TREATMENT FOR AGRICULTURAL WASTE MANAGEMENT

POLITEKNIK JELI KELANTAN

NOOR ANIZAH BINTI MAAROF
MUHAMAD SYAZWAN BIN AZIZI

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17600 Jeli
Kelantan
http://www.pjk.edu.my/

EMAIL:
nooranizahmaarof@pjk.edu.my
syazwanazizi@pjk.edu.my

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INTRODUCTION

Agriculture is essential to our daily lives, but it also produces a significant amount of waste that can harm the environment if not managed properly. Effective agricultural waste management helps protect natural resources, supports sustainable farming, and turns waste into valuable products like compost, biofuel, and animal feed. This eBook, **Treatment for Agricultural Waste Management**, introduces key methods such as biological, chemical, and physical treatments, along with ways to measure the effectiveness of these processes. By providing clear explanations and real-world examples, this book aims to help students, farmers, and practitioners develop better waste management practices and contribute to a cleaner, greener future. This eBook also serves as a valuable resource for Diploma in Agrotechnology students enrolled in the DYA30323 Agricultural Waste Management course.

ACKNOWLEDGMENT

Acknowledgement

First and foremost, we would like to express our utmost gratitude to Allah SWT for granting us the strength, determination, and guidance to successfully complete this eBook titled “Treatment for Agriculture Waste Management.”

This work would not have been possible without the continuous support and contributions from many individuals and organizations. We would like to sincerely thank our institution, Politeknik Jeli Kelantan, for providing us with the knowledge, resources, and academic environment that made this project possible. The encouragement from our lecturers and peers has been a driving force throughout the process.

A special note of appreciation goes to Kilang Sawit Tapis for their valuable collaboration and practical insights into real-world agricultural waste management practices. Their cooperation provided us with the opportunity to understand industrial applications and challenges, which greatly enriched the content and relevance of this eBook.

We are also deeply thankful to all parties who have directly or indirectly supported us throughout this journey — including our families and friends — for their endless motivation, patience, and encouragement.

May this eBook serve as a useful reference for students, educators, and agricultural practitioners striving toward more sustainable and responsible waste management solutions in the agricultural sector.

Noor Anizah Binti Maarof
Muhamad Syazwan Bin Azizi
Politeknik Jeli Kelantan

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INTRODUCTION TO AGRICULTURAL WASTE MANAGEMENT

INTRODUCTION TO AGRICULTURAL WASTE MANAGEMENT

The collecting, processing, and disposal of waste resulting from farming operations is referred to as agricultural waste management. These wastes might originate from agro-industrial processes, animal husbandry, and agricultural cultivation. They include materials like:

- **Food processing by-products**
- **Wastewater**
- **Food processing by-products**
- **Pesticide containers**
- **Crop residue**

The purpose of agricultural waste management is to reduce these negative effects by converting trash into useful resources such as compost, biofuel, or animal feed. Sustainable waste management procedures not only benefit the environment but also help to create a circular economy in agriculture. Key principles of agricultural waste management include:

REDUCE	**the generation of waste**
REUSE	**where possible**
RECYCLE	**organic materials into fertilizer**
DISPOSAL	**of hazardous wastes**

DID YOU KNOW?

In 2024, Malaysia generated around 38,000 tons of municipal solid waste daily, with over 30% being food waste.

INTRODUCTION TO COMPLETE WASTEWATER TREATMENT

INTRODUCTION TO COMPLETE WASTEWATER TREATMENT

Wastewater treatment is a critical process that ensures the safe and effective removal of contaminants from water that has been used in homes, industries, and agricultural. The primary goal is to produce an effluent that can be safely returned to the environment or reused, minimizing environmental pollution and protecting public health.

Complete wastewater treatment typically involves a series of physical, chemical, and biological processes that work together to remove solids, organic matter, nutrients, pathogens, and other pollutants.

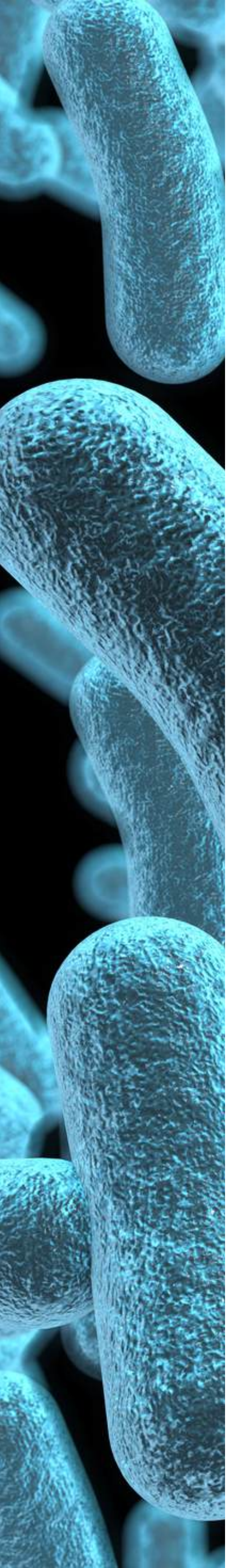
Sludge from a wastewater treatment plant.

These treatment processes are generally classified as primary, secondary and tertiary treatment processes. Primary treatment may utilize physical and/or chemical processes to prepare the effluent for the next stage of treatment that is biological treatment processes. Tertiary treatment using chemical and/or physical processes is normally warranted to further polish the treated effluent to comply with more stringent discharged standard.

It is to be noted that there is no hard and fast rule about the classification of treatment processes, but what has been described above is commonly being used in practice.

Classification of Treatment	Treatment process
Primary (Preliminary / Pretreatment)	**Filtration** **Coagulation/Flocculation** **Sedimentation** **Flotation**
Secondary (Biological Treatment)	**Activated sludge** **Oxidation pond** **Aerated lagoon** **Trickling filter**
Tertiary (Advanced treatment)	**Nitrogen removal** **Phosphorus removal** **Chemical oxidation** **Ion exchange**

BIOLOGICAL PROCESS

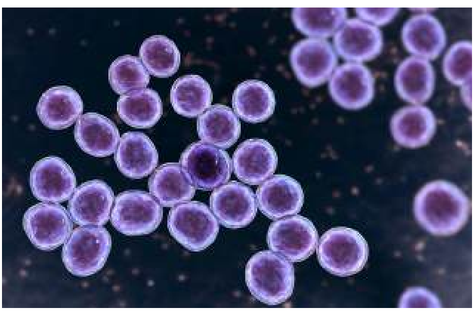


BIOLOGICAL PROCESS

The biological process of wastewater treatment involves using microorganisms like bacteria, protozoa, and fungi to break down and remove organic matter and nutrients from sewage or industrial wastewater.

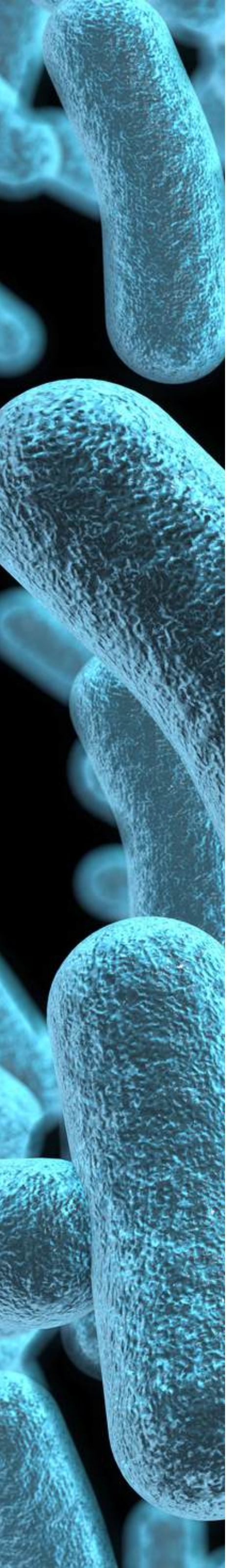
Protozoa

Fungi



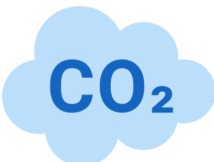
Bacteria

AEROBIC TREATMENT

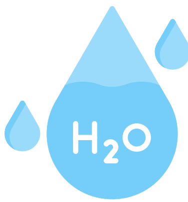


AEROBIC TREATMENT

The **aerobic treatment** of wastewater is a biological process that uses **oxygen** and **aerobic microorganisms** to break down organic pollutants in the water. It's a key part of secondary treatment in most modern wastewater treatment plants. In aerobic treatment, bacteria and other microbes require oxygen to survive. They consume the organic matter like sugars, fats, proteins in wastewater, converting it into:



Carbon dioxide



Water

Biomass (sludge)

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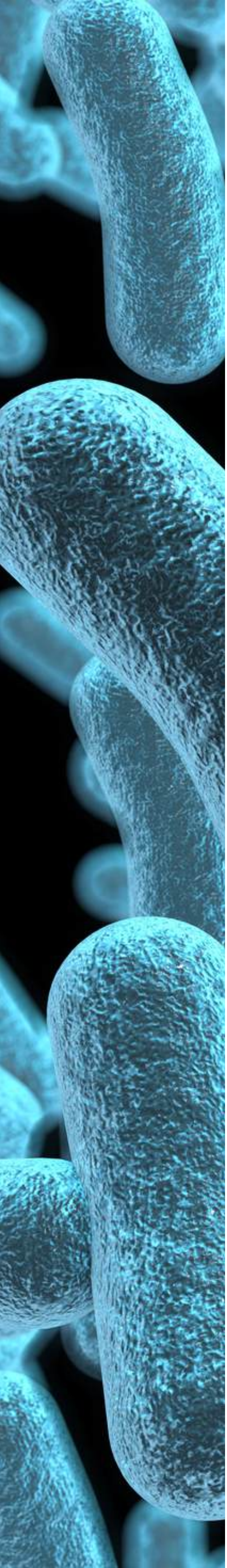
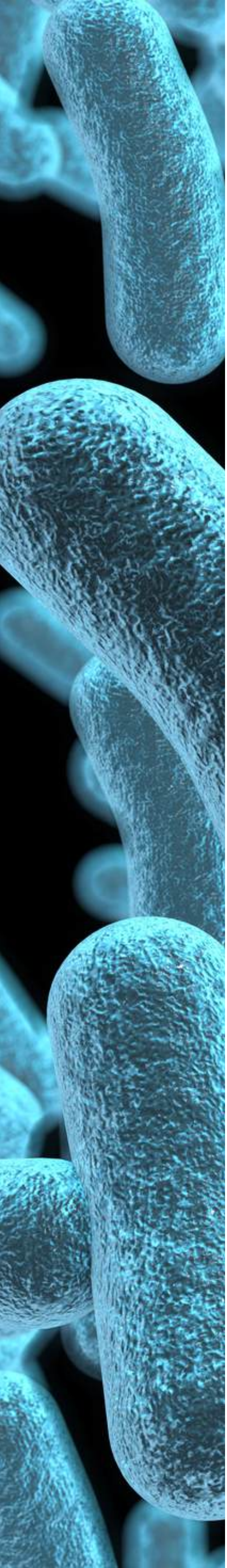


MAIN STEPS IN AEROBIC TREATMENT

1. Aeration Tank (Bioreactor)

- Wastewater is pumped into a tank where air (or pure oxygen) is bubbled through.
- Microorganisms such as Pseudomonas and Nitrosomonas in the tank feed on the organic pollutants.
- This is often called the **Activated Sludge Process.**

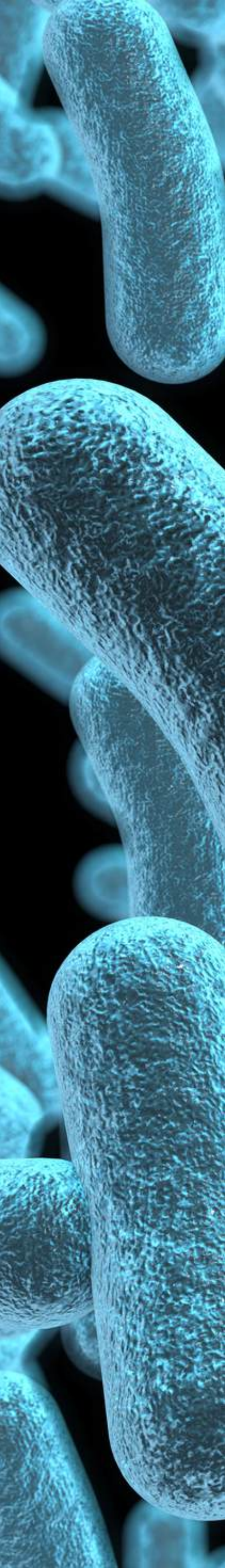


2. Secondary Clarifier (Settling Tank)

- After aeration, the mixture flows to a settling tank.
- Microbial flocs (activated sludge) settle at the bottom.
- Clear treated water (effluent) flows out the top.

3. Sludge Recycling

- Some of the settled sludge is returned to the aeration tank to maintain a high population of microbes.
- Excess sludge is removed and treated separately



TYPES OF AEROBIC TREATMENT SYSTEMS

ACTIVATED SLUDGE SYSTEM

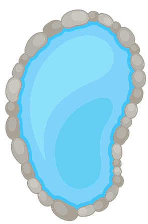
Most common in large municipal plants.

TRICKLING FILTERS

Wastewater passes over rocks or plastic media colonized by microbes.

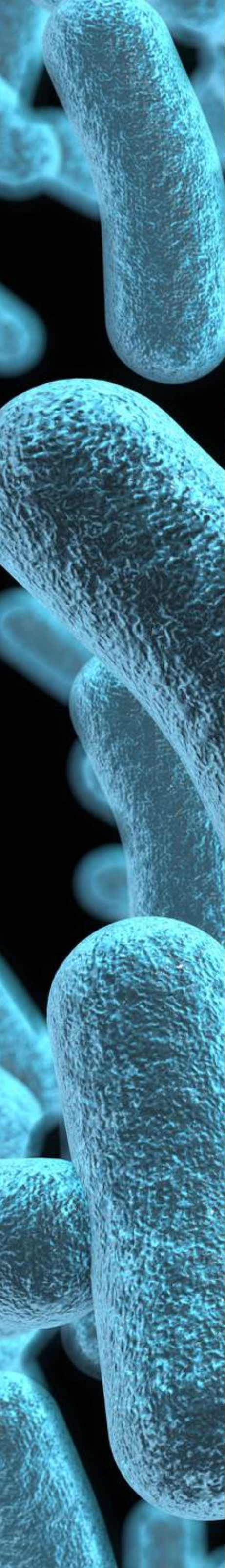
ROTATING BIOLOGICAL CONTACTORS (RBCS)

Discs rotate through wastewater and air, growing microbial films.



AERATED LAGOONS

Large ponds with mechanical aeration, used in small towns or rural areas.



Advantages of Aerobic Treatment

Efficient at removing BOD (Biochemical Oxygen Demand) and organic pollutants.

Faster than anaerobic processes.

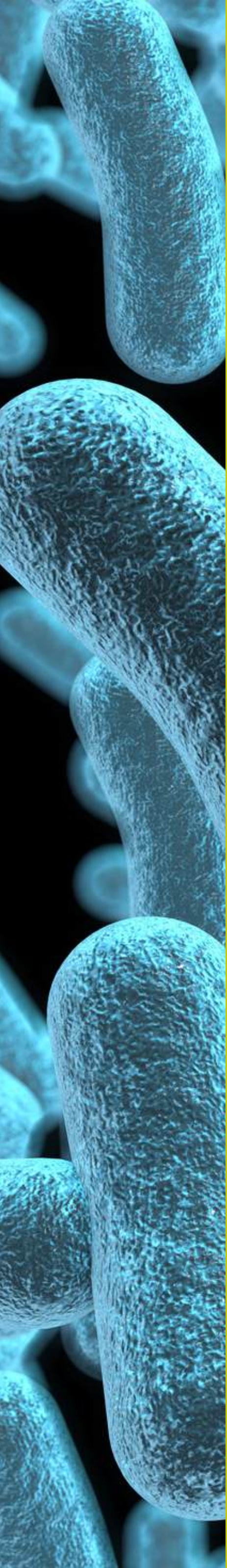
Can also help with nitrification (ammonia nitrate).

Disadvantages of Aerobic Treatment

High energy cost for aeration.

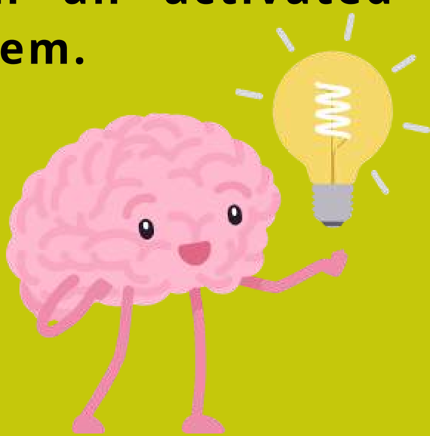
Produces more sludge than anaerobic systems.

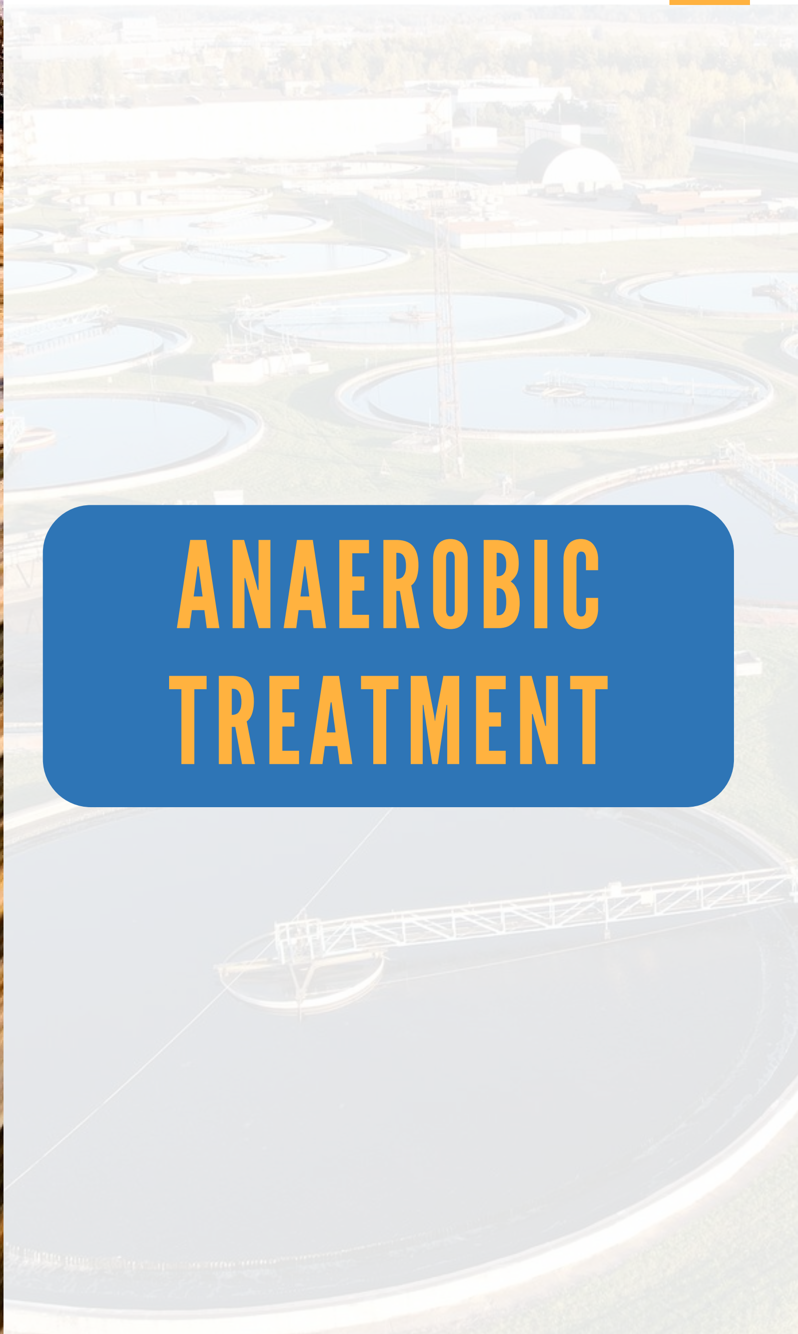
Sensitive to temperature and pH changes



TUTORIAL 1

1. **Explain the role of oxygen in aerobic wastewater treatment.**
2. **Compare and contrast the processes of aerobic and anaerobic treatment.**
3. **Describe the typical stages involved in an activated sludge system.**



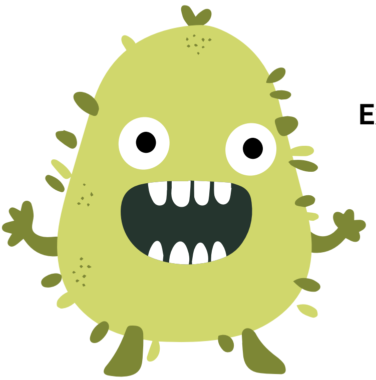


ANAEROBIC TREATMENT

ANAEROBIC TREATMENT

Anaerobic treatment is a biological process used in wastewater treatment that breaks down organic matter in the **absence** of oxygen. It's particularly effective for high-strength organic wastewater like from food processing or agriculture and for sludge stabilization in municipal treatment plants. It uses **anaerobic microorganisms** (bacteria that thrive without oxygen).

These microbes break down biodegradable material into biogas (mainly methane and carbon dioxide) and a stabilized sludge.



Examples of anaerobic bacteria:
Clostridium
Bacteroides
Fusobacterium

How does it works?

HYDROLYSIS

Complex organic matter like fats, proteins, and carbohydrates is broken down into simpler soluble compounds.

ACIDOGENESIS

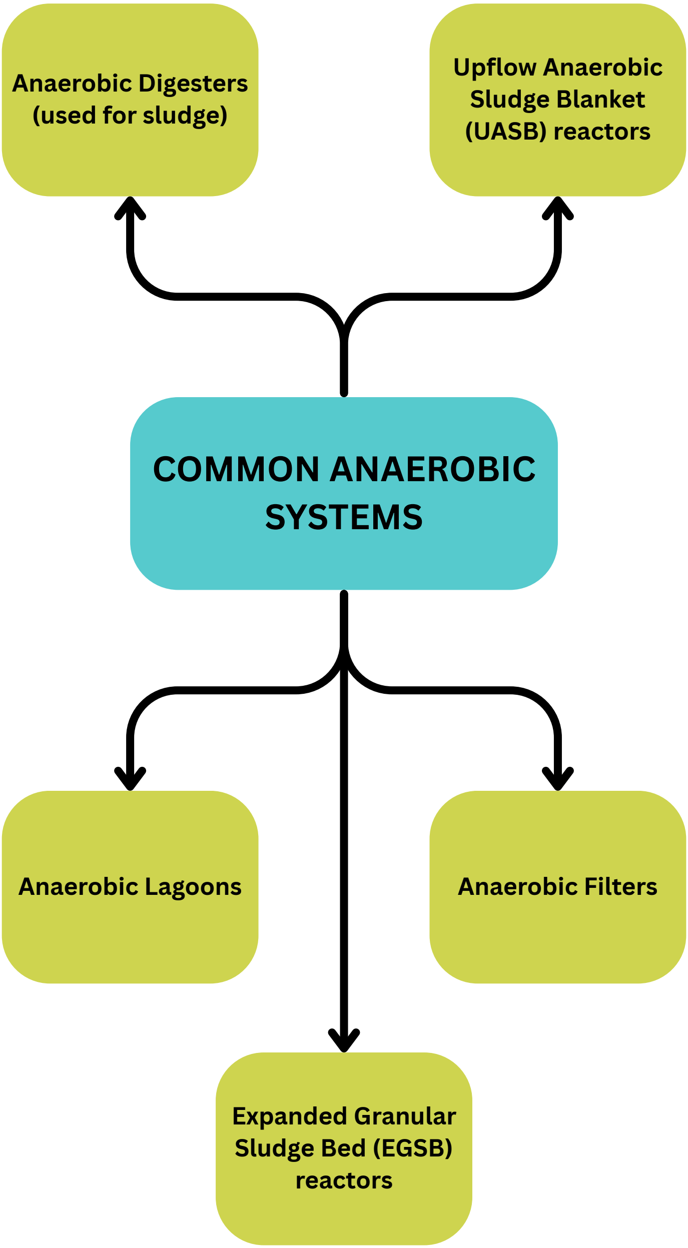
These compounds are converted into volatile fatty acids, alcohols, and gases.

ACETOGENESIS

Further conversion into acetic acid, hydrogen, and carbon dioxide.

METHANOGENESIS

Methane-producing bacteria (methanogens) convert acetic acid and hydrogen into methane (CH_4) and CO_2.


Anaerobic Digesters (used for sludge)
Upflow Anaerobic Sludge Blanket (UASB) reactors
COMMON ANAEROBIC SYSTEMS
Anaerobic Lagoons
Anaerobic Filters
Expanded Granular Sludge Bed (EGSB) reactors

Advantages of Anaerobic Treatment

Energy recovery (from biogas)

Lower sludge production compared to aerobic systems

• Can treat high-strength organic waste

Lower nutrient requirements

Disadvantages of Anaerobic Treatment

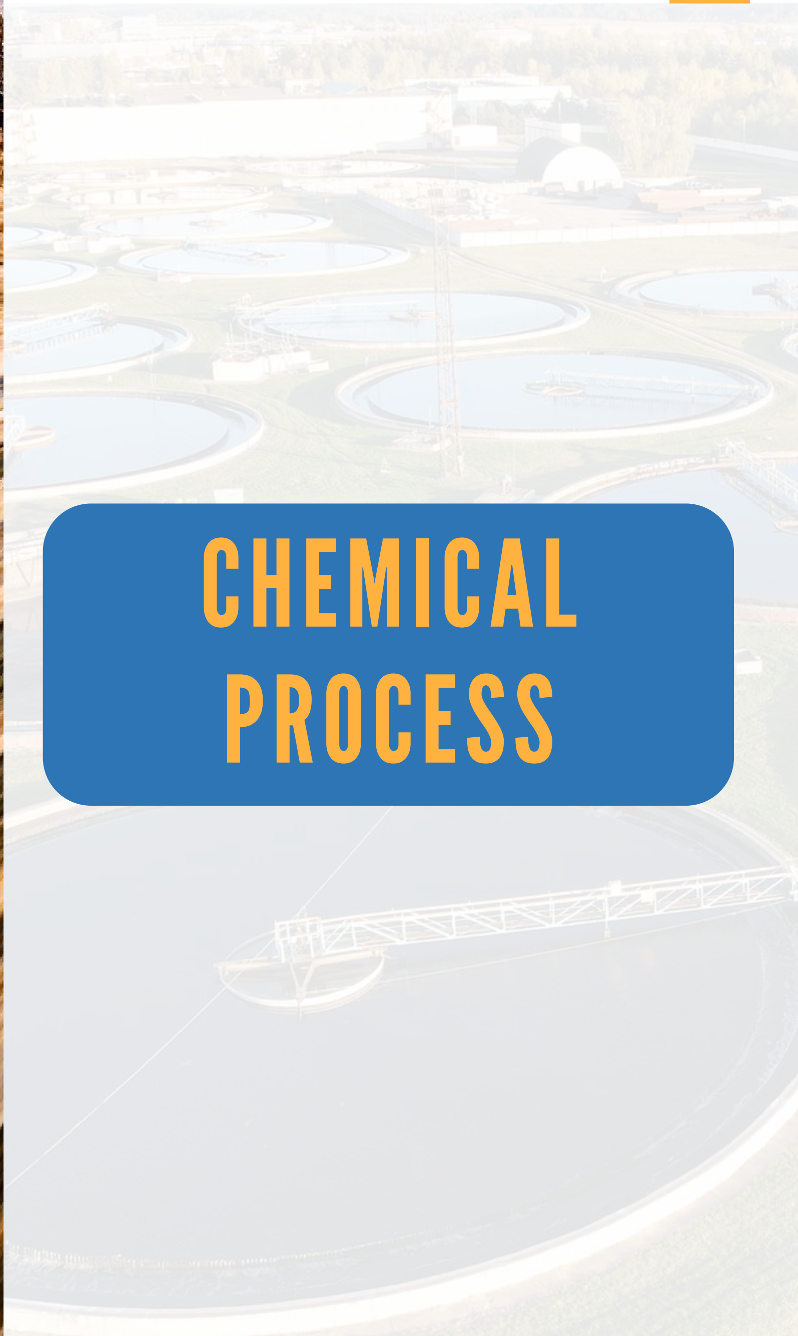
High energy cost for aeration.

Produces more sludge than anaerobic systems.

Sensitive to temperature and pH changes

TUTORIAL 2

1. **Describe the main stages of anaerobic digestion and the types of microorganisms involved in each stage.**
2. **What are the advantages and limitations of using anaerobic treatment for wastewater compared to aerobic treatment?**
3. **Explain how biogas is produced during anaerobic treatment and list its main components.**



CHEMICAL PROCESS

CHEMICAL PROCESS

In wastewater treatment, several chemical processes are used to remove contaminants and make the water safe for discharge or reuse. Here’s a breakdown of the main chemical processes involved:

Coagulation and Flocculation
Neutralization
Precipitation
Disinfection
Oxidation
Ion Exchange
Chemical Phosphorus Removal

FLOCCULATION TREATMENT

FLOCCULATION TREATMENT

Flocculation treatment is a key process in water and wastewater treatment, used to remove suspended solids by aggregating them into larger particles (called flocs) that can be more easily separated from the water. Flocculation is the gentle mixing stage where small particles come together to form larger, visible clumps (flocs). It typically follows a process called coagulation, where chemicals (coagulants) are added to destabilize the suspended particles.

1 COAGULATION (PRE-STEP)

- Coagulants like alum, ferric chloride are added.
- These neutralize the charges on particles, making it easier for them to stick together.

2 FLOCCULATION

- Gentle stirring helps the particles collide and bind.
- Polymers (flocculants) may be added to help strengthen the flocs.
- This process usually takes 15–45 minutes, depending on the water characteristics

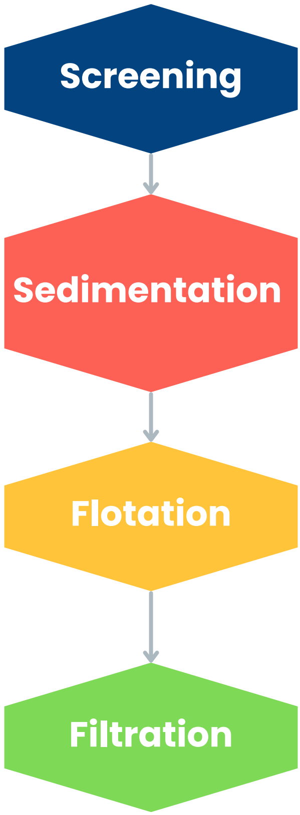
3 SEPARATION

- The larger flocs are removed by sedimentation, flotation, or filtration.

PHYSICAL PROCESS

PHYSICAL PROCESS

The physical process of water treatment involves removing solid particles and impurities from water without using chemicals. These processes are primarily mechanical and focus on separating contaminants based on their physical characteristics like size, shape, and density. Here are the main physical processes used in water treatment:



FILTRATION TREATMENT

FILTRATION TREATMENT

Filtration is a physical process used in wastewater treatment to remove suspended solids, particulates, and microorganisms from water after primary and sometimes secondary treatment stages. It is a key step in producing cleaner effluent, especially if the water is being discharged into sensitive environments or reused. Filtration usually takes place after secondary treatment (biological treatment) and is part of the tertiary (advanced) treatment stage. However, preliminary filtration (like screening) may occur at the start to remove large debris.

Purpose & Benefits

- **Improves clarity and quality of effluent.**
- **Reduces biological oxygen demand (BOD) and total suspended solids (TSS).**
- **Prepares water for disinfection**
- **Necessary for water reuse or discharge into sensitive environments.**

Types of Filtration Methods

1. Sand Filtration

- Water passes through layers of sand and gravel.
- Removes suspended particles and some microorganisms.
- Common in municipal and industrial plants.

Cloth or Disk Filters

- Compact and effective for fine filtration.
- Often used in retrofits or space-limited applications.

Membrane Filtration

- Includes microfiltration (MF), ultrafiltration (UF), nanofiltration (NF), and reverse osmosis (RO).
- Removes very fine particles, bacteria, viruses, and even dissolved salts depending on the membrane.

Activated Carbon Filtration

- Uses carbon to remove organic compounds, chlorine, and odors.
- Effective for polishing treated water.

FLOTATION TREATMENT

FLOTATION TREATMENT

Flotation treatment is a widely used physical process for wastewater treatment, especially effective in removing suspended solids, oils, greases, and other light contaminants. The main principle involves introducing fine air bubbles into the wastewater, which attach to the particles and float them to the surface, where they can be easily removed.

Types of Flotation in Wastewater Treatment:

- **Dissolved Air Flotation (DAF)**
  - Most common method.
  - Air is dissolved in water under pressure and then released at atmospheric pressure into the wastewater.
  - As pressure is released, microbubbles form and attach to particles, floating them to the top.
  - Ideal for: Oily wastewater, food processing, slaughterhouses, and paper industries.

- **Induced Air Flotation (IAF)**
  - Air is introduced without dissolving; often through mechanical agitation or sparging.
  - Used in oil refineries and petrochemical industries.

- **Vacuum Flotation**
  - Air-saturated water is placed in a vacuum tank, causing air to come out of solution and form bubbles.
  - Less common due to operational complexity

- **Electroflotation**
  - Uses electrolysis to generate bubbles (hydrogen and oxygen) directly in the water.
  - Useful in fine particle separation and where chemical addition is undesirable.

ANALYSIS OF EFFECTIVENESS OF TREATMENT

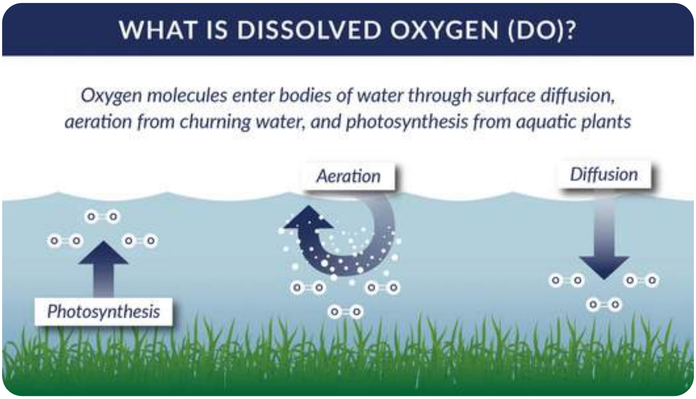
PH

pH is functionally defined as the measure of a solution's acidity or alkalinity. It directly reflects the acid concentration and is typically represented on a scale from 0 to 14, with 7 being neutral; values below 7 are acidic, while those above 7 are alkaline. Measuring pH in the treatment process is important for several reasons, including:

- **microorganisms work best within certain pH range between 6.5 to 8.5 hence this pH range needs to be monitored and maintained**
- **certain chemical aids such as polyelectrolytes have optimal pH range for best application**

DISSOLVE OXYGEN (DO)

Dissolved oxygen (DO) is a crucial parameter in the treatment process, as aerobic bacteria rely on it for survival. The necessary DO concentration in aeration tanks varies based on the specific operation mode of the activated sludge process. For extended aeration systems, the recommended DO range is typically between 4 and 6 mg/L.

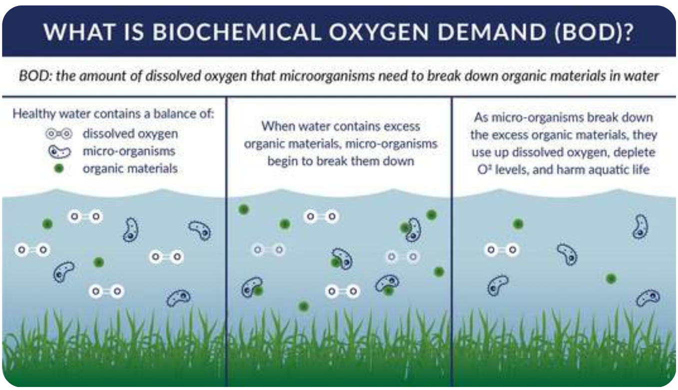


BIOCHEMICAL OXYGEN DEMAND (BOD)

Biochemical Oxygen Demand (BOD) measures the amount of oxygen microorganisms use to biologically degrade organic matter in an effluent.

A higher organic content results in a higher BOD, indicating greater pollution potential. BOD is often used to express the organic strength of wastewater — the stronger the effluent, the higher its BOD.

The BOD_5 test, widely used in water pollution analysis, assesses dissolved oxygen (DO) concentrations at the beginning and after a five-day incubation. The reduction in DO indicates the amount of oxygen used during the breakdown of organic matter. Since BOD closely correlates with the level of organic pollution, it is an important measure of the effectiveness of wastewater treatment processes.

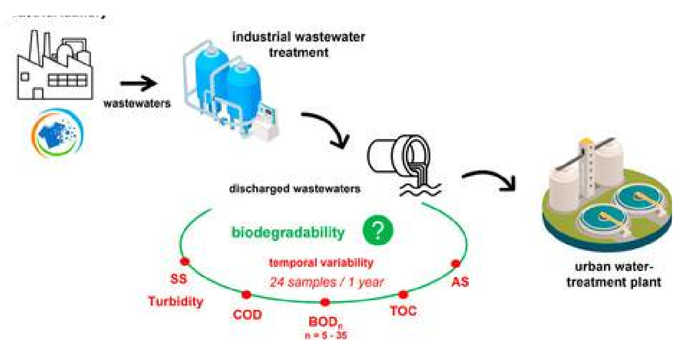


CHEMICAL OXYGEN DEMAND (COD)

This test uses a strong oxidizing agent, potassium dichromate to oxidize the organic matter contained in the effluent and some inorganic compounds.

COD is invariably always bigger than BOD because more organic compounds are oxidized in the test. COD test results can be obtained in 3 to 4 hours as compared to BOD results in 5 days.

COD does not only measure the biodegradable organic matter but all components which can be oxidized by the oxidizing agent including some inorganic components.

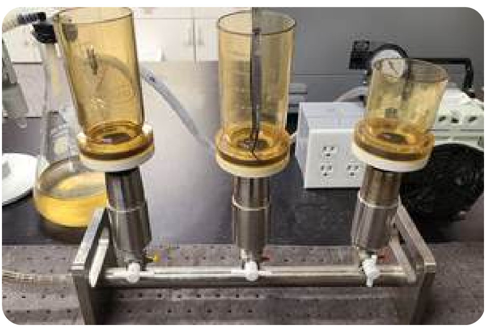


MIXED LIQUOR VOLATILE SUSPENDED SOLID (MLVSS)

Suspended solids in the aeration tank (mixed liquor) are made up of organic and inorganic solids.

The organic solids are also known as volatile solids, which consists of living and non-living organic matter (mixed liquor volatile suspended solid).

MLVSS is measured as an estimate for living organic matter.



NUTRIENT ANALYSIS

Cells are composed of approximately 2.5% phosphorus and 12.4% nitrogen.

Microorganisms require an adequate supply of nutrients to support their growth and to effectively decompose the organic material present in effluent. Regular monitoring is carried out to maintain the proper balance between organic matter and nutrients. A commonly recommended guideline is to maintain a BOD:N:P ratio of 100:5:1.

1 NITROGEN

Key component of amino acids, proteins, enzymes, and nucleic acids (DNA and RNA). Without enough nitrogen, microorganisms cannot build the proteins and genetic material necessary for cell function and division.

2 PHOSPHORUS

critical for the formation of energy-carrying molecules like ATP (adenosine triphosphate) and is also a part of cell membranes and nucleic acids. Phosphorus helps in energy transfer within the cells, which is essential for metabolism and other life processes.

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PROFILE OF AUTHORS

Noor Anizah Binti Maarof is a graduate of Universiti Malaysia Terengganu, where she earned her Bachelor's Degree in Agrotechnology (Post Harvest Technology) in 2009. She began her professional career as an Assistant Manager in the Quality Assurance (QA) Department at Kerabat Processing. She is also certified in Operation of Industrial Effluent Treatment Systems (CePIETSO) from Department of Environment.

Driven by a passion for education and agricultural development, Noor Anizah transitioned into academia. She served for seven years at Politeknik Sandakan Sabah, where she played a key role in training and mentoring future agricultural professionals. Currently, she is in her third year at Politeknik Jeli Kelantan, continuing her commitment to educating students in agricultural technology and sustainable waste management.

Muhamad Syazwan Bin Azizi graduated from Universiti Malaysia Terengganu with a Bachelor's Degree in Agrotechnology (Post Harvest Technology) in 2011. He began his career as a Conference Producer at Trueventus before taking on the role of Cadet Planter at IOI Plantation, where he developed practical skills in event coordination, agricultural operations, and plantation management.

Motivated by a passion for education and agriculture, Muhamad Syazwan later moved into academia. He dedicated nine years to Politeknik Sandakan Sabah, where he played a significant role in educating and mentoring aspiring agricultural professionals. Currently in his third year at Politeknik Jeli Kelantan, he remains committed to advancing agricultural technology, plantation management, and sustainable development among his students.

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