Announcements

- No class Monday due to holiday
- Wednesday lab meet at the ISU Power Plant – see map on course website
- Air Pollution Problems
  - Chapter 7: 2, 5, 7, 10, 15 due 1/26/2009
Air Pollution Factoids

- Americans make the equivalent of 3M round trips to the moon each year in their automobiles.
- National air quality levels have shown significant improvements over the last 30 years in the U.S.
- Since 1970, aggregate emissions of the six principal pollutants have been cut by 48%, while the gross domestic product has increased 164%, energy consumption has increased 42%, and vehicle miles traveled has increased 155%.
- 160 million tons of pollution are emitted into the air each year in the U.S.
Air Pollution Factoids

- Approximately 146 million people live in counties where monitored air in 2002 was unhealthy at times because of high levels of at least one of the six principal air pollutants.
- The vast majority of areas that experienced unhealthy air did so because of one or both of two pollutants - ozone and particulate matter, PM10 and PM2.5.
- Clean Skies legislation currently being considered would mandate additional reductions of 70% from current emission levels from power plants through a cap and trade program.
- Of the six pollutants (NOx, Ozone, SOx, PM10, CO, lead) ground level ozone has been the slowest to achieve reductions.
Air pollution Episodes

- Meuse Valley, Belgium, 1930 – zinc smelters, 60-70 deaths
- Donora, Pennsylvania, 1948 – 23 deaths over Halloween weekend
De Standaard 7-12-1930

De Maasvallei, de "Vallei van den Dood"

Reeds 64 personen werden op geheimzinnige wijze uit het leven gehaald. — Ook veel vee is in de weiden omgekomen. — Zit de mist vol giftige gassen? — Dokters en geleerden trachten het tragisch raadsel op te lossen.

Le Soir 12-12-1930

Le tragique mystère de la Vallée de la Meuse

De nieuwe autopsies liënt 16 december.

De Standaard 8-12-1930

Doodende mist in de Maasvallei

In het geheel zouden er 63 slachtoffers zijn. — Er zijn nog honderden ziekten, die evenwel geen gevaar lopen nu de mist weg is. — Een soort Spaansche griepe? — Het oordeel van de geleerden. — H. M. de Koningin heeft zich ter plaatse begeven.

Le Soir 11-12-1930

Le Brouillard homicide

Une communication du gouvernement

M. Jaspar, premier ministre, devant la Chambre, dehors, presente les condamnations du gouvernement aux familles des victimes du brouillard dans la vallée de la Meuse.

Le Peuple 6-12-1930

Une catastrophe extraordinaire encheville la vallée de la Meuse depuis Jemeppe à Engis

Quarante-trois personnes périssent dans le brouillard sous l'influence de gaz délétères.

L'Indépendance Belge 6-12-1930

Le grand jour!

Trente-neuf personnes meurent mystérieusement à Engis et Flémalle.

Depuis jeudi matin toute une région prise dans un épais brouillard, vit dans les bras de la mort.

Un mystérieux « brouillard-tueur » sème la panique dans la vallée mosane : déjà soixante-cinq morts.
Belgium’s Poison Fog Cases Likened to the ‘Black Death’

Special Cable to THE NEW YORK TIMES.
LONDON, Dec. 5.—The suggestion that the Belgian fog deaths may be due to some form of plague was advanced tonight by Professor J. B. S. Haldane, prominent Cambridge scientist.

“It seems like something in the nature of the Black Death to me,” he told The Daily Mail tonight. “I don’t think it can be caused by war gas, because the deaths occurred in different villages. They have been having floods in that district lately and that may be responsible.”

The Black Death was the name given in the Middle Ages to the bubonic plague, which was responsible for millions of deaths in the fourteenth century in various parts of Europe.

Meuse Valley, Belgium, 1930 – zinc smelters, 60-70 deaths

FOG BROUGHT DEATH ONLY TO OLD AND ILL

Toll of 70 in Belgian Towns Laid to Natural Causes as Menace Passes Away.

PEASANTS STILL IN TERROR

Many Credit Malignant Force — Authorities the World Over Speculate on Phenomenon.

Special Cable to THE NEW YORK TIMES.
BRUSSELS, Dec. 6.—While it is asserted by some medical authorities that the appalling number of deaths attributed to the dense fog in Belgium of the last three days were due in reality only to natural causes, the peasants refuse to relinquish the theory of poison. They point to the great numbers of cattle killed as supporting their belief.

Upward of seventy persons are reported dead, while the hospitals of Liège are choked with victims.

A conference of Red Cross doctors held today in Engis, one of the stricken villages, was unable to submit a report for want of definite evidence. In a conference here at the

BELGIAN FOG DEATHS LAID TO POISONOUS GAS

Doctor Who Performs Autopsy Unable to Identify It — Brussels Inquiry Today.

Special Cable to THE NEW YORK TIMES.
BRUSSELS, Dec. 8.—The deaths caused by the fog in the Meuse Valley were ascribed to a poisonous gas by Professor Firket, who performed an autopsy upon several victims today in Liège. He said, however, that he had been unable to determine exactly what gas had wrought the havoc.

“It is neither any known form of war gas, nor a gas such as might be derived from an ammonia explosion,” he said. “We rather incline to the theory that it had its origin in some industrial accident, which resulted in the release of noxious gas.”

Scientists investigating the incident agree that such a noxious gas could be carried by the fog. At the same time, no progress has been made by the authorities in discovering information concerning any such accident, and for the moment the mystery remains unsolved.

An inquiry will be held here tomorrow by the Cabinet of Ministers to seek a solution of the mystery.

LONDON, Dec. 8.—The mysterious “death fog” of the Meuse Valley in Belgium, which last week claimed more than three hundred human lives, was not due to any communicable disease, in the opinion of Belgian health authorities, and they so informed the British Ministry of
Donora, Pennsylvania, 1948 – 23 deaths over Halloween weekend

Fig. 1-2. Environs of Donora, Pennsylvania. Horseshoe curve of Monongahela River is surrounded by mountains. Railroad tracks are located on both sides of the river. Low-lying stretch of Monongahela Valley between railroad and river is natural trap for pollutants.
Fig. 4–9  Fumigation of a valley floor caused by an inversion layer that restricts diffusion from a stack.
Central London during the killer smog, December 1952. At this point, visibility is less than 30 feet. During the height of the smog, people could not see their own hands or feet, and buses had to be led by policemen walking with flares.

Credit: 'When Smoke Ran Like Water', by Devra Davis, Perseus Books

Research by Rutgers University's Paul Lioy and others shows that as the amount of smoke and pollutants in the air shot up during the week of Dec. 5, 1952, so did the death rate in greater London. Estimates say the smog killed anywhere from 4,000 to 11,000 people.

Credit: Paul Lioy, Rutgers University
Smog: Sulfur Dioxide, Acidic Aerosols and Soot (particulates)

TABLE 1.1 Some Incidents of Excess Deaths Associated with Smog

<table>
<thead>
<tr>
<th>Year</th>
<th>Place</th>
<th>Number of excess deaths</th>
</tr>
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<tbody>
<tr>
<td>1930</td>
<td>Meuse Valley, Belgium</td>
<td>63</td>
</tr>
<tr>
<td>1948</td>
<td>Donora, Pennsylvania</td>
<td>20</td>
</tr>
<tr>
<td>1952</td>
<td>London</td>
<td>4000</td>
</tr>
<tr>
<td>1962</td>
<td>London</td>
<td>700</td>
</tr>
</tbody>
</table>

*From Firket (1936), Wilkins (1954), Rouéché (1965), and Cochran et al. (1992).*

FIGURE 1.2 Concentrations of SO$_2$ and "smoke" as well as the death rate during the 1952 smog episode (adapted from Wilkins, 1954).
Primary vs. secondary standards

- **Primary standard** - to protect
  public health with an adequate margin of safety

- **Secondary standard** - to protect public welfare (plants, animals, and property)
Primary vs. secondary pollutants

- **Primary pollutant** - discharged directly into the atmosphere (e.g., automobile exhaust)

- **Secondary pollutant** - formed in the atmosphere through a variety of chemical reactions (e.g., photochemical smog)
Stationary vs. mobile sources

- **Stationary Sources**
  - Contribute approximately 40% of total air pollution
  - 98% of SO$_x$
  - 95% of particulates,
  - 56% of total hydrocarbons,
  - 53% of NO$_x$, and
  - 22% of CO
Stationary vs. mobile sources

Mobile Sources

- Contribute approximately 60% of total air pollution
  - 78% of CO,
  - 47% of NO$_x$,
  - 44% of total hydrocarbons,
  - 5% of particulates, and
  - 2% of SO$_x$

See: National Emissions Inventory from EPA

CE 326 Principles of Environmental Engineering, Copyright © 2009 Tim Ellis, Iowa State University
### National Emissions Estimates
(fires and dust excluded)
For Common Pollutants and their Precursors

<table>
<thead>
<tr>
<th></th>
<th>Millions of Tons Per Year</th>
</tr>
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<tbody>
<tr>
<td>Carbon Monoxide (CO)</td>
<td>178</td>
</tr>
<tr>
<td>Lead</td>
<td>0.074</td>
</tr>
<tr>
<td>Nitrogen Oxides (NO\textsubscript{X})</td>
<td>27</td>
</tr>
<tr>
<td>Volatile Organic</td>
<td></td>
</tr>
<tr>
<td>Compounds (VOC)</td>
<td>30</td>
</tr>
<tr>
<td>Particulate Matter (PM)</td>
<td></td>
</tr>
<tr>
<td>PM\textsubscript{10}</td>
<td>6</td>
</tr>
<tr>
<td>PM\textsubscript{2.5}</td>
<td>NA</td>
</tr>
<tr>
<td>Sulfur Dioxide (SO\textsubscript{2})</td>
<td>26</td>
</tr>
<tr>
<td>Totals</td>
<td>267</td>
</tr>
</tbody>
</table>
Effects of air pollution

- Damage to human health and welfare
- Damage to vegetation and animals
- Damage to materials and surfaces
  - Abrasion
  - Deposition on surfaces
  - Direct chemical attack
  - Indirect chemical attack
  - Electrochemical cell

- Damage to the atmosphere, soil, and water
Air Pollution Effects

Statue damaged by acid rain

Melon leaves damaged by ozone

Feedlot
Definitions

- **Criteria pollutant** – pollutant that is regulated based on health or environmental criteria.
- **NAAQS** - National Ambient Air Quality Standards - revised in 1987, set air quality standards.
- **SIP** – State Implementation Plan to achieve air quality standard.
- **AQR** – Air Quality Region – areas that have air quality that meets primary standards is classified as an attainment area, if not, then it’s a non-attainment area.
- **NESHAPs** – National Emission Standards for Hazardous Air Pollutants
- **MACT** – Maximum Achievable Control Technology
  - also BACT – best available control technology) – the best available control equipment that is technologically feasible and is currently available.
- **NSPS** – New Source Performance Standards
Seven Major Pollutants of Concern

1. Particulates
2. Sulfur Oxides (SO\textsubscript{x})
3. Ozone
4. Nitrogen Oxides (NO\textsubscript{x})
5. Carbon Monoxide (CO and other hydrocarbons)
6. Volatile Organic Compounds (VOCs)
7. Lead (& others: mercury, other inorganic metals, radon, HCl)