CIVE 3331 - ENVIRONMENTAL ENGINEERING
Spring 2003

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Air Pollution

Air pollution has caused death and illness (Donora, PA). Death from air pollution is still rare (not counting war gasses), but increased morbidity is still of great concern. Most efforts focus on six criteria (indicator) pollutants.

Table 1. Criteria Pollutants and Their Effects

Symbol	Name	Health Concern
CO	Carbon Monoxide	Reduces O_2 in blood; cardiac stress.
NO_2	Nitrogen dioxide	Respiratory irritant
O_3	Ozone	Respiratory irritant; stress heart and lungs
SO_2	Sulfur dioxide	Respiratory irritant
PM10;2.5	Particulates less than ten microns; 2.5 microns	Respiratory irritant; visibility; vector for toxic chemicals.
Pb	Lead	Blood poison, neurological effects

Recently the focus has expanded to include air toxics.

Sources of Air Pollutants

1. Emissions from combustion
2. Emissions from evaporation
3. Emissions from abrasion

Combustion

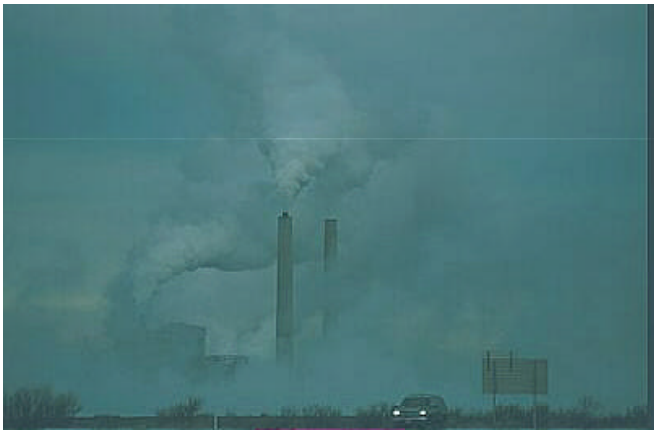

Figure 1. Coal-Fired Power Plant

Figure 2. Grilled Food

Figure 3. Oil-well fire in Iraq

Figure 4. Automobiles in Traffic

Combustion includes automobile emissions, electricity generation, agriculture, home and office heating, cement manufacture, air, sea, rail transport, and food preparation.

A model reaction is

$$CH_4 + 2O_2 \rightarrow CO_2 + H_2O$$

Most combustion is oxygen starved, even with excess O_2, thus the model reaction is

$$CH_4 + O_2 \rightarrow \alpha(CO_2 + 2H_2O) + (CO + HC)\beta$$

$$\alpha >> \beta$$

$$\alpha + \beta = 1$$

Furthermore most combustion is air breathing (not pure O_2) so that the N_2 in the air gets incorporated into the waste products.

$$(N_2 + O_2) + Heat \rightarrow NO_x \text{ (thermal)}$$

Most fuels are not pure hydrocarbons but have impurities like N,S,Pb, and other materials.

$$(H, C, S, N, Pb, Ash)_{Fuel} + (N_2 + O_2)_{AIR} \longrightarrow HEAT + USEFUL\ WORK$$

$$+ (CO_2, H_2O, CO, NO_x, SO_x, Pb, PM) + \underset{Emmissions}{Ash} + HC$$

The emissions react with each other in the presence of light to produce yet other pollutants.

$$HC(VOC) + NO_x + h\nu \rightarrow (O_3 + etc.)_{PC\,smog}$$

Visit: www.epa.gov/airnow

Evaporation

Figure 5. Refinery

Gasoline, paints, solvents, even plant transpiration introduce VOCs into the air. Largest contribution is from man-made sources, but natural sources of VOCs are not trivial.

Abrasion

Figure 6. Sand storm in Iraq

Figure 7 Sand blasting tent (industrial use)

Particles, soil (dust), silica (dust) are introduced by erosion and abrasion processes. Like small particles in water, small particles in air can remain suspended for long times.

Standards

Air quality standards are based on both ambient (background) conditions and specific emissions standards.

Ambient

The Clean Air Act (CAA) establishes National Ambient Air Quality Standards (NAAQS). If a region (airshed) meets these standards it is said to be incompliance with the NAAQS. If an area is in violation of one or more of the NAAQS, then the area must develop and submit a State Implementation Plan (SIP). If the SIP does not enable the region to meet the NAAQS by a certain date, then the EPA may impose economic sanctions, typical threat is to cut off Federal Highway Funds.

Emissions

Emissions standards are specific amounts (usually masses) of particular pollutants that a generator or region may discharge into an air shed.

Sanctions

Sanctions are the tool to force change in emissions if the SIP fails. The effect is twofold. First is the anger generated by paying taxes and receiving no service, secondly the local economic impact is that business will leave the area (as will the employees) and the air quality will be improved simply by reduced population pressure. To date, sanctions have never been implemented, Houston may be the test case.

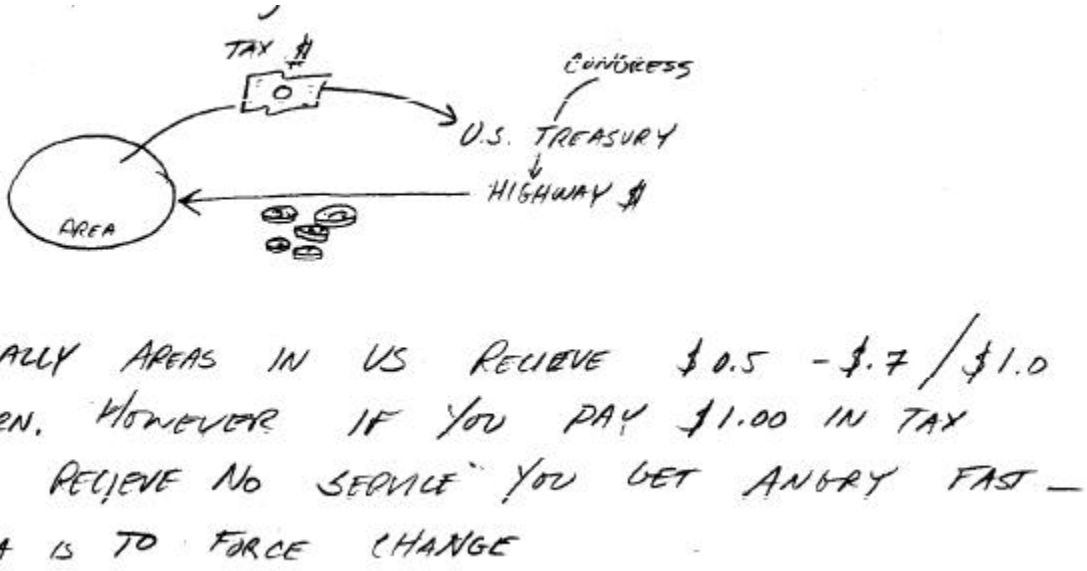

Figure 8. Cartoon of Economic Sanction Concept

Non-attainment means that one violates one or more standards 2 days per year (or more days). A single violation in one year is considered acceptable.

Measures employed in non-attainment areas:

1. No new net emissions. Offsets – new sources OK, if can reduce existing sources enough to offset the new source contribution. Creates an emission market.
2. New sources must employ Lowest Achievable Emissions Rate (LAER) technology regardless of cost.

Attainment areas are classified by amount of degredation allowed (PSD).

Class I-No increase in pollution allowed.

Class-II – Moderate increase allowed.

Class-III – Large increase allowed (air shed sacrifice areas).

In all PSD areas, must use BACT (Best Achievable Control Technology) (economics are allowed in choice)

CAA 1990 Amendments

"SO2 allowance" - degredation permits (a form of resource allocation) and conservation reserve concepts (negawatts) introduced into the legislation.

Non-attainment areas (acceleration) are classified by the degree of non-attainment.

1. Marginal – new source requires cost + 10% offset.
2. Moderate
3. Serious
4. Severe
5. Extreme – new source requires cost + 50% offset.

Added 189 pollutants to air toxic list (asbestos, benzene, beryllium, coke, arsenic, mercury, radionulides, vinyl chloride …etc.)

Air Quality Index

Previously known as the pollutant standard index, numerical system supplemented with a color system to indicate health based approximation of air quality.