2024 January

6. With reference to sewage treatment plants:

(a) state the purpose of the vent, and explain why it is fitted with a gauze; (3)

(b) explain the difference between aerobic and anaerobic micro organisms; (3)

(c) explain why air is bubbled through the effluent in the aeration tank; (2)

(d) explain why calcium hypochlorite is added to the treated sewage before discharge overboard. (2)

Sewage Treatment Plants on Ships: Components and Processes

(a) Vent with Gauze:

- **Purpose:** The vent on a sewage treatment plant allows the release of gases generated during the treatment process. These gases can include methane, carbon dioxide, and potentially some unpleasant odors.
- **Gauze:** The vent is fitted with a gauze to:
  - Prevent the escape of larger particles or aerosols that might carry bacteria or viruses.
  - Allow for proper ventilation while minimizing the spread of potential airborne contaminants.

(b) Aerobic vs. Anaerobic Microorganisms:

- **Aerobic Microorganisms:**
  - Thrive in environments with dissolved oxygen.
  - They play a crucial role in sewage treatment by breaking down organic matter in the presence of oxygen.
  - Examples include bacteria like nitrifying bacteria and some protozoa.
- **Anaerobic Microorganisms:**
  - Function in environments with little to no dissolved oxygen.
  - They break down organic matter through a different process that doesn't require oxygen.
  - Examples include some bacteria and archaea.

Sewage treatment plants on ships typically utilize a combination of aerobic and anaerobic processes for efficient waste breakdown.

(c) Air Bubbling in Aeration Tank:

The aeration tank is a vital component in the aerobic treatment process. Air is bubbled through the effluent in the aeration tank for several reasons:

- **Supplies Oxygen:** The bubbles provide dissolved oxygen necessary for the survival and activity of aerobic microorganisms.
- **Mixing:** The air bubbles promote efficient mixing of the effluent, ensuring all parts of the wastewater come into contact with the microorganisms for optimal biological treatment.

- **Flocculation:** The air bubbles can also aid in the formation of flocs, which are clumps of organic matter and microorganisms that settle more readily for separation during later stages.

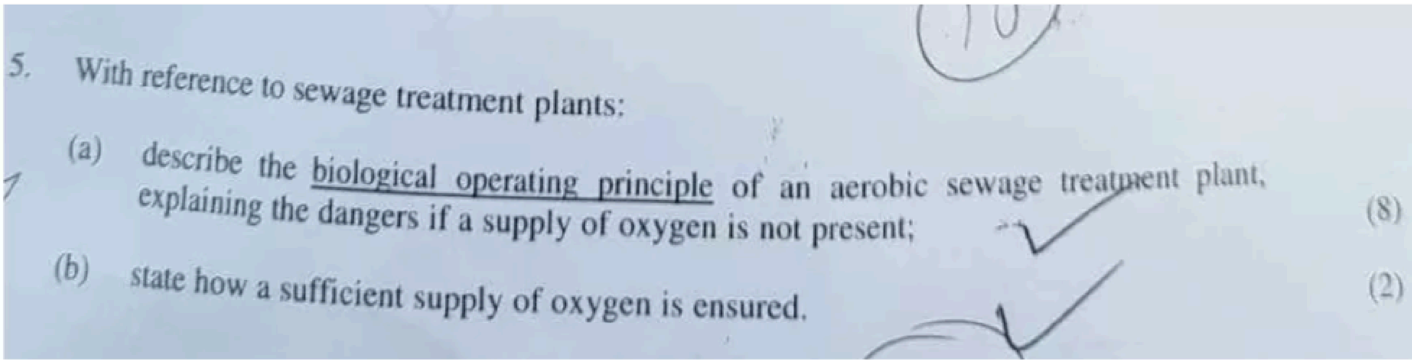
(d) Calcium Hypochlorite Addition:

Calcium hypochlorite (Ca(OCl)2), also known as bleaching powder, is often added to the treated sewage before discharge overboard for disinfection purposes. Here's why:

- **Disinfection:** Calcium hypochlorite releases chlorine when added to water. Chlorine is a powerful disinfectant that inactivates harmful bacteria and viruses present in the treated sewage effluent. This helps minimize the risk of spreading pathogens in the marine environment and protects public health.
- **Controlled Dosage:** The amount of calcium hypochlorite added is carefully controlled to ensure effective disinfection while minimizing the environmental impact of chlorine.
- **Alternative Methods:** Some treatment plants may utilize other disinfection methods like ultraviolet (UV) radiation instead of chlorine, depending on regulations and specific considerations.

aug 2023

AUG 2023


5. With reference to sewage treatment plants:

(a) describe the biological operating principle of an aerobic sewage treatment plant, explaining the dangers if a supply of oxygen is not present; (8)

(b) state how a sufficient supply of oxygen is ensured. (2)

Aerobic Sewage Treatment Plants: Biological Process and Oxygen Supply

(a) Biological Principle and Dangers of Oxygen Depletion:

Aerobic sewage treatment plants rely on the activity of **aerobic microorganisms** to break down organic matter present in sewage. Here's a breakdown of the process:

1. **Primary Treatment:** Initially, sewage undergoes a physical separation process to remove larger solids.
2. **Biological Treatment (Aerobic Process):** The pretreated wastewater enters the aeration tank, where:
    - **Aerobic bacteria** are present in abundance.
    - **Air is continuously bubbled** through the tank to maintain a dissolved oxygen supply.
    - These bacteria feed on the organic matter in the wastewater, breaking it down into simpler compounds like carbon dioxide and water.
    - The process is similar to natural biodegradation that occurs in well-oxygenated environments.

Dangers of Insufficient Oxygen Supply:

If the oxygen supply to the aeration tank is insufficient, several problems can arise:

- **Inefficient Breakdown:** Aerobic bacteria become inactive or die in the absence of oxygen. This hinders the breakdown of organic matter, leading to the accumulation of pollutants in the wastewater.

- **Anaerobic Processes Take Over:** Anaerobic microorganisms, which don't require oxygen, can take over in the low-oxygen environment. However, their waste products include methane, a potent greenhouse gas, and other potentially harmful substances.
- **Increased Odors:** Anaerobic processes often generate unpleasant odors due to the production of hydrogen sulfide gas.

These issues can significantly compromise the effectiveness of the sewage treatment plant and pose environmental concerns.

(b) Ensuring Sufficient Oxygen Supply:

Here are some key methods to ensure a sufficient oxygen supply in the aeration tank of a sewage treatment plant:

- **Diffusers:** Fine bubble diffusers are commonly used to disperse compressed air efficiently throughout the tank volume, maximizing oxygen transfer to the wastewater.
- **Blowers:** Powerful blowers provide the compressed air necessary for the diffusers to function effectively.
- **Monitoring and Control:** Dissolved oxygen levels in the aeration tank are continuously monitored. If levels drop below a set point, alarms can trigger, and air supply can be adjusted to maintain optimal conditions.

By implementing these measures, sewage treatment plants can ensure a healthy environment for aerobic microorganisms and achieve efficient wastewater treatment.

feb 2021

Feb 2021

5. (a) With reference to sewage treatment systems, explain EACH of the following terms:

(i) aerobic; (2)

(ii) anaerobic. (2)

(b) Sketch a Biological Sewage Treatment Plant, labelling the MAIN compartments and indicating the direction of flow through the plant. (6)

Sewage Treatment Systems: Aerobic vs. Anaerobic and Plant Processes

(a) Explaining Aerobic and Anaerobic Processes:

(i) Aerobic:

- **Definition:** Refers to a biological process that occurs in the presence of dissolved oxygen.
- **Microorganisms:** Involves the activity of **aerobic microorganisms** such as bacteria and protozoa.
- **Breakdown Process:** These microorganisms utilize oxygen to break down organic matter (waste) present in sewage into simpler compounds like water and carbon dioxide.
- **Sewage Treatment:** Aerobic processes are widely used in biological sewage treatment plants for efficient wastewater treatment.

(ii) Anaerobic:

- **Definition:** Refers to a biological process that takes place in an environment with little to no dissolved oxygen.
- **Microorganisms: Anaerobic microorganisms** such as certain bacteria and archaea are responsible for the breakdown process in this case.
- **Breakdown Process:** These microorganisms break down organic matter through a different metabolic pathway that doesn't require oxygen.
- **Sewage Treatment:** While some stages of sewage treatment may involve limited oxygen conditions, complete anaerobic treatment is less common due to its lower efficiency and generation of methane, a greenhouse gas.

(b) Biological Sewage Treatment Plant:

A biological sewage treatment plant utilizes a combination of physical and biological processes to break down and treat wastewater. Here's a breakdown of the main compartments and the flow direction:

1. **Screening and Comminution:**
    - **Function:** Large solids and debris are removed from the incoming sewage using screens or grinders (comminutors).
    - **Flow Direction:** The screened or comminuted wastewater flows onward.
2. **Primary Clarification Tank:**
    - **Function:** Allows heavier solids to settle at the bottom (sludge) for removal, while lighter organic matter and water remain in the supernatant.
    - **Flow Direction:** Settled sludge is removed for further treatment, and the supernatant (partially treated wastewater) flows to the next stage.
3. **Biological Treatment (Aerobic Process):**
    - **Main Compartment:** Aeration Tank
    - **Function:** This is the heart of the aerobic treatment process.
        - Aerobic microorganisms break down organic matter in the presence of dissolved oxygen supplied through diffusers.
        - The process promotes the growth of microorganisms, which form flocs (clumps) that aid in further separation.
    - **Flow Direction:** Treated wastewater exits the aeration tank and flows onward.
4. **Secondary Clarification Tank:**
    - **Function:** Allows the formed flocs (containing microorganisms and organic matter) to settle at the bottom as secondary sludge. The remaining liquid is the treated effluent.
    - **Flow Direction:** Settled sludge may be returned to the aeration tank or undergo further processing. The treated effluent undergoes disinfection (e.g., chlorination) before discharge.

Flow Summary: Wastewater enters the plant, undergoes screening/comminution, primary clarification, biological treatment (aeration tank), secondary clarification, and disinfection before final discharge.

April 2021

6. (a) State the THREE main stages of a Biological Sewage Treatment Plant. (3)

(b) Describe the operation of a Biological Sewage Treatment Plant, explaining the process carried out in EACH of the stages stated in part (a). (7)

Biological Sewage Treatment Plant: Stages and Processes

(a) Three Main Stages:

A Biological Sewage Treatment Plant utilizes a three-stage process for efficient wastewater treatment:

1. **Primary Treatment (Physical Separation)**
2. **Secondary Treatment (Biological Treatment)**
3. **Tertiary Treatment (Disinfection)**

(b) Description of Each Stage:

(1) Primary Treatment (Physical Separation):

- **Function:** Removes large solids and suspended materials from the incoming sewage through physical processes.
- **Process:**
  - **Screening:** Large objects like rags, plastics, and debris are removed using screens with varying bar spacing.
  - **Comminution:** Remaining solids are shredded or ground into smaller particles using grinders (comminutors) to facilitate further processing.
  - **Settling:** The screened/comminuted wastewater flows into a primary clarifier tank. Here, heavier solids settle at the bottom due to gravity (forming primary sludge), while lighter organic matter and water remain in the supernatant. The supernatant then moves on to the next stage.
  - **Sludge Removal:** Settled primary sludge is periodically removed for further treatment or disposal.

(2) Secondary Treatment (Biological Treatment):

- **Function:** Employs aerobic microorganisms to break down organic matter remaining in the wastewater.
- **Process:**
  - **Aeration Tank:** The primary-treated wastewater enters the aeration tank, where:
    - **Air is continuously bubbled** through diffusers, maintaining a dissolved oxygen supply.
    - **Aerobic bacteria** present in abundance feed on the organic matter, breaking it down into simpler compounds.
    - The process promotes the growth of microorganisms, which form flocs (clumps) that aid in separation.
  - **Mixing:** The air bubbles also help mix the wastewater, ensuring all parts come into contact with the microorganisms for optimal treatment.

(3) Tertiary Treatment (Disinfection):

- **Function:** Reduces or eliminates harmful bacteria and viruses present in the treated wastewater before discharge.
- **Process:**
    - **Disinfection Methods:**
        - **Chlorination:** Calcium hypochlorite (bleach powder) is commonly used, releasing chlorine that inactivates pathogens.
        - **Ultraviolet (UV) Radiation:** Another method utilizes UV light to kill or inactivate microorganisms.
    - **Effluent Discharge:** The disinfected wastewater (effluent) undergoes final quality checks and is then discharged overboard, meeting the required environmental standards.

aug 2021

Aug 2021

5. With reference to sewage treatment plants:

(a) describe the biological operating principle of an aerobic sewage treatment plant, explaining the dangers if a supply of oxygen is not present; (8)

(b) state how a sufficient supply of oxygen is ensured. (2)

Aerobic Sewage Treatment: Process, Dangers, and Oxygen Supply

(a) Biological Principle and Dangers of Oxygen Depletion:

Aerobic sewage treatment plants rely on the activity of **aerobic microorganisms** for efficient wastewater treatment. Here's a breakdown of the process and the dangers of insufficient oxygen:

Biological Principle:

1. **Primary Treatment:** Initially, sewage undergoes a physical separation process to remove larger solids.
2. **Biological Treatment (Aerobic Process):** The pretreated wastewater enters the aeration tank, where:
    - **Aerobic bacteria** are present in abundance.
    - **Air is continuously bubbled** through the tank to maintain a dissolved oxygen supply.
    - These bacteria feed on the organic matter in the wastewater, breaking it down into simpler compounds like carbon dioxide and water.
    - This process is similar to natural biodegradation that occurs in well-oxygenated environments.

Dangers of Insufficient Oxygen Supply:

If the oxygen supply to the aeration tank is insufficient, several problems can arise:

- **Inefficient Breakdown:** Aerobic bacteria become inactive or die in the absence of oxygen. This hinders the breakdown of organic matter, leading to the accumulation of pollutants in the wastewater.
- **Anaerobic Processes Take Over:** Anaerobic microorganisms, which don't require oxygen, can take over in the low-oxygen environment. However, their waste products include methane, a potent greenhouse gas, and other potentially harmful substances.
- **Increased Odors:** Anaerobic processes often generate unpleasant odors due to the production of hydrogen sulfide gas.

These issues can significantly compromise the effectiveness of the sewage treatment plant and pose environmental concerns.

(b) Ensuring Sufficient Oxygen Supply:

Here are some key methods to ensure a sufficient oxygen supply in the aeration tank of a sewage treatment plant:

- **Diffusers:** Fine bubble diffusers are commonly used to disperse compressed air efficiently throughout the tank volume, maximizing oxygen transfer to the wastewater.
- **Blowers:** Powerful blowers provide the compressed air necessary for the diffusers to function effectively.
- **Monitoring and Control:** Dissolved oxygen levels in the aeration tank are continuously monitored. If levels drop below a set point, alarms can trigger, and air supply can be adjusted to maintain optimal conditions.

By implementing these measures, sewage treatment plants can ensure a healthy environment for aerobic microorganisms and achieve efficient wastewater treatment.

sept 2020

Sept 2020

5. (a) State the IMO regulations for the disposal of sewage. (4)

   (b) With reference to aerobic sewage treatment plants, explain EACH of the following:

      (i) why air is bubbled through the effluent in the aeration tank; (2)

      (ii) why care must be taken over the choice of toilet cleansers used; (2)

      (iii) why calcium hypochlorite is added to the treated sewage before discharge overboard. (2)

Sewage Disposal and Aerobic Treatment Plants

(a) IMO Regulations for Sewage Disposal:

The International Maritime Organization (IMO) regulates sewage disposal from ships through Annex IV of the MARPOL Convention - **"Regulations for the Prevention of Pollution by Sewage from Ships"**. Here's a summary of the key points:

- **Discharge Prohibition:** Generally, the discharge of **untreated sewage** from ships is **prohibited**. Exceptions are allowed only in specific circumstances, with strict distance requirements from land.
- **Treatment Requirements:** Ships can discharge **comminuted and disinfected sewage** or **treated sewage** from approved sewage treatment plants when meeting specific conditions and at greater distances from land compared to untreated sewage.
- **Discharge Records:** MARPOL requires ships to maintain an **Oil Record Book (ORB)**, which also includes a section for recording sewage discharges, including date, time, location, quantity, and operational conditions.

(b) Aerobic Sewage Treatment Processes:

(i) Air Bubbling in Aeration Tank:

Air is continuously bubbled through the effluent in the aeration tank of a sewage treatment plant for several reasons:

- **Supplies Oxygen:** The bubbles provide **dissolved oxygen** necessary for the survival and activity of **aerobic microorganisms**. These bacteria are crucial for breaking down organic matter present in the sewage.
- **Mixing:** The air bubbles promote efficient **mixing** of the effluent. This ensures all parts of the wastewater come into contact with the microorganisms for optimal biological treatment.
- **Floc Formation:** The air bubbles can also aid in the formation of **flocs**. These are clumps of organic matter and microorganisms that settle more readily for separation during later stages in the treatment process.

(ii) Choosing Toilet Cleansers:

Care must be taken over the choice of toilet cleansers used on ships with aerobic sewage treatment plants because:

- **Harmful Chemicals:** Some conventional toilet cleansers contain harsh chemicals that can be toxic to aerobic bacteria. These chemicals can hinder the bacteria's ability to break down organic matter, compromising the efficiency of the treatment process.
- **Biodegradable Options:** Using **biodegradable toilet cleansers** specifically formulated for marine sanitation systems is recommended. These cleansers are effective while being less harmful to the beneficial bacteria in the treatment plant.

(iii) Adding Calcium Hypochlorite:

Calcium hypochlorite (Ca(OCl)2), also known as bleaching powder, is often added to the treated sewage before discharge overboard for disinfection purposes:

- **Disinfection:** Calcium hypochlorite releases chlorine when added to water. Chlorine is a powerful disinfectant that inactivates harmful bacteria and viruses present in the treated sewage effluent. This helps minimize the risk of spreading pathogens in the marine environment and protects public health.
- **Controlled Dosage:** The amount of calcium hypochlorite added is carefully controlled to ensure effective disinfection while minimizing the environmental impact of chlorine.
- **Alternative Methods:** Some treatment plants may utilize other disinfection methods like ultraviolet (UV) radiation instead of chlorine, depending on regulations and specific considerations.

nov 2020

Nov 2020

5. With reference to sewage treatment plants:

   (a) explain the difference between *black water* and *grey water*; (2)

   (b) explain the difference between aerobic and anaerobic micro organisms; (3)

   (c) list THREE dangerous gases produced under anaerobic conditions; (3)

   (d) explain the dangers of producing the gases listed in part(c) in a confined space. (2)

Sewage Treatment and Microorganisms: Black Water, Aerobic vs. Anaerobic, and Gas Dangers

(a) Black Water vs. Grey Water:

- **Black Water:**
  - Wastewater containing human waste (feces and urine) from toilets and urinals.
  - It has the highest concentration of organic matter and pathogens, requiring the most stringent treatment in sewage plants.
- **Grey Water:**
  - Wastewater generated from household activities excluding toilets.
  - Examples include water from showers, sinks, dishwashers, and washing machines.
  - It contains lower levels of organic matter and pathogens compared to black water.

In some advanced shipboard systems, black water and grey water may be treated separately due to their differing compositions.

(b) Aerobic vs. Anaerobic Microorganisms:

- **Aerobic Microorganisms:**
  - Thrive in environments with **dissolved oxygen**.
  - Play a crucial role in sewage treatment by breaking down organic matter in the presence of oxygen.
  - Examples include bacteria like nitrifying bacteria and some protozoa.
- **Anaerobic Microorganisms:**
  - Function in environments with **little to no dissolved oxygen**.
  - Break down organic matter through a different process that doesn't require oxygen.
  - Examples include some bacteria and archaea.

Sewage treatment plants on ships typically utilize a combination of aerobic and anaerobic processes for efficient waste breakdown.

(c) Dangerous Gases Produced Under Anaerobic Conditions:

Here are three dangerous gases produced under anaerobic conditions in sewage treatment or confined spaces:

1. **Hydrogen Sulfide (H_2S):**
   - Highly toxic gas with a characteristic rotten egg odor.
   - Exposure can cause respiratory problems, irritation, and even death at high concentrations.
2. **Methane (CH_4):**
   - Flammable gas with no odor or color.
   - Can accumulate in confined spaces and pose an explosion risk if ignited.
3. **Carbon Dioxide (CO_2):**
   - Colorless and odorless gas.
   - Displaces oxygen, leading to suffocation in confined spaces with high CO_2 concentrations.

(d) Dangers of Gases in Confined Spaces:

The confined space environment aboard a ship can exacerbate the dangers of the gases listed above:

- **Limited Ventilation:** Confined spaces often have limited air circulation, allowing these gases to accumulate to dangerous levels more quickly.

- **Reduced Awareness:** Workers in confined spaces may not be aware of the presence of these gases due to their lack of odor (methane) or due to the overwhelming effect of H2S on the sense of smell.

- **Rapid Intoxication:** Inhaling these gases in confined spaces can lead to rapid incapacitation and death if not addressed promptly.

Therefore, proper safety precautions, ventilation, and gas monitoring are crucial when working in confined spaces on ships, especially those containing sewage treatment systems.

oct 2020

30 October 2020

5. Explain, with the aid of a sketch, how an *Aerobic Sewage Treatment* plant operates. (10)

Aerobic Sewage Treatment Plant Operation: A Breakdown

An aerobic sewage treatment plant utilizes a combination of physical and biological processes to efficiently break down and treat wastewater. Here's a breakdown of the key steps involved:

1. Pretreatment (Physical Separation):

- **Screening and Comminution:** Large solids and debris are removed from the incoming sewage using screens with varying bar spacing or grinders (comminutors) that shred the material.
- **Primary Clarification:** The screened/comminuted wastewater flows into a primary clarifier tank. Here, heavier solids settle at the bottom due to gravity (forming primary sludge), while lighter organic matter and water remain in the supernatant (partially treated wastewater). Settled sludge is removed for further treatment or disposal, and the supernatant moves on to the next stage.

2. Biological Treatment (Aerobic Process):

- **Aeration Tank:** This is the heart of the aerobic treatment process.
    - The pretreated wastewater enters the aeration tank, where:
        - **Air is continuously bubbled** through diffusers located at the bottom of the tank. This ensures a constant supply of dissolved oxygen throughout the water.
        - **Aerobic microorganisms**, primarily bacteria, are present in abundance within the tank. These bacteria feed on the organic matter in the wastewater, breaking it down into simpler compounds like carbon dioxide and water. This process is similar to natural biodegradation that occurs in well-oxygenated environments.
        - The breakdown process promotes the growth of microorganisms, which form **flocs** (clumps) that contain both the bacteria and organic matter. These flocs are crucial for efficient separation in the next stage.
    - **Mixing:** The air bubbles also play a role in efficiently mixing the wastewater. This ensures all parts of the wastewater come into contact with the microorganisms for optimal treatment.

3. Secondary Clarification:

- **Secondary Clarifier Tank:** The treated wastewater from the aeration tank flows into a secondary clarifier tank.
  - Here, the formed flocs (containing microorganisms and organic matter) settle at the bottom as **secondary sludge**. The remaining liquid is the **treated effluent**.
  - Settled sludge may be returned to the aeration tank to maintain the population of microorganisms or undergo further processing.

4. Disinfection (Optional):

- **Disinfection Process:** In some cases, the treated effluent may undergo an additional disinfection step before discharge overboard. This is done to further reduce or eliminate any remaining harmful bacteria and viruses.
  - Common disinfection methods include:
    - **Chlorination:** Calcium hypochlorite (bleach powder) is added, releasing chlorine that inactivates pathogens.
    - **Ultraviolet (UV) Radiation:** UV light is used to kill or inactivate microorganisms.

5. Discharge:

- **Treated Effluent:** The disinfected wastewater (effluent) undergoes final quality checks before being discharged overboard, meeting the required environmental standards set by regulations like MARPOL Annex IV.

Key Points:

- Aerobic microorganisms require oxygen for their breakdown process. The continuous supply of air through diffusers is crucial for their activity.
- The formation of flocs in the aeration tank is important for efficient separation of treated wastewater from the remaining organic matter.
- Disinfection is an additional step to ensure the treated effluent meets environmental regulations and minimizes the risk of spreading pathogens.

june 2021

June 2021

6. (a) State the THREE main stages of a Biological Sewage Treatment Plant. (3)

(b) Describe the operation of a Biological Sewage Treatment Plant, explaining the process carried out in EACH of the stages stated in part (a). (7)

Biological Sewage Treatment Plant: Stages and Processes

(a) Three Main Stages:

A Biological Sewage Treatment Plant utilizes a three-stage process for efficient wastewater treatment:

1. **Primary Treatment (Physical Separation)**
2. **Secondary Treatment (Biological Treatment)**
3. **Tertiary Treatment (Disinfection)** (Optional)

(b) Description of Each Stage:

(1) Primary Treatment (Physical Separation):

- **Function:** Removes large solids and suspended materials from the incoming sewage through physical processes.
- **Process:**
  - **Screening:** Large objects like rags, plastics, and debris are removed using screens with varying bar spacing.
  - **Comminution:** Remaining solids are shredded or ground into smaller particles using grinders (comminutors) to facilitate further processing.
  - **Settling:** The screened/comminuted wastewater flows into a primary clarifier tank. Here, heavier solids settle at the bottom due to gravity (forming primary sludge), while lighter organic matter and water remain in the supernatant. The supernatant then moves on to the next stage.
  - **Sludge Removal:** Settled primary sludge is periodically removed for further treatment or disposal.

(2) Secondary Treatment (Biological Treatment):

- **Function:** Employs aerobic microorganisms to break down organic matter remaining in the wastewater.
- **Process:**
  - **Aeration Tank:** The primary-treated wastewater enters the aeration tank, where:
    - **Air is continuously bubbled** through diffusers, maintaining a dissolved oxygen supply.
    - **Aerobic bacteria** present in abundance feed on the organic matter, breaking it down into simpler compounds.
    - The process promotes the growth of microorganisms, which form flocs (clumps) that aid in separation.
  - **Mixing:** The air bubbles also help mix the wastewater, ensuring all parts come into contact with the microorganisms for optimal treatment.

(3) Tertiary Treatment (Disinfection) (Optional):

- **Function:** Reduces or eliminates harmful bacteria and viruses present in the treated wastewater before discharge. (Not all plants have this stage)
- **Process:**
  - **Disinfection Methods:**
    - **Chlorination:** Calcium hypochlorite (bleach powder) is commonly used, releasing chlorine that inactivates pathogens.
    - **Ultraviolet (UV) Radiation:** Another method utilizes UV light to kill or inactivate microorganisms.
  - **Effluent Discharge:** The disinfected wastewater (effluent) undergoes final quality checks and is then discharged overboard, meeting the required environmental standards.

aug 2020

Aug 2020

6. Describe the operation of a Biological Sewage Treatment Plant. (10)

oct 2018

Oct 2018

5. Describe the operation of a Biological Sewage Treatment Plant. (10)

Biological Sewage Treatment Plant: A Step-by-Step Breakdown

A biological sewage treatment plant utilizes a three-stage process to efficiently break down and treat wastewater:

1. Primary Treatment (Physical Separation):

This stage focuses on removing large solids and suspended materials through physical processes.

- **Screening:** Large objects like rags, plastics, and debris are removed using screens with varying bar spacing. Imagine a colander catching large food scraps while letting the water flow through.
- **Comminution:** Remaining solids are shredded or ground into smaller particles using grinders (comminutors). Think of a food processor breaking down large chunks into smaller pieces for easier handling.
- **Settling:** The screened/comminuted wastewater flows into a primary clarifier tank. Here, heavier solids settle at the bottom due to gravity (forming primary sludge), while lighter organic matter and water remain in the supernatant (partially treated wastewater). The supernatant looks like murky water after some larger particles have settled out.
- **Sludge Removal:** Settled primary sludge is periodically removed for further treatment or disposal. Think of scooping out the settled material at the bottom of a pond.

2. Secondary Treatment (Biological Treatment):

This is the heart of the process, where microorganisms become the workhorses for wastewater treatment.

- **Aeration Tank:** The primary-treated wastewater enters the aeration tank, a large tank teeming with life (microorganisms).
    - **Air is continuously bubbled** through diffusers at the bottom. This ensures a constant supply of dissolved oxygen, crucial for the survival and activity of **aerobic bacteria**. Think of an air pump keeping an aquarium oxygenated.
    - These bacteria feed on the organic matter in the wastewater, breaking it down into simpler compounds like carbon dioxide and water. The process is similar to natural biodegradation in well-oxygenated environments.
    - The breakdown process promotes the growth of microorganisms, which form **flocs** (clumps) that contain both bacteria and organic matter. These flocs are essential for efficient separation in the next stage. Imagine tiny organisms attaching themselves to food particles, forming larger clumps that will settle more easily.
    - **Mixing:** The air bubbles also play a role in efficiently mixing the wastewater. This ensures all parts come into contact with the microorganisms for optimal treatment.

3. Secondary Clarification:

Here, the wastewater separates from the biological treatment products.

- **Secondary Clarifier Tank:** The treated wastewater from the aeration tank flows into a secondary clarifier tank.

- The formed flocs (containing microorganisms and organic matter) settle at the bottom as **secondary sludge**. The remaining liquid is the **treated effluent**, which looks significantly clearer than the influent (untreated sewage).
- Settled sludge may be returned to the aeration tank to maintain the population of microorganisms or undergo further processing.

4. Disinfection (Optional):

In some cases, an additional disinfection step ensures minimal risk of pathogens in the discharged water.

- **Disinfection Process:** The treated effluent may undergo disinfection before discharge overboard. This is done to further reduce or eliminate any remaining harmful bacteria and viruses.
    - Common disinfection methods include:
        - **Chlorination:** Calcium hypochlorite (bleach powder) is added, releasing chlorine that inactivates pathogens.
        - **Ultraviolet (UV) Radiation:** UV light is used to kill or inactivate microorganisms.

5. Discharge:

- **Treated Effluent:** The disinfected wastewater (effluent) undergoes final quality checks and is then discharged overboard, meeting the required environmental standards set by regulations.

Key Points:

- Each stage plays a crucial role in achieving efficient wastewater treatment.
- The biological treatment stage depends heavily on the activity of aerobic microorganisms, which require oxygen for their breakdown process.
- The formation of flocs in the aeration tank is what allows for efficient separation of treated wastewater from the remaining organic matter.
- Disinfection is an optional step that ensures the treated effluent meets environmental regulations and minimizes the risk of spreading pathogens.

may 2021

May 2021

6. (a) With reference to MARPOL Annex IV, explain what is meant by the term *sewage*. (4)

(b) State the current regulations for the discharge of *sewage*. (6)

MARPOL Annex IV and Sewage Regulations

(a) Sewage Definition according to MARPOL Annex IV:

MARPOL Annex IV, titled "**Regulations for the Prevention of Pollution by Sewage from Ships**," defines sewage as:

- **Human body waste** and the drainage from toilets and urinals.
- **Scum** originating from galley, pantry, bar, sick bay, laundry, dishwasher or similar provisions.
- **Drainage** from sinks, washbasins, **laundry machines** and **baths** (**greywater** is sometimes included in this category depending on the specific regulations).

In essence, MARPOL Annex IV considers sewage to be any wastewater generated on a ship from human activities, excluding bilge water (engine room drainage) and cargo residues.

(b) Current Regulations for Sewage Discharge:

MARPOL Annex IV sets out regulations for the discharge of sewage from ships to minimize pollution and protect the marine environment. Here's a summary of the key points:

- **General Prohibition:** The discharge of **untreated sewage** from ships is generally **prohibited**. Exceptions are allowed only in specific circumstances, with strict distance requirements from land. These distances vary depending on the ship type and location.

- **Treatment Requirements:** Ships can discharge **comminuted and disinfected sewage** or **treated sewage** from approved sewage treatment plants when meeting specific conditions. These conditions include:

    - **Comminuted and Disinfected Sewage:** Solid particles are shredded and the effluent is disinfected before discharge. This is allowed further from land compared to untreated sewage.
    - **Treated Sewage:** Sewage undergoes a biological treatment process in an approved sewage treatment plant, resulting in significantly reduced organic matter and bacterial content. This allows for discharge closer to land compared to other options.
- **Special Areas:** For particularly sensitive areas like the Baltic Sea, even stricter regulations apply. Discharges of treated sewage from passenger ships may be further restricted or even prohibited entirely.

- **Discharge Records:** MARPOL requires ships to maintain an **Oil Record Book (ORB)**. This record book also includes a section for recording sewage discharges, including date, time, location, quantity, and operational conditions. This allows for monitoring and enforcement of the regulations.

By adhering to these regulations, ships can minimize their impact on the marine environment and contribute to cleaner seas.