: Pollution and Its Control:

Introduction: when a foregien particle enters the environmente & changes its originality. Such scenioria is called Pollution.

& Cause of this will be human activities.

* Now adays, the air we breathe, the water we drink and place where we live. are contaminated with undesirable substances, these ulters the natural quality of the environment. These undesirable substances are called pollutants.
* Pollutants can be gaseous or liquid effluents.
* These pollutants may contain some valuable / useful products, so we have to recover these by chemical analysis of effluents.

Types

1) Air
2) Water
3) Soil
4) Noise.

Air Pollution:

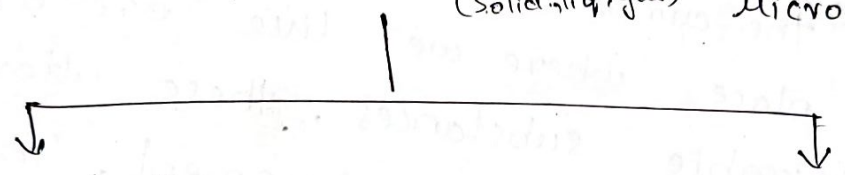
Meaning ⇒ Any ~~change~~ in qualitative. & Quantitative change in air (air is made up of different type of gases. ; change in quantity of gas). change in normal composition of

of air., which is harmfull to human being, plants, animals & property.

* Every individual person breaths 20000 times in a day., & inhaling 15-22 kg of air.

Causes of air poldution:

1) Suspended particulate matter. (airborne suspensions of extremely small solid or liq. particles.) (Solid, liq, gas) (0.002 µm - 100 µm). (Micron - unit of length)



(a) Natural Sources

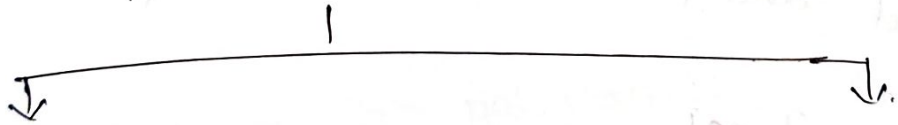
Ex: Volcanic Eruptions.
- Volcano - liquid.
- Volcanic ashes - solid.
- Radioactive minerals present in earth crust.

(b) Manmade Sources. (Anthropogenic Sources).

Ex: Industries.

Ex: Dust, smoke, Smog, Asbestos lead, mercury, cadmium.

(2) Gaseous pollutants:



Natural Source.

* forrest fires
* Wind blown dust.

Man-made Source. (Anthropogenic source).

* Burning wood.
* fossil fuel burning.

Ex: SO_2, SO_3, H_2S, NO_x, CO, CO_2, Hydrocarbons.

Types of air pollutants:

1) Primary air pollutants.
2) Secondary air pollutants.

This classification is done on bases of sources from which they are produced.

Sources: Point Sources

→ Single identifiable sources of pollution from which pollutants are discharged.

· Ex: Factory smokes.
Brick kilns.
Thermal power plants.
Fossil fuel consumption
volcanic eruption
Automobiles.

Non-Point Sources.

→ Diffused sources.

Ex: - Excess fertilizers.
- herbicides
- Insecticides
· From agricultural & residential areas.

1st Type: Primary air pollutants:

The primary air pollutants are directly emitted from the processes. (Point Sources).

The major primary pollutants are oxides of sulphur, oxides of Nitrogen, Oxides of Carbon, Particulate matter, Methane, Ammonia, Chlorofluorocarbons, Toxic metals etc.

Secondary air pollutants:

* Secondary pollutants are not directly emitted.
* When primary pollutants react with themselves, or with other components of the atmosphere.

Ex:- ~~Smoke~~ Smog. (Smoke + fog).

- Ground level ozone (Propospheric ozone/Bad ozone)

* Organic pollutants.

- hydrogen cyanide.

$2SO_2 + O_2 \rightarrow 2SO_3$.

Ex: $SO_3 + H_2O \longrightarrow H_2SO_4$.

Ex: $2NO_2 + H_2O \longrightarrow 2HNO_3$.

Nitrogen dioxide. — primary pollutant.

Nitric acid — Secondary pollutant.

1°-pollutant → CO, NO, SO_2, NO_2, NH_3, volatile org. compounds.

2°-pollutant → SO_3, HNO_3, H_2SO_4, H_2O_2, O_3, NH_4^+.

Types of air pollutants as per WHO:

6 Common air pollutants according to WHO.

- Carbon monoxide (CO)
- lead
- Nitrogen oxides
- Ground level ozone
- particle pollution (particulate matter).
- Sulfur oxides.

- These are also called as Criteria pollutants (designated by U.S. - Environmental Protection Agency (EPA)).

Criteria pollutants → "Concentrations of these pollutants in the atmosphere are useful as indicators of overall air quality"

Particulate matters : Like lead., Fly ash, metallic oxides Nanoparticles.

Gaseous pollutants : CO, CO_2, CFC's, O_3, NO, SO_2, benzene biological pollutants.

→ Gaseous criteria pollutants are observed in urban cities.

Ex: SO_2, NO_2, CO. → these are emitted directly into air from fossil fuels (such as fuel oil, gasoline, natural gas) that are burnt in power plants., automobiles & other combustion sources.

Ex: Ozone (Key component of smog → smoke + fog. is also a gaseous criteria pollutant.
- It is formed in atmosphere via complex reactions occuring between nitrogen dioxide & various volatile organic compounds. ex → gasoline vapours).

Ex: Lead fumes → Airborne particulates
- Size less than 0.5 μm.

or acid

- They are toxic & major pollutants.
- Released from diesel fuels.
- In humans, lead damages the Nervous system, digestive tissues, kidney tissues, on brain activity.

Ex: Fly ash → * Oxides of heavy metals.
Silicate, Silicon dioxide, Cal Calcium oxide
* Source of fly ash is thermal power plant

Ex: Nanoparticles → Diameter is less than 100 nm.
* Makes clouds of dust particles.
* Due to these ozone diplition will takes place.
* Changes temperature in stratosphere.

Air Pollution Control : At Source.

* Most effective way to control the air pollution is to prevent the formation of pollutants.
* And reduce their emission at the source itself.

Source Correction Method: In case of Industrial pollutants, the designing & developments of plant may be selected so as to minimize the air pollutants.

- Various air pollutio

: Various Air Pollution Control methods:

(or)

Source correction methods:

1st Method: Use of correct grade of raw material.

Ex: low-sulphur oil & coal is recommended.

2nd Method: If needed, operational changes can be done. [Industrial technology].

Ex: Reduction of atmospheric ~~pollution~~ emission of pollutants.

⇒ H_2S produced can be recycled to recover sulphur.

3rd method: Equipment modification. - also helpful in reducing atmospheric emission pollutants.

Ex: Design modification of tanks., evaporation from petroleum refineries can be minimised.

Particulate ~~Control~~ pollution control:

* Here the removal of pollutants from effluents & are used in conjunction with source correction methods.
* For removal of pollutants from effluents., control devices are used.
* Selection of control devices is based on physical & chemical character of particulate.
  - the particle size.

or

Particulate matter control.

Particulate matter is sum of all solid, liquid particles suspended in air, many of these particulate matter are hazardous.
Ex: dust, soot, smog, etc.

Selection of Controlling devices:

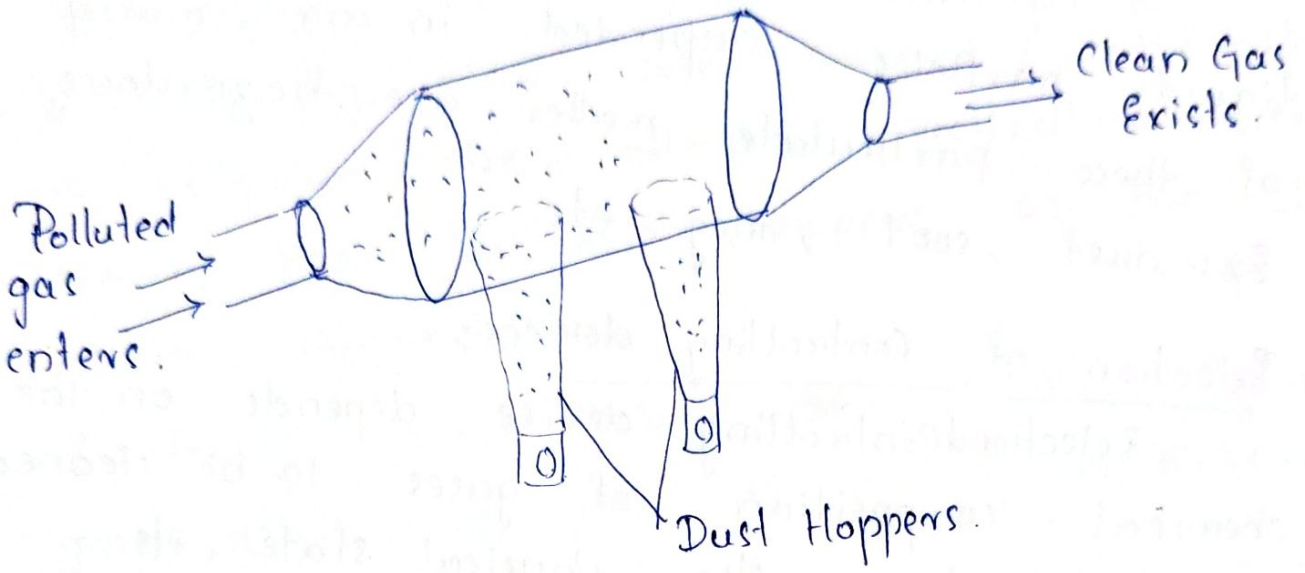
Selection of Controlling device depends on the chemical composition of gases to be cleaned & its temperature. Also physical state, its abrasive property, size, shape, chemical composition & electrical sensitivity is also considered for selection of controlling devices.

5 major group of controlling methods:

1. Settling chambers.
2. Inertial separator / Cyclonic collector.
3. Electrostatic precipitator.
4. Bag houses & filters.
5. Wet scrubbers.

I] Settling Chambers:

* Simple device, which collects the particles of size greater than 10 μm.
* Settling chambers uses gravity force to remove solid particles.



The polluted gas enters the chamber where the velocity of gas is reduced. Large particles droped out of the gas due to gravity & collects in Hoppers.

Settling chambers are effective in removing only larger particles

In Settling chamber, the size, shape of particles & density, viscosity are important parameters.

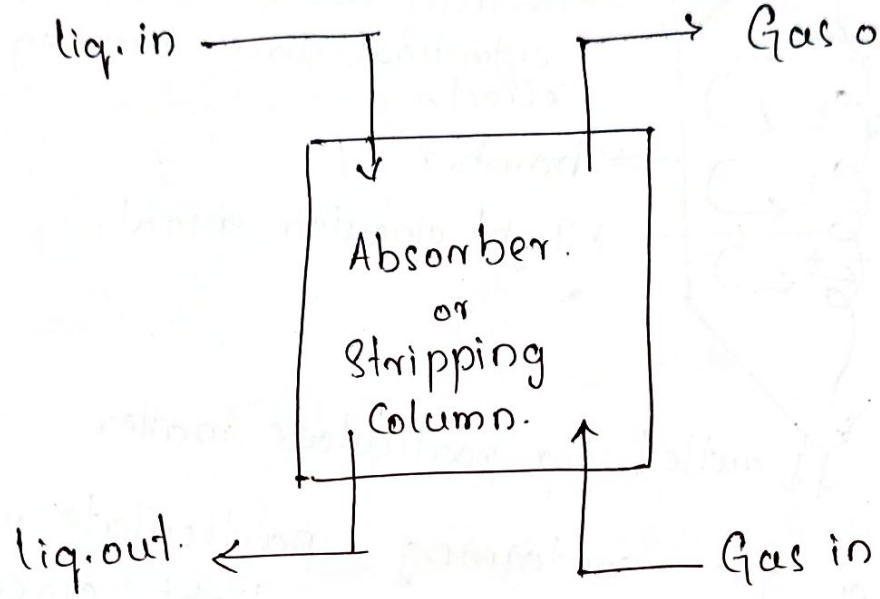
Electrostatic Precipitators:

* In electrostatic precipitators, the polluted air which contains particulate matter was passed between high voltage discharge electrodes.

* Many of particulate matters gets charged & collects on the collecting plates.
* At regular intervals, the discharge electrodes & collecting plates are rapped (strike (or) knock) to dislodge the collected particulate matter, which then fall into hoppers at the bottom of the precipitator.
* Electronic precipitators are efficient for the particulate matter of size below 0.01 μm.
* Precipitators can operate at high temperature as high as 700°C.

method:

General mechanism of Scrubber:



Absorber → Can be any solid substance or Gel which (Dry Scrubber) can absorb (or) react with pollutant to convert it into less toxic.

Stripping Column → A Column which is used to flow of water. (Wet Scrubber)

Arrestors : I. → Cyclone Collectors:

* Cyclone collectors are used to preclean the air.
* These collectors are based on principle that particulate present in gaseous stream possess greater interia than that of gaseous molecules.

Set up → Consists of Chamber in which a light circular spiral is fitted.

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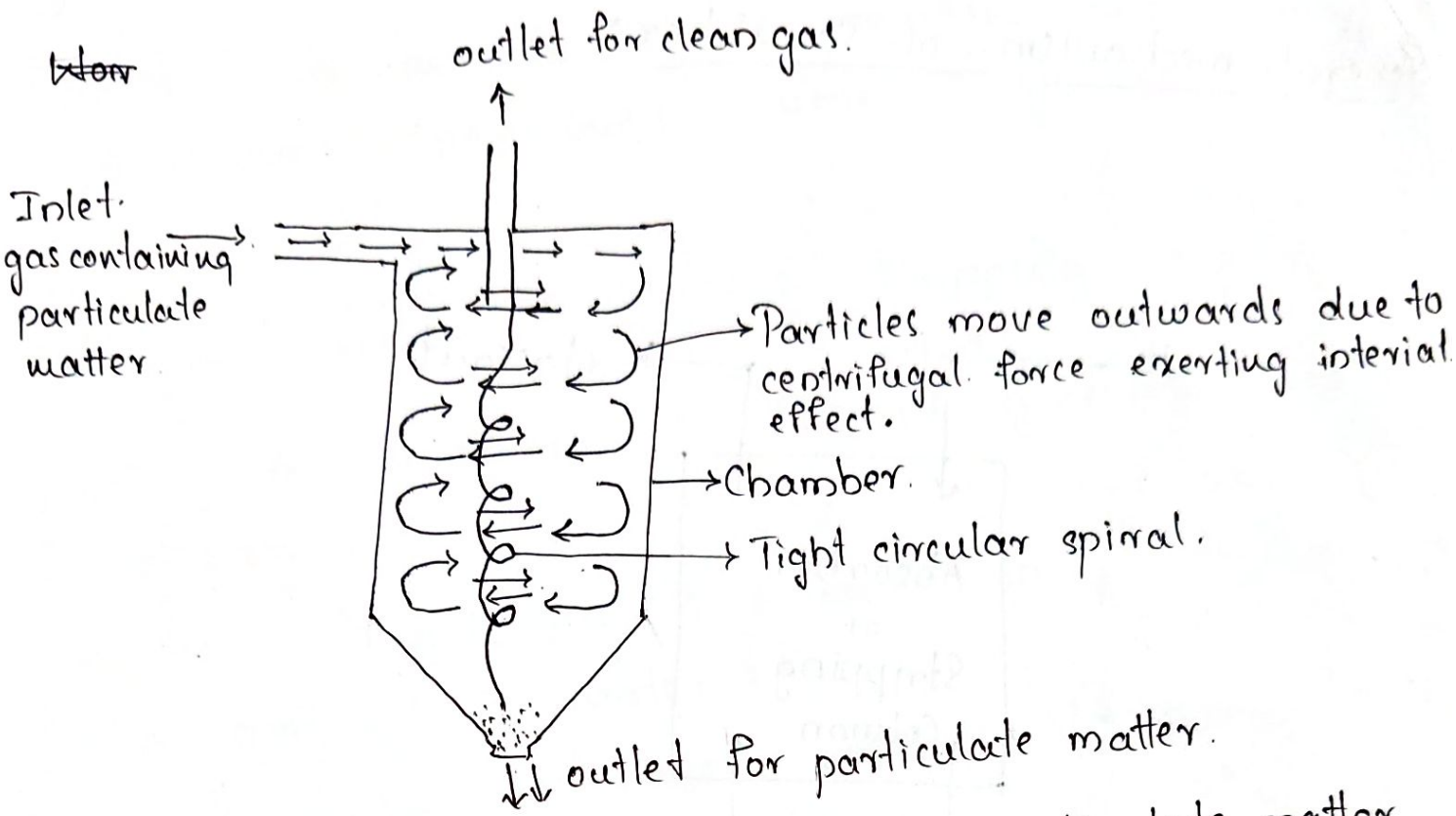


Working: When a gas containing particulate matter is allowed to flow into a tight circular spiral - fitted chamber.

- The particulate move away from the gas and move towards the chamber.
- From where they settle down due to the force of gravity.
- The collected particulates at the outlet and be taken out.
- And clean gas flows out of the chamber.

Efficiency: Cyclone collector is most efficient for the removal of particulates of size 5 - 20 μm.

This cyclone collector is more effective than gravitati- -onal setting chamber, b-coz the centrifugal force acting on the particles in spinning gas

stream is much stronger than the force of gravity.
- Another advantage is it requires less space to handle the same volume of gas.

Scrubbers: Wet Scrubbers: - Stripping Columns are used.
- In Wet Scrubbers the liquid generally used is water.
- The exhaust gas is allowed to pass through a spring of water.
- The stream of water removes the particulates with it along with little gas pollutants.
- It is used to remove.
- Some times the water used can be mixed with lime.
- Lime reacts with sulphur dioxide to and forms a precipitate of calcium sulphate.

Efficiency → Efficiency of wet scrubber is greater than 75%.

Disadvantage → The waster water may cause water pollution.

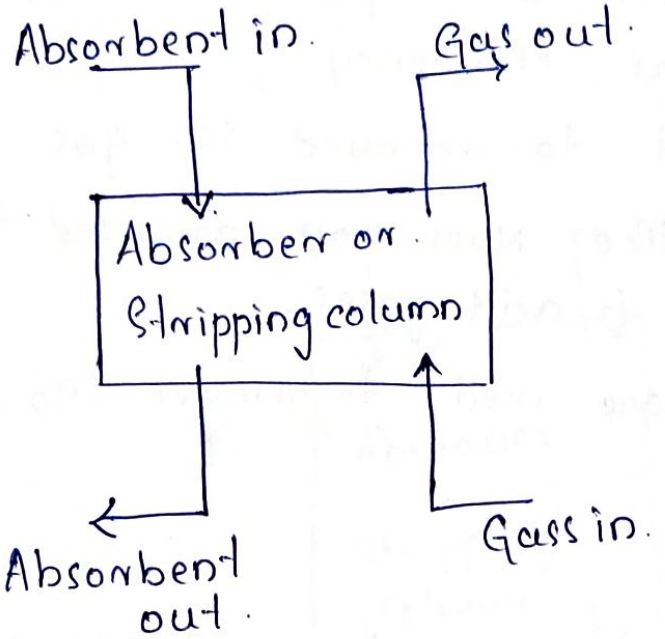
Gaseous Pollutant Control method:

The removal methods used for gaseous pollutants are designed to concentrate the gaseous pollutants, or direct conversion by combustion. Selection of Process depends on pollutant chemistry, concentration, gas flowrate, temperature.

1. Absorption
2. Adsorption
3. Combustion.
4. Redox reactions.
5. Condensation.
6. Catalytic processes.

1. **Absorption:** In this method gaseous pollutants are removed by dissolution into a liquid solvent such as water, caustic solutions or acidic solutions. (most commonly used

absorbent is water).



As gas streams is allowed to pass through liquid absorbent, the absorbent absorbs the gas.

Absorption is commonly used to purify the gas streams which contains high concentration of organic compounds.

Important points to be remembered in absorption.

* Selection of suitable solvent which acts as absorbent.
* Limits of absorption efficiency.
* Selection of equipment for liquid-gas contact
* Capital cost of the unit.

Types of absorption:

1) Physical absorption: Uses water or any inert solvent as absorbent. Effective for highly soluble gases like NH_3 & HCl.

2. Chemical absorption:

Absorbent reacts with pollutant hence increases the removal efficiency.

Ex: * Limestone is used to removed SO_2 gas.

* Alkali solutions like NaOH, KOH are used to remove H_2S gas & acid gases.
* Amine solvents are used to remove CO_2.

II. Adsorption:

The gaseous pollutants molecules adhere on the surface of the solid adsorbents through weak vanderwaals forces or by chemical bonding.

Common adsorbent used are:-

- ⇒ Zeolites
- ⇒ Activated carbon
- ⇒ Silicat gel
- ⇒ Alumina.

III Combustion: Combustion method can be used at source to reduce the pollutant formation.

Important techniques used are.

- ⇒ Low-NO_x burners
- ⇒ Flue gas recirculation
- ⇒ low excess air operation.

: Water Pollution :

97% → In Salt ~~Ocean~~ Water, Oceans, Seas, some lakes & Groundwater.

2.4% → Glaciers & Ice Caps.

0.5% → Fresh water that is unavailable., or too far, may be underground or polluted.

Only 0.03% → Water to drink.

Defination: Water pollution is defined as the alternation in the physical, chemical or bidogical characteristics of water so that it either becomes health hazard or unfit for use.

* Contamination of water bodies, usually as a result of human activities. Water bodies include for example lakes, rivers, oceans, groundwater.
* Water is typically referred as polluted when it is impaired with antropogenic contaminants
* Due to these contaminants, it either does not support a human use. & undergo shift in its ability to support the biotic communities such as fish.

Types of Water Pollution:

1) Surface water pollution: Water over the surface of earth gets polluted.

2) Underground water pollution: Water below the earth's surface gets polluted.

Sources of Water Pollution: 1) Point Source
2) Non-Point Source.

1) **Point Source:** Contaminants directly enter the water bodies from a single identifiable source. such as pipe or ditch.

Ex: - Sewage treatment plants
- factories.
- City ~~storm~~ storm drains.

2) **Non-Point Source:** Diffused contaminants that does not originate from a single source.

Ex: leaching out of nitrogen compounds from fertilized agricultural lands.

Point & non-point sources are broadly classified as

1) Domestic effluents
2) Industrial effluents.
3) Surface runoff
4) Waste heat.

1) Domestic Effluents: Waste waters are discharged in a common public sewage.

- Human & Animal Excreta.
- Organic matter in the form of food residue.
- Detergents
- large number of bacteria like faecal coliforms, Salmonella etc.

BOD ⇒ Biological Oxygen Demand:

Amount of dissolved oxygen needed by bacteria in decomposing the organic wastes present in water.

BOD increased - Water is Polluted.

BOD ∝ to input of organic wastes.

Pure water BOD < 1 ppm
Pollutated water ≥ 5 ppm.

2) Industrical Effluents:

* Industries usually discharge waste water into ponds, lakes & rivers.
* Industrial waste water contains heavy metals like
  - Mercury
  - Lead
  - Arsenic
  - Copper
  - Cadmium.
* Also contain Inorganic pollutants like.
  - acid.
  - alkalies

- bleaching liquids.

* Organic Pollutants like.
  - Proteins
  - Cellulose
  - fibres
  - putrescible organic matter.

3) Surface Runoff: Surface runoff from the flow of surface of field which contains fertilizers, insecticides, pesticides., manures which brings a heavy loads of pollutants to water bodies.

- Fertilizers includes - phosphates
  - nitrates
  - Sulphates
  } of potassium.

Effects:

1) Eutrophication: / Hypertrophication.
- when a water body becomes overly enriched. with minerals & nutrients (nitrates from the fertilizers) which induces the excessive growth of algae.
- This process leads or results the oxygen depletion of the water.

2) Biomagnification : Refers the condition where, there is a increase in the concentration of chemicals in the bodies of organisms which are present in water.
So water becomes unfit.

4) Waste heat / Thermal water Pollution :

* It is rise in the temperature of water.
* Thermal power plants & refineries uses water as coolant, & discharge the hot water into nearby lakes, rivers & seas.

Effects of water pollution on Human.

1) Source of water borne diseases like diarrhoea, jaundice, cholera, typhoid, amoebiasis etc.
2) Mercury compounds in waste water are converted by bacterial action into extremely toxic compound like methyl mercury, which can cause numbness of limbs, lips & tongue, deafness, blurring of vision & mental problems.
- Minamata disease (1952) → affects central nervous system.
3) Water contaminated with cadmium causes itai itai disease (a painful disease of bones & joints) & cancer of lungs & liver.

4) Excess of Nitrates in drinking water, dangerous to human health which reacts with haemoglobin of the blood & forms Methaemoglobin & impairs oxygen, transport. This condition is called blue ~~baby~~ body syndrome. (or) methaemoglobinaemia.

5) Excess of fluorides in drinking water causes neuromuscular disorders, gastrointestinal problems, teeth deformity, hardening of bones & stiff, painful joints. (Skeletal fluorisis).

6) Drinking of Arsenic polluted water causes black foot disease. It also causes diarrhoea, peripheral neuritis, hyperkerartosis & also numbness / tingling of hand & feet. (thickening of skin in certain places). Lung & skin cancer.

Control Measures of Water Pollution:

1) Hot water should be cooled before the release.
2) Cleaning in tanks, streams & rivers
3) Proper use of ~~agricul~~ agrochemicals which will reduce their runoff & leaching.
4) Organic farming & efficient use of animal residues as fertilizers.
5) Use of nitrogen fixing plants.
6) Planting the tree will reduce the pollution & by sediments & will also prevent soil erosion.

7) The industrial wastes & toxic compounds should be purified before draining.

8) waste water should be properly treated by primary & secondary treatments.

9) An aquatic weed water hyacinth which can purify the water by taking toxic & chemicals & heavy metals.

Water Quality Index: Water Quality is checked by considering different parameters like.

- Colour
- Odour
- taste
- pH
- Hardness etc.

By taking all these n no.. of parameters & expressin in a single parameter is called water quality index.

Water Quality Parameters

Physical	Chemical	Biological.
- Colour	- Total alkalinity	- Most Probable number.
- Temp.	- Total hardness	
- Odour	- DO	
- Turbidity	- pH	
- Electrical Conductivity.	- Flourides, chlorides	
- Taste.	- Sulphates.	
	- Solids → Suspendent S.	
	↘ Dissolved. S.	

- Each and every parameter has its own std Permissible limit.

- Expressing all std permissible limits are expressed in single parameter i.e., called water quality index.

"The most effective way to describe all quality parameters of water as a single component to express suitability of water resources for human consumption is called WQI."

Water Pollution - Control methods.

I. **Ecosystem Stabilization:** Refers to restoring the natural balance & self-purifying capacity of aquatic environments after they have been stressed by pollutants. When pollutants enters water bodies, they disturbs the biological communities, hence by reducing dissolved oxygen, and damages the food chain.

Ecosystem stabilization focuses on actions that can rebuild ecological structure & function so the ecosystem can once again regulate nutrients, degrades contaminants & support the biodiversity.

Key approaches

→ Improving water quality to restore healthy microbial & algal populations.

→ Re-establishing vegetation

→ Enhancing habitat complexity.

→ Increasing dissolved oxygen by aereation.

Overall, ecosystem stabilization strengthens natural resilience, enabling water bodies to maintain long term ecological health & sustain their essential purification processes.

II. Nanotechnology: For Environmental Remediation.

① Nano zero valent Iron: (nZVI)

These are tiny iron particles in the zero oxidation state (Fe^0). Because of their extremly small size & large surface area, they are highly reactive. They quickly interact with pollutant in water & breaks harmful chemicals. nZVI sticks to the pollutants such as dyes & heavy metals. And also reacts with metals like chromium, lead by converting them into insoluble solid forms, which settles down in the water & can be removed easily.

② Metal Oxide & Carbon-Based Nanomaterials.

Common nanomaterials used are.

- ⇒ Metal oxide = TiO_2, ZnO.
- ⇒ Carbon based = Graphene, CNTs (carbon-nanotubes).

* TiO_2, ZnO uses sunlight by producing reactive •OH radical., which breaks down the organic pollutants likes dyes, pesticides, pharmaceutical residues. These metal oxides can also interact with pathogens like bacteria.
* CNTs have high surface area, which allow them to trap heavy metals, organics & microbes.

③ Nanofiltration (NF) Membranes:

Nanofiltration is a pressure driven process. The pore size is in between ultrafiltration & reverse osmosis (RO). These membranes are capable of removing divalent ions like Pb^{2+}, Cd^{2+}, Cr^{3+} & colour, pathogens & some large organics. Nanofiltration uses very less energy compared to RO.

III. Advanced Oxidation Processes (AOPs).

In AOPs, a super reactive particle called hydroxyl radical (•OH) is used, which acts as super cleaner by breaking down many organic pollutants. These radicals are strong enough to break complex molecules into simple, harmless compounds like H_2O & CO_2. & this process is called Mineralization.

Hydroxyl radical can be prepared by.

- Reacting Hydrogen peroxide (H_2O_2) with UV light.
- Fenton reaction (Iron + H_2O_2).
- Iron + H_2O_2 + UV light.
- Photocatalysts + H_2O_2.

IV. Bioaugmentation:

Bioaugmentation means by using good microbes cleaning the wastewater in a faster & a better way.

- In this method, bacteria (or) fungi like Bacillus & Pseudomonas are used to treat wastewater. These microbes eat & break down the harmful organic pollutants, reduces the toxicity of wastewater. The added microbes must fit in with the existing microbial community, or the process won't work properly.

V. Ion Exchange Processes.

Resins & Zeolites act like filters that attract & remove harmful ions from water. Resins & Zeolite pick & trap the specific ions from water, these work through ion exchange process. (means swapping bad ions in water with harmless ions on their surface).

Recycling of the Waste water by Reclamation:

Reclamation means cleaning wastewater so that it can be used again safely.

Reclamation is done in 3 steps.

1) Primary [Removes solid].
2) Secondary [Uses of microbes to remove organic matter].
3) Tertiary [Advanced cleaning].

Strict laws & Regulations, Public awareness.

Government create laws, rules & standards to control water pollution.

The most important is.

- Water Prevention & Control of Pollution Act, 1974.
  → Supported by Water Cess Act, 1977, which encourages industries to use & treat water responsibly.
- Environment Protection act 1986.
  provides wide power to set discharge standards & regulate pollutants.
- Policies like National water Policy (2012).
  promotes conservation, recycling & sustainable water use.
- Coastal Regulation Zone Rules (2011).
- Wetlands Rules. (2016).
- Biomedical Waste Management Rules (2016).
- Hazardous & other waste management & transboundary movement Rules (2016).

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AQI : Air Quality Index.

* AQI is a general & easy approach to judge the quality of air.
* launched in 2014 by Environmental Minister Mr. Prakash Javadekar under Swachh Bharat Abhiyan.

Principle behind AQI - One number - One Colour - One description.

"AQI is a number used by government agencies to communicate to the public how polluted the air currently is or how polluted it is forecast to become."

Salient features of AQI :

1) The measurement of AQI is based on 8 pollutants like PM 10, PM 2.5, SO_2, NO_2, O_3, CO, NH_3 & lead.
2) There are six categories for eight parameters (pollutants).
3) AQI system was recommended by IIT Kanpur.

4) The measurement is limited to 24 hours & 8 hours for CO & O_3.

Air Quality Index

AQI Category & colour	Index value	Description of air quality.
Good Green	0 to 50	Air quality is satisfactory and air pollution poses little or no risk.
Moderate Yellow	51 to 100	Air quality is acceptable, However, there may be a risk for some people.
Unhealthy Orange	101 to 150	Members of sensitive groups may experience health effects.
Unhealthy Red	151 to 200	Some members of general pubic may experience health effects.
Very unhealthy Purple	201 to 300	Health alert.
Hazardous Maroon	301 & higher	Health warning, emergency conditions.