Syllabus

AIR POLLUTION AND CONTROL

Subject Code: 10CV765

PART - A

UNIT - 1

INTRODUCTION: Definition – Classification and Characterization of Air Pollutants, Emission Sources, Behavior and Fate of air Pollutants, Chemical Reactions in the Atmosphere, Photo-chemical Smog, Coal-induced smog, Air Pollution Inventories.   **6 Hours**

UNIT - 2

EFFECTS OF AIR POLLUTION: On Human Health, Animals, Plants and Materials – Major Environmental Air Pollution Episodes – London Smog, Los Angeles Smog & Bhopal Gas Tragedy.   **6 Hours**

UNIT - 3

METEOROLOGY: Introduction – Meteorological Variables, Primary and Secondary Lapse Rate, Inversions, Stability Conditions, Windrose, General Characteristics of Stack Plumes, Meterological Models.   **8 Hours**

UNIT - 4

Factors to be considered in Industrial Plant Location and Planning, Noise pollution – sources, measurement units, effects and control   **4 Hours**

PART - B

UNIT - 5

SAMPLING, ANALYSIS AND CONTROL: Sampling and Measurement of Gaseous and Particulate matter, Stack Sampling, Analysis of Air Pollutants, Smoke and Smoke Measurement, Air Pollution Control Methods – Particulate, Emission Control, Gravitational Settling Chambers,

Cyclone Separators, Fabric Filters, Electrostatic Precipitators, Wet Scrubbers, Selection of a Particulate Collecting Equipment, Control of Gaseous Emissions, Adsorption by Liquids, Adsorption by Solids, Combustion Odours and their control. **16 Hours**

UNIT - 6

AIR POLLUTION DUE TO AUTOMOBILES: Air Pollution due to Gasoline Driven and Diesel Driven Engines, Effects, Direct and Indirect Methods of control. **5 Hours**

UNIT - 7

BURNING ENVIRONMENTAL ISSUES:

1.   Acid Rain

2.   Global Warming

3.   Ozone Depletion in Stratosphere

4.   Indoor Air Pollution **4 Hours**

UNIT - 8

ENVIRONMENTAL LEGISLATION: Environmental Policy, Environmental Acts, Water, Air and Noise Pollution Standards. **3 Hours**

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2. Crawford, M., (1980), **Air Pollution Control Theory** –TMH Edition, Tata Mc Graw Hill Publishing Co. Ltd., New Delhi.
3. Henry. C. Perkins, (1980), **Air Pollution** –McGraw Hill.
4. Peavy, H.S., Rowe, D.R., and Tchobanoglous, G., (1986), **Environmental Engineering** –Mc Graw Hill Book Co.
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6. Wark, K., Warner, C.F. and Davies, W.T., (1998), **Air Pollution- Its Origin and Control** – Harper & Row Publishers, New York.

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Unit 1 - INTRODUCTION

GENERAL DEFINITION FOR AIR POLLUTION

"Air Pollution is the pollution is the presence of undesirable material in air, in quantities large enough to produce harmful effects".

ISI DEFINITION FOR AIR POLLUTION [ISI-IS:4167(1966)]

"Air pollution is the presence in – ambient atmosphere of substances, generally resulting from the activity of man in sufficient concentration, present for a sufficient time and under circumstances which interfere significantly with the comfort, health or welfare of persons or with the full use or enjoyment of property"

DEFINITION BY AMERICAN MEDICAL ASSOCIATION (AMA)

"Air pollution is the excessive concentration of foreign matter in the air which adversely affect the well being of the individual causes damage to property"

CLASSIFICATION AND PROPERTIES OF AIR POLLUTION

CLASSIFICATION: The variety of matter emitted into the atmosphere by natural and anthropogenic sources is so diverse that it is difficult to classify air pollutants neatly at easily. However usually they are divided into two categories

1.   Primary pollutants

2.   Secondary pollutants

PRIMARY POLLUTANTS	SECONDARY POLLUTANTS
Primary pollutants are those that are emitted alicctly from the sources, typical	Secondary pollutants are those formed in the atmosphere by chemical reactions

pollutants are particulate matter such as ash, smoke, dust, fumes, mist and spreay; inorganic gases such as SO_2, H_2S, , nitric oxide, ammonia, CO, CO_2, hydrogen fluoride, olefinic and aromatic hydro carbons and also radio carbon and also radioactive components.

Of the Large number of primary pollutants into the present in sufficient – concentration to be of immediate concern. These are 5 major types particulate matter, sulphur dioxide, oxides of nitrogen hydro carbons. CO_2 is generally not considered because of its increased global concentration, its influence on the global climate patterns is of great concern.

between primary pollutants and normal atmospheric constituents. Pollutants such as SO_3,NO_2 pcroxy acetyl nitrate (PAN), ozone, aldehydes, ketones and various sulphate and nitrate salts are included in this category Secondary pollutants as formed from the chemical and photo chemical reaction in the atmosphere. The reaction mechanisms are influenced by concentration of reactants at pollutants, the amount of moisture contents, degree of photo activation,

Meteorological forces and local photography.

PROPERTIES OF AIR POLLUTION

(1) **PARTICULATE MATTER** – In general the term particulate refers to all atmospheric substances that are not gases. They can be suspended droplets at solid particles at mixtures of the extremely reactive materials ranging in size from 100μm down to 0.1μm and less. The inert – materials do not react readily with the environment nor do they exhibit any morphological changes as a result of combustion or any other process, whereas the reactive materials could be with the environment as a result of combustion or any other process, whereas the reactive materials could be further oxidized at may react chemically with the environment.

The classification of various particulates one as follows:

DUST: It contains particles of size ranging from 1 to 200 μm. These are formed by natural disintegration of rock and soil at by the mechanical processes of grinding and spraying. They have large settling velocities and one removed from the air by gravity and other inertial processes. Fine dust particles act as centres of – catalysis for many of the chemical reactions taking place in the atmosphere.

SMOKE   It contains fire particles of the size ranging from 0.01 to 1 μm, which can be liquid at solid and are formed by combustion at chemical processes, smoke may have different colours depending on nature of materials burned

FUMES   These are solid particles of the size ranging from 0.1 to 1 μm and are normally released from chemical at metallurgical processes

MIST   It is made U.P. of liquid droplets generally   smaller than 10μ which are formed by condensation in the   atmosphere or released from Industrial operation.

FOG   It is the mist in which the liquid is water and is sufficiently dense to obstruct vision.

AEROSOL   Under this category are included all air borne suspensions either solid at liquid. These are generally smaller than 1 μm.

Particulates in the size range 1 to 10 μm have measurable settling velocities but are – readily disturbed by air movements, where as particles of size 0-1 to 1μm have small settling velocities. Those below 0.1μ a sub microscopic size found in urban all, undergo random – Brownian motion resulting from collision among individual molecules. Most particulates in urban all have sizes in the range 0.1 to 10μ, The finest and the smallest particles are the ones which cause significant damage to health.

(2) **OXIDES OF SULPHUR** : The most important emitted by pollution sources is SO_2 [sulphur] It is a colourless gas with a characteristic, pungent odour. It is moderately soluble in water [11.3 gm / 100ml] Forming weak acidic sulphurous acid (H_2SO_3). It is oxidized slowly in clean air to sulphur trioxide (SO_3). In a polluted atmosphere, SO_2 reacts photochemically at catalitically with other pollutants at normal atmospheric constituents to form SO_3, H_2SO_4 and salts of H_2SO_4.

SO_3 is generally emitted along with SO_2 at about 1-5% of SO_2 concentration, SO_3 rapidly which has a low dew point. Both SO_2 and SO_3 are relatively quickly washed out of the – atmospheres by rain at settle out as Aerosols.

(3) **NITROGEN OXIDES** - of the six or seven oxides of nitrogen only three – nitrous oxide (N_2O), Nitric in any appreciable quantities in the atmosphere.

Nitrous oxide (N_2O) is a colour less, odourless, non toxic gas present in the natural atmosphere major sources of N_2O, in the natural atmosphere in relatively large concentration (0.25 ppm). The major sources of N_20 in the atmosphere is the biological activity of the soil and there are no anthropogenic sources. It has a low reactivity and is generally not considered as an Air Pollutant.

Nitric oxide (ND)is a colour less, odourless, gas produced largely by fuel combustion. It is oxidized to NO_2 through photo chemical – secondary reactions. NO_2 is a brown pungent gas with an initiating odour which can be detected at concentrations of about 0.12 ppm. It absorbs sunlight and initiates a series of photo chemical reactions.

NO_2 is probably produced by the oxidation of NO by ozone. NO_2 is of major concern as a pollutant and is committed by fuel combustion and Nitric acid plants.

(4) **CARBON MONOXIDE (CO)** : It constitutes the single largest pollutant in the urban atmosphere CO is colourless, odourless and tasteless and has a boiling point of $0.192^{o}c$. It has a strong affinity towards Hemoglobin and is a dangerous pollutant. The rate of

oxidation of CO to CO_2 in the atmosphere seems to be very slow, mixtures of CO and O_2 exposed to sunlight remain almost uncharged CO is present in small concentrations, 0.1 ppm in the natural atmosphere and has a residential time of about a months. The main sources of CO in the urban air are smoke, exhaust fumes of many devices, burning coal, gas or oil.

HYDRO CARBONS

The gaseous and volatile liquid hydrocarbons are of particular interest as air pollutants. Hydro carbons can be saturated or unsaturated, branched or straight chain or can have a ring structure as in the case of saturated class, methane is by for the most abundant hydrocarbons constituting about 40-80% of the total hydrocarbons present in an urban atmosphere. The unsaturated class include alkenes (ole fins) and acetylenes. Among alkenes the prominent pollutants are ethylene and propenes. The First member of aromatic class is benzene, but most of its substituted derivatives such as toluene and M-xylene are usually present in larger concentration in the urban atmosphere. Tarpenes are a particular class of volatile hydrocarbons emitted largely by a natural source: These are cyclic non-aromatic hydrocarbons found in pine for and other wood sources.

The Hydrocarbons in air by themselves alone cause no harmfully effects. They are of concern because the hydrocarbons undergo chemical reaction in the presence of sunlight and nitrogen oxides forming photochemical oxidants of which the predominant one is ozone. Methane has a very cow photo chemical activity as compared to that of other hydrocarbons for this reason. He is the non methane hydrocarbons concentration is of interest while considering air pollution.

EMISSION SOURCES

The source of air pollution is numerous they can be grouped according to :

i)   A variety of methods including type of source.

ii)   Number of spatial distribution of sources

iii)   Types of emissions:

SOURCE TYPE: Source type refers to natural and anthropogenic sources as well as to additional sub classifications within each group. Natural sources include wind blow dust, pollen grains, sea salt nuclei, volcanic gas and ash, smoking and trace gases from forest fires and terpenes from forest. Anthropogenic sources cover a wide spectrum of types.

CLASSIFICATION OF ANTHROPOGENIC AID POLLUTION SOURCES

Source type	Category	Important sources	Typical pollutants
Combustion	a) Stationary	Power plants, industrial boilers, diesel generations, municipal and industrial incineration refused	Oxides of sulphur, NOx, co, smoke fly ash, trace metal oxides.
	b)Mobile	Motor vehicles aircraft	CO, HC's, NOx, SO_2, particulars
Roasting and Heating processes	a)Non-Ferrous metallurgical	Roasting, smelting and refilling operations	Dust, Smoke, metal fumes (Cu, pd, Zn) Sox
	b) Ferrous Metallurgical	Materials handling are sintering & palletising, coke owns, blast furnace, steel furnaces	Smoke, fumes, co odours, H_2S_2, organic vapours, fluorides
	c) non-metallic minerals	Crushed stone, gravel sand processing, cement glass, refractories and ceramic manufactures etc.,	Mineral and organic SO_2 particulates, NOx, dust fumes
Chemical petroleum pulp and paper	a)Petroleum refilling	Biogas, process heaters, catalyst regenerators, tractors, Store, storage tanks compressor engines	Sox, HC's, NOx, particulate matter, CO, aldehydes, ammonia, odour,

	b) Inorganic chemicals	Sulphuric acid, plants, fertilizer, manufacture, nitric acid and ammonia plants, phosphoric acid manufacture	SO_2, HF, H_2S, NOx, NH_3, particulate matter H_3PO4, etc.,
	c) Organic chemicals	Plastics, paint and varnish manufacture, synthetic rubber, rayon insecticide, soap and detergent manufacture, methanol, phenol etc.,	Particulate matter, odours, SO_2, CO, organic intermediates, product gases and vapours, solvent vapours etc.,
	d) Pulp and paper (kraft process)	Digester below system pulp washers, recovery furnace, evaporaters, oxidation towers	Particulate matter, odours sulphur, compounds (H_2S Methyne,,. Dimethyle sulphide and SO2 (sulphite process)
Food and Agriculture	a)Food processing	Drying, Preserving and packaging	Vapours, odours dust
	b) Crop spraying and dusting	Pest and weed control	Organic phosphates Chlorinated HC arsenic, lead
	c) Field burning	Refuse burning	Smoke, Flyash and soot

ACCORDING TO NUMBER AND SPATIAL DISTRIBUTION

(EMISSION INVENTORY SOURCE CLASSIFICATION)

Air pollution sources can also be grouped – according to number and spatial distribution. These include

i)   Single at point sources (large stationary sources)

ii)   Area sources (small stationary sources and mobile sources with indefinite routes)

iii)   Line sources (mobile sources with definite routes)

TOTAL SOURCES

Stationary Sources		Mobile Sources	
POINT SOURCES	AREA SOURCES	LINE SOURCES	AREA SOURCES
1. Industrial processing 2. Power plants 3. Fuel Combustion (Industrial) 4. solid waste disposal (Municipal	1. Residential heating (coal, gas at oil) 2. Institutional and commercial heating (coal, oil & gas)	1. High way vehicles 2. Rail road coco motives 3. channel vessels	1. Motor Vehicles light duty, medium duty, heavy duty 2. Railyard locomotives 3. Port vessels 4. Airports

incinerators, open burning)	3. On site incineration		5. Miscellaneous
5. Miscellaneous	4. Open burning (large scale)		
	5. Evaporative losses		
	6. Miscellaneous		

TYPE OF EMISSIONS

Another source grouping by the type of emissions, with particulate and gaseous emissions being the major divisions.

CONCENTRATION OF POLLUTANTS (SCALES OF POLLUTANTS)

The concentration of a pollutant in the atmosphere can be expressed in a number of ways involving units of weights at volume/ unit weight at volume of air.

Four concentration scales are generally used to describe the concentrations of either gaseous at particulate pollutants.

1ST SCALE OF CONCENTRATION : The first is the mass concentration (WP) defined as the ratio of mass of pollutant to the mass of air + mass of pollutant i.e.,

$$WP = \frac{mp}{m_a + m_p}$$

Where,

'mp' is the mass of the pollutant

'ma' is the mass of pure air in a given volume of Air Pollutant mixture

2nd SCALE OF CONCENTRATION : The Second concentration scale is colume concentration (yp) defined as the ration of the volume of pollutant to the volume of air + volume of pollutant i.e.

$$Yp = \frac{Vp}{V_a + V_p}$$

3rd SCALE OF CONCENTRATION : The third concentration scale is the mass volume concentration 'ρp' pollutant to the volume of air and pollutant i.e.

$$\rho p = \frac{mp}{V_a + V_p}$$

4th SCALE OF CONCENTRATION: Number of relationships can be developed among these concentrations, but the conversion between y_{ppm} and ρ_p in $\mu g/m^3$ for gaseous pollutants is of special interest. Therefore combining equations 2, 3, and 4 we get.

$$\rho_p = \frac{mp}{vp}\ y_{ppm}\ x\ 10^{-6}$$

Assuming that the perfect gas law holds for pollutants that are usually formed in the atmosphere, the mass density of the pure components pollutant, $\dfrac{mp}{vp}$, in $\mu g/m^3$ can be expressed as.

$$\frac{mp}{vp} = \frac{PMp(10^\rho)}{(8.314x10^{-2})T}$$

Where

      P   =   Total pressure in bars

      Mp =   Molecular Weight of the pollutant

T   =   absolute temperature in K (Kelvin) and

8.314×10^{-2} =   Value of universal gas constant in m3-

A   Number of relationship can be developed among these concentrations, but the conversion between y_{ppm} and Sp in g/m3 for gaseous pollutants is of special interest. Therefore combining equations 2, 3 and 4, we get

$$Sp = \frac{Mp}{Vp} \, y_{ppm} \times 10^{-6}$$

Assuming that the perfect gas law hold for pollutants that are usually Formed in the atmosphere, the mass density of the pure component pollutant $\dfrac{mp}{vp}$ can be expressed as,

$$\frac{Mp}{Vp} = \frac{PMp\,(10^9)}{(8.314 \times 10^{-2})\,T}$$

Where,

P=Total pressure in bars

Mp = Molecular weight of the pollutant

T = absolute temperature in K(Kelvin) and

8.314×10^{-2} = Value of universal gas constant in

m^3-bar/Kgmol-K

At the STD temperature (25C) and pressure (1.01cc bars) the above equation reduces to

$\underline{Mp} \quad = \underline{Mp(10^9)}$

$Vp \qquad 24.45$

Substituting eqn(7) in eqn.(5), we get the relationship between and as

$Sp \quad = \quad \underline{Mp(109)}$

$\qquad\qquad 24.45$

The constant in the denominator becomes 22.4 at 0^0C and 1 atmosphere pressure.

PROBLEM :

1) The exhaust gas from a motor vehicle shows a CD concentration of 2% by volume. What is the concentration of CO in mg/m^3 at 0C and 1 atmospheric pressure.

SOLUTION :

1) We have volume concentration

   $y_p = 0.01960$

2) Volume concentration in ppm,

   $y_{ppm} = 0.01960 \times 10^6$

The mass volume concentration (or) concentration of pollution in µg/m3.

Where,

Mp = Molecular weight of 'CO'

=12+16=28

ρ_{CO} = 28x0.0196078x106x10/ 22.4

=22.50975x106   µg/m3

ρ_{CO} = 245097.5x106 µg/m3

1. CO is present in std. Atmospheric air at a concentration of 50ppm. Compute volume concentration, mass-volume concentration and mass concentration.

SOLUTION :

From the statement of the problem, Yppm=5D

Therefore volume concentration.

$Y_p = Y_{ppm} \times 10^{-6}$

$= 50 \times 10^{-6}$

$Y_p = 0.00005$

Mass-volume concentration, $\rho_p = M_p\ Y_{ppm}(10^8)\ /\ 24.45$

$\rho_p = 28 \times 50 \times 10^3\ /\ 24.45$

$\rho_p = 57.26 \times 10^3$ µg/m3

NOTE :

Mass concentration $(W_p) = p$

$X(1-Y_p)+p$

Where,

ρ_A = Air density at Std. Condition is $1.185 kg/m^3$

$\rho_p = 57.26 \times 103 \times 10^{-9} = 57.26 \times 10^{-6}$ Kg/m^3

$W_p = 57.26 \times 10^{-6}$

$1.185(1-0.00005) + (57.26 \times 10^{-6})$

$W_p = 4.33 \times 10^{-5}$ Kg/m^3

BEHAVIOUR AND FATE OF AIR POLLUTANTS

Although large amounts of pollutants are discharged into the atmosphere, the very fact that their ambient levels have remained very much the same throughout the world suggests that there are certain pathways of exchange from the atmosphere to the earth, whereby the pollutants are continuously removed. These pathway or the scavenging process, as they are called may be grouped as follows for both particulates and gases.

I. **FOR PARTICULATES** :

        a) wet removal by precipitation

        b) dry removal by sedimentation, impaction and diffusion.

II. **FOR GASES :**

a) Wet removal by precipitation

b) Chemical reaction in the atmosphere to produce aerosols and/or absorption on aerosols with subsequent removal.

c) absorption or reaction at Land and ocean surfaces.

WET PRECIPITATION :

Wet precipitation has two distinct Mechanisms- rain out and washout. The first includes various processes taking place inside clouds where the containments serve as condensation nuclei on which droplets condense. The second Mechanism repairs to the removal of pollutants below the cloud level by falling rain wet precipitation is one the most effective scavenging process for both particulates and gaseous pollutants in a global sense.

DRY DEPOSITION :

  Particulate matter smaller than 0.1 often coagulates through mutual collisions and forms larger aggregates which are effectively removed by gravitational settling. Brownian motion is the major mechanism of coagulation, although atmospheric turbulence also enhances the diffusive motion of particles Atmospheric turbulence is particularly effective for coagulating larger particles whose brownian motion is less pronounced.

The rate of the settling of particles depends on their settling velocities according to the STOKE'S LAW.

STOKE'S LAW

$$Vt = \{gd\rho^2 / 18\mu a\}(\rho_p - \rho_a) [1 + 2c / d_p p]$$

Where,

Vt	=	Terminal settling Velocity
dp	=	particle dia = ………….. cm
ρ_p, ρ_a	=	density of particle and a r
μa	=	viscosity of air
P	=	air pressure millibars
C	=	constant = 0.0084

From the above equation, it is seen that the rate of sedimentation is strongly influenced by the particle size. Particles larger than 10mm have high settling rates and hence have short resident time in the atmosphere.

CHEMICAL REACTIONS IN THE ATMOSPHERE

Many of the   gaseous pollutants undergo chemical reactions within the atmosphere and from either new compounds or aerosols. This made of removal is of great importance for SO_2

A large part of SO_2 in the atmosphere is oxidized to SO_2 which quickly combines with moisture to form $H2SO_4$ mist. The overall reaction is represented as

$2SO_2 + 2 H_2O = O_2 \longrightarrow 2 H_2SO_2$
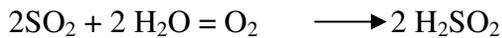
This process has been catalyzed by metal salts such as iron and manganese. Commonly formed in the fly ash. These particle serve as Nucleation sites for droplet formation and the Sulphuric acid droplet may in turn react with metal salts, metal oxides such as MgO, $Fe_2 O_3$

ZnO and Mn_2O_3 or Ammonia to produce Sulphate

$2 Nacl + H_2So_4 \longrightarrow Na_2 So_4 + 2Hcl$

$Mgo + H_2So_4 \longrightarrow Mg So_4 + H_2O$

$2 NH_3 + H_2So_4 \longrightarrow (NH_4)_2 So_4$
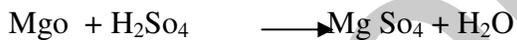
With these reactions the sulphuric acid droplet is neutralized and the solubility of So_2 in the is further increased and thereby enhancing the oxidation process. Both the acid droplets and the sulphate particles are rapidly removed from the atmosphere primarily by wet perception.

Similarly a major process of removal of NOx appears to be through their conversion to form Nitric acid. However the Mechanism of such a conversion has not been clearly determined. The direct conversion of NO2 to HNO2 in the presence of moisture appears to be too slow to account for the observed rate of removal.

$$2\,NO_2 + H_2O \rightleftharpoons HNO_3 + HNO_2$$

$$3\,HNO_3 \rightleftharpoons HNO_3 + 2NO + H_2O$$

$$3\,NO_2 + H_2O \longrightarrow 2HNO_3 + NO$$

Since the direct conversion of SO_3 to SO_3 and NO_3 to HNO_3 is slow, other mechanisms have been postulated, based mainly on theory and to a lesser extent an experimental observations made mechanisms involve the oxidation by reactive species such as radicals, atomic oxygen, ozone.

The First step in the excitation of SO_2 is the photo excitation of the SO2 molecule through its absorption of solar radiation.

$$SO_2 + hr \longrightarrow SO_2$$
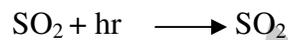
Where SO_2 represents an excited SO_2 molecule. These molecules in their excited state react more readily with molecular oxygen. Then several reactions follow to complete the oxidation of SO_2 to SO_3

$$SO_2 + O_2 \longrightarrow SO_4^{2-}$$

$$SO_4^{2-} + O_2 \longrightarrow SO_3 + O_3$$

$$SO_2 + O_3 + hr \longrightarrow SO_3 + O_2$$

A three-body reaction with atomic oxygen has also been suggested as a possible

$$O_2 + hr \longrightarrow 2\,O$$

$$SO_2 + O + M \longrightarrow SO_3 + M$$
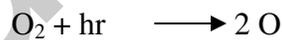
A three-body 'M' is required in order to carry off excess energy of reaction.

A proposed rapid Mechanism for the conversion of NO_2 to HNO_3 is the reaction of NO_2 atmospheric ozone to give NO_3.

In addition, NO_3 can be formed by reaction with atomic oxygen.

$$NO_2 + O + M \longrightarrow NO_3 + M$$
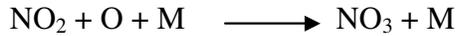
The NO_3 is radical is removed by reaction with NO_2. Forming N_2O_5, which in the presence of moisture forms Nitric acid.

$$NO_2 + NO_2 \longrightarrow N_2O_5$$
$$N_2O_5 + H_2O \longrightarrow 2HNO_3$$
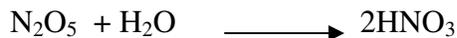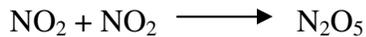
The HNO_3, so formed is then washed out of the atmosphere in the form of nitrate salts by precipitation.

For Carbon Monoxide, its reaction with atmospheric oxygen, in this presence of sunlight is found to be very slow and accounts for the removal of only 0.1 percent of available CO for each hour of sunlight, of major interest as an atmospheric sink for CO is the relatively fast reaction of CO with hydroxyl radicals present in the atmosphere.

$$CO + OH^- \longrightarrow CO_2 + H^+$$
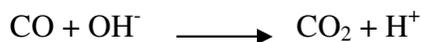
The above mechanism may account for the removal of a substantial portion of CO concentration of OH^- radicals. Another possible mechanism is the migration of CO into the stratosphere. In fact all these gaseous pollutants including hydrocarbons interact by photo chemical processes in the phenomenon known as the PHOTOCHEMICAL SMOG.

SMOG = SMOKE + FOG

SMOG is a sychronium of two words smoke and Fog, smog can be two types, namely
   1) Photo-Chemical Smog
   2) 2) Coal – Induced Smog

PHOTO-CHEMICAL SMOG : Photochemical Smog was first observed in Los Angeles, USA in the Mid1940's and since then the phenomenon has been detected in most major metropolitan cities of the world. The conditions for the formation of Photo chemical Smog are air stagnation, abundant sunlight and high concentration of hydrocarbon and NO_x in the atmosphere. In India, Bombay and Calcutta are ideal candidates for the formation of PCS, but it may be masked by smoke and Fog.

It occurs under adverse Meteorological conditions when the air movement is restricted in highly motorized areas and is caused by the interaction of some hydro carbons and oxidants under the influence of sunlight giving rise to dangerous PETROXYACYL NITRATES [PANS]. Its main constituents are No_x, PANS, hydrocarbons, CO and Ozone. It reduces visibility, causes eye imitation, damage to vegetation and cracking of rubber.

Smog arises from photochemical reactions in the lower atmosphere by the interaction of hydrocarbons and No_x released by the exhaust of automobiles and some stationery sources. This interaction results in a series of complex reactions producing secondary pollutants such as ozone, aldehydes, ketones and peroxy acyl Nitrates [PANS]. The reaction Mechanisms are complex and are not fully understood.

The starting Mechanism is absorption of ultraviolet rays from the sun by NO_2. This causes the NO_2 to decompose into nitric oxide (NO) and highly reactive atomic oxygen.

$$NO_x + hr \longrightarrow NO + O$$

The atomic oxygen initiates oxidizing processes or quickly combines with molecular oxygen to form ozone, which itself is reactive and acts as an oxidant:

$$O + O_2 + M \longrightarrow O_3 + M$$
$$O_3 + NO \longrightarrow NO_2 + O_2$$
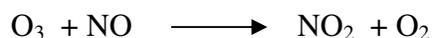
Ann energy absorbing molecule or particle (M) is required to stabilize "O_3" or else it will ozone(O_3) formed will be quickly removed by reaction with NO to provide NO_2 and O_2 as shown in the above equation. However when hydrocarbons are present in the atmosphere, this mechanism is partially eliminated as 'NO' reacts with the hydrocarbon radical peroxy acyl (RCO_3) and as a result, ozone concentration builds up to dangerous levels.

Hydrocarbons compete for free oxygen released by NO2 b decomposition to form oxygen bearing free radicals such as the acyl radical.

$$HC + O \longrightarrow RCO \text{ [acyl Radical]}$$

This radical takes part in the series of reactions involving the formation of still more reactive species, which in turn react with 'O_2', hydrocarbons and Nitric oxide.

$$RCO + O_2 \qquad RCO_3 \text{ [Peroxy acyl radical]} \text{-------} \quad (1)$$
$$RCO_3 + HC \qquad RCHO \text{ [Aldehydes]} \text{-----------------} (2)$$
$$R_2Co \text{ [Ketones]}$$
$$RCO_3 + NO \qquad RCO_2 + NO_2 \text{-------------------------} (3)$$
$$RCO + O_2 \qquad RCO + O_3 \text{---------------------------} (4)$$

Reactions represented by eqn(2) are termination reactions forming aldehydes and ketones. However in equations (3) and (4) the peroxy acyl radical reacts with 'NO' and 'O_2' to produce another oxidized hydrocarbon radical (RCO_2) as well as more NO_2 and O_3. Further the acylate radixal (RCO_2) can react with NO generate even more NO_2.

$$RCO_2 + NO \longrightarrow RCO + NO_2$$

The NO level in the atmospheric eventually drops OFF with the accumulation of NO_2 and O_3. When reactions such as these increase the NO_2 level sufficiently, another reaction begins to compare for the peroxy acyl radical.

$$RCO_2 + NO \longrightarrow RCO + NO_2 \text{ [PANS]}$$

The end products are known as peroxy acyl nitrates or PANS. Numerous could be formed, corresponding to the different possible R group three of the common members of PAN family are

HCOO NO2 : Perody Formyl nitrate {PFN]

CH3 COONO$_2$: Peroxy acetyl nitrate [PAN]

C6H5-COONO$_2$: Peroxy benzoyl nitrate [PBzN]

      The above equations represent in a broad sense the nature of the overall photo chemical reactions leading to formation of smog and they are no means the only important Mechanisms.

COAL INDUCED SMOG : Another Form of smog is called industrial smog. This smog is created by burning coal and heavy oil that contains sulphur impurities in power plants, industrial plants, etc. The smog consists mostly of a mixture of SO_2 and Fog. Suspended droplets of H_2SO_4 were formed from some of the SO_2 and a variety of suspended particulate matter. This smog is common during the winter in cities such as London [Dee 1952], Chicago, Pitts burg, when the cities burned large amounts of coal and heavy oil without control over the emissions, large scale problems were witnessed. In 1952, London, 4000 people died as a result of this type of smog. Today heavy oil and coal are burned only in large boilers and with reasonably good control or tall Chimneys so that industrial smog is less of a problem. However come countries such as China, Poland Czechoslovakia and some other Eastern European countries still burn Large quantities of coal without using adequate controlling measures.

Unit 2 - EFFECTS OF VARIOUS POLLUTANTS ON HUMAN HEALTH, MATERIALS AND VEGETATION

INTRODUCTION :

All the impurities in the inhaled air do not necessary cause harm. Depending upon the chemical nature of the pollutants, some may be harmful when pleasant in the air in small concentrations and others only if they are present in high concentrations. The duration of exposure of the body to polluted air is also an important factor, therefore prime factors affecting human health are :

1) nature of pollutants
2) Concentration of the pollutants
3) Duration of exposure
4) State of Health of the receptor
5) Age group of the receptor

Susceptibility to the effects of air pollution is more incase of infants and also elder people and those who are suffering from diseases. Those with Chronic diseases of lungs or heart are thought to be at great risk. The effect of air pollution on human health is worst during the winter seasons, when pollution levels reach a maximum.

An objectionable odour, visibility reduction, eye intimation or vegetation damage are useful guides to the health effects.

VARIOUS HEALTH EFFECTS DUE TO AIR POLLUTION

1) Eye imitation
2) Throat and Nose imitation
3) Imitation of the respiratory tract
4) Bases like H2S, NH3 and mercaptans cause odour nuisance even at low concentrations.

5) Increase in mortality rate and morbidity rate.

6) A variety of particulates particularly pollens, initiates asthmatic attacks.

7) Chronic pulmonary diseases like bronchitis and asthama are aggregates by a high concentration of SO_2, NO_2, particulate matter and PCS.

8) CO combines with the haemoglobin in the blood and consequently increases stress on those suffering from CARDIOVASCULAR and PULBONARY DISEASES.

9) Hydrogen Fluoride causes disease of the bone [Fluorosis] and mattling of teeth.

10) Carcinogenic agents cause cancer.

11) Dust particles cause respiratory diseases. Diseases like Silicosis, asbestosis etc. result from specific clusts.

12) Certain heavy metals like lead may enter the body through the longs and cause poisoning.

MECHANISM OF ACTION OF POLLUTANTS

The effect of an pollution on human health generally occurs as a result of contact between the pollutants and the body. Normally, bodily contact occurs at the surfaces of skin and exposes membranes contact with exposed membranous surfaces is of utmost important because of their absorptive capacity, compared to that of dry skin. Air borne gases, vapours, mist and dust may cause imitation of the membranes of the eyes, nose throat, larynx, tacheo-brochial tree and lungs some imitates even reach the mucosa of the digestive tract.

CASE STUDY IN ALLERGIC ANGENTS IN BANGALORE CITY

The garden city of Bangalore known for its fine climate is also known as the city of Asthama for many people. The incidence of Branchial Asthma is particularly high in this city. Instances have been cited where people who have never exhibited tendencies earlier, have on coming to Bangalore has attacks of Asthma. Further those who have had only mild attacks elsewhere experienced severe once here, Also it has been recorded that the percentage of aasthmatics who reported relief when they left Bangalore is as high as 37.6%.

The survey undertaken by the aasthma research society revealed that housewives [37.01%] and office workers [40.31%] are more susceptible to aasthma attacks than industrial workers [7.11%] and retired persons [11.29%]. This suggests that as a casual factor for aasthma and that attention should be focused on pollens, spores and dust particles.

Some industrial operation may add to the allergens. Industrial operations like cotton, milling, for processing, hair processing, father processing, jute processing, leather processing, floor processing, wood working and tobacco processing may be included under this category.

EFFECTS ON VEGETATION

Air pollution has long been known to have an adverse effects on plants. At first is only sulphur dioxide that was considered a dangerous pollutant. Now with the advent of various pesticides and new industrial processes the range of harmful pollutants has multiplied tremendously.

STRUCTURE OF A NORMAL LEAF :
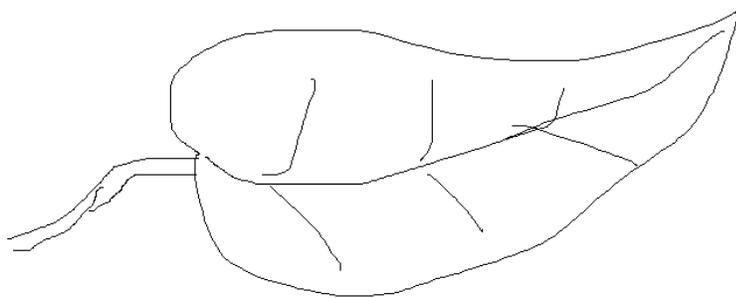
A knowledge of a structure of a Leaf will help us to understand why damage occurs to examined, one will normally see a network of cleanser structures, the veins, all inter connected to the base or stem of the leaf. The leaf veins act as the transport system, For water and food just like blood vessels in animals. The leaf tissue is in layers with a skin or epidermis on top and bottom and photosynthetic cells in between. The stomata are the entrances in the leaves [top or bottom] through which CO2 enters to play its role in photosynthesis. These openings are protected by pairs of specialized guard cells which open and close to all gases to enter or leave the leaf. Such gases also include pollutants like SO_2

EFFECT OF ENVIRONMENT ON PLANTS :

The primary factor which controls gas absorption by the leaves is the degree of the opening of the stomata. When the stomata are wide open absorption is maximum and vice versa. Consequently some conditions that enhance the absorption of the gas [CO_2 for photosynthesis] predispose the plant to injury [by absorption a pollutant like SO_2] conditions that cause the stomata to open are

1) High Light intensity [morning hours]
2) High relative humidity
3) Adequate moisture supply to the roots of the plants.
4) Moderate temperatures

LIST OF AIR POLLUTANTS AFFECTING PLANTS

i) SO_2

ii)   Fluoride compounds

iii) Ozone

iv)   Chlorine

v)   Hydrogen Chloride

vi)   Nitrogen oxides [NO, NO_2…….]

vii) Ammonia

viii) Hydrogen Sulphide

ix)   Hydrogen Cyanide

        x)   Mercury

        xi)   Ethylene

        xii)   PAN

        xiii)   Herbicides

        xiv)   Smog

FORMS OF DAMAGE TO LEAVES

      Damage to leaves takes several forms

1) NECROSIS   Necrosis is the killing or collapse of tissue.

2) CHLOROSIS   It is a loss or reduction of the green plant pigment
                                [chlorophyll]
                                The loss of chlorophyll usually results in a pale green
                                or yellow pattern. Chlorosis generally indicates
                                a deficiency of some nutrient required by the plant.
                                In many respects it is analogous to anaemia
                                in animals.

3) ABSCISSION   Leaf abscission is dropping of leaves.

4) EPINASTY   Leaf epinasty is the downward curvatured of a leaf
                                due to higher rate growth on the upper surface.

POLLUTANT	DOSE	EFECTS
Nitrogen dioxide	Mild	Suppressed growth, leaf bleaching
Ethylene	Mild	Epinasty, leaf absorption
PAN	Mild	Bronzing of lower leaf surface [upper surface normal], suppressed growth, and leaves more susceptible.

TIME CONCENTRATION EQUATIONS :

The effect of concentration versus time is an important variable in assessing damage. A high dose for a short time may cause an ACUTE INJURY [eg. Bhopal Gas tragedy] whereas the same total dose over a longer time may cause no visible effects at all longer time may cause no visible effects at all.

A concentration time equation may be expressed as

$t(C-C_o) = K$

Whereas

t = time in hours to produce a certain effect on a certain species.

C = concentration of a specific gas in ppm

C_o = Threshold concentration of the gas(ppm) to cause injury.

K = experimentally determined constant

The equation can be re-written as

$C = C_o + K/t$

Then, plotting 'C' versus 1/t, we get a straight line whose intercept 'Co' is the threshold for injury with the exception of some results for sulphurdioxide and ozone, sufficient data is not available at present to determine these parameters assuming that a linear model is accurate.

The equation is based on the exposure of a plant for a single pollutant. However in the field, exposures are not due to individual gases, but to a intimate of pollutants whose relative concentrations change as functions of time. Thus there are almost infinite number of possible combinations of pollutants which could be tested and severely injured by air pollutants often has characteristic colour. Bleaching is associated with SO_2, yellowing with ammonia, browning with Fluoride, A silvering (or) bronzing of the under surface of same leaves is associated with PAN injury PHYTO-TOXICANT is the name given to plant damaging substances.

KINDS OF INJURY TO PLANTS

1) **ACUTE INJURY :** It results from short time exposures to relatively high concentrations, such as might occur under fumigation conditions. The effects are noted within a few hours to few days and may result in visible markings on the leaves due to collapse and death of cells. This leads to narcotic patterns i.e. areas of dead tissues.

2) **CHRONIC INJURY :** It results from long term low level exposure and usually causes chlorosis (or) leaf abscission.

3) **GROWTH OR YIELD RETARDATION**: Hare the injury is in the form of an effect on growth without visible markings [invisible injuries]. Usually a suppression of growth or yield occurs.

EFFECTS OF AIR POLLUTANTS ON PLANTS

POLLUTANT	DOSE	EFFECTS
Sulphor dioxide	a) Mild	Intervenal chlorotic bleaching of leaves
	b) Severe	Netrosis in intervenal areas and skeletonized leaves
Ozne	a) Mild	Flecks on upper surfaces, premature aging and suppressed growth.
	b) Severe	Collapse of leaf, necrosis and bleaching
Fluorides	Cumulative effects	Necrosis at leaf tip.

EFFECTS ON MATERIALS

MECHANISM OF DETERIORATION

Air pollution cause damage to materials by 5 mechanisms

1. **ABRASION:** Solid particles of sufficient size and travelling at high velocities can cause abrasive action.

2. **DEPOSITION AND REMOVAL:** Solid and liquid particles deposited on a surface may not damage the material itself but it may spoil its appearance

3. **DIRECT CHEMICAL ATTACK:** Some air pollutants react directly and irreversibly with materials to cause deterioration.

    Eg: The bleaching of marble by SO_2, tarnishing of silver by H_2S, etching of metallic surface by an acid mist

4. **INDIRECT CHEMICAL ATTACK:** Certain materials absorb some pollutants and get damaged when the pollutants undergo chemical changes.

5. **CORROSION:** The atmospheric deterioration of famous metals is by an electrochemical process i.e. corrosion. This is due to the action of air pollutants facilitated by the presence of moisture

FACTORS INFLUENCING ATMOSPHERIC DETERIORATION:

1. **MOISTURE:** The presence of moisture in the atmosphere greatly helps the process of corrosion. In case of SO_2 and various particulars, the rate of corrosion of metals will increase as relative humidity in the air increases.

2. **TEMPERATURE:** Affects the rate of chemical reaction and consequently affects the rate of deterioration.

3. **SUNLIGHT:** In addition to producing damaging agents such as ozone, PAN through a series of complex photo chemical reactions, sunlight can cause direct deterioration of certain materials.

4. **AIR MOVEMENT:** Wind direction is an important factor to be considered in places where deterioration is caused by pollutants released from nearby factories. Similarly wind speed is also an important factor in determining the impact of air pollutants on the receiving surfaces.

AIR POLLUTION DAMAGE TO VARIOUS MATERIALS

MATERIALS	PRINCIPAL AIR POLLUTANTS	EFFECTS
1. Metal	SO_2 Acid Gases	Corrosion, loss of metal, spoilage of surface, tarnishing
2. Building Materials	SO_2, Acid gases particulates	Discoloration, leaching
3. Paint	SO_2, H_2S, Particulates	Discoloration
4. Textiles and Textile dyes	SO_2, Acid gases, NO_2, ozone	Deterioration reduced textile strength and fading
5. Rubber	Oxidants, ozone	Cracking, weakening
6. Leather	SO_2, acid gases	Disintegration, powdered surface
7. Paper	SO_2, acid gases	Embrittlement
8. Ceramics	Acid gases	Change in surface appearance

AIR POLLUTION EPISODES(in a chronological order along with mortality rates)

YEAR AND MONTH	LOCATION	DEATHS REPORTED
1873, Dec 9-11	London, England	250
1880, Jan 26-29	London, England	1000
1892, Dec 28-30	London, England	Not available
1920, Dec	Meuse Valley, Belgium	63
1948, Oct	Donora, Pennsylvania	20
1948, Nov 26 – Dec 21	London, England	800
1950 Nov	Mexico	22
1952, Dec 5-9	London, England	4000
1953, Nov	Newyork	250

1956, Jan 3-6	London, England	1000
1957, Dec 2-5	London, England	800
1958	Newyork	!
1959, Jan 26-31	Newyork	250
1962, Dec 5 – 10	London, England	700
1963, Jan 7-22	London, England	700
1963, Jan 9 – Feb 12	Newyork	400
1966, Nov 23-25	Newyork	170
1976, July	Sevesco, Italy	!
A984, Dec – 2	Bhopal, India	2500
1984, April	Chernobal, Ukraine (Reactor Explosion)	2500

BHOPAL GAS TRAGEDY:

Modern Technological developments have multiplied the hazards to which human beings are exposes, Nearly 5 Million chemicals have been synthesized in the world during the last 40 years and some 50,000 to 70,000 chemicals are used extensively in million of different commercial products without the availability of proper taxi logical information on the majority of the chemicals.

On the fateful night on 2-12-1984, and in the early hours of 3-12-1984 more than 1 million residents of Bhopal, Capital of M.P India reported irritation of eyes that quickly became unbearable, followed by the death dancing in their residences. A cloud of poisonous gas was released from the Union Carbide Factory. The plant was a pesticide manufacturing unit owned by Union Carbide India Ltd, a subsidiary of Union Carbide, a leading company based in the USA. The factory was licensed to produce Methyl, Isocyanite (MIC) i.e CH_3NCO, an extremely hazardous chemical which is used in the manufacture of several pesticides like SEVIN CARBARYL and TEMIR-106. MIC is also used by various organic industries as an intermediate. CO obtained by partial oxidation of coal is combined with chlorine gas in the presence of

activated carbon to form phosgene ($COCL_2$). Phosgene and Methylamine combine to form MIC. The product is stored in tanks for further use to produce carbonite insecticide.

$$COCL_2 + CH_3 NH_2 \ - CH_3 NCO + 2 HCL$$
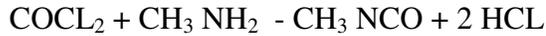
The carbide plant has three storage tanks for MIC, each capable of holding 45 tonnes. The Union Carbide manual on standard operating procedure warns that if water leaks into the system, it results in the evolution of a lot of gas and liberation of heat. This is precisely what had happened on the fateful day of 2nd December 1984.

EFFECT OF ART TREASURES IN INDIA – TAJ MAHAL A CASE STUDY

Taj Mahal a miracle in marble and a historical monument is facing great danger from pollution created by existing foundries, power houses, railway yards and Industrial units. Accordingly to some environmentalist, the problem now seems to have been aggravated, because of the commissioning of Mathura Oil Refinery, about 40 Km from the priceless monument. However it is to be hoped that certain antipollution safeguards built in the refineries will minimize the effect of pollutions on the monument.

According to some reports, pollutants from existing foundations, power houses and railway yards are already affecting Taj Mahal. Black and brown patches are disfiguring the shiny white surface of Taj Mahal and also there is formation of gypsum, scaling and flaking effects.

SO_2 from various sources mentioned mixes with the atmospheric moisture and gets converted into H_2SO_4 which settles down on the exterior surface of the Taj Mahal. The acid reacts with marble and corrosion and discoloration of monument is the ultimate result.

SULPHUR DIOXIDE	CHREON MONOXIDE	OXIDES OF NITROGEN	OXIDES OF NITROGEN
SO_2 is an instant gas which affects the mucosa membranes when inhaled. Under certain conditions some of the air borne SO_2 is oxidized to SO_3.. Each of these two gases in the presence of water vapour forms sulphurs and sulphuric acid respectively. SO_3 is a very strong irritant, much stronger than SO_2 causing severe Branchospasms at relatively low levels of concentration.	Co has a strong affinity for combining with Heamoglobin to form Carboxy Haemoglobin. This reduces the ability if the haemoglobin to carry oxygen to the body tissues. CO has about 200 times the affinity of O2 for attaching itself to the Haemoglobin, so that low levels of CO can still result in high levels of COHb. CO also affects the control nervous system. It is also responsible for Heart attacks and a high mortality rate.	Of the seven oxides of Nitrogen known to exist in the ambient air, only two are though to affect human health. These are Nitric oxides (NO) and Nitrogen dioxide(NO_2) which some questions remain about haemoglobin reactions with oxides of sulphur. There is no positive evidence, that no exposure is a health hazard associated with community air pollution. NO_2 is known to cause occupational disease. Among occupations with NO_2 hazards are the manufacture of Nitric acid, exposures of farmers to silage that has had high nitrate fertilization, electric are welding, and mining utilizing nitrogen compounds as explosives. It is estimated that eye and nasal imitation	will be observed after exposure to about 15ppm of NO_2 and pulmonary discomfort after brief exposures to 25ppm of NO_2

HYDROGEN SULPHIDE	OZONE	LEAD	HYDROCARBONS
H2S is a fool smelling gas. It is well known for its rotten egg like odour. Exposures to H2S for short periods can lesubt in fatigue of the sense of smell. Other sulphur compounds that are of interest in air pollution mainly because of their strong odours are Methyl mercdaptan [CH_3SH] and ethyl mercaptan [C_2H_5SH]. But it has been reported that a the concentrations at which they are odour nuisances, they have no other effect on human health. In fact, mercaptons are often added to natural (or) manufactured gas supplies, so that leakage of gas will be noticed.	Ozone is a gas that has an imitate action in the respiration tract, reaching much claspers into the lungs than the oxides of sulphur.	The main source of lead in Urban atmosphere is the automobile. It creates Urban concentration of in organic lead of about 1-3 $\mu g/m^3$, with high values in areas of heavy traffic. In organic lead acts as an agent which causes a variety of human health disorders. The effects include gastro-intestinal damage, liver and kidney damage, abnormalities in Fertility and pregnancy, and mental development of children gets affected.	Some of the hydro-carbon vapours in the atmosphere have health implications. The effect of formal dehyde is primarily irritating. It is a major contributor to eye and respiratory irritation caused by photo chemical smog.

CARCINOGENIC AGENTS	INSECTICIDES	RADIOACTIVE ISOTOPES	ALLERGIC AGENTS
Are responsible for cancer for eg.: the polycyclic organic compounds, 3,4-Benzo pyrene. The origin of these compounds is in the incomplete combustion of hydro carbons and other carbonaceous materials. They are also reported to be present in Exhaust discharges from I.C. engines. In addition, it has been found that some alphatic hydrocarbons are also carcinogenic.	Are not only harmful for insects but also poisonoius for man. Eg:DDT [lichloro diphenyl Trichloro ethane]. This van affect the central nervous systems and may attack other vital organs. Infact DDT has been found in mother's milk in western countries and even in our own countries . Hence the use of DDT has been banned in U.S.A. and in other European countries. According to study conducted at the industrial Toxicology research center[[ITRC] Lucknow, the accumulation of pesticides in the environment due to their growing use for agricultural purposes can also cause premature labour and due to high concentration of pesticides in the body of expectant	Important radio isotopes that may reach ambient air are Iodme 131, phosphorous 32, cobalt 60, strontium 90, Radium 226, Carbon 14, sulphar 95, ---- 45 and Uranium the serious health effects are anemia, leukemia and cancer, they also cause genetic defects and sterility as well as embryo defects and congenital information. It also shortens the life span of an individual.	It is Generally --- by medical personnel that the air we breathe is the natural carrier at many microscopic organ materials which may act as allergens our body reactions to such allergens occur mainly in the skin and the respiratory tract. Organic allergens have their origins in living things like plants (pollen grains) yeasts or moulds or in animal hair for or feathers.

Unit 3 - METEOROLOGY AND AIR POLLUTION
METEOROLOGICAL FACTORS INFLUENCING AIR POLLUTION

The degree to which all pollutants discharged from various sources concentrate in a particular area, depends largely on meteorological conditions. The application of dispersion theory and a knowledge of local weather conditions are necessary to determine the required stock height for an emission and the evaluate the intensity of Air Pollution.

Even though the total discharge of contaminants into the atmospheric in a given area remains constant from day to day, the degree of air pollution may vary widely because of differences in meteorological conditions. In a specified place the emission of pollutions may be the same but it is the weather that can trigger on air pollution episode.

Important meteorological parameters that influences air pollution can be classified into

1. Primary parameters and
2. Secondary parameters

1. **PRIMARY PARAMETERS** are
   a) Wind direction and speed
   b) Temperature
   c) Atmospheric stability
   d) Mixing height

2. **SECONDARY PARAMETERS** are
   a) Precipitation
   b) Humidity
   c) Solar radiation
   d) Visibility

WIND DIRECTION AND SPEED: The direction and speed of surface winds governs the drift and diffusion of air pollutants, discharged near the ground level. The higher the wind speed at or near the point of discharge of pollution, the more rapidly are the pollutants carried away from the source. The pollutants so dispersed will not exist at the same concentration but will rapidly be diluted with greater and greater values of air on the other hand when wind speeds are low, pollutants tend to be concentrated bear the area of discharge and the longer the periods of such light winds the greater will be the concentration of pollutants. Further, turbulence a very important characteristic of surface winds is directly proportional to its speed and determine the extent to which pollutants are mixed and diluted with the surrounding air. In rough terrain, it cannot be assumed that the wind direction and the speed near the source govern the subsequent motion of the contaminants. Hills may deflect the air flow either horizontally, vertically, or both, the amount of deflection depending on the vertical stability of the atmosphere. In valleys, the winds carrying a pollutant tend to flow either up or down the valley, following its meanderings. The deeper the valley the more pronounced is this channelizing effect.

ATMOSPHERIC STABILITY AND TEMPERATURE INVERSIONS
LAPSE RATE:

In well mixed air which is dry for every 100m MCI case in altitude, the temperature decreases by about 1o C. This vertical temperature gradient is known as dry adiabatic lapse rate (DALR). Ambient and adiabatic lapse rates are a measure of atmospheric stability. Since the stability of the air reflects the susceptibility of rising air parcel to vertical motion, consideration of atmospheric stability or instability is essential in establishing the dispersion rate of pollutants.

The atmospheric is said to be unstable as long as a rising parcel of air remains warmer than the surrounding air.

Conversely, when a rising parcel of air arrives at an altitude in a colder and denser state than the surrounding air, the resultant downward buoyancy force pushes the parcel of air downward (Earthward) and away from the direction of displacement. Under such conditions atmosphere is said to be stable.

Stability is a function of vertical distribution of atmospheric temperature and plotting the ambient lapse rate can give an indication of the stability of the atmosphere. Though dry, moist or wet adiabatic lapse rate may be used, in such a comparison, the DALR issued as the measure against which several possible ambient lapse rates are plotted. Thus the boundary line between the stability and instability is DALR

When ALR exceeds DALR, the ALR is said to be SUPER – ADIABTIC and the atmosphere is highly unstable. When the two lapse rate are exactly equal, the atmosphere is said to be neutral. When the ALR is less than the DALR, the ALR is termed SUB-ADIABATIC and the atmosphere is stable. If air temperature is constant throughout a layer of atmospheric, ALR =O, the atmospheric layer is described as isothermal and the atmosphere is stable.

When temperature of the ambient air increases rather than decrease with attitude, the lapse rate is negative or inverted from the normal state. Negative lapse rate occurs under conditions, commonly referred to as an INVERSION, a state in which warmer air blankets colder air.

INVERSIONS:

When the reverse or negative lapse rate occurs, a dense cold stratum of air at ground level gets covered by lighter warmer air at higher level, This phenomena is known as INVERSION. During inversion vertical air movement is stopped and pollution will be concentrated beneath the inversion layer i.e. in the denser air at ground level. As a result, during temperature inversion, the atmospheric is stable and very little turbulence or mixing takes place under such conditions pollutants in the air do not disperse.

Inversion is a frequent occurrence in the autumn and winter months and the accumulation of smoke and other contaminants further aggravates pollution by preventing the sunrays from warming the ground and adjacent air. Fog is commonly associated with inversions, narrow valleys are favourable to inversions. The horizontal air movement is restricted. At the time of inversions, visibility is greatly reduced and contaminants are at a maximum. Inversion occurs when dT/dz is +ve, when n < 1 i.e. when the temperature of atmosphere increase with elevation instead of decreasing.

TYPES OF INVERSIONS:

Different types of inversions are

1) Radiation inversion
2) Subsidence inversion
3) Double inversion (combination of above two)

And wind turbulences under certain circumstances it may be related to all three

MAXIMUM MIXING DEPTH (MMD)

Once an pollutants are reloaded into the atmosphere, their subsequent fate i.e dispersion is entirely dependent on the weather conditions. The Vertical extent to which the mixing takes place varies from season to season, and is also affected by topographical features. The rate of the vertical extent, the larger the volume of the atmosphere available to dilute the pollutant concentration, thermal buoyancy effects determine the depth, the corrective mixing layer which is called MAXM MIXING DEPTH (MMD). The MMD values available as an average for a period of one month are known as MEAN MAXM MIXING DEPTH (MMMD)

The values of the MMD are usually low at night and increase during the day light hours, under a severe inversion at night, the value may be essentially zero, while values up to 2000 and 5000m are common in the day time. On a seasonal basis the MMMD is at a minimum in the winter (December and January) and at a maximum during the summer (May and June). It has been noted that extensive urban air pollution episodes frequently occur, when the MMD value is less than 1500m. before locating an industry. It should be seen that MMD values are not less than 2000m

PRECIPITATION: Precipitation exerts a low fold cleansing action on the pollutants discharged into the atmospheric . It accelerates the deposition of particular matter on the ground and hence its removal from the atmosphere. It also helps to remove the concentration of gaseous pollutants which are soluble in water. The washout by precipitation of air borne radioactive wastes is a matter of particular concern. Precipitation can be determined by using various types of rain gauges.

HUMIDITY: The moisture content of the atmosphere influences the corrosive action of the air pollutants and indicates the potentially for fog formation in relation to the degree of air pollution of the various means by which humidity may be expressed, the relative humidity may be expressed, the relative humidity is most frequently used in air pollution studies.

RADIATION: Depending on the location solar radiation can have a pronounced effect on the type and rate of chemical reactions in the atmosphere. The PCS formation at Los Angeles is a typical example of the effect of solar radiation on Air Pollution.

WINDROSE DIAGRAM: is defined as any one of a class of diagrams designed to show the distribution of wind direction experienced at a given location over a considerable period. In other words the wind rose shows the prevailing direction of the wind

The most common form consists of a circle from which eight or sixteen lines Cinergy, one for each direction. The length of each line is proportional to the frequency calm conditions is centered in the centre. There are many variations in the construction of wind roses.

The wind rose diagram is prepared using an appropriate scale to represent percentage frequencies of wind directions and appropriate index shades, lines etc… to represent various wind speeds observation corresponding to wind speed below 1 lm/hr are recorded as CALM.
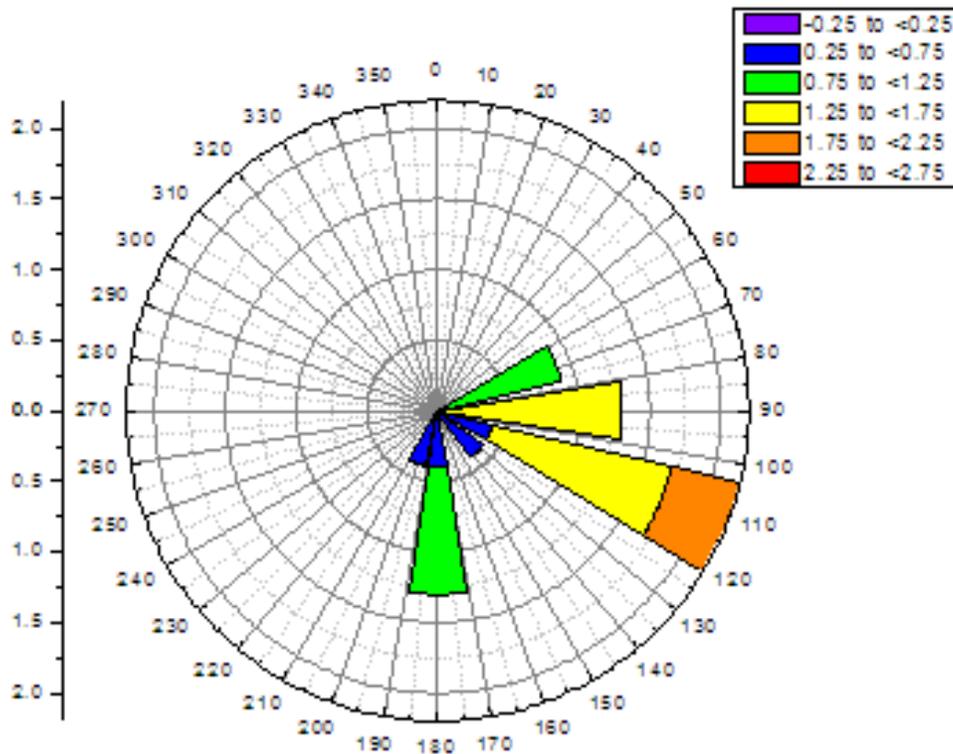
POLLUTION ROSES :

Special wind roses are sometimes constructed like,

1. Precipitation wind rose

2. Smoke wind rose

3. SO2 wind rose

4. Hydrocarbons wind rose

Instead of wind speed, the parameters of precipitation, smoke SO_2 hydrocarbons etc., are attached to the wind direction, these are known as POLLUTION ROSES.

PROBLEM

1. Draw wind rose diagram for following data

Wind Direction	Duration of Wind %			Total Wind Direction %
	6.4-25 Kmph	26-40-Kmph	40 – 60 Kmph	
N	7.4	2.7	0.2	10.3
NNE	5.7	2.1	0.3	8.1
NE	2.4	0.9	0.6	3.9
ENE	1.2	0.4	0.2	1.8
E	0.8	0.2	0.0	1.0
ESE	0.3	0.1	0.0	0.4
SE	4.3	2.8	0.0	7.1
SSE	5.5	3.2	0.0	8.7
S	9.7	4.6	0.0	14.3
SSW	6.3	3.2	0.5	10.0
SW	3.6	1.8	0.3	5.7
WSW	1.0	0.5	0.1	1.6
W	0.4	0.1	0.0	0.5
WNW	0.2	0.1	0.0	0.3
NW	5.3	1.9	0.0	7.2
NNW	4.0	1.3	0.3	5.6
			Total	**06.5%**

Average time during which the wind speed is less than 6.4 kmph = 100-86.5 = 13.5% i.e calm period = 13.5%

PLUME BEHAVIOUR:

Plume refers to the path and extent in the atmosphere of the gaseous effluents – released from a source usually a stack (chimney)

The behavior of a plume emitted from any stack depends on localized air stability. The Geometric forms of stack plumes are a function of the vertical temperature and wind profiles, vice versa, by looking at the plume one can state stability condition and dispersive capacity of atmosphere. The behavior and dispersion of a plume entirely depend on the environmental lapse rate (ELR).

Effluents from town stacks are often injected to an effective height of several 100m above ground because of the cumulative effects of buoyancy and velocity on plume rise other factors influencing the flume behavior are the diurnal (seasonal) variations in the atmospheric stability and the long term variations which occur with change in seasons
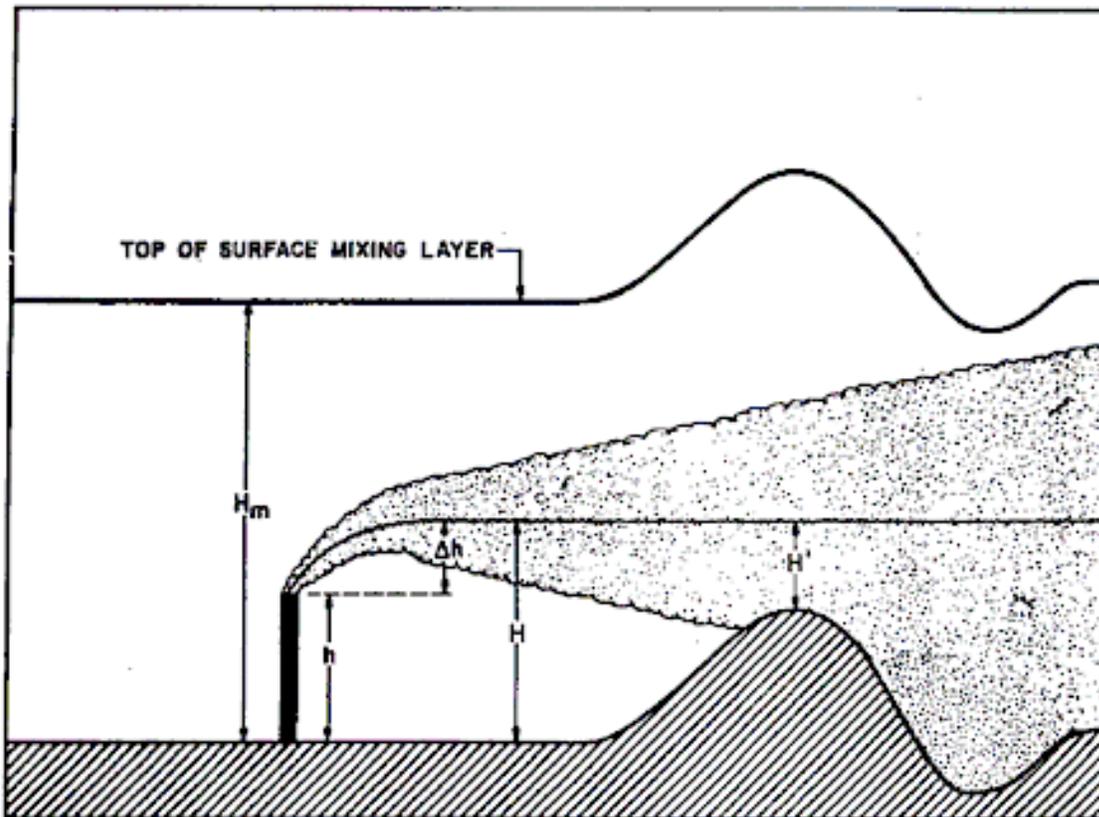
Six types of plume behavior are shown in the figure below, the spread of the plume is directly related to the vertical temperature gradient as shown in the figure.

    i)   Looping

    ii) Coning

    iii) Fanning

    iv) Lofting

    v) Fumigation

    vi) Trapping

LOOPING:

It is a type of plume which has a wavy character. It occurs in a highly unstable atmosphere because of rapid mixing. The high degree of turbulence helps in dispersing the plume rapidly but high concentrations may occur close to the stack if the plume touches the ground.

CONING:

It is a type of plume which is shaped like a CONE. This takes place in a near neutral atmosphere, when the wind velocity is greater than 32 km/hr. However the plume reaches the ground at greater distances than with loping.

FANNING:

It is a type of plume emitted under extreme inversion conditions. the plume under these condition will spread horizontally, but little if at all vertically. Therefore the prediction of ground level concentration (SLC) is difficult here.

LOFTING:

Lofting occurs when there is a strong lapse rate above a surface inversion. under this condition, diffusion is rapid upwards, but downward diffusion does not penetrate the inversion layer under these conditions, emission will not reach surface.

FUMIGATION:

It is a phenomenon in which pollutants that are emitted into the atmosphere are brought rapidly to the ground level when the air destabilizes.

TRAPPING:

This refers to conditions where the plume is caught between inversion and can only diffuse within a limited vertical height.

The lofting plume is most favorable air to minimizing air pollution. The fumigation and trapping plumes are very critical from the points of ground level pollutant concentrations.

AIR POLLUTION MODELS AND STACK EFFLUENT DISPERSION THEORIES

AIR POLLUTION MODEL: Models give answers to many questions conserving pollution and are an important tool for making decisions concerning air pollution. The fundamental of all pollution modeling is to calculate air concentrations of one (or) more pollutants in space and time as related to the independent variables such as emissions into the atmosphere, the meteorological variables and parameters which describe removal and transformation process. This is achieved by a system which quantitatively relates the concentrations of pollutions to other parameters by mathematical or physical methods such as procedure is called the MODEL.

The selection of appropriate model depends upon their use and purpose. An ideal model should be physically realistic and accurate suitable for various Meteorological and topographical conditions, suitable for various emission sources and suitable for various air pollution species. But unfortunately an ideal model does not exist. Also a universal model will not be easy to use efficiently, that is why each model is a comprises between accuracy and practicality, simplicity and sophistication.

VARIOUS TYPES OF MODELS:
Models are developed to address various atmospheric problems. The variety of existing models may be classified according to the different attributes of a model. The models are
   1) Eularian grid Model
   2) Lagrangian Trajectory Model
   3) Guassian Plume Model

GAUSSIAN PLUME MODEL:

There are several models available for predicting the concentrations downwind of a single source, but most of them are Numerical methods. However under a set of simplifying assumptions the analytical solutions can be obtained. The first formulation for the steady state concentration downwind from a continuous point source was presented by SUTTON and further developed by PASQUILL AND GIFFORD. This solution is commonly known as GAUSSIAN PLUME MODEL. The concentration distribution perpendicular to the plume axis is assumed to be Gaussian

Consider a continuous point source located at x-y=o and at a height Z-H. A description of the pollutant concentration (ga) could be facilitated by assuming hat all the pollutants are reflected an image source of equal strength at x=y=o and Z= -H. in this method, known as the method of images, the solutions of both the
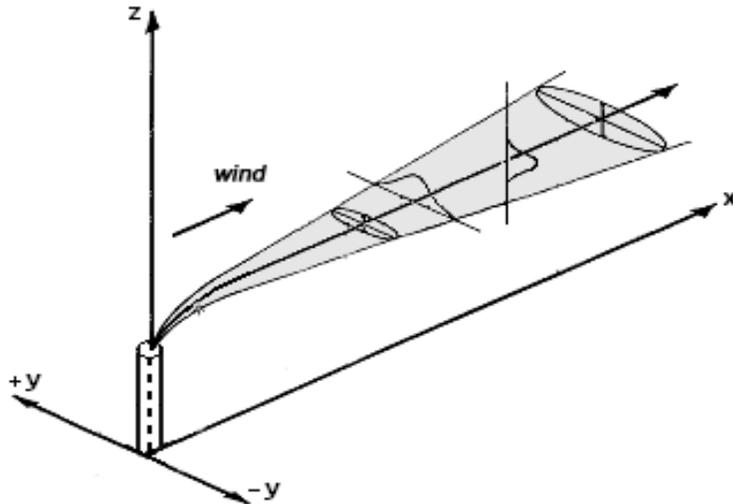
Real and image sources are added together. The resultant equation for pollutant concentration at a elected location (x,y,z) in the three dimensional filed downwind of the elevated point source is given by

$$C(x, y, z) = \frac{Q}{2\pi u \sigma_y \sigma_z} \times$$

$$\left[\exp - \left(\frac{y^2}{2\sigma_y^2} \right) \right] \left\{ \exp \left(\frac{-(z-H)^2}{2\sigma_z^2} \right) + \exp \left(\frac{-(z+H)^2}{2\sigma_z^2} \right) \right\}$$

C = Concentration of the chemical in air. $[M/L^3]$
Q = Rate of chemical emission. $[M/T]$
u = Wind speed in x direction. $[L/T]$
σ_y = Standard deviation in y direction. [L]
σ_z = Standard deviation in z direction. [L]
y = Distance along a horizontal axis perpendicular to the wind. [L]
z = Distance along a vertical axis. [L]
H = Effective stack height. [L]

Three common forms obtained from the basic equation are frequently used to analyze specific situations

EQUATION: Consists of three terms representing

1) The center line concentration as a function of downwind distance

2) The lateral spread relative to the centre line value

3) The vertical spread relative to the centre line value

A. GROUND LEVEL CONCENTRATION: (GLC)

In this case Z = O and cgn.1 reduces to

In the above equation, the factor 'Z' does not appear in the denominator, it gets cancelled when the two vertical exponential terms are combined

B. GROUND LEVEL CENTER-LINE CONCENTRATION (GLCC)

In this case Z=0 and Y = 0

Equation 3 is used to estimate the ground level concentrations expected at any distance downwind of an elevated source.

In case the emission source is also at the G.L. i.e H=0, eqn 3 Further simplifies to,

Equation (4) represents the maximum GLC – expected   at any distance downwind from an emission source which is at the S.L

INFINITE LINE SOURCE:

An infinite line source can often be represented by a series of industries located along a river or by a road along which pollution are continuously emitted by heavy traffic. It is thus spatially extended and the direction of the wind with respect to the geometry of the source will influence the downward concentration of the pollutants. When the wind direction is normal to the line of emission, the ELC downwind (x) of a source emitting at a height 'H' is given by

Where,

'Q1' = source strength/unit distance

If the source is also at the G.L then eqn-6 can be further simplified

i) The plume has a Gaussian distribution in both horizontal and vertical places, with 'Jy' and 'J2' as the standard deviation of the concentrations of the plume in horizontal cross wind and vertical directions irrespectively

ii) The mean speed affecting the plume is 'u' which is the wind speed at the source level i.e. at the point where dispersion starts.

iii) Uniform and continuous emission of 'Q' of pollutant takes place.

iv) Diffusion of pollutant in 'x' direction is negligible compared to diffusion in cross wind direction. This B +ve if emission is continuous and if wind speed is more than 1m/sec

v) Parameters governing the diffusion of the pollutant do not change in space and time is steady state conditions prevail.

vi) The terrain underlying the plume is flat

LIMITATIONS OF THE MODEL:

i) It does not consider the existence of various stability layers at different heights in the atmosphere.

ii) It does not consider the change in stability characteristics with time.

iii) It does not consider the terrain characteristics such as terrain roughness, existence of mountains and valleys, distribution of land and water masses, etc

iv) It does not consider the existence of free concentration regions and strong wind shears like change of wind directions and change of wind speed with height

v) It can be applied only for shorter distances (up to 10 km) and of shorter travel time (order of 2 hrs). The model is most accurate for downwind distances between approximately 100 and 2000m

DISPERSION COEFFICIENTS AND ITS ESTIMATION:

Dispersion coefficients 'Jy' and 'Jz' are defined as parameters which describe the growth of the dimension of a Gaussian plume as a function of travel distance or travel time and atmosphere stability. They also depend on the source height and the surface roughness. For estimating the concentration downwind resulting from a continuous plume, the values of dispersion coefficients Jy, Jz, and wind speed are necessary besides the physical data such as co-ordinates x,y,z emission rate 'Q', effective height 'H' etc.. In foot dispersion coefficients are standard deviations of plume concentration distribution in the crosswind 'Jy' and vertical 'Jz' directions, 'Jy' and 'Jz' are a function of downwind position 'x' as well as the atmospheric stability conditions

Based on experimental observations of the dispersion of real plumes, Pasquill and Gifford have devised a method for calculating 'Jy' and 'Jz' of a spreading plums from a knowledge of the atmospheric stability. Six categories of atmospheric stability 'A' through 'F' were suggested and

these are functions of wind and solar radiations, when the stability category is known from appropriate weather conditions. 'Jy' and 'Jz' values for any downwind distance 'x' can be calculated from the equations.

$$Jy = A_x \ 0.903$$

$$Jz = B_x \ p$$

Where the values of A,B and P are as given in the table

EFFECTIVE STACK HEIGHT:

Generally efficient plumes from chimneys are released into the atmospheric at elevated temperatures. The rise of plume after released into the atmosphere is caused by the buoyancy and the vertical momentum of the effluent under windless conditions, the plume rises vertically but more often it is bent as a result of the wind that is usually present. This rise of the plume odds to the stack. An additional height '-H' such that the height 'H' is obtained by adding the term –H (plume rise) to the actual (physical) (HS) height of the stack. The plume and height (H) = HS + -H is known as the eff stack height and it is this height that is used in Gaussian plume calculations. This additional height(-H)d doc to plume rise is very significant including downwind GLC

MINIMUM STACK HEIGHT:

If the physical height of the stack is more, the eff stack height also will be more and a better dispersion is possible. Smaller stacks lead to higher GLC the maximum concentration is usually inversely proportional to the square of the eff stack height

According to the BIS (central board for prevention and control of water pollution, New Delhi). A minimum stack height of 30m is to be provided. The minimum stack height, H min be arrived at, by using the following formulas

i)   Hmm = 30 m

ii) Hmm = 742 0.27

     Where

     Q = Particulate emission rate in tones/Hr

iii) Hmm = 14 Q 0.3

Where

Q = SO$_2$ emission rate in Kg/hr

The physical height of the stack to be provided is the maximum of the three 'Hmm' values obtained

PLUME RISE AND ESTIMATION OF PLUME RISE

Because of the inertial force and the buoyancy, the plume released from a stack rises to a certain height and then gets disposed by the wind. This height is called plume rise (-H). It is a function of exit gas velocity, temperatures of ambient air and stack gas, emission rate wind speed, atmospheric stability and shear of the wind speed. Plume rise typically increased the effective stack height by a factor of 2-10 times and can reduce the maximum GLC of pollutants by a factor of as much as 100

ESTIMATION

BUOYANT PLUMES: In the case of buoyant plumes, the influence of buoyancy is much greater than the influence of vertical momentum such plumes are usually obtained when the release temperatures are more than 500 C greater than ambient atmosphere temperatures.

NON-BUOYANT PLUMES:

For sources at temperature close to the ambient are less than 50oC above ambient having exit speeds of at least 10m/Sec. The following equation was proposed by ASME committee.

PROBLEMS:

1) Determine the effective height of stack from the following data

i) Physical height of stack = 180 m

ii) Inside dia of stack = 0.95 m

iii) Wind velocity = 2.75 m/sec

iv) Air temperature = 20 ^{o}C

v) Borometric pressure = 1000 mb

vi) Stack gas velocity = 11.12 m/sec

vii) Stack gas temperature = 160°C

SOLUTION:

Calculation of Plume rise:

Applying TURNER'S EQUATION

$\quad$ Vs $\quad$ = 11.12 m/sec

$\quad$ Ds $\quad$ = 0.95m

$\quad$ Pa $\quad$ = 1000mb

$\quad$ u $\quad$ = 2.75m/sec

$\quad$ Ts $\quad$ = 160°C + 273 = 433 K

$\quad$ Ta $\quad$ = 20°C + 273 = 293K

$\quad$ ΔH = 8.924 m

2) Find the eff stack height of 40m stack releases SPM at a rate of 1.25gm/sec. The atmospheric pressure is 10.8m of water

Note: 1kg/sm2 = 1 bar

The temperature of ambient air and gas are 27oC and 400oC respectively. The stack diameter is 2.3m stack gas velocity is 6m/sec and wind velocity is 1.8m/sec. Also find the GLC at 1km, 5km, 10km distances in the direction of wind

$\quad$ [Given 'σz' = 95 for 5 km, 30 for 1 km and 150 for 10 km]

$\quad$ ['σy' = 4 for 1 km, 300 for 5 km and 510 for 10 km]

SOLUTION:

$\quad$ i) $\quad$ Calculation of effective stack height

$\qquad$ Turners Equation

$\quad$ Vs $\quad$ = 6 m/sec

$\quad$ Ds $\quad$ = 2.3m

$\quad$ Pa $\quad$ = 1080mb

$\quad$ u $\quad$ = 1.8m/sec

Ts $= 400^{o}C + 273 = 673$ K

Ta $= 27^{o}C + 273 = 300K$

ΔH   = 39.787m

Effective stack height (H) = 39.787 + 40 = 79.787m

3)A thermal power plant burns 5.45 tonners with 4.2% sulphur per hour and discharges through a stack of effective height 75m. The average wind speed at the top of the stack is 6m/sec. The atmospheric is slightly to moderately stable find

   a. maximum GLC if Jz = 53 m and Jy= 88m

   b. GLC at SKM downwind and 0.4 km cross wind distance, if Jz = 170m
      and Jy = 280m

Solution:

5.45   tonnes/hr = 5.45×10^{3} kg/hr

sulphur emission is equal to = 229 kg/hr

emission rate = 127.22 g/sec

4) A factory uses 2 Lakh liters of furnace oil per month. If for 1 million liters of oil used per year , the particulate matter emitted is 3 tonnes/year, SO2 emitted is 59.7% tones/yr, NOx emitted is 7.5 tonnes/yr, hydrocarbons emitted are 0.37 tonnes/yr and CO emitted is 0.52 tonner/yr calculate the height of the chimney required to be provided for safe dispersion of the

6) A thermal power plant burns 100 tonnes of coal with 5.5% silphur content. Calculate minimum stack height required. Particulate concentration in plume gases is 8000mg/m^{3} and the gas flow rate is 20m^{3}/sec

Unit 4 - INDUSTRIAL PLANT LOCATION AND CITY PLANNING

INTRODUCTION :

       To date, the factors considered for locating a new industrial; plant were the availability of raw materials, power water supply transportation facilities, labour and the market. Now one more critical factor has to be considered by the plant management i.e the factor of air pollution control in the past by many large industries has proved to be a costly error. For today they are facing heavy damage claims, litigation and the necessity of taking control measures after several years of operation.

FACTORS TO BE CONSIDERED FOR INDUSTRIAL PLANT LOCATION FROM THE POINT OF AIR POLLUTION CONTROL

While selecting a site from the point of air pollution and control, the following factors should be taken into consideration to avoid costly control measures, improve public relations and prevent litigation, there are 6 factors to be considered.

      i)   Existing levels of air contaminants

      ii)   Potential effects on the surrounding area.

      iii)   Meteorological factors and climate

      iv)   Topographical features

      v)   Clean air available

      vi)   Planning and zoning

EXISTING LEVELS OF AIR CONTAMINANTS

If the new plant is to be located in an area which is already individualized, it is a good practice to undertake a pre operational survey to know the existing levels of contaminates under prevailing mineralogical conditions. This type of survey gives an idea regarding the nature of pollution due to existing industries i.e whether the existing level of pollution is high, medium or low. The results of such a survey with respect to known operational data on the magnitude of emissions

from the new sources would provide information on the extent to which waste products could be safely discharges into the atmosphere without resulting in too much contamination.

POTENTIAL EFFECTS ON THE SURROUNDING

Another important factor from the point of site selection is to have a knowledge of the specific effects of the major pollutants likely to be discharges into the atmosphere in relation to the population and   land use of the area surrounding the site. Eg. Whether the pollutants will have any effect on the health of people, whether it causes damage to vegetation, whether it effects the farm animals in that area is to be considered. A rural and predominantly agricultural area is more affected by fluorides and SO2 than in urban population. This is because certain pollutants are more toxic and harmful to vegetation and animals than to people. H2S has little effect on vegetation but is obnoxious and even dangerous to human life in comparatively low concentration.

METEOROGICAL FACTORS AND CLIMATE

The prime factors which have to be considered in order to minimize air pollution problems are the climate and meteorology of the location   under consideration. It is important to know the prevailing wind direction, wind speed and factors favourble for stable atmosphere is inversion conditions. The dispersive ability of the air at each possible site has o be determined. This can be done on the basis of the average values for wind movement and inversion conditions. Wind roses for each possible site have to be constructed and studied. Metrological factors should be favourable for the air to dilute the pollutional load down to acceptable levels of contamination.

TOPOGRAPHICAL FEATURES:

Air movement is greatly influenced by the topography in the neighborhood of the site under consideration, like valleys, mountains, sea, oceans. In fact more attention has to be given for air pollution control in valleys than in level terrain. Especially when the average wind velocity is less than 16km/hr.

The location of industries in valleys, mountainous areas and undulating terrain present difficult problem from the point of air pollution control. Air pollution disasters in Meuse valley (Belgium) and at Donora, Pennsylvania are good examples. If an industrial plant is located at the bottom of a narrow valley with mountains rising fairly steeply on either side the situation become very critical probably one of the worst site conditions one can think off.

CLEAN AIR AVAILABLE

The requirement if many industrial processes for supplies of clean air produces another important aspect of air pollution into the problem of site selection. Eg Industries requiring clean air for manufacture are factories dealing with manufacture of D.C boards, anti Biotic electronic components and life saving vaccines, also clean air is required for cooling the reactors of atomic energy plants since if polluted air were used, the impurities present would become radioactive above and their escape would create a hazard in those cases, location of industries in areas of heavy air pollution will add maternally to the cost of cleansing the air.

PLANNING AND ZONING

Proper planning and zoning of industrial areas and residential areas can play an important role in the control of Air pollution. Residential areas and heavy industries should not be located too close to each other it is always better to have green belt between industrial areas and residential areas the encourage the creation of green belt. If there are any municipal authorities should are any municipal and regulations regarding this aspect they should be strictly enforced.

Recently scientists have identified a dozen species of trees which have a capacity to observe industrial pollutants from the air many of these trees grow in our county for eg it has been reported that tamarind and margosa trees are atmosphere polluted by cement forties chemical industries and quarries therefore growing industries trees is an important way of solving the problem of air pollution.

CITY PLANNING

Today Many critics developing in a vary haphazard manner. They are now paying the price for the failure for plan for future systematic and homogenous development, smoke, dust, fumes, odors and poor zoning practices have spoilt fire residential areas and created ugly sights in central parts of cities. In many cases good residential areas have degenerated into slums.

One of the basic principle of country planning is it must be flexible continuous and adopted for local requirements. While planning the growth trend in population and industries that may come up in near further should be taken into consideration residential commercial and industrial areas most be property planned. Prime importance most be given for locating sufficient number of public parks and gardens. for their act as
Long Spaces:- Also thick most be sufficient provision for traffic lanes and parking facilities.

For the proper growth and development of a city a zoning lake is required L.C. Residential, the city must be clearly defined by the competent authority and of course the regulations must be strictly implemental.

Every city or town requires its own zoning ordinate according to the local conditions AS Land Usage changed zoning regulations, satellite towns bordering a city must also be subjected to zoning to provide for orderly growth.

In fact in some western countries the effects of Air pollution on future Zoning are being taken into consideration by city planning. For effective control larger air pollution zoning districts or even interstate contracts or international agreement may be required dependents on metrological conditions for Eg to prevent or reduce the effects of acid rain this may be necessary.

Following are some of the measures that can be taken for APC by planning and zoning.

1. Decentralization of industry.
2. Creation of green belt b/n industry and Receptor areas.
3. Regulations over automobile exhaust
4. Traffic control.
5. Creation of smokeless zones in selected areas by Limiting industries.
6. Prohibiting Use of volatile Fuels.

NOISE POLLUTION, SOURCES, EFFECTS AND CONTROL MEASURES

Definition: -

The word noise is derived from the Latin term nausea. It has been defined as unwanted sound, a potential hazard to health and communication dumped into the environment with regard to the adverse effect it may have on unwilling ears.

Noise is defined as unwanted sound. Sound, which pleases the listeners, is music and that which causes pain and annoyance is noise. At times, what is music for some can be noise for others.

Section 2 (a) of the Air (Prevention and Control of Pollution) Act, 1981 includes noise in the definition of 'air pollutant'.

Section 2(a) air pollution means any solid, liquid or gaseous substance including noise present in the atmosphere such concentration as may be or tent to injurious to human beings or other living creatures or plants or property or environment.

Noise can be described as sound without agreeable musical quality or as an unwanted or undesired sound. Thus noise can be taken as a group of laud, non harmonious sounds or vibrations that are unpleasant and irritating to ear.

Measurement:-

A decibel is the standard for the measurement of noise. The zero on a decibel scale is at the threshold of hearing, the lowest sound pressure that can be heard, on the scale acc. To smith, 20 db is whisper, 40 db the noise in a quiet office. 60 db is normal conversation, 80 db is the level at which sound becomes physically painful.

The Noise quantum of some of the cities in our country indicate their pitch in decibel in the nosiest areas of corresponding cities, e.g. Delhi- 80 db, Kolkata - 87,Bombay-85, Chennai-89 db etc.

Sources of Noise Pollution

Noise pollution like other pollutants is also a by- product of industrialization, urbanizations and modern civilization.

Broadly speaking, the noise pollution has two sources, i.e. industrial and non- industrial. The industrial source includes the noise from various industries and big machines working at a very high speed and high noise intensity. Non- industrial source of noise includes the noise created by transport/vehicular traffic and the neighborhood noise generated by various noise pollution can also be divided in the categories, namely, natural and manmade. Most leading noise sources will fall into the following categories: roads traffic, aircraft, railroads, construction, industry, noise in buildings, and consumer products

1. Road Traffic Noise:-

In the city, the main sources of traffic noise are the motors and exhaust system of autos, smaller trucks, buses, and motorcycles. This type of noise can be augmented by narrow streets and tall buildings, which produce a canyon in which traffic noise reverberates.

2. Air Craft Noise: -

Now-a-days , the problem of low flying military aircraft has added a new dimension to community annoyance, as the nation seeks to improve its nap-of the- earth aircraft operations over national parks, wilderness areas , and other areas previously unaffected by aircraft noise has claimed national attention over recent years.

3. Noise from railroads: -

The noise from locomotive engines, horns and whistles, and switching and shunting operation in rail yards can impact neighboring communities and railroad workers. For example, rail car retarders can produce a high frequency, high level screech that can reach peak levels of 120 dB at a distance of 100 feet, which translates to levels as high as 138, or 140 dB at the railroad worker's ear.

4. Construction Noise:-

The noise from the construction of highways , city streets , and buildings is a major contributor to the urban scene . Construction noise sources include pneumatic hammers, air compressors, bulldozers, loaders, dump trucks (and their back-up signals), and pavement breakers.

5. Noise in Industry: -

Although industrial noise is one of the less prevalent community noise problems, neighbors of noisy manufacturing plants can be disturbed by sources such as fans, motors, and compressors mounted on the outside of buildings Interior noise can also be transmitted to the community through open windows and doors, and even through building walls. These interior noise sources have significant impacts on industrial workers, among whom noise- induced hearing loss is unfortunately common.

6. Noise in building: -

Apartment dwellers are often annoyed by noise in their homes, especially when the building is not well designed and constructed. In this case, internal building noise from plumbing, boilers, generators, air conditioners, and fans, can be audible and annoying. Improperly insulated walls and ceilings can reveal the sound of-amplified music, voices, footfalls and noisy activities from neighboring units. External noise from emergency vehicles, traffic, refuse collection, and other city noises can be a problem for urban residents, especially when windows are open or insufficiently glazed.

7. Noise from Consumer products:-

Certain household equipment, such as vacuum cleaners and some kitchen appliances have been and continue to be noisemakers, although their contribution to the daily noise dose is usually not very large.

Harmful Effects:

On Human Being, Animal and Property: Noise has always been with the human civilization but it was never so obvious, so intense, so varied & so pervasive as it is seen in the last of this century. Noise pollution makes men more irritable. The effect of noise pollution is multifaceted & inter related. The effects of Noise Pollution on Human Being, Animal and property are as follows:

I. It decreases the efficiency of a man:- Regarding the impact of noise on human efficiency there are number of experiments which print out the fact that human efficiency increases with noise reduction. A study suggested that reducing industrial booths could improve the quality of their work. Thus human efficiency is related with noise.

II. Lack of concentration:- For better quality of work there should be concentration , Noise causes lack of concentration. In big cities , mostly all the offices are on main road. The noise of traffic or the loud speakers of different types of horns divert the attention of the people working in offices.

III. Fatigue:- Because of Noise Pollution, people cannot concentrate on their work. Thus they have to give their more time for completing the work and they feel tiring

IV. Abortion is caused: - There should be cool and calm atmosphere during the pregnancy. Unpleasant sounds make a lady of irriative nature. Sudden Noise causes abortion in females.

V. It causes Blood Pressure: - Noise Pollution causes certain diseases in human. It attacks on the person's peace of mind. The noises are recognized as major contributing factors in accelerating the already existing tensions of modern living. These tensions result in certain disease like blood pressure or mental illness etc.

VI. Temporary or permanent Deafness:- The effect of noise on audition is well recognized. Mechanics, locomotive drivers, telephone operators etc. All have their hearing Impairment as a result of noise at the place of work. Physicist, physicians & psychologists are of the view that continued exposure to noise level above. 80 to 100 db is unsafe, loud noise causes temporary or permanent deafness.

VII. EFFECT ON VEGETATION Poor quality of Crops:- Now is well known to all that plants are similar to human being. They are also as sensitive as man. There should be cool & peaceful

environment for their better growth. Noise pollution causes poor quality of crops in a pleasant atmosphere.

VIII. EFFECT ON ANIMAL:- Noise pollution damage the nervous system of animal. Animal looses the control of its mind. They become dangerous.

IX. EFFECT ON PROPERTY:- Loud noise is very dangerous to buildings, bridges and monuments. It creates waves which struck the walls and put the building in danger condition. It weakens the edifice of buildings.

 Legal Control:-

(a) Constitution of India

Right to Life:- Article 21 of the Constitution guarantees life and personal liberty to all persons. It is well settled by repeated pronouncements of the Supreme Court that right to life enshrined in Article 21 is not of mere survival or existence. It guarantees a right of persons to life with human dignity. Anyone who wishes to live in peace, comfort and quiet within his house has a right to prevent the noise as pollutant reaching him.

Right to Information:- Everyone has the right to information know about the norms and conditions on which Govt. permit the industry which effect the environment.

Right to Religion and Noise:- Right to religion does not include right to perform religious activities on loud speaker and electronic goods which produce high velocity of noise.

Directive Principal of State Policy:- The state has the object to make the enviorment pollution free.

Fundamental Duties:- every citizen of the country has the fundamental duty to clean the environment.

 (b) Factories Act Reduction of Noise and Oil of Machinery:- The Factories Act does not contain any specific provision for noise control. However, under the Third Schedule Sections 89 and 90 of the Act, noise induced hearing loss, is mentioned as notifiable disease. Similarly, under the Modal Rules, limits for noise exposure for work zone area have been prescribed.

(c) Motor Vehicle Act. Provision Relation to use of horn and change of Engine:- In Motor vehicle Act rules regarding use horns and any modification in engine are made.

(d) Noise Pollution Control Rule 2000 under Environment Protection Act 1996 :-

Further for better regulation for noise pollution There are The Noise Pollution (Regulation and Control) Rules, 2000 – in order to curb the growing problem of noise pollution the government of India has enacted the noise pollution rules 2000 that includes the following main provisions:-

The state government may categories the areas in the industrial or commercial or residential

The ambient air quality standards in respect of noise for different areas have been specified.

State government shall take measure for abatement of noise including noise emanating from vehicular movement and ensure that the existing noise levels do not exceed the ambient air quality standards specified under these rules.

An area not less than 100 m around hospitals educations institutions and court may be declare as silence are for the purpose of these rules.

A loud speaker or a public address system shall not be used except after obtaining written permission from the authority and the same shall not be used at night. Between 10 pm to 6 am

A person found violating the provisions as to the maximum noise permissible in any particular area shall be liable to be punished for it as per the provision of these rules and any other law in force.

Schedule

(see rule 3(l) and 4(l)

Ambient Air Quality Standards in respect of Noise

Area Code Category of Area/Zone Limits in dB

Day Time - Night Time

(A) Industrial area 75 - 70

(B) Commercial area 65 - 55

(C) Residential area 55 - 45

(D) Silence Zone 50 – 40

Control of Noise Pollution

Noise generation is associated with most of our daily activities. A healthy human ear responds to a very wide range of SPL from - the threshold of hearing at zero dB, uncomfortable at 100-120 dB and painful at 130-140 dB. Due to the various adverse impacts of noise on humans and environment (See LO-5), noise should be controlled. The technique or the combination of techniques to be employed for noise control depend upon the extent of the noise reduction required, nature of the equipment used and the economy aspects of the available techniques. Reduction in the noise exposure time or isolation of species from the sources form part of the noise control techniques besides providing personal ear protection, engineered control for noise reduction at source and/or diversion in the trajectory of sound waves.

The techniques employed for noise control can be broadly classified as

· **Control at source**

· **Control in the transmission path**

· **Using protective equipment.**

Noise Control at Source

The noise pollution can be controlled at the source of generation itself by employing

techniques like-

· **Reducing the noise levels from domestic sectors:** The domestic noise coming from radio, tape recorders, television sets, mixers, washing machines, cooking operations can be minimised by their selective and judicious operation. By usage of carpets or any absorbing material, the noise generated from felling of items in house can be minimised.

· **Maintenance of automobiles:** Regular servicing and tuning of vehicles will reduce the noise levels. Fixing of silencers to automobiles, two wheelers etc., will reduce the noise levels.

· **Control over vibrations:** The vibrations of materials may be controlled using proper foundations, rubber padding etc. to reduce the noise levels caused by vibrations.

· **Low voice speaking:** Speaking at low voices enough for communication reduces the excess noise levels.

· **Prohibition on usage of loud speakers:** By not permitting the usage of loudspeakers in the habitant zones except for important meetings / functions. Now-a-days, the urban Administration of the metro cities in India, is becoming stringent on usage of loudspeakers.

· **Selection of machinery:** Optimum selection of machinery tools or equipment reduces excess noise levels. For example selection of chairs, or selection of certain machinery/equipment which generate less noise (Sound) due to its superior technology etc. is also an important factor in noise minimization strategy.

· **Maintenance of machines:** Proper lubrication and maintenance of machines, vehicles etc. will reduce noise levels. For example, it is a common experience that, many parts of a vehicle will become loose while on a rugged path of journey. If these loose parts are not properly fitted, they will generate noise and cause annoyance to the river/passenger. Similarly is the case of machines. Proper handling and regular maintenance is essential not only for noise control but also to improve the life of machine.

Control in the transmission path

The change in the transmission path will increase the length of travel for the wave and get absorbed/refracted/radiated in the surrounding environment.

Installation of barriers: Installation of barriers between noise source and receiver can attenuate the noise levels.

Design of building: The design of the building incorporating the use of suitable noise absorbing material for wall/door/window/ceiling will reduce the noise levels. Installation of panels or enclosures: A sound source may be enclosed within a paneled structure such as room as a means of reducing the noise levels at the receiver. The actual difference between the sound pressure levels inside and outside an enclosure depends not only on the transmission loss of the enclosure

panels but also on the acoustic absorption within the enclosure and the details of the panel penetrations which may include windows or doors.

Green belt development: Green belt development can attenuate the sound levels. The degree of attenuation varies with species of greenbelt. The statutory regulations direct the industry to develop greenbelt four times the built-up area for attenuation of various atmospheric pollutants, including noise.

Using protection equipment

Protective equipment usage is the ultimate step in noise control technology, i.e. after noise reduction at source and/or after the diversion or engineered control of transmission path of noise.

The first step in the technique of using protective equipment is to gauge the intensity of the problem, identification of the sufferer and his exposure to the noise levels.

The usage of protective equipment and the worker's exposure to the high noise levels can be minimized by -

· **Job rotation:** By rotating the job between the workers working at a particular noise source or isolating a person, the adverse impacts can be reduced.

· **Exposure reduction:** Regulations prescribe that, noise level of 90 dB for more than 8 hr continuous exposure is prohibited. Persons who are working under such conditions will be exposed to occupational health hazards. The schedule of the workers should be planned in such a way that, they should not be over exposed to the high noise levels.

· **Hearing protection:** Equipment like earmuffs, ear plugs etc. are the commonly used devices for hearing protection. Attenuation provided by ear-muffs vary widely in respect to their size, shape, seal material etc. Literature survey shows that, an average noise attenuation up to 32 dB can be achieved using earmuffs

PART - B

Unit 5 - SAMPLING ANALYSIS AND CONTROL

INTRODUCTION

Sampling and measurement of Air pollutants, generality known as air quality monitoring, is an integral component of any air pollution control programme through monitoring, the current trends in air quality can be evaluated by comparing the data with the regulated standards. The information so obtained is helpful in implementing control measures for reducing pollutant concentrations to acceptable levels and in assessing the effect of air pollution control strategies.

Short-term sampling is preferred than long term sampling to establish the existence of high levels of air pollutants.

There are two different situations in which the air quality measurement is undertaken one of these is the Ambient Air Quality Measurement where the pollutant levels in the Ambient atmosphere are measured.

The second type of measurement generally deals with the pollutants emitted from a Source such as smoke tack and is known as stack sampling it provides information on the nature and quantities of various pollutants that are emitted into the atmosphere.

CLASSIFICATION OF SAMPLING METHODS

The Sampling methods used for the study of air pollution can be classified under three different headings.

1. Sampling of impunities of every nature (ranging from particulate matter to gases)
2. Sampling under Various environmental conditions.
   (Ranging from samples taken from chimneys to samples taken in the open air)
3. Sampling methods varying according to the time factory (Ranging from intermittent. To continues sampling)

Note : The most important objective of any air sampling exercise in to obtain a genuine and representative sample.

DIFFICULTIES ENCOUNTERED IN SAMPLINGS
1. Collecting samples of true representative character
2. Errors arising from methods used for the collection and separation of the various components of pollution.
3. Difficulty in preventing any Chong in the concentration of particulars   matter in suspension as a result of sampling operations.

PRELIMINARY CONSIDERATIONS AND STAGES OF SAMPLING

Following principles should be followed to ensure correct sampling.

1. **Statistical Stickiest:** They are of utmost importance to establish the bask data eg size and frequency of sampling. Statistical studies use the basic principle of probability i.e they do not give absolute results but only indicate the percentage probability that a given since of data will be accurate within certain limits.
2. **Size of sample:** The samples should be large enough to make analysis possible
3. **Changes in the sample During And After Sampling**
   This is one of the fundamental cases of more there possibilities should always be borne in mind by the investigator so that he can try to avoid such serious scores of error.
4. **Continuous and intermittent sampling**: An automatic recording apparatus is becoming more and more popular. Intermittent sampling can also be made, but continuous recording is always preferable many of the continuous recording instruments combine the operations of sampling and analysis.
5. **Sampling of Volatile constituents:**
   In this case to avoid the sources of error, it is better to carry out sampling with large volumes of air.

6. **Sampling of Particulates:** Here errors may be introduced doctor agglomeration or breaking up of particulate matter in order to claimant the sources of error.

   a) Sampling should be carried out under conditions which are as is kinetic as possible.

   b) A gas stream should be sampled as for as possible in the same direction and at the same speed itself, but never counter – current.

   c) The collecting surface should be as close as possible to the source of the gas stream. To avoid reducing the efficiency of sampling deposits and condensation should not be allowed to form on the walls of sampling vessels.

7. **Sampling of waste Gas:** Here difficulties are encountered due to high temperature, lack of uniformity in the composition of gas flow, and difference in speed due to disturbances. Hence to avoid error, the gas stream should be sampled at several points and maximum number of samples should be taken to get the average value.

8. **Sampling in the open air**

   Here difficulties arise due to

   a) High velocity of the pollutants dispersed in air

   b) Consequent head to collect large number of samples.

   c) Difficulty of sampling under is kinetic conditions.

BASIC CONSIDERATIONS OF AIR SAMPLING

1. The sample collected must be representative in terms of time and location.

2. The sample volume should be large enough to permit accurate analysis.

3. The sampling rate must be such as to provide maximum efficiency of collection.

4. The duration of sampling and frequency of sampling should reflect accurately the occurrence of fluctuations in pollution levels.

5. The contaminants must not be modified or altered in to process of collections.

TYPICAL AIR SAMPLING SYSTEM

A typical air sampling system consists of a sample collector a flow meter to measures the air flow through the collector and a pump to draw the air sample through the system. The Fig. below shows a typical arrangement of an sampling equipment.

Sample collector   Flow metal   Pump

Flow metal   Sample collector   Pump
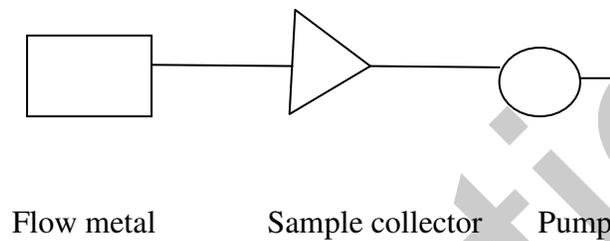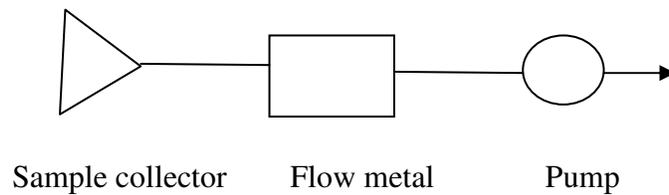
TYPICAL   AIR SAMPLE   SET UP

COLLECTION OF GASEOUS AIR POLLUTANTS :

Several methods are available for collection of gaseous. Air pollutants from ambient atmosphere. The common ones are:

  i) Grab sampling

  ii) Absorption in Liquids

  iii)Adsorption on a solid material

  iv) Freeze out sampling

GRAB SAMPLING :

In this method the sample is collected by filling an evacuated flask or an inflatable bag, grab samples may be taken using rigid wall containers made from glasses or stainless steel. These containers are first evacuated and then filled by allowing air to enter.

ABSORPTION IN LIQUIDS:

Absorption of gaseous pollutants into a Liquid Medium is probably the most commonly employed method of collecting the samples. The efficiency of this process depends on.

 i) Amount of surface contact between gas and liquid.

 ii) Contact time

 iii) Concentration of absorbing medium.

 iv) Speed of reaction between the absorbent and gas.

Absorbents are being used to remove sculptor dioxide, by brogan sup hide, sulphur trioxide and fluorides and oxides of Nitrogen.

The equipments using the principle of absorption for the removal of gaseous pollutant includes

 i) Packed tower

 ii) Plate tower

 iii) Bubble cap plate cover

 iv) Spray tower

 v) Liquid jet scrubber absorbers.

A gas can be sampled by means of a suitable absorption reagent for this purpose, U-shaped absorbers are used. These absorbers are filled with a certain measured amount of reagent and fitted with a porous glass partition, so that the air or gas led into them passes through the reagent solution in the form of fine dabbles thus ensuring intimate contact. Sampling by means of such absorbers is usually calmed cut at an average rate of about 100-150 liters per hour of gas stream the absorbers may be arrange in series of two more elements continuing the same reagent solution to ensure more complete absorption of the impurity in question or in sense, or in series of two or more elements containing two more different reagent solutions so as to absorb different pollutants successively from the same column of gas or air sampled a typical sampling train is shown in figure comprising an impinge, trap, manometer, flow meter, valve and pump.
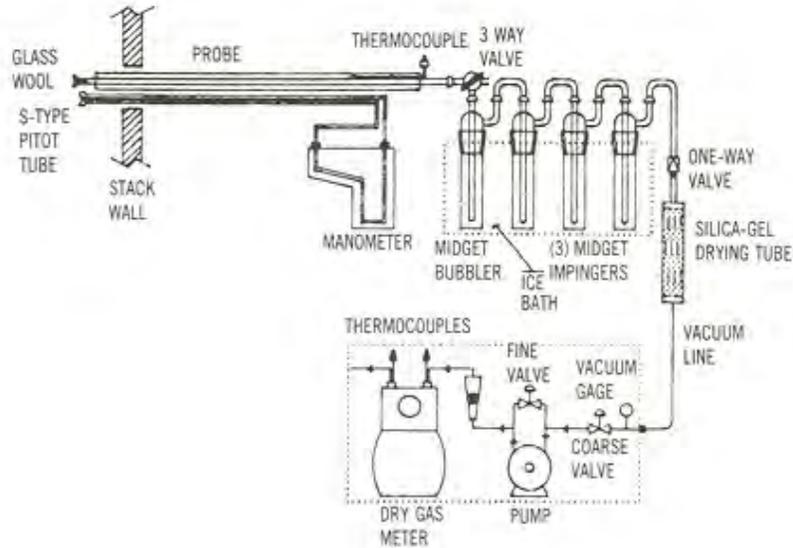
ADSORPTION ON SOLIDS

This Method is based on the tendency of gases to be absorbed on the surface of solid materials. The sample air is passed through solid absorbent on whose surface the pollutants are retained and concentrated. The most commonly used solid absorbents are granular porous solids such as activated charcoal and silica gel with very large surface area.

After adsorption, the sample gases are described for Analysis. This may be accomplished be heating the adsorbent to Volatiles the trapped material by washing it with a liquid solvent But because of many problems. An adsorptive scalping is not much used for pollutant measurements.

FREEZE – OUT SAMPLING (CONDENSERS)

In Freeze out sampling a series of cold traps, which are maintained at progressively lower temperature. Are used to draw, the air sample whole by the pollutants are condensed. The traps are brought to the laboratory the samples are removed and analyzed by means of gas chromatographic, infrared Ultraviolet spectro photometry, mass spectrometry, or by net chemical means.

COOLANTS USED FOR FREEZE OUT TRAPS

Coolant	Temp Attained (^{0}C)
Ice water	0
Ice Salt	21
Pry ice and	79
Acetone	147
Liquid oxygen	183
Liquid nitrogen	196

DURATION OF SAMPLING PERIOD

Two types of sampling are used in studies of air pollution short period or spot sampling and continuous sampling for the evaluation of peak and average concentrations over definite time intervals. Spot samples are collected aver periods varying from less than 30 minutes to several hours for specific ell defined purpose. The choke of sum ping period depends upon the nature of the compound under study and its stability of oxidation, light or other factors such as sensitivity accuracy and precision of the analytical method to be used for the measurement of pollutants. Shot sampling is useful for the random checking of pollution at many points. Such samples have only limited valve because pollution levels fluctuate widely depending on meteorological conditions, to geographical factures. And various factures associated with source of pollutions (if misuse rules of emission of pollutants from smoke stacks the temperature velocity and density of stack gases, the height of smoke stacks, the distribution of sources, and the downwind distance for other sources where the measurements and made) consequently. Spot sampling cannot give adequate data on the nature and magnitude of an air pollution problem.

LOCATION OF SAMPLING SITES

Sampling sites must be carefully selected so as to be preventatives of the areas under study, for the study of health effects, the sited must be located so that the collected samples represent air that is actually breathed by the exposed population groups. Since the concentration of pollutants arks with altitude, results obtained on the roofs of tall buildings may differ substantially from conditions at the ground or breathing level. The necessary number of singling stations, and their location, depend on several facture including the objectives of the programme the size of the study area, the proximity of the sources of pollution. Topographical factors and the weather. A representative number of sampling stations for a given area may be established by means of a preliminary survey, whose objectives should be.

1. To gather information of the nature and magnitude of the emission from Principal sources of pollution.

2. To review the available climatologically and meteorological data.

3. To gather data on the concentration of pollutants in areas of severe and slight pollution.

COLLECTION OF PARTICULATE POLLUTANTS (SAMPLING METHODS)

Particulate pollutants are classified generally into dust that settles in air and dust that remains suspended. The particles of size greater than 1µm diameter, can be collected using sedimentation techniques while for the second category containing particles of smaller size more sophisticated techniques like filtration, impingement and electrostatic and thermal precipitation are used.

SEDIMENTATION [DUST FALL JAR]
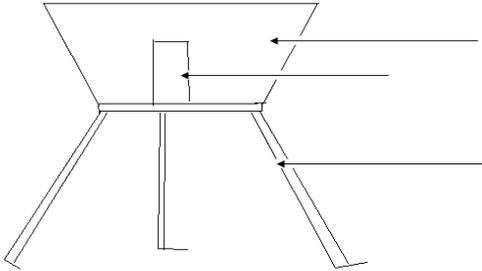
Sedimentation is one of the simplest techniques for the collection of particulate matter. This method is adopted in general for particles whose diameter exceed about 10μ.

The container is usually more than as high as its diameter at the base. A typical dust fall container is constructed of plastic and is 20-32 cm high and 10-15cm in diameter at the base with a slight inward taper of the walls from tap to bottom. After an exposure period, usually a month, the soluble, and insoluble matter is determined and the total solids collected are expressed in terms of weight per unit area per 30 days. It is common to employ at least one dust fall container for every 2600 hectares. General considerations in site selections are

1) The site should be free from overhead obstructions and away from interference such as an incinerator or Chimney.

2) The mouth of the dust full collector should be lesser than 2mm and in more than 10mm above ground level with a std. Height of 6m as recommended elevation.

3) When sampling in Urban areas, the dust fall collector should be sat no less than 10 stack and no closer to a vertical wall than the distance that provides a 30°angle from the sampler to the top of the wall or roof.

FILTRATION:

Particulates having a diameter of less than 10μ tend to remain entertained in an air stream such particulates are referred to as suspended particulates.

The most commonly used methods of particulate sampling employ the principle of filtration, where by particles are quantitatively removed from an air stream flowing through a dense material containing sub-micrometer pore sizes. Any material that passes through such a Fitter is considered, rather arbitrarily, to be non-particulate.

Particle collection is achieved by a combination of five distinct processes, namely direct interception, internal deposition, diffusional deposition, electrical attraction and gravitational attraction. Only in the first of these processes must the particle be larger than filter pores. The other four all involve migration of a particle which would otherwise pass through a fitter pore, from a stream line to the fitter surface under the action of initial, diffusional, gravitational or electrostatic forces.

IMPINGEMENT METHODS:

Separation of particulates from an air stream by abrupt collision against a flat surface forms the basis of these methods. The apparatus employed may be either a wet or dry type. We impinge collect particles by causing them to impinge a surface referred to as impact. Collect particles by impaction on a dry surface. The efficiency or collection by impingement or impurities is high for particles whose diameter is 1μ are greater for collection of submicron particles. The impinger should be operated at high velocities.

The GREEN BURG –SMITH type impinger an example of wet collectors activities 90 to 99% efficiency for particle of the size equal to or greater than 1μm.

Dry impingers operate on the principle of impaction on a dry surface for particle collection. These impingers are not as efficient as wet devices for collecting smaller particles. (L2μ)

ELECTROSTATIC PRECIPITATION

Air sampling can be done on the basis of the principle of electrostatic precipitation. Several types of portable, commercial precipitators are available in the market. During their operation a negative charge is imported to a wire placed axially inside a cylinder which is positively charged when the particle laden air stream passes through the cylinder, the particles acquire a negative change from a corona discharge occurring on the central wire. The particles migrate towards the inner surface of the cylinder and are conceived for subsequent chemical or microscopic analysis.

THERMAL PRECIPITATION

Thermal precipitators operate on the principle that small particles, under the influence of a strong temperature gradient between two surfaces, have a tendency to move towards the lower temperature and get deposited on the colder of these two surfaces. These temperature gradients are normally of the order of 2000°C per centimeter. To maintain such high gradients the gas velocity through the sampling device must be maintained low.

The collection efficiencies of the thermal precipitators are gutte high for small particles and are virtually 100% for particles in the size range from 10μm down to 0.01μm. The particles are collected on a grid or a thin microscope cover glass for later analysis.

CENTRIFUGAL METHODS

Most centrifugal sampling devices are constructed on the principle of the cyclone. The dust laden gas moving at high velocity, is directed tangentially into a cylindrical chamber, in which it forms a confined vortex. The centrifugal force tends to drive the suspended particles to the wall of the cyclone body, from which they drop into a dust collection chamber. An axial outlet B provided for the clean gas.

The advantages of this sampling device include procurement of a dry chemically pure. Sample, the single most important disadvantage is the limit of this method to the particle sizes greater than 5μ.

**SAMPLING SUSPENDED PARTICULATES BY HIGH VOLUME FILTRATION
[HIGH VOLUMN SAMPLER]**

In this method, a known volume of air is sucked by a high speed blower through a fine fitter and the increase in weight due to the made of fibrous or granular material provides a dense porous medium, through which an air stream must change direction in a random Fashion, allowing the entertained particles to impact on the fitter material. A typical glass fibre fitter used, in the air samplers has an efficiency of over 99% for particles of size 0.3μm and it is moderately effective for trapping particles of as small size as small as 0.05μm.

The sampling time B generally 24 hours and during this time over 2000m^3 of air is sucked through the fitter. The analysis is gravimetric and the particulate levels is generally expressed in terms of μg/m^3 of air. Based on typical results of such a sampling, the following example would illustrate the calculation.

Air flow through clean fitter = 1.7 M^3/mm

Air flow through the fitter at the end of the test = 1.4m^3/min

Average Air flow = 1.55m3/min = 2232m^3 in 24hrs.

Weight of the clear fitter – 5000 gm

Weight of the fitter after after exposure = 5.3348gm

Weight of the particulate lost = 0.348gm = 0.348x10^{6}μg

Suspended particulate =   0.398x10^6 μg / 2232 m^3

=155.91μg/m^3

PROCEDURE FOR THE COLLECTION OF SUSPENDED PARTICULATES

1) **APPARATUS**

   a) High volume sampler with flow meter and elapsed time meter.

   b) Barometer capable of recording atmospheric pressure to nearest millimeter of mercury.

   c) Desiccator (50% humidity) to condition the fitter.

d) Thermometer to record ambient temperatures.

e) Glass fibre fitters having a collection efficiency of atleast 99% for particles of 0.3µ diameter.

2) PROCEDURE :

a) Check the fibre glass filter for pin holes, particles or other imperfections. Fitters with visible imperfections should not be used.

b) Number the fitter and equilibrate the fitter in the desiccators for 24 hours and weigh to the nearest milligram.

c) Record tare weight and filter identification number (do not bend or fold the Filter before collection of the sample)

d) Open the shelter of the high volume sampler, loosen the wing nuts and remove the face plate from the fitter holder.

e) Install a numbered, pre-weighed, glass fibre filter in position (rough side up). Replace the face plate without disturbing the filter and fasten securely. A very light application of talcum powder may be used on the rubber face plate gasket to prevent the filter from sticking.

f) Close the roof of the shelter.

g) Set the on off timer to start sampling for the prescribed the (24h) recording the starting time.

h) After five minutes note down the flow rate.

i) At the end of the sampling period, record the length of the sampling period and flow rate.

j) Remove the face plate and carefully remove the exposed filter without tearing or touching the collected surface.

k) Fold the filter that only surfaces with collected particulars are in contact and place in the special folder.

STACK SAMPLING

Stack sampling or source sampling may be defined as a method of collecting reprehensive samples of pollutant laden air/gases at the place of origin of pollutants to determine the total amount of pollutants emitted into the atmosphere from a given source in a given time.

OBJECTIVES OF STACK SAMPLING

1) To determine the quantity and quality of pollutant emitted by the source.
2) To measure the efficiency of the control equipment by conducting a survey before and after installation.
3) To determine the effect on the emission due to changes in raw materials and processes.
4) To compare the efficiency of different control equipments for a given condition.
5) To acquire data from an innocuous individual source so an to determine the cumulative effective of many such sources.
6) To compare with emission standards in order to assess the need for local control.

PLANNING THE STUDY :

The success of stack sampling depends on proper initial planning prior to the conduction of a survey the planning includes.

1) Familiarity of the process and operations to determine the time of cyclic operations, peak loading that might cause venations in the characteristics.
2) Methods of sampling
3) Methods of analysis of samples.
4) Sampling time because certain industries undergo cyclic changes.
5) Amount of samples required.
6) Sampling frequency.

REPRESENTATIVE SAMPLE

It is mainly reported that the sample collected must truly represent the conditions prevailing inside the stack. The important consideration for accurate representative sample collection include.

1) Accurate measurement of pressure, moisture, humidity and gas composition.
2) The Selection of suitable locations for sampling.
3) Determinations of the traverse points required for a velocity and temperature profile across the cross section of the stack and sampling for particulate matter.
4) The measurement of the rate of flow of gas or air through the stack.
5) Selection of a suitable sampling fresh.
6) Accurate isokinetic sampling rate especially for particulate sampling.
7) Accurate measurement of weight and volume of samples collected.

SELECTION OF SAMPLING LOCATION :

The sampling point should be as far as possible from any disturbing influence, such as elbows, ends, transaction places, baffles or other obstructions.

SIZE SAMPLING POINT : Usually, there will not be any opening in the stack. Hence for collection of samples, an opening has to be made to an extent of accommodating the probes. The size of sampling point may be made in the range of 7-10 in diameter.

TRAVERSE POINTS : For the sample to become representative, it should be collection at various points across the stack. This is essential as there will be changes in velocity and temperature across selection of the stack.

TRAVERSE POINTS

Cross selection area of stack sqm	No. of points
0.2	4
0.2 to 2.5	12
2.5 and above	20

ISOKINETIC CONDITIONS

The efficiency of the sampling depends on the conditions at which sampling was carried out. The sample collected must be representative likes composite waste water collection. This can be achieved by ISO KINETIC SAMPLING, ISOKINETIC CONDITIONS exist when the velocity in the stack (Vs) equals the velocity at the top of the probe nozzle (Yn) at the sample point. This B especially than 3μ as it presents a problem in that, the inertial effects on the particles can result in erroneous samples.

When the velocity of the gas within the sampling nozzle is less than the gas velocity in the duct, portions of the gas stream approaching at a higher velocity are deflected. This results in the deflection of the light particles to follow the deflected gas stream and they do not enter the probe. The heavier particles by virtue of their inertia, continue into the probe with the result that a non-representative high concentration of course particles is collected and the sample weight is in error on higher side. Conversely, when the velocity in the probe is higher than that of the gas stream being sampled, a convergent air stream will develop at the nozzle face, with an excessive amount of lighter particles entering the probe. This results in high concentration of lighter particles and hence the sample weight is on lower side.

a) Flow rate less than isokinetic Rate
b) Flow rate greater than isokinetic rate

SMOKE

Smoke is a collection of airborne solid and liquid particulates and gases emitted when a material undergoes combustion or pyrolysis, together with the quantity of air that is entrained or otherwise mixed into the mass. It is commonly an unwanted by-product of fires (including stoves, candles, oil lamps, and fireplaces), but may also be used for pest control (fumigation), communication (smoke signals), defensive and offensive capabilities in the military (smoke-screen), cooking (smoked salmon), or smoking (tobacco, cannabis, etc.). Smoke is used in rituals, when incense, sage, or resin is burned to produce a smell for spiritual purposes.

Smoke is sometimes used as a flavoring agent, and preservative for various foodstuffs. Smoke is also a component of internal combustion engine exhaust gas, particularly diesel exhaust.

Smoke inhalation is the primary cause of death in victims of indoor fires. The smoke kills by a combination of thermal damage, poisoning and pulmonary irritation caused by carbon monoxide, hydrogen cyanide and other combustion products.

Smoke particles are an aerosol (or mist) of solid particles and liquid droplets that are close to the ideal range of sizes for Mie scattering of visible light. This effect has been likened to three-dimensional textured privacy glass — a smoke cloud does not obstruct an image, but thoroughly scrambles it.

The composition of smoke depends on the nature of the burning fuel and the conditions of combustion.

Fires with high availability of oxygen burn at a high temperature and with small amount of smoke produced; the particles are mostly composed of ash, or with large temperature differences, of condensed aerosol of water. High temperature also leads to production of nitrogen oxides. Sulfur content yields sulfur dioxide, or in case of incomplete combustion, hydrogen sulfide. Carbon and hydrogen are almost completely oxidized to carbon dioxide and water. Fires burning with lack of oxygen produce a significantly wider palette of compounds, many of them toxic. Partial oxidation of carbon produces carbon monoxide, nitrogen-containing materials can yield hydrogen cyanide, ammonia, and nitrogen oxides. Hydrogen gas can be produced instead of water. Content of halogens such as chlorine (e.g. in polyvinyl chloride or brominated flame retardants) may lead to production of e.g. hydrogen chloride, phosgene, dioxin, and chloromethane, bromomethane and other halocarbons. Hydrogen fluoride can be formed from fluorocarbons, whether fluoropolymers subjected to fire or halocarbon fire suppression agents. Phosphorus and antimony oxides and their reaction products can be formed from some fire retardant additives, increasing smoke toxicity and corrosivity. Pyrolysis of polychlorinated biphenyls (PCB), e.g. from burning older transformer oil, and to lower degree also of other chlorine-containing materials, can produce 2,3,7,8-tetrachlorodibenzodioxin, a potent carcinogen, and other polychlorinated dibenzodioxins. Pyrolysis of fluoropolymers, e.g. teflon, in presence of oxygen yields carbonyl fluoride (which

hydrolyzes readily to HF and CO2); other compounds may be formed as well, e.g. carbon tetrafluoride, hexafluoropropylene, and highly toxic perfluoroisobutene (PFIB).

Pyrolysis of burning material, especially incomplete combustion or smoldering without adequate oxygen supply, also results in production of a large amount of hydrocarbons, both aliphatic (methane, ethane, ethylene, acetylene) and aromatic (benzene and its derivates, polycyclic aromatic hydrocarbons; e.g. benzo[a]pyrene, studied as a carcinogen, or retene), terpenes. Heterocyclic compounds may be also present. Heavier hydrocarbons may condense as tar; smoke with significant tar content is yellow to brown. Presence of such smoke, soot, and/or brown oily deposits during a fire indicates a possible hazardous situation, as the atmosphere may be saturated with combustible pyrolysis products with concentration above the upper flammability limit, and sudden inrush of air can cause flashover or backdraft.

Presence of sulfur can lead to formation of e.g. hydrogen sulfide, carbonyl sulfide, sulfur dioxide, carbon disulfide, and thiols; especially thiols tend to get adsorbed on surfaces and produce a lingering odor even long after the fire. Partial oxidation of the released hydrocarbons yields in a wide palette of other compounds: aldehydes (e.g. formaldehyde, acrolein, and furfural), ketones, alcohols (often aromatic, e.g. phenol, guaiacol, syringol, catechol, and cresols), carboxylic acids (formic acid, acetic acid, etc.).

The visible particulate matter in such smokes is most commonly composed of carbon (soot). Other particulates may be composed of drops of condensed tar, or solid particles of ash. The presence of metals in the fuel yields particles of metal oxides. Particles of inorganicsalts may also be formed, e.g. ammonium sulfate, ammonium nitrate, or sodium chloride. Inorganic salts present on the surface of the soot particles may make them hydrophilic. Many organic compounds, typically the aromatic hydrocarbons, may be also adsorbed on the surface of the solid particles. Metal oxides can be present when metal-containing fuels are burned, e.g. solid rocket fuels containingaluminium. Depleted uranium projectiles after impacting the target ignite, producing particles of uranium oxides. Magnetic particles, spherules of magnetite-like ferrous ferric oxide, are present in coal smoke; their increase in deposits after 1860 marks the beginning of the Industrial Revolution. (Magnetic iron oxide nanoparticles can be also produced in the smoke from meteorites burning in the atmosphere.) Magnetic remanence, recorded in the iron oxide

particles, indicates the strength of Earth's magnetic field when they were cooled beyond their Curie temperature; this can be used to distinguish magnetic particles of terrestrial and meteoric origin. Fly ash is composed mainly of silica and calcium oxide. Cenospheres are present in smoke from liquid hydrocarbon fuels. Minute metal particles produced by abrasion can be present in engine smokes. Amorphous silica particles are present in smokes from burning silicones; small proportion of silicon nitride particles can be formed in fires with insufficient oxygen. The silica particles have about 10 nm size, clumped to 70-100 nm aggregates and further agglomerated to chains. Radioactive particles may be present due to traces of uranium, thorium, or other radionuclides in the fuel; hot particles can be present in case of fires during nuclear accidents (e.g. Chernobyl disaster) or nuclear war.

Smoke particulates have three modes of particle size distribution:

nuclei mode, with geometric mean radius between 2.5–20 nm, likely forming by condensation of carbon moieties.

accumulation mode, ranging between 75–250 nm and formed by coagulation of nuclei mode particles

coarse mode, with particles in micrometer range

Most of the smoke material is primarily in coarse particles. Those undergo rapid dry precipitation, and the smoke damage in more distant areas outside of the room where the fire occurs is therefore primarily mediated by the smaller particles.

Aerosol of particles beyond visible size is an early indicator of materials in a preignition stage of a fire.

Burning of hydrogen-rich fuel produces water; this results in smoke containing droplets of water vapor. In absence of other color sources (nitrogen oxides, particulates...), such smoke is white and cloud-like.

Smoke emissions may contain characteristic trace elements. Vanadium is present in emissions from oil fired power plants and refineries; oil plants also emit some nickel.

Coal combustion produces emissions containing aluminium, arsenic, chromium, cobalt, copper, iron, mercury, selenium, and uranium.

Traces of vanadium in high-temperature combustion products form droplets of molten vanadates. These attack the passivation layers on metals and cause high temperature corrosion, which is a concern especially for internal combustion engines. Molten sulfate and lead particulates also have such effect.

Some components of smoke are characteristic of the combustion source. Guaiacol and its derivatives are products of pyrolysis of lignin and are characteristic of wood smoke; other markers are syringol and derivates, and other methoxy phenols. Retene, a product of pyrolysis of conifer trees, is an indicator of forest fires. Levoglucosan is a pyrolysis product of cellulose. Hardwood vs softwood smokes differ in the ratio of guaiacols/syringols. Markers for vehicle exhaust include polycyclic aromatic hydrocarbons, hopanes, steranes, and specific nitroarenes (e.g. 1-nitropyrene). The ratio of hopanes and steranes to elemental carbon can be used to distinguish between emissions of gasoline and diesel engines.

Many compounds can be associated with particulates; whether by being adsorbed on their surfaces, or by being dissolved in liquid droplets. Hydrogen chloride is well absorbed in the soot particles.

Inert particulate matter can be disturbed and entrained into the smoke. Of particular concern are particles of asbestos.

Deposited hot particles of radioactive fallout and bio-accumulated radioisotopes can be reintroduced into the atmosphere by wildfires and forest fires; this is a concern in e.g. the Zone of alienation containing contaminants from the Chernobyl disaster.

Polymers are a significant source of smoke. Aromatic side groups, e.g. in polystyrene, enhance generation of smoke. Aromatic groups integrated in the polymer backbone produce less smoke, likely due to significant charring. Aliphatic polymers tend to generate the least smoke, and are non-self-extinguishing. However presence of additives can significantly increase smoke formation. Phosphorus-based and halogen-based flame retardants decrease production of smoke. Higher degree of cross-linking between the polymer chains has such effect too.

DANGERS OF SMOKE

Smoke from oxygen-deprived fires contains a significant concentration of compounds that are flammable. A cloud of smoke, in contact with atmospheric oxygen, therefore has the potential of being ignited – either by another open flame in the area, or by its own temperature. This leads to effects like backdraft and flashover. Smoke inhalation is also a danger of smoke that can cause serious injury and death.

Many compounds of smoke from fires are highly toxic and/or irritating. The most dangerous is carbon monoxide leading to carbon monoxide poisoning, sometimes with the additive effects of hydrogen cyanide and phosgene. Smoke inhalation can therefore quickly lead to incapacitation and loss of consciousness. Sulfur oxides, hydrogen chloride and hydrogen fluoride in contact with moisture form sulfuric, hydrochloric and hydrofluoric acid, which are corrosive to both lungs and materials. When asleep the nose does not sense smoke nor does the brain, but the body will wake up if the lungs become enveloped in smoke and the brain will be stimulated and the person will be awoken. This does not work if the person is incapacitated or under the influence of Drugs and/or alcohol

Cigarette smoke is a major modifiable risk factor for lung disease, heart disease, and many cancers.

Reduced visibility due to wildfire smoke in Sheremetyevo airport (Moscow, Russia) 7 August 2010.

Smoke can obscure visibility, impeding occupant exiting from fire areas. In fact, the poor visibility due to the smoke that was in theWorcester Cold Storage Warehouse fire in Worcester, Massachusetts was the exact reason why the trapped rescue firefighters couldn't evacuate the building in time. Because of the striking similarity that each floor shared, the dense smoke caused the firefighters to become disoriented.

SMOKE CORROSION

Smoke contains a wide variety of chemicals, many of them aggressive in nature. Examples are hydrochloric acid and hydrobromic acid, produced from halogen-containing plastics and fire retardants, hydro fluoric acid released by pyrolysis of fluorocarbon fire suppression agents, sulfuric acid from burning of sulfur-containing materials, nitric acid from high

temperature fires where nitrousoxide gets formed,phosphoric acid and antimony compounds from P and Sb based fire retardants, and many others. Such corrosion is not significant for structural materials, but delicate structures, especially microelectronics, are strongly affected. Corrosion of circuit board traces, penetration of aggressive chemicals through the casings of parts, and other effects can cause an immediate or gradual deterioration of parameters or even premature (and often delayed, as the corrosion can progress over long time) failure of equipment subjected to smoke. Many smoke components are also electrically conductive; deposition of a conductive layer on the circuits can cause crosstalks and other deteriorations of the operating parameters or even cause short circuits and total failures. Electrical contacts can be affected by corrosion of surfaces, and by deposition of soot and other conductive particles or nonconductive layers on or across the contacts. Deposited particles may adversely affect the performance of optoelectronics by absorbing or scattering the light beams.

Corrosivity of smoke produced by materials is characterized by the corrosion index (CI), defined as material loss rate (angstrom/minute) per amount of material gasified products (grams) per volume of air (m3). It is measured by exposing strips of metal to flow of combustion products in a test tunnel. Polymers containing halogen and hydrogen (polyvinyl chloride, polyolefins with halogenated additives, etc.) have the highest CI as the corrosive acids are formed directly with water produced by the combustion, polymers containing halogen only (e.g. poly tetra fluoro ethylene) have lower CI as the formation of acid is limited to reactions with airborne humidity, and halogen-free materials (polyolefins, wood) have the lowest CI. However, some halogen-free materials can also release significant amount of corrosive products.

Smoke damage to electronic equipment can be significantly more extensive than the fire itself. Cable fires are of special concern; low smoke zero halogen materials are preferable for cable insulation.

When smoke comes into contact with the surface of any substance or structure, the chemicals contained in it are transferred to it. The corrosive properties of the chemicals cause the substance or structure to decompose at a rapid rate. In some instances the chemicals are absorbed into the substance or structure that it comes into contact with, i.e. clothing, unsealed surfaces, potable

water piping, wood, etc., which is why in most cases dealing with a structure fire they are replaced.

MEASUREMENT OF SMOKE

As early as the 15th Century Leonardo da Vinci commented at length on the difficulty of assessing smoke, and distinguished between black smoke (carbonized particles) and white 'smoke' which is not a smoke at all but merely a suspension of harmless water droplets. Smoke from heating appliances is commonly measured in one of the following ways:

In-line capture. A smoke sample is simply sucked through a filter which is weighed before and after the test and the mass of smoke found. This is the simplest and probably the most accurate method, but can only be used where the smoke concentration is slight, as the filter can quickly become blocked.

Filter/dilution tunnel. A smoke sample is drawn through a tube where it is diluted with air, the resulting smoke/air mixture is then pulled through a filter and weighed. This is the internationally recognized method of measuring smoke from combustion.

Electrostatic precipitation. The smoke is passed through an array of metal tubes which contain suspended wires. A (huge) electrical potential is applied across the tubes and wires so that the smoke particles become charged and are attracted to the sides of the tubes. This method can over-read by capturing harmless condensates, or under-read due to the insulating effect of the smoke. However, it is the necessary method for assessing volumes of smoke too great to be forced through a filter, i.e., from bituminous coal.

Ringelmann scale. A measure of smoke color. Invented by Professor Maximilian Ringelmann in Paris in 1888, it is essentially a card with squares of black, white and shades of gray which is held up and the comparative grayness of the smoke judged. Highly dependent on light conditions and the skill of the observer it allocates a grayness number from 0 (white) to 5 (black) which has only a passing relationship to the actual quantity of smoke. Nonetheless, the simplicity of the Ringelmann scale means that it has been adopted as a standard in many countries.

Optical scattering. A light beam is passed through the smoke. A light detector is situated at an angle to the light source, typically at 90°, so that it receives only light reflected from passing

particles. A measurement is made of the light received which will be lower as the concentration of smoke particles becomes higher.

Optical obscuration. A light beam is passed through the smoke and a detector opposite measures the light. The more smoke particles are present between the two, the less light will be measured.

Combined optical methods. There are various proprietary optical smoke measurement devices such as the 'nephelometer' or the 'aethalometer' which use several different optical methods, including more than one wavelength of light, inside a single instrument and apply an algorithm to give a good estimate of smoke.

Inference from carbon monoxide. Smoke is incompletely burned fuel, carbon monoxide is incompletely burned carbon, therefore it has long been assumed that measurement of CO in flue gas (a cheap, simple and very accurate procedure) will provide a good indication of the levels of smoke. Indeed, several jurisdictions use CO measurement as the basis of smoke control. However it is far from clear how accurate the correspondence is.

CONTROL OF AIR POLLUTION BY EQUIPMENTS

The most effective methods of particulate control, are reduction at the source by the application of control equipment and process control.

The remove the particulate matter from gas streams, various types of control equipment are available. But to select the required equipment, certain basic data must be available. The required data is

1) Quantity of gas to be treated and its variation with the
2) Nature and concentration of the particulate matter to be removed.
3) Temperature and pressure of the gas stream.
4) Nature of the gas phase (for solubility and corrosive effects)
5) Desired quality of the treated effluent i.e. efficiency of removal of particulars required.

OBJECTIVES OF USING CONTROL EQUIPMENT :

1. Prevention of nuisance.
2. Prevention of physical damages to property.

3. Elimination of health hazards to plant personal and general population.

4. Recovery of valuable waste products.

5. Minimization of economic losses through reduction of plant maintenance.

6. Improvement of product quality.

PARTICULATE EMISSION CONTROL :

Particulate matter emitted in gaseous streams consists of discrete and minute suspended particles. Particle glazes range generally from 100μm down to 1.0μm and even less. The choice of collection devices depends upon a number of footers the physical and chemical characteristics of particulates, the particle size and concentration in the gas, volume of particulates to be handled, and the temperature and humidity of gaseous medium. In particular factors like toxicity and inflammability must be taken into consideration when evaluating operating efficiency.

PARTICULAR CONTROL EQUIPMENT

Control devices re diverted into five major groups

1) Gravitational setting chambers
2) Cyclones
3) Fabric filters
4) Electrostatic precipitators
5) Scrubbers or wet collectors
6) Inertial separaters

SETTLING CHAMBERS

It is one of the most simplest type of collection equipment for aerosols. The principle it works on is that it consists of a chamber in which the carrier gas velocity is reduced so as to allow the particulates to settle out of the moving stream under the action of gravity.

It is constructed from brick and concrete. It is of the form of long box like structure with an inlet and an outlet set horizontally on the ground. The carrier gas is made and pass at low velocities

through the inlet. The solid particulates having higher density than the surrounding gas settle at the bottom of the chamber under the influence of gravity which is removed using happens. Usually the gas velocity must be kept low say less than 3m/set to prevent re-entertainment of the settled particles, less than 0.5m/sec for good results and hence to reduce turbulence and uniform velocity curtains, rods and mesh screens may be suspended in the chamber.

ADVANTAGES :

1) Low initial cost
2) Simple construction
3) Low maintenance cost
4) Low pressure drop
5) Dry and continuous disposal of solid particulates
6) It can be constructed out of any material
7) Temperature and pressure limitations imposed only to be materials of construction used.

DISADVANTAGES :

1) Large space requirements
2) Only large particles can be collected (above 40μ)

APPLICATIONS :

Setting chambers are used generally to remove particulates above 40μ in diameter, such as carbon black and various metallurgical fumes from agglomerates.

They are used widely for the removal of large solid particles from natural draft furnace, Kilns etc. and some times used in the process industries such as good and metallurgical industries as a first step in dust control.

INERTIAL (OR) IMPACT SEPARATORS

There are 3 different types of inertial separators

1) Baffle type separator
2) Louvre type separator
3) Dust traps

BAFFLE TYPE SEPARATOR : It is one of the simplest form of inertial separator which is simple to operate. It has no moving parts and construction expenses are more because of As interior work of fabricating at installing the buffles. Here the gas stream is made to follow a tortuous flow path which is obtained by the insertion of staggered path into the path of the gas stream. As a result, the gas is subjected to service of solid surfaces. This device is suitable for removing particles larger than 20μ in diameter. These devices are widely used for particulate removal in power plants and rotary kilns.

LOUVRE TYPE SEPARATOR

Louvre type separator is one of the inertial separator. The separator usually is set at an angle to the carrier gas stream so as to cause a rapid reversal of the gas flow the direction which causes particulates to impinge on the louvers which are bound back into the moving gas stream in the inlet diameter which are removed by secondary air circuit. This device is suitable for removing particles larger than 30μ in diameter.

The efficiency depends on louvre spacing, closer spacing producing higher efficiency and the operating velocities are of order 12-15m/s at the inlet.

DUST TRAP
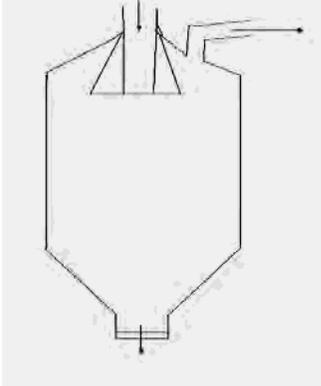
It is another common type of impact separator. Here dust Laden gas is introduced into a control pipe and is made to undergo a change in direction by 180°, due to inertia the dust settles in the control chamber. It is not important of reverse flow of gas. The dust trap B used as a pre cleaner and to reduce the load of the larger diameter particles so as to pass through more efficient mechanisms, for removing smaller particles. The gas velocity of the inlet is about 10M/S and in chamber it is about 1 M/S. The collection efficiency for particles greater than 30µ is about 70%.

CYCLONE SEPARATORS

Cyclone separators diffused centrifugal force generated by the spinning gas stream to separate the particulate matter from the carrier gas. The centrifugal force on particles in a spinning gas stream is much greater than gravity therefore cyclones are effective in the removal of much smaller particles than gravitational setting chambers and negative much less space to handle the same gas volume.

STRUTPATENT.COM
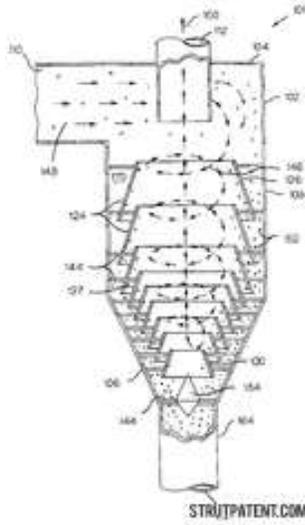
REVERSE FLOW CYCLONE SEPARATOR

A simple reverse flow cyclone separator consists of a vertical cylinder having a conical bottom and is fitted with a tangential inlet located near the top, and an out-let at the bottom of the cone for discharging separated particles. The gas outlet pipe is extended into the cylinder to prevent short circulating of gas from inlet to outlet.

In operation, the particle-laden gas open entering the cyclone cylinder receives a rotating motion. The velocity so formed develops a centrifugal force, which acts to throw the particles radically towards the wall. The gas spirals downward to the bottom of the cone and at the bottom the gas flow reverses to form an inner vertex which leaving through the outlet pipe.

 ADVANTAGES :

   1) Low initial cost

   2) Simple construction and operation

   3) Low pressure drop and low maintenance requirements.

   4) It has no moving points

   5) Continuous disposal of solid, particles

Air Pollution And Control   10CV765

DISADVANTAGES :

1) Low collection efficiency for particles below 5-10μ in diameter.

2) Equipment is subjected severe abrasive deterioration.

APPLICATIONS :

1) Cyclones are widely used in cement manufacturers, feed and grain processing and wood working industries for the control of gas borne particulates.

2) They are used in rock crushing, ore handling, sand conditioning in industries to separate dust in disintegration operation.

3) Also used as catalyst dusts in the petroleum industry and in the reduction fly ash emissions.

FABRIC FILTERES [BAG HOUSE FILTER]

Fabric filter
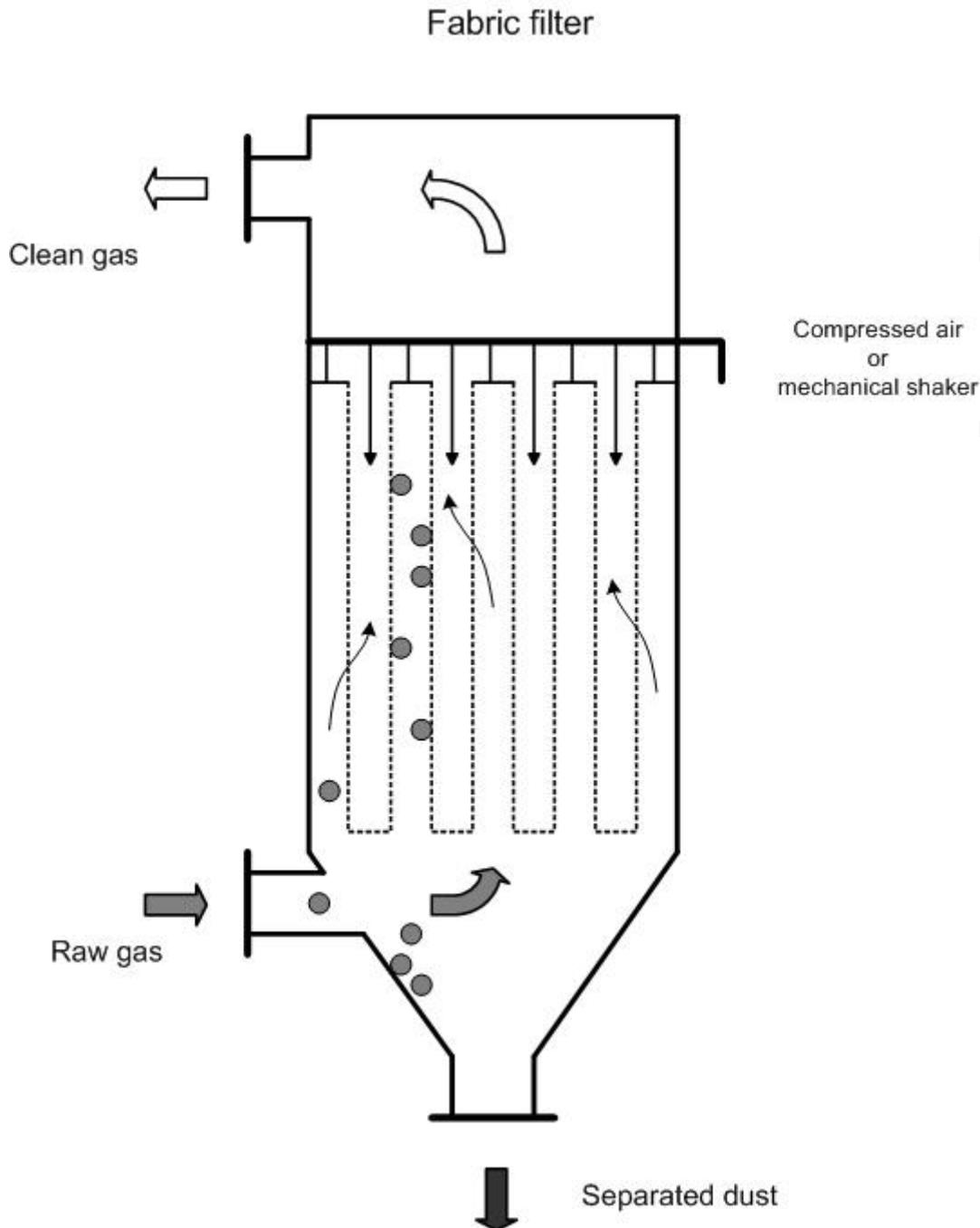
As the name indicates is in the form of a Fabric bag arrangement or cloth envelops. That is numerous vertical bags 120-400mm diameter and 2-10m long are housed together which are

suspended with open ends attached to a manifold, and a hopper is attached at the bottom for the collection of dust.

The gas entering through the inlet pipes strikes a baffle plate, which causes the larger particles to fall into a hopper due to gravity. The carrier gas then flows upwards into tubes and then outward through the Fabric leaving the surface of the bags, which requires a periodical cleaning by rapping, shaking or vibration or by reverse air flow.

Some of the operating problems of filters are,

1) Cleaning
2) Rapture of cloth
3) Temperature
4) Bleeding
5) Humidity
6) Chemical attack

Efficiency during pre-coat formation is low but as the pre coat (cack) is formed efficiency is 99%.

Factors Affecting Efficiency :

1) Excessive filter ratios i.e. the ratio of the carrier gas volume to grass filter area, per minute flow of the gas.
2) Improper selection of : filter media

ADVANTAGES :

1) High collection efficiency for all particle sizes especially for particles smaller than 10 mirror diameter.
2) Simple construction and operation
3) Normal power consumption
4) Dry disposal of collected material

DISADVANTAGES :

1) Operating units are imposed by high carrier gas temperature, high humidity, etc.

2) High maintenance and fabric replacement costs (replacement of lacking bags)

3) Larger size of equipment.

4) Problems in handling dust which may abrade, carrode or blind the dust.

APPLICATIONS

Fabric filters are extensively used in the follows industries and operations.

1) Metallurgical industry

2) Foundries

3) Cement lime plants

4) Chalk and lime plants

5) Brick works

6) Ceramic industry

7) Floor Mills etc.

ELECTROSTATIC PRECIPITATORS [ESP]

The electrostatic precipitator is one of the most widely used devices for controlling particulate emissions from industrial installations ranging from house hold appliances to power plants, cement and proper mills and oil refineries.
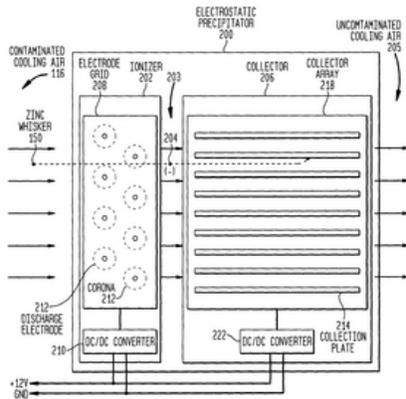
It is a physical process by which particles suspended in gas stream are charged electrically and under the influence of the electrical field, separated from the gas stream.

ELECTROSTATIC PRECIPITATOR : Consists of six major components,

   i)   A source of high voltage

   ii)   Discharge electrodes and collecting electrodes

   iii)   Inlet and outlet for the gas

   iv)   An electric cleaning system

   v)   'Hopper' for collection and disposal of particulates

   vi)   An outer casing [called shell] to form an enclosure around the electrodes.

TYPES OF PRECIPITATORS

Based on the electrode arrangements they may be classified into

   i)   pipe type precipitator

   ii)   plate type precipitator

PIPE TYPE PRECIPITATOR

In this type, the nest of parallel pipes acts as the collecting electrode. The pipes may be of round, square or octagonal cross-section. Generally the pipe is about 30cm or less in diameter. The discharge electrode is a wire {[2.8mm dia] with a small radius of curvature suspended along the axis of each pipe. The wires are suspended from an insoluble hanger at the top and kept under tension by weights attached to their lower ends and strong enough to with stand rapping or vibrating for cleaning purposes. The gas flow path is down around the outside of the tubes and then up through the inside of the tubes. The pipe electrodes are 2 to 5m is height / Length.

As the gas flows upwards, electrostatic forces causes the dust particles to migrate to the collector electrode where they stick. The cleaned gas then emerges at the top. The collected dust (aerosols) is removed periodically from the collector electrodes by rapping it ; this dust then falls to the dust hopper and is accumulated there fore periodic removal . Generally the pipe type precipitators are used for the removal of liquid particles in which case no cleaning mechanism is required.

PLATE-TYPE PRECIPITATORS

In the plate-type precipitators, the collecting electrodes consists of parallel plates of size 1-2m wide and 3-cm high. These parallel plates are special at 20-30cm. The number of plates in the precipitators depends upon the inlet flow; so that the inlet gas velocities are 1-2m/set in each channel. The discharge electrodes are similar to those used in pipe type precipitators. Sometimes electrodes of square rods (4 to 5mm) and twisted square rods (3.2 to 6.4mm) are used. These discharge electrodes (i.e. wires), made from non-corrosive materials like tungsten, alloys of steel and copped are suspended from the top and hang free with a weight attached at the bottom to keep them straight. The collection of the aerosols takes place on the inner sides of the parallel plates. The dust material can be removed by rapping and vibrating periodically.

The plate type precipitators are generally employed for the collection of solid particulates.

COLLECTION EFFICIENCY OF ESP

The ESP is a high efficiency collector with 98-99%

ADVANTAGES :

1) High collection efficiency.

2) Particles as small as 0.1 micron can be removed.

3) Low maintenance and operative cost.

4) Low pressure drop (0.25 to 1.25 of water)

5) Satisfactory handling of large quantities of high temperature gas.

6) Treatment time is negligible (0.1 to 10 seconds)

7) Cleaning is easy by removing units of the precipitator from operation.

8) There is no limit to solid, liquid or corrosive chemical usage.

DISADVANTAGES

1) High initial cost

2) Space requirements is more because of the large size of the equipment

3) Possible explosion hazards during collection of combustible gases or particulates well trained personnel are necessary to operate.

4) The poisonous gas, ozone is produced by the negatively charged discharge electrodes during gas ionization.

5) Precautions are necessary to maintain safety during operation.

6) Gases cannot be removed by ESP's

APPLICATIONS

1) Cement factories : Cleaning of floogas from cement kilns, recovery of cement dust from kilns.

2) Pulp and paper : Soda-Fume recovery in kraft pulp mills.

3) Steel plants : Cleaning blast furnace gas, removing tars from coke over gases, cleaning open hearth and electric furnace gases.

4) Chemical Industries – collection of So_x. Phosphoric Acid mist, cleaning various types of gases i.e., hydrogen, CO_2, SO_2, Removing dost from elemental phosphorus in the vapor state.

5) Petroleum industry:- Recovery of catalyst.

6) Carbon black industry :- Agglomeration and collection of carbon black.

7) Thermal Power plants:- collecting Fly ash from coal fired boilers.

WET SCRUBBERS OR WET COLLECTORS

These devices utilize a liquid called scrubbing liquid such as water to assist in the removal of particulates from the carrier gas stream. The Operational range for particulate removal by scrubbers include material less than 0.2µ in diameter. To large particles which can be suspended in the gas phase.

COLLECTION MECHANISMS

Particulates are removed from the gas stream by the following merchandisers.

1. IMPINGEMENT :- Here gas containing dust is swept through as area counseling liquid droplets from where dust particles will impinge upon the droplets, once they adhere they will be collected by them.

2. INTERCEPTION :- some time particles moving may not impinge on the droplets but can be captured because they brush against the droplet and adhere there, this is called interception.

3. DIFFUSION :- diffusion of the dispersoid onto the liquid medium helps in removal of the particulate matter.

4. CONDENSATION :- condensation of liquid medium vapors on the particulate, increases the size and weight of particles which can be easily removed.

TYPES OF SCRUBBERS

The common and important types of scrubbers are as follows.

1. Spray towers
2. Venation Scrubbers.
3. Cyclone   Scrubbers.
4. Packed scrubbers.
5. Mechanical Scrubbers.

SPRAY TOWER

A spray tower is the simplest type of wet scrubber into which water is introduce by means of spray nozzles. It can be ether round or rectangular in which gas is passes. Counter current to falling drops of liquid (usually   water) from spray nozzles the particle collection can be done by the mechanism of inertial impaction and interception on the droplets spray towers cause. Very little pressure loss and can handle large volume of gasser the towers are very effective in removing particles in excess o0f 10 um.

The efficiency of a spray tower depends upon the droplet size, flow velocity of the gas validity of liquid etc., it is 94% for sill particles to 99% for 25 um particles.

VENTURI SCRUBBERS

They are high energy wet scrubbers with high performance collection of fine particles, usually smaller than 0.5 5 llm diameter. The high performance of the various scrubber b. achieved by accelerating the gas strew to very high velocities.
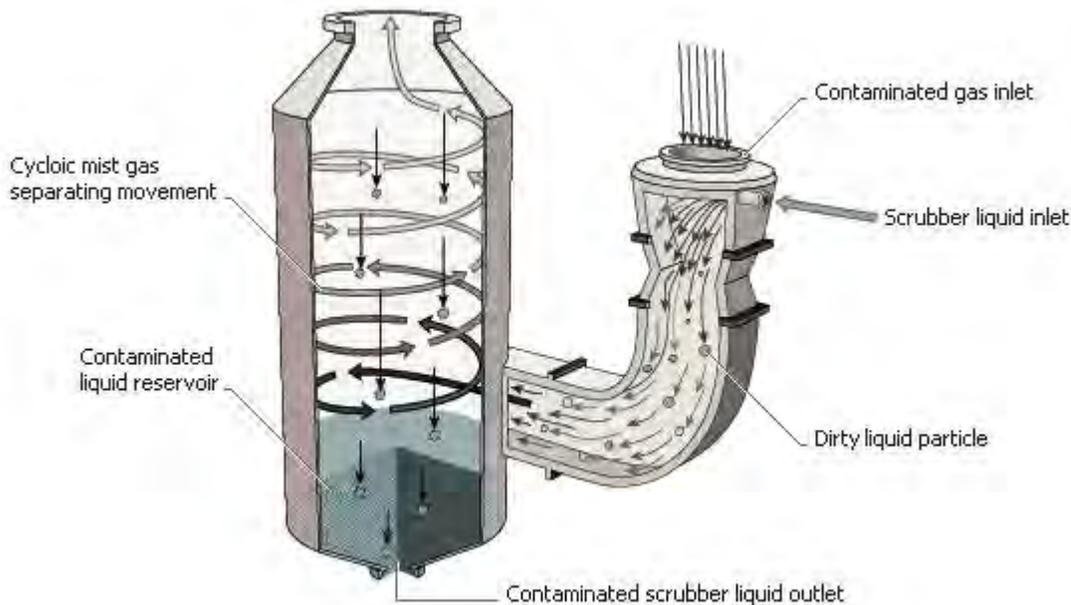
The droplets accelerate – throat section and due to the velocity difference between the particles and the droplets the particles are impacted agonist the   slow moving droplets. The celebration continues to some extent into the leveraging section of the venture. The gas liquid mixture is then directed   to a separation device such as cyclone separator where particulate matter is separated from the gas stream.

The application of various scrubber is more often in kraft mill furnaces metallurgical furnaces Sulphuric Acid concentrators etc., for removing mists and dusts from gases.

CYCLONE SCRUBBERS :

It is the modification of the dry cyclone by the addition of liquid phase. In cyclone scrubbers the gas is tangentially swirled around, same as in dry cyclone. Water sprays from the top of cyclone and outside the wall. These sprays assists in the collection of the disporsoid and prevent re entertainment. In cyclone scrubbers inertial impaction and separation are the main collection mechanisms. For droplets of 100um efficiency approaches 100% and 90 to 98% removal is achieved for droplets between 5 and 50um.
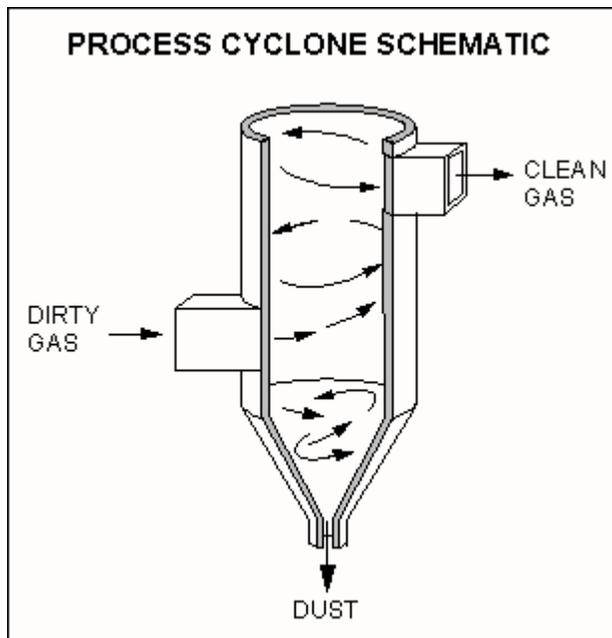
PACKED SCRUBBER (PACKED TOWER)

In packed scrubber fibre glass (fine glass filaments) or other packing (coke or broken stone) accused as the collection material. The polluted gas stream moves upward in a counter current flow packed scrubber and comes in contact with the scrubbing liquid stream which is moving downward over the packing in a film. The gas stream pass through the packing pore spaces and captures the particles by inertial impaction. Because of the good mass transfer

characteristics of the packing, efficient collection of the fine particles by diffusion is also possible. Similar packing increases the efficiency of collection but its shape does not appear to affect the collection efficiency. Sometimes packing towards encounter plugging problems, which can be reduced by employing sprays to wash the packing or by using low density spheres etc.,

MECHANICAL SCRUBBER :

It is the high energy scrubber and ha mechanical means of breaking up the scrubbing liquid into small droplet and simultaneously creating turbulence. It has internal rotating mechanical part. Where the liquid dispersoid contact is achieved by the simultaneously introduction of the liquid medium and the gas stream. The scrubbing liquid dribbles down on the rotating part and is struck violently and disintegrated by the centrifugal force and are removed quite easily. These scrubbers have a high initial cost; high operating cost and requires considerable maintenance.

ADVANTAGES OF SCRUBBERS (WET COLLECTORS)

1. Simultaneous removal of gases and particulates
2. Effective performance ever a wide loading range
3. Equipment occupies only a moderate amount of space compared to dry collectors such as bag houses.
4. Hazards of explosive dust air mixtures air reduced.
5. Indifference to the temperature and moisture content of gas.
6. Corrosive gases may be neutralized by proper choice of scrubbing liquid.

DISADVANTAGES:
1. Relatively high energy costs
2. Problem of wet sludge disposal
3. Corrosion problems

4. Visible wet plume, reduction to buoyancy.

5. Very small particles (sub-micron particles) may not be captured.

CONTROL OF GASEOUS EMISSIONS

There are essentially two classes of techniques by which gaseous pollutants may be removed from an effluent stream

1. Sorption of pollutant
   a. Absorption in a liquid
   b. Adsorption on a solid surface
2. Chemical alteration of the pollutant, through combustion or catalytic treatment

ABSORPTION BY LIQUIDS

Absorption is one of the most frequently used techniques for controlling of gaseous pollutants before they are discharges into the atmosphere. It involves the transfer of the pollutant from the gas phase to the liquid phase across the interface in response to a concentration gradient with the concentration decreasing in the direction of mass transfer.

ABSORPTION BY SOLIDS

Adsorption is a surface phenomenon by which gas or liquid molecules are captured by and adhere to the surface of a solid adsorbent. The attractive forces holding the molecules at the surface may be either physical (physical adsorption) or chemical (chemisorptions) in nature

Unit 6 - AIR POLLUTION DUE TO AUTOMOBILES

The automobile emissions plays a major role in the air pollution menance. Various causes of the genesis and exodus of those pollutants have been identified.

CLASSIFICATION OF AUTOMOBILES IN INDIA:

The three main types of automotive vehicles being used in our country are

a) Passenger cars powered by four stroke gasoline engines

b) Motor cycles, scooters and auto rickshaws powered mostly by small two stroke gasoline engines

c) Large buses and trucks powered mostly by four stroke diesel engines

EMISSIONS FROM GASOLINE POWERED VEHICLES are generally classified as

a) Exhaust emissions

b) Crank case emissions and

c) Evaporative emissions

EXHAUST EMISSIONS: The important exhaust emissions from a gasoline engine care carbon oxide , un burnt hydro carbons, nitrogen oxides and particulates containing lead compounds. These emissions vary with the air fuel ration spark timings and the engine operating conditions.

CRANK CASE EMISSIONS: It consist of engine blow by which leaks past the piston mainly during the compression stroke, and of all vapors generated into the crank case. The quality of blow by depends on engine design and operating conditions. Worn out piston rings and cylinder liner may greatly increase blow by. Those gases mainly contain hydro carbons and account nearly for 25% of the total hydro carbon emissions from a passenger car.

EVAPORATIVE EMISSIONS: Through a short term experimental determination it has been estimated that an average Indian passenger car would emit about 20 kg of hydro carbons through evaporation annually. For controlling evaporation of fuel from the carburetor and fuel system.

Systems are being developed that store fuel vapours in the crank case or on a charcoal canister that absorbs hydro carbons for recycling the engine.

Evaporative emissions essentially constitute the fuel evaporation from the fuel tank and carburetors and consists of hydro carbons alone

The amount of pollutants, that an automobile emits depends on a number of factors, including the design and operation (idle, acceleration etc) of the hydro carbons emitted by a car with no controls, the exhaust gases account for roughly 65%, evaporation from the fuel tank and carburetors for roughly 15% and blow by crank emission gases that escape around the piston rings for about 20%

DIESEL POWERED ENGINES: Diesel powered vehicles create relatively minor pollution problems compared to gasoline powered ones. The diesel engine exhausts only about a tenth of the amount of carbon monoxide exhausted by a gasoline engine, although its hydro carbon emissions. They approach those of the gasoline engine. Blow by is negligible in the diesel, since the cylinders contain only air on the compression stroke. Evaporative emissions are also low because the diesel engine uses a closed injection fuel system and because the fuel is less volatile than gasoline. The major problems of diesel engines are smoke and odour.

ADVERSE EFFECTS OF VEHICLE EXHAUSTS:

i) Contacts with pollutants – Irritation of the skin, eyes and respiratory system

ii) Excess amount of carbon dioxide and Methane – Asphyxiates

iii) Lack of Oxygen – destroys brain cells and affects central nervous system

The adverse effects experiment by the individual depends on

i)   Age

ii) General state of health and nutrition

iii) Concurrent exposure

iv) Pre existing disease

v)   Temperature and humidity of the time of exposure, duration of exposure

vi) Nature and concentration of pollutants

ADVERSE EFFECTS OF SOME POLLUTANTS ARE

1) Particular matter – smoke from diesel engines and load from gas line engines produces skin cancer and tumours of the lungs.

   Lead – long term effects, high blood levels, anaemia affects liver and kidney functions.

2) Carbon monoxide – it reduces oxygen carrying capacity of blood. Irreversible damage to the central nervous system.

3) Hydrocarbons – it causes smog which in tern damage plant, eye and imitation in respiratory tract.

4) NOx – death and chronic respiratory diseases.

CONTROL OF EXHAUST EMISSIONS IN VEHICLES:

Two main approaches to minimize exhaust emissions are

1. Modifications in the engine design and operating variables.

2. Treatment of exhaust gases after emission from the engine.

1. The following modifications may help in cleaner exhaust.

   a. Use of cleaner idle mixtures.

   b. Use of cleanest possible mixture and maximum spark retard compatible with good power output and drivability

   c. Use of minimum valve over tap necessary.

   d. Pre treatment of the mixture to improve vaporization and mixing of fuel with air.

   e. Low quench combustion chambers

   f. Piston and ring variables

2. Exhaust treatment devices

   The basic techniques is to promote oxidation of HC and CO after emission from the engine. Exhaust oxidation devices fall into two categories

   a. Promotion of after burning of the pollutants by exhaust heat conservation, introduction of additional air and by providing sufficient volume to ensure adequate reaction time

b. Use of catalytic converters. In after burners air from an engine driven blower is injected into the exhaust stream just after the exhaust valve. Sometimes an additional source of ignition is provided in the exhaust passage to initiate the after burning under certain engine conditions.

Other methods

1) Petrol injection
2) Stratified charge engine

CONTROL OF EVAPORATIVE EMISSIONS:

Insulation of the fuel tank to reduce temperature, sealed and pressurized fuel systems, and vapor collection systems have all been explored to reduce tank emissions.

CONTROL OF CRANK CASE EMISSIONS:

Designers are shifting crank-case exhaust vents from simple open ending to a feed back. New engines equipped with the positive crank-base ventilation (PVC) system return crank-case vapors through a vaccum valve, back to downstream side of the carburetor recycling burns hydrocarbon in the cylinders, dropping overall pollution by 25%

UNIT 7 – BURNING ENVIRONMENTAL ISSUES

ACID RAIN:

The term ACID RAIN is used to describe all precipitations rain, snow and dew which is more acidic than normal

ACID RAIN PRECIPITION is defined as one which has a pH less than 5.67

The destruction by acid rain is not confined only to lakes and forests. It corrodes buildings, monuments, statues and metals. Further it poses a serious threat to human health, since it contaminates drinking water

Generally 'CLEAN RAIN' is slightly acidic as it dissolves varying amounts of carbon dioxide, which is a common constituent of the earth's atmosphere. The lowest P_H vale of rain is 5.6 when it is clean. Rain having a ph of 4.6 is common in Eastern North America. This means, it is 10 times more acidic than the clean rain. In some places, PH as low as 3.7 or even less has been reported.

CAUSES:

Large quantities of sulphur and nitrogen oxides are emitted into the atmosphere from the chimneys of industrial plants. They react with the moisture in the air to form sulphuric and nitric acids which fall as acid precipitation for away. Acid rain therefore is a cocktail of sulphuric and nitric acids currently above 60-70% of the acidity is thought to be due to sulphuric acid and 30-40% to nitric acid.

The ecological impact of acid rain is quite serious. It's likely to produce irreversible charges. The acidification of streams and lakes affects aquatic animals and plants. High acidity results in the killing of fish, reduced growth, and perhaps reproductive failure charge in P_H prevents hatching of fish eggs. Large scale destruction of trout and salmon have been reported, due to high acidity. Acidity increases beyond the tolerable limits the concentration of heavy metals such as lead, cadmium, copper and zinc in water. Acid rain effects vegetation and soil in many ways. The growth of trees is adversely effected by acid rain.

REMEDY:

Are of simple solutions to the problem is to neutralize the acid with lime. It is a short term measure and it is required to be repeated periodically. It is quite expensive, especially when large areas of water bodies have to be limed.

Probably the best way to overcome this problem is to reduce the emission of SO_2 and oxides of nitrogen from industries. In other words it requires effective air pollution preventives, and control, for both stationery sources (like industries) and mobile sources (like automobiles) of pollution

GREEN HOUSE EFFECT
EFFECT OF CARBON DIOXIDE

Man's in advertent activities are: increasing the carbon dioxide content of the atmosphere which may probably bring about drastic changes in the world climate in the next 50 years. Increasing global consumption of fossil fuels is steadily increasing the CO_2 level in the atmosphere since the beginning of the tewntieth century . it has been estimated that the world's consumption of fossil fuels results in the release of nearly 9×10^9 tonnes of CO_2 per year.

The primary source of CO_2, is the consumption of fossil fuels. The secondary source is the oxidation of carbon compounds in marshes and forests by natural degradation. Manufacture of cement is another factor contributing to increasing of CO_2 in the atmosphere.

The production of CO_2 is very fast and has an influence on climate through what is called the GREEN HOUSE EFFECT.

The layer of CO_2 act like the glass in a green house because while the sun's radiation can pass through it and heat up the earth, It stops that same heat being required by the earth. In other words CO_2 is transparent to short wave radiation from the sun but absorbs the longer wave radiation from the earth. The net result of all this is that there is a danger of the earth gradually being heated up.

If the CO_2 content of the atmosphere is doubled which can occur by the middle of the next century then it will result in increase in the present world temperature by about $3.6^{\circ}C$. It is estimated that if the earth continues to warm up, all the glaciers will iced and the ice caps in the

Antarctic and Arctic will begin to melt. Consequently the sea level will rise by a few meters and most of the cities on the sea shore may be submerged

There are some factors which may concentrate the CO_2 effect. The warming of the atmosphere will increase cloud over and this will reduce the amount of incoming solar radiation. Agricultural and industrial operations as well as deforestation may generate a large quantity of dust which in turn can reduce the effective radiation and thus maintain the atmospheric temperature more or less at the same level.

To overcome the ecological crises due to CO_2 community based forestry schemes should be undertaken.

OZONE DEPLETION IN STRATOSPHERE:

The ozone layer serves as a shield, protecting the earth's surface from most of the ultra violet radiation found in the sun's radiation. However this layer may be depleted by reactions involving a variety of compounds, which reach the stratosphere of particular concern are the water vapour and nitrogen oxides released by high altitude aircrafts, nitrous oxide produced by the action of bacteria in soils comounts of which have became significant with the large scale use of nitrate fertilizers and chloroform hydrocarbon which are widely used as aerosol spray propellants and refrigerants. It is postulated that the combined effect of aircraft engine effluents, nitrate fertilizers and halogens would cause considerable depletion of the ozone layer and could result in an increase in ultraviolent radiation reaching the earth leading to drop damage and marked rise in cases of skin cancer. The recent reports of the ozone hole in the atmosphere over the Antarctica is a cause for great concern.

INDOOR AIR POLLUTION:

The inside environment of houses often has a higher level of air pollution then the surroundings in cities and towns. Unfortunately, indoor importance although most people spend as much as 80-90% of their time indoors. The various causes of indoor pollution are use of traditional fuel for cooking, tobacco smoke, temperature, humidity, micro organisms and

allergies. These of formaldehydes in construction materials and poor ventilation due to energy conservation measures in new homes and offices area also responsible for indoor pollution.

DUE TO BURNING OF TRADITIONAL FUELS:

About 50% of the world's households are using traditional fuels such as fire wood, animal dung, coke etc for cooking. The common pollutants which cause indoor air pollution problems due to combustion of fuel are particulate matter, oxides of sulphur, oxides of nitrogen, carbon monoxide, hydrocarbons and organic and odour causing chemicals. The emission quantity of these pollutants depends upon the type of fuel used, type of stove or furnace used, feed rate amount of additional air and operating conditions.

DUE TO POLLENS:

Studies have revealed that pollens, frugal spores and various types of dusts pollute indoor air and cause allergic all gases especially asthma----

DUE TO ARTIFICAL BUILDING MATERIALS AND POOR VENTILATION:

Indoor air pollution, especially in new energy efficient homes and offices is making many people around the world sick

The most serious problems so far have been reported in new and remodeled office buildings and homes with energy saving features, and in mobile homes. Most involves formaldehyde in construction materials, such as particle board and indoor plywood and in urea formaldehydes foam insulation.

Formaldehyde vapours leak into the air when the temperature rises and they combine with other contaminants into a mix that can cause headaches respiratory irritations watery eyes, nausea, diarrhea, skin irritations and heart problems.

REMEDY:

The following precautionary measures should be taken to overcome this special problem of indoor pollution.

i) Cautionary labels should be attached to construction materials that contain formaldehyde resins.

ii) Municipal health authorities should be authorized to test air within homes when a physician suspects formaldehyde or other vapours might be damaging a residents health.

iii) The air pollution control regulatory should have provision for compulsory testing of products at the point of manufacture to assure that they will not pollute indoor air

iv) Architects and construction engineers must make sure that air flow is not reduced to a danger point in the quest for energy efficiency.

UNIT 8 – STANDARDS AND LEGISLATION

INTRODUCTION TO AIR QUALITY

The Air (Prevention and Control of Pollution) Act, 1981 of the Government of India came into force from may 16, 1981. The Act is applicable throughout the country unlike the earlier Central Water Pollution Control Act, which is applicable only in states, which have adopted it. The Act provides for an integrated approach for tackling environmental problems relating to the pollution. Fuelwood and biomass burning is the primary reason for near-permanent haze and smoke observed above rural and urban India, and in satellite pictures of the country. Fuelwood and biomass cakes are used for cooking and general heating needs. These are burnt in cook stoves known as *chullah* or *chulha* in some parts of India. These cook stoves are present in over 100 million Indian households, and are used two to three times a day, daily. As of 2009, majority of Indians still use traditional fuels such as dried cow dung, agricultural wastes, and firewood as cooking fuel.

This form of fuel is inefficient source of energy, its burning releases high levels of smoke, PM10 particulate matter, NOX, SOX, PAHs, polyaromatics, formaldehyde, carbon monoxide and other air pollutants.Some reports, including one by the World Health Organization, claim 300,000 to 400,000 people die of indoor air pollution and carbon monoxide poisoning in India because of biomass burning and use of chullahs. Burning of biomass and firewood will not stop, unless electricity or clean burning fuel and combustion technologies become reliably available and widely adopted in rural and urban India.

India is the world's largest consumer of fuelwood, agricultural waste and biomass for energy purposes. From the most recent available nationwide study, India used 148.7 million tonnes coal replacement worth of fuelwood and biomass annually for domestic energy use. India's national average annual per capita consumption of fuel wood, agri waste and biomass cakes was 206 kilogram coal equivalent.

In 2010 terms, with India's population increased to about 1.2 billion, the country burns over 200 million tonnes of coal replacement worth of fuel wood and biomass every year to meet its energy need for cooking and other domestic use. The study found that the households consumed around 95 million tonnes of fuelwood, one-third of which was logs and the rest was twigs. Twigs were mostly consumed in the villages, and logs were more popular in cities of India.

AMBIENT AIR QUALITY STANDARDS

Section 16(h) empowers the Central Board to lay down standards for the quality of air in ambient air for the entire country. In exercise of these powers, the Central Board has notified the ambient air quality in its notification dated 16.12.82. For this purpose, the entire country is classified into three main categories as indicated below:

- A. Industrial and mixed use areas
- B. Residential and rural areas
- C. Sensitive areas

To begin with, standards for four major parameters like SPM, SO_2, CO, NO_x only are prescribed. As can be seen from standards laid down, the air quality is stringent as we go from category A to C. The standards laid down envisage a monitoring period of eight hours.

EMISSION STANDARDS

Section 17(1)(g) empowers the State Board to lay down, in consultation with the central board and having regard to the standards for the quality of air laid down by the Central Board, standards for emission of air pollutants into the atmosphere from industries, plants and automobiles or for the discharge of any air pollutant into the atmosphere from any other source, what-so-ever not being a ship or an aircraft. This section also provides for laying down different standards for emission for different industrial plants considering the quantity and composition of emissions of air pollutant into the atmosphere from such industrial plants.

Thus, it is observed that there are two types of limits on the emissions from major polluting scheduled industries:

i.   Standards laid down under Sec. 17(1)(g) and applicable over the entire state which the industry concerned will have to comply with wherever it might be located.
ii.   Specific emission limits that may be prescribed by the pollution control Boards in the consent conditions under Sec. 21(5). These limits should generally be more stringent than the standards set under Sec. 17(1)(g).

The Central and State Boards are evolving industry specific emission standards duly considering the prevailing ISI standards, and the guidelines given by the Policy Planning Committee set up by the Central Board. Emission standards stipulated should not only be easily enforceable but also be achievable with the present stage of technology and the equipment available in the country. The standards could be either based on total emission per unit of production or per unit volume of air emitted. As air pollution control is being adopted for the first time, the emission limits that are being laid down need to be revised progressively once in 3-5 years. Some of the State Boards have already laid down emission standards in respect of few specific industries.

PENAL PROVISIONS OF THE ACT

Failure to comply with the specific provisions of Sec. 21(5), Sec. 22, Sec. 23(1) and any other provisions of the act and directions issued under the Air Act, attract the penal provisions enumerated under Secs. 37-40 of the Act. The Act provides for stringent punishment including penalty. A Metropolitan Magistrate's Court or a First Class Judicial Magistrate's Court and higher courts are the courts where offences under this Act can be tried, that too on a written complaint made by the Pollution Control Board. Implementation of the Air Act calls for greater cooperation between polluter and the implementing authority.

Petrol Vehicles				
Three - Wheelers (g/km)				
Year	CO	HC	HC+Nox	
1991	12 - 30	8 - 12	-	-
1996	6.75	-	5.40	-
2000	4.00	-	2.00	-
2005(BS II)	2.25	-	2.00	(DF =1.2)
Two - Wheelers (g/km)				
Year	CO	HC	HC+Nox	
1991	12 - 30	8 - 12	-	-
1996	4.50	-	3.60	-
2000	2.00	-	2.00	-
2005(BS II)	1.50	-	1.50	(DF =1.2)
Car (g/km)				
Year	CO	HC	Nox	HC+Nox
1991	14.3 - 27.1	2.0-2.9		
1996	8.68 - 12.4			3.00 - 4.36
1998*	4.34 - 6.20			1.50 - 2.18
2000	2.78			0.97
B.S II	2.2			0.5
B.S II	2.2 - 5.0			0.5 - 0.7
B.S III	2.30	0.2	0.15	
B.S III	2.3 - 5.22	0.20 - 0.29	0.15 - 0.21	

Fuel quality plays a very important role in meeting the stringent emission regulation.

The fuel specifications of gasoline and diesel have been aligned with the Corresponding European Fuel Specifications for meeting the Euro II, Euro III and Euro IV emission norms.

The use of alternative fuels has been promoted in India both for energy security and emission reduction. Delhi and Mumbai have more than 100,000 commercial vehicles running on CNG fuel. Delhi has the largest number of CNG commercial vehicles running anywhere in the World. India is planning to introduce Biodiesel, ethanol gasoline blends in a phased manner and has drawn up a

road map for the same. The Indian auto industry is working with the authorities to facilitate for introduction of the alternative fuels. India has also set up a task force for preparing the Hydrogen road map. The use of LPG has also been introduced as an auto fuel and the oil industry has drawn up plans for setting up of auto LPG dispensing stations in major cities.

Environmental laws

In the Constitution of India it is clearly stated that it is the duty of the state to 'protect and improve the environment and to safeguard the forests and wildlife of the country'. It imposes a duty on every citizen 'to protect and improve the natural environment including forests, lakes, rivers, and wildlife'. Reference to the environment has also been made in the Directive Principles of State Policy as well as the Fundamental Rights. The Department of Environment was established in India in 1980 to ensure a healthy environment for the country. This later became the Ministry of Environment and Forests in 1985.

The constitutional provisions are backed by a number of laws – acts, rules, and notifications. The EPA (Environment Protection Act), 1986 came into force soon after the Bhopal Gas Tragedy and is considered an umbrella legislation as it fills many gaps in the existing laws. Thereafter a large number of laws came into existence as the problems began arising, for example, Handling and Management of Hazardous Waste Rules in 1989.

Following is a list of the environmental legislations that have come into effect:
- **General**
- **Forest and wildlife**
- **Water**
- **Air**

National Environmental Policy of India

Summary

"The National Environment Policy is intended to be a guide to action: in regulatory reform, programs and projects for environmental conservation; and review and enactment of legislation, by agencies of the Central, State, and Local Governments.

The policy also seeks to stimulate partnerships of different stakeholders, i.e. public agencies, local communities, academic and scientific institutions, the investment community, and international development partners, in harnessing their respective resources and strengths for environmental management. The dominant theme of this policy is that while conservation of environmental resources is necessary to secure livelihoods and well-being of all, the most secure basis for conservation is to ensure that people dependent on particular resources obtain better livelihoods from the fact of conservation, than from degradation of the resource."

ENVIRONMENTAL REGULATIONS AND LEGAL FRAMEWORK IN INDIA

1.1 ENVIRONMENT PROTECTION – FROM INDIAN CONSTITUTION PRESPECTIVE

a) The State's responsibility with regard to environmental protection has been laid down under Article 48-A of our Constitution, which reads as follows:

"The State shall endeavor to protect and improve the environment and to safeguard the forests and wildlife of the country".

b) Environmental protection is a fundamental duty of every citizen of this country under Article 51-A(g) of our Constitution which reads as follows:

"It shall be the duty of every citizen of India to protect and improve the natural environment including forests, lakes, rivers and wildlife and to have compassion for living creatures."

c) Article 21 of the Constitution is a fundamental right which reads as follows:

"No person shall be deprived of his life or personal liberty except according to procedure established by law."

d) Article 48-A of the Constitution comes under Directive Principles of State Policy and Article 51 A(g) of the Constitution comes under Fundamental Duties.

e) The State's responsibility with regard to raising the level of nutrition and the standard of living and to improve public health has been laid down under Article 47 of the Constitution which reads as follows:

"The State shall regard the raising of the level of nutrition and the standard of living of its people and the improvement of public health as among its primary duties and, in particular, the State shall endeavor to bring about prohibition of the consumption except for medicinal purposes of intoxicating drinks and of drugs which are injurious to health."

h) The 42nd amendment to the Constitution was brought about in the year 1974 makes it the responsibility of the State Government to protect and improve the environment and to safeguard the forests and wildlife of the country. The latter, under Fundamental Duties, makes it the fundamental duty of every citizen to protect and improve the natural environment including forests, lakes, rivers and wildlife and to have compassion for living creatures.

1.2 The subjects related to environment in the seventh schedule of the Constitution:

Union List

Entries	
52	Industries.
53	Regulation and development of oil fields and mineral oil resources.
54	Regulation of mines and mineral development.
56	Regulation and development of inter-State rivers and river valleys.
57	Fishing and fisheries beyond territorial waters.

State List

Entries	
6	Public health and sanitation.
14	Agriculture, protection against pest and prevention of plant diseases.
18	Land, colonisation, etc.
21	Fisheries.
23	Regulation of mines and mineral development subject to the provisions of List-I
24	Industries subject to the provisions of List-I.

Common or Concurrent List

Entries	
17A	Forests.
17B	Protection of wild animals and birds.
20	Economic and social planning.
20A	Population control and family planning

As conferred by Article 246(1), while the Union is supreme to make any law over the subjects enumerated in List I, the States, under Article 246 (3), enjoy competence to legislate on the entries contained in List II, and both the Union and the States under Article 246(2) have concurrent jurisdiction on entries contained in List III. In the event of a clash, the Union enjoys a primacy over States in that its legislation in the Union and the Concurrent List prevails over State legislations. Also, the Parliament has residuary powers to legislate on any matter not covered in the three Lists (Art. 248).

ENVIRONMENTAL (PROTECTION) ACT, 1986

The Environment (Protection) Act, 1986 was introduced as an umbrella legislation that provides a holistic framework for the protection and improvement to the environment.

In terms of responsibilities, the Act and the associated Rules requires for obtaining environmental clearances for specific types of new / expansion projects (addressed under Environmental Impact Assessment Notification, 1994) and for submission of an environmental statement to the State

Pollution Control Board annually. Environmental clearance is not applicable to hydro projects also. SJVNL undertakes Environmental Impact **Assessment** for all projects as a standard management procedure as laid down in The Environment (Protection) Act, 1986 and also functions within permissible standards of ambient air quality and noise levels as prescribed by national laws and international regulations. The Environmental Clearance procedure is at Appendix- III. Other rules and regulations under the Environmental (Protection) Act, 1986 applicable to the **operation** of SJVNL are described below:

AIR (PREVENTION AND CONTROL OF POLLUTION) ACT 1981

The objective of this Act is to provide for the prevention, control and abatement of air pollution, **for** the establishment, with a view to carrying out the aforesaid purposes, of Boards, for conferring on and assigning to such Boards powers and functions relating thereto and for matters connected therewith.

Decisions were taken at the United Nations Conference on the Human Environment held in Stockholm in June 1972, in which India participated, to take appropriate steps for the preservation of the natural resources of the earth which, among other things, includes the preservation of the quality of air and control of air pollution.

Therefore it is considered necessary to implement the decisions foresaid in so far as they relate to the preservation of the quality of air and control of air pollution.

WATER (PREVENTION & CONTROL) ACT 1974

The **objectives** of the Water (Prevention and Control of Pollution) Act are to provide for the Prevention and Control of Water Pollution and the maintenance or restoration of the wholesomeness of water for the establishment, with a view to carrying out the purposes aforesaid, of Boards for the prevention and control of water pollution, for conferring on and assigning to

such Boards powers and functions relating thereto and for matters connected therewith.

WILDLIFE PROTECTION ACT, 1972

According **to** the Wildlife Protection Act, 1972 "wildlife" includes any animal, bees, butterflies, crustacea, fish and moths; and aquatic or land vegetation which forms part of any habitat. In accordance with Wildlife (Protection) Amendment Act, 2002 "no alternation of boundaries / National Park / Sanctuary shall be made by the State Govt. except on recommendation of the National Board for Wildlife (NBWL)".

Further, in terms of Supreme Court Order dated 13.11.2000 the State Govts have to seek prior **permission** of Supreme Court before submitting the proposal for diversion of forest land in National Park sanctuaries.

THE BIOLOGICAL DIVERSITY ACT, 2002

The Ministry of Environment and Forests has enacted the Biological Diversity Act, 2002 under the United Nations Convention on Biological Diversity signed at Rio de Janeiro on the 5th day of June, 1992 of which India is also a party. This Act is to "provide for the conservation of biological diversity, sustainable use of its components, and fair and equitable sharing of the benefits arising out of the sued of biological resources, knowledge and for matters connected therewith or incidental thereto." As per the provision of act certain areas, which are rich in biodiversity and encompass unique and representative ecosystems, are identified and designated as biosphere reserve to facilitate its conservation. All restrictions applicable to protected areas like National Park & Sanctuaries are also applicable to these reserves. SJVNL abides by the provision of act wherever applicable and try avoiding these biosphere reserves while finalising the project infrastructure locations.

HAZARDOUS WASTES (MANAGEMENT AND HANDLING) AMENDMENT RULES, 2003

These Rules classify used mineral oil as hazardous waste under the Hazardous Waste (Management & Handling) Rules, 2003 that requires proper handling and disposal. Organisation will seek authorisation for disposal of hazardous waste from concerned State Pollution Control Boards (SPCB) as and when required.

OZONE DEPLETING SUBSTANCES (REGULATION AND CONTROL) RULES, 2000

MoEF vide its notification dt. 17th July, 2000 under the section of 6, 8 and 25 of the Environment (Protection) Act, 1986 has notified rules for regulation/ control of Ozone Depleting Substances (ODS) under Montreal Protocol. As per the notification certain control and regulation has been imposed on manufacturing, import, export, and use of these compounds. Organisations as per provisions of notification shall is phase out all equipment, which uses these substances, and is aiming at CFC free organisation in near future.

Air

1948 – The Factories Act and Amendment in 1987 was the first to express concern for the working environment of the workers. The amendment of 1987 has sharpened its environmental focus and expanded its application to hazardous processes.

1981 - The Air (Prevention and Control of Pollution) Act provides for the control and abatement of air pollution. It entrusts the power of enforcing this act to the CPCB.

1982 - The Air (Prevention and Control of Pollution) Rules defines the procedures of the meetings of the Boards and the powers entrusted to them.

1982 - The Atomic Energy Act deals with the radioactive waste.

1987 - The Air (Prevention and Control of Pollution) Amendment Act empowers the central and state pollution control boards to meet with grave emergencies of air pollution.

1988 - The Motor Vehicles Act states that all hazardous waste is to be properly packaged, labeled, and transported.