UNIT IV - TREATMENT TECHNOLOGIES

COMBINED TREATMENT OF INDUSTRIAL AND MUNICIPAL WASTES

1. Two major pieces of legislation establish as a national goal the elimination of the discharge of pollutants.
2. They provide for the development of definite guidelines for effluent discharge from all point sources, public and private.
3. They also provide for Federal financial assistance in the form of capital subsidies to communities attempting to achieve these guidelines.
4. Many communities are designing upgraded or new wastewater treatment facilities.
5. The magnitude of the public investment required in wastewater treatment during the next few years makes it imperative that relevant decision makers have a thorough understanding of the issues involved.
6. One particular issue is industrial participation in the municipal wastewater treatment system.
7. Industrial discharges often significantly alter the total flow and concentrations of various wastewater constituents, such as biochemical oxygen demand (BOD), suspended solids, and heavy metals, to be treated by municipal treatment facilities
8. These factors are important in deter- mining the size and type of treatment processes required to meet the increasingly stringent standards being imposed on communities, so specific attention must be paid to the expected level of industrial participation during the planning and design stages of the new construction
9. Planning for the joint treatment of domestic and industrial wastewater is a crucial element in the design of cost-effective treatment systems.
10. The impact of joint treatment on the various participants and their corresponding responses will be important in determining the type and size of facilities required.
11. The municipality is required to provide joint treatment when certain conditions are met, but it has considerable flexibility in making use of such policy instruments as pricing strategies and pretreatment requirements to encourage or discourage joint treatment.
12. The municipality will compare the additional benefits and costs of joint treatment in order to determine its policies.
13. Inclusion of industrial wastes in municipal wastewater treatment systems can, however, lead to additional system costs.
14. Many industrial wastewaters, while compatible with common treatment processes, are more highly concentrated, in terms of constituents such as BOD and suspended solids, than normal domestic sewage.
15. The inclusion of these wastes, therefore, may require longer detention times and/or equipment with larger capacities, resulting in higher per unit treatment costs.

Chart of a Poultry Processing Plant

- Potable water
- Scalding
- Washing
- Final washing
- Grading, weighing & packing

- Product
- By-product
- Potable water
- Process water
- Wastewater
- Final product
- Final wastewater collection & control

RESIDUE MANAGEMENT

What is residue management?

1. Pacific Island farmers use left-over plant materials (leaves, branches, stalks, etc.) called **residue** or slash on their fields to nourish and protect their topsoil.
2. Leaving soil bare and uncovered in tropical climates often causes problems.
3. Instead of leaving the soil bare in your fields, arrange plant matter left over from the harvest in strips across the slope or beneath orchard trees.
4. Then plant the next crop into the plant matter, by hand either with a digging stick or tool, or with special machinery.
5. This is a very respected and traditional practice used by farmers around the Pacific.

Why use residue management?

1. Pacific Island farmers can benefit from residue management on their farm. Using this practice can:
   - Save labor on collecting and burning slash.
   - Protect the soil surface and help preventraindrop erosion.
   - slow water down and let it to soak intothe soil
   - Fertilize the crops and increase the harvest, especially if using slash from nitrogen fixing crops (called legumes) that are rich innutrients.
   - Organic matter from plantmaterial helps the soil become more fertile and easier to work.
   - Protect new plantings and smother outweeds.
   - Provide food and shelter for wildlife.

Where and when is residue management used?

- Between rows in crops
- Under fruit trees
- Early in the growing season when newcrops are still small and filling in Between growing seasons when fields are left unplanted

Where is residue management not used?

1. If your field is infected with certain plant diseases, crop residues may infect the next crop. Don't place residue directly against plant stems and trunks.
2. Consider using crop rotations to break disease cycles. Consult with the Cooperative Extension Service about how to manage plant diseases.

Plan for Residue Management

Leave soil covered.

1. After the harvest, instead of cleaning the fields and burning slash, leave leftover plant material in place.
2. Save time and labor by letting leaves, branches, and stalks break down on the ground until you are ready to plant again.
3. This will protect your valuable top soil fromerosion until you are ready to plow.

Use strip cropping on sloping fields.

1. Leaving most of your field covered with slash, clear and cultivate small rows (or strips) of ground across the slope for planting.
2. Clear small areas with tilling or through careful applications of herbicide, and plant each section quickly.
3. Between rows, leave strips of soil covered with slash or much.

Weed Management

1. Sometimes certain weeds can be used to protect the soil while your crop is growing.
2. Weed residue left in the field will provide ground cover between your crop plants.
3. Cut, pull or spot-spray weeds instead of using mechanical tillage, and leave plant material in place.
4. Do not do this with weeds that grow from cut pieces or that can escape from the farm and become problem weeds in natural areas or forests.
5. Remove these invasive weeds from your land.
6. Consult with your local Cooperative Extension Service about weed management options for your farm.

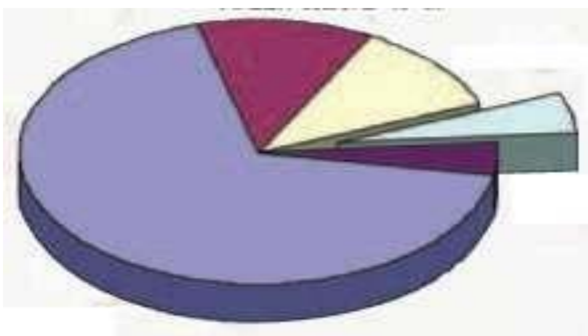
For the best results, combine **residue management** with other conservation practices:

- **Vegetative Barriers** : growing small strips of stiff plants across the slope
- **Hillside Ditch** : digging a small ditch across the slope to divert rainwater
- **Contour Farming for Cropland** : carrying out farm operations across the slope
- **Contour Farming for Orchards** : carrying out farm operations across the slope
- **Alley Cropping & Hedgerow Planting**: growing hedges of bushes and trees across the slope

DISPOSAL

1. Effective integrated solid waste management program must be capable of managing all types of solid waste.
2. The Egyptian National Environmental Action Plan defines the following five broad categories of solid waste:
   - Municipal waste from urban and rural areas.
   - Hazardous waste from hospitals.
   - Industrial non-hazardous waste.
   - Industrial hazardous waste.
   - Agricultural waste.

3. Two of the above solid waste categories are derived from Egyptian industrial plants that manufacture all types of goods for domestic use or export to other countries.



4. Large scale industries are not the only generators of industrial waste. Small-scale industry, small workshops, garages, and very small production units collectively produce large quantities of industrial wastes.
5. Some of the common industrial waste sources in Egypt include:
   - Electric power generation.
   - Fertilizer and agricultural chemical production.
   - Food production and related by-products.
   - Chemical production.
   - Iron and steel manufacturing.
   - Leather and leather product manufacturing.
   - Nonferrous metal manufacturing and foundries
   - Plastics and resin manufacturing.
   - Pulp and paper manufacturing.
   - Rubber and miscellaneous rubber products manufacturing.
   - Stone, glass, clay, and concrete products production.
   - Textile manufacturing.
6. Manufacturing processes commonly generate all forms of waste including liquid and solid wastes.
7. Some of these waste products have particularly dangerous properties and can negatively impact human health and the environment.

Industrial Waste Characterization and Classification

1. Understanding the enormous diversity of characteristics of the solid waste generated by industry is important for the following reasons:
2. They define the potential hazards of handling the material.
3. They define the design of transportation, treatment, and disposal systems incorporated
into a solid waste management programto handle them.
4. They define the procedures and precautions that must be used in collection and disposal.
5. They determine how the material will be classified underEgyptian environmental regulations.
6. They may determine which of the industrial solid waste generated in any particular industry is actually managed in a private sec

DEWATERING

What is Dewatering?

1. Dewatering systems are routinely used in the construction industry to provide temporary reductions in ground water levels for structures which extend to below groundwater level.
2. A dewatering system generally comprises an array of wells or sumps which are continuously pumped so as to lower the water table to provide stable and dry conditions to facilitate excavation.
3. Dewatering systems may be used around open cut excavations or in conjunction with shoring or retaining walls used to support the excavation.
4. Where retaining walls are used the dewatering well array may be installed internally to exploit the cut-off effect of the shoring arrangements.
5. Alternatively an external well array may be deployed to reduce the hydrostatic loading on the shoring system or allow use of lower cost shoring arrangements such as contiguous piles as opposed to secant piles.

Purpose of Dewatering Containers

1. Required when the waste product contains high water content and is not a strong candidate for pumping into a vacuum truck
2. This box will separate water from the sludge
3. Come in a standard 25 yard size

Benefits of Dewatering Containers (Boxes)

1. Use to remove water content before transporting the waste
2. Dewatering reduces the waste volume, save cost and results in reduced transportation weight
3. T-Gasket door for exceptional sealing

Transportation of Dewatering Containers (Boxes)

1. Extremely versatile and can be transported over the road using most standard rolloff frames and straight trucks
2. Single or double frame trucks can be used to transport vacuum rolloffs
3. Clean Harbors has the transportation resources available to service all of your container delivery and removal needs

Availability of Dewatering Containers (Boxes)

- Typically found in Gulf and West Coast markets; however Clean Harbors can provide dewatering boxes in other areas as required

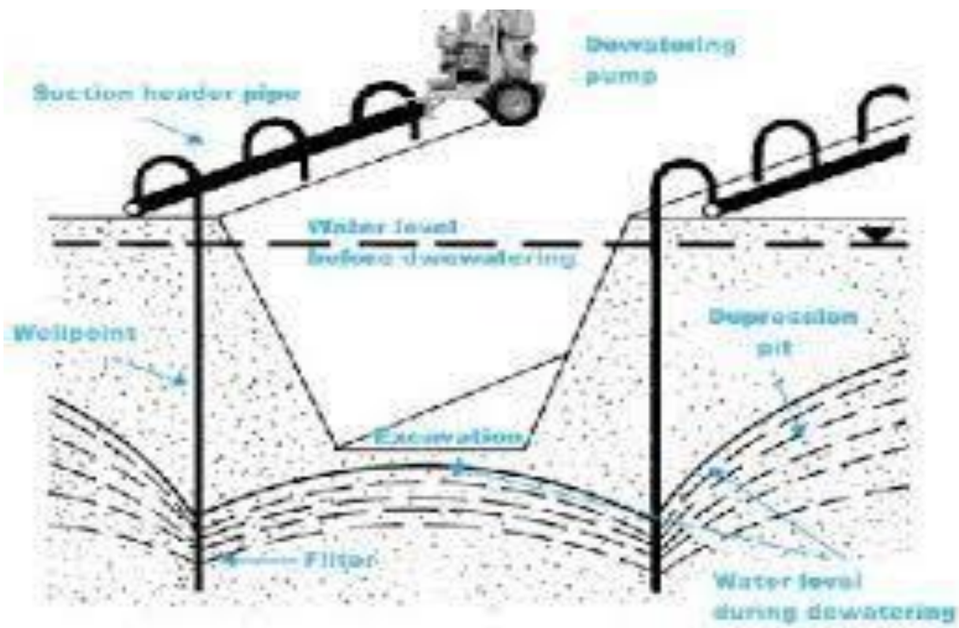
Industry Uses of Dewatering Containers (Boxes)

- Waste Disposal
- Industrial Maintenance
- Field Services
- Refinery & Petrochemical
- Chemical & Specialty Chemical
- Utilities
- Engineering & Consulting

- Clean Harbors "Apollo" Program for On-Site Container Management
- Once the structure is completed or sufficiently complete to resist hydrostatic loads that the pumping can be stopped and groundwater levels allowed to recovery back to their natural levels. Very occasionally it can prove cost effective to provide long term or permanent groundwater control to avoid uplift pressures

Procedure

1. Groundwater control extends this definition to encompass any pumping or recharge system used to manipulate groundwater levels for a range of purposes.
2. Recharge systems used to limit external drawdown and mitigate settlement risks.
3. Vacuum drainage systems for pore pressure control in fine soils.
4. Hydraulic barriers used to control migration of contaminate.
5. Groundwater lowering used to under-drain and consolidate weak soils; and groundwater lowering to facilitate pile construction.
6. The choice of pumping system used for dewatering or groundwater systems depends on the amount of drawdown required and the ground condition



* EQUALIZATION METHODS IN WASTE MANAGEMENT

Equalization methods in Waste management are the techni-ques used to even out variations in the flow rate and pollutant Concentration of Incoming wastewater before it enters the main treatment units.

* Especially used in treating Waste water.
* Industries usually generate waste water that is non-uniform - it may vary by hour, shift or process cycle. With this method we can reduce efficiency and equipment damage.

⇒ Equalization method can be achieved by using the following:

1. FLOW EQUALIZATION:

* This method will balance the fluctuations in waste water flow over time.
* This method can be achieved by usage of equaliz-ation tanks (large basins or ponds) to store wastewa-ter during high-flow periods and release it slowly during low-flow periods.
* It is used to protect downstream biological or Chemical treatment units from hydraullic shock.

2. LOAD (POLLUTANT) EQUALIZATION:

* To balance Variations in Pollutant Concentration [BOD, COD, PH, toxic, chemicals]

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* In this method, continuous mixing in equalization tanks using mechanical mixers or air diffusers will takes place in order to homogenize the waste water.
* Ensures consistent quality of wastewater entering treatment units.

3. COMBINED FLOW AND LOAD EQUALIZATION:
* Handles both hydraulic and pollutant variations simultaneoulsly.
* Specially designed aerated equalization tanks that provide both mixing and controlled pumping.
* Most effective in industries with highly variable effluents.

4. IN-PROCESS EQUALIZATION (SOURCE CONTROL):
* Minimize variations before wastewater reaches the treatment plant.
* Scheduling production processes to avoid peak discharges.
* Recycling and Reusing process water.
* Reduces size/cost of equalization tanks.

⇒ Two arrangements of equalization tanks are:

1. On-line Equalization: [online Flow]
- In this method, all wastewater flows directly through the equalization tank before entering the treatment units.
- Wastewater from various sources → Equalization tank → Treatment plant.

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2. Side-line Equalization: [Offline flow]
• In this method, only a portion of the wastewater is diverted into the equalization tank.
• Only variable or shock load streams are diverted into the equalization tank.

⇒ Objectives of Equalization Methods

1. Stabilize Flow:
* To even out fluctuations in wastewater flow

2. Stabilize Pollutant Load:
* To homogenize variations in BOD, COD, PH, color, toxic chemicals.

3. Improve Treatment Efficiency:
* By maintaining uniform conditions, downstream process can operate optimally.

4. Facilitate pH Control and Neutralization:
* Equalization tanks allow for chemical dosing to adjust and maintain neutral PH.

5. Enhance Settling and Aeration:
* Provides opportunity for pre-aeration.

6. Reduce Treatment Costs:
* Avoids need for oversized units that can handle extreme peak loads.

7. Enable Representative Sampling & Monitoring:
* A well-mixed equalized flow gives a true averag sample, useful for compliance.

8. Provide Flexibility in Operations:
* Stores wastewater temporarily, allowing controlled discharge to treatment depending on plant capacity.

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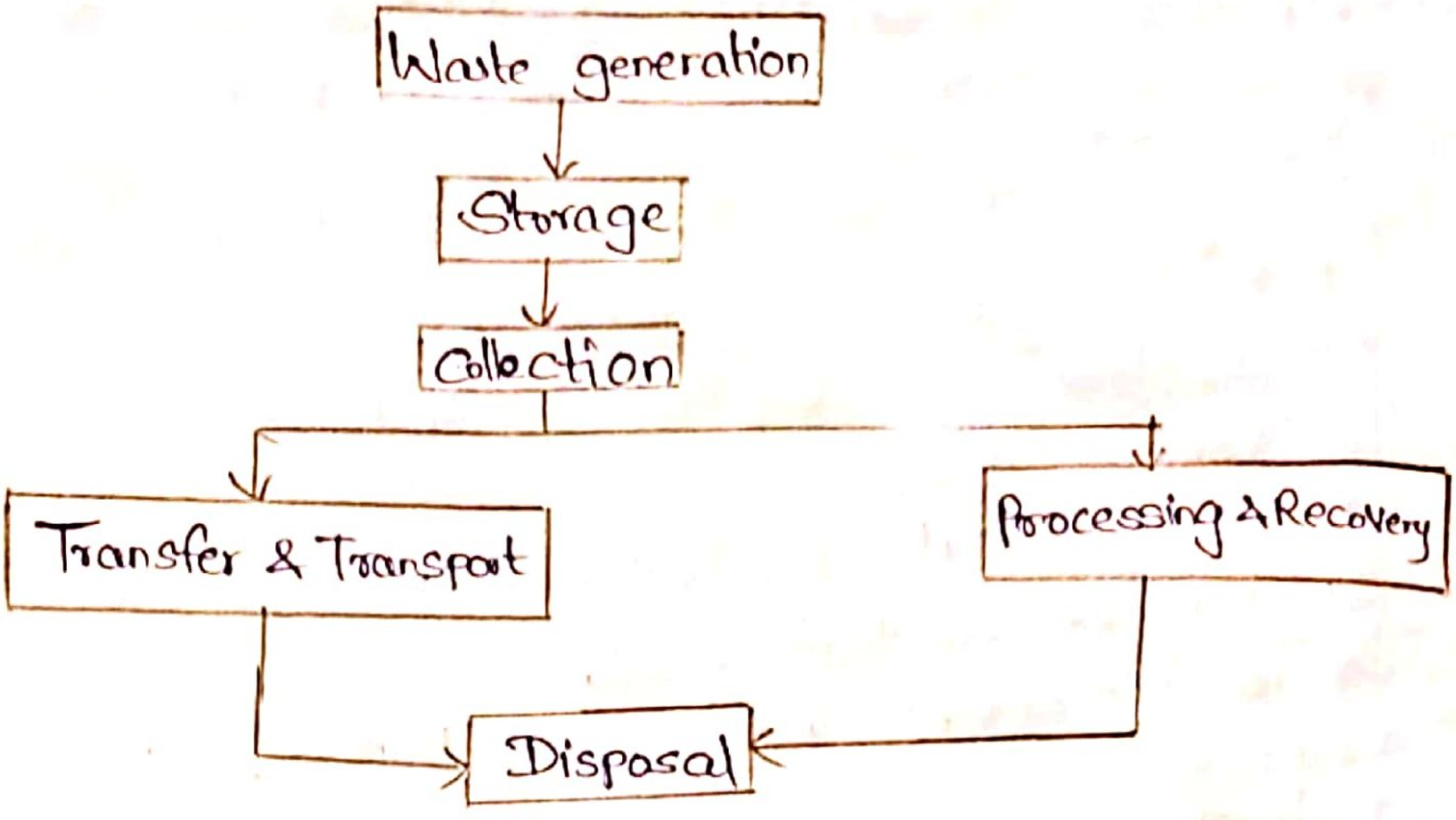
FLOW CHART:



Example: TEXTILE DYEING INDUSTRY

* Waste water comes from Bleaching, Dyeing, Printing and finishing

Methods:

1. Collection tank:
Divert wastewater into collection tank

2. Mixing:
Use mechanical mixers to homoginize waste water

3. pH Adjustment:
Lime or acid is dosed into tank to maintain pH value to 6.5 - 7.5.

4. Pumps with Flow Control:
Releases the wastewater steadily to treatment plants to avoid ~~seho~~ shocks.

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1) Explain Removal of Suspended solids.

Ans: Suspended Solids:

Suspended solids are tiny particles that float in water but do not dissolve and the particles will not settle down immediately.

* They are not dissolved like salt or sugar.

Ex:- Soil particles - Clay, sand

Organic Matter - decaying leaves

Micro organisms - bacteria

Industrial waste particles - fibers from textile, paper industry, metal particles.

Domestic sewage - water from homes, soap particles and organic matter.

Why Do we need to Remove suspended solids:

⇒ To make water safe for drinking.

⇒ To improve water Clarity.

⇒ To protect machines [pipes, filters].

⇒ To protect fishes and rivers.

Methods of Removal:

1) Physical Methods:- These methods remove solids using physical processes without using chemicals.

i) Screening:- Used to remove large size suspended solids [sticks, plastic, cloth] using wire mesh screen.

Ex: A Kitchen strainer seperates rice from water.

ii) Sedimentation:- water is left in tanks or basins for a long time. Heavier particles will settle at the bottom by gravity.

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* Removes 60-70% suspended solids.

Ex:
= Mud settles at the bottom of a bucket of pond water.

iii) Grift Chamber:
Removes heavier inorganic particles like sand, stones, glass pieces and egg shells from wastewater.
⇒ This method is used to prevent damage to pumps, pipes.

Ex: In sewage treatment plants, grift chambers are always placed after screening.

iv) Filtration:- water passes through filters like sand or membranes and it trap small solids.

Ex: Using a coffee filter to trap powder.

v) Centrifugation:- water is spun rapidly in a machine.
* The duration when the water is spinning rapidly the heavier solids go outwards and separate.

Ex: washing machine spin separates water from clothes.

b) Chemical Methods:- These methods use chemicals to help solids clump together so they can be moved easily.
* Some solids are so fine they don't settle easily.
* So, we add chemicals (Alum, Ferric chloride. etc) to water.
* These chemicals make small particles stick together and form bigger clumps called "flocs"
* This process is called Coagulation & Flocculation.

Ex: when you add lemon juice to dirty water, fine particles sometime clump and settle.

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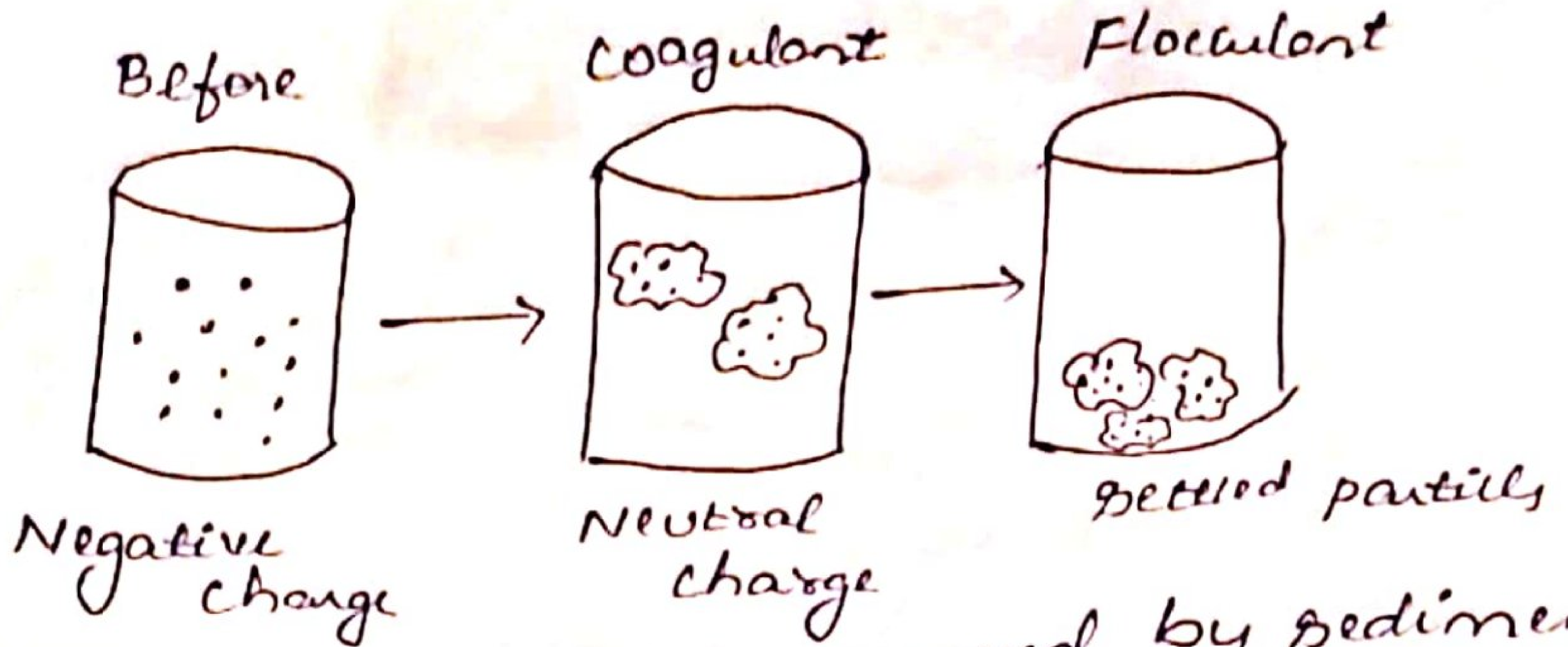

⇒ Later this flocs are removed by sedimentation.

c) **Biological Methods**:- In this method, micro-organisms (like bacteria) eat organic suspended solids.

Ex: In sewage treatment bacteria eat left over food particles → "Activated Sludge Process."

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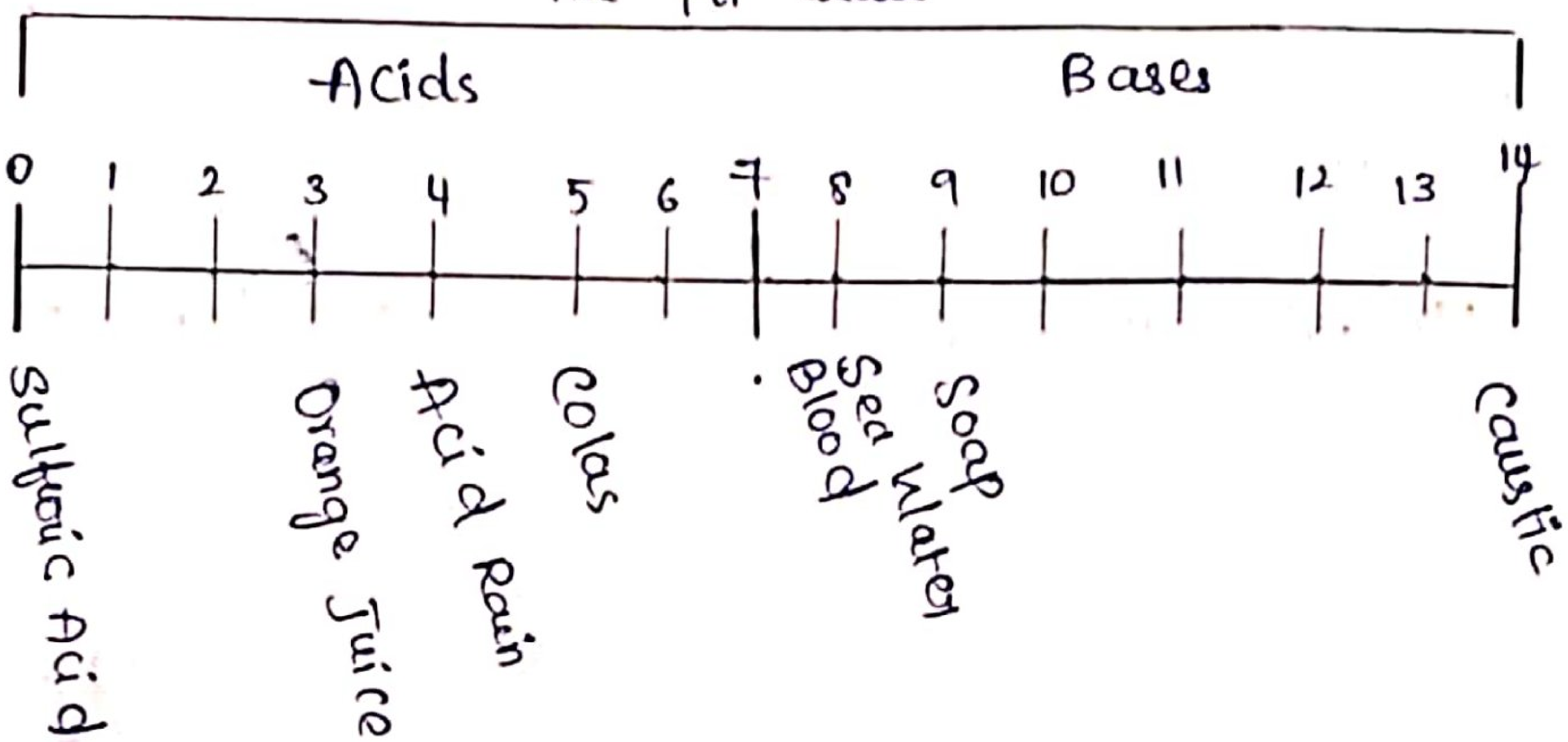
* Neutralization Methods in Waste Management?

A. Neutralization in waste management refers to the process of treating acidic or alkaline wastes to bring their pH closer to neutral (pH 7) before disposal, discharge, or further treatment. This helps protect the environment, prevent corrosin of treatment equipment, and meet regulatory Standards.

Neutralization methods used in waste management.

The pH scale



* Chemical Neutralization.

→ Acidic Wastes (low pH) are neutralized using alkaline agents.

* Common agents : lime ($Ca(OH)_2$), sodium hydroxide ($NaOH$), calcium carbonate ($CaCO_3$), ammonia.

→ Alkaline Waste (high pH) are neutralized using acids

* Common agents ; Sulfuric acid (H_2SO_4), hydrochloric acid (HCl), Carbondioxide (CO_2).

* used in industrial effluent treatment, laboratories, Pharmaceutical plants.

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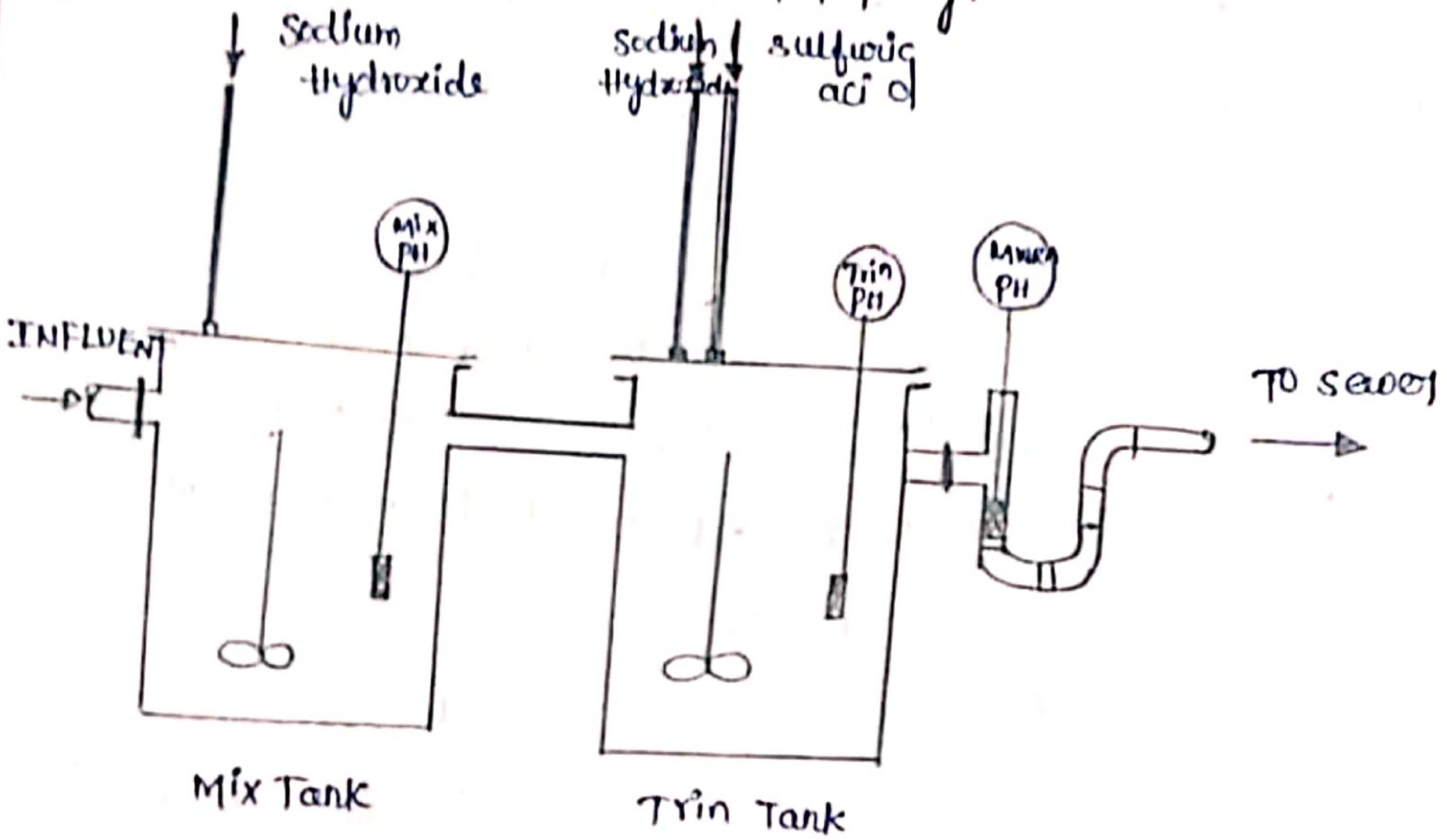
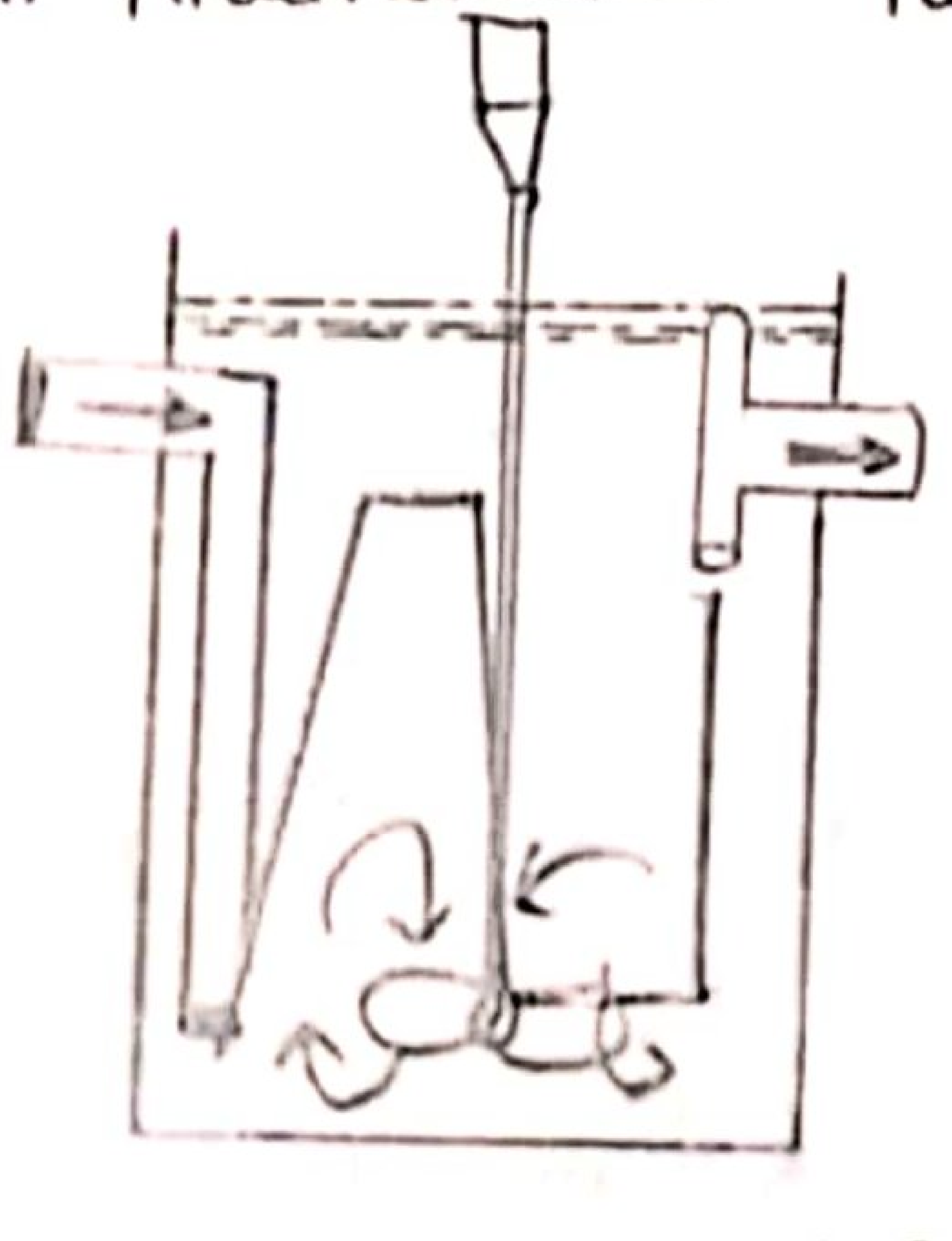
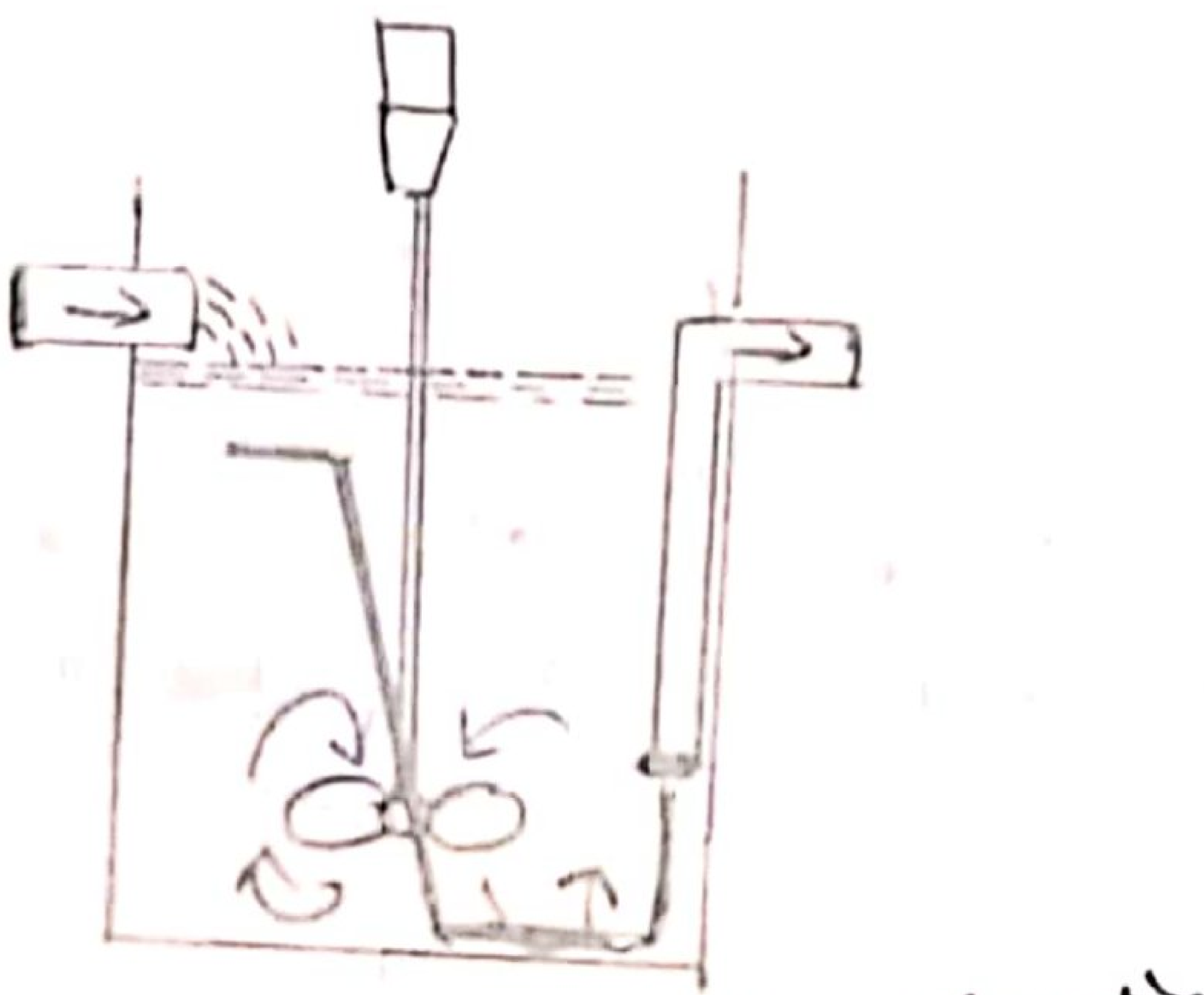
Typical PH Neutralization Tank piping.



PH Neutralization Tank Inlet & out-let Location.



Bottom in - Top out Configuration



TOP in - Bottom out Configuration

* Carbon Dioxide Neutralization.
* CO_2 is bubbled into alkaline wastewater, forming carbonic acid (H_2CO_3) which lowers PH.
* Safer and easier to handle than strong mineral acids.
* Often used in power plants, food industries and breweries.

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* Sulfuric acid neutralization :

* Neutralization of sulfuric acid (H_2SO_4) in waste management is a common treatment step because sulfuric acid is widely used in industries (like metal finishing, fertilizer, petroleum refining, batteries, etc.) and often ends up in waste water.

* Using alkaline chemicals

* Lime ($Ca(OH)_2$ / CaO)
  Lime slurry is added to acidic wastewater.
  Reaction :
  $$H_2SO_4 + Ca(OH)_2 \rightarrow CaSO_4 + 2H_2O$$

* Sodium Hydroxide ($NaOH$)
  → Strong base, neutralizes quickly.
  Reaction :
  $$H_2SO_4 + 2NaOH \rightarrow Na_2SO_4 + 2H_2O$$

* Soda Ash (Na_2CO_3)
  Reaction :
  $$H_2SO_4 + Na_2CO_3 \rightarrow Na_2SO_4 + CO_2 + H_2O$$

Sulfuric acid Solution (H_2SO_4) → [Neutralisation] → PH

[Filteration] → Salt (Na_2SO_4)

[Gravitational separation] → Fatty acids

[Evaporation] → methonal water.

There are a number of neutralising agents available. selection Criteria should consider:

* Reaction rate
* sludge production and disposal
* safety and ease of handling for addition and storage
* Total cost including chemical feed and storage equipment.
* Side reactions, including dissolved salts, scale formation, and heat produced.
* The effect of overdosage.

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* Introduction to Adsorption

Adsorption is a surface phenomenon where molecules from a fluid phase adhere to the surface of a solid.

It plays crucial role in removing contaminants from liquids and gases.

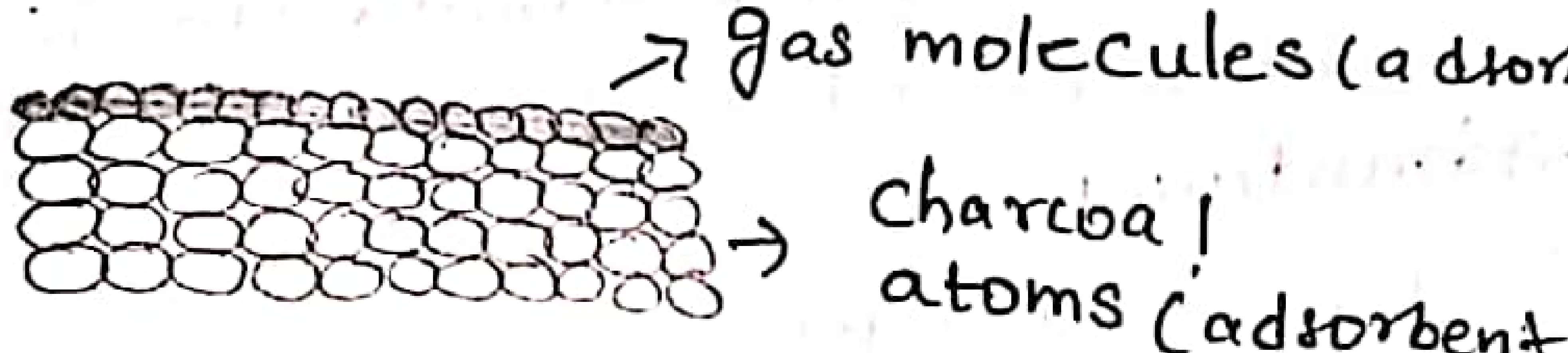
understanding adsorption is essential for designing effective treatment technologies for environmental cleanup.

Types of Adsorption

Two types of adsorption

Physical adsorption (physisorption) involves weak Van der waals forces and is reversible.

Chemical adsorption (chemisorption) involves stronger chemical bonds and is often irreversible.



Schematic representation of adsorption of gas molecules over the surface of charcoal

The choice of adsorption type depends on the target pollutants & treatment process requirements.

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Adsorbents used in Treatment Technologies

Common adsorbents include activated Carbon, zeolites, and biochar due to their high Surface area.

Activated Carbon is widely used for removing organic Compounds and odors from water and air.

The Selection of an adsorbent depends on the Specific application and pollutant Characteristics.

Applications

Adsorption is employed in water treatment for removing dyes, heavy metals, and organic pollutants.

* It is also used in air purification systems to eliminate Volatile organic Compounds (VOCs).

Additionally, adsorption processes are integral to wastewater treatment & environmental remediation efforts.

Advantages

* High efficiency and flexibility
* Cost-effectiveness in pollutant removal
* Innovations in adsorbent materials aim to improve Capacity, selectivity, and regeneration Capabilities.

1. Removal of Dissolved Inorganics:

Introduction to dissolved Inorganics

-> Dissolved inorganics are inorganic substances present in water in ionic form.

-> They include metals, salts, and minerals such as calcium, magnesium, and chlorides.

-> Their presence in water can affect quality and the treatment processes.

Importance of Removing dissolved Inorganics:

-> Elevated levels of dissolved inorganics can cause health issues and environmental concerns.

-> They can lead to scaling, corrosion, and fouling in water treatment systems.

-> Effective removal ensures water safety, equipm-ent longevity, and compliance with standards.

Common Removal Techniques:

-> Ion exchange is widely used to replace undesirable ions with less harmful ones.

-> Reverse osmosis effectively removes a broad range of inorganic dissolved solids.

-> Chemical precipitation can remove specific inorganic by forming insoluble compounds.

Ion Exchange process:

-> Ion exchange uses resin beads that swap

ions in water with ions on the resin.
→ It is highly effective for softening water and removing heavy metals.
→ Resin regeneration is necessary periodically to restore its exchange capacity.

Reverse osmosis (RO) method
→ RO employs a semi-permeable membrane to separate dissolved inorganics from water.
→ It provides high removal efficiency for salts, metals, and other ions.
→ pre-treatment is essential to prevent membrane fouling and damage.

Chemical precipitation Techniques:
* chemical agents like lime or alum are added to convert dissolved inorganics into insoluble solids
* The method is cost-effective

Factors Affecting Removal Efficiency:-
* water PH, temperature, and concentration of ions influence removal effectiveness
* proper pre-treatment and system maintenance are vital for consistent result.

Conclusion and Future Trends:
* Combining multiple treatment methods can optimize removal of dissolved inorganics
* Advance in membrane technology and resin regeneration are improving efficiency
* Ongoing research aims to develop more sustainable and cost effective removal solutions.

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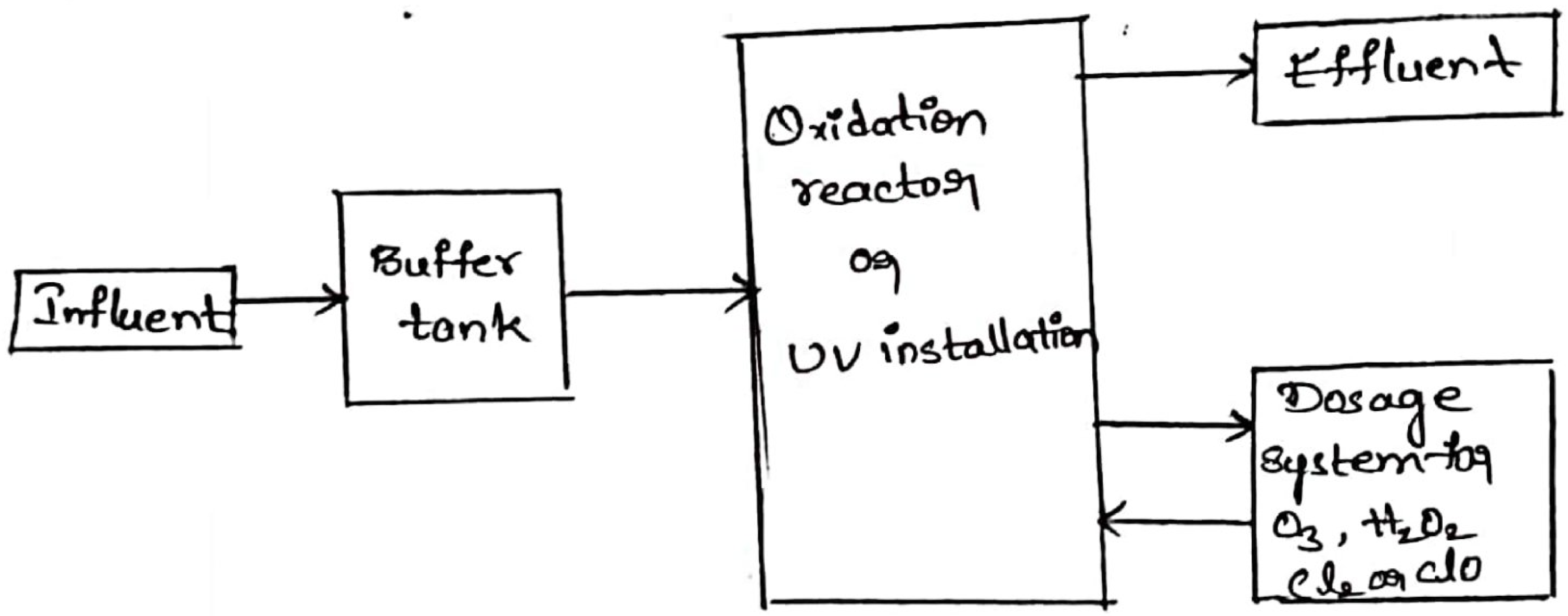
* Explain about the Chemical Oxidation

Chemical Oxidation in wastewater treatment

Chemical Oxidation means using chemicals that release Oxygen or Other reactive Species to Oxidize (chemically break down) Organic and inOrganic contaminants in wastewater.

The goal is to convert harmful compounds into Simpler, less toxic, or more biodegradable forms.

How it works:



1. pre-treatment (Screening & primary Treatment)
   - Large solids, grit, and Oils are removed by physical methods
   - This ensures that Oxidation chemicals are not wasted on non-dissolved solids.
2. Chemical Addition
   - Selected Oxidizing agent (chlorine, Ozone, Hydrogen peroxide, or Permanganate) is added to wastewater.
   - Dosing is done based on pollutant concentration and type of treatment needed.

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3. Reaction phase (Oxidation Reactions)

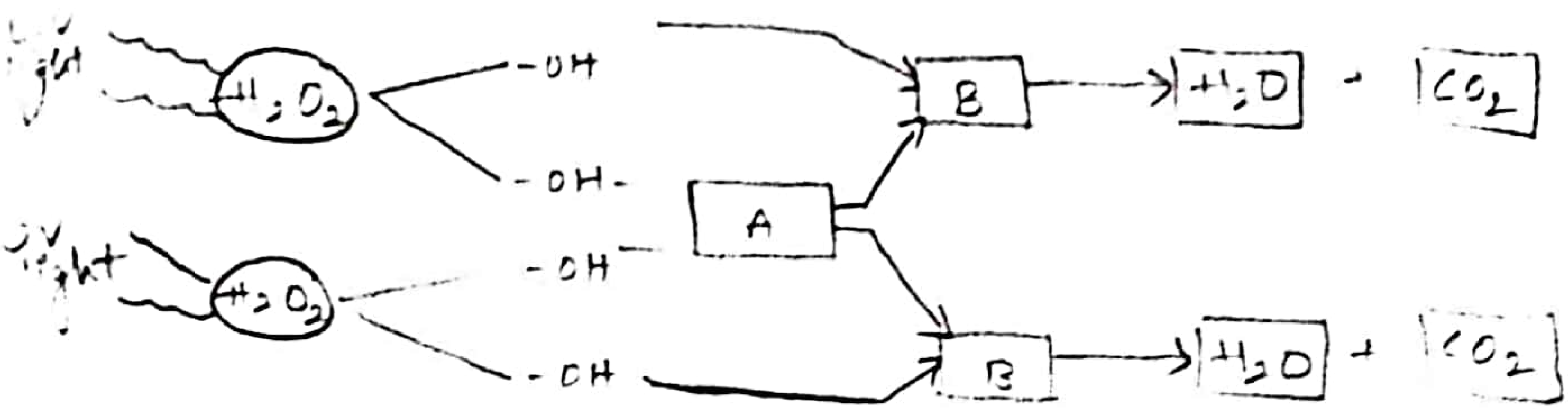
The Oxidant agent (Cl_2, O_3, H_2O_2 or per reacts with contaminants present in wastewater.

Electron Transfer

Oxidation involves the transfer of electrons from the pollutants to the Oxidant, which changes the chemical structure of the pollutant into less toxic form

Hydroxyl Radicals

AOPs (Advanced Oxidation processes), a subset of chemical oxidation, generates extremely reactive hydroxyl radicals (.OH) that rapidly break down complex contaminants into simpler, often non toxic products.



4. Mixing and contact time

- proper mixing ensures all wastewater comes in contact with Oxidant.
- contact tanks are used to allow enough reaction time (Usually minutes to hours)

5. By-product Handling

- Some reaction form by-products (like sludge, chlorinated Organics or precipitates).
- These are removed by sedimentation or filtration

6. post-treatment/ polishing

- If Oxidation was used for disinfection, the treated water may go directly to discharge.
- If used for pollutant breakdown, the effluent often goes to biological treatment for final polishing.

Common Oxidizing Agents Used

1. Chlorine (Cl_2) & Hypochlorite ($NaOCl$) - kills pathogens, removes color, oxidizes ammonia.
2. Ozone (O_3) - strong oxidant, effective in breaking down organic pollutants, removes odor and color.
3. Hydrogen peroxide (H_2O_2) – often used with catalysts (Fenton's reagent)
4. Potassium permanganate ($KMnO_4$) - used for iron, manganese, and odor removal.

Advantages

- Effective for removing resistant or toxic pollutants.
- provides strong disinfection
- Reduces odor and improves clarity of water.

Limitations

- High cost of chemicals and equipment.
- Formation of by-products.
- Requires careful control of chemical dosage.