Air Pollution, Smog and Health Impacts

What is Air Pollution?

Air pollution is the presence in the air of any substance in high enough concentrations to be harmful to the environment or to human health.

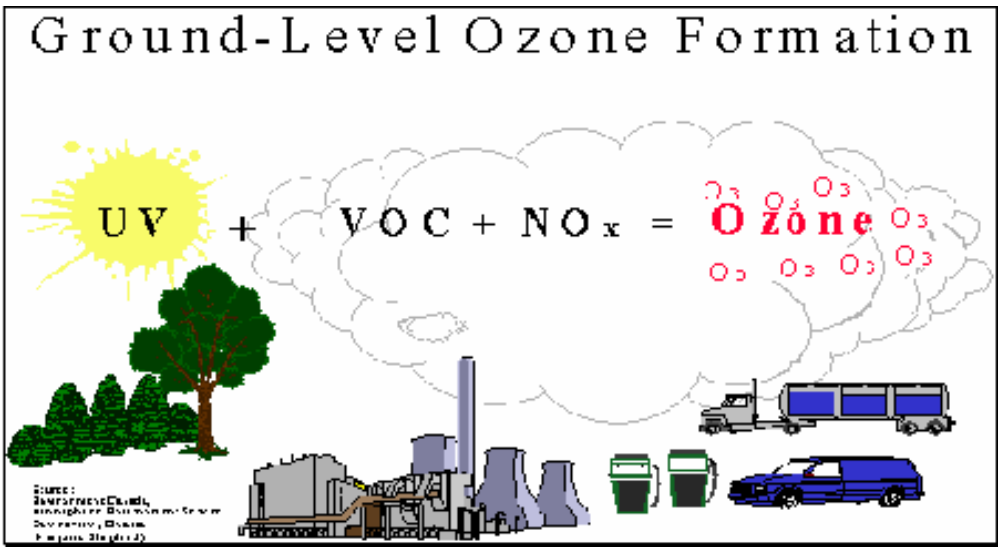
Human activities (e.g. combustion of fossil fuels and industrial processes) are the primary source of most pollutants, although pollutants can also come from natural sources (e.g. fires, wind-blown dust, volcanoes). The main air pollutants are:

1. **Nitrous Oxides** (NOx), which are produced during the combustion of fossil fuels, are a pollutant themselves, but also react with water vapour to form fine acidic droplets, and react with VOCs to generate ozone. NOx are both air pollutants and GHGs.
2. **Sulphur Dioxide** (SO_2), which is generated by industrial processes and combustion of fossil fuels, is a pollutant itself, but also reacts with water vapour to form fine acidic droplets (e.g. sulphuric acid). SO_2 is not a GHG.
3. **Carbon Monoxide** (CO) is generated by combustion of fossil fuels (primarily from automobiles), but is also released by wild fires and volcanic eruptions. CO is not a GHG.
4. **Volatile Organic Compounds** (VOCs) are a group of carbon-containing compounds (both natural and synthetic) released primarily by the evaporation of petroleum products (e.g. gasoline, natural gas), solvents and other volatile products (e.g. paints). VOCs react with NOx in the presence of sunlight to form ground level ozone. Some VOCs are carcinogenic (e.g. benzene, formaldehyde). VOCs by themselves do not contribute to the greenhouse effect.
5. **Ground level Ozone** is formed by a chemical reaction between VOCs and NOxs, in the presence of sunlight. Ground level ozone is one of the main components of smog. Because the reaction that generates ozone accelerates at higher temperatures, global warming is expected to increase concentrations of ground level ozone and lead to more smog. Ground level ozone is also a GHG.
6. **Airborne particles** (Particulate Matter – PM) include both solids and droplets from a variety of natural sources and human activities. In most cases, coarse particles, (2.5-10 microns) are emitted directly into the air (e.g. dust, pollen, diesel soot, smoke) and fine particles (less than 2.5 microns) are formed through chemical reactions involving NOx, SO_2, water vapour, VOCs and ammonia. Particulate matter is one of the main components of smog, but does not contribute to the greenhouse effect.
7. Various **heavy metals** (lead, mercury, cadmium, manganese) and various **persistent organic compounds** (e.g. PCBs, dioxins) are also found in air pollution. Heavy metals and persistent organic compounds do not contribute to the greenhouse effect.

Stratospheric Ozone – The Good Ozone
Stratospheric ozone, or the 'good' ozone layer is located 16-50 km above the ground. It has a cooling effect on the earth and protects humans and other life from ultraviolet (UV) radiation. When scientists refer to 'holes in the ozone layer' (caused primarily by chlorofluorocarbons or CFCs) they are referring to the stratospheric ozone layer. Stratospheric ozone is not a pollutant; ground level ozone is.

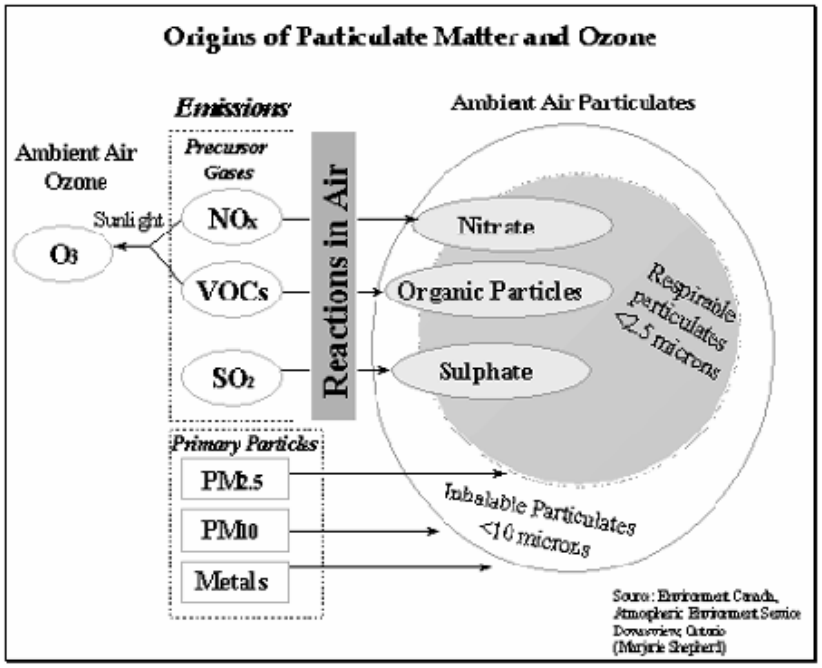
Groundlevel Ozone – The Bad Ozone
Ground level ozone is formed when VOCs and NOxs react in sunlight (NOx + VOx + Sunlight = GLO). Ground level ozone is toxic to humans, contributes to smog and climate change, and does not protect us from UV radiation.

Figure 1 Ground –Level Ozone Formation



Source: http://www.hc-sc.gc.ca/ewh-semt/air/out-ext/effe/talk-a_propos_e.html

Figure 2 Origins of Particulate Matter and Ozone



Source: http://www.hc-sc.gc.ca/ewh-semt/air/out-ext/effe/talk-a_propos_e.html

What is Smog?

The term 'air pollution' is a general term covering all forms of pollutants while 'smog' refers to a phenomenon caused by a chemical reaction of certain pollutants in the atmosphere. Smog occurs most frequently on hot, sunny, calm days and appears as a yellowish haze that sits over cities, towns and regions.

The two main ingredients of smog are ground-level ozone, which is formed by a chemical reaction between NOx and VOCs in the presence of sunlight, and fine airborne particles. Because smog formation depends on heat and sunlight, smog generally peaks in the late afternoon and early evening. It is most obvious in large cities, but wind patterns and topography mean that smog can travel and be trapped in areas distant from the source (e.g. smog is often worse in the Fraser Valley than in Vancouver). Smog is both an urban and rural phenomenon and can occur at any time of the year, although summer tends to be the season with the highest frequency due to the higher temperatures. Smog will stay in an area until it is dispersed by heavy winds or washed out of the local atmosphere by rain (which is why smog is worse on calm, sunny days).

General Impacts of Air Pollution and Smog

Air pollution and smog can affect us in a variety of ways: impair lung function, make breathing more difficult and make us more susceptible to respiratory diseases.

Air pollution and smog can also:

- contaminate soil and water (e.g. by acid rain)
- compromise the health of wildlife by affecting habitat and food quality
- reduce plant health and productivity (e.g. decrease crop yields)
- diminish our ability to enjoy the outdoor environment (e.g. through reduced visibility on smoggy days, discomfort from exercising/recreating outside on smoggy days)
- damage buildings (e.g. acid rain and deposition of particulates)
- compromise our health and increase risk of mortality
- impede athletic performance

Damage from air pollution is not always localized. The long-range transport of pollutants can mean that soils, water, plants, animals and people can be affected far away from sources of pollutants. The effects of air pollution are not limited to urban areas.

Air Pollution, Smog and Human Health

The health effects caused by air pollutants may range from subtle biochemical and physiological changes to difficulty breathing, wheezing, coughing and aggravation of existing respiratory and cardiac conditions. These effects can result in increased medication use, increased doctor or emergency room visits, more hospital admissions and even premature death. Exposure to toxic airborne substances (e.g. mercury and lead) can also lead to neurological damage, particularly in children.

The respiratory system

Air pollutants can irritate your eyes, nose, and throat and irritate and inflame your airways and lung tissue. This can diminish the ability of your lungs to collect and deliver oxygen, cause long-term lung damage, and aggravate existing respiratory conditions (e.g. asthma, bronchitis, chronic obstructive pulmonary disease). Chronic exposure to pollutants (especially ozone) can damage deep portions of the lung even after symptoms such as coughing or a sore throat disappear. Air pollution can also reduce your resistance to respiratory infections.

The cardio-vascular system

Pollutants are absorbed into the bloodstream, where they can then travel throughout the body, starting a 'chemical chain reaction'. Through a variety of complex pathways, this can affect blood vessels and ultimately the heart. For example, air pollutants can contribute to degenerative necrosis, inflammatory reactions, and arrhythmias. They may lead to the formation of free radicals, which are thought to contribute to narrowing of the arteries (by formation of atherosclerotic plaques).

Exposure to air pollution is linked to increased hospital admissions and emergency room visits, increased use of medications, shortened life span and increased mortality (deaths).

Ozone and particulate matter

All air pollutants, including NOx, SO_2 and CO, affect our health, but ozone and particulate matter are the biggest concern. Ozone is highly reactive and can damage lung tissue and significantly reduce lung function, even when the exposure is to low concentrations, for relatively short periods. Particulates irritate and inflame the respiratory system, impairing lung function. Fine and ultra-fine particles cause the greatest damage, as they can penetrate deep into the lung, carrying with them allergens and toxins. Particles generated by combustion of fossil fuels are particularly toxic.

There is no 'safe' level of exposure to air pollution (particularly ozone and PM).[3] Health effects result from both long term and short-term exposure, and even at low levels of pollution. This means that we need to be concerned about ozone and PM levels even on days when no smog warning is in effect.

Who is affected by air pollution and smog?

Everyone. Individual reactions to air pollutants depend on the type of pollutant a person is exposed to, the degree of exposure, the individual's health status and genetics. Children, the elderly, those who are physically active outdoors, and those with pre-existing medical conditions, are particularly vulnerable. But the reality is that air pollution affects all of us. Even healthy people have difficulty breathing on days when the air is heavily polluted. Ozone and particulates cause inflammation and swelling in lung issue and decreased lung function *in everyone*.

Children are particularly vulnerable to the effects of air pollution because:

- their respiratory and neurological systems are still developing
- they tend to spend more time outdoors, being active (so they inhale more pollutants)
- they breathe more per unit of body weight than adults (meaning they filter more polluted air through their lungs)
- they have smaller airways and lungs
- their immune systems are immature (making them more vulnerable to respiratory infections)

The WHO strongly recommends reducing children's exposure to air pollutants, in particular those related to traffic.[3]

Athletes are also particularly at risk from air pollution and smog because they spend a lot of time training outdoors. During exercise, particularly at high intensity, athletes inhale deeply, drawing large volumes of dirty air deep into their lungs, and they breath via their mouth, bypassing the filtration system in the nose. They also have high metabolic rates and are more susceptible to infections, because intense training depresses the immune system temporarily.

Effects of air pollution on human health

- Irritation to eyes, nose and throat
- Irritation, inflammation and damage to lung tissues
- Decreased lung function
- Impaired ability to use oxygen
- Shortness of breath, coughing, wheezing, chest pain, pulmonary congestion
- Heart failure
- Aggravated asthma, chronic obstructive pulmonary disease
- Acute and chronic bronchitis
- Decreased resistance to respiratory infections

Smog-related deaths

- A 2005 study by Toronto Public Health found that the air pollution was the cause of 822 deaths a year in Toronto, 818 in Montreal, 368 in Ottawa and 258 in Windsor (based on data from 1954-2000). The study estimates that increased ozone levels from global warming will result in 20 per cent more smog-related deaths by 2050 and 25 per cent more by 2080.[1]

- In 1952, deadly smog descended on London, England. Motor vehicles were abandoned, trains were disrupted and airports were forced to close. The smog lasted for 4 days and resulted in over 4000 deaths.[2]
- A 2005 study by the federal government estimated that air pollution leads to 5900 premature deaths each year in 8 large Canadian cities. (This estimate is probably low because it only considered short-term impacts of air pollution). The Ontario Medical Association estimated that in 2005 there were 16,000 hospital admissions and 60,000 emergency room visits in Ontario because of illnesses associated with air pollution, and that air pollution led to direct health care costs of over $500 million.[3]

What to Do and What Not to Do on Smog Days

Study after study shows that the overall health benefits of exercising far outweigh the alternative of not exercising at all -- even despite the associated risks of exposure to air pollution and smog (confirmed by Canadian Association of Physicians for the Environment and many other sources).

However -- we urge caution and common sense by telling Canadians to do the following on smog alert days:

- Exercise indoors if this is possible
- Exercise very early in the a.m. before peak traffic times or after evening rush hour
- Choose locations to exercise as far away as possible from traffic areas
- Keeps kids indoors at times of high traffic or take them to a gym or indoor play center
- Make sure kids are not playing near traffic areas or take them to a park area away from traffic and at off peak traffic times
- Make your 'day off' on a smog alert day and modify your outdoor training days/times to minimize exposure to smog
- Fill up gas tank after dusk
- Use human-powered or electric rather than gasoline-powered lawn equipment
- Leave your car behind and walk, ride, run, roll, or take public transit or carpool

EVERY STEP DOES MAKE A DIFFERENCE

The Connection between Air Pollution, Smog and Climate Change

There are two main connections:

1. Climate change and air pollution have a common source and thus a common solution.

Combustion of fossil fuels (e.g. burning of coal, gas, and oil in cars, homes and power plants) is the primary source of both air pollutants and the rising levels of GHGs that are contributing to climate change. CO_2, while not considered an air pollutant, is the GHG that is increasing most rapidly, largely as a result of combustion of fossil fuels. NOx is a GHG, a primary air pollutant and leads to the creation of ground level ozone. Ground level ozone is both an air pollutant and a GHG.

We can address both air pollution (the intensity and frequency of smog episodes in particular) and climate change by reducing our reliance on fossil fuels.

2. Climate change is expected to increase air pollution (ground-level ozone and smog) and exacerbate its effects.

Climate change is expected to magnify the effects of air pollution, because hotter, sunnier days will provide optimal conditions for the creation of ground-level ozone. Heat waves can also lead to temperature inversions, where smog is trapped near the Earth, further increasing exposure to pollutants. The combination of more smog and more intense and frequent heat waves will compound health problems for those who are vulnerable (children, elderly, athletes and those with pre-existing respiratory and cardiac disease). Airborne allergens (pollen, moulds, and dust) are also expected to increase with climate change, further aggravating asthma and related respiratory diseases.

Did You Know?

- Throughout Canada, children are more likely to be hospitalized for respiratory problems resulting from exposure to air pollution than any other cause.[4]
- Running in a polluted urban area for 30 minutes is equivalent to smoking a pack of cigarettes a day.[5]
- Asthma rates among children in some parts of North America are four times higher than they were 20 years ago. Children from lower income families living in inner-city neighbourhoods are particularly at-risk, in part because of higher exposure to pollutants (such as ozone, particulates, nitrous oxides).[11]
- Studies in Greater Vancouver have found that more than 2700 deaths and 33,000 emergency room visits could be avoided with a 25% reduction in particulate matter.[6]
- Air pollution with particulate matter (PM) claims an average of 8.6 months from the life of every person in the European Union (EU).[7]
- Exposure to fine PM in outdoor air leads to about 100,000 deaths each year in Europe.[4]
- Exposure to ground-level ozone for even short periods at relatively low concentrations has been found to significantly reduce lung function in healthy people during periods of exercise.[3]

Sources and Useful Links

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