Atmospheric Pollution

Lecture 2

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## Definition of Air Pollution

Buildup in the air of anthropogenically-emitted gases and/or aerosol particles in concentrations sufficiently high to cause damage to humans, plants, animals, other life forms, ecosystems, structures, or works of art.

### Pollutants may be divided into two categories

*Primary pollutant*: These are the chemical species emitted directly from identifiable sources, including nitrogen oxides, carbon monoxide, sulphur dioxide, particulate matter and volatile organic compounds (VOCs).

ذرات معلق (Particulate matter) ذرات

به مواد جامد و مایع معلق در هوا اطلاق می شود که اندازه آنها از قطر یک مولکول (۲۰۰۰،)میکرومتر بزرگتر و از ۵۰۰ میکرومتر کوچکتر باشند.

(Volatile Organic Compounds)

VOCs are organic chemicals that easily vaporize at room temperature.

They are called organic because they contain the element carbon in their molecular structures.

#### 2) Secondary pollutant:

These are species formed from the primary pollutants by chemical transformation or these are formed by gas-to-particle conversion.

Adverse effects of pollution are often associated more with the secondary than with the primary pollutants.

For example, although atmospheric sulphur dioxide has itself many harmful effects, the sulphuric acid formed as a secondary pollutant by oxidation of  $SO_2$  is even more damaging to the environment.

# Air Pollution – Major Pollutants

| <u>Pollutant</u>              | <u>Abbreviation</u> | <u>Source</u>                              |
|-------------------------------|---------------------|--|
| Carbon Monoxide               | СО                  | Primary<br>(emitted)                       |
| Sulfur Dioxide                | SO <sub>2</sub>     | Primary                                    |
| Ozone                         | 03                  | Secondary<br>(formed in the<br>atmosphere) |
| Nitrogen Dioxide              | NO <sub>2</sub>     | Secondary                                  |
| Volatile Organic<br>Compounds | VOCs                | Primary & Secondary                        |
| Particulate Matter            | PM                  | Primary & Secondary                        |

Air pollution is a problem in many of areas of the world.

It can damage trees, lakes and animals, and make people sick.

It can also damage buildings and other structures.

Air pollution also can cause haze, reducing visibility in national parks and sometimes interfere with aviation (Perkins, 1974).

### Air is never 100% clean

90% Natural Sources: Volcanoes, Sea Spray, Spores and Pollen, Terpenes, Dust, Soot, Smoke from Forest Fires 10% Anthropogenic Sources: Agriculture, Industry, Transportation By accident or design, <u>every</u> chemical species contributes to air pollution.

But Anthropogenic Pollutants:

Are the most toxic. Are emitted where people live, work, and play. Typically have the highest concentrations. Typically cause the greatest health problems. Are mostly controllable.

Scales

| Personal, | Indoor,    | Local,  | Regional, | Global                           |
|-----------|------------|---------|-----------|----------------------------------|
| Lungs,    | Buildings, | Cities, | Areas,    | the World                        |
| Smoke,    | Toxins,    | Smog,   | Acids,    | O <sub>3</sub> / CO <sub>2</sub> |

جدول ۱-۳- مشخصه های گازهای موجود در هوا (٦).

| کسر حجم ٪ | وزن مولکولی | نماد شيميايى   | نام         |
|-----------|-------------|----------------|-------------|
|           |             |                | گازهای ثابت |
| ٧٨/٠٨     | ۲۸/۰۱       | N <sub>r</sub> | نيتروژن     |
| ۲۰/۹٥     | ۳۲/۰۰       | O,             | اکسیڑن      |
| • /٩٣     | ۳۹/۹٥       | Ar             | آرگون       |
| •/••١٨    | ۲./۱۸       | Ne             | نئون        |
| •/••••    | ٤/٠٠        | Не             | هليوم       |
| •/••••    | ۲/۰۲        | H <sub>v</sub> | ھيدروژن     |
| ٠/٠٠٠٩    | ۱۳۱/۳۰      | Xe             | گزنون       |

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|                 |       |                  | گازهای متغیر         |
|-----------------|-------|------------------|----------------------|
| ۰ - ٤           | ۱۸/۰۲ | H <sub>7</sub> O | بخار آب              |
| ۰/۰۳٥           | ٤٤/٠١ | CO <sub>v</sub>  | کربن دی اکسید        |
| ۰/۰۰۳٥          | ۲۸/۰۱ | СО               | كربن منواكسيد        |
| •/••• <b>\V</b> | ۱٦/۰٤ | CH <sub>1</sub>  | متان                 |
| •/••••٣         | ٤٤/٠١ | N <sub>7</sub> O | دی نیتروژن اکسید     |
| ٠/٠٠٠٠ ١٤       | ٦٤/٠٦ | SO <sub>y</sub>  | گوگرد دی اکسید       |
| •/••••١٢        | ٤٨/٠٠ | O <sub>7</sub>   | ازن                  |
| •/•••••         | ٤٦/٠١ | NO               | نيتروژن دی اکسيد     |
| ۱۰۰/۰           | ۲۸/۹۶ |                  | شرايط متوسط براى هوا |

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 $p(z) = p_0 e^{-z/H}$ 

 $H = RT / M_{air}g$ 



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ELEMENTS AND COMPOUNDS ATMOSPHERIC IMPORTANCE

Reactive elements that make up most gases are:

hydrogen (H), carbon (C), nitrogen (N), oxygen (O), fluorine (F), sulfur (S), chlorine (Cl), and bromine (Br).

Unreactive elements in the air include:

helium (He), argon (Ar), krypton (Kr), neon (Ne), and xenon (Xe)

Two radioactive elements of importance are:

polonium (Po) and radon (Rn)

Aerosol particles contain the elements present in gases and possibly

sodium (Na), magnesium (Mg), aluminum (Al), silicon (Si), potassium (K), calcium (Ca), iron (Fe), lead (Pb), or phosphorus (P)

Iron present in soil dust and industrial particles and appears reddish

Lead (Pb) Dense, bluish-white metal, emitted today during battery manufacturing, lead-ore smelting, leaded fuel.

Sulfur (S) Nonmetallic, pale-yellow crystal found in volcanic, hot springs.

Carbon (C) appears in gas and particle form in the atmosphere. In diamonds, graphite in pure form; in charcoal, coal, and coke in amorphous form.



Sodium carbonate  $[Na_2CO_3(s)]$ Calcium carbonate  $[CaCO_3(s)]$ Sodium chloride [NaCl(s)]  $[KNO_3(s)]$ Potassium nitrate Sulfurous acid  $[H_2SO_3(aq)]$ Calcium sulfate dihydrate (Gypsum)  $[CaSO_4 - 2H_2O(s)]$  $[NH_4Cl(s)]$ 

Ammonium Chloride

Sulfuric Acid (Aqueous) Nitric Acid (Aqueous) Hydrochloric Acid (Aqueous) Ammonium Nitrate (Solid) Ammonium Sulfate (Solid) Potassium Sulfate (Solid) Calcium Nitrate (Solid) Magnesium Sulfate (Solid)

 $[H_2SO_4(aq)]$  $[HNO_3(aq)]$ [HCl(aq)]  $[NH_4NO_3(s)]$  $[(NH4)_2 SO_4(s)]$  $[K_2SO_4(s)]$  $[Ca(NO_3)_2(s)]$  $[MgSO_4-7H_2O(s)]$ 

# **Temperature Versus Altitude**



Figure 3.3

