Module 7: Combustion and Environment

Lecture 37: Major Sources of CO Emission

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Major Sources of CO Emission

Source category	Emissions (Millions tons per year)	%
Gasoline motor vehicles	95.8	36.69
Diesel, aircraft, trains, vessels	5.6	2.14
Off-highway vehicles	9.5	3.64
Coal	0.5	0.19
Fuel oil	0.1	0.038
Natural gas	0.1	0.038
Wood	0.1	0.038
Total stationary sources	0.8	0.30
Total fuel combustion	111.7	42.78
Industrial processes	11.4	4.36
Agricultural burning	13.8	5.28
Solid waste disposal	7.2	2.75
Miscellaneous	4.5	1.72
Total	**261.1**	**100.0**

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Chemicals From Combustion

Emission of NO, NO_2

NO and NO_2 are main components producing O_3 in troposphere.

The life of these gases are quite short even less than 1 day.

Combustion of fossil fuel is the largest source of NO_x .

The quantities are sufficient enough to affect the quality of atmospheric air.

Combustion of fossil fuel is the largest source of NO_x around 22 Mt/yr.

Stationary source contribution is around 13 Mt/yr.

Contribution of NO_x emission by biomass is quite small.

Due to combustion, there is a four fold increase in the tropospheric NO_x.

The major sources of NO_x emission and their contributions are depicted in the next section.

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Major Sources of NO Emission

Source category	Emissions (Millions tons per year)	%
Gasoline motor vehicles	7.8	17.53
Diesel, Aircraft , trains, ships	2.0	4.49
Off-highway vehicles	1.9	4.27
Coal	3.9	8.76
Fuel oil	1.3	2.92
Natural gas	4.7	10.56
Wood	0.1	0.22
Total fuel combustion	21.7	48.76
Industrial processes	0.2	0.45
Agricultural burning	0.3	0.67
Solid waste disposal	0.4	0.90
Miscellaneous	0.2	0.45
Total	**44.5**	**100**

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Chemicals From Combustion (Contd..)

Emission of Hydrocarbon

- Non-methane hydrocarbons (NMHC) are short lived and highly reactive.
- Oxidization of these hydrocarbons leads to the formation of O_3.
- Volatile organic compounds include NMHC as well as oxygenated species such as aldehydes and alcohols.
- These are mainly contributed by gasoline vehicles, solvent evaporation and biomass burning.
- These bio-organic hydrocarbons are quite reactive and are usually destroyed within the boundary layer.

Emission of Sulphur Dioxide and Sulphate Aerosols

- Sulphur content of fossil fuels such as coal and oil is in the range of 0.5 – 2.5 by mass.
- Sulphur in the fossil fuel is usually emitted as SO_2 and leads to the formation of sulphuric acid.
- SO_2 takes very less time to get converted into sulphate to wet or dry deposition on the earth surface.
- Combustion of fossil fuels contributes significant amount of SO_2 in troposphere, which is about 80 Mt/yr.

Source	SO_2 (Million tons per year)
Fossil fuel	80
Metal smelting	8
Biomass burning	2
Natural sources (Ocean, oil, vegetables)	25

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Quantification of Emission

- Emission levels are reported in several different ways while dealing with different devices.
- **Gas turbine combustors**: ppm by volume at 15% O_2
- **Furnace:** ppm at 3% O_2
- **Automobiles:** g/km
- **Boiler:** g/kW

Species emission and its corrected value

- Generally combustion system is characterized in terms of level of emissions.
- Confusion prevails due to the change in sampling condition
  - Degree of dilution
  - Dry or wet condition
- If the moisture is removed from the exhaust sample then it will yield dry concentration.
- In some situations, it may not be possible to remove moistures, then it is known as wet concentration.

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Species Emission and Its Corrected Value

- Consider a hydrocarbon fuel-air mixture at lean or stoichiometric condition

$$C_xH_{2y} + a(O_2 + 3.76N_2) \rightarrow xCO_2 + yH_2O + bO_2 + 3.76\,a\,N_2 + trace\ species$$

- Wet mole fraction of i^{th} species is defined as

$$X_{i,wet} = \frac{N_i}{N_{mix,wet}} = \frac{N_i}{x + y + b + 3.76a}$$

- Dry mole fraction of i^{th} species is defined as

$$X_{i,dry} = \frac{N_i}{N_{mix,dry}} = \frac{N_i}{x + b + 3.76a}$$

- Carrying out an atom balance for O atom,

$$a = x + \frac{y}{2} + b$$

- Ratio of total number of moles in wet mixture to dry mixture is

$$\frac{N_{mix,wet}}{N_{mix,dry}} = \frac{X_{mix,dry}}{X_{mix,wet}} = 1 + \frac{y}{(4.76a - y/2)}$$

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