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Lecture 14 – AIR POLLUTION – PART 2

14-1 SOME WEATHER FACTORS THAT AFFECT AIR POLLUTION

14-1-1 The role of the Wind

- The wind speed plays a role in diluting pollution
- When vast quantities of pollutants are spewed into the air, the wind speed determines how quickly the pollutants mix with the surrounding air and, of course, how fast they move away from their source
- Strong winds tend to lower the concentration of pollutants by spreading them apart as they move downwind
- Moreover, the stronger the wind, the more turbulent the air
- Turbulent air produces swirling eddies that dilute the pollutants by mixing them with the cleaner surrounding air
- Hence, when the wind dies down, pollutants are not readily dispersed, and they tend to become more concentrated

14-1-2 The role of the Atmospheric Stability

- Remember from Lecture **4** that an **unstable atmosphere** favors vertical air currents, whereas a **stable atmosphere** strongly resists upward vertical motions
- Consequently, smoke emitted into a **stable atmosphere** tends to spread horizontally, while smoke emitted into a **unstable atmosphere** tends to mix vertically
- Since , when the atmosphere is **stable** , the pollution remains near the ground, while when the atmosphere is **unstable** , vertical mixing lifts the pollution upward and reduces concentrations at the ground

- (**A**) One type of very **stable** atmosphere usually exists during the night and early morning hours
- If the sky is clear and the winds are light, the air near the ground can become much cooler than the air higher up
- Recall that this situation is called a **radiation** (or **surface**) **inversion**
- Figure **(14.1**) shows a strong radiation inversion on a clear calm winter night

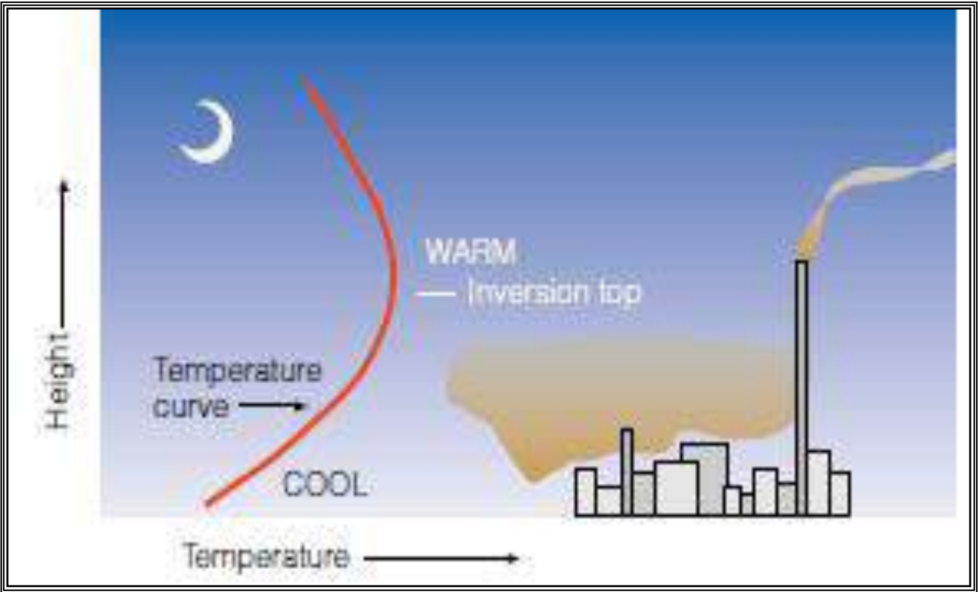

Fig. (14.1) : A strong radiation inversion on a clear calm winter night

- Notice that within the stable inversion, the smoke from the shorter stack does not rise very high, but spreads out, contaminating the area around it
- In the relatively unstable air above the inversion, smoke from the taller stack is able to rise and become dispersed
- In fact, taller chimneys disperse pollutants better than shorter ones even in the absence of a surface inversion because the taller chimneys are able to mix pollutants throughout a greater volume of air
- As the sun rises and the surface warms, the radiation inversion normally weakens and disappears before noon

- (**B**) By afternoon, the atmosphere is sufficiently unstable so that, with adequate winds, pollutants are able to disperse vertically
- A typical temperature profile of a subsidence inversion is shown in figure **(14.2**)

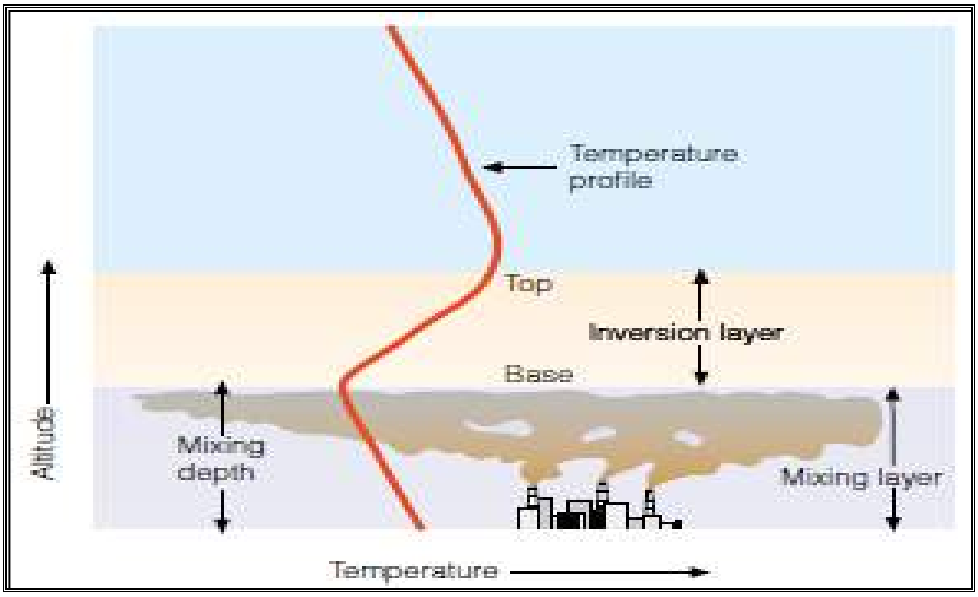

Fig.(14.2) : A typical temperature profile of a subsidence inversion

- Notice that in the relatively unstable air beneath the inversion, the pollutants are able to mix vertically up to the inversion base

- In figure **(14.2)** , the region of relatively unstable (well mixed) air that extends from the surface to the base of the inversion is referred to as the **mixing layer**
- The vertical extent of the mixing layer is called the **mixing depth**
- Observe that :
- **If the inversion rises**, the mixing depth increases and the pollutants would be dispersed throughout a greater volume of air
- **If the inversion lowers**, the mixing depth would decrease and the pollutants would become more concentrated, sometimes reaching unhealthy levels
- Since the atmosphere tends to be most unstable in the afternoon and most stable in the early morning, we typically find the greatest mixing depth in the afternoon and the most shallow one (if one exists at all) in the early morning

14-2 SOME IMPORTANT EFFECTS OF AIR POLLUTION

14-2-1 Acid Deposition

- Acidity is measured on the **pH** scale, with numbers below **7** being *acidic*, and numbers above **7** being *basic* as shown in figure (**14.3**)

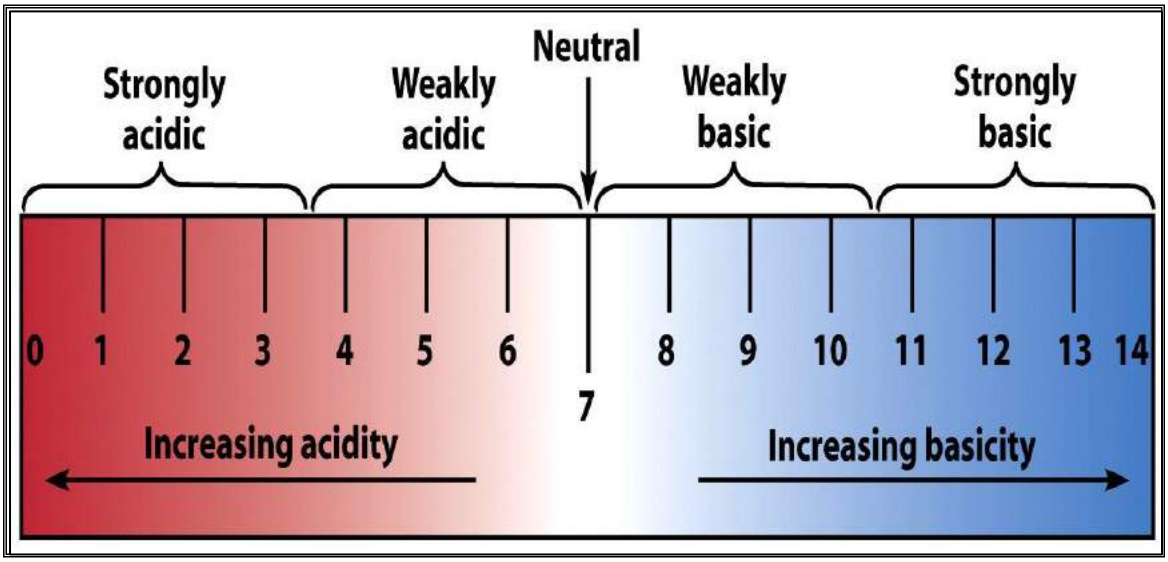

Fig.(14.3) : pH scale

- **Acid Deposition forms when** sulfur dioxide (**SO_2**) and nitrogen dioxide (**NO_2**) emissions react with water vapor in the atmosphere and form acids of sulfuric acid (**H_2SO_4**) and nitric acid (**HNO_3**) during a complex series of chemical reactions involving sunlight, water vapor, and other gases that return to the surface as wet deposition as shown in figure (**14.4**)

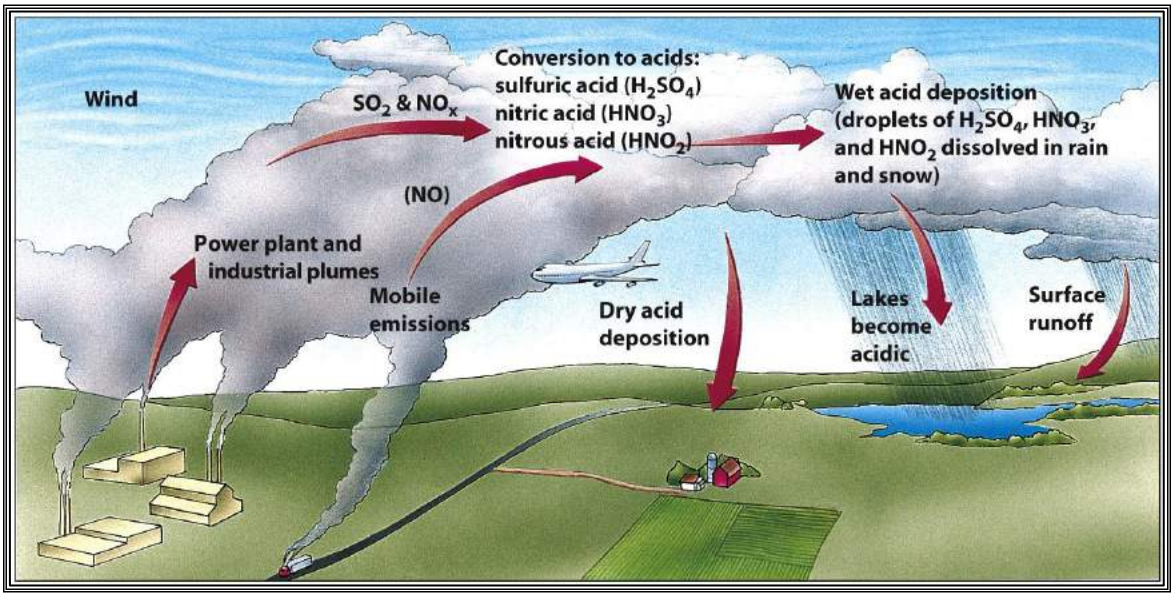

Fig. (14.4) : Acid Deposition

- Cloud droplets and rain are normally acidic (with a **pH** averaging around **5.6**) because of the $\mathbf{CO_2}$ present in the atmosphere, which forms carbonic acid in water
- Consequently, precipitation is considered acidic when its **pH** is below about **5.0**
- Effects of the Acid rain are :
  - damages statues and stone
  - forest decline
  - damages streams and lakes

14-2-2 Photochemical Smog

- Photochemical smog is a summertime pollution phenomena
- Brownish-orange haze formed by chemical reactions involving sunlight, nitrogen oxide, and hydrocarbons as shown in figure (**14.5**)
- The necessary conditions to form photochemical smog are :
  - a source of Volatile Organic Compounds (**VOC**) – hydrocarbons, usually from unburned or partially burned fossil fuel
  - a source of $\mathbf{NO_X}$ – from combustion of fossil fuel
  - warm temperatures (in the 80’s or 90’s Fahrenheit)
  - sunlight

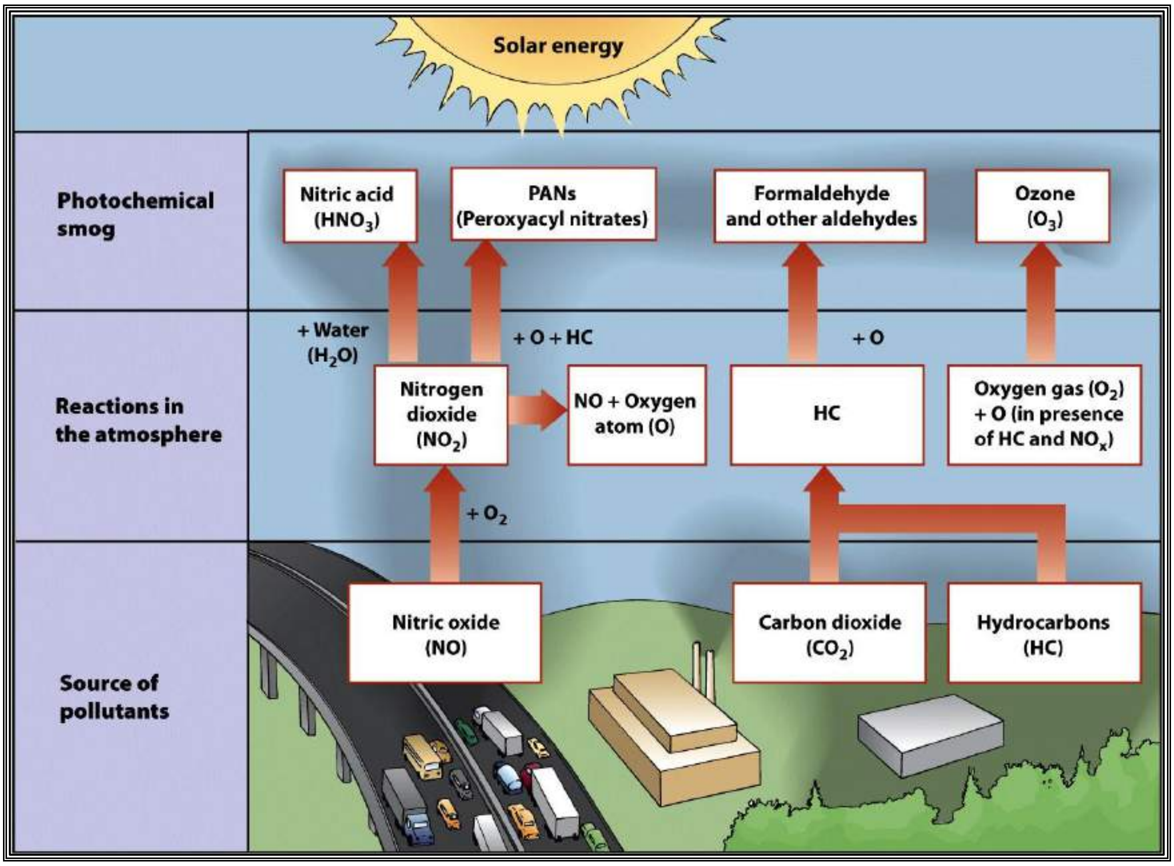

Fig. (14.5) : Photochemical Smog

14-2-3 Ozone Depletion

- Ozone is a relatively unstable molecule made up of three oxygen atoms
- The majority of this compound exists in the **stratosphere** and shields the Earth from harmful **UV** radiation from the sun , this is known as "**good**"
- Ozone also naturally exists at the Earth's surface (**troposphere**); formed in the troposphere by human activities is a harmful pollutant: dangerous to health, this is known as "**bad**" ozone
- The Ozone layer and it is two types are shown in figure (**14.6**)

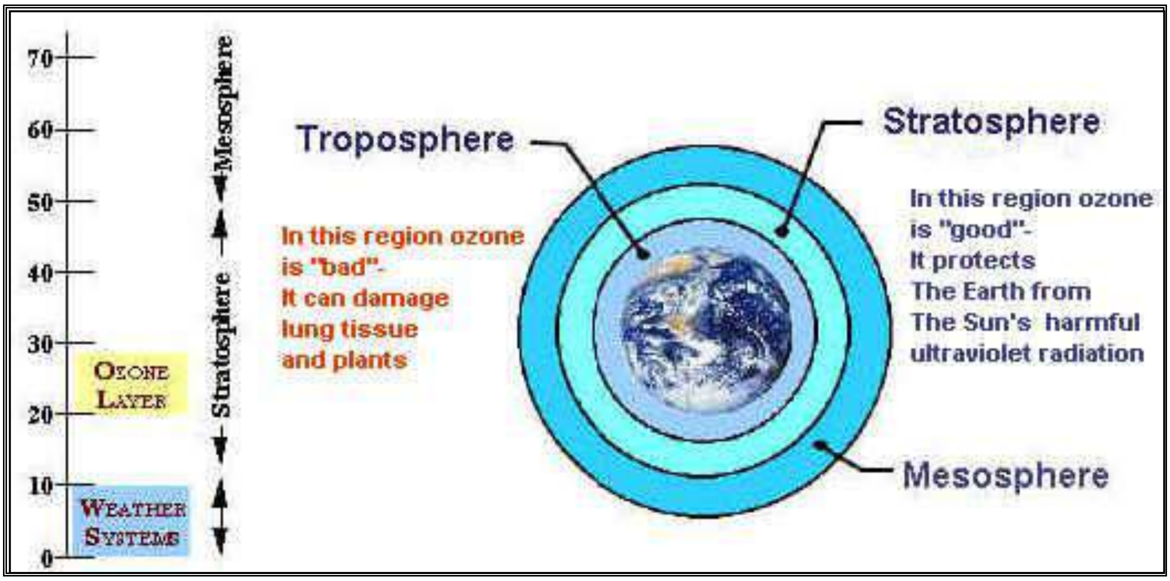

Fig. (14.6) : Ozone layer

- Ozone in the troposphere is produced when sunlight and heat react with nitrous oxides and volatile organic compounds, known as ozone precursors
- These pollutants are emitted by vehicles, power plants, refineries, and chemical plants

- The amounts of "**good**" and "**bad**" ozone in the atmosphere depend on a balance between processes that create and destroy ozone; an upset in this balance has serious consequences for life on Earth
- Ozone depletion refers to the thinning of the ozone layer, which allows more **UV** radiation to reach the Earth's surface
- **Major Cause** : chlorofluorocarbons (**CFCs**) Chemicals invented in the **1920**s, used in refrigerator and air-conditioner, aerosol spray cans , are very harmful to ozone, especially at cold temperatures (north and south poles) as shown in figure (**14.7**)

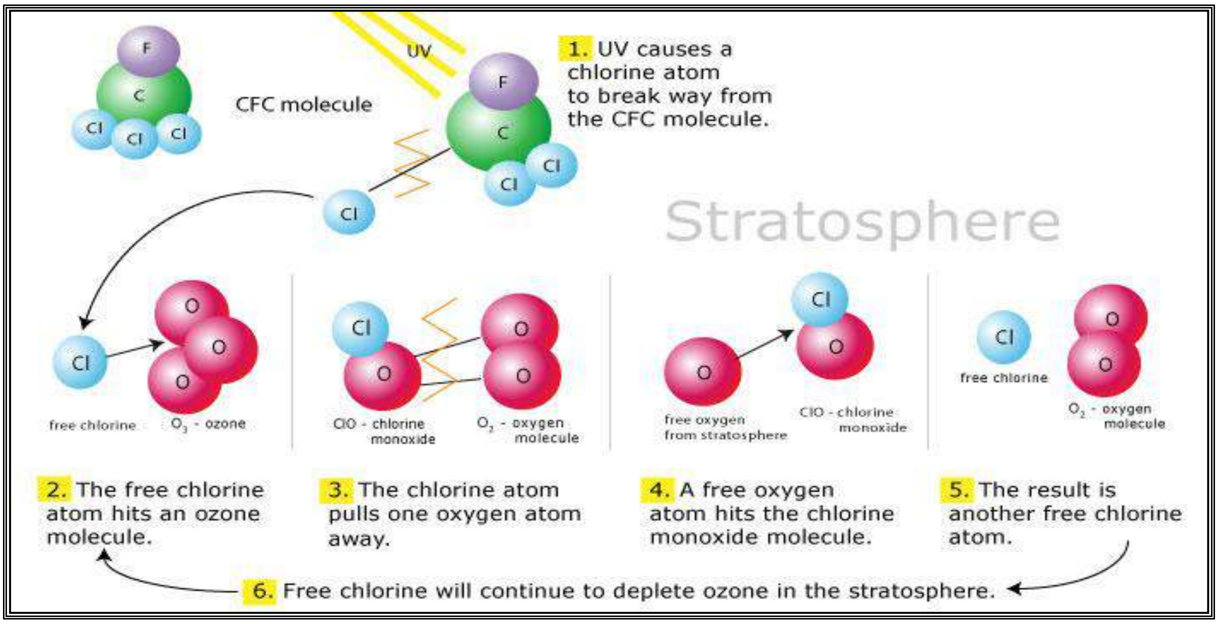

Fig. (14.7) : Ozone depletion