

Air Pollution

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1. Air Pollution and Air Pollutants

Air pollution is the presence in the atmosphere of some substances added directly or indirectly generally by an anthropogenic activity, in such quantity and of such duration so as to affect or try to affect human beings, animals, vegetations, materials, climates etc adversely.

The atmosphere is made up almost entirely of nitrogen and oxygen. Other gases and particulates exist in very small concentrations. The other gases are carbon dioxide, nitrous oxide, methane, ozone, inert gases and also some manmade gases called halocarbons that include CFCs, HCFCs, HFCs, halons etc.

Air pollutants are those substances that cause air pollution. These may be primary pollutants (directly added to atmosphere) or secondary pollutants (generated within the atmosphere usually from some primary pollutants). Example of primary air pollutants are: CO; SO₂; NO_x; Primary particulates etc. Examples of secondary pollutants are O₃, NO₂, H₂SO₄, HNO₃, etc. So, to control acid rain problem, caused by acids like H₂SO₄ or HNO₃, primary pollutants like SO₂ and NO_x are to be minimized.

Sources of air pollutants can be classified on the basis of mode of generation (natural sources and man made or anthropogenic sources) and also on the basis of shape or geometry of source (point, line or area sources). Example of point source may be a single stack, and a road with a number of vehicles may be a line source. Whereas an industrial belt with number of stacks is to be treated as an area source. Pollutants generated from area sources are the most difficult to control.

Sources, properties and effects of main criteria pollutants are shown in the tabulated form in Table 1.

2. Sources, Properties and Effects of Main Criteria Pollutants

Table-1: Sources, Properties and Effects of Main Criteria Pollutants

Name of the pollutant	Sources	Properties	Most relevant effects
Carbon monoxide (CO)	Mainly from mobile sources (due to incomplete combustion)	Colourless, odourless, tasteless, poisonous, haemoglobin has more affinity towards CO than oxygen.	Asphyxiation, Aggravation of angina pectoris; decreased exercise tolerance; possible risk to fetuses;
Nitrogen dioxide (NO ₂)	NO is produced in combustion with high temperature. NO ₂ is produced generally from oxidation of NO	Brown coloured, only air pollutant which is photolytically dissociable.	Formation of O ₃ , aggravation of respiratory disease; atmospheric discolouration
Sulfur dioxide (SO ₂)	Static sources like thermal power plants.	Odorous, water soluble	Wheezing, shortness of breath, chest tightness; plant damage and odour, synergy with particulate.
PM ₁₀	Static sources like thermal power plants.	Aerodynamic diameter ≤10μm, respirable	Exacerbation of respiratory mean disease symptoms; excess death; visibility
O ₃ (tropospheric)	NO-NO ₂ -O ₃ photolytic cycle	Oxidant	Decreased pulmonary function; surrogate for eye irritation; materials and vegetation damages
Lead	TEL used as additives in petrol/gasoline	Heavy metal	Impaired blood formation; infant development.
Ammonia	Industrial processes.	Odorous, form secondary fine particulate, water soluble	Generation of secondary fine particulates, odour

CO generates for incomplete combustion of carbon in suboxic condition. It causes asphyxiation. Automobiles are the most common sources of CO. NO_x is mainly emitted as NO from automobiles for combustion with high temperature, and further oxidized to NO_2 . NO_x is responsible for formation of O_3 , aggravation of respiratory disease; atmospheric discolouration. The most common source of Pb was Tetra Ethyl Lead, which was used as additive in gasoline. Lead may be responsible for impaired blood formation; infant development problems. Atmospheric particulate matters consist of any dispersed matter, solid, or liquid. These are characterized by their aerodynamic diameter (i.e. diameter of aerodynamically equivalent spherical particle). Particulates can be classified as Fig-1.

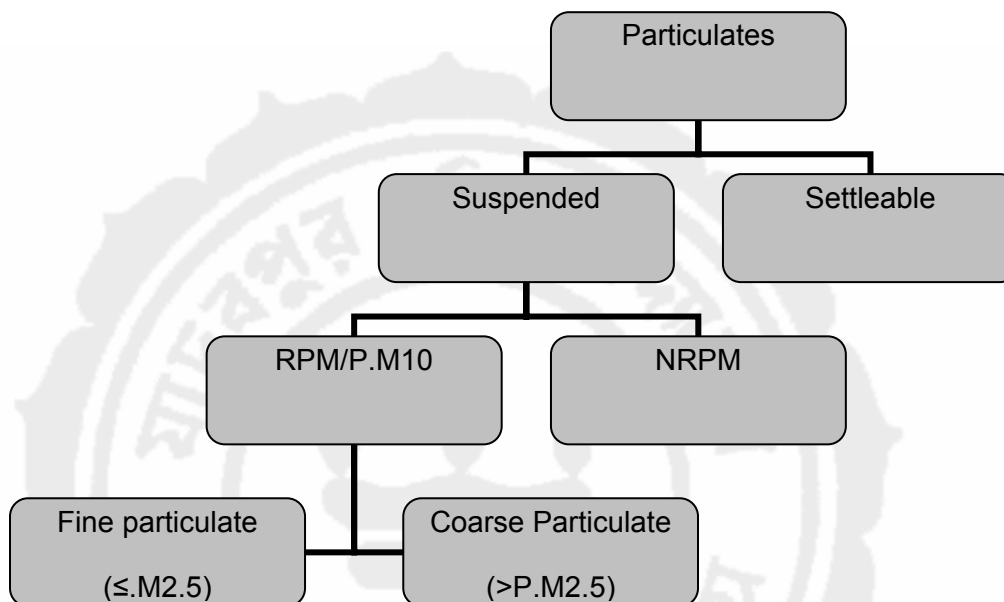


Fig 1: Classification of particulates.

Respirable particulates are responsible mainly for respiratory track related problems. Sources of SO_2 are mainly stationary fossil-fuel combusting units like thermal power plants. This is responsible for wheezing, shortness of breath, chest tightness; plant damage and capable to show synergistic health effect in presence of particulates. NH_3 being the pollutant that is the primary source of various secondary fine particulates.

In order to establish the need of monitoring and also uniform air strips, providing sufficient health safety, air quality standards are prescribed, based on pollutant criteria and depending on the best available technology (BAT) of the country. Pollutant criteria are the scientific information of any pollutant from dose response relationships of different epidemiological and toxicological studies. Air quality standards can be classified as Fig 2.

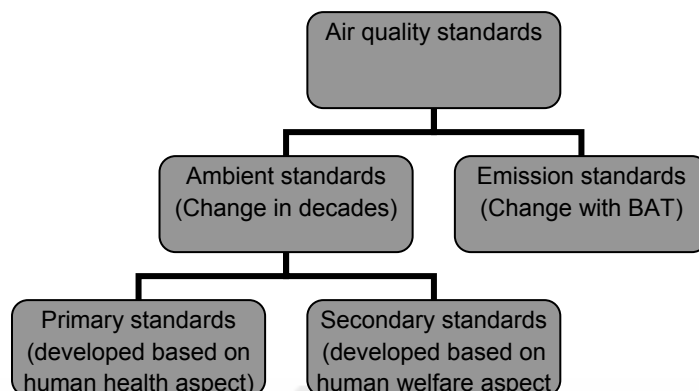


Fig 2: Classification of Air Quality Standards.

The air quality standard of any country is commonly known as National Ambient Air Quality Standards (NAAQS). NAAQS in the context of Indian air quality for different pollutants, including their averaging times and methods of measurements are given in the following table.

Table 2: National Ambient Air Quality Standards (NAAQS)

Pollutants	Averaging time	Concentration in ambient air		
		Land use		
		Industrial Areas	Residential, Rural & other Areas	Sensitive Areas
Sulphur Dioxide (SO ₂)	Annual Average	80 µg/m ³	60 µg/m ³	15 µg/m ³
	24 hours	120 µg/m ³	80 µg/m ³	30 µg/m ³
Oxides of Nitrogen as (NO ₂)	Annual Average	80 µg/m ³	60 µg/m ³	15 µg/m ³
	24 hours	120 µg/m ³	80 µg/m ³	30 µg/m ³
Suspended Particulate Matter (SPM)	Annual Average	360 µg/m ³	140 µg/m ³	70 µg/m ³
	24 hours	500 µg/m ³	200 µg/m ³	100 µg/m ³
Respirable Particulate Matter (RPM) (size less than 10 microns)	Annual Average	120 µg/m ³	60 µg/m ³	50 µg/m ³
	24 hours	150 µg/m ³	100 µg/m ³	75 µg/m ³
Lead (Pb)	Annual Average	1.0 µg/m ³	0.75 µg/m ³	0.50 µg/m ³
	24 hours	1.5 µg/m ³	1.00 µg/m ³	0.75 µg/m ³
Ammonia	Annual Average	0.1 mg/m ³	0.1 mg/m ³	0.1 mg/m ³
	24 hours	0.4 mg/m ³	0.4 mg/m ³	0.4 mg/m ³
Carbon Monoxide	8 hours	10.0 mg/m ³	4.0 mg/m ³	2.0 mg/m ³

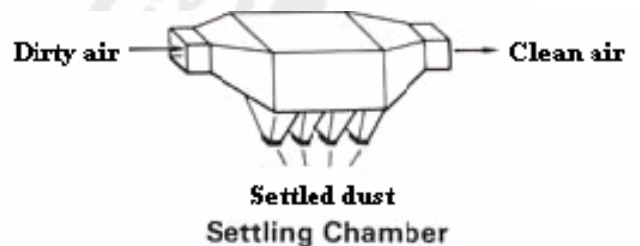
- Note: 1. Annual average is annual Arithmetic mean of minimum 104 measurements in a year taken twice a week 24 hourly at uniform interval
2. Daily average is 24 hourly/8 hourly values should be met 98% of the time in a year. However, 2% of the time, it may exceed but not on two consecutive days.
3. Most of the pollutants can be measures with high volume sampler (flow rate $\geq 1.1 \text{ m}^3/\text{min}$)

3. Control of Air Pollution

Nature has certain mechanisms to clean itself: natural cleansing mechanisms, which involve natural phenomena like spatial redistribution of pollutants, gravitational settling, rain out, wash out etc. Another very important mechanism is absorption of settled particulates by greenbelts to prevent re-entrainment to the atmosphere. The particulate matters settled by different forces are captured by leaves and other parts of trees, plants and grasses, which could have otherwise re-enter the atmosphere. Apart from this, artificial techniques are also employed. Out of those, the most significant one is waste minimization and comprises two basic steps: namely before and after the generation of wastes. Regarding sustainability of development and carrying capacity from the view of recurring accumulation of wastes, these steps are very much important. The first one can be achieved by changing process (e.g. converting coal fired thermal power plants to oil fired), changing raw materials (e.g. using unleaded petrol in place of leaded petrol) or by treating raw materials prior to use (e.g. coal washing, desulphurization), while the second one takes into account recycle, reuse or recovery of wastes. Apart from these downstream air pollution controlling equipments like gravitational settling chamber, cyclone, bughouse, ESP (for particulate control), scrubbers (for particulate and gaseous pollutants) can be installed to meet the standards. A brief description of some widely used air pollution controlling equipments is given below.

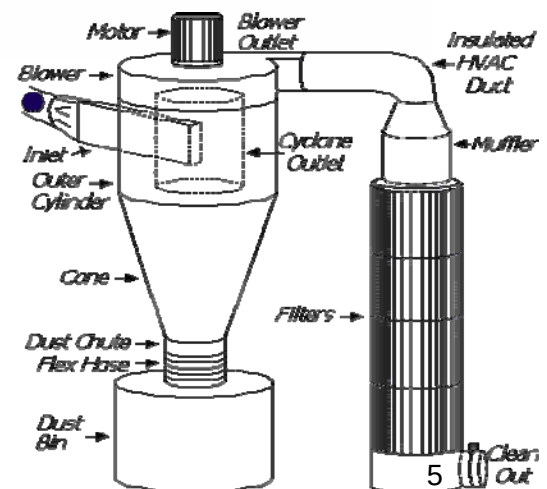
Settling chamber

A settling chamber consists of a large box installed in the ductwork. The sudden expansion of size at the chamber reduces the speed of the dust-filled airstreams and heavier particles settle out by gravitational force. Settling chambers are simple in design and can be manufactured from almost any material.



Cyclone separator

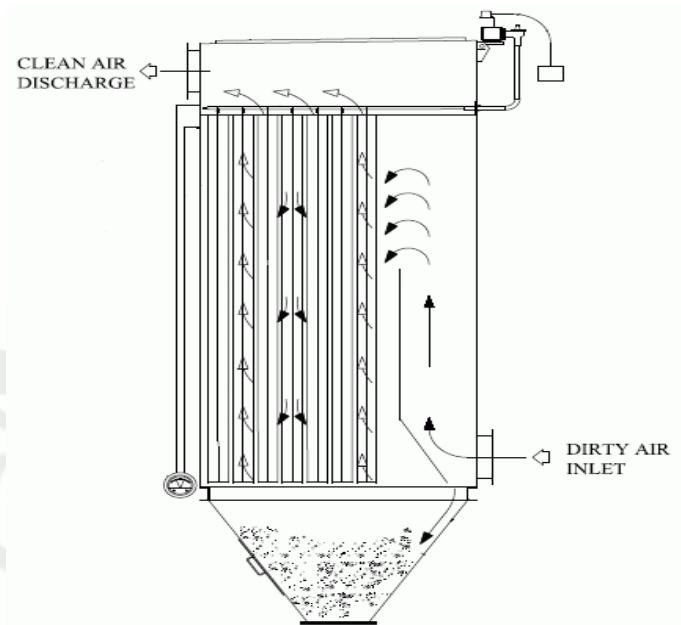
A cyclone separator is an apparatus for the separation, of fine particles suspended in air or gas by centrifugal means. In a typical cyclone, the dust gas stream enters at an angle and is spun rapidly. The centrifugal force created by the circular flow throws the dust particles toward the wall of the cyclone. After striking the wall, these particles fall into a hopper located underneath.



Baghouse

A baghouse is an air pollution abatement device used to trap particulate by filtering gas streams through large fabric bags. They are typically made of glass fibers or fabric.

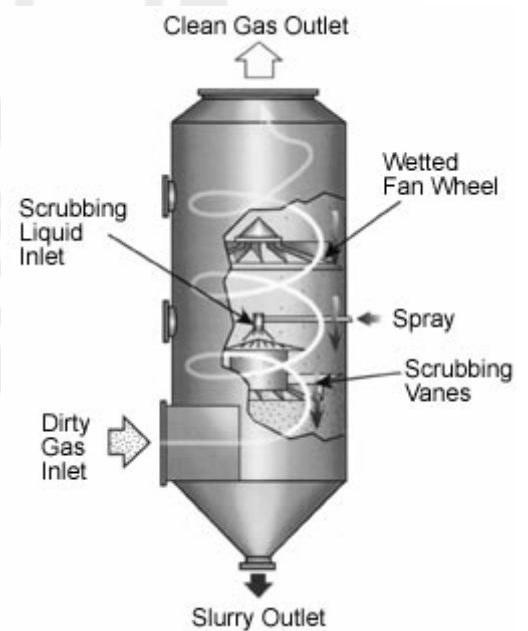
Cyclone separator



Scrubbers (wet scrubbers)

Dust collectors that use liquid are commonly known as scrubber (wet scrubbers). In these systems, the scrubbing liquid (usually water) comes into contact with a gas stream containing dust particles. The greater the contact of the gas and liquid streams, the higher the removal efficiency

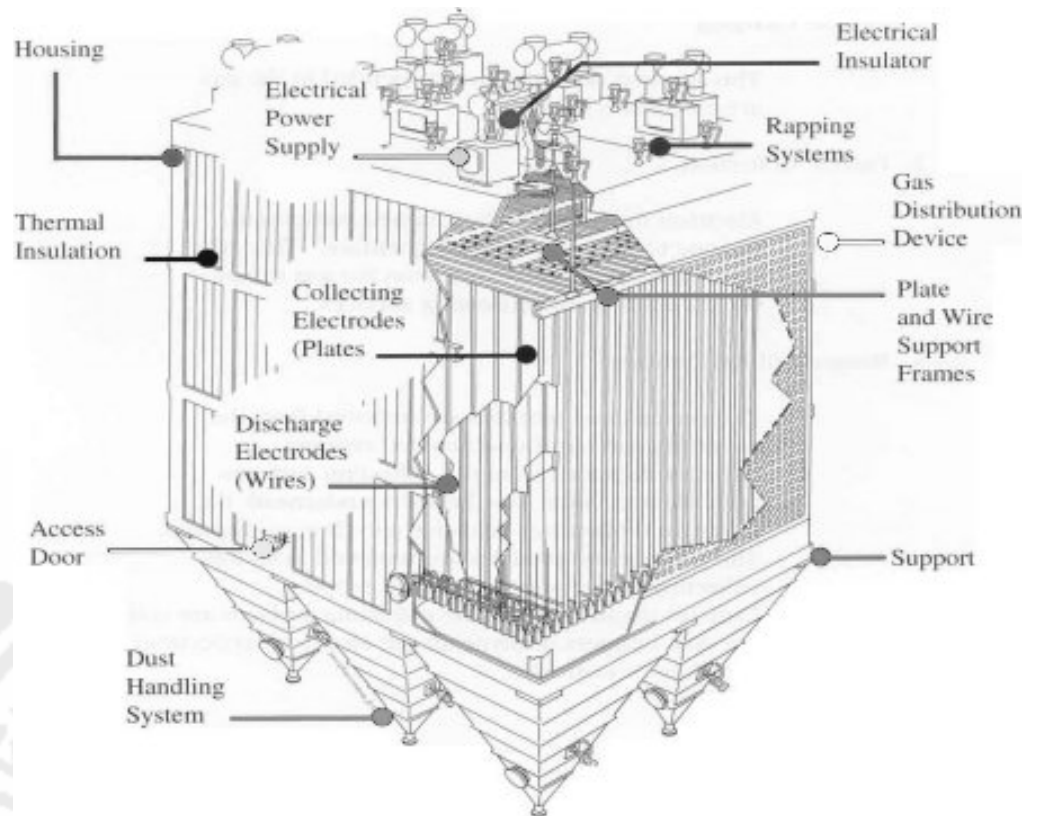
Baghouse



Wet scrubber

Electrostatic Precipitators (ESP)

Electrostatic precipitators use electrostatic forces to separate dust particles from exhaust gases. A number of high-voltage, direct-current discharge electrodes are placed between grounded collecting electrodes. The contaminated gases flow through the passage formed by the discharge and collecting electrodes. The precipitated dust is collected at the bottom of the unit and is removed by a dust handling system.



Electrostatic precipitators