – Online at <http://www.osha.gov/SLTC/indoorairquality/index.html> (accessed: 19 October 2020)

### **Non-Government Organizations**

- American Lung Association (ALA) - - Online at <http://www.lung.org> (accessed: 19 October).  
The American Lung Association works to “save lives by improving lung health and preventing lung disease through Education, Advocacy and Research”.
- The National Association of Clean Air Agencies (NACAA) – Online at <http://www.4cleanair.org/> (accessed: 19 October 2020)  
Provides information on air pollution and represents air pollution control agencies in 45 states and territories and over 116 major metropolitan areas across the United States.

- Natural Resources Defense Council – AIR – Online:  
<https://www.nrdc.org/stories/air-pollution-everything-you-need-know> (accessed: 28 October 2020)  
 A basic introduction to air and its pollution.

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