

# Air Pollution

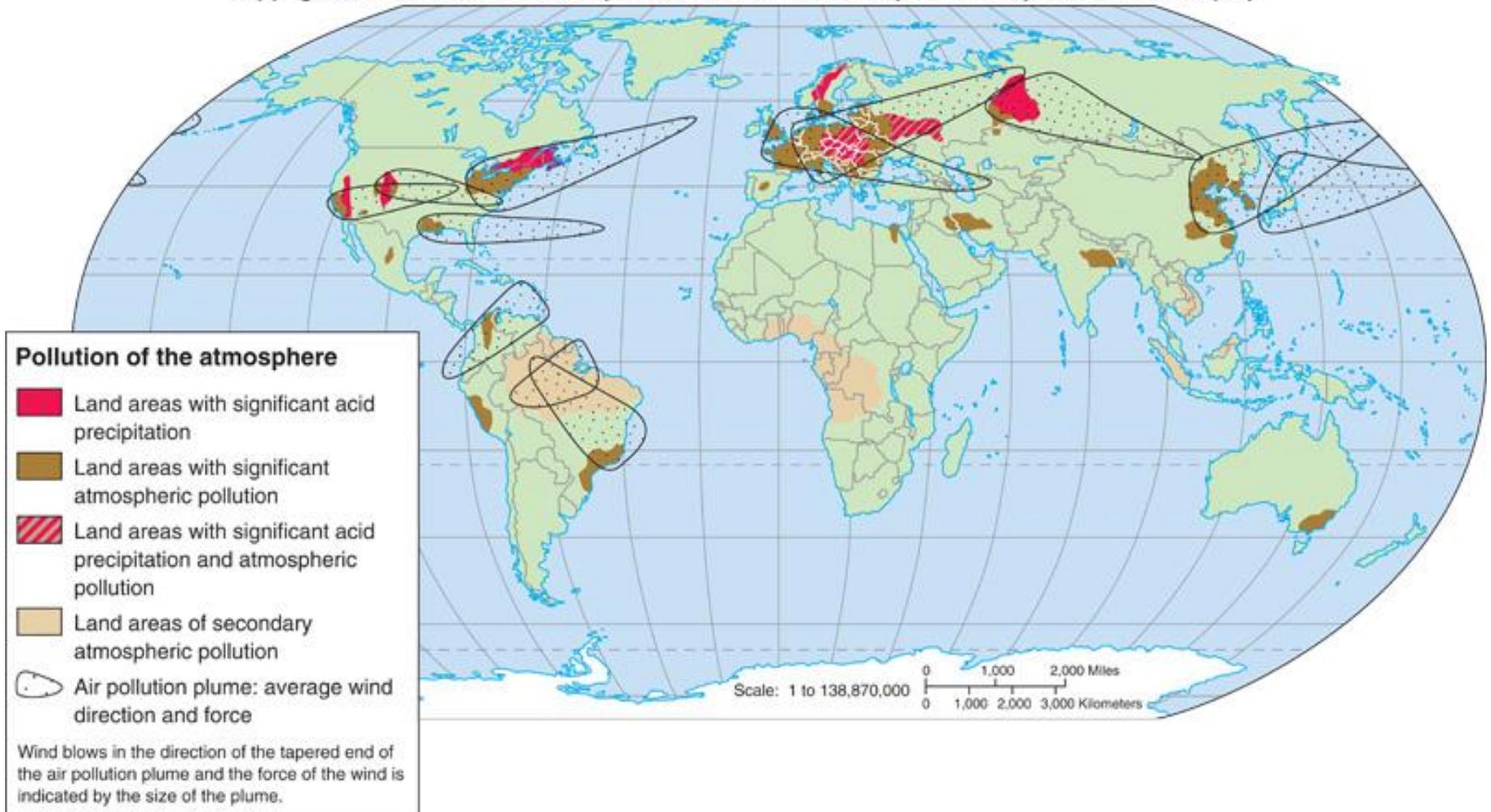


# Climate Processes And Air Pollution

- Air pollution is defined as any contaminant added to the air that is harmful to the health of living organisms.
- Due to the nature of air and wind, this pollution can be carried great distances.

# Long-Range Transport

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# Air Pollution Classification

- **Primary Pollutants**

Released directly into the air

- **Secondary Pollutants**

Formed as a result of a chemical reaction in the air.

1. **Smog**: Reaction of sunlight with nitrogen oxide (NO<sub>x</sub>), the words smoke and fog
2. **Acid Rain**: Reaction of sulfur dioxide (SO<sub>2</sub>) with water to form sulfuric acid.
3. **Ozone**: Tropospheric, or ground level ozone, is not emitted directly into the air, but is created by **chemical reactions between oxides of nitrogen (NO<sub>x</sub>) and volatile organic compounds (VOC)**.

## AIR POLLUTION SOURCES

1. Anthropogenic Activities
  - a. Industrial Activities
  - b. Combustion Fossil Fuel
  - c. **Vehicular Emission**
2. Natural Processes



## High Concentration of Air Pollutants

1. CO
2. Ozone
3. **Particulate Matter (TSP, PM10)**
4. NO<sub>x</sub>
5. SO<sub>2</sub>
6. Lead



## ASSOCIATED FACTORS

1. **Environmental Factors**
  - a. Physical Environment
  - b. Temperature
  - c. Humidity
  - d. Altitude
  - e. Climatic Changes
  - f. Geographical Distribution
  - g. Distance From the Main Roads
  - h. Closed Area
2. **Human Factors**
  - a. History
  - b. Socioeconomic Status
  - c. Indoor Air Quality
  - d. Demographics



## HEALTH EFFECTS

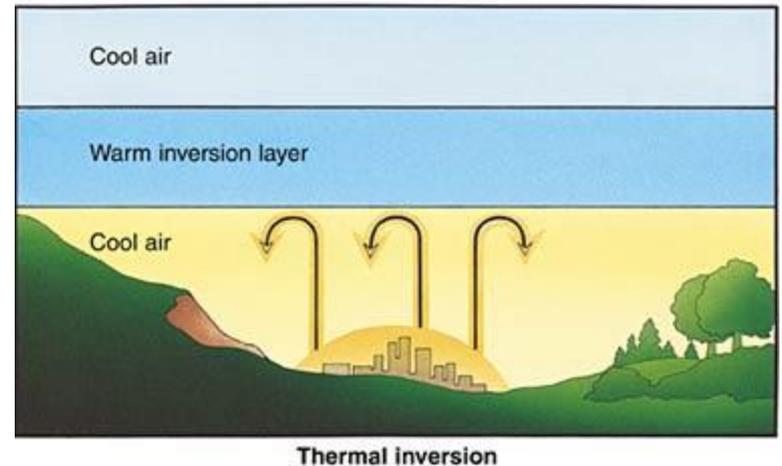
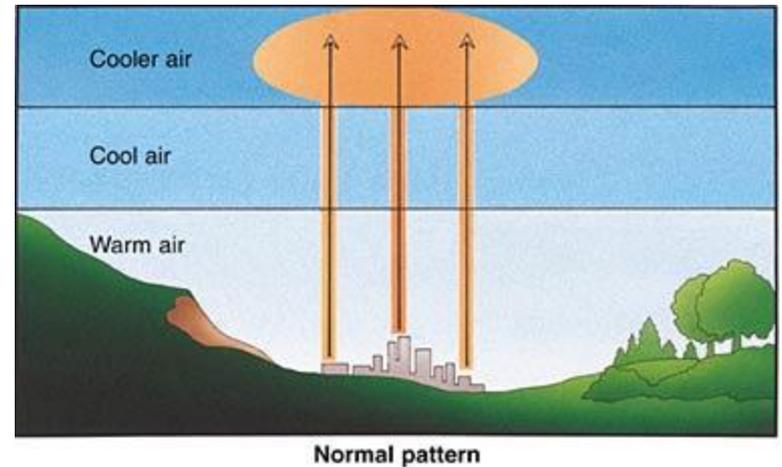
1. **Respiratory Symptoms**
  - a. Cough
  - b. Phlegm
  - c. Wheezing
  - d. Breathlessness
2. **Respiratory diseases**
  - a. Bronchitis
  - b. Pneumonia
  - c. Hay fever
  - d. Bronchial Asthma
  - e. Chronic Bronchitis
3. **Medical visits**
4. **Hospital admissions**

# Air Pollution and Topography

- The effects of air pollution are also influenced by the shape of the land.
- Temperature inversions occur when a layer of dense, cool air is trapped below a layer of lighter, warmer air. ظاهرة الانقلاب الحراري
  - Most likely to occur in valleys and canyons.

# Temperature Inversion

- Temperature inversions trap any air pollution produced, allowing it to accumulate to much higher than normal levels.
- Two major air pollution events occurred in the 20<sup>th</sup> century because of this phenomenon.



# Air Pollution History

## The Donora Fluoride Fog of 1948

- In late October, the town of Donora experienced a temperature inversion.
- The town is located along the Monongahela River south of Pittsburgh, within a small valley.
- The main employer of the town was a US Steel Zinc smelting plant.



# Donora Fluoride Fog

- Emissions of sulfur dioxide, nitrogen dioxide, and fluoride from the zinc smelting plant began to accumulate.
- The smog became so thick that driving was impossible.
- The plant itself did not cease operations until 4 days later.
- The smog finally broke up as a rainstorm entered the area after 5 days.

# Donora Fluoride Fog

- A total of 20 residents died; About a 1/3 to a 1/2 of the town's entire population of 14,000 became sickened.
- Donora experienced higher than normal mortality rates for 10 years afterwards.



# Air Pollution History

## The London Smog of 1952

- London naturally has very calm air, and regularly experiences thick sea fog.
- The weather turned unusually cold, causing the residents to burn greater amounts of coal to heat their homes.
- This combined with a temperature inversion to create a thick smog of sulfur dioxide over the city.
- The number of fatalities is unknown, but estimated to be around 12,000.

# The London Smog of 1952

- As a result of this disaster, London passed its own Clean Air Act.
- One of the specific changes made was to make chimneys taller to reach above a temperature inversion.



# Clean Air Act

- Initially, the law ( in USA) required the EPA to **set and enforce limits** for 6 different air pollutants.
- These are called criteria pollutants.
  1. Sulfur Dioxide
  2. Carbon Monoxide
  3. Particulates
  4. Ozone
  5. Nitrogen Oxides
  6. Lead



# Criteria Pollutants

## 1. Sulfur dioxide

- Colorless gas often associated with “rotten eggs” smell
- **Forms sulfuric acid in clouds.**
- **Biggest source: coal burning power plants**

## 2. Nitrogen oxides

- Reddish brown gas
- **Reacts with water vapor to form nitric acid (HNO<sub>3</sub>)**
- **Reacts with sunlight to form smog**
- **Biggest source: car exhaust (traffic)**

### 3. Carbon Monoxide

- Colorless, odorless, highly toxic gas
- Binds to hemoglobin in red blood cells, interfering with oxygen transport
- Biggest source: car exhaust

### 4. Particulate Matter

- Dust, ash, soot, lint, smoke, pollen, spores, and all other suspended matter.
- Cause the most visibility problems
- Biggest source: unpaved road dust and construction

# Criteria Pollutants

## 5. Ozone

- Molecule made of three oxygen atoms →  $O_3$
- Pale blue gas, odor resembling chlorine bleach
- Secondary pollutant; not released directly

## 6. Lead

- Enters the air as particles or part of dust.
- The biggest source used to be exhaust from cars using leaded gas

# Clean Air Act

- The Clean Air Act was amended in 1990 and included additional provisions and controls for:
  1. Acid Rain
  2. Urban Smog
  3. Toxic and Hazardous Air Pollutants
  4. Protection of the Ozone Layer
  5. Leakage of volatile organic compounds

# Other Major Pollutants

## – Volatile organic compounds

- Organic (carbon-based) gases like methane ( $\text{CH}_4$ ) that can decompose or react easily, forming carbon dioxide or carbon monoxide in the air.
- Biggest sources:
- Spilled/leaking gasoline that evaporates
- Paint and paint cleaners

# Acid Deposition

- Acid Precipitation – Rainfall or snowfall that contains an lower than normal pH.
  - pH scale ranges from 0-14.
    - 7 = Neutral; <7 = Acidic; >7 = Basic
  - **Unpolluted rain generally has pH of 5.6.**
    - Carbonic acid from atmospheric CO<sub>2</sub>.
  - In industrialized areas, the pH level can reach as low as 4.3
    - Rain of pH 2.1 was recorded in the 1970s and 1980s

# Acid Deposition Cont'd

- Aquatic Effects

- Fish and other aquatic organisms are extremely sensitive to pH changes.

- pH below 5 = eggs will not hatch

- pH below 4 = kills adult fish

# Acid Deposition Cont'd

- Forest Damage
  - Acid rain can cause the pH of soil to decrease.
  - This interferes with trees' ability to absorb nutrients properly.
- Buildings and Monuments
  - Limestone and marble are slowly dissolved as they are exposed to acid rain.
  - Acid rain can also corrode steel, weakening structures like bridges.



Tombstone in Hamilton, NY

# Indoor Air Pollution

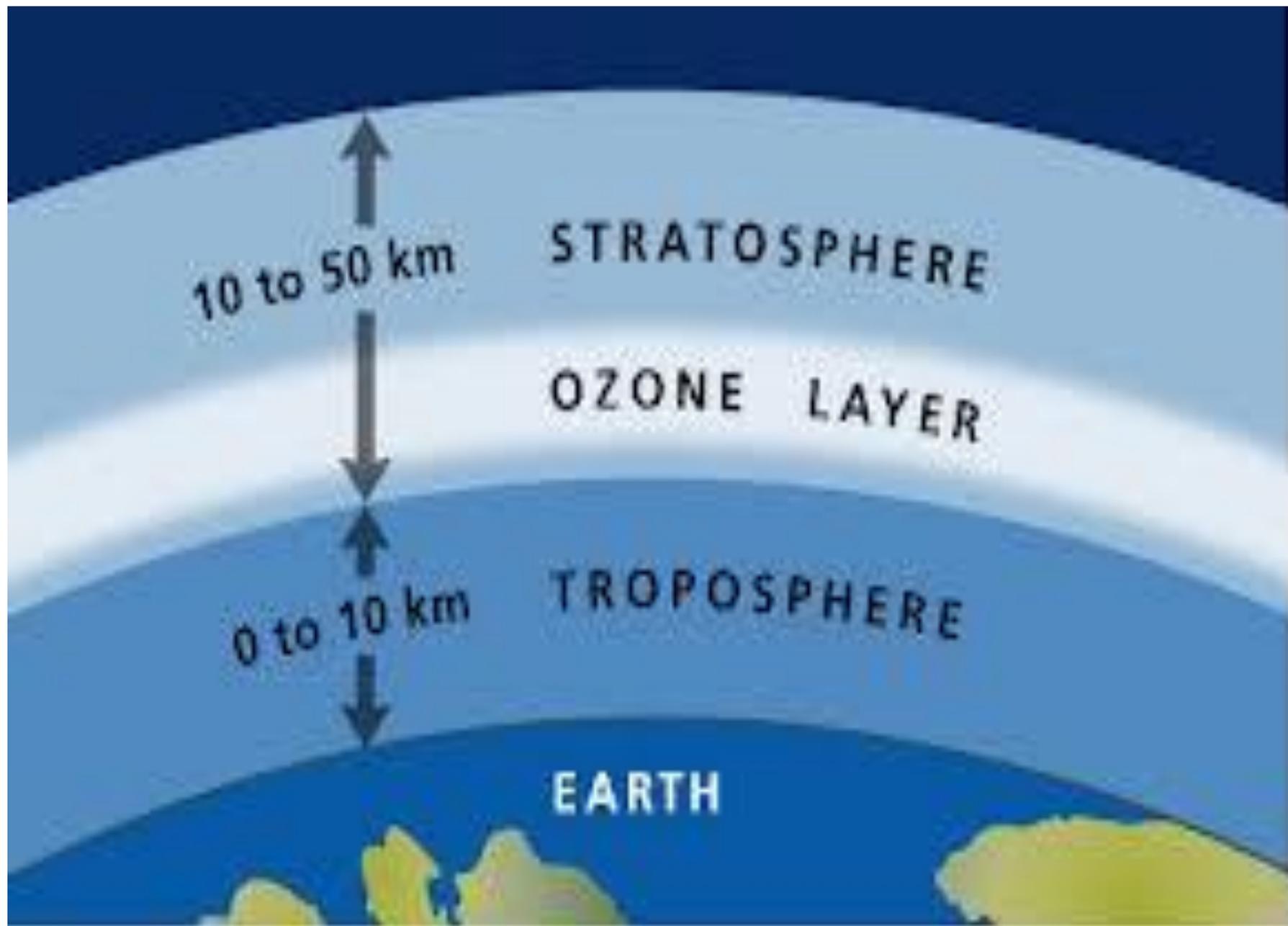
- Indoor air pollution can have more significant effects on human health than outdoor pollution.
  - People generally spend more time indoors.
  - Cigarette smoke is the most common indoor air pollutant in the U.S.

# Indoor Air Pollution Cont'd

- Less-developed countries also suffer from indoor air pollution.
  - Organic fuels make up majority of household energy.
  - These fuels are often burned in smoky, poorly ventilated heating and cooking fires.

# Atmospheric Ozone

- Ozone is a gas found in the upper atmosphere that blocks some UV radiation.
- Scientists discovered that atmospheric ozone levels were dropping rapidly every year, during September and October.
  - Occurring since at least 1960.
  - A 1% decrease in ozone results in a 2% increase in UV rays reaching the earth.
  - **The ozone was being depleted by pollutants containing chlorine.**



# Stratospheric Ozone Cont'd

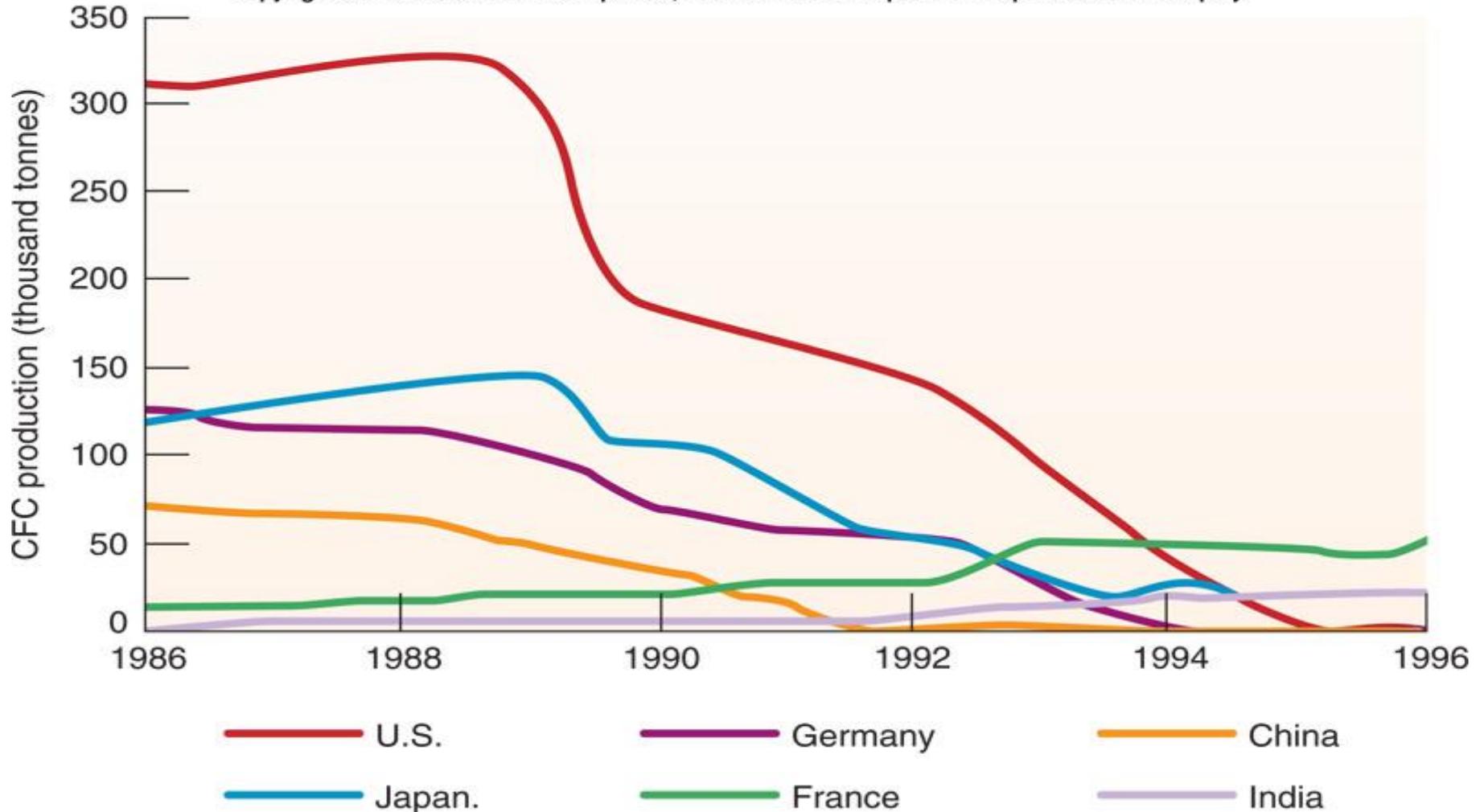
- A concentration of pollution at the poles and other factors caused chlorine pollution to be concentrated in Antarctica.
  - **When the sun returns in the spring, the energy liberates the chlorine from ice.**
  - **Chlorine causes ozone ( $O_3$ ) to be broken down into oxygen ( $O_2$ ).**

# Montreal Protocol

- The main pollutant behind ozone depletion was **Chlorofluorocarbons (CFCs)**.
  - Used in coolants (refrigerators, air conditioners) and aerosols (hair spray, spray paint).
- The Montreal Protocol was passed in 1989.
  - Countries agreed to phase out CFC use by the year 2000.
  - CFC levels in the atmosphere decreased and the ozone layer is beginning to recover.

# CFC Production

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# EFFECTS OF AIR POLLUTION

- Human Health

- EPA estimates each year 50,000 people die prematurely from illnesses related to air pollution.

- Likelihood of suffering ill health is related to intensity and duration of exposure.

- Inhalation is the most common route, but absorption through the skin and consumption via food can also occur.

# Plant Pathology

- Chemical pollutants can directly damage plants, or can cause indirect damage by disrupting normal growth and development patterns.

# Visibility Reduction

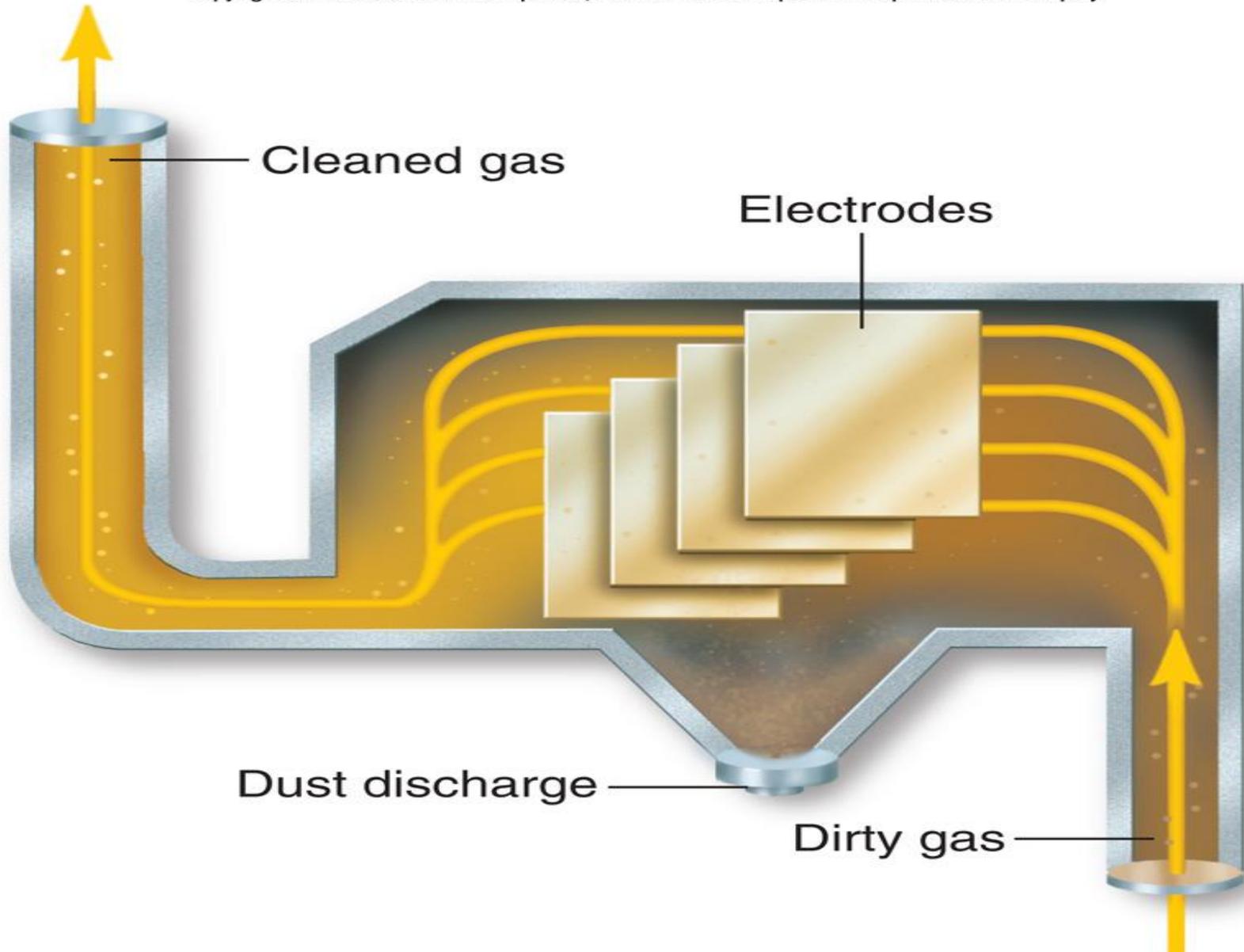
- The production of pollution haze or smog can reduce visibility by as much as 80 percent.



# AIR POLLUTION CONTROL

– Most effective strategy for controlling pollution is **to not produce it in the first place.**

- *Particulate Removal - Remove particles physically by trapping them in a porous mesh which allows air to pass through but holds back solids.*
- *Electrostatic Precipitators – Pass air across electrically charged plates that attract the particles of pollution.*



# Reducing Pollution

- **Sulfur Dioxide Reduction**

1. **Heating Fuel Switching**

- a. Switch from soft coal with a high sulfur content (like was used in London in 1952) to low sulfur coal.
- b. Change to another fuel (natural gas).

2. **Limestone Injection**

- Can reduce sulfur emissions by 90% by mixing crushed limestone with coal before it is fed into a boiler.

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