

Environmental Engineering-1

Lecture 3- Air Pollution

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Air Pollution

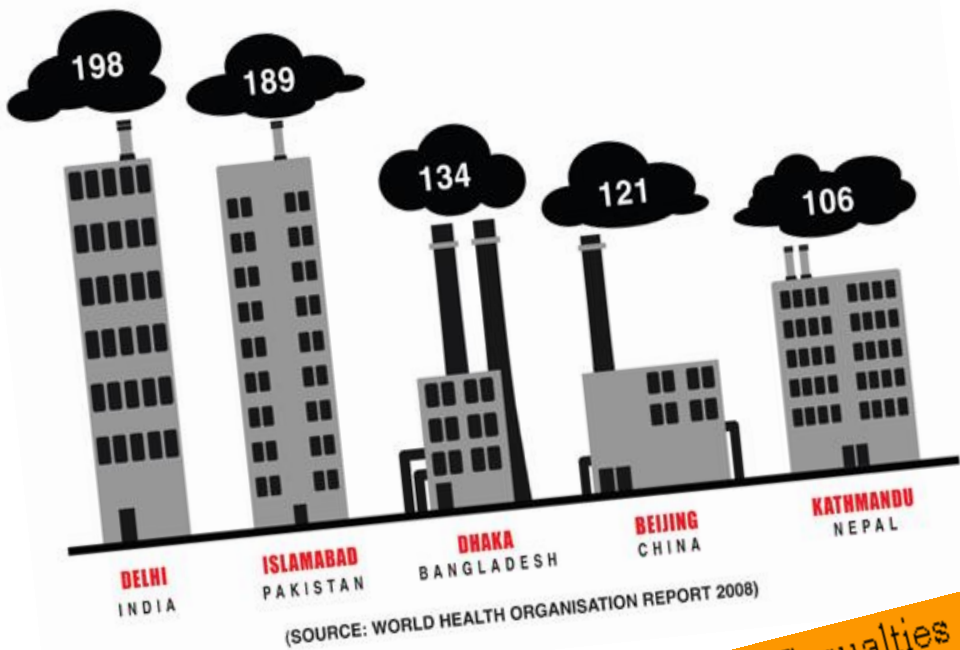
- Definition: the presence of one or more contaminants in air in such a concentration and of such duration as to a anything harmful or offensive to communiity **nuisance** or to be injurious to human life, animal life or vegetation.
- Sources of air pollution:
 1. Natural source: dust storms, volcanoes, lightning, biological decay etc.
 2. Anthropogenic Source: industries, power plants, vehicular emissions , agricultural, burning of solid wastes

Types of Anthropogenic Sources


- Stationary: with relatively fixed location (smoke stacks, chimneys , construction site, storage piles, industrial estates)
- Mobile: moving sources of emissions (Automobiles, aircrafts, ships ,trains)

Air Pollution Episode

MOST POLLUTED CAPITAL CITIES IN ASIA



Lung cancer cases peaked in '09-'11



- ▶ Delhi, Jharkhand, West Bengal and Maharashtra have worst air quality
- ▶ Highest number of lung cancer cases during 2009-11 reported in Delhi, Mumbai and Kolkata
- ▶ Half of urban population breathes air that exceeds the accepted standard of PM10

Analysis of three pollutants (SO₂, NO₂ and particulate matter) at 450 air monitoring locations in 190 cities/towns across the country shows

One-third of urban population lives in cities/towns with PM10 levels classified as 'critical'

Year	Location	Casualties
1948	Donora, Pennsylvania	20 dead, 6000 injured
1953	New York, New York	250 dead
1963	New York, New York	200-400 dead
1965	New York, New York	400 dead
1966	New York, New York	165 dead



Lots of Health Impacts

Study Links Cancer in Women to Dirty Air

■ **Health:** Those living in areas with significant dust pollution face a 37% higher risk of developing the disease than those living in a purer environment.

By JUDY PASTERNAK
TIMES STAFF WRITER

Women living in areas with high concentrations of suspended dust in the air face a 37% higher risk of developing cancer than women in less polluted areas, Loma Linda University researchers report.

Most of the women who developed cancer during a 10-year epidemiological study lived in the Los Angeles region, which exceeds federal standards for very small dust particles, primarily resulting from cars and industry. But others were

exposed to high dust levels from agricultural activity or in wind-whipped desert areas.

The scientists did not find a corresponding increased risk in men. They said they could not explain the disparity.

The Loma Linda study of 6,000 Seventh-day Adventists throughout the state also raised the possibility that suspended dust may place both sexes at greater risk for respiratory cancers, bronchitis, asthma and other airway disorders. In addition to dust, the researchers suggested that ozone, a major component of urban smog, could contribute to cancer of the respiratory tract.

W. Lawrence Beeson, data manager for the study, said the number of cases was too small to definitively conclude that those conditions were caused by pollution.

Still, said another of the researchers, Floyd F. Petersen: "If you have a history of airway obstructive disease in your family, if you suffer from asthma, I would hate to

tell you to move, but I would certainly think about it."

Petersen cautioned that smoking poses a much higher risk than breathing polluted air, at least at the levels in the study.

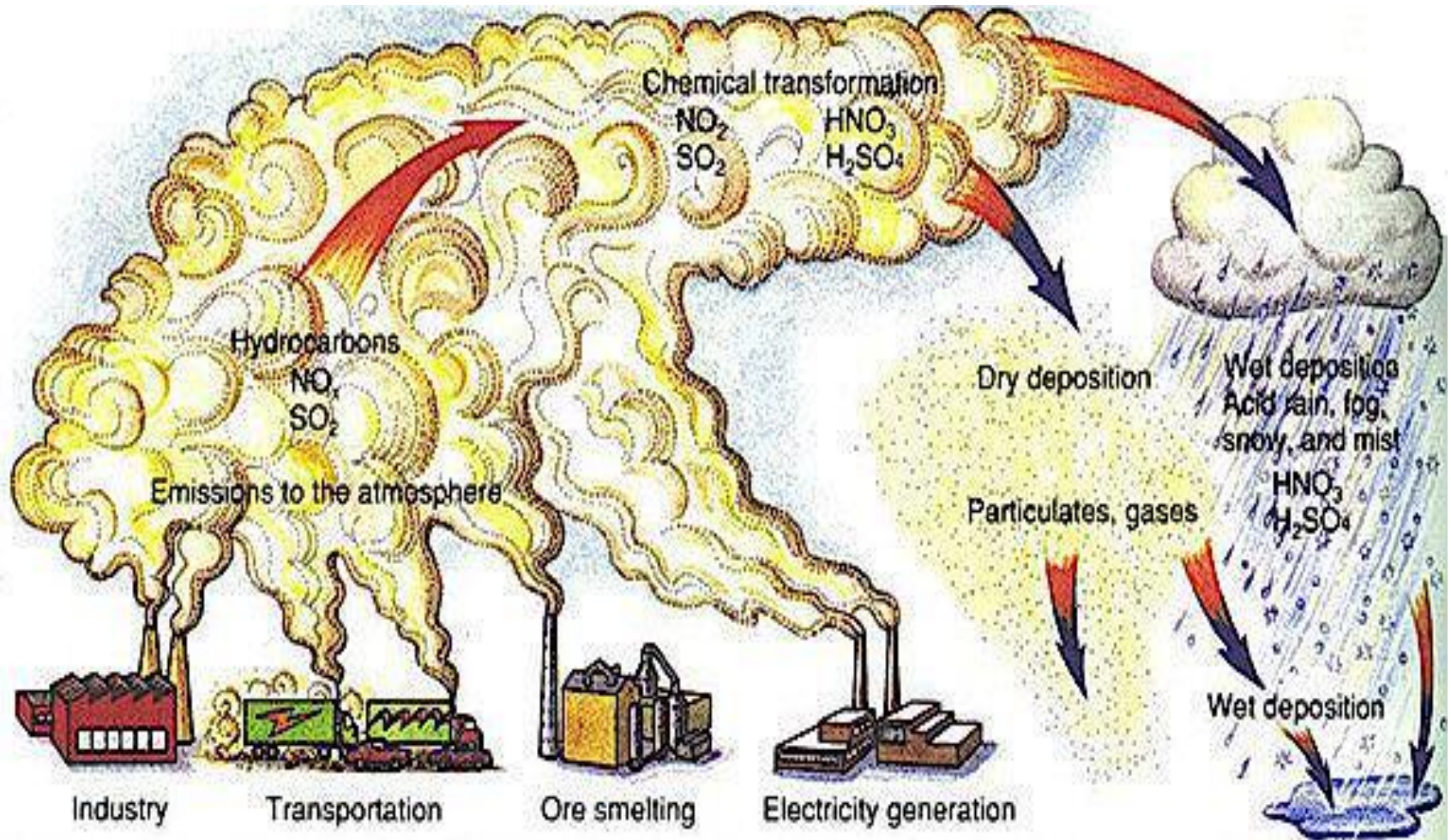
"It's a fairly loud signal, there's no doubt about it," said John Holmes, research director of the California Air Resources Board, which financed the study. The findings linking dust pollution to cancer in women "confirm a lot of suspicions."

UCLA epidemiologist Roger W. Detels, who has linked air pollution to long-term lung damage, said he has questions about the research, which was published in the journal *Environmental Health Perspectives*. "It's very unlikely that all malignancies are related to air pollution," he said. "It would have been interesting to see if there were any patterns in the types of malignancies that were occurring."

The study is part of an \$8-million
Please see WOMEN, B2

Studies consistently show significant negative health effects from living in polluted environments.

Air Pollutants



Classification of Air Pollutants

Primary Pollutants: the ones emitted directly into the air.

For Example:

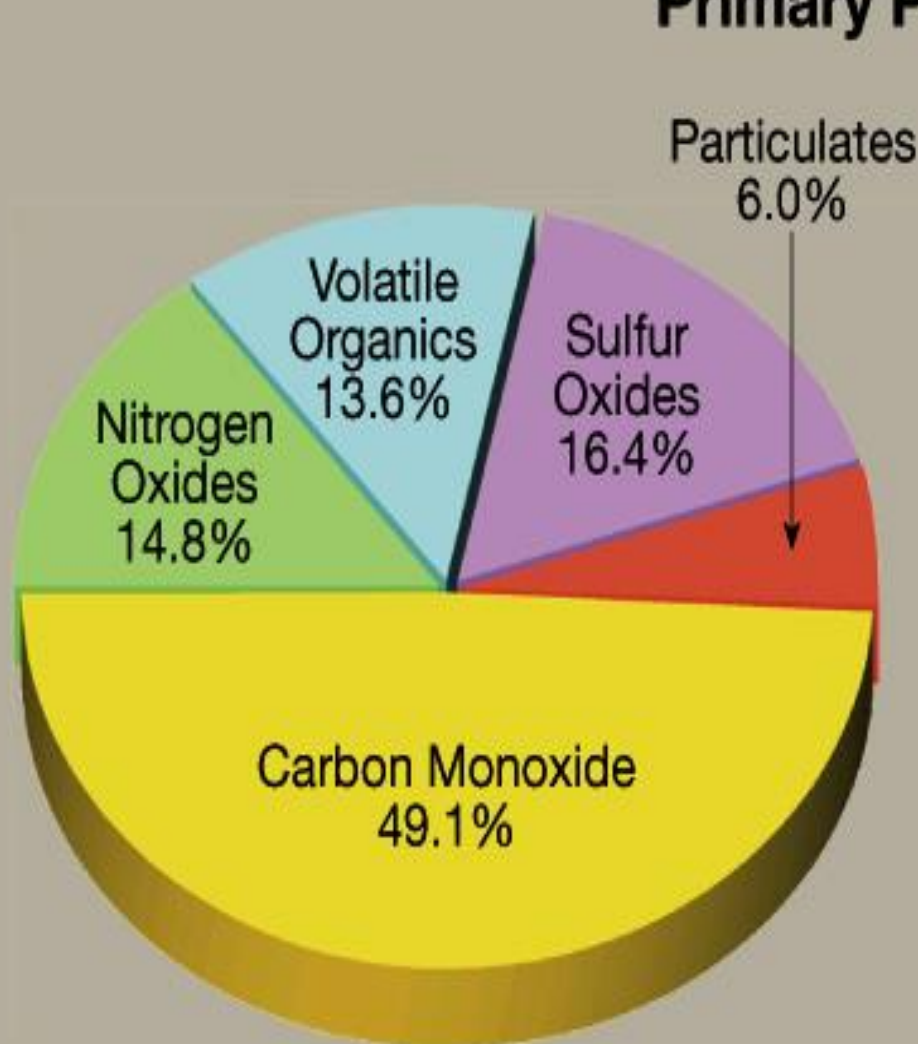
1. Particular matter (PM)
2. SO_2
3. CO, CO_2
4. NO_x
5. Hydrocarbon (HC)
6. Lead (Pb)

Major Source:

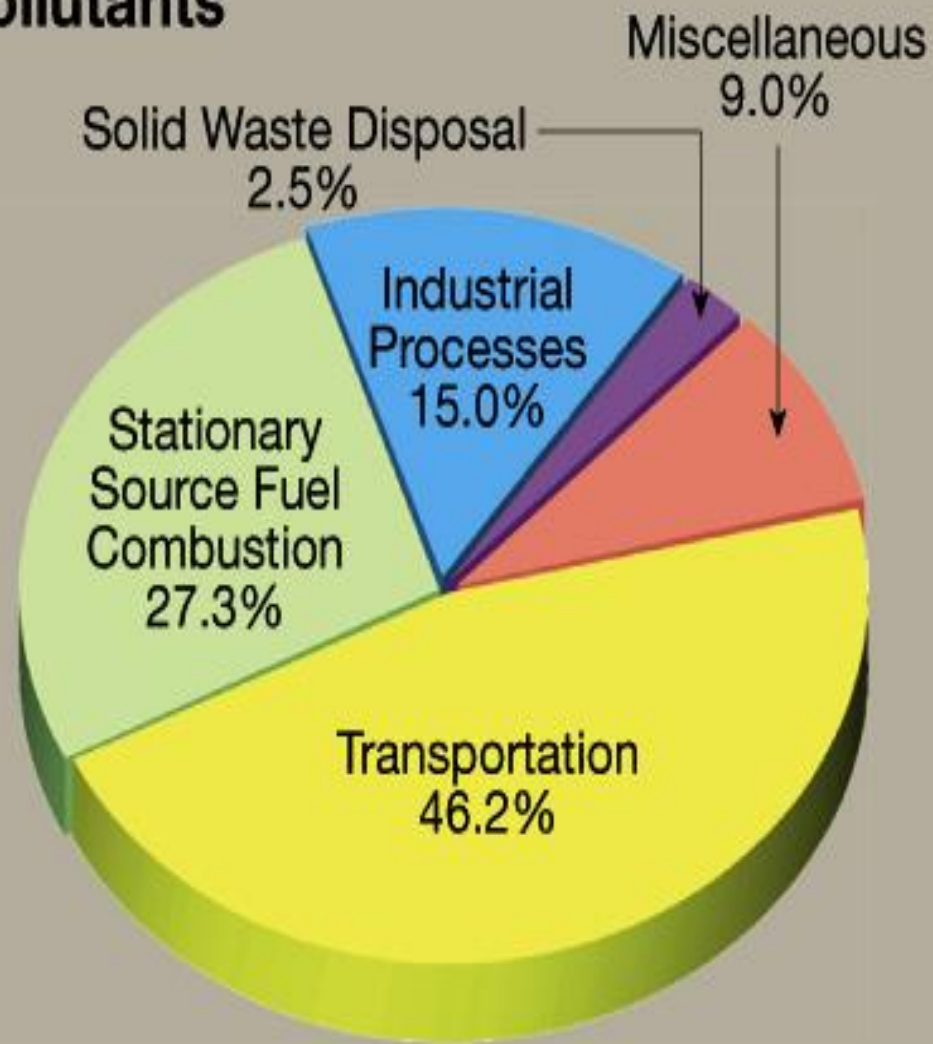
1. Motor vehicle : $\text{CO}_x, \text{NO}_x, \text{PM}, \text{HC}, \text{Pb}$
2. Industries : $\text{CO}_x, \text{NO}_x, \text{PM}, \text{HC}, \text{SO}_2$

Primary Pollutants

Primary Pollutants



What They Are



Where They Come From

Classification of Air Pollutants

Secondary Air Pollutants: Produced through reactions between primary air pollutants, and normal atmospheric constituent.

For Example:

1. $\text{NO}_x + \text{HC} + \text{O}_2 \rightarrow \text{O}_3 + \text{other pollutants} \rightarrow \text{PAN}_{(\text{photo chemical smog})}$
2. $\text{SO}_2 + \text{O} \rightarrow \text{SO}_3$
3. $\text{NO}_x + \text{H}_2\text{O} \rightarrow \text{HNO}_3$
4. $\text{SO}_2 + \text{H}_2\text{O} + \text{O} \rightarrow \text{H}_2\text{SO}_4$

Criteria

- Conveying **Convectional** Pollutants: USEPA, through Clean Air Act (1970) has designated **7 major** air pollutants for which surrounding **ambient** air levels are mandated : SO_2 , CO, PM, NO_x , Pb, HC, photochemical oxidants (O_3 + PAN).
- Non-Convectional Pollutants: USEPA has considered some pollutants as non convectional, setting standards for their emissions.
- These are considered especially toxic and hazardous. **For example**; asbestos , benzene, beryllium, mercury, PCBS, Volatile hydrocarbons

Effects of Air pollution

- Damage to human health
- Damage to property, equipment and facilities
- Harmful effects on plants
- Reduced visibility

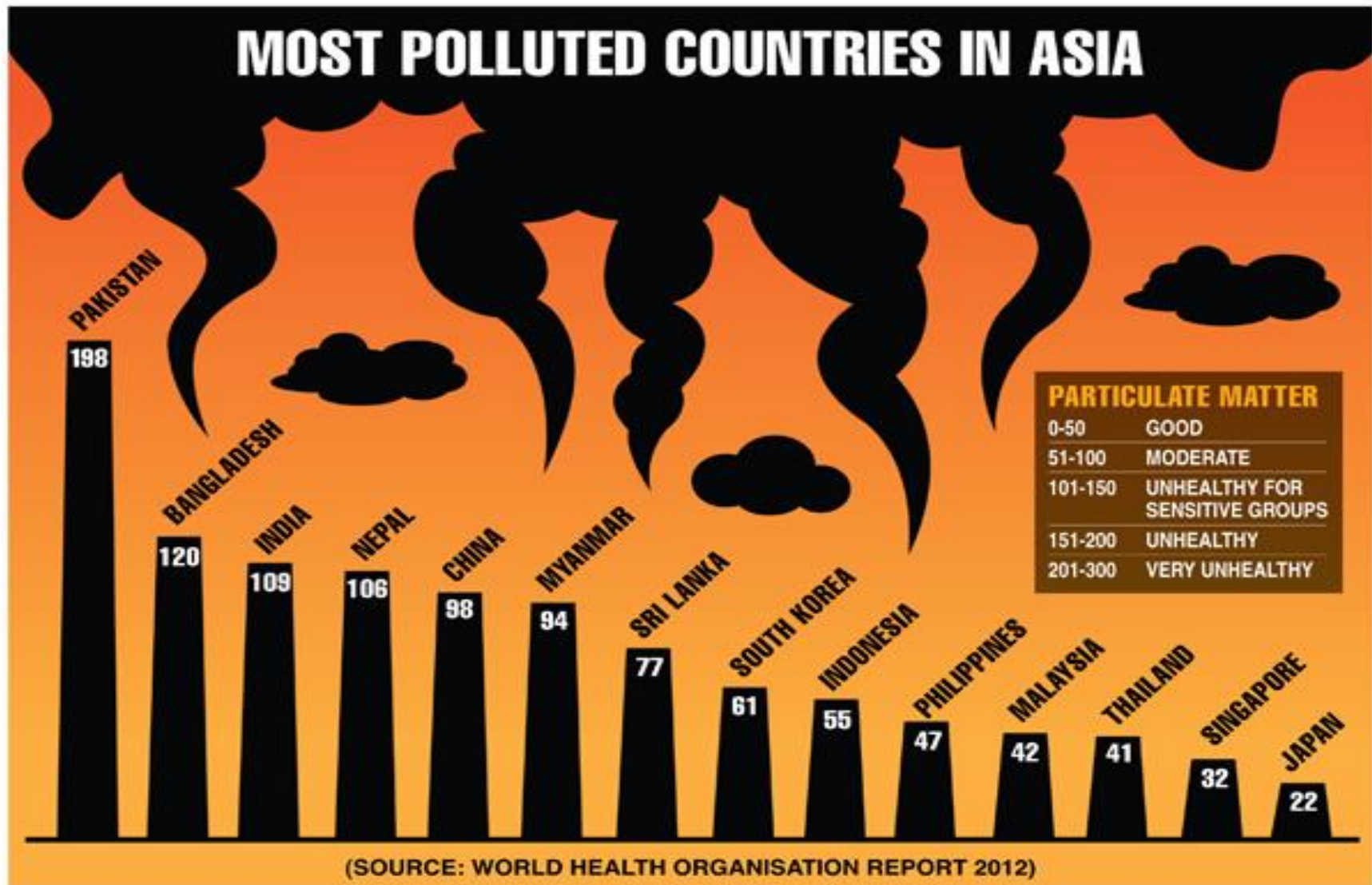
Major Urban Air pollutants

1. Particulate Matter:

- There are both natural and human sources of atmospheric particulates
- The biggest natural sources are dust, volcanoes, and forest fires.
- The biggest human sources of particles are combustion sources , mainly the burning of fuels in internal combustion engines in automobiles and power plants.

Major Urban Air pollutants

Particulate Matter Level



Major Urban Air Pollutants

Particulate matter: Environmental Effects

- Reduced visibility
- Metal/building corrosion
- Soiling of clothes
- Health problems, **bronchitis** inflammation (congestion) of lungs
- Reduced plant growth

Major Urban Air pollutants

2. Carbon monoxide:

- ✓ Most abundant air pollutant
- ✓ Produced by incomplete combustion
- ✓ Major source (app.77%) is motor vehicle exhaust

Health effects

- ✓ CO enters the blood stream and binds preferentially to hemoglobin, thereby replacing oxygen; thus oxygen carrying capacity of the blood reduces.
- ✓ 320 times stronger than oxygen

Major Urban Air pollutants

3. Oxides of Nitrogen (NO_x):

- ✓ Primarily Nitric oxide(NO) and Nitrogen dioxide(NO₂)

Sources

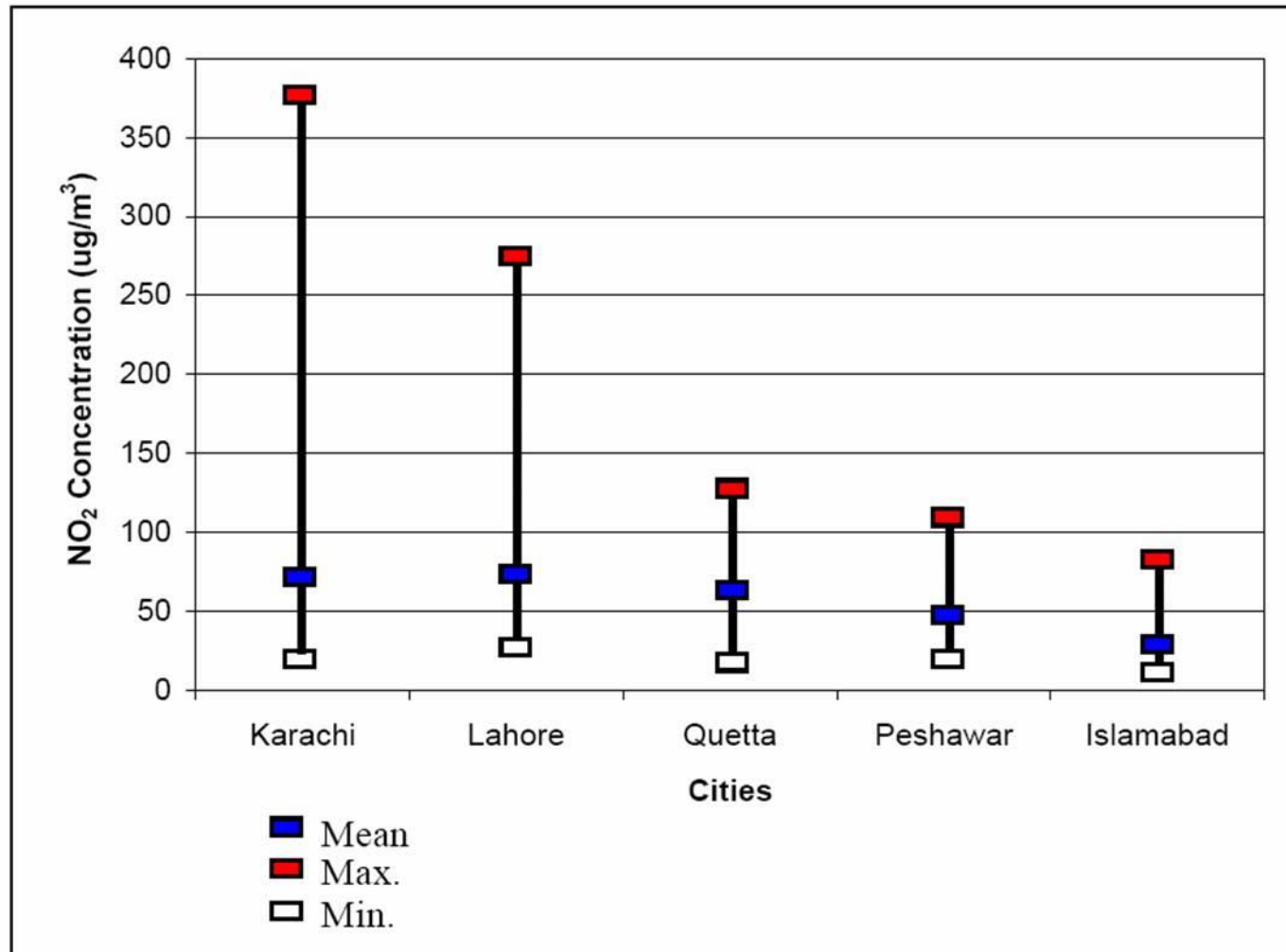
- ✓ Fuel combustion in power plants and automobiles.
- ✓ Motor vehicles account for about 30 % of emissions of nitrogen oxides.
- ✓ In city centers the values rises upto 70% .

Effects

- ✓ High levels may be fatal, while lower levels affect the delicate structure of lung tissue.
- ✓ Affects plant growth
- ✓ Deterioration of fabrics& structure
- ✓ Acid rain
- ✓ Global warming

Major Urban Air Pollutants

NITROGEN DIOXIDE (NO₂) POLLUTION in DIFFERENT CITIES of PAKISTAN



Major Urban Air Pollutants

4. Sulfur oxides (SO_x)

- ✓ Formed during combustion of fuel containing sulfur
- ✓ Thermal power plant

Effects

- ✓ Irritation of lung and throat, impairs the respiratory system's defence against foreign particles and bacteria. So increased respiratory tract infections.
- ✓ Damage to plants and structures
- ✓ Acid rain

5. Hydrocarbon:

- Sources
 - ✓ Internal combustion engine, refineries, industries etc.
- Effects
 - ✓ Cause oil film after the rain
 - ✓ Injure respiratory tract area
 - ✓ Carcinogens
 - ✓ Global warming
 - ✓ Photochemical smog

Major Urban Air pollutants

6. Volatile Organic Compounds(VOC):

→ VOCs are organic compounds that vaporize easily.

For example

→ Gasoline, benzene, toluene, and xylenes.

- Sources

- Burning of fuels, solvents, cleaning supplies, paints and glues.

- Effects

- → Contribute to smog formation

- → Can cause serious health problems such as cancer

- → Can harm plants

Major Urban Air Pollutants

7. Lead (Pb):

- ✓ Pb is a metal found naturally in the environment as well as in manufactured products.
- ✓ Small solid particles of Pb can become suspended in the air.
- ✓ Pb can then be deposited on soil and in water
- Sources
 - ✓ Metal processing industries
 - ✓ Lead acid battery
- Effects
 - ✓ Can cause blood, organ, neurological damage in humans and animals.
 - ✓ Lead can also slow down the growth rate of plants.

8. Ozone (O₃):

- Ozone is not emitted directly into the air but it is created by chemical reactions between oxides of nitrogen (NO_x) and volatile organic compound (VOC) in the presence of sunlight.

Health effects:

- Breathing ozone can trigger a variety of health problems including chest pain, coughing, throat irritation, and congestion. It can worsen bronchitis, and asthma.

Environmental Effects

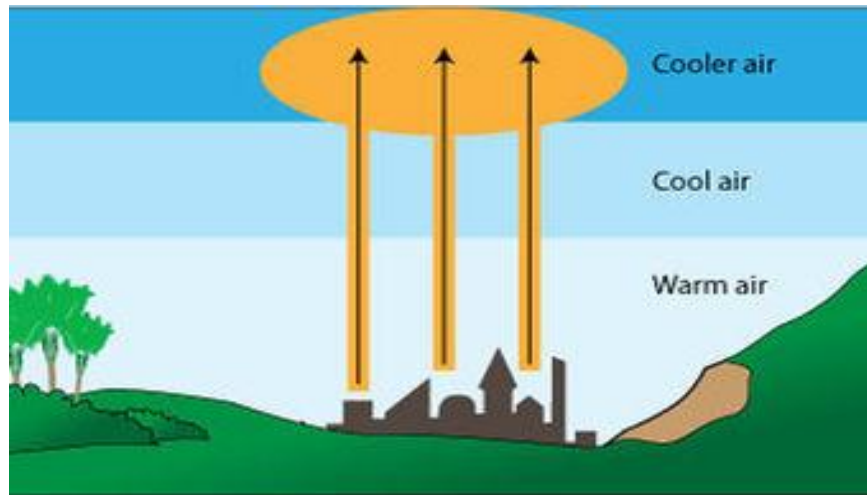
Ozone also effects vegetation and ecosystems:

- Reduction in agricultural and commercial forest yields
- Reduced growth and survivability of tree seeding
- Increased plant susceptibility to disease, pests, and other environment stresses(e.g. Harsh weather)

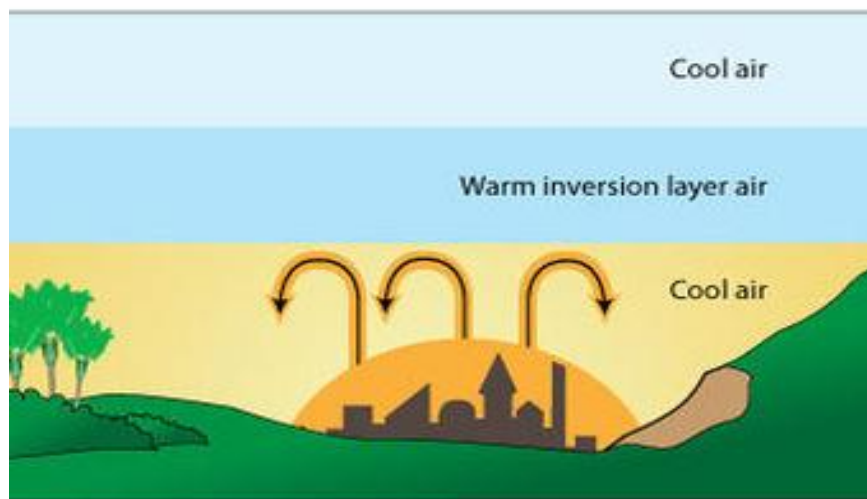
Thermal Inversion

Thermal Inversion

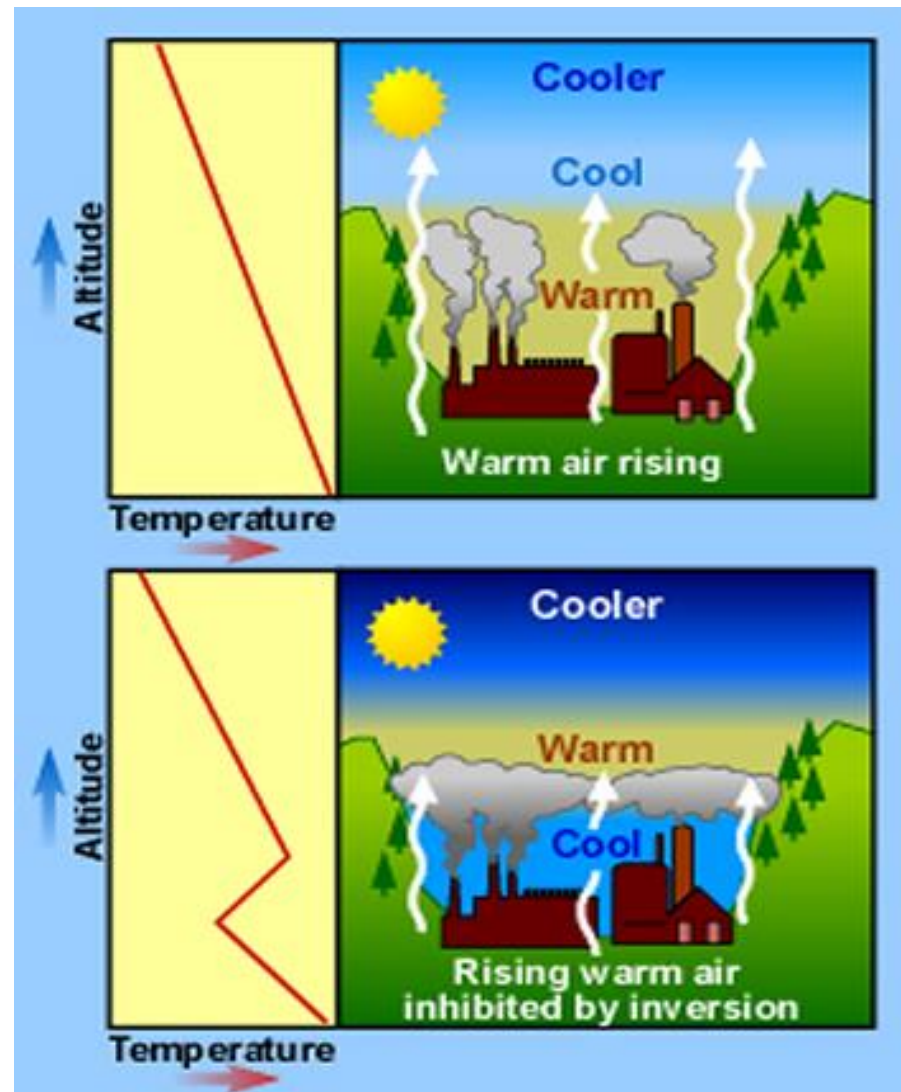
Thermal Inversion



Normal pattern

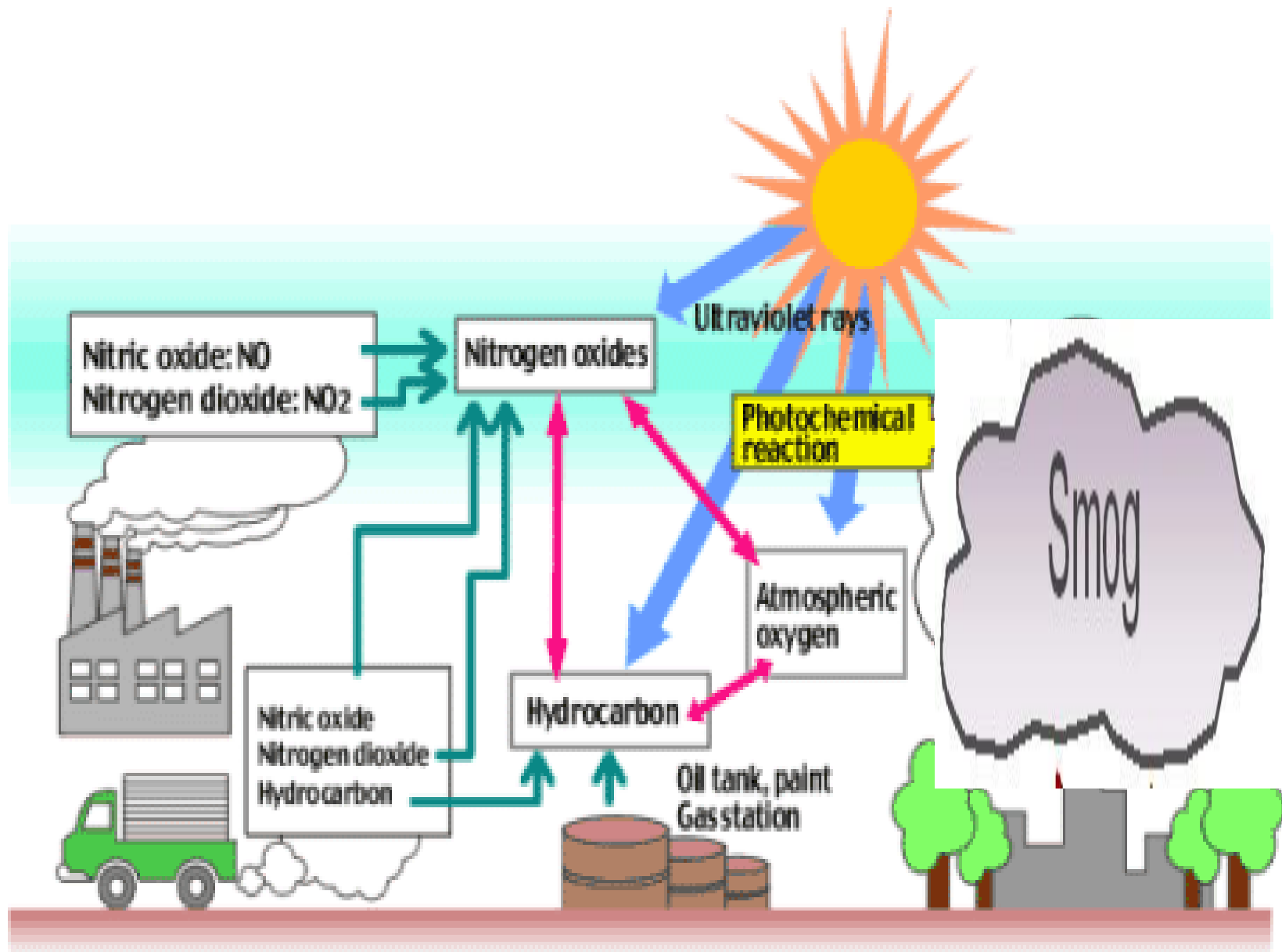


Thermal inversion



Photochemical Smog

Photochemical Smog

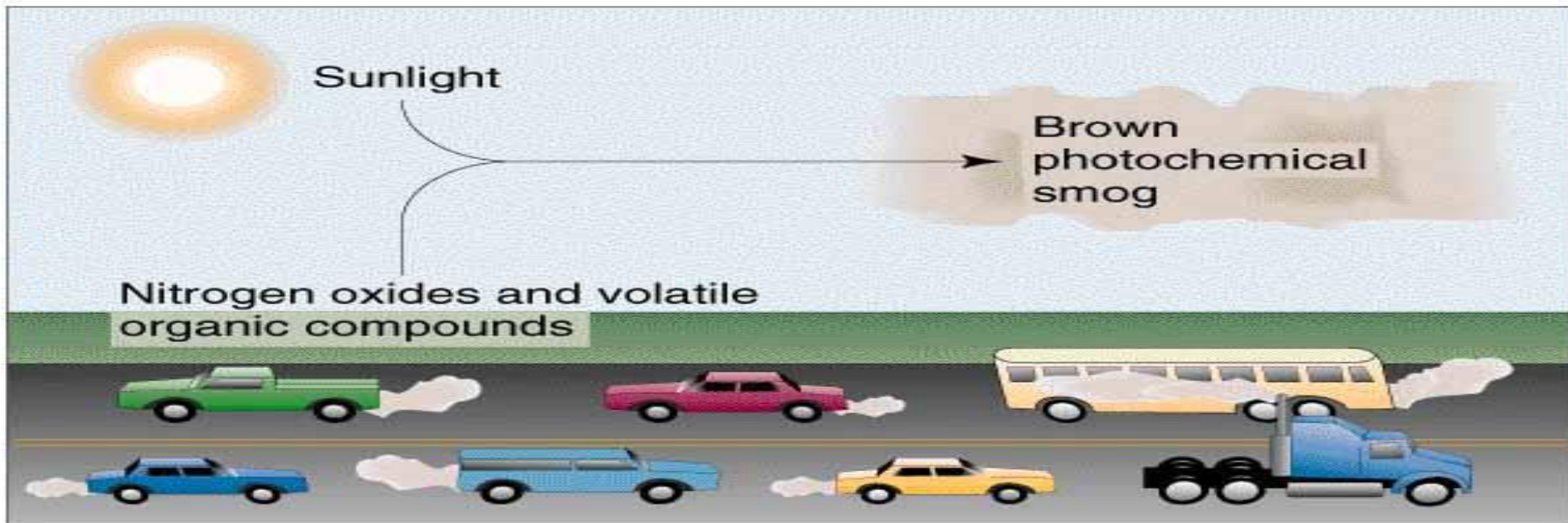


Formation of Photochemical Smog

Conditions:

Photochemical smog formation requires the following conditions:

1. Sunny day
 2. NO_x
 3. HC
- Temperature inversion (pollutants accumulate in the lower inversion layer)
 - The **Peroxyacetylnitrate (PAN)** ($\text{CH}_3 \text{CO-OO-NO}_2$) in photochemical smog can irritate the eyes, causing them to water and sting.



(b) Photochemical smog

Photochemical Smog



Effects

Exposure can cause irritation to the respiratory system, or even inflict severe damage on the lungs and heart, such as causing bronchitis and lung cancer, resulting in premature deaths. This can occur in both humans and animals.

Certain plants such as tobacco and tomato are highly responsive to ozone, so a large amount of photochemical smog can destroy these sensitive crops, trees and other vegetation.

For example

Mexico City

Due to its geographical situation, air is prevented from escaping and thus maximises the impact of gases from vehicles. The air pollutants react with the photons from the sun, resulting in the creation of photochemical smog. The city has one of the worst smog pollutions, with pollutants such as nitrogen oxide being double or even triple international standards. 4000 had died prematurely and 100000 were made ill due to the smog.

Photochemical Smog Episodes

- Cities subject to frequent smog episodes
 - Los Angeles
 - Denver
 - Mexico City
 - Tokyo
 - Athens
 - Rome
- Geographically situated near mountains
- Densely populated



Prevention

The best possible solution to this problem is to find a source of energy that does not involve burning hydrocarbons in automobiles. Solar, Hydro and wind energy are all good starts but they are not able to be used as primary means yet for locomotion for the majority. When these technologies are advanced we can have total relief from the effects of photochemical smog.

For now, the use of catalytic converters in automobiles is encouraged. These additions to the exhaust system use platinum or rhodium to cause a chemical reaction with unburnt hydrocarbons to produce carbon dioxide and water instead of harmful nitrogen oxides. Measures such as buying environmental friendly products, using protocols and reducing pesticide are also taken.

For example

Smog Watch

Smog Watch is a voluntary governmental protocol to prevent the Seattle, Washington region from exceeding the federal health standards on ozone and protect all around public health during the hot months of summer, in which smog levels are highest. At these certain times during the summer, agency meteorologists will issue a smog watch for 48 hours when there is elevated smog levels. During this 48 hour period, citizens of the Seattle district are encouraged to partake in this event to lower smog levels by taking steps to decrease pollution to avoid further elevation of smog levels.

Control for Air pollution

- Use cleaner fuels

- ✓ Elimination of the pollutant from the process input like lead free petrol
- ✓ Low sulphur fuels
- ✓ Better land use planning
- ✓ Reduced use of private cars



Control for Air pollution

- Make process changes

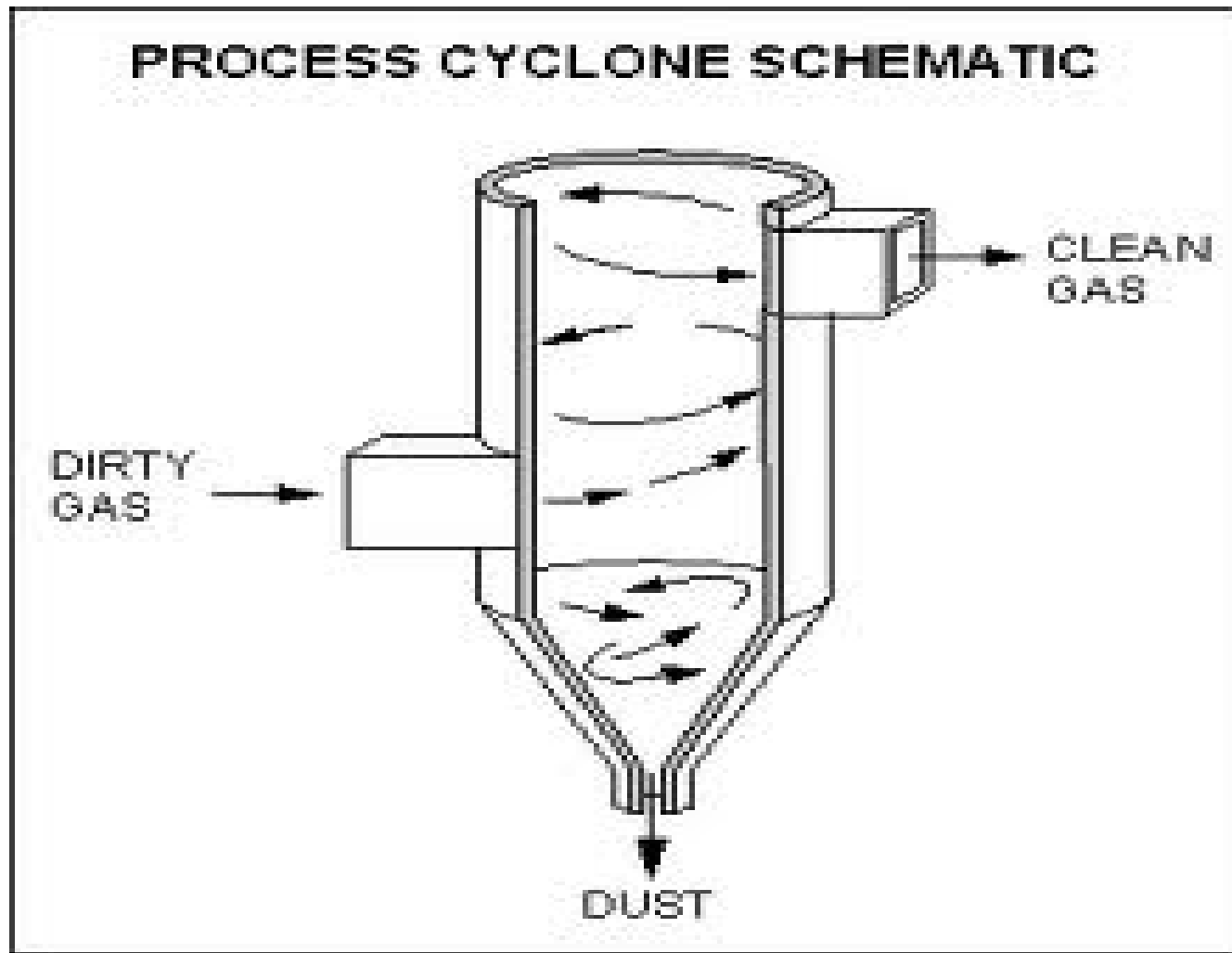
- ✓ Combustion temperature to reduce NO_x

- ✓ Replace thermal plants with hydroelectric

- Use control equipment for emissions

- ✓ Use of cyclones, electrostatic precipitators, bag house filter, wet scrubbers

Air Pollution Control Equipments



Air Pollution Control Equipment

