

Organic Matter $\xrightarrow{\text{Anaerobic decomposition}}$ CH_4

CH_4 oxidised $\rightarrow \text{CO}$.

(5) CLASSMATE

AIR POLLUTION

colourless, odourless, tasteless gas, poorly soluble in water, has lower density than air.

1.) **CO**

This gas is produced by incomplete combustion of coal, charcoal, petrol & its products.

Internal combustion engines are the largest source of combustion produced CO.

Automobiles, combustion process of stoves, furnaces, forest & bush fires, burning coal mines, factories, power plants are sources. (Also oceanic & atmospheric reactions are the major sources of CO.)

From combustion sources, CO emission per year in the world is about 2.6×10^8 tonnes (2600 million tonnes).

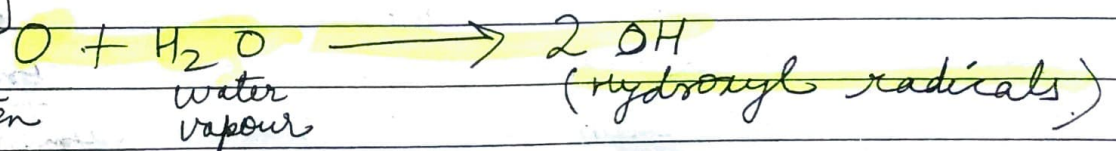
There is a flux of CO from ocean surface to the atmosphere. In surface water, supersaturation of CO is increased in sunlight. 2 mechanisms operate for this:

→ Photochemical oxidation of organic matter

→ Biological oxidation by living marine organisms. Higher animals produce CO from breakdown of Haemoglobin.

• CO is also liberated from bile juice.
• Breakdown of photosynthetic pigments in algae release CO.
• Plants produce 10^3 tonnes of CO/year on an average.

Source of atmospheric CO is oxidation of CH_4 . Anaerobic decomposition of organic matter produces CH_4 which is oxidised to produce CO.



The hydroxyl radical initiates methane oxidation. Thus CO production in the atmosphere is associated with photochemical reaction.

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In upper stratosphere, CO maintains constant concentration.

In troposphere ^(up to 5 km) CO is oxidised to CO_2 .

Imp. But when there is higher conc. of CO it forms photochemical SMOGI .

→ Soil Fungi & higher plants also absorb CO in presence of sunlight & is reduced to 5-formyl-tetrahydrofolic acid.

Which is fixed as Serine (amino acid) & enters protein & carbohydrate metabolism.

Imp. → In the dark, CO is oxidised to CO_2 in leaves & released in atmosphere.

Hence plants destroy CO with no dependence on light.

Toxic Effect of CO :

1.) CO causes difficulty in breathing, headache, irritation of mucous membranes.

2.) ★ It combines with haemoglobin of blood reducing its O_2 carrying capacity. (The gas is fatal over 1000 ppm causing unconsciousness in an hour & death in four hours).

→ If this gas is inhaled for few hours at even low concentration of 200 ppm, it causes symptoms of poisoning.

→ Inhaled CO combines with blood haemoglobin to form Carboxyhaemoglobin (Hb CO) about 210 times faster than O_2 can combine. Formation of Hb-CO

O_2 carrying capacity of haemoglobin is affected

CO competes with O_2 to combine with haemoglobin. It combines faster.

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decreases overall O_2 carrying capacity of blood to cells resulting into (Oxygen deficiency) $\leftarrow$ Hypoxia

Increase in Hb-CO level from 1-2% to 3-4% may cause Cerebral anoxia causing psychomotor ^{disorders} activity & vision impairing.

An exposure of 120 mg/kg CO for 1 hr increases Hb CO content in blood to 5%, a level usually found in blood of cigarette smokers.

Sulphur Dioxide as Primary Pollutant

Sulphur remains in atmosphere in three forms - SO_2 , H_2S & sulphate particles (aerosol sulphates)

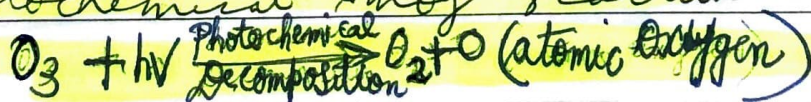
→ Chief source of oxides of sulphur are the combustion of coal & petroleum & mobile oil (3% S). Thus most oxides come from thermal power plants & other coal based plants & smelting complexes (3%) (smelting of sulphide ores). Automobiles (4%) also release SO_2 in air.

H_2S - Source of H_2S is decomposition of organic waste. Its conc. in polluted areas reach $100 \mu\text{g}/\text{m}^3$ while in unpolluted areas is $0.3 \mu\text{g}/\text{m}^3$.

→ H_2S is oxidised to SO_2 at atmospheric pressure & temp, though slowly.

Its reaction with Ozone is measurable
 $\text{H}_2\text{S} \xrightarrow{\text{oxidised}} \text{SO}_2$ (slow process)
 $\text{H}_2\text{S} + \text{O}_3 \rightarrow \text{SO}_2 + \text{H}_2\text{O}$

→ A chain oxidation reaction may occur with atomic oxygen, derived from photochemical dissociation of O_3 or photochemical smog reaction.



* It has a sharp odour

* SO_2 is highly soluble in water. ↑

[SO_2 is oxidised to SO_4 & returned to earth through rain.] Solution of SO_2 in water contains:

SO_2 , H_2SO_3 ($\text{H}_2\text{O} \cdot \text{SO}_2$), HSO_3^- , SO_3^{2-} & $\text{S}_2\text{O}_5^{2-}$ in proportions depending on pH & conc.

* Rain water has pH of 4-6 & (predominant ion⁺ is HSO_3^-)

From data collected it is estimated that mean ^(lifetime) residence time of SO_2 in atmosphere ranges from 12 hrs to six days.

Toxicity of SO_2 :

1. Causes intense irritation to eyes & respiratory tract. Continuous inhalation of this gas cause severe headache. If it reaches lungs, it causes respiratory problem.
2. Effects On Plants:
 - a.) Plants are affected at lower concentrations of SO_2 than human beings.
 - b.) Continuous exposure to SO_2 for considerable time $300 \mu\text{g}/\text{m}^3$ causes

→ Lichens are sensitive to SO_2 . In ^{areas where} sulphur dioxide conc. is high, lichens are absent.

→ Causes chlorosis of leaves without cellular collapse. ^{collapse} Pine trees are more susceptible than broad leaf trees.

→ severe leaf damage & pin sensitive species.

c.) Leaf blotching, necrosis & loss of yield are the main damages caused by SO_2 . (Alfalfa¹, barley², Cotton & wheat are sensitive to SO_2). (Potato, onion & corn are resistant).

d.) Exposure to SO_2 causes ~~leaf~~ bleaching of leaf pigments due to conversion of Chl-a to phaeophytin-a.

e.) Some plants like Nerium indicum in Delhi serves as indicators of SO_2 pollution.

SO_2 affects stomatal pores, stomatal frequency & trichomes as well as chloroplast str. (f.) SO_2 enters plants through stomatal opening. (while passing

through stomata SO_2 gets oxidised to H_2SO_4 or sulphate ions. Sulphuric acid aerosols are toxic to plants).

3. → Limestone & marble are severely affected by SO_2 . It gets absorbed by [limestone] which is maximum at high relative humidity. → Absorbed SO_2 is oxidised to sulphate in the CaCO_3 matrix. Mechanical stress arises as molecular volume of CaSO_4 is greater than ^{that of} CaCO_3 . (Chemical reaction leads to formation of CaSO_4). CaSO_4 leaches out in rain water as its solubility in it is higher than CaCO_3 .

Causes Pores.

Marble has low porosity so is less damaged.

4. Leather is damaged by SO_2 due to formation of H_2SO_4 on leather causing acid hydrolysis of leather protein.

5. Iron & Steel ^{in Al} gets corroded by SO_2 laden air, when Relative humidity is high.

ACID Rain + Toxic

Photochemical Products causing Photochemical Smog.

Photochemical Smog is a case of synergism where 2 primary pollutants react with one another in presence of sunlight to produce sec. pollutants.

which is highly dangerous. O_3 PAN, PBZ N,

→ eg. Primary pollutants [Hydrocarbon] + nitrogen oxide (NO) $\xrightarrow[\text{produce}]{O_2, \text{Sunlight}}$ PAN (peroxyacetyl nitrate). O_3 is also formed.

This appears as yellowish brown haze called Photochemical Smog which reduces visibility.

Formed only during night or cloudy days.

⇒ The principle photochemical products are Olefins⁽¹⁾, aldehydes⁽²⁾, Ozone⁽³⁾, Peroxyacetyl nitrate⁽⁴⁾ (PAN), PBZ N⁽⁵⁾ (Peroxybenzoyl nitrate) &

photochemical Smog (comprises of O_3 , PAN, PBZ N, organic peroxides⁽⁶⁾, H_2O_2 ⁽⁷⁾).

Toxicity - Olefins affect plants seriously at very low conc.

- a.) They wither the sepals of orchid flowers,
 - b.) Retard opening of carnation flowers & may cause dropping of their petals.
 - c.) At high levels they retard the growth of tomatoes.
- ⇒ Aldehydes are produced in atmosphere from ethylene (Hydrocarbon) & produced directly from exhaust.

Toxicity of

PAN — is an eye irritant at about 1 ppm or less. It persists for more than 24 hrs. in photochemical smog. PAN & O_3 both cause respiratory distress & are toxic to plants.

- NO_x & PAN cause death of forest trees.
- PAN blocks Hill reaction in plants.
- PAN causes injury in Spinach, beets, celery, tobacco, pepper, lettuce, alfalfa, primrose, aster etc.
- It causes silverying of ~~underside~~ underside of leaves
- ~~It causes silverying of underside of leaves~~
- Aldehyde of photochemical smog cause eye irritation, sore throat, respiratory irritation etc.

X [In 1987, Bombay experienced heavy smog for about 10 days. Formation of oxidants, particularly of O_3 when exceeds 0.15 ppm for more than 10 hrs.

The reason was stagnant winds trapping various sources of smoke. Primary source of smoke was stubble burning, lit garbage, road dust, power plants, factories & vehicles. Air quality. ✕

O₃ : the destroyer

Ozone is also formed in the atmosphere through chemical reactions involving pollutants like SO₂, NO₂, aldehydes on absorption of UV radiations. ✕

TOXICITY OF OZONE

In plants O₃ enters through stomata.

It damages leaves, reduce crop yields. → O₃ cause tip burn in plants.

→ At 0.02 ppm, it damages tobacco, tomato, bean, pine & other plants.

→ O₃ alone & in combination with pollutants SO₂ & NO_x is causing crop losses of over 50% in several European countries.

→ In Netherlands & Denmark O₃ presence in troposphere (atmosphere) reduced yields of potato & beans.

→ O₃ reacts with ^{fibres} ^{damaging them} ^{consistently} cotton, nylon & polyester & dyes. Light & humidity aggravates the ^{extent of} damage.

→ O₃ hardens rubber.

→ Weakens plants & increase the infestation by pests.