CHEMICAL PROCESS TECHNOLOGY CASE STUDY

DEPARTMENT OF CHEMICAL ENGINEERING,
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TOPIC :-

WASTEWATER TREATMENT AND MANAGEMENT IN CHEMICAL INDUSTRIES

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MOTIVATION FOR CHOOSING THE TOPIC & GENERAL INFORMATION

- Wastewater treatment is a process used to remove contaminants and harmful chemicals from wastewater or sewage, and convert it into an effluent that can be returned to the water cycle with acceptable impact on the environment, or re-used for varoious purposes, called water reclamation.
- **Motivation :-** Wastewater treatment & its management is an important aspect of modern urban life, because it is essential for minimizing water pollution that can disrupt delicate ecosystems, interfere with foodchains, and transmit diseases. The major aim of wastewater treatment is to remove as much of the harmful chemicals and the suspended solids as possible, before the effluent is discharged back to the environment.

WASTEWATER TREATMENT IN IRON & STEEL INDUSTRY

A) **INTRODUCTION :-**

The iron and steel industry is the basic industry, since all the other industries-heavy, medium and light, depend on it for their machinery. Steel is needed to manufacture a variety of engineering goods, construction material, defence, medical, telephonic, scientific equipment and a variety of consumer goods. Production and consumption of steel is often regarded as the index of a country's development. Iron and steel is a heavy industry because all the raw materials as well as finished goods are heavy and bulky entailing heavy transportation costs.

B) DEFINITION :-

- Wastewater treatment represents an important option to investigate in iron and steel industries. Environmental impact can be reduced decreasing drawing in fresh water and wastewater blow down.
- Steel plants use a tremendous amount of water for waste transfer, cooling and dust control. The steel plants have sintering mills, coke plants, blast furnaces, chemical byproducts and chemical processes, water cooled rolls, pumps, extrusion experiment, transfer lines for sludges and slurries. All these plants use a tremendous amount of water to cool the products and flush the impurities away from the finished stock.
- Wastewater is generated in huge quantity in steel industries. It contains many dissolved, undisclosed substances and chemicals in the wastewater. The steel industries produce wastewater and sludge during different industrial processes.

C) HISTORY :-

- Since iron and steel industry is a major and vast industry, and is the backbone of all other industries, hence, almost everything is either made from iron or steel, or has been made using tools and machineries of these metals.
- The production in iron and steel industries requires huge amount of water for various industrial operations.
- The wastewater generated is dumped into water bodies(rivers, seas) without proper treatment, which causes undesired harmful effects on the environment, leading to water pollution and is against the norms and guidelines laid down by the environmental protection agencies.
- Sometimes, it also poses potential risks for the workmen. For example, an explosion at a wastewater treatment works in Avonmouth, UK, has left four workers dead and one more injured. Three of the dead were employees of Wessex Water, which runs the site, and the fourth was a contractor.

D) ORIGIN/SOURCE :-

Wastewater from iron and steel works, where the smelting of pig iron in blast furnaces and of steel in open hearth furnaces takes place, contains a considerable amount of oil, dust, acid, iron, and other metals.

Blast furnace gas is treated by water spraying to remove dust. This wastewater contains cyanides, sulfur compounds, phenol, dust, metal ions, ashes, slags, and ore particles.

The steel industrial wastewater also contains several solids, oil and grease, biodegradable organics, acids and alkalis, and several other toxics chemicals.

Moreover, in an integrated iron and steel industry, wastewater generated from Coke Oven By-product plant is considered to be the most polluting.

This wastewater contains toxic chemicals like phenol, cyanide and ammonia, which are harmful to the receiving water bodies when discharged untreated or partially treated.

E) PLAN & EXECUTION FOR WASTEWATER TREATMENT IN IRON & STEEL INDUSTRY :-

➢ OBJECTIVES :-

The objectives of the wastewater management plan are - to improve and maintain the water quality of the various iron and steel industries at a level acceptable for its ecosystem by implementing affordable and effective wastewater management.

➢ STRATEGIES :-

- Target of Ambient Water Quality and Sediment Quality
- Target of Pollution Load Reduction
- Targets for Heavy Metals
- Management of Industrial Effluent

Food Processing Industry

Introduction:

- Food processing is the transformation of raw ingredients , by physical or chemical changes into food or one form of food into another .It combines raw ingredients to produce marketable food products that can be easily prepared and served by the consumer.
- Food processing industries consist of a variety of industries such as dairy , snacks , sweets , beverages , and distillery .Waste waters from these industries come from different plant operations such as production , cleaning ,sanitizing ,cooling ,and materials transport.
- Benefits of food processing includes preservation ,toxin removal ,easing marketing and distribution tasks and increased consistency.

Definition:

- Waste water produced by food Industry is a potential hazard to the natural water system .
- This wastewater contains many inorganic and organic matters, which are toxic to the various life forms of the ecosystem . The majority of food processing industries are considered by very high water intake and high organic compounds rich wastewater generation. Waste water treatment can involve physical, chemical or biological processes or combinations of these processes depending on the required outflow standards.
- Food processing industries require large amounts of water and also discharge wastewater of varying quality.
- The quality parameter of waste water produced at food industry is pH , temperature , nitrogen ,phosphorus, biological oxygen demand (BOD), chemical oxygen demand (COD), total dissolved solids (TDS), total suspended solids (TSS) and appearance and odor.

Picture of Food processing industry wastewater treatment plant.

History:

- The wastewater generated from the food processing industry has been directly allowed to flow into rivers or streams without proper treatment which is harmful to aquatic lives and also to humans and animals directly or indirectly.
- The construction of centralized waste water treatment plants began in the late 19th and early 20th centuries, principally in the United Kingdom and the United States. Instead of discharging wastewater directly into a nearby body of water, it was first passed through a combination of physical, biological, and chemical processes that removed some or most of the pollutants.
- After the middle of the 20th century, increasing public concern for environmental quality led to broader and more stringent regulation of wastewater disposal practices.

Consequences:

- While most industries must find solutions for the problem of wastewater production, the food industry is consistently one of the top sources for industrial wastewater. Not only is a large volume of wastewater generated by the production and processing of food, but this water typically contains a high contaminant load that could potentially damage receiving waters, such as nearby rivers, lakes and streams.
- Discharging untreated wastewaters from food processing industries into rivers and other aquatic environment contribute to eutrophication by addition of phosphorus and nitrogen compounds. Hence, many food processing industries used a whole array of methods in treating their wastewater before the eventual disposal.
- Food processing industry wastewater poses pollution problems due to its high COD (Chemical Oxygen Demand) and BOD (Biochemical Oxygen Demand). ... This is due to the different additives used for different food products. Wastewater depicted COD/BOD and SS of 11220 mg/l, 6860 mg/L and 2210 mg/L respectively.

Challenges faced by the industry for wastewater treatment:

- Wastewater from food industry contains very high amounts of contaminants, up to 500 times higher than in the municipal or low strength industrial wastewater influents.
- The space available for the wastewater plant is often very limited.
- The cost of coagulants and flocculants needed for primary treatment can also be very high.
- Wastewater treatment plant consumes a lot of electric power. This contributes to the expenses bared by the food industries.

Plan/execution:

- Objective: The main objective of wastewater treatment and management in food processing industry is to improve and maintain the water quality coming out from the industry for its ecosystem by implementing affordable and effective wastewater management.
- Strategies:

  -Proper treatment of wastewater of food processing industry.

  -Target of pollution load reduction.

  -Management of industrial effluents.

  -Target of ambient water quality.

Fertilizer Industry

INTRODUCTION-

- Fertilizer is a key ingredient in feeding a growing global population.

- Fertilizers play a key role in increasing soil fertility, crop productivity and meeting food demand for growing population of the country. The success of India's green revolution and consequent self-reliance in food grain production is largely attributed to use of fertilizers.

- The **fertilizer industry** is made up of **companies** that represent the entire supply chain from production to distribution to retail, all working together to deliver **fertilizer** to farmers in a safe, timely, and sustainable manner.
- The primary objective of this **industry** is to ensure the inflow of both primary and secondary elements required for crop production in the desirable quantities.
- The success of the agricultural sector is largely dependent on the fertilizer industry. The benchmark that the food industry has set is mainly due to the many technically competent fertilizer producing companies in the country.

DEFINITION:-

- Water is a significant resource in the production of phosphate and potash, and to a lesser extent for nitrogen fertilizers.
- Wastewaters from chemical fertilizer industry mainly contain organics, alcohols, ammonia, nitrates, phosphorous, heavy metals such as cadmium and suspended solids.
- The **use of water** in the **fertilizer industry** increases with the increasing demand for **fertilizers**. Therefore, to meet the needs of **water** and electricity, **fertilizer industry** builds river **water** treatment plants into clean **water** by using coagulation, flocculation and filtration but still improvements are required for treatment of waste water.
- By quantifying industry water usage, we can assess the magnitude and usage per-ton of water consumed to provide benchmarks for continuous improvement.

HISTORY:

- Fertilizer industry is the backbone of agriculture and with passage of time the requirement of fertilizers increases which enables more and more production in short time due to which the management and treatment of wastewater has been ignored.
- The wastewater generated has been directly allowed to flow into rivers or streams without proper treatment which might be dangerous if consumed by humans or animals.
- In recent years, ammonical nitrogen in the effluents has received wide attention due to serious threat to environment, requiring further effective pollution control strategies and newer adsorbents

ORIGIN & CONSEQUENCES:

- High application rates of inorganic nitrogen fertilizers in order to maximize crop yields, combined with the high solubilities of these fertilizers leads to increased runoff into surface water as well as leaching into groundwater.
- The use of ammonium nitrate in inorganic fertilizers is particularly damaging, as plants absorb ammonium ions preferentially over nitrate ions, while excess nitrate ions which are not absorbed dissolve (by rain or irrigation) into runoff or groundwater.
- The nitrogen - rich compounds found in fertilizer run-off is the primary cause of a serious depletion of oxygen in many parts of the ocean, especially in coastal zones; the resulting lack of dissolved oxygen is greatly reducing the ability of these areas to sustain oceanic fauna . Visually, water may become cloudy and discolored (green, yellow, brown, or red).
- Nitrate levels above 10 mg / L (10 ppm) in groundwater can cause 'blue baby syndrome' (acquired methemoglobinemia) , leading to hypoxia (which can lead to coma and death if not treated).

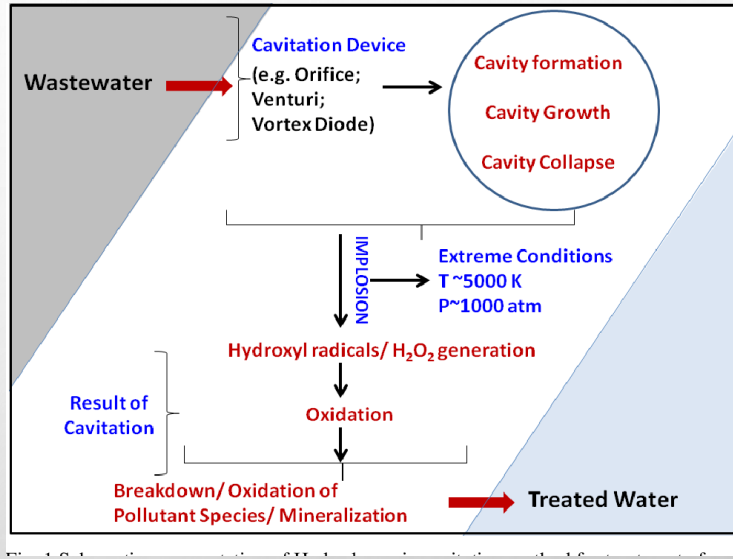
PLAN/EXECUTION:

OBJECTIVE:-

The main objective of wastewater treatment and management in fertilizer industry is to maintain the quality of water coming out as by products for the well being of nature as well as humans by implementing affordable as well as efficient management without harming our nature.

STRATEGIES:-

- Development of highly specific methodologies that help in effectively removing refractory pollutants.
- Effectively use of removal and recovery processes (e.g. adsorption).
- application of destructive methods such as hydrodynamic cavitation.
- Proper treatment of industrial effluents.



SOLUTION TO WASTEWATER TREATMENT IN IRON & STEEL INDUSTRY

As engineering technology in the industrial space is undergoing a rapid change, hence, we have come with cutting edge technologies to cater to the demands of wastewater treatment in iron and steel industries. These methods for the wastewater treatment in iron and steel industry are-

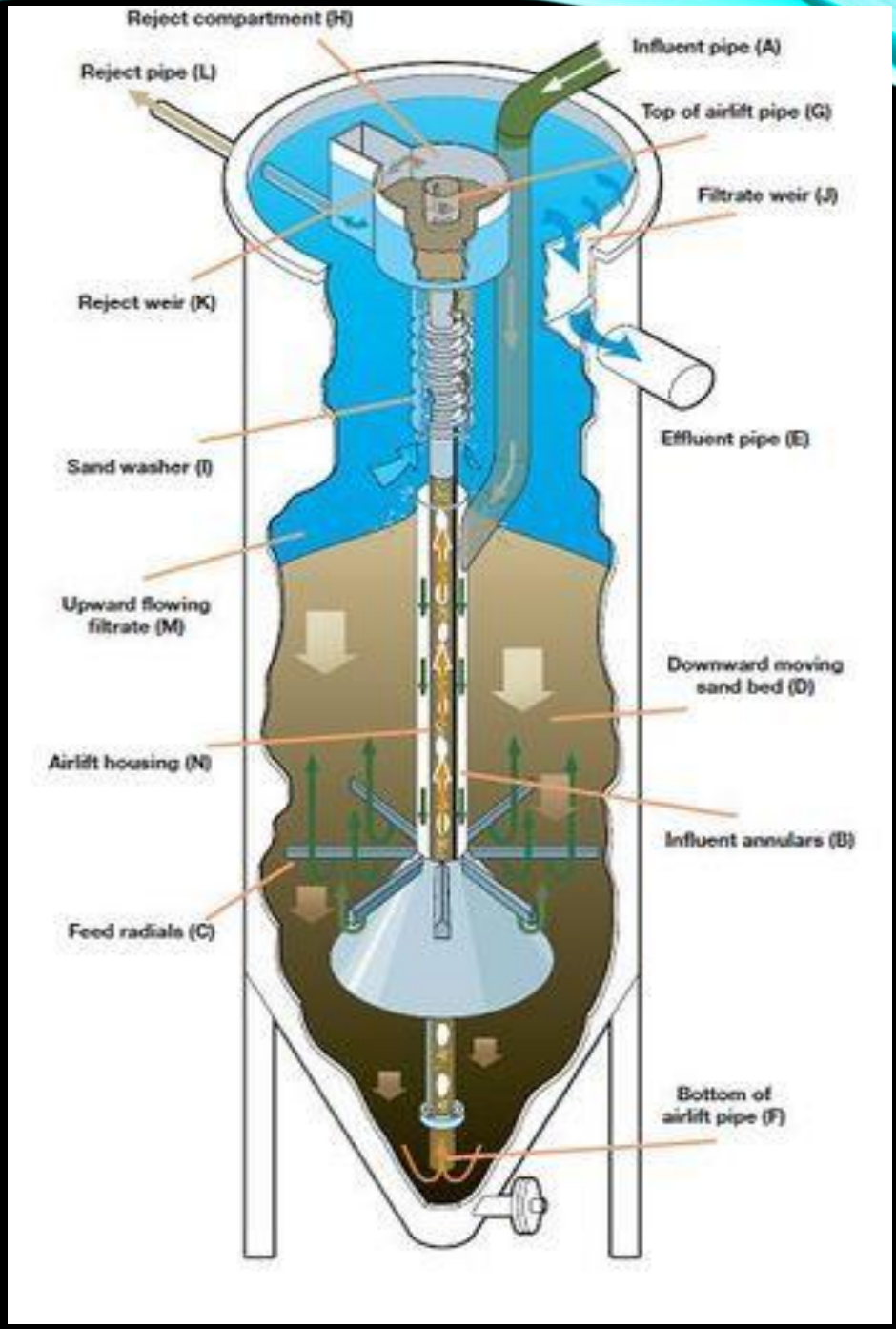
1. MEMBRANE FILTRATION :- Membrane filtration is an innovative and an essential method for the development of advanced water reclamation systems. There are two types of membrane filtration technology for wastewater treatment, namely ultrafiltration(UF) and microfiltration(MF). Micro and ultra-filtration membranes provide excellent pretreatment to remove a wide range of dissolved contaminants and industrial effluents.

2. NANOTECHNOLOGY :- Nanoparticles have a great potential to be used in waste water treatment. Its unique characteristic of having high surface area can be used efficiently for removing toxic metal ions, heavy metals, disease causing microbes, organic and inorganic effluents from water. Various classes of nanomaterials are also proved to be efficient for water treatment like metal-containing nanoparticles, carbonaceous nanomaterials, zeolites and dendrimers.

3. AUTOMATIC VARIABLE FILTRATION(AVF) TECHNOLOGY :-

Automated Variable Filtration (AVF) technology is a state of the art technology used for wastewater treatment in which upward flow of influent is cleaned by downward flow of filter media. During the treatment process itself, the filter media is cleaned by the filtered influent thus there is no requirement for any additional filter media cleaning or fresh water. The advantages of AVF technology are -

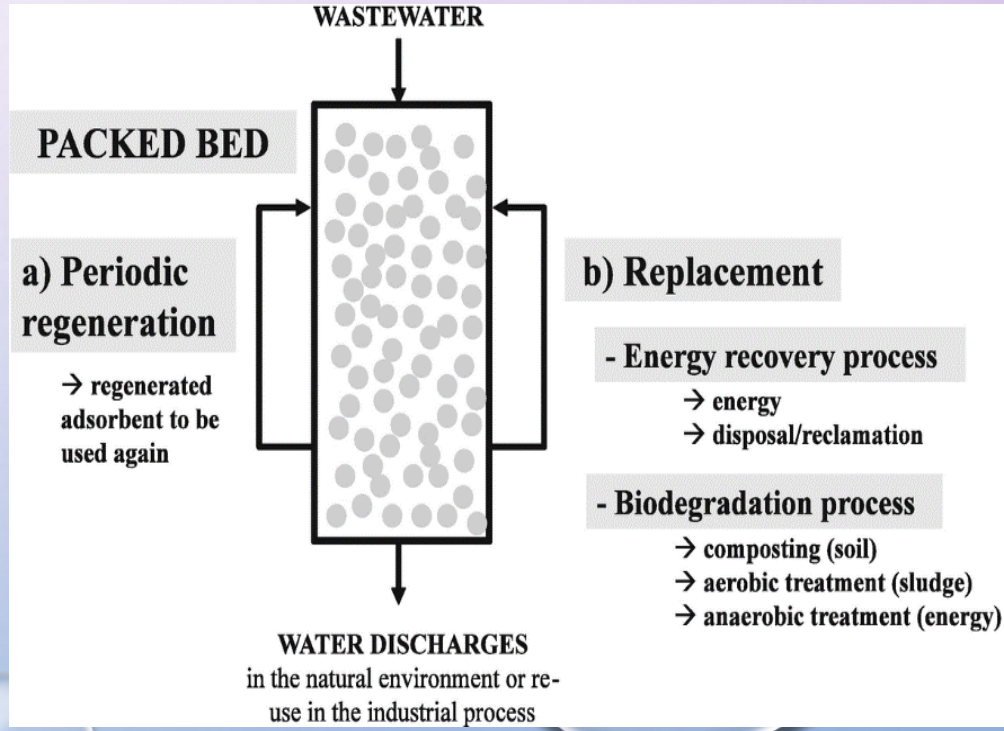
- Even flow distribution.
- Cost effective to install and low operating and maintenance costs.
- Continuously cleaned media beds, and extremely low power consumption.



Solutions to Waste Water Treatment In Fertilizer Industries:-

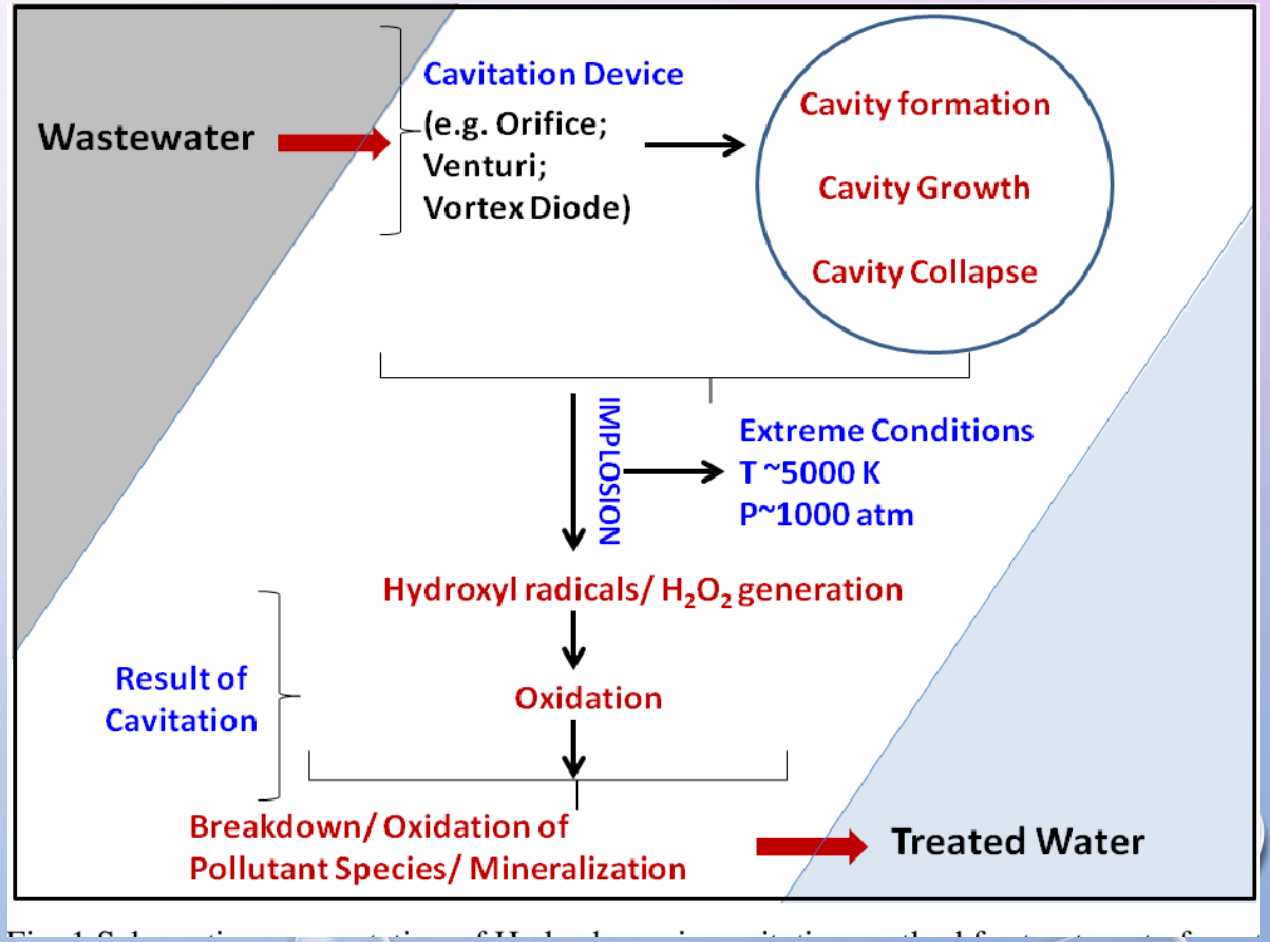
1. Adsorption:-

- Removal and Recovery process.
- In adsorption, exploring newer types of adsorbents will help in realizing better capacity for removal of various organics and metals .
- It can easily serve in reducing the COD of the effluent.
- Screening of the adsorbent is very important since hundreds of commercial adsorbents of different types are available or can be made .



2. Hydrodynamic Cavitation:-

- Cavitation can be considered to work similar to advanced oxidation process without employing complex catalyst, high temperature and pressure
- The overall cavitation process can be viewed as a combination of physical and chemical processes.
- Hydrodynamic cavitation in general can be employed for industrial wastewater treatment using simple mechanical devices such as orifice, venturi or complex device such as vortex diode
- Its implementation in actual industrial practice is still insignificant due to the reasons of the high cost of the treatment and operational difficulties



What's Next:-

- Newer types of commercially available modified carbon based adsorbents can be used for effluent treatment using adsorption process.
- It has been reported that cavitation coupled with other methods such as coagulation or adsorption can be effective in water treatment and pollutant removal
- Hydrodynamic cavitation with vortex diode as a cavitating device was highly effective in reducing the ammonical nitrogen from the effluent streams

SOLUTIONS TO WASTE WATER TREATMENT IN FOOD PROCESSING INDUSTRY

- PRELIMINARY TECHNIQUES

Include processes that reduce the potential for upsets in downstream wastewater treatment process.

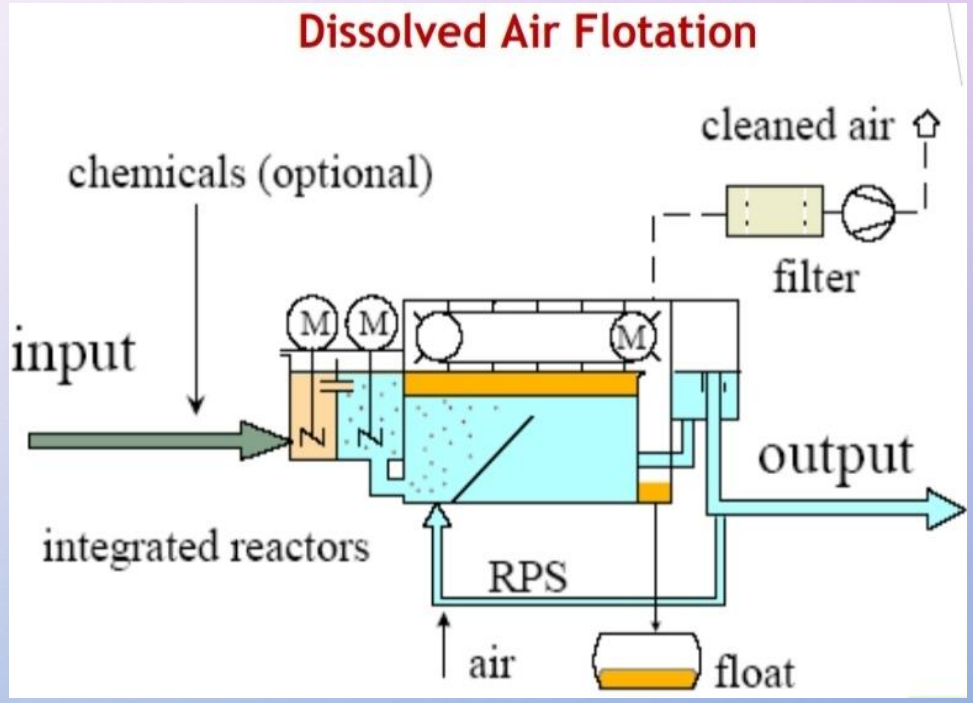
- PRIMARY TREATMENT

Technologies included are:

Screening – remove solids

Dissolved air flotation – remove FOG

Flow equalization – to cut down on flow variations for better treatment



PRIMARY TREATMENT

- Primary sedimentation - designed to remove settleable solids and reduce the organic load (BOD) on the secondary units.

SECONDARY TREATMENT

OBJECTIVE-Reduction of BOD through the removal of organic matter , primarily in the form of soluble organic compounds, remaining after primary treatment.

- Technologies included are:-biological treatment ,lagoons.

ANAEROBIC BIOLOGICAL TREATMENT

Anaerobic wastewater treatment processes make use of microbiological activated reduction of complex organic compounds to methane and carbon dioxide as the mechanism for organic matter and BOD reduction.

AEROBIC BIOLOGICAL TREATMENT

The primary objective of aerobic wastewater treatment is transforming the soluble and suspended organic compounds into microbial biomass, with the subsequent removal of the biomass formed by settling or mechanical separation.

Lagoon systems

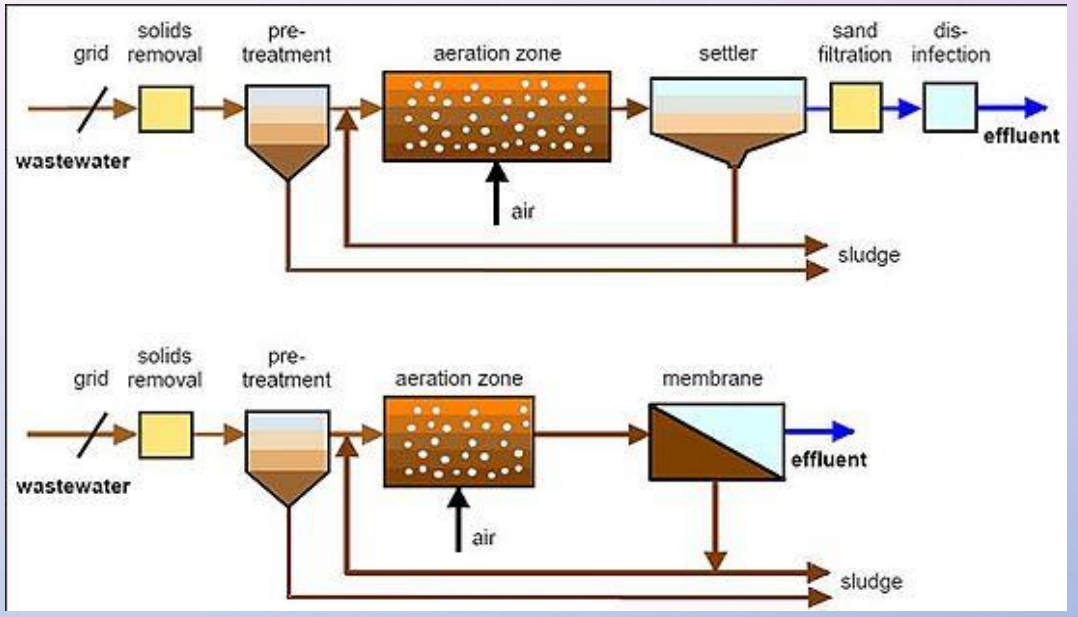
- In the lagoon, wastewater is treated through a combination of physical, biological, and chemical processes. Much of the treatment occurs naturally, but some systems use aeration devices to add oxygen to the wastewater. Aeration makes treatment more efficient, so that less land area is necessary. Types of lagoons are aerobic lagoons, facultative lagoons, partial-mixed aerated lagoons , tertiary lagoons, anaerobic lagoons.

TERTIARY TREATMENT

- Tertiary treatment generally involves any treatment beyond conventional secondary treatment to remove suspended or dissolved substances. This may involve one or more treatment objectives and processing steps. For example, tertiary treatment may be used to: 1) remove nitrogen and phosphorus; 2) further reduce suspended solids concentration after secondary clarification; or 3) remove soluble toxic or dissolved inorganic substances. Disinfection for pathogen control has been included in this category.

MEMBRANE BIOREACTORS

- Membrane bioreactors combine conventional biological treatment (e.G. Activated sludge) processes with membrane filtration to provide an advanced level of organic and suspended solids removal. When designed accordingly, these systems can also provide an advanced level of nutrient removal.



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