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Water and Sewage Treatment. An Intergral Part of Disease Prevention and Control

1. Uyigue, Paulinus Osarodion, 2.Omonigbehin, Emmanuel Adedayo, 3. Paulinus Osarodion Uyigue

1.Address: Department of Medical Laboratory Science, Achievers University Owo. Ondo state, Nigeria.
2.Address: Department of Medical Laboratory Science, Achievers University Owo. Ondo state, Nigeria.
3.Address: Department of Medical Laboratory Science, Achievers University Owo. Ondo state, Nigeria.

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ABSTRACT
Waste water and sewage are usually generated from homes through various activities such as bathing, washing, cleaning, faecal discharge. These materials have high microbial load which is dangerous to health. Treating them renders them safe as they can be converted to potable water for drinking and cooking,manure for improved crop yield in agricultural sector. Several treatmrnt methodologies are in use, the choice depends on the level of pollution.Jounals and other materials used for this review revealed treatment procedures starting with simple to highly sophisticated ones depending on the level of contamination. It is recommended that Central/municipal waste water/sewage system should be encouraged especially where such practice is not available. Sludge from sewage when treated and converted to manure will help improve agricultural yields in the community, while potable water recovered will increase water availability in the area especially where water is scarce.

I. INTRODUCTION

Water treatment is the process of removing all substances, whether biological, chemical or physical, that are potentially harmful in water supply for human and domestic use. This treatment helps to produce water that is safe, palatable, clear, colourless and odourless (Zhand et al., 2019). Water also needs to be non-corrosive, meaning it will not cause damage to pipework. Water and wastewater treatment are pivotal processes essential for ensuring the safety of our drinking water and safeguarding environmental integrity (Selcuk et al., 2019). These multifaceted procedures are designed to eliminate impurities, contaminants, and pollutants from raw water sources and wastewater before they are reintroduced into the environment. The significance of water and wastewater treatment cannot be overstated (Ritchie et al., 2023). Firstly, it plays a fundamental role in safeguarding public health by providing clean, potable water. Effective treatment processes remove harmful pathogens, chemicals, and toxins, mitigating the risk of waterborne diseases and ensuring that water is safe for consumption (Ambulkar et al., 2023). Moreover, water treatment helps prevent the spread of illnesses and contributes to overall community well-being. Additionally, water treatment is crucial for environmental conservation. Wastewater, if released untreated, contains pollutants that can harm aquatic ecosystems and wildlife (Salas et al., 2023). By removing contaminants and improving water quality, treatment facilities help minimize environmental degradation and protect fragile ecosystems. Clean water bodies support biodiversity and provide essential habitats for aquatic life, contributing to the overall health of our planet. The water treatment process consists of several key stages (Mowbray et al., 2023). It begins with preliminary treatment, where large debris is removed through screening and sedimentation. This is followed by primary treatment, which involves the physical separation of suspended solids and organic matter. Secondary treatment employs biological processes to break down organic pollutants using microorganisms (Brdjanovic et al., 2023). Finally, tertiary treatment employs advanced techniques to remove remaining contaminants, such as nitrogen, phosphorus, and pathogens, ensuring that water meets stringent quality standards. Similarly, wastewater treatment involves a series of steps, including collection and conveyance, primary treatment to remove solids, secondary treatment using biological processes, and tertiary treatment to further purify the wastewater (Ghimire et al., 2021). These processes collectively ensure that wastewater is treated to acceptable standards before it is discharged back into the environment. Water and wastewater treatment are vital components of public health and environmental stewardship (Zarei et al., 2020).

WATER TREATMENT STEPS

Coagulation: Coagulation is often the first step in water treatment. During coagulation, chemicals with a positive charge are added to the water. The positive charge neutralizes the negative charge of dirt and other dissolved particles in the water. When this occurs, the particles bind with the chemicals to form slightly larger particles. Common chemicals used in this step include specific types of salts, aluminum, or iron (Li et al., 2023).

Flocculation: Flocculation follows the coagulation step. Flocculation is the gentle mixing of the water to form larger, heavier particles called flocs. Often, water treatment plants will add additional chemicals during this step to help the flocs form (Sardana et al., 2019).

Sedimentation: Sedimentation is one of the steps water treatment plants use to separate out solids from the water. During sedimentation, flocs settle to the bottom of the water because they are heavier than water (Liang et al., 2017).

Filtration: Once the flocs have settled to the bottom of the water, the clear water on top is filtered to separate additional solids from the water. During filtration, the clear water passes through filters that have different pore sizes and are made of different materials (such as sand, gravel, and charcoal). These filters remove dissolved particles and germs, such as dust, chemicals, parasites, bacteria, and viruses (Hunag et al., 2021). Activated carbon filters also remove any bad odors. Water treatment plants can use a process called ultrafiltration in addition to or instead of traditional filtration. During ultrafiltration, the water goes through a filter membrane with very small pores. This filter only lets through water and other small molecules (such as salts and tiny, charged molecules). Reverse osmosis external icon is another filtration method that removes additional particles from water. Water treatment plants often use reverse osmosis when treating recycled water (also called reused water) or salt water for drinking (Herrero et al., 2015).

Disinfection: After the water has been filtered, water treatment plants may add one or more chemical disinfectants (such as chlorine, chloramine, or chlorine dioxide) to kill any remaining parasites, bacteria, or viruses. To help keep water safe as it travels to homes and businesses, water treatment plants will make sure the water has low levels of the chemical disinfectant when it leaves the treatment plant. This remaining disinfectant kills germs living in the pipes between the water treatment plant and your tap (Palansooriya et al., 2020). In addition to or instead of adding chlorine, chloramine, or chlorine dioxide, water treatment plants can also disinfect water using ultraviolet (UV) light, UV light and ozone work well to disinfect water in the treatment plant, but these disinfection methods do not continue killing germs as water travels through the pipes between the treatment plant and your tap (Rashid et al., 2021). Water treatment plants also commonly adjust water pH and add fluoride after the disinfection step. Adjusting the pH improves taste, reduces corrosion (breakdown) of pipes, and ensures chemical disinfectants continue killing germs as the water travels through pipes. Drinking water with the right amount of fluoride keeps teeth strong and reduces cavities (Fito et al., 2021). Surface water collects on the ground or in a stream, river, lake, reservoir, or ocean while ground water is located below the surface of the earth in spaces between rock and soil. Water treatment differs by community: Water may be treated differently in different communities depending on the quality of the source water that enters the treatment plant (Issaoui et al., 2022). The water that enters the treatment plant is most often either surface water or ground water. Surface water typically requires more treatment and filtration than ground water because lakes, rivers, and streams contain more sediment (sand, clay, silt, and other soil particles), germs, chemicals, and toxins than ground water. Some water supplies may contain radionuclides (small radioactive particles), specific chemicals (such as nitrates), or toxins (such as those made by cyanobacteria). Specialized methods to control or remove these contaminants can also be part of water treatment (Kamble et al., 2019).

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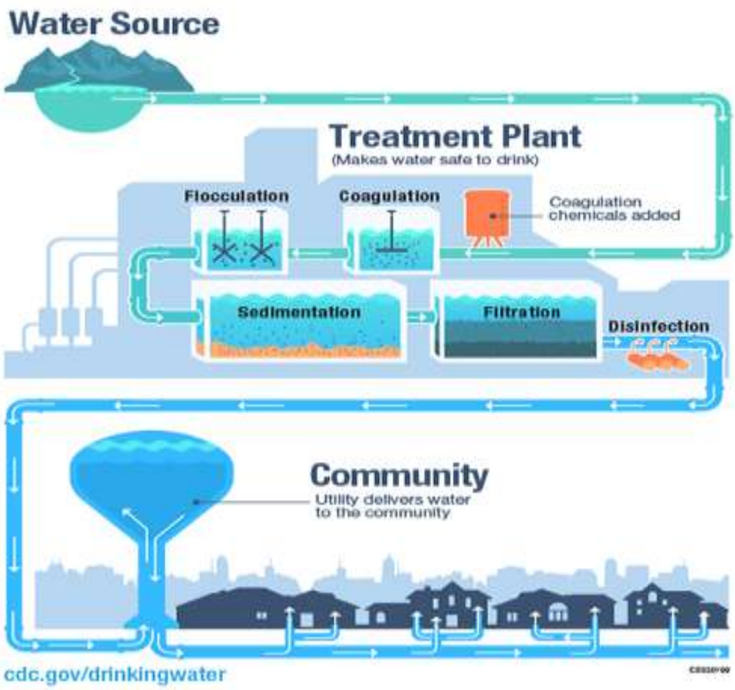

Figure 1: Water source

Source: Roychand et al., 2019

CONVENTIONAL WATER AND SEWAGE TREATMENT

Conventional wastewater treatment processes are essential for purifying wastewater before it is discharged back into the environment. These processes involve a series of physical, chemical, and biological steps designed to remove contaminants and pollutants, ensuring the protection of public health and the environment (Kesari et al., 2021). The treatment of wastewater typically begins with preliminary treatment, which involves the removal of large debris and solids through processes like screening and sedimentation. Screening removes large objects like sticks, rags, and plastics, while sedimentation allows heavier solids to settle at the bottom of tanks or basins (Khan et al., 2022). Following preliminary treatment, the wastewater undergoes primary treatment, where suspended solids and organic matter are further separated from the water. Primary treatment usually involves the use of sedimentation tanks or clarifiers, where gravity allows the heavier particles to settle, forming a sludge layer at the bottom (Liao et al., 2021). Secondary treatment is the next stage in the process, focusing on the removal of dissolved and suspended organic matter through biological processes. In secondary treatment, microorganisms like bacteria and protozoa break down the organic pollutants present in the wastewater. Common methods of secondary treatment include activated sludge processes, trickling filters, and rotating biological contactors (RBCs) (Lopez-Morales et al., 2019). After secondary treatment, the wastewater may undergo tertiary treatment, which aims to further purify the water by removing specific contaminants like nutrients, pathogens, and fine particles. Tertiary treatment processes often involve advanced filtration techniques, chemical disinfection, and nutrient removal through coagulation and flocculation (Nair et al., 2021). The treated wastewater is then discharged into receiving bodies of water or reused for non-potable purposes like irrigation or industrial processes. However, the quality of the treated water must meet regulatory standards to ensure it does not pose a risk to public health or the environment (Ofori et al., 2021). Conventional wastewater treatment processes are vital for maintaining clean and safe water resources. By effectively removing contaminants and pollutants, these processes help protect human health, preserve aquatic ecosystems, and support sustainable water management practices. Continued research and innovation in wastewater treatment technologies will further enhance the efficiency and effectiveness of these critical processes (Novarro-Ramirez et al., 2020).

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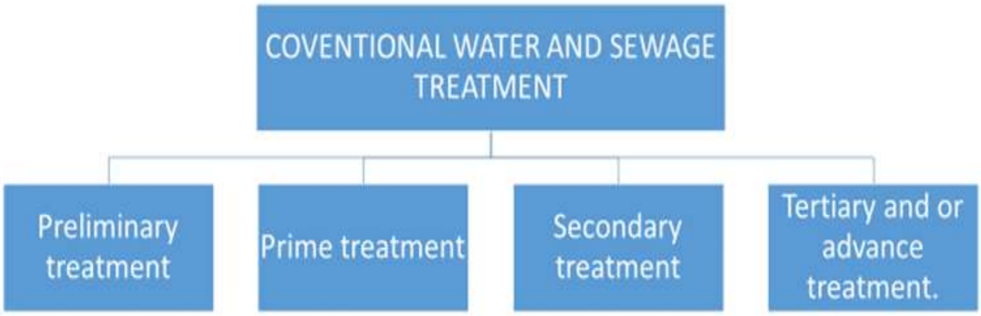
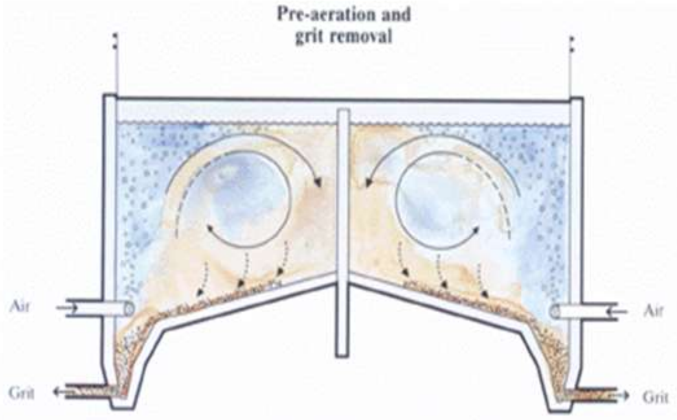


PRELIMINARY TREATMENT

Preliminary treatment methods play a crucial role in the initial stage of wastewater treatment by removing large solids and debris before further processing (Ruiz et al., 2016). Among these methods, comminutors are widely used for solid waste removal in wastewater treatment plants (Milano et al., 2016). Comminutors are mechanical devices designed to break down and shred large solid materials present in wastewater into smaller, more manageable pieces (Vreys et al., 2019). They typically consist of rotating blades or cutters that grind and chop solid debris such as rags, plastics, and other bulky items into smaller fragments (Martin et al., 2018). These smaller particles are easier to handle and remove in subsequent treatment processes, preventing clogging and damage to downstream equipment (Zhang et al., 2014). The operation of comminutors involves the intake of raw wastewater containing various solid objects and debris. As the wastewater passes through the comminutor, the rotating blades or cutters shred and reduce the size of the solid materials present in the flow (Vonshak et al., 2017). The shredded particles are then discharged along with the wastewater into subsequent treatment processes. Comminutors are typically installed at the inlet of wastewater treatment plants or at pumping stations where large solid materials are commonly found (Loftus & Johnson, 2017). They help protect downstream equipment such as pumps, screens, and sedimentation tanks from damage caused by oversized debris. By breaking down large solids into smaller particles, comminutors also facilitate more efficient and effective treatment processes downstream (Lu et al., 2019). Overall, comminutors are essential components of preliminary treatment systems in wastewater treatment plants, providing an initial line of defense against the ingress of large solid materials (Sabia et al., 2015). Their use helps improve the reliability, performance, and longevity of wastewater treatment infrastructure by minimizing the risk of equipment failure and operational disruptions caused by solid waste accumulation (Carlson et al., 2015).

PRIMARY TREATMENT

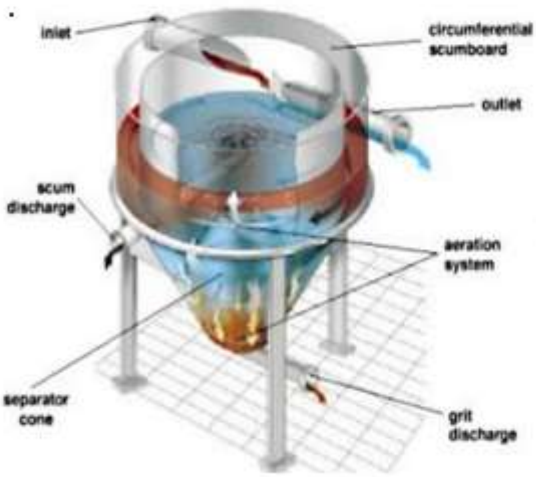
Primary treatment processes, including sedimentation tanks and clarifiers, are fundamental components of wastewater treatment plants aimed at removing suspended solids and other larger particles from wastewater before further treatment (Castrillo et al., 2013). Sedimentation tanks, also known as settling tanks or primary clarifiers, are large, rectangular or circular basins where the initial settling of solids occurs (Delanka-Pedige et al., 2021). The wastewater enters these tanks from the influent pipe and is allowed to stand still for a period, typically several hours (Baawain et al., 2020). During this time, gravity causes the heavier particles and solids to settle to the bottom of the tank, forming a layer of sludge, while the clearer water remains at the top (Meena et al., 2019). The design of sedimentation tanks allows for the separation of suspended solids, organic matter, and other materials from the wastewater (Machineni et al., 2019). The settled solids, known as primary sludge, are periodically removed from the bottom of the tank and transferred to sludge treatment processes for further treatment or disposal (Mahtab et al., 2021). Meanwhile, the clarified water, with reduced levels of suspended solids, flows out of the tank for further treatment in secondary or tertiary treatment processes (Ashraf et al., 2021). Clarifiers function similarly to sedimentation tanks but are typically equipped with mechanisms to enhance the settling process. These mechanisms may include mechanical scrapers or skimmers that continuously remove settled solids from the bottom of the tank to prevent buildup and improve efficiency (Jodar-Abellan et al., 2019). Additionally, some clarifiers may incorporate inclined plates or tube settlers to increase the surface area available for particles to settle, thereby enhancing the sedimentation process (Chauque et al., 2021). Overall, sedimentation tanks and clarifiers are essential components of primary treatment in wastewater treatment plants, providing an effective means of removing suspended solids and reducing the organic load in wastewater (Van der Bruggen et al., 2021). By facilitating the settling of solids, these processes help improve the overall efficiency and performance of downstream treatment processes, ensuring the production of treated effluent that meets regulatory standards for discharge or reuse (Melo et al., 2019).



Aerated grit chamber: Diffused air keeps organic solid in suspension as grit settle (Issauli et al., 2022).

Figure 2: Grit removal

Source: Baskar et al., 2022



Vortex- Type Grit Chambers
Vortex is create
Grit move to outside the unit and gets collected
(Kamble et al., 2019).

Figure 3: Grit removal

Source: Baskar et al., 2022

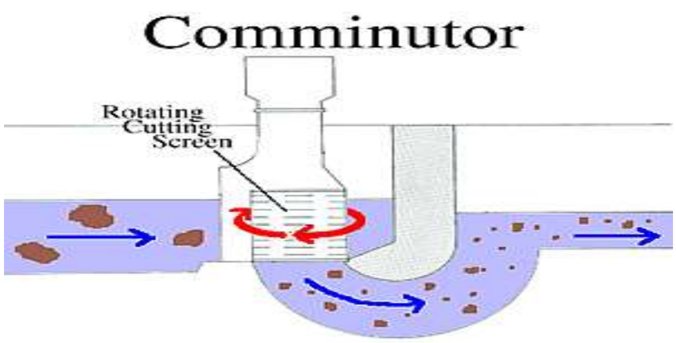


Figure 4: Comminutor

Source: Capodaglio al., 2021

- In this device all of the wastewater flow passes through the grinder assembly (Kesari et al., 2021).
- The grinder consist of a screen or slotted basket, a rotating or oscillating cutter and a stationary cutter (Khan et al., 2022).
- Solids pass through the screen and are chopped or shredded between the two cutters (Liao et al., 2021).

SECONDARY TREATMENT

Secondary treatment methods, including activated sludge, trickling filters, and rotary biological contractors, are critical processes in wastewater treatment plants designed to further remove organic matter and pollutants from wastewater after primary treatment (Rashid et al., 2021).

1. Activated Sludge: Activated sludge is a widely used biological treatment process that relies on microbial activity to break down organic pollutants in wastewater. In this method, wastewater from primary treatment is mixed with a culture of microorganisms, or activated sludge, in aeration tanks (Palansooriya et al., 2020). Air is continuously pumped into the tanks to provide oxygen for the microbial community, facilitating the aerobic degradation of organic matter. The microorganisms consume organic pollutants as a food source, converting them into simpler, less harmful substances (Angelakis et al., 2015). After aeration, the wastewater and activated sludge mixture undergoes settling in a secondary clarifier, where the biomass settles out as sludge, and the clarified effluent is discharged or undergoes further treatment (Kalair et al., 2021).
2. Trickling Filters: Trickling filters are another biological treatment process that utilizes microbial activity to degrade organic pollutants in wastewater. In this method, wastewater is distributed over a bed of inert media, such as rock or plastic, in a trickling filter tank (Ali et al., 2017). Microorganisms attached to the media form a biofilm, where they metabolize and break down organic pollutants in the wastewater as it trickles over the surface. The aerobic conditions within the biofilm support microbial growth and activity, facilitating the degradation of organic matter (Bello et al., 2017). The treated wastewater collects at the bottom of the filter and is discharged or undergoes further treatment (Adrados et al., 2014).
3. Rotary Biological Contractors (RBCs): Rotary biological contractors are mechanical treatment units that utilize rotating discs or drums to support microbial growth and activity for wastewater treatment (Alexandros et al., 2014). Wastewater is applied onto the rotating media, where microorganisms attach and form biofilms similar to trickling filters (Ben et al., 2017). As the media rotates, the biofilm comes into contact with the wastewater, allowing for the aerobic degradation of organic pollutants (Bodik et al., 2013). The continuous rotation of the media ensures efficient mixing and oxygen transfer, promoting microbial activity and treatment efficiency (Brix et al., 2020). Treated wastewater is collected at the bottom of the unit and discharged or subjected to additional treatment processes (Demirbas et al., 2017).

Secondary treatment methods such as activated sludge, trickling filters, and rotary biological contractors play a crucial role in removing organic matter and pollutants from wastewater, producing treated effluent that meets regulatory standards for discharge or reuse. These biological treatment processes offer effective and environmentally sustainable solutions for wastewater treatment, contributing to the protection of public health and the environment (Lee et al., 2017).

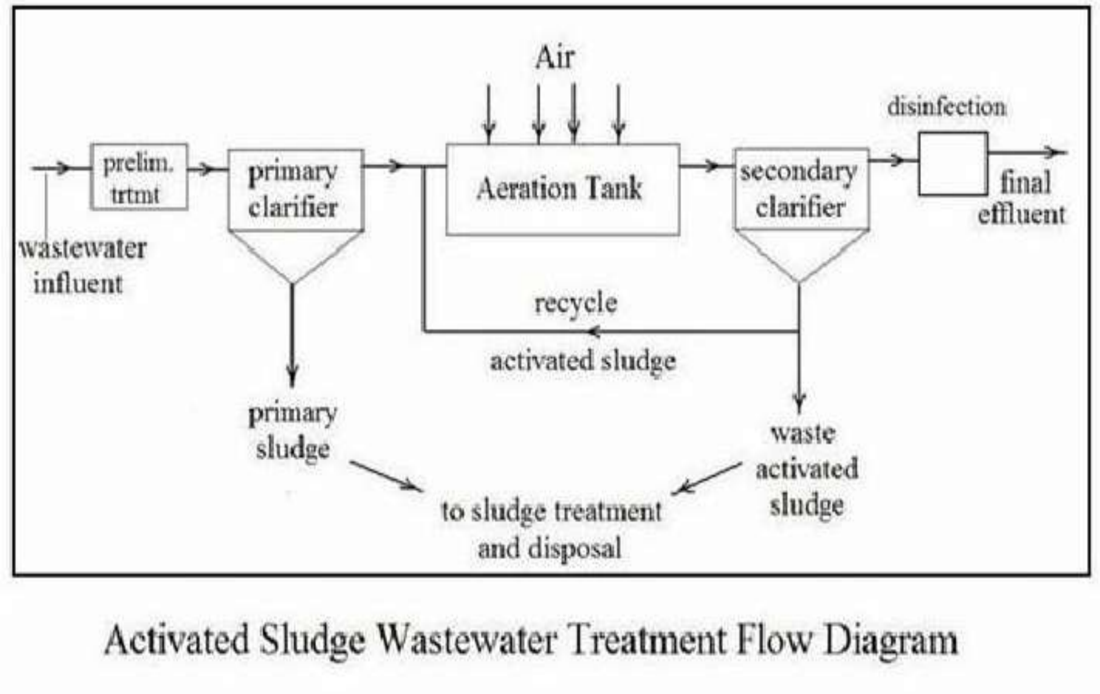


Figure 5: Activated sludge wastewater treatment

Source: Yenkie et al., 2019.

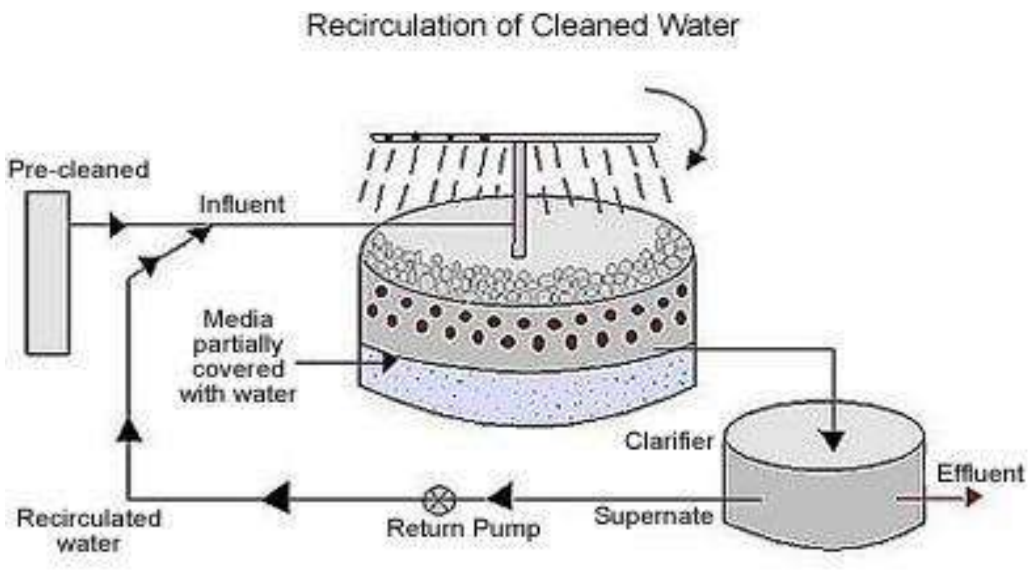


Figure 6: Trickling filters

Source: Loftus et al., 2020.

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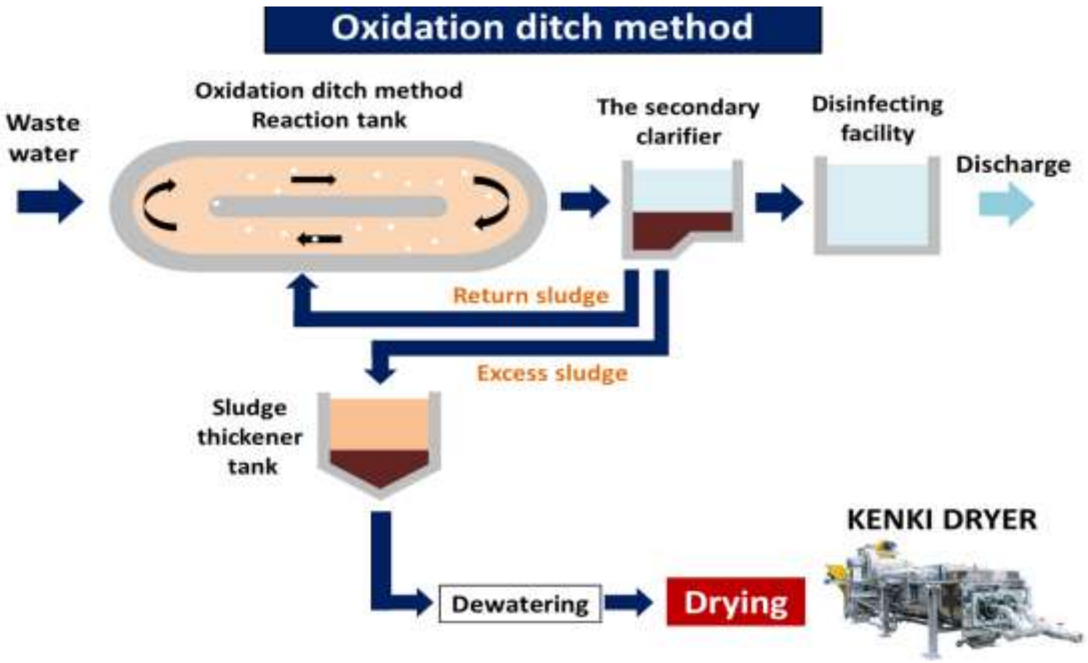

Figure 7: Oxidation ditches

Source: Delanka-Pedige e et al., 2021

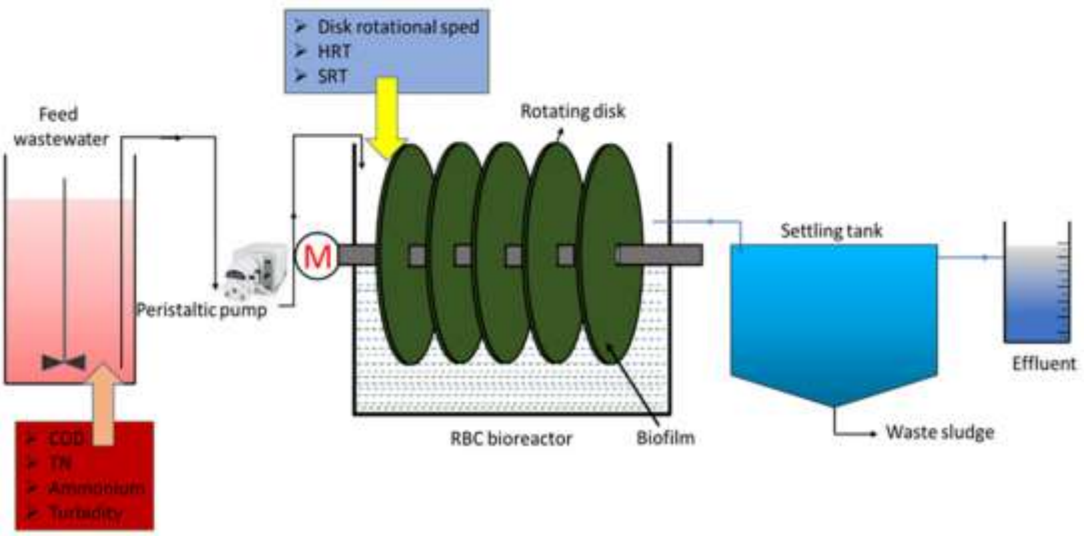

Figure 8: Rotating biological contactors

Source: Pettygrove et al., 2019

TERTIARY AND ADVANCE TREATMENT

Tertiary and advanced treatment methods play a crucial role in further purifying wastewater beyond primary and secondary treatment stages, ensuring that the effluent meets stringent quality standards for discharge or reuse (Mao et al., 2015).

Coagulation and filtration are common processes used in tertiary treatment to remove remaining suspended solids, dissolved organic matter, and other contaminants from wastewater. During coagulation, chemical coagulants such as aluminum sulfate (alum) or ferric chloride are added to the wastewater (Manning et al., 2016). These coagulants destabilize particles and organic compounds, causing them to clump together and form larger aggregates called flocs. The flocs settle more readily during subsequent sedimentation or filtration processes, facilitating their removal from the wastewater (Panepito et al., 2016).

Filtration involves passing the coagulated wastewater through a filter medium, such as sand, gravel, or multimedia filters, to physically trap and remove remaining suspended solids and flocs. Filtration not only removes particulate matter but also helps to improve water clarity and reduce turbidity, ensuring that the effluent meets aesthetic and regulatory requirements (Sardana et al., 2019).

In addition to coagulation and filtration, advanced treatment techniques may be employed to address specific contaminants or achieve higher levels of water quality. These techniques may include:

Membrane Filtration: Membrane processes, such as microfiltration, ultrafiltration, nanofiltration, and reverse osmosis, utilize semipermeable membranes to physically separate contaminants from water molecules based on size, charge, and molecular weight (). Membrane filtration is highly effective in removing suspended solids, pathogens, dissolved organic compounds, and even ions from wastewater, producing high-quality effluent suitable for various reuse applications (Li et al., 2023).

Advanced Oxidation Processes (AOPs): AOPs involve the use of powerful oxidants, such as ozone, hydrogen peroxide, or ultraviolet (UV) light, to degrade and mineralize recalcitrant organic pollutants and micro pollutants present in wastewater. These processes generate highly reactive hydroxyl radicals (•OH), which oxidize and break down organic molecules into simpler, less harmful byproducts (lin et al., 2023).

Ion Exchange: Ion exchange is a chemical process that involves the exchange of ions between a solid resin matrix and wastewater. This method is effective in removing specific ions, such as heavy metals, nitrates, phosphates, and hardness ions, from wastewater by replacing them with less harmful ions present in the resin (Ghimire et al., 2021).

In sequence tertiary treatments zones are:

(i) Anaerobic fermentation zone (characterized by very low dissolved oxygen levels and the absence of nitrates
(ii) Anoxic zone (low dissolved oxygen levels but nitrate present
(iii) Aerobic zone (aerated)
(iv) Secondary anoxic zone
(v) Final aeration zone (Chauque et al., 2021).

By integrating these tertiary and advanced treatment techniques into wastewater treatment plants, it is possible to achieve significant reductions in contaminants and produce treated effluent of exceptional quality, suitable for various non-potable reuse applications such as irrigation, industrial processes, and environmental restoration. Additionally, advanced treatment can help alleviate the strain on freshwater resources and promote sustainable water management practices in water-stressed regions (Brdjanovic et al., 2023).

UNIT OF OPERATION IN ADVANCE TREATMENT

Unit operations involved in advanced treatment processes are designed to target specific contaminants and improve the quality of wastewater to meet stringent regulatory standards or enable safe reuse. These unit operations employ various physical, chemical, and biological methods to remove pollutants and ensure the production of high-quality effluent (Mowbrey et al., 2023). Some key unit operations in advanced treatment processes include:

1. Coagulation and Flocculation: Coagulation involves the addition of chemical coagulants, such as aluminum sulfate (alum) or ferric chloride, to destabilize colloidal particles and organic matter present in wastewater. Flocculation facilitates the formation of larger flocs through gentle mixing, allowing the particles to aggregate and settle more readily during subsequent sedimentation or filtration processes (Salas et al., 2023).
2. Sedimentation: Sedimentation tanks or clarifiers are used to allow suspended particles and flocs formed during coagulation-flocculation to settle under gravity. The settled solids are then removed from the bottom of the tank, while clarified water is collected from the top for further treatment (Ambulka et al., 2023).
3. Filtration: Filtration processes, such as multimedia filtration, sand filtration, or membrane filtration, are employed to remove remaining suspended solids, fine particles, and microorganisms from the water. Filters act as physical barriers, trapping impurities and producing clear, treated water (Sun et al., 2023).
4. Disinfection: Disinfection is a critical step to inactivate pathogenic microorganisms and prevent the transmission of waterborne diseases. Common disinfection methods include chlorination, ultraviolet (UV) irradiation, ozone treatment, and advanced oxidation processes (AOPs). These methods target bacteria, viruses, and other pathogens present in the water, ensuring the safety of the treated effluent (Zeng et al., 2017).
5. Adsorption: Adsorption involves the attachment of contaminants to the surface of adsorbent materials, such as activated carbon

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or zeolites. Adsorption is effective in removing organic compounds, trace contaminants, and dissolved pollutants from wastewater through physical and chemical interactions between the adsorbent and the contaminants (Parker et al., 2019).

6. Ion Exchange: Ion exchange processes utilize ion exchange resins to remove dissolved ions and heavy metals from water by exchanging them with less harmful ions present in the resin. This method is particularly effective in reducing hardness, removing nitrates, phosphates, and removing heavy metals from wastewater streams (Selcuk et al., 2019).
7. Advanced Oxidation Processes (AOPs): AOPs involve the generation of highly reactive hydroxyl radicals (•OH) through the decomposition of powerful oxidants, such as ozone, hydrogen peroxide, or UV light (Ritchie et al., 2023). These radicals oxidize and degrade recalcitrant organic pollutants, pharmaceuticals, and emerging contaminants present in wastewater, leading to their mineralization into simpler, less harmful byproducts (Danielsson et al., 2023).

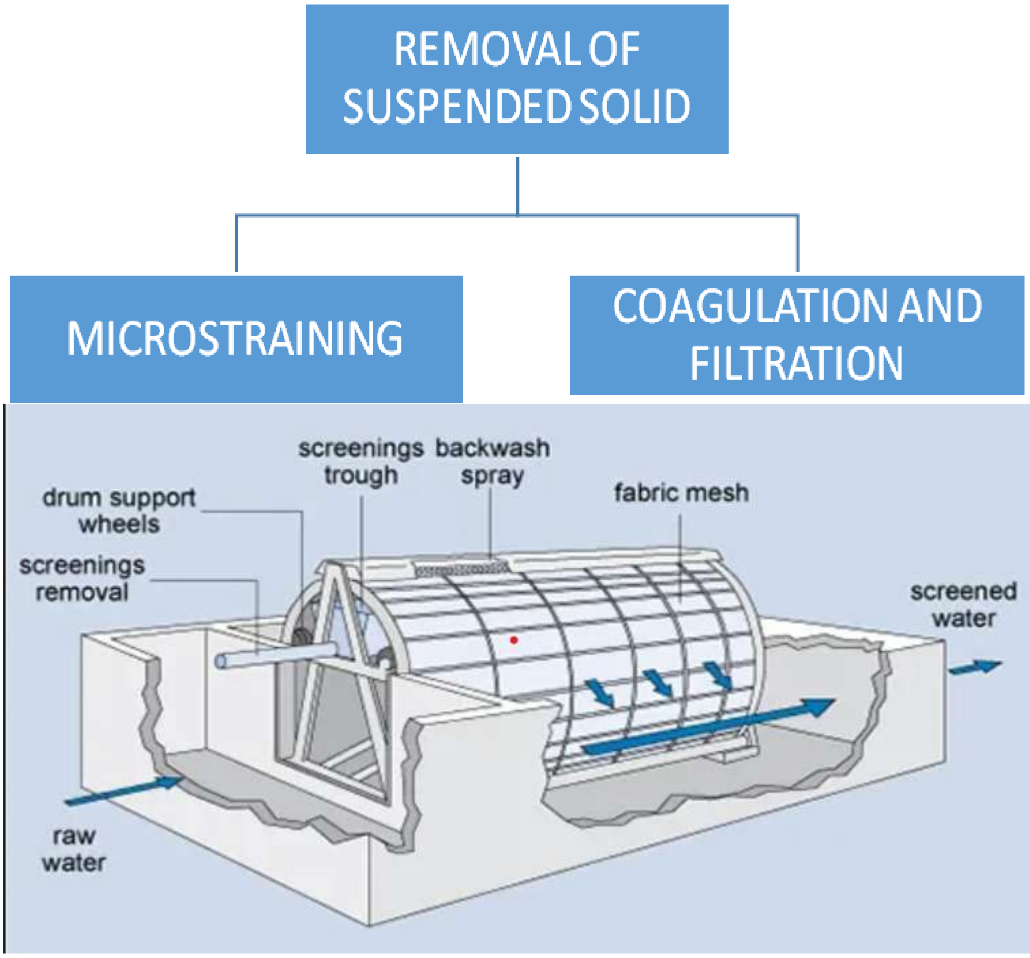

Figure 9: Microstrainig

Source: Melo et al., 2019

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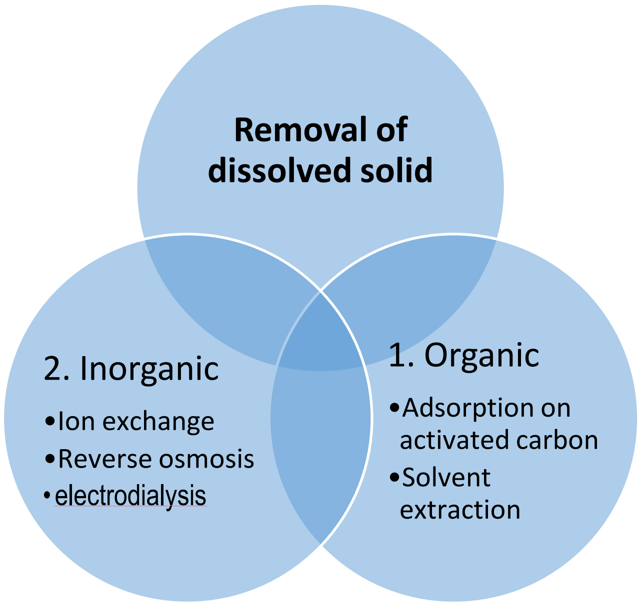
REMOVAL OF DISSOLVED SOLID



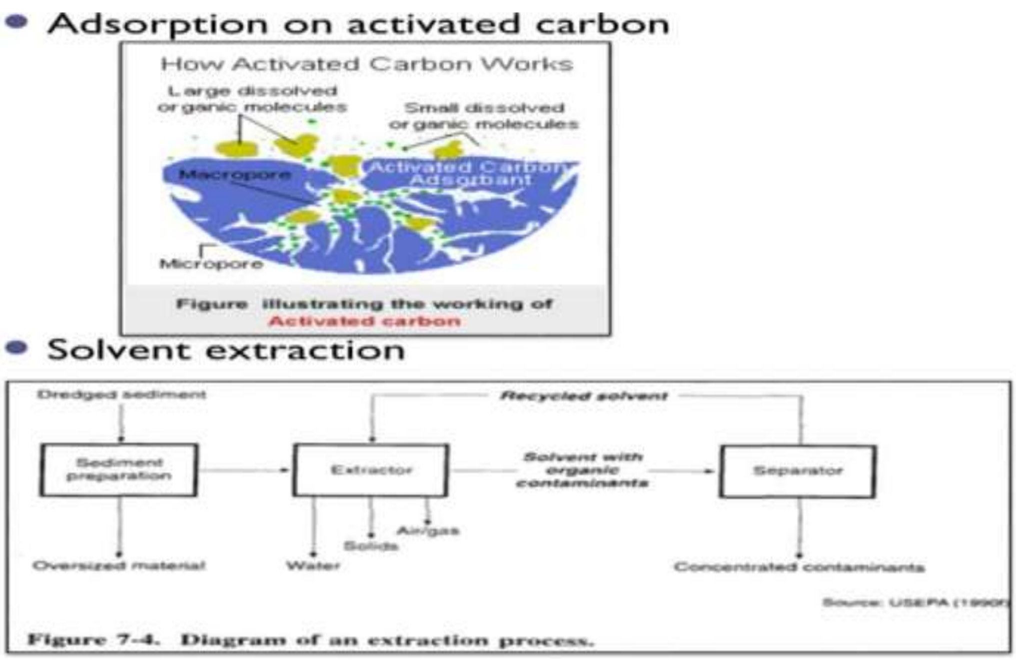


Figure 10: Adsorption on activated carbon and solvent extraction

Source: Sardana et al., 2019

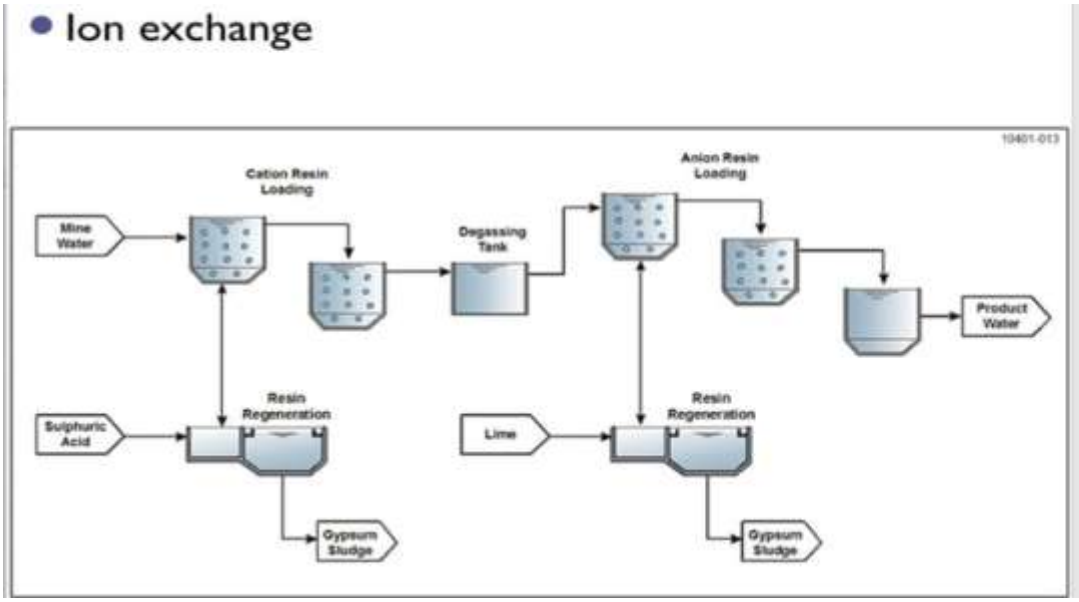


Figure 11: Ion exchange

Source: Zarei et al., 2020

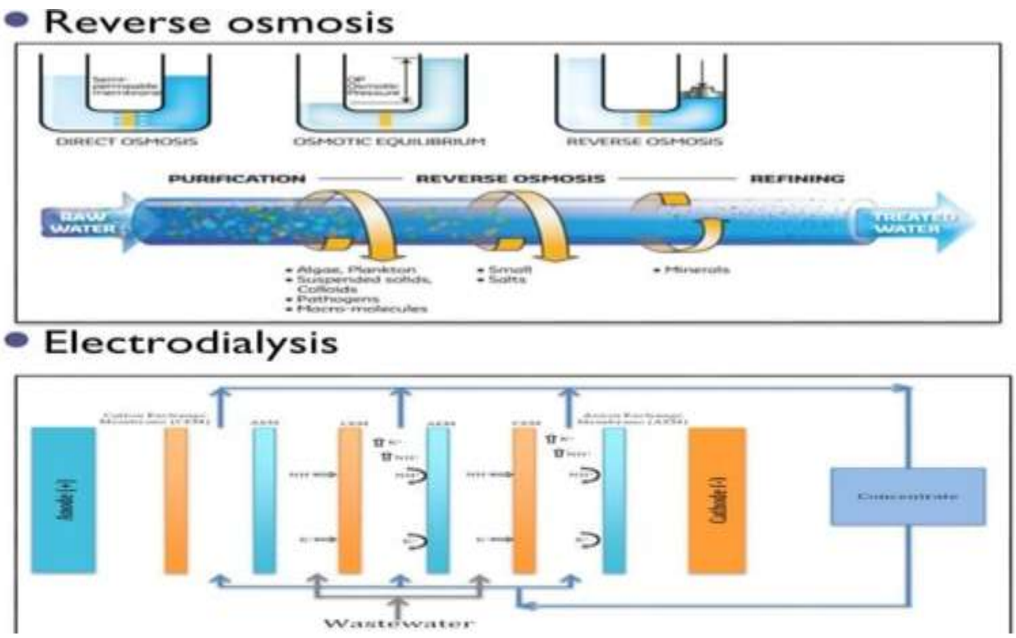


Figure 12: Reverse osmosis and electrodialysis

Source: Li et al., 2023

MICROBIOLOGICAL ANALYSIS OF WATER PURITY

Total Coliform Testing: Total coliform bacteria are a group of bacteria found in the intestines of warm-blooded animals and in the environment. Total coliform testing provides an overall assessment of water quality (Contreras et al., 2017).

Fecal Coliform and Escherichia coli (E. coli) Testing: Fecal coliform bacteria, including E. coli, are specific types of coliform bacteria found in the intestines and feces of humans and other animals (yang et al., 2017). Their presence in water indicates fecal contamination and the potential presence of pathogens that can cause gastrointestinal illnesses. Testing for fecal coliforms and E. coli is essential for assessing water safety, especially for drinking water sources (Ungureanu et al., 2018).

Heterotrophic Plate Count (HPC): Heterotrophic bacteria are naturally occurring microorganisms found in water and soil. HPC testing measures the concentration of these bacteria in water samples. While some heterotrophic bacteria are harmless, excessively high levels may indicate poor water quality or the presence of organic matter that can support microbial growth ().

Presence/Absence Testing for Specific Pathogens: In addition to general microbiological testing, water samples may be tested for the presence of specific pathogens such as Salmonella, Giardia, Cryptosporidium, and other disease-causing microorganisms. These tests are typically more specialized and targeted, focusing on known waterborne pathogens of concern (Singh et al., 2019).

Membrane Filtration Technique: This method involves passing water samples through a membrane filter that traps bacteria and other microorganisms. The filter is then incubated on a nutrient medium, allowing bacteria to grow and form colonies that can be counted and analyzed (Sengupta et al., 2015).

Most Probable Number (MPN) Method: The MPN method is a statistical technique used to estimate the concentration of coliform bacteria in water samples based on the presence or absence of bacterial growth in multiple dilutions of the sample (Jeong et al., 2016).

By employing these unit operations in advanced treatment processes, wastewater treatment plants can achieve significant reductions in pollutants, produce high-quality effluent, and meet stringent regulatory requirements for discharge or reuse. Advanced treatment technologies play a crucial role in ensuring the protection of public health and the environment while promoting sustainable water management practices (Ungureanu et al., 2020).

BENEFITS OF SEWAGE AND WASTEWATER TREATMENT, INCLUDING IMPROVED PUBLIC HEALTH AND ENVIRONMENTAL QUALITY.

Sewage and wastewater treatment play a crucial role in improving public health and environmental quality by addressing various challenges associated with untreated wastewater discharge (Mahfooz et al., 2020). Here are some key benefits of sewage and wastewater treatment:

1. Protection of Public Health: Proper treatment of sewage and wastewater helps prevent the spread of waterborne diseases caused by pathogenic microorganisms present in untreated water. By removing harmful bacteria, viruses, and parasites, treated wastewater becomes safer for human contact, reducing the risk of illnesses such as cholera, typhoid fever, and gastroenteritis (Njuguna et al., 2019).
2. Environmental Protection: Wastewater treatment helps protect natural ecosystems and aquatic habitats by reducing the pollution load discharged into water bodies. Untreated sewage and wastewater contain pollutants such as nutrients (nitrogen and phosphorus), organic matter, heavy metals, and toxic chemicals, which can degrade water quality, harm aquatic life, and disrupt ecological balance (Xiao et al., 2017). Treatment processes remove or significantly reduce these pollutants, mitigating adverse impacts on aquatic ecosystems and biodiversity (narain et al., 2020).
3. Prevention of Water Contamination: Untreated sewage and wastewater can contaminate surface water, groundwater, and soil, posing risks to both human health and the environment (Adegoke et al., 2018). Through treatment, contaminants are removed or reduced to levels that meet regulatory standards, ensuring that discharged water does not pose a threat to drinking water sources, recreational areas, or agricultural lands (Adegoke et al., 2016).
4. Resource Recovery: Wastewater treatment facilities can recover valuable resources from sewage and wastewater, such as nutrients (nitrogen and phosphorus) and organic matter, through processes like sludge digestion and nutrient removal (Adedgoke et al., 2017). These resources can be reused in agriculture as fertilizers or in energy production through anaerobic digestion, contributing to resource conservation and circular economy principles (Panthi et al., 2019).
5. Compliance with Regulations: Sewage and wastewater treatment are often regulated by environmental agencies to ensure compliance with water quality standards and regulations. Proper treatment and management of wastewater help industries, municipalities, and communities meet regulatory requirements, avoid penalties for non-compliance, and demonstrate commitment to environmental stewardship (Amoah et al., 2018).
6. Enhanced Aesthetic and Recreational Value: Clean water bodies and aesthetically pleasing

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environments contribute to the quality of life and well-being of communities. Treated wastewater can support recreational activities such as swimming, fishing, and boating, fostering social interaction and promoting outdoor recreation opportunities (Dickin et al., 2016).

Sewage and wastewater treatment offer numerous benefits that extend beyond public health protection to encompass environmental sustainability, resource recovery, regulatory compliance, and community well-being (Soni et al., 2020). By investing in wastewater infrastructure and implementing effective treatment practices, societies can safeguard water resources, protect ecosystems, and support sustainable development goals.

IMPORTANCE OF SEWAGE AND WASTEWATER TREATMENT AND ITS IMPACT ON SOCIETY AND THE ENVIRONMENT.

Sewage and wastewater treatment plays a vital role in safeguarding public health, protecting the environment, and promoting sustainable development (Alghobar et al., 2014). Here's a summarized overview of its importance and impact:

1. Public Health Protection: Effective sewage and wastewater treatment prevents the spread of waterborne diseases by removing harmful pathogens, bacteria, and viruses from wastewater. This reduces the risk of illnesses and outbreaks, ensuring safer water for drinking, bathing, and recreational activities, thus improving overall public health outcomes (Duan et al., 2017).
2. Environmental Protection: Untreated sewage and wastewater contain pollutants such as nutrients, organic matter, heavy metals, and toxic chemicals, which can degrade water quality, harm aquatic life, and disrupt ecosystems (Tytla et al., 2019). Treatment processes remove or reduce these pollutants, minimizing environmental degradation and preserving the health and integrity of water bodies, ecosystems, and natural habitats (Hussain et al., 2019).
3. Resource Recovery and Sustainability: Wastewater treatment facilities can recover valuable resources from sewage and wastewater, including nutrients like nitrogen and phosphorus, organic matter, and energy (Tacconelli et al., 2018). These resources can be reused in agriculture, energy production, and industrial processes, promoting resource conservation, circular economy principles, and sustainable resource management practices (Giddins et al., 2017).
4. Regulatory Compliance and Standards: Sewage and wastewater treatment are regulated by environmental agencies to ensure compliance with water quality standards and regulations (Zaman et al., 2017). By adhering to regulatory requirements and implementing effective treatment measures, industries, municipalities, and communities demonstrate their commitment to environmental stewardship, minimize pollution, and avoid penalties for non-compliance (Naylor et al., 2018).
5. Community Well-being and Quality of Life: Clean water bodies and healthy environments contribute to the well-being and quality of life of communities. Treated wastewater supports recreational activities, enhances aesthetic value, and fosters social interaction and community engagement (Herc et al., 2017). Access to clean water and sanitation services improves living conditions, promotes economic development, and enhances overall quality of life for individuals and communities (he et al., 2020).

Sewage and wastewater treatment is essential for protecting public health, preserving environmental quality, promoting resource sustainability, and enhancing community well-being (Knig et al., 2017). By investing in wastewater infrastructure, adopting innovative treatment technologies, and implementing effective management practices, societies can address the challenges of wastewater management, mitigate environmental impacts, and build resilient and sustainable communities for future generations (Soni et al., 2020).

II. CONCLUSION

Sewage and wastewater treatment are critical components of modern infrastructure, essential for protecting public health and preserving environmental quality. Conventional wastewater treatment processes involve several key stages. Preliminary treatment methods, including the use of comminutors, focus on the removal of large solid waste particles from wastewater streams. Following preliminary treatment, primary treatment processes, such as sedimentation tanks and clarifiers, facilitate the settling of suspended solids, reducing their presence in the water Secondary treatment methods, such as activated sludge, trickling filters, and rotary biological contractors, target the removal of organic matter and pathogens from wastewater. These processes utilize microbial activity to break down and digest organic pollutants, resulting in cleaner effluent. Tertiary and advanced treatment techniques further enhance water quality by employing methods like coagulation and filtration to remove fine particles and dissolved contaminants.

Unit operations in advanced treatment encompass various processes designed to purify wastewater to high standards. These operations may include advanced filtration, membrane technologies, and chemical treatment methods. By employing a combination of these techniques, wastewater treatment plants can achieve significant reductions in pollutant levels and produce effluent suitable for reuse or safe discharge into the environment. The benefits of sewage and wastewater treatment are multifaceted. Effective treatment processes help mitigate the spread of waterborne diseases, protect aquatic ecosystems, and safeguard drinking water supplies. Additionally, wastewater treatment facilities can recover valuable resources from sewage, such as nutrients and energy, contributing to resource conservation and sustainability. Sewage and wastewater treatment play a vital role in maintaining public health and environmental integrity. By implementing comprehensive treatment strategies and embracing sustainable practices, societies can ensure the responsible management of wastewater resources and foster a healthier, more sustainable future for all. Also, by employing a combination of physical, chemical, and biological processes, treatment facilities play a crucial role in ensuring that our water resources remain clean, safe, and sustainable for future generations. Continued investment in research, innovation, and infrastructure is essential to enhance the efficiency and effectiveness of water and wastewater treatment systems, ultimately benefiting society and the environment alike.

III. RECOMMENDATION

In light of the importance of sewage and wastewater treatment, it is imperative to prioritize investment in infrastructure and technology to improve treatment efficiency and expand treatment capacity. Governments and regulatory bodies should work collaboratively with stakeholders to develop and enforce stringent water quality standards, ensuring that wastewater treatment facilities meet or exceed regulatory requirements. Furthermore, there is a need for increased public awareness and education regarding the importance of proper wastewater management and the role individuals can play in reducing water pollution. Community outreach programs and educational initiatives can help promote responsible water use practices, encourage the adoption of water-saving technologies, and raise awareness about the impact of wastewater on human health and the environment. In addition, research and development efforts should focus on advancing wastewater treatment technologies, exploring innovative treatment methods, and identifying sustainable solutions for wastewater reuse and resource recovery. Embracing emerging technologies such as membrane filtration, advanced oxidation processes, and decentralized treatment systems can enhance treatment efficiency, reduce environmental impact, and promote resource recovery from wastewater streams. Moreover, collaboration between industries, academia, and government agencies is essential to foster innovation and knowledge sharing in the field of wastewater treatment. By facilitating interdisciplinary collaboration and fostering a culture of innovation, stakeholders can collectively address the evolving challenges associated with wastewater management and develop holistic solutions that promote environmental sustainability and public health. Therefore investing in infrastructure, raising public awareness, fostering innovation, and promoting collaboration, stakeholders can work together to ensure effective sewage and wastewater treatment, protect water resources, and safeguard public health and environmental quality for present and future generations.

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