ENSC 201 Environmental Toxicology and Chemical Risks

Week 10 March 7. Atmospheric pollution. Pamela Welbourn

Recommended reading
W&W Chapter 4, case study 4.4 on Nanticoke Generating Station pp 197- 2016
W&W Chapter 6, section 6.4 on mercury pp 274 – 282, especially table 6.3 and figure 6.14;
W&W Chapter 6, section 6.11, section on fluorine, pp 313 - 315
W&W chapter 9, section 9.2 on mining and smelting of metals, parts that deal with smelting especially parts of table 9.1 and 9.2;
W&W chapter 9, section 9.4 on electrical power generation, mainly section 9.4.1, electricity from fossil fuel
W&W chapter 9. Section 9.6, on atmospheric pollution, pp 465-474.

Web site for Ontario's regulation of air quality
www.ene.gov.on.ca/air.htm Choose links for any topics concerning regulation and other control measures, to follow the various actions and reports.

Terms/concepts to be learned

- Types of compounds that contribute to air pollution

- In brief, risks to human and environmental health from the following substances in air (some of this is review from earlier lectures):
  Oxides of S; Oxides of N;
  VOCs;
  Ozone;
  Particulates, metallic;
  Organo-metallics;
  Fluorides;
  BETX;
  Chlorinated organic compounds;
  PAHs;
  CFCs;
  "Greenhouse gases"

- The formation of ozone

- Major processes and activities that are sources of air-borne contaminants

- Smog: reducing and oxidizing

- Ontario's smog alerts

Working definition for atmospheric pollution: *substances that are released into the atmosphere, deliberately or inadvertently, from natural or anthropogenic sources and that have the potential to be toxic.*

Receptors and routes of exposure for atmospheric pollutants: Note that although at this point we shall deal mainly with atmospheric pollutants that result in exposure via the air, many substances that are released into the atmosphere are subsequently deposited into or onto soil, water or sediments and thus the route of exposure for the receptor(s) is not directly from the air.

Types of compounds that contribute to air pollution. Substances in a number of physical states can be air-borne. These include true gases, aerosols and fine particulates of solid material.

Examples of gases: CH_4; CO; CO_2; SO_2; NO_x; VOCs; O_3; some chlorinated hydrocarbons; BTEX; dimethylmercury;

Examples of aerosols: sulphates; fine droplets of organic material

Examples of particulates: carbon (soot); oxides, salts and other metallic compounds; chemical mixtures of particles with organic substances adsorbed onto them;

Brief outline of the risks to human and environmental health from substances that are air-borne.

1. Oxides of sulphur
2. Oxides of nitrogen
3. Hydrocarbons, VOCs
4. Ozone
5. Metallic particulates
6. Organo-metals
7. Fluorides
8. BETX – organic solvents such as benzene, ethylbenzene, toluene and xylene
9. Organochlorines, dioxins, furans
10. PAHs
11. CFCs
12. "Greenhouse gases"

Formation of ozone O_3

From oxides of nitrogen:

$NO_2 + h\nu = NO + O$ (photolysis)

$O + O_2 = O_3$

Reversible reaction: $NO + O_3 \leftrightarrow NO_2 + O_2$

From hydrocarbons

$RO_2 + NO = RO + NO_2$

Figure 9.3 shows the daily fluctuations in photochemical oxidants

Note the distinction between stratospheric ozone (GOOD) and ground level ozone (BAD)

Major processes and activities that are sources of air-borne contaminants
Combustion of fossils fuels;
Smelting;
Waste incineration (municipal and hazardous waste);
Landfills;
Forest fires;

Volcanoes;
Geological faults;
Wetlands

Pathways in the environment. Distribution ranges from vary from local, to regional to LRTAP and could even be considered as global. Acidic deposition and contamination of arctic ecosystems, as well as some examples of mercury deposition are examples of LRTAP. Figure 6.11, provided in lecture 10 shows spatial distribution from a local source of metals; Figure 4.5 shows lead deposition from distant sources.

What is "Smog"?
1. Reducing smog (SO_2 combined with dust particles and moisture) – the old industrial smog of London UK and European cities.

2. Oxidizing smog. Ozone, formed mainly from automobile emissions – photolysis of oxides of nitrogen and hydrocarbons – with particles in the atmosphere – a haze, the "Los Angeles" type of smog

Concentration of smog over urban areas is worsened when there is a temperature inversion, illustrated in figure 9.4

Regulatory aspects. Concern for human health and for ecosystems, natural and managed, prompt attempts to regulate air quality. For this, knowledge of the most important contributing sources is utilized, and where possible these known sources are themselves regulated. Other means of protection includes various warnings, e.g., smog alerts, which provide the means for humans to avoid the risk of exposure. This latter is an example of *Risk Management,* which will be discussed in later lectures.

Air Quality Standards. Regulatory Authorities develop and/or implement and enforce:
Point of Impingement Standards; Point of Impingement Guidelines; Ambient Air Quality Criteria

Monitoring and reporting. Most jurisdictions require the major know air pollution sources to monitor their emissions and report regularly. Typically an industry or large operation (e.g., a large smelter complex such as Sudbury; a coal-fired power plant such as Nanticoke) will have permitted limits and if not in compliance, will be subject to fines, control orders or other punitive actions.

Case study 4.4 illustrates some of Ontario's work on air quality monitoring. It also illustrates the use of indicator plants, discussed in an earlier lecture. In addition to chemical measurements of emissions or ambient air quality, test plots of sensitive plants are laid out at suitable points and their response will indicate poor air quality, integrating any emissions over time.

Anti Smog Action Plan and Smog alerts. The aim of the Ontario Ministry of the Environment's (OMOE) ASAP is to achieve a 75% reduction in the average number of times that the one-hour Ambient Air Quality Criterion for ozone (80 ppb) is exceeded. Since the two main components of smog are ozone and fine particles, smog reduction involves targeting sources of NO_x, VOCs and particulate matter. SO_2 is also of concern mainly because of acid rain but also because of its role in forming fine particulates.

In Southern Ontario, the highest concentrations of ozone and fine particulates occur between May and September. Warnings are issued when smog conditions rise to dangerous levels. The OMOE will issue a smog alert to notify public health offices and the general public, and to urge then to take appropriate action. This is an example of *Risk Management by avoidance of the risk. Risk Reduction* is the long-term aim and will reduce exposure by controlling the source(s) of air pollutants.