CHAPTER - II

ENVIRONMENTAL POLLUTION

2.1 Environmental Segments

The environment consists of four segments, namely atmosphere, hydrosphere, lithosphere and biosphere.

Atmosphere

The atmosphere is the protective blanket of gases surrounding the earth. It is the blanket which sustains life on earth and saves it from the hostile environment of outer space. It absorbs most of the cosmic rays from outer space and a major portion of the electromagnetic radiation from the sun. It transmits only near ultraviolet, visible and infrared radiation (300-2500nm) and radio waves (0.14-40) and filters out ultraviolet radiation(below 300nm), which are tissue damaging.

The atmosphere plays a major role in maintaining the heat balance of the earth through absorption of infrared radiation emitted by the sun and reemitted from the earth.

Components of the atmosphere

The atmosphere consists of the following major, minor and trace elements:

Major components:

Nitrogen (78%)

Oxygen (20.94%)

Water vapour (0.1-5%)

Minor Components

Argon (9.34 X 10-1)

Carbon-di-oxide (3.25 X 10-2)

Trace components

Neon (1.82 X 10-3)

Helium (5.24X 10-4)

Krypton (1.14 X10-4)

Nitrous oxide (2.5 X 10-5)

Hydrogen (5X10-5)

Xenon (8.7 X 10-8)

Sulphur dioxide (2X10-8)

Ozone (trace)

Ammonia (1X10-6)

Carbondioxide (1.2 X 10-5)

Nitrogen dioxide(1X10-5)

Importance of the atmosphere

1. The atmosphere is the source of oxygen which is essential for the life on earth and carbon dioxide, which is essential for photosynthesis.

2. It also supplies nitrogen which nitrogen fixing bacteria and ammonia manufacturing plants utilize to yield chemically bound nitrogen essential for life.
3. It is a vital carrier of water from oceans to land, as part of the hydrological cycle.

Lithosphere

This is the outer mantle of the solid earth, consisting of minerals occurring in the earth's crust and the soil. The latter consists of a complex mixture of minerals, organic matters, air and water. The soil is the most important part of the lithosphere.

Biosphere

Biosphere denotes the realm of living organisms and their interactions with the environment, viz., atmosphere, hydrosphere and lithosphere.

Both the biosphere and environment influence each other. Thus, the oxygen and carbon dioxide levels of the atmosphere depend entirely on the plant kingdom. Green plants are responsible for the accumulation of oxygen in the atmosphere through photo synthesis and decay.

Hydrosphere

The hydrosphere includes all types of water resources, such as oceans, seas, rivers, lakes, streams, reservoirs, glaciers polar ice caps and ground water. About 97% of the earth's water supply is in the oceans, where the high salt content does not present its use for human consumption. About 2% of the water resource is locked in the polar ice caps and glaciers. Only 1% of the water

resource is available as fresh water, such as, surface water-rivers, lakes, streams and ground water for human consumption and forother uses.

The major uses of water are

Irrigation (30%)

Thermal power plants (50%)

Domestic usage (7%)

Industrial usage (12%)

2.2 Air Pollution

2.2.1 Introduction

Everyday man breaths nearly about 22000 times and inhales approximately about 15 to 22 kg of air. The air is available abundantly on the earth and it contains oxygen, carbon dioxide, nitrogen and small amounts of other gases which are harmless to us. However, it also contains substances that are harmful, like sulphur dioxide, carbon monoxide, nitrogen oxides, sulfur oxides, hydrocarbons, dust, soot, smoke and other suspended matter. Every time we inhale, we carry dangerous air pollutants into our bodies. These pollutants can cause short-term effects as well as long-term effects to the human beings.

The air pollutants enter into the atmosphere from various natural and man-made activities, such as forest fires, volcanic eruptions, dust storms, rapid growth of industries and vehicles. Polluted air causes physical ill-effects besides causing undesirable aesthetic

and physiological effects.

Air pollution from automobiles, industrial plants, coals burning power plants, incinerators and furnaces have created serious environmental pollution problems.

Definition

Air pollution may be defined as the presence of one or more contaminants like dust, smoke, mist and odour in the atmosphere which are injurious to human beings, plants, animals and materials.

2.2.2 Sources of Air Pollution

The two main sources of air pollution are

a) Natural Sources b) Man made or anthropogenic sources

Natural Sources

Natural sources are due to the natural phenomenon.

Examples

Forest fires, volcanic eruptions, dust storms, smoke, radioactive materials, pollen grains, marshes etc

Man made or anthropogenic sources

Pollution caused by the activities of human beings are called Anthropogenic sources. The man made sources are agricultural activities, industrial growth, domestic wastes, automobile exhausts, etc.

2.2.3 Types of Air Pollutants

Air pollutants are classified into two types. They are

1. Particulate Pollutants and
2. Gaseous Pollutants

1. Particulate Pollutants

The term *'particulate'* refers to all atmospheric substances that are not gases. They can be suspended droplets or solid particles or mixtures of the two. Particulates can be composed of materials ranging in the size from 100μm to 0.1μm

Examples

Dust , Smoke, Fumes, Mist, Fog, Aerosol.

Sources

The largest source of particulate matter is

- ❖ Coal-fired power plants.
- ❖ Exhaust of automobiles in a busy transportation area.

a) Dust

Dust contains particles of size ranging from I to 200μm.

Examples

Coal, wheat flour, cornstarch, magnesium, aluminum, silica etc.

Sources

These are formed by natural disintegration of rock and soil or by

the mechanical processes of grinding and spraying. They have large settling velocities and are removed from the air by gravity and other inertial processes. They vary in size and shape and are not uniformly diffusible. They tend to gravitate and those less than 5 m in size reach the lungs.

b) Fumes

Fumes are solid particles formed by the condensation from gaseous state. They are less than 1m size and come from molten metals.

Examples: Lead,Cadmium.

Sources

Chemicals and metallurgical processes.

c) Smoke

Smoke may have different colours depending on the nature of material burnt. It contains fine particles of the size ranging from 0.01 to 1 μm.

Sources

Smoke is formed from the incomplete combustion of organic matter.

d) Mist

Mist is made up of liquid droplets generally smaller than 10μm. They are formed by condensation in the atmosphere or are released from industrial operations.

e) *Fog*

Fog is similar to mist but the droplet size is bigger (> 10μ) and water is the liquid. Fog is sufficiently dense to incomprehensible vision.

f) *Bacteria*

These are particulate and submicroscopic.

2. Gaseous Pollutants

1. *Carbon monoxide (CO)*

Carbon monoxide is a colourless, odourless, invisible and poisonous gas. It is formed by the incomplete combustion of carbon containing fuels.

Sources

- Cigarette smoke, domestic heat appliances, automobile exhaust, wood stoves, incinerators and other industrial sources.
- It has been reported that about 95 to 98% of CO pollution comes from man made sources.
- Around the world about 4000 million tons of CO is emitted from the natural sources.

Ileffects

Inhalation of carbon monoxide affects the oxygen carrying capacity of blood and cause *Carboxyhaemoglobin*. Exposure to high level concentration leads to coma, irreversible brain damage

and even death.

2. Sulphurdioxide (SO_2)

Description

It is a colorless and irritating gas. Coals contain a significa amount of sulphur. SO_2 is emitted largely from burning of coa high-sulphur oil, and diesel fuel in industries like steel mill refineries, paper and pulp mills. It is not possible to remov sulphur from the coal, oil and diesel before burning. Hence th process of combustion results in the formation of SO_2.

Approximately about 200 million tons of SO_2 are generated annually from natural sources.

Sources

Coal burning in power plants.

Ill effects

1. SO_2 causes irritation of the mucous membranes of the respiratory tracks. Higher concentration causes bronchitis.
2. They attack building materials especially marble, limestone and mortar.
3. Affects cloth, leather and paper.
4. High concentration of SO_2 causes chlorosis (disappearance of chlorophyll), metabolic inhibition, plasmolysis and even death in plants.

3. Nitrogen Oxides (NOx)

Description

It is a reddish brown irritating gas. It reacts with other gases to form ozone and smog. There are various compounds, such as NO and NO_2, and hence they are designated as NOx. Oxides of nitrogen are originated from both natural and anthropogenic sources. Among nitrogen oxides, nitrogen dioxide pollution is contributed by anthropogenic sources. Among the sources, about 65% of NOx is emitted from automobiles, 25% is from burning of coal and 10% is from the use of natural gas.

Sources

1. Combustion of fossil fuels in automobiles or industry.
2. Lightning
3. Forest fires, bacterial decomposition of organic matter
4. Radiations

Illeffects

Lung irritation, acute bronchitis

4. Lead

Descripton

Lead is a solid toxic metal and it is emitted into the atmosphere as the particulate matter.

Sources

Paint, smelters (metal refineries),lead manufacture, storage batteries, leaded petrol.

Illeffects

1. Brain and other nervous system disorders.
2. Mental disorder in children.
3. Digestive disorder.
4. Cancer in test animals.
5. Convulsions.
6. Coma and even death.

5. Ozone

Description

Ozone is a highly reactive irritating gas with an unpleasant odour that is formed in the atmosphere. It is the major component of the photochemical smog.

Sources

Chemical reactions with volatile organic compounds emitted by cars and automobiles, and nitrogen oxides.

Effects

- Moderates the climate.
- Damages lung tissue.
- Breathing problems, including asthma, coughing, sneezing,
- Chest pain.

6. Hydrocarbons

Description

The gaseous and volatile hydrocarbons, such as methane, acetylene, ethylene and terpines are the examples of pollutants belonging to this category. Ethylene undergoes chemical reaction in the presence of sunlight and nitrogen oxide forming photo chemical oxidants, like ozone which are harmful.

Sources

1. Coal fields
2. Natural fields
3. Incomplete combustion from car engines
4. Industrial sources
5. Forest fires
6. Agricultural burning
7. Coal waste burning

Ill effects

Carcinogenic

7. Chromium

Description

Chromium is a toxic metal emitted into the atmosphere as particulate matter.

Sources

Paint, smelters, chromium manufacture,chromium paintings.

Illeffects

Nasal septum perforation,chrome holes.

8. Photochemical Smog

Description

Photochemical smog is a brownish smoke that appears on clea sunny days over large cities with significant amount of automobile traffic. It is formed by the chemical reaction among the nitrogen oxides and hydrocarbon in the presence of sunlight.

Illeffects

Causes breathing problem, cough, eye, nose and throat irritation heart diseases, reduces immunity.

1. Suspended Particulate Matter (SPM)

Description

It includes variety of particles and droplets (aerosols). They can be suspended in atmosphere for short periods to long periods.

Sources

Burning coal in power and industrial plants (40%),burning diesel and other fuels in vehicles(17%),agriculture, unpaved roads. construction etc.

Illeffects

- Nose and throat irritation, lung cancer, asthma. reproductive problems and cancer.
- Reduces visibility
- Causes acid deposition

- H_2SO_4 droplets damage trees, soils and aquatic life in lakes.

2. Cadmium

Generally, it is present in urban atmosphere and cigarette smoke. Cigarette smoking is the major source of cadmium accumulation in the body. Its normal level in air is 0.002 to 0.3 g/m ^{3} • The exposure to cadmium results cardiovascular diseases, hypertension, kidney and liver failure, and even death to human beings.

3. Mercury

Sources

It has relatively high vapour pressure. It is present in gaseous form in the atmosphere. Neurological damage, birth defects and damage to cerebellum and the cortex are the causes of mercury poisoning.

4. Asbestos

Chrysolite is the main type of asbestos fiber most abundantly used.

Illeffects

Inhalation of the asbestos fibres causes *asbestosis*. The symptoms are shortness of breath, lung cancer and *mesothelioma*(an incurable fatal cancer).

Studies observe that the possibility of cancer is eight times higher among asbestos workers who smoke compared to that among non smoking workers.

2.2.4 Air Pollution due to Industries

Many air pollutants are dispersed over areas hundreds kilometers from their sources where they affect many differe ecosystems. These pollutants often remain toxic in t environment for a very long time.

Table 2.1 Air pollutants from industries

S.No.	Type of Industry	Origin of emission	Pollutants emitte
I.	Chemical and Metallurgical Industries	Roasting and heating of lead, zinc and copper ores	SOx, NOx, C dusts, fumes an trace metals.
2.	Iron and Steel Industries	High temperature processing of coal and iron ore.	CO, CO_2 , PM Dust, fume hydrocarbons, H_2 and SO_2
3.	Chemical process industries	Raw material processing, reaction products and their purification.	SO_2, NH_3 , NO_2 hydrogen fluoride HCl, H_2S, variety of hydrocarbon compounds and solvents.
4.	Petroleum refining Industries	Various stages of refining process.	Oxides of sulphur, sulphur containing vapour, H_2S and

			hydrocarbons.
5.	Non-metallic mineral industries (Cement, glass , ceramics & refractories)	Operations of mining, crushing, transport and storage of materials.	Large quantities of hazardous dust.
6.	Food and agricultural industries	Food processing, crop spraying and dusting, use of fertilizers and field burning.	Vapours, odours, dust, chlorinated hydrocarbons, lead, arsenic, phosphate, smoke, fly ash and soot.
7.	Pulp and paper industry	Combustion of wood.	H_2S, methyl mercaptain, methyl sulphides, particulate matters, odour.
8.	Thermal power stations	Burning of coal and oil.	Fly ash, soot, SO_2 and trace elements.
9.	Fertilizer plants.		Oxides of sulphur,Ammonia, Particulate matter and fluorine.

2.2.5 Effects of Air Pollution

The effects of air pollution are listed below.

1. Effects of air pollutants on materials

The effect of air pollutants on materials are given in the follow table (Table 2.2)

Table 2.2 Effects of air pollutants on materials

Responsible Air Pollutants	Effects on Materials
Discoloration and deterioration of limestone and building materials.	NO_2 , CO, SO_2, acids a aerosols
Reduction in tensile strength of textiles.	SO_2, acids and gases
Cracking and strength loss of rubber.	O_3, Oxidants
Discoloration, surface erosion and soiling of paints.	CO, O_3, SO_2 , H_2 S and SPM
Embrittlement and discolouration of paper.	SO_2, acids and gases
Corrosion, tarnishing & strength loss in metals.	NO_2, SO_2,acids and gases
Disintegration and strength loss of leather.	SO_2, acids and gases

2. Effects of air pollutants on vegetation

The effects of air pollutants on vegetation are given in the following table (Table 2.3):

Table 2.3 Effects of air pollutants on vegetation

Pollutants	Effects on Vegetation
SO_2	Chlorosis (Disappearance of chlorophyll and yellowing of leaves).
NO_2	Premature fall of leaves and suppressed growth of plants and reduced yield.
Ozone	Necrosis (Dead areas on leaves), leaf damages and reduced yield.
PAN (Peroxyacylnitrate)	Premature fall of leaves, discolouration and Epinasty (downward curvature of leaves due to higher growth rate on the upper surface).

3. Effects on Animals

Animals take up fluorides of air through plants. Their milk production falls and their teeth and bones are affected. They are also prone to lead poisoning and paralysis.

Effects on Physical properties of Atmosphere

Some of the effects of air pollution on the physical properties atmosphere are:

i. Decrease in the visibility

ii. Reduction of Solar radiation

iii. Effects on weather conditions

iv. Effects -on atmospheric constituents

2.2.6 Control measures of Air pollution

The two types of control measures of air pollution are

1. Dilution
2. Control at source

1. Dilution

Tall chimneys are used to dilute the air pollutants into the atmosphere. The tall chimneys may penetrate the inversion layer of the atmosphere and disperse the contaminants by reducing the ground level contamination.

However, the method of dilution is a short term control measure and it is not suitable for long term control. Because, the pollutants dispersed by the tall chimneys are carried and spread around the area of disposal. This may cause harmful effects to the surrounding area.

2. Control at Source

Control of contaminants at the source is better option than the method of dilution.

This can be achieved by the following ways:

a. Proper use of the existing equipment.
b. Change in the process
c. Modification or Replacement of equipments.
d. Installation of controlling equipments.

a) Change in process

Table. 2.4 Changes in Processes of Industries

Industry	Pollutants	Control measure
Chemical & petroleum industries	Many air pollutants	• The volatile substances are removed by condensation. • Non-condensable gases are recycled and used foradditional reactions. • The hydrogen sulphide gas is recycled and used to recover the elemental sulphur.
Cement industries	Dust	• By reducing gas velocity within the rotary kiln. • By modifying the rate and location of the feed to the kiln. • By introducing a de curtain near the outlet.
Smelting & Paper industries	Highly objectionable sulph orous	• By hydro metallurgical separations of ores and use of

	material	no sulphides in paper making
Steel & Power plants	Oxides of sulphur	• By introducing a molten iron bath
	Oxides of nitrogen	• By recirculation of flue gas and water injection
	Fly ash particles	• By washing the coal before pulverization.

b) *Modification or Replacement of Equipments*

Table 2.5 Modification or Replacement of Equipments

S. No	Source	Type of Pollutant	Modification/ Replacement
1.	Automobile engines	Unburnt Carbon monoxide and hydrocarbon	Proper modification and maintenance of engine parts.
2.	Petroleum Refinieries	HC	
3.	Steel industries	Open-hearth furnace	Oxygen furnace or Electrical furnace.
4.	Automobiles	IC engines	Alternative power source.

1. Gravitational Settling Chambers

In this type of equipments, the particulate-laden gas is allowed to enter an enlarged area with a particular velocity. Inside the chamber, the velocity of the gas is reduced due to the enlarged portion. The gravitation force makes the dust particles to deposit at bottom of the hopper portion and makes clean gas.

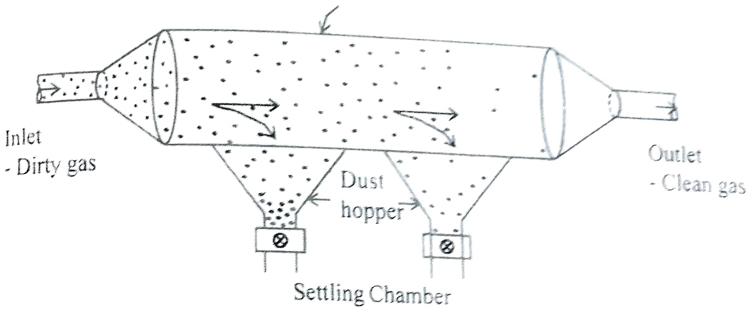

Figure 2.1 Gravitational Settling chamber

These types of gravitational settling chambers are generally used to remove large particles of size about 50mm from gas streams.

Advantages

- Simple in design, construction and operation
- Very less initial cost.
- Low operating cost.

Disadvantages

- Requires more space for installation.
- Less efficiency for particles of size smaller than 50m.

2. Cyclone Separators

A cyclone separator consists of an inlet, cylindrical shell, conical base and dust hopper. The dust-laden gas is allowed to enter tangentially in the inlet. A centrifugal force is generated by spinning the gas stream. This centrifugal force throws the particulates on the walls of cyclone which separates the particulate matters from the particulate laden gas. The cleaned air goes upward and the dust particles are collected at the bottom of the hopper.

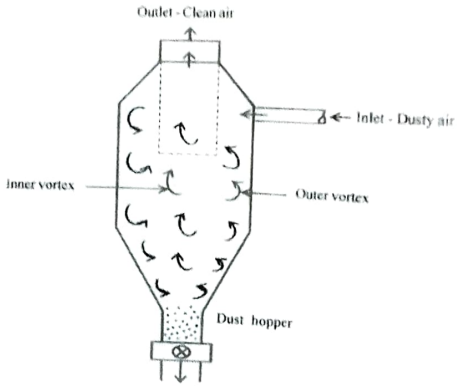

Fig.2.2. Cyclone separator

Advantages

- More effective than the gravitational settling chambers in the removal of much smaller particles.
- It is inexpensive.
- Operative cost is less.
- Handle large volume of gases at temperatures up to 98°C.

3. Fabric Filters (or) Bag Filters

These are the oldest equipments adopted for removal of particulate matters from industrial wastes.

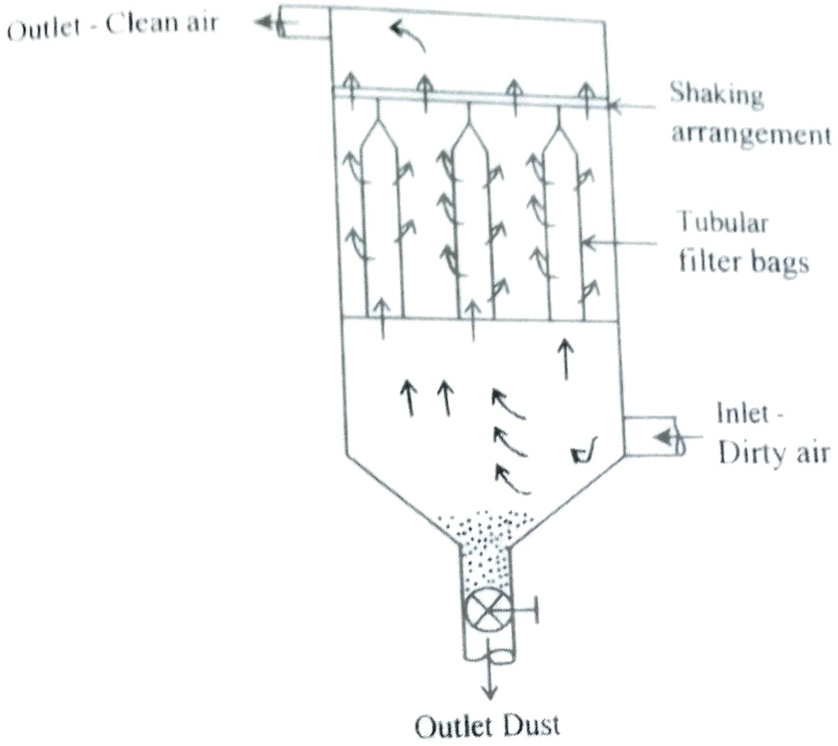

Fig. 2.3 Fabric filters

The bag houses consist of a group of bag (or fabric) filters suspended from an overhead support. The dust laden gas is allowed at the bottom of the bag house. The gas stream is allowed to pass through the bags. The dust particles are trapped at the fabric surface and the clean air is collected at the top. This accumulated dust particles are collected at the bottom of the bag house as solid waste. The bags are cleaned either by mechanical shakers or by reverse air.

Advantages

- ❖ High collection efficiency (99%).
- ❖ Collects broad range of particles.
- ❖ Cleans large volume of gases.
- ❖ Particles are collected in dry state.
- ❖ Particles up to 0.1μ are collected.

Disadvantages

- ❖ The possibility of explosion or fire.
- ❖ Requires more space for installation.
- ❖ Size of the unit is large.
- ❖ Construction cost is high.

4. Electrostatic Precipitator (ESP)

In this type of equipment, two electrodes are used to separate the dust particles from a gas stream. The gas stream is allowed to pass between the two electrode wires (which are called as discharge electrodes). The electrical charge is imparted to the particles through a high-voltage direct current corona. The high-voltage field ionizes the gas molecules in the air stream and makes the particulate matters with negative charge. The negatively charged particles are attracted by the positively charged electrodes which are called as collectors. The charge of the particles is neutralized at the moment of collection, and they can be removed from the collectors by rapping, washing or plain gravity.

Advantages

- Efficiency is very high (99%).
- More suitable for wide range of particle sizes.
- Sub-micron particles can also be collected.
- Large volumes of gases (25 to 1000 m^3/sec) can be cleaned.
- Maintenance is easy.
- Used to collect acid or tar mists.

Disadvantages

- High initial installation cost.
- Require more space.
- Require more power.
- More surface area is required for obtaining high efficiency .

8. Wet collectors (or) Scrubbers

The basic function of the Wet scrubber is to remove the particulate contaminants by making them contact with liquids, usually water.

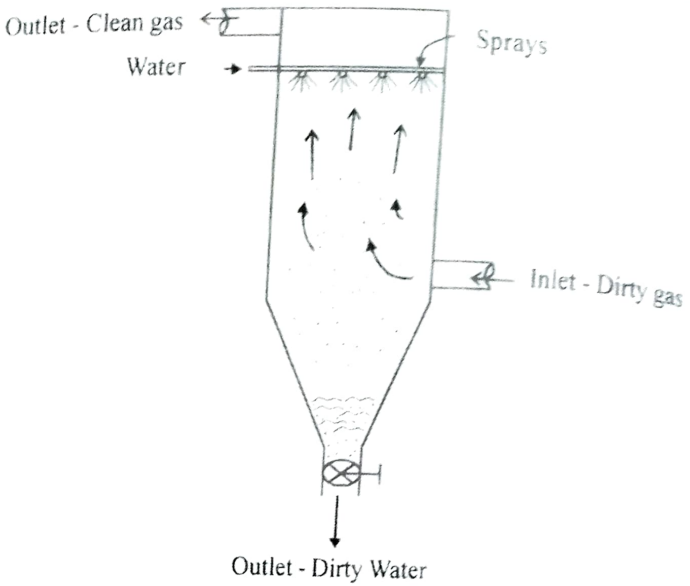

Fig 2.4 Spray Towers

The spray tower is a type of wet scrubber in which the air stream with particles is introduced at the bottom. The polluted gas flows upward. Water is introduced at the top by means of spray nozzles. By inertial impaction and interception, the particulate matters are entrained by the water molecules. The water with particles is collected at the bottom and disposed.

Advantages

- Very effective in the removal of gases and particulates.
- Effective in wide range of loading.
- Requires less space.
- Lesser chance of explosion of dust-air mixtures.
- Corrosive gases may be neutralized by proper choice of scrubbing liquid.

Disadvantages

- High energy cost is
- Difficult to dispose wastewater.
- More possibility of corrosion.
- Less efficient in collecting very small particles.

2.3 Water Pollution

2.3.1 Definition

Water pollution is defined as any physical, chemical or biological change in quality of water that has a harmful effect on living organisms or makes the water unsuitable for needs.

2.3.2 Sources of water pollution

Water pollution may be caused by many sources. But the two major sources of water pollution are:

1. Point sources and
2. Non-point sources.

1. Point sources

- Point sources discharge pollutants at a specific place through pipelines, sewer lines, or ditches into water bodies.
- Identification, monitoring and control of discharge from point source are easy.