Journal of Research and Innovation for Sustainable Society (JRISS)
Volume 6, Issue 2, 2024
ISSN: 2668-0416
Thoth Publishing House

DOI: 10.33727/JRISS.2024.2.14:126-133

Research on Industrial Wastewater Treatment

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Abstract. In a context of rapid urbanization, urban wastewater represents a major challenge for the environment and public health. This paper analyzes the sources of wastewater generation, the technologies and infrastructure for its collection, as well as modern treatment method. Considering the values of the quality indicators of wastewater discharged into the sewage networks of localities and the fact that there are companies that use a large volume of water and, implicitly, discharge a large volume of water, the article presents the technologies used to bring the characteristics of the water discharged into the sewage networks of localities and directly into the treatment plants, to the level required by legislation.
Keywords: *treatment, collection, wastewater*

1.Introduction

Water pollution constitutes a major global issue, impacting aquatic ecosystems and human health. Numerous human activities lead to water pollution.
Here are several of them:

- Industrial waste disposal: Industries may release dangerous chemicals into water bodies, including heavy metals, solvents, toxic compounds, and various chemicals.
- Intensive agriculture: The release of nutrients, including nitrogen and phosphorus, from agricultural practices, together with the overapplication of fertilizers and pesticides, can result in their runoff into water bodies, compromising water quality and causing eutrophication.
- Urban waste disposal: Municipal wastewater, laden with chemicals, bacteria, and nutrients from residential and urban establishments, along with the inappropriate disposal of solid waste such as plastics, paper, and other items, can result in water contamination.
- Construction waste disposal: construction materials: Improper disposal of construction waste, including concrete and other building materials, can contaminate water sources.
- Oil incidents: Oil spills originating from tankers or platforms, as well as from drilling and storage facilities, provide a significant hazard to the aquatic ecosystem.
- Motor vehicle leaks: Oils and fluids: Leaks from motor vehicles can contaminate water systems via storm drains, resulting in pollution.
- Wastewater discharge:
  - Municipal wastewater: Unregulated release of municipal wastewater, perhaps including chemicals and pathogens, can result in water contamination.
  - Industrial wastewater: The release of liquid and solid waste from many sectors, which may contain hazardous chemicals and heavy metals.
  - Mineral waste: Byproducts from mining, including minerals and heavy metals, that may contaminate water sources by erosion or runoff.

2. **Level of generation, collection and treatment of urban wastewater**

Urban wastewater is composed of waste from domestic, commercial and industrial activities. They pose a threat to environmental quality and public health if not properly managed. In the context of rapid urbanization, wastewater management systems are under increasing pressure.

Domestic and industrial wastewater exerts significant pressure on the aquatic environment, due to loads of organic matter, nutrients and hazardous substances. Given the high percentage of the population living in urban agglomerations, a significant part of the wastewater is collected through sewerage systems and transported to treatment plants. The level of treatment, before discharge, and the state of the receiving waters determine the intensity of the impact on aquatic ecosystems.

In terms of activity profile, most of the agro-industrial units fall into the fields of meat and milk industrialization, manufacture of alcoholic beverages, manufacture of vegetable and fruit products and manufacture and bottling of non-alcoholic beverages (Figure 2*).* The highest percentage share of the biodegradable load produced by agri-food industrial units with more than 4000 l.e. at discharge into water resources was identified for the meat industry (approx. 53%) and the milk processing industry (39%), and the units in the field of brewing and bottling of non-alcoholic beverages are either closed, or have greatly reduced their production (<4,000 l.e.) or have ceased their activity.

The sewerage network is the essential infrastructure for urban wastewater collection, usually consisting of two main types of systems:

- **Unitary systems:** transport domestic wastewater and stormwater in the same channel, which can lead to uncontrolled doscharges during periods of heavy rainfall.
- **Separate systems:** transports domestic wastewater and rainwated separately, which reduces the risk of contamination and overloading of wastewater treatments plants..

In many cities, sewerage networks are outdated, requiring significant investment to adapt to current wastewater management requirements and avoid accidental losses and contamination.

Wastewater treatment plants are essential for reducing water pollution before discharge. Wastewater treatment involves three essential steps:

- **Primary treatment:** involves the removal of large solids and suspended solids thorugh physical processses such as settling and filtration.
- **Secondary treatment:** biological processes of decomposition of organic matter by bacteria and microorganismns(e.g. aerobic digestion), which significantly reduce the organic load of waters.
- **Tertiary treatment:** advanced techniques for the removal of nutrients and micropollutants such as phosphorus, nitrogen, pharmaceutical compounds and heavy materials.

This treatment involves methods such as membrane filtration, ozonation, activated carbon adsorption.

For a high quality of treated water, it is essential that these three stages are fully implemented, especially in large and densely populated cities.

To assess the quality of wastewater and the efficiency of the treatment process, a number of indicators are used:

- **BOD5 (Biological Oxygen Consumption)**: shows the level of biologically decomposed organic matter and is essential for the evaluation of secondary treatment.
- **COC (Chemical Oxygen Consumption)**: indicates the total amount of oxygen required for the chemical oxidation of organic and unorganic compounds.
- **Total nitrogen and total phosphorus**: measures nutrient concentrations, which, if not properly removed, can cause eutrophication of natural waters.
- **Concentration of heavy metals**: it is crucial for assessing the toxic risks of discharged wastewater.

These indicators are regularly monitored to assess the quality of treated water and prevent negative effects on ecosystems.

3.Treatment of industrial wastewater

The volume and properties of wastewater are contingent upon the industrial type, the technology employed, and the raw materials utilized.

Industrial wastewater treatment facilities are engineered and constructed to process wastewater generated by industrial operations, diminishing pollutant levels and assuring adherence to environmental regulations. These facilities are frequently tailored to the particulars of the industrial process and the characteristics of the produced wastewater. Below are few typical components of industrial wastewater treatment facilities.

3.1.Pretreatment

Oil and grease separators: utilized for the extraction of oils and fats from industrial wastes. Oil and grease separators are apparatuses engineered to extract oils and fats from wastewater, thereby mitigating pollution and safeguarding sewage systems. These separators are utilized in many settings, including industrial, residential, and other domains where effluent may contain oils and fats.

Oil and grease separators utilize the disparity in density between wastewater and the oils or fats it contains. These separators contain a sedimentation chamber where wastewater decelerates, enabling oils and fats to ascend to the surface, creating a superior layer.

Primary elements:

- Inlet area: wastewater comprising lipids and fats enters the separator.
- Sedimentation zone: in this zone, the water decelerates, permitting oils and fats to ascend and create a layer atop the water's surface.
- The treated water outflow directs pure water to an alternate basin or tartar system.

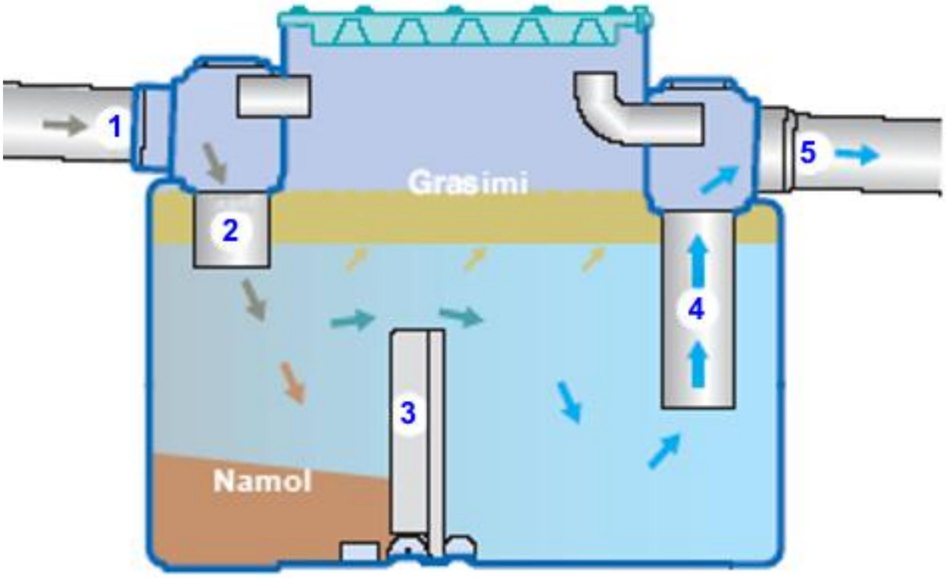

Figure 1. Oil and grease separator :1 – Inlet; 2 – Anti-splash nozzle; 3 – Dividing wall; 4 – Outlet siphon; 5 – Drainage

3.2.Design and classifications:

Underground separators are installed below the surface and are typically located near wastewater sources, such parking lots, garages, or other industrial zones.
Overhead separators are typically located within buildings and utilized in commercial kitchens or spaces where wastewater contains substantial quantities of oils and fats.
Sanitation and upkeep:

- Regular evacuation: The accumulation of oils and fats must be routinely emptied and eliminated to preserve the separator's efficiency.

- Continuous oversight: It is essential to perpetually oversee and maintain the separators to prevent capacity overload and to guarantee optimal functionality.

The utilization of oil and grease separators is crucial in mitigating water pollution and safeguarding sewage and treatment systems. These devices are a crucial element in the prudent management of wastewater across many settings.

Pre-sedimentation: The pre-sedimentation phase in wastewater treatment is a preliminary stage when bigger particulates are eliminated through sedimentation prior to entering the primary treatment units. This phase lowers the organic load and turbidity of the water, facilitating subsequent treatment. Inflow to the pre-sedimentation basin: The wastewater is directed into a designated basin for pre-sedimentation. This basin is often broader and less deep than those employed for ultimate sedimentation.

Large particle sedimentation: The reduced water velocity in the pre-sedimentation basin allows larger particles, including sand, gravel, and other solid materials, to settle to the bottom. This natural sedimentation facilitates the removal of these particles from the water flow. Reduction of organic load: Larger organic materials, including leaves and other detritus, can be eliminated during this phase. This diminishes the organic burden that may disrupt following treatment units.

Water discharge: Following the sedimentation of bigger particles, the clarified water is channeled to the subsequent phases of the wastewater treatment process.
It is essential to recognize that pre-sedimentation does not eliminate all particles or organic matter from the water, but only the larger ones. The ensuing wastewater treatment process, which may encompass coagulation, flocculation, sedimentation, and biological treatments, persists in eliminating residual contaminants to guarantee the quality of the treated water.
Pre-sedimentation is an essential phase in wastewater treatment, as it safeguards and prolongs the lifespan of other system components, including pumps and equipment. This procedure ensures the optimal functioning of the complete wastewater treatment system.

3.2.1.Chemical and physical treatment

Incorporating coagulants and flocculants to aggregate pollutants and enhance the sedimentation process. The chemical and physical treatment of wastewater employs many procedures and substances to eliminate pollutants from water. These techniques seek to enhance water quality by diminishing the levels of organic compounds, solid particulates, hazardous chemicals, and other contaminants. The application of coagulants and flocculants is a crucial phase in the wastewater treatment process. These chemical compounds enhance the separation of particles from water, aiding in the removal of pollutants by sedimentation or filtration.

This is the procedure for this therapy step:

Coagulation and flocculation include the addition of coagulants, such as aluminum sulfate or ferric chloride, to water to destabilize fine particles and colloidal substances, including suspended organic debris and microorganisms. Coagulants function by neutralizing the negative electrical charges of suspended particles. Negatively charged particles exert a repulsive force on one another. The introduction of a coagulant alters this charge, enabling the particles to attract one another and form aggregates known as "flocs".

Flocculation: Flocculants, or flocculant polymers, are introduced to promote the creation and development of flocs. Following coagulation, flocculants are added to bind and aggregate the destabilized particles into bigger flocs. These flocs possess more density, facilitating their settling and enhancing removal efficiency via filtration.

The application of coagulants and flocculants is a crucial phase in the wastewater treatment process. These chemical compounds enhance the separation of particles from water, aiding in the removal of pollutants by sedimentation or filtration. This is the operational procedure of this therapy phase: Settlement and Filtration

Primary settling: the treated water is allowed to reside in a settling tank, where the flocs descend to the bottom, and the purified water is channeled to subsequent stages.
Filtration: in certain systems, the clarified water is subjected to filters to eliminate any residual flocs or particles.

The application of coagulants and flocculants enhances the efficacy of wastewater treatment by diminishing turbidity and eliminating suspended solids. This guarantees enhanced quality of the treated water, priming it for the later phases of the treatment process, including biological treatment or sophisticated methodologies.

It is essential to modify the dosages of coagulants and flocculants based on the particular composition of the wastewater and to oversee the process to guarantee the best efficacy of the treatment facility. The use of these chemicals must comply with environmental rules and should not generate undesirable by-products that compromise the quality of the treated water or adversely affect the environment.

Neutralization
Wastewater neutralization is a technique that entails modifying the pH of the water to an ideal level. This technique is crucial in wastewater treatment as many substances can influence the water's pH, and high values may be detrimental to the environment and aquatic life. Below are many prevalent techniques for wastewater neutralization:

Incorporating alkaline or acidic agents:
Alkaline chemicals, such as sodium hydroxide (caustic soda) or calcium carbonate, can be introduced to elevate the water's pH, therefore neutralizing acids.

Acidic compounds, such as sulfuric acid or hydrochloric acid, can be introduced to decrease the pH of water and neutralize bases.

- neutralizing reactors: specialized reactors in which alkaline or acidic substances are introduced based on the specific neutralizing needs.
- precipitation processes: Insoluble salts can be formed by adding chemicals to neutralize acidic or alkaline substances.
- Adsorption methods involve the utilization of adsorbent materials; certain adsorbents, such as limestone or calcium carbonate, can be employed to neutralize acids in water.

3.2.2.Biological Remediation
Biological wastewater treatment employs microorganisms to decompose and eliminate organic compounds from wastewater. Biological processes are very effective wastewater treatment systems crucial for mitigating pollutants and environmental impact.

The primary methods of biological wastewater treatment are as follows:
Oxidation ponds:
Aerobic oxidation ponds (lagoons): Wastewater is channeled into open ponds, where aerobic microorganisms decompose organic matter in aerobic conditions.
Anaerobic oxidation basins:
Analogous to the aerobic process, although occurring in the lack of oxygen. Utilized for the treatment of wastewater abundant in organic materials.
Biological Reactors: Active suspension reactors (SBR - Sequential Batch Reactors) utilize sequential cycles of filling, aeration, and settling within a single tank for the treatment of wastewater. Activated Jet Reactors (ASBR - Anaerobic Sequencing Batch Reactors): An anaerobic process wherein wastewater is sequentially filled and aerated.
Biodiscs or Biorotors: Employ revolving discs or rotor systems to enhance the interaction between wastewater and microorganisms involved in water treatment.
The biofilter facilitates the passage of wastewater through a medium containing a dense layer of adhering microorganisms that decompose organic contaminants.Aerobic Thin Layer Treatment (ASP - Activated Sludge Process): Wastewater is combined with aerated microorganisms, resulting in a mixture termed "activated pellets".Anaerobic Treatment (UASB - Upflow Anaerobic Sludge Blanket)

is an anaerobic technique wherein wastewater traverses a medium inhabited by anaerobic microorganisms that decompose organic matter.

Integrated Treatment Systems (Membrane Bioreactors - MBR)
The integration of biological processes with membrane filtration technologies for enhanced wastewater treatment.

Phytoremediation
The utilization of flora to enhance water quality via absorption and biofiltration mechanisms. Algal lagoonsThe utilization of lagoons for the cultivation of algae that aids in the water cleaning process.

Biological processes efficiently decompose organic matter into water and carbon dioxide, yet necessitate appropriate regulation and oversight to guarantee optimal efficacy. Biological wastewater treatment can be tailored to the characteristics of the effluent and local environmental regulations.

Sophisticated therapy:Membrane filtration
The application of membranes for the elimination of particles and bacteria. Membrane filtration of wastewater is a sophisticated water treatment process that use semi-permeable membranes to eliminate particles, chemicals, and microbes from water. This technique yields enhanced quality of treated water and is frequently employed in wastewater treatment systems.

The membrane filtration method operates as follows:
Categories of Membranes:

Microfiltration (MF): Employs membranes with comparatively wide pores to eliminate bigger particles, including bacteria and microbial cells.

Ultrafiltration (UF): Utilizes membranes with diminutive pores to eliminate tiny particles, including bacteria and viruses.

Reverse Osmosis (RO) employs membranes with minuscule pores to eliminate dissolved solutes, salts, and chemicals.

4. Reuse of purified water

To prepare wastewater for reuse in diverse applications, such as irrigation, industrial process water, or, in specific circumstances, potable water, several supplementary treatment techniques may be employed. These systems are designed to eliminate residual pollutants and guarantee water quality in accordance with the unique needs of each application. Below are supplementary treatment technologies for water reclamation:

Enhanced Filtration:
Membrane Filters: The application of membrane filters, including ultrafiltration and reverse osmosis, to eliminate tiny particles, germs, and chemicals from water.
Activated Carbon Filtration: To eliminate organic compounds, residual chlorine, and various chemical contaminants

Enhanced Therapy:
Adsorption: The application of adsorbent materials, such as zeolites, to eliminate contaminants, including heavy metals or organic compounds.
Precipitation: The introduction of chemicals to facilitate the precipitation and removal of undesirable substances from water.
Supplementary Disinfection: o The application of ultraviolet radiation to eliminate bacteria, viruses, and other pathogenic germs.
Ozone Disinfection: The utilization of ozone to eliminate bacteria and oxidize chemical substances in water.
Advanced Chlorination: The incorporation of chlorine or alternative chemicals for disinfection and to sustain an active residual inside the system.
Remineralization and pH Rebalancing: Addition of minerals to enhance water composition and restore mineral equilibrium.

pH Adjustment: To achieve an appropriate pH level based on the application requirements.
Supplementary Mechanical Separation and Filtration:
Fine Screening: To eliminate fine particles or residual suspended materials.
Rotary Drum Filtration: Utilized for the separation of solid particulates from water. Nutrient
Management: Nutrient Removal: Targeted processes designed to eliminate nitrogen and phosphate from water, hence mitigating eutrophication.

The deployment of these supplementary systems is contingent upon the original quality of the wastewater, any local or international legislation regarding water reuse, and the particular demands of the application. An effectively built and administered system may guarantee efficient and sustainable water reclamation.

4.1.Elimination of Heavy Metals

The extraction of heavy metals from wastewater and other pollution sources is crucial for safeguarding water quality and the environment. Numerous technologies and techniques exist for the remediation of heavy metals. Here are few examples:

Chemical precipitation involves the addition of metal salts, such as iron sulfate or aluminum chloride, to create precipitates with heavy metals, thereby facilitating their separation from water.
Ion exchangers: ion exchange resins are specialized resins that absorb heavy metals from water and release them in exchange for other ions, therefore eliminating them from the solution.
Membrane Filtration: Reverse Osmosis (RO): Employs a semi-permeable membrane to eliminate heavy metals and other contaminants from water.

Ultrafiltration (UF) and Microfiltration (MF) employ fine-pored membranes to capture particles, including heavy metals.

Adsorption: Activated carbon adsorption use activated carbon to extract heavy metals from water, therefore diminishing their concentration.

Biosorption: Utilizing microorganisms, such as bacteria or fungi, to adsorb heavy metals for water treatment purposes.

Electrocoagulation: Utilizing electrical currents. Utilizing electrical currents to generate coagulants in water that adhere to heavy metals and facilitate their precipitation for removal.

Phytoremediation: The utilization of specific plants, termed phytoremediators, which can absorb and sequester heavy metals from soil and water, offers an eco-friendly remediation method.
Specific biological treatments for heavy metals include the utilization of particular microbes; certain bacteria can precipitate heavy metals as sulfides or bind them in a less soluble form.

Adsorption onto iron hydroxide or aluminum hydroxide:Salts are added: iron or aluminum hydroxide is introduced to create insoluble hydroxides with heavy metals, facilitating their removal through sedimentation.

Solvent extraction: Utilization of organic solvents, which can remove heavy metals from water, resulting in the formation of complex compounds that are then separated.
It is essential to consider the characteristics of the heavy metals in wastewater and the environmental criteria while selecting and executing the suitable treatment system.

5.Drawbacks of employing traditional wastewater treatment techniques

While traditional water treatment systems are efficient and prevalent, they may possess certain drawbacks.
Here are few examples:

- Ineffectiveness against specific contaminantsTraditional approaches may be inadequate for eliminating specific pollutants, like persistent organic pollutants, volatile organic compounds, or heavy metals at elevated quantities.
- Generation of undesirable by-productsSpecific treatment methods, like chlorination, may produce undesirable by-products, including trihalomethanes, which can adversely affect human health and the environment.

- Substantial expenses on a grand scaleThe execution and continuous functioning of traditional treatment systems can incur substantial expenses, particularly regarding considerable infrastructure and the management of resultant by-products or trash.
- Elevated energy consumption. Certain operations, such reverse osmosis water treatment and UV sterilization, may necessitate substantial energy consumption, hence increasing operational expenses and environmental repercussions.
- Requirement for supplementary therapy. To comply with ever rigorous water quality regulations, supplementary or advanced treatment methods may be necessary, thereby elevating the cost and complexity of treatment systems.
- Risk of exceeding plant capacity. During periods of fast population increase or industrialization, traditional treatment facilities may attain full capacity, jeopardizing the quality of the treated water.
- Effects on aquatic ecology.Certain chemicals and by-products generated from treatment operations might adversely affect aquatic habitats and fish species.
- Requirement for waste management

Conclusions

Conventional operations might produce solid or liquid waste, necessitating proper management to mitigate environmental impact.It is crucial to evaluate these drawbacks within the particular context of each water treatment system and to investigate innovative methods and technologies to enhance the efficiency and sustainability of water purification operations.

Taking into account the quality indicators of wastewater released into local sewage systems and the existence of companies that utilize substantial water volumes, thereby discharging significant quantities, the article delineates the technologies employed to ensure that the characteristics of wastewater discharged into local sewage networks and directly into treatment facilities comply with the standards mandated by legislation (NORMATIVE NTPA 002/2002).

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