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Introduction

- Environmental biotechnology may revamp the possibilities for the prevention of pollution and ensuring the health of the environment through biomonitoring and genetic engineering.
- Environmental biotechnology is concerned with the application of biotechnology to solve problems in ecosystem.
- It can be considered as a driving force for integrated environmental protection leading to sustainable development.

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Bioremediation

• It involve the engineering of systems that use biological processes to degrade, detoxify or accumulate contaminants.

• Bioremediation is a process in which microorganisms, green plants or their enzymes for the remediation of contaminated environments and their high-performance in biodegradation of pollutants.

Bioremediation Treatment Methods

- Composting
- Biopiling
- Landfarming
- Biostimulation
- Bioventing

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Types of Bioremediation

Phytoremediation

Microbial remediation

Mycoremediation

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Phytoremediation

- Involves the interaction of plant roots and the microorganisms associated with these root systems to remediate soils containing elevated concentrations of organic compounds.
- Alternative to engineering procedures that are usually more destructive to the soil.

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Types of Phytoremediation

1. Phytoextraction: Based on the ability of certain plants to gradually accumulate contaminants (mainly metals) into their biomass.

2. Rhizofiltration: Involve the pumping of contaminated groundwater into troughs filled with the large root systems of appropriate plant species.

3. Phytostabilization : Immobilize contaminants through adsorption, accumulation, precipitation within the root zone.

4. Phytodegradation: Attenuation of organic contaminants into less toxic substances within the rhizosphere through biodegradation of soil microbes.

5. Phytovolatilization: Contaminants taken up by the roots through the plants to the leaves and are volatized through stomata.

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Microbial Remediation

- Use of microorganisms to degrade organic contaminants and to bind the use of metals in less bioavailable form. Mycoremediation

- White-rot fungi degrades a wide range of organic molecules that are broadly similar to lignin.

- The release of extra-cellular lignin-modifying enzymes, with a low substrate-specificity so they can act upon various molecules.

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Biomining

• Two stage combined biological system in order to perform the extraction and recovery of the metals from ores.

• Most current biomining operations target valuable metals like copper, uranium, nickel and gold.

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Methods of Biomining

- In-situ leaching
- Dump leaching
- Heap leaching
- Vat leaching

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Biomarkers

• Biological measures of a biological state.

• An indicator of normal biological processes: -pathogenic processes - pharmacological responses to a therapeutic intervention.

• Used in biomonitoring programmers: -exposure, - effect, -susceptibility.

Significant Features of The Use of Biomarkers

- Sublethal effects between contaminants and the organisms.
- Detect both known and unknown contaminants.
- Sub lethality and early detection of effects.
- Measure of bioavailable pollutants.

ROLE OF MICROORGANISMS IN BIODEGRADATION OF POLLUTANTS

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Factors Affecting Microbial Degradation

- Biological factor
- Nutrients , oxygen , temperature , pH ,moisture. Environmental factor
- Soil type and soil organic matter content .

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Sewage Treatment/Waste Water Treatment

• Sewage treatment is the process of removing contaminants from municipal wastewater.

• Three steps of waste water treatment- Primary treatment Secondary treatment Tertiary treatment

Pretreatment

• Removes all materials that can be easily collected from the raw sewage .

Primary Treatment

• Temporarily holding the sewage in a quiescent basin where heavy solids can settle to the bottom while oil, grease and lighter solids float to the surface.

Secondary Treatment

- Secondary treatment removes dissolved and suspended biological matter.

- Classified as –
- Trickling filters
- Constructed wetlands
- Rotating biological contactors Fixed film system
- Activated sludge process Suspended growth system

Secondary Treatment

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- It is the process for treating sewage or industrial wastewaters using aeration and a biological floc .

Tertiary Treatment

• The purpose is to provide a final treatment stage to further improve the effluent quality before it is discharged to the receiving environment.

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- Sand filtration.
- Lagoons or ponds

Environmental monitoring can be defined as the systematic sampling of air, water, soil, and biota in order to observe and study the environment, as well as to derive knowledge from this process.

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- Monitoring of the environment may be undertaken for a number of reasons. In general monitoring is done in order to gain information about the present levels of harmful or potentially harmful pollutants in discharges to the environment, within the environment itself or in living creatures that may be affected by these pollutants.
- This definition can be expanded as follows:-

- Monitoring may be carried out to assess pollution effects on man and his environment in order to identify any possible cause and effect relationship between pollutant concentration and health effects, climatic changes etc.

– To evaluate pollution interactions and patterns

– To assess the need for legislative controls and emissions of pollutants and to ensure compliance with emission standards.

ENVIRONMENT MONITORING METHODS

1. Ground-based Sampling and Measurements
2. Model-based Monitoring
3. Satellite based Monitoring

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Satellite Based Environment Monitoring Areas

- Atmosphere Monitoring
- Air Quality Monitoring
- Climate Change Studies
- Resource Management
- Glaciers and Snow
- Flood and Drought Management
- Landuse / Landcover
- Weather Prediction
- Hazards Monitoring
- Aviation
- Agriculture
- Marine & Phytoplankton Studies
- Dust Storm

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This may be carried out for a number of reasons

- Identification and characterization of main sources in urban areas.
- Determination of the mass emission rates of pollutants from a particular source and assessment of how these are affected by process variations.
- Evaluation of the effectiveness of control devices for pollution abatement.
- Evaluation of compliance with statutory limitations on emissions from individual sources.

Monitoring the environment may be carried out for a number of reasons:

- Mapping the concentration of pollutants in the environment. Identification of pollution sensitive zones.
- Identification of possible sites for the environmental monitoring stations.
- Tracking progress towards National Quality Standards attainment and emission reductions.
- Serve as the basis for modeling of predicted pollutant concentrations in ambient air.
- Provide input for human health risk assessment studies.

- Ambient environment monitoring includes:
  Air Pollution Monitoring
  Water Pollution Monitoring
  Sediment,
  Soil and Biological Monitoring
  Noise Level Monitoring

WATER BORNE INFECTIOUS AGENTS

- Drinking water is a major source of microbial pathogens in developing countries.

• Waterborne disease cause more than 2 million deaths and 4 billion cases of diarrhea annually.

• 9 out of 10 deaths are in children and virtually all of the deaths are in developing countries.

The importance of water quality

• Safe water is a precondition for health and development and a basic human right.

•Water-related diseases caused by insufficient safe water supplies coupled with poor sanitation and hygiene.

Terms to be known

- Potable(clean) water: It is free of all objectional material, including pathogens, tastes, odors, colours, toxins, radioactive material, organisms, oils, gases, etc.
- Contaminated or polluted water: Water contaminated with sewage, domestic or industrial waste with chemicals and pathogenic microorganisms .

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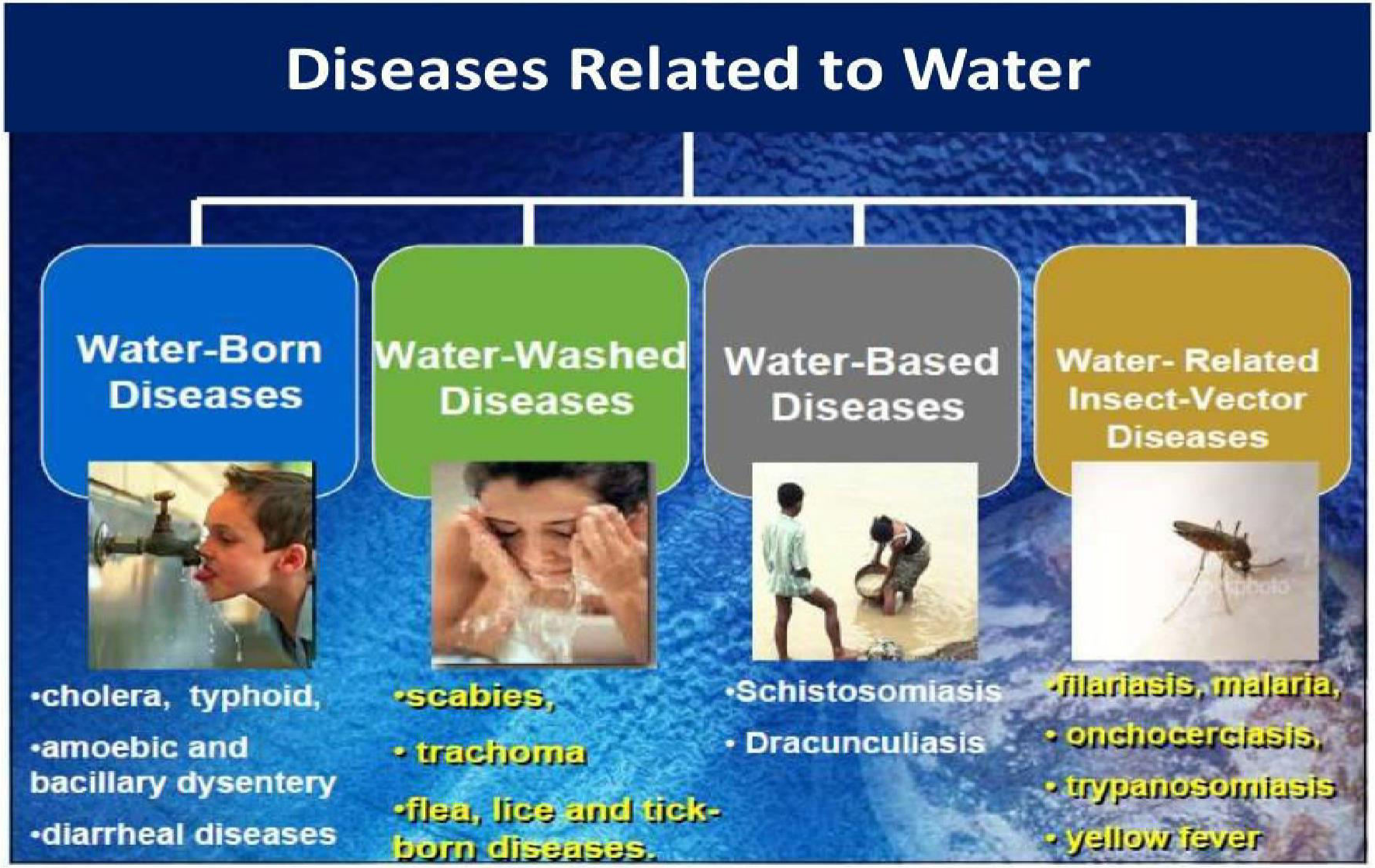
Diseases Related to Water



04 categories of water-related infections

1. **Water-borne infections**
2. **Water-washed infections**
   Water-washed Diseases: Diseases caused by poor personal hygiene and skin and eye contact with contaminated water
3. **Water-based infections**
4. **Water-related infections**

Water - borne infections

- Infections in which the enteric **microorganism** enters the water source through **faecal contamination** and transmission occurs by the ingestion of contaminated water

- Route of transmission and infection depends on
  - Amount of faecal contamination in water
  - Concentration of pathogens in the faecal contamination
  - Survival of the pathogenic organism in water
  - Infectivity of the organism
  - Individual Health status

Control

- Improvement of microbiological water quality (water treatment or source protection)

Examples: **Typhoid and Cholera**

Water - washed infections

- These diseases mainly occur due to **poor personal and/or domestic hygiene** and lack of readily accessible water sources

- This permits transmission of infectious agents such as ***Shigella*** spp. by limiting the washing of contaminated hands and utensils
- The spread of diseases is also facilitated by the **lack of water for bathing and other hygienic personal** care thereby resulting in diseases such as **trachoma, conjunctivitis, and scabies** mainly affecting the eyes and skin.

Water - based infections

- In this category the **pathogen must spend a part of its life cycle** in the aquatic environment

- Transmission route: Ingestion and/or contact with water

- Example,
  - **Dracunculiasis** - Ingestion of water contaminated with guinea worm (*Dracunculus medinensis*)
  - **Schistosomiasis** is transmitted by contact with water contaminated with the trematode genus *Schistosoma*

Control

- Protection of the water sources
- Limiting the skin contact with infected water
- Eradication of Intermediate hosts of these diseases.

Water – related infections

- These infections are transmitted by **insects/ vectors which breed in water**
- E.g., Mosquitoes causing many diseases like malaria, dengue, chickungunya and Japanese encephalitis or
- Insects bite near water sources (tsetse flies- sleeping sickness)

Control

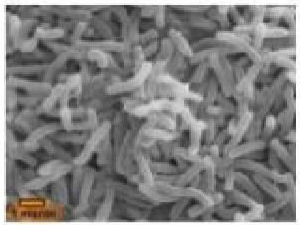
- Vector destruction by the application of pesticides, destruction of breeding grounds, and construction of piped water supplies.

An overview of important Water related pathogens

Bacteria	Parasites	Viruses	Fungus
➢ Vibrio species ➢ *E. coli* ➢ Campylobacter ➢ Salmonella ➢ Leptospira ➢ Legionella	➢ Cryptosporidium ➢ Giardia ➢ Toxoplasmosis ➢ Cyclospora ➢ Naegleria	➢ Hep A ➢ Polio ➢ Norovirus	➢ Cryptococcus ➢ Aspergillus ➢ Harmful Algae Bloom (HAB)

Bacterial Contamination

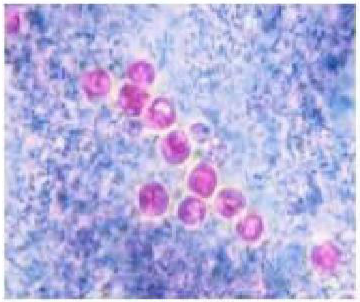
- ***E. Coli* O157:H7** from contaminated food and water
- Bloody diarrhea, vomiting-may lead to kidney failure and even death (Complications: HUS & HC)
- ***Campylobacter***-common cause of food poisoning from meats/unpasteurized dairy products/contaminated water. (Complication- Guillain-Barré Syndrome)
- ***Salmonella***-common cause of food poisoning
- ***Leptospira***-spread through the **urine** of infected animals, rodents, through the soil and water, and during flooding. Infections in urban kids increasing.



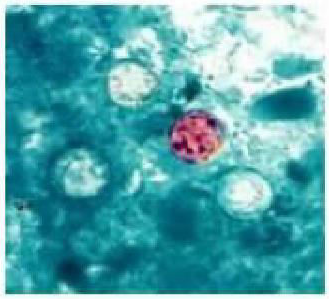
Vibrio Species & Legionella

- **Vibrio** is strongly influenced by climate-both fresh & marine waters
- ***V. Cholera*** causes estimated 3-5 million cases and 100,000-120,000 deaths yearly world-wide. Young children in endemic areas most affected (Velazquez-Roman *et al.*, 2014).
- Climate warming can increase pathogen development and survival rates, disease transmission and host vulnerability.

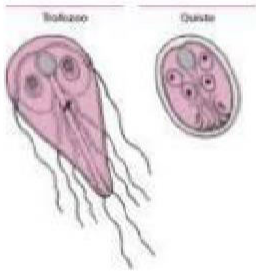
- ***Legionella*** (Legionnaire's Disease)-respiratory illness transmitted solely by water. Warm water and perhaps other factors, like association with amoebas, influence the potential to colonize water systems.



Parasitic Disease



- **Cryptosporidium**
  - Common disinfectants, like chlorination is ineffective
  - 1993 outbreak in Milwaukee was the largest outbreak ever documented in the U.S. with 400,000 cases and 100 deaths.

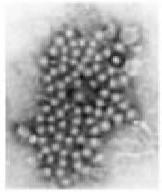


- ***Giardia lamblia***
  - Cyst found in raw surface water from animal and human feces

- **Cyclospora**-often associated with fresh produce (vegetables, fruits) from contaminated water

Viral, Fungal & HAB Diseases

- **Viruses** are heat resistant and likely to survive sewer treatment processes. Viruses found in shellfish contaminated with wastewater and fecal sources.
  - Hepatitis A
  - Norovirus
  - Norwalk virus



- **Fugal Diseases**
  - Cryptococcus
  - Aspergillus

- **Harmful Algae Blooms (HAB)** are organisms that can severely lower oxygen levels in natural waters, killing marine life.
- Some HABs are associated with algae-produced toxins

Prevention and Control

- Improve quality and quantity of drinking at source, at the tap, or in the storage vessel.
- Interrupt routes of transmission by empting accumulated water sources
- Chlorinate water
- Change hygiene behavior, like hand washing
- Breastfeeding first 6 months of life
- Proper use of latrines
- Careful disposal of all waste products
- Proper maintenance of water supply, sanitation systems, pumps and wells
- Good food hygiene-wash before eating, protect from flies
- Improved immunizations practices, especially rotavirus
- Develop or enhance public health surveillance system
- Faster responses to emergent and dangerous pandemic strains of pathogenic infections.
- Health education programs across the country
- In natural epidemics- superchlorination of eater resources is preferable

Waste Water Treatment Methods

Waste water Treatment:

- When effluent discharged into a river body such as lake, river or sea a number of process occur like physical, chemical and biological characteristics of water change which cause loss of organism.
- The extent of damage depend upon type pf pollutant present in effluent. Non bio-degradable pollutant like mercury are most deadly as they accumulate in aquatic organism which lead to Biomagnifications.
- Large quantity of biodegradable waste can affect living organism in the water bodies in which waste are discharged.

It is necessary to treat effluent or waste water before discharging in water body. The treatment procedure are generally divided into three groups-

1. Primary Treatment or Mechanical Treatment
2. Secondary Treatment or Biological Treatment
3. Tertiary Treatment or Advance Biological or Chemical Treatment

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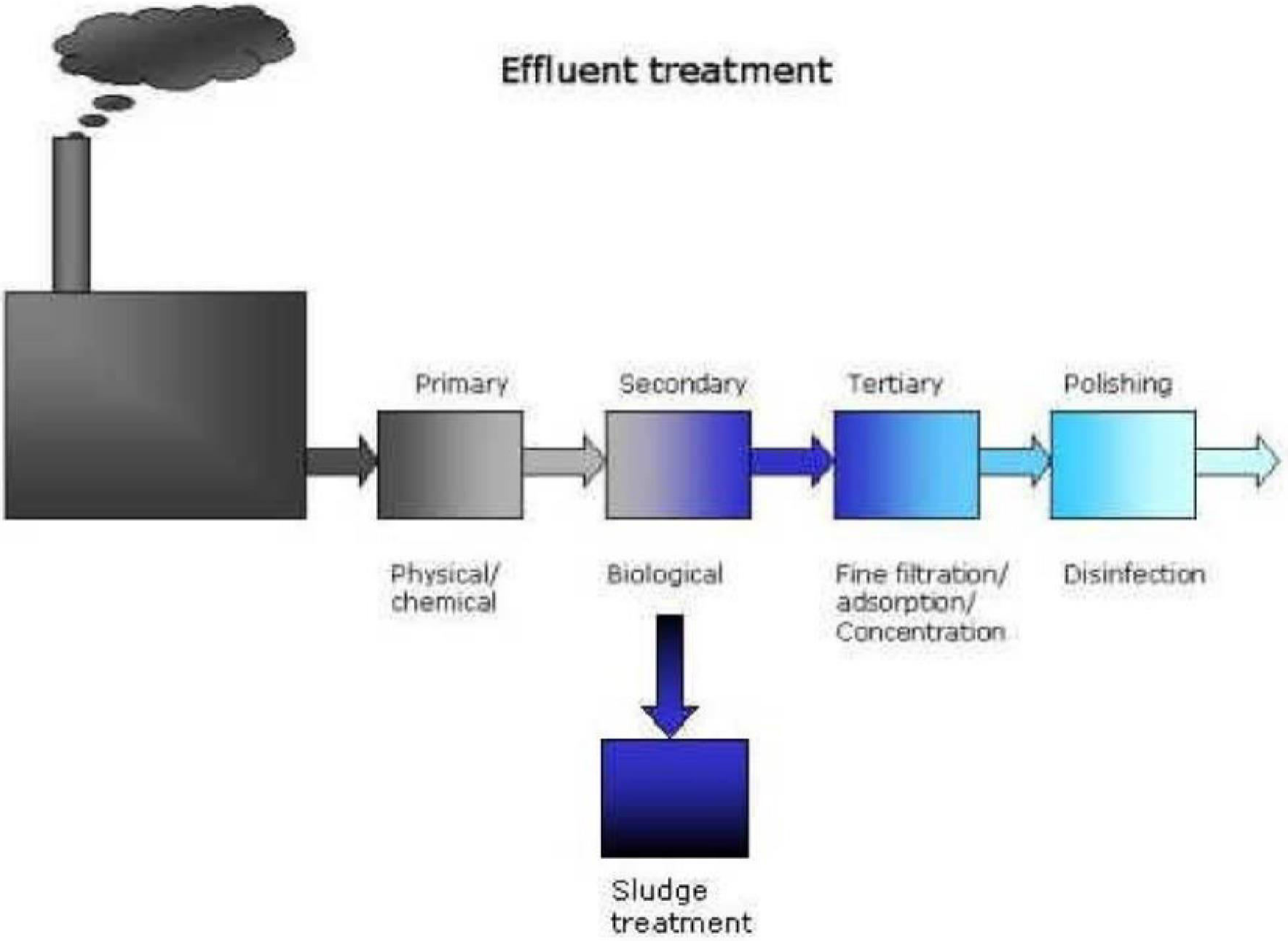
Effluent treatment



Primary Treatment-

- In primary treatment suspended solid and floating material is removed. Effluent is passes through a screen which is used to remove certain material like wood pieces, plastic , paper, floating debris.
- Then effluent is passed through chamber which is known as grit chamber.
- Fatty and oily substance can be removed by flotation method.
- In order to trap fatty and oily substance a instrument called Centrifugal Separator is used in this process fatty substance are reached to outside and clean water remain in the center of cyclone. The water is passed in Settling Tank in which water remain for a long time in which suspended particles are settled down this process is known as Sedimentation.

Sedimentation can be accelerated by adding chemical substance known as Coagulant like Alum.- Some small particles may be separated by Floatation Method . In this method bubble of air pass through the bottom of tank and small particles come in the contact with bubble come out on the surface of water.- Colloidal particles can be removed by Flocculation and Precipitation.

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Primary Clarifier

Revolving bar to collect and remove floating scum.

Clarified water flows out through V-notches.

After the grit tank, the sewage is directed to one of four primary clarifiers or settling tanks. The primary clarifiers remove the larger suspended solids and less dense floating material such as fats, oils, and scum. The clarifiers can effectively remove 50-60% of the suspended solids and 25-40% of the BOD (Biochemical Oxygen Demand) from the waste water. Solids eventually settle to the bottom of the tank and are removed. Clarified water overflows the top.

C. Ophardt c. 1999

1.Primary Treatment- Physical Treatment- Chemical Treatment Physical chemical waste water treatment techniques are techniques to remove the coarse fraction. Oil, fatty acids and suspended solids could be removed by the use of the following techniques:1. Physical Treatment a) Screening b) Grit Chamberc) Floatation or skimming tank

Chemical Treatment- Sedimentation- Coagulation- Flocculation- FilterationPhysical chemical treatment is normally used toprepare the waste water for the next treatmenttechnique, in many cases biological treatment.

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Screen Chamber: Screen chamber remove dead animals, branches of tree, logs of wood, rags and other coarse floating material. The effluent is passed through the bar screens for removal. In this section, two automatic bar screen cleaners remove large solids (rags, plastics, etc.) from the raw sewage. The collected material is placed in dumpsters to be taken laterto the landfill

Preliminary Screens

C. Ophardt c. 1999

The raw sewage passes through bar screens below the floor in this room to remove rags, plastic, etc. The device shown is an automatic bar screen cleaner, which removes the debri into the dumpster for later removal.

This device is also used for preliminary screening of the sewage.

Grit Tanks: Grit include sand, ash, egg shell etc . Of diameter less then0.2 mm. Next, the effluent moves to the grit tanks. These tanks reduce the velocity of the effluent so that heavy particles may fall to the bottom. The solids are pumped to an auger pump which separates the water from the grit while the water moves onward. The grit (mostly inorganic solids)goes to a dumpster which is taken to a landfill. There are two complete grit removal systems which are rotated in operation for equal hours.

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Grit Settling Tank

C. Ophardt c. 1999

Next the sewage moves to the grit tanks. These tanks reduce the velocity of the sewage so that heavy particles may fall to the bottom. The solids are pumped to an auger pump which separates the water from the grit while the water moves onward. The grit (mostly inorganic) goes to a dumpster which is then taken to a landfill.

Skimming Tank Fats, waxes, fatty acid, soap, minerals and vegetable oil present in waste water are collectively called as oil and grease. As oil and grease are lighter than water they are normally separated by natural flotation .The bubbles of air are passed on the bottom of the tank and floating matter rises and remain on the surface of waste water which can be separated easily.

Sedimentation: Settling down of suspended particles at the bottom of water is called Sedimentation. This process is also known as clarification. In this process water is collected into big pond , slowly- slowly impurities are settled down by gravitation. The process of sedimentation can be accelerated by adding Alum. The main objective of Sedimentation are :- The suspended and colloidal impurities are separated in sedimentation tank by gravitation.- It reduce heavy sediment load before treating water for other purposes.

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The main principle of sedimentation is to allow water to restor flow at a very slow velocity. So that heavier particles settle down due to gravity.- The process of settling of particles depend mainly on velocity of flow, size, shape and specific gravity of particles and viscosity of liquid.- The velocity of water decreased by increasing the length off low. This principle is used in the process of sedimentation.- The size and shape of particles are increased by formation of precipitates because of addition of coagulants.

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Coagulation- In plain sedimentation, the heavier particles settle down. However fine particles take many hours or sometimes days to settle down.- Colloidal particles which are fine particles of size finer than 0.0001 mm carry electric charges on them.- The water possesses colour which is mainly due to colloidal matter and dissolve organic matter in water.- The turbidity in water is mainly due to the presence of very fine particles of clay, silt and organic matter.- Sedimentation alone is not sufficient o remove all the suspended matter. The process of coagulation is used to remove colloidal particles from water.- Coagulation is the process in which certain chemical agent is mixed with water then colloidal and suspended particles are agglomerated and form insoluble metal hydroxide known as flocks.

Filtration- Filtration is done in order to remove colloidal and Suspended matter remaining after sedimentation and to remove bacterial load.- The process of filtration usually consist of allowing the waterpass through thick layer of sand or porous material which retain coarse impurities on its surface and in pores.- The apparatus used for filtration is called filter and the porous material that fill the filter is known as filtering medium.

Flocculation is the agglomeration of destabilized particles into microfloc and after into bulky floccules which can be settled called floc. The addition of another reagent called flocculants or aflocculants aid may promote the formation of the floc.The factors, which can promote the coagulation-flocculation, are the velocity gradient, the time, and the pH. The time and the velocity gradient are important to increase the probability of the particles to come

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Secondary Treatment or Biological Treatment

It is the process in which microorganism play a very important role for the treatment of effluent. Microorganism like bacteria, fungi decompose the organic waste and convert into simpler form. The main function of secondary treatment is to convert the reaming organic matter of sewage into stable form by oxidation and nitrification. Biological Treatment Can be classified into1. Aerobic Treatment a) Activated Sludge Process b) Trickling Filter c)2. Anaerobic Treatment

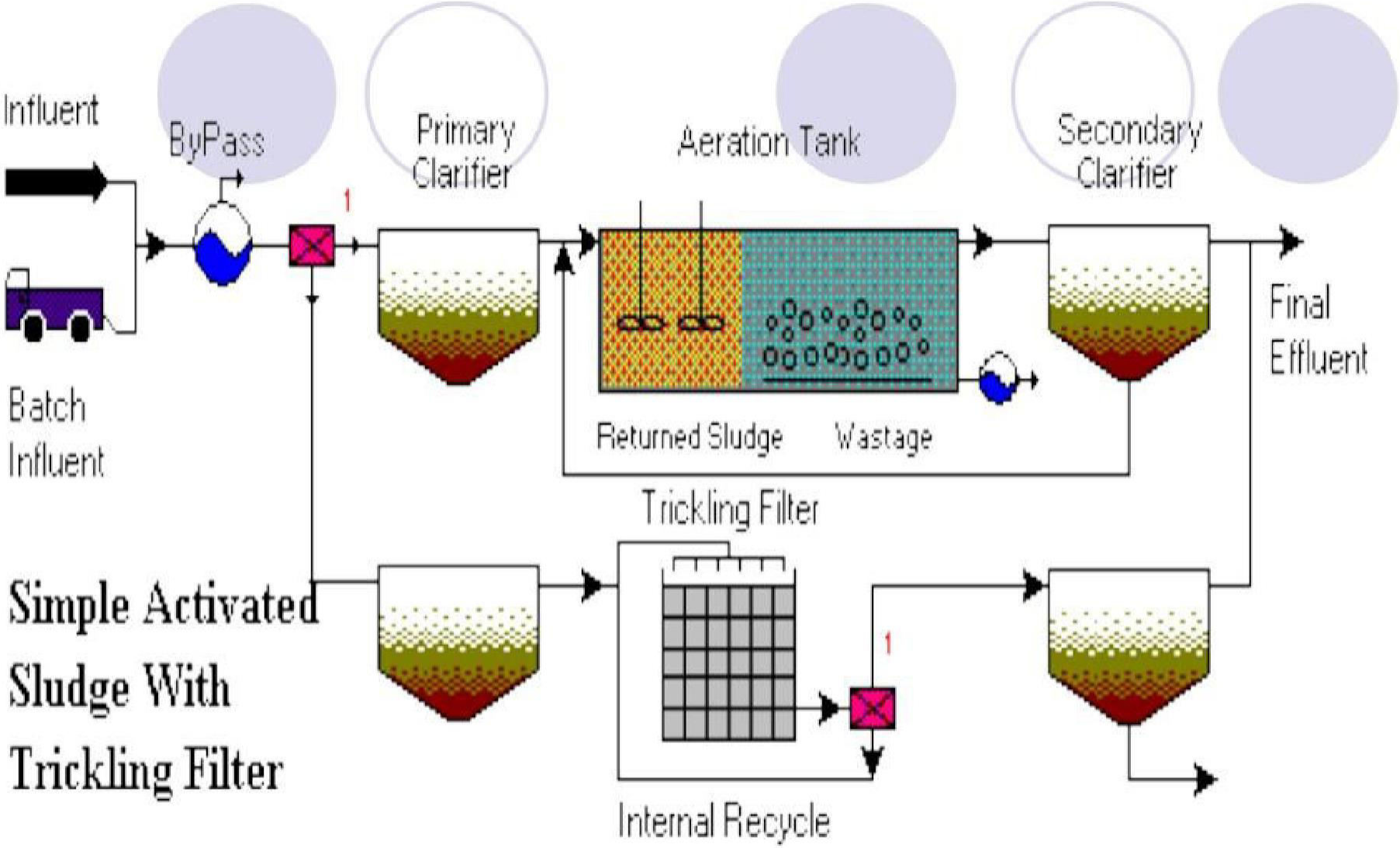
Aerobic Treatment :The treatment which is carried out by microorganism in the presence of oxygen. Anaerobic Treatment :The treatment which is carried out by aerobes in the absence of oxygen. The need of oxygen is supplied by oxidation of oxygenated compound for e.g SO2

Activated Sludge Process- This is most versatile biological oxidation process employed for the treatment of waste water contain dissolve solid, collides, coarse solid and organic matter.- Sewage from sedimentation tank enter into aeration tank. Here 20 – 30% of active sludge is mixed. The mixture is aerated and mixed in the tank for about 4 to 8 hours .- An efficient aeration for 3 – 6 hour is occupied for sludge while for industrial waste 6 – 24 hour of aeration is required.- The microorganism oxidize organic matter , in the presence of abundant quantity of oxygen in the aeration tank. Sewage is allowed to settle in secondary sedimentation tank.- This settled sewage has undergo aeration and has active microorganism. So some portion of activated sludge is recalculated into the aeration tank.

The activated sludge is obtained by settling sewage in the presence of excess oxygen. Thus activated sludge is that sludge which settle down after the sewage has been freely aerated and agitated for a certain time.- The activated sludge is biologically active and contain alarge number of aerobic bacteria and other microorganism.- When activate d sludge is mixed with effluent , the aerobic bacteria oxidize the organic matter and promote coagulation and flocculation.- Some advantages of activated sludge method is) The effluent is free from bed smell and odour) Give Clear sparkling treated liquid

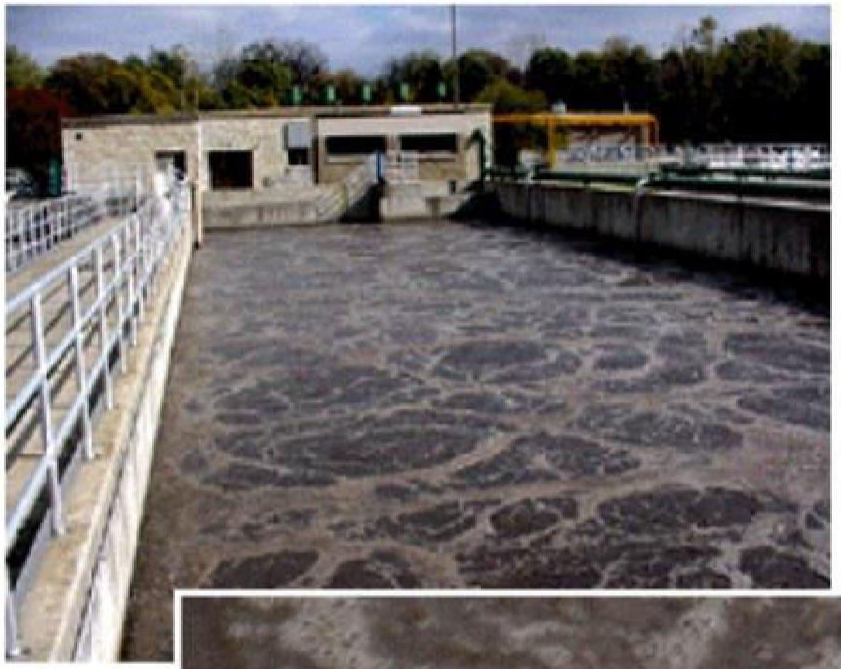
Activated Sludge Process

Trickling Filter- After primary treatment the effluent is passed through the the bed the filter medium which is consisting of bed of stone in which microorganism or bacteria are present.- Bacteria get nutrient . Bacteria attack on carbohydrate, protein, oil, fats which is essential for the growth of bacteria.

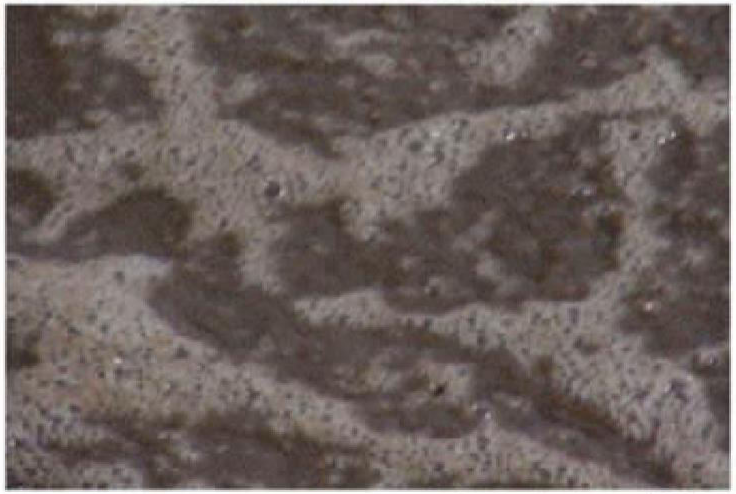

Influent
ByPass
Primary Clarifier
Aeration Tank
Secondary Clarifier
1
Final Effluent
Batch Influent
Returned Sludge
Wastage
Trickling Filter
Simple Activated Sludge With Trickling Filter
1
Internal Recycle

Oxidation Pond (Lagoon): New biological method have been introduced now days for waste water treatment. The oxygen pond is shallow pond where waste water is purified by action of algae and aerobic bacteria. Organic matter are decomposed by bacteria and are consumed by algae. Latter on oxygen is released during the process of photosynthesis. Aerobic bacteria get O_2 from atmosphere and convert the organic matter present in sewage and liberate CO_2 which is again taken by algae during the process of photosynthesis.

Aeration or Activated Sludge Tank



After leaving the primary clarifiers, the sewage goes to any one of ten aeration tanks, which is activated sludge treatment. The aeration tanks provide a location where biological treatment of the wastewater takes place. In these tanks, bacteria and microorganisms and wastewater are mixed, aerated, and maintained in suspension by bubbling compressed air.



The air contains oxygen which is used by the aerobic bacteria in the process of "eating" the organic waste. The activated sludge converts organic substances into carbon dioxide and water.

C. Ophardt c. 1999

Final Settling Tanks

After leaving the aeration tanks, the sewage and bacteria enter the secondary clarifiers. These tanks provde a location where the activated sludge solids can be separated from the water.

As you can see the water is fairly clear in this tank. The solids gradually settle to the bottom of the tank where they can later be removed.

C. Ophardt c. 1999

The aqua colored corrugated sheets cover the V-shape slots where the clear water flows over the edges. In the summer time the covering is used to prevent the excess growth of algae.

Close-up of the solids skimmer. The arm goes around the tank and collects floating solids. At the location shown, there is a slot where the solids can fall into a tank below, but not the water.

Tertiary Treatment (Advance waste water treatment)The main function of tertiary treatment is to decrease the load of nitrogen and phosphorous compound present in the effluent by the following process. a) Precipitation b) Nitrogen Stripping c) Chlorination a) Precipitation: The effluent received after the secondary treatment is mixed with calcium oxide. The lime then react with phosphorous compound in waste to from insoluble calcium phosphate, which then settle down a the bottom of settling tank.

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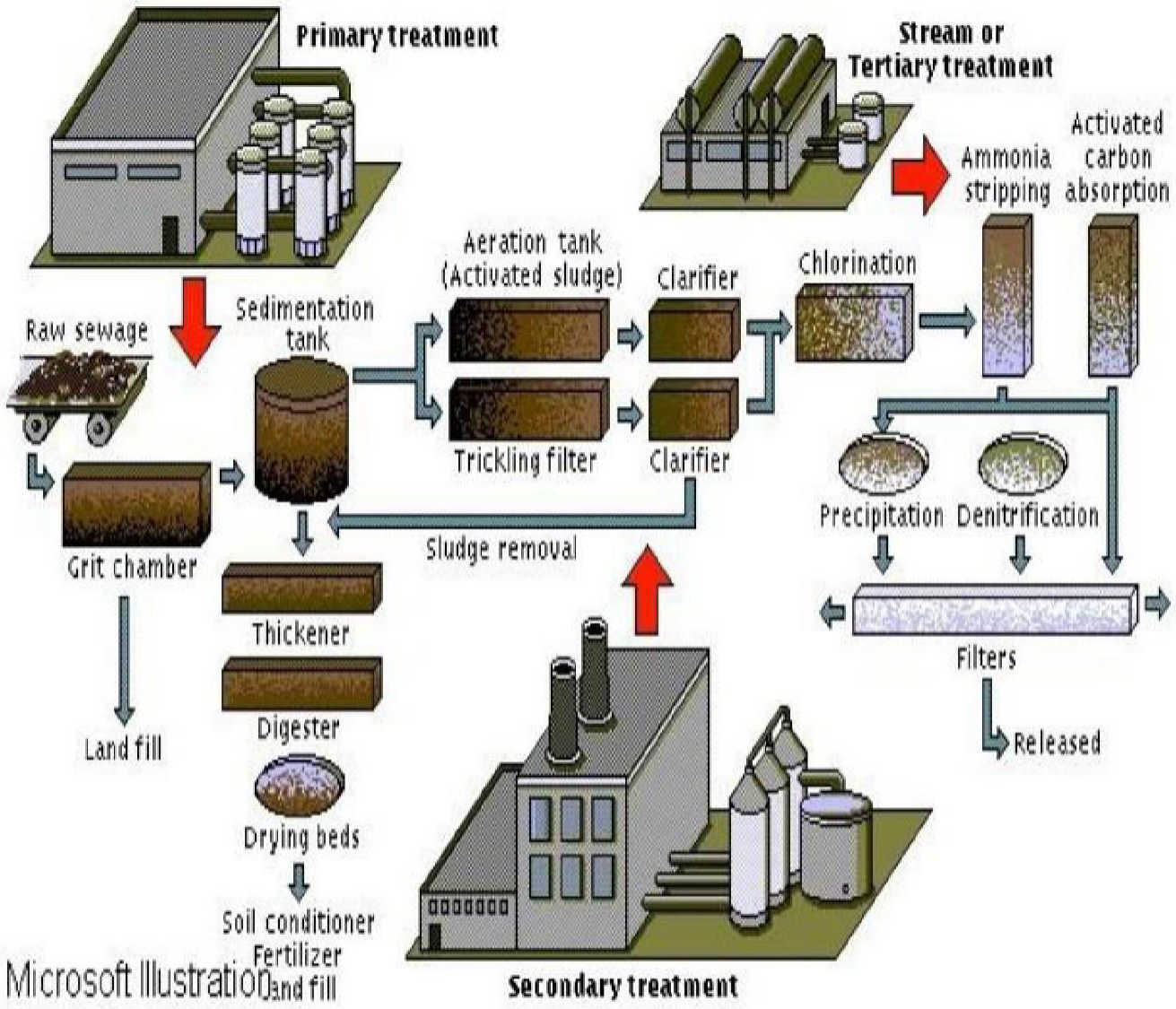
b) Nitrogen Stripping

Nitrogen present in waste water is generally in the form of ammonia gas ,nitrates and nitrites. Ammonia is highly undesirable in streams and lakes because it is extremely lethal to aquatic biota. Nitrogen eventually enhance Eutrophication. In order to remove nitrogen air is forced through the effluent which there by result in the removal of ammonia gas. Chlorination It is the process in which chlorine is used to kill micro-organism .The main purpose of chlorination are- To assist in the formation of floc in the process of coagulation together with other chemical.- To prevent corrosion of sewers.- To prevent spread of epidemic.


Primary treatment
Stream or
Tertiary treatment
Ammonia stripping
Activated carbon absorption
Aeration tank (Activated sludge)
Clarifier
Chlorination
Raw sewage
Sedimentation tank
Trickling filter
Clarifier
Precipitation
Denitrification
Sludge removal
Grit chamber
Thickener
Filters
Land fill
Digester
Released
Drying beds
Soil conditioner
Fertilizer
Land fill
Secondary treatment
Microsoft Illustration