# An Overview on Wastewater Treatment Plant and its Control Strategies

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**Abstract: -** *Diverse substances have been collected in this larger group of micropollutants (MPs) as a result of the extensive research done on contaminants of emerging concern (CECs) over the past few decades. This is because these materials are not well controlled by water resource observing initiatives around the globe. Given that wastewater treatment plants (WWTPs) are thought to be the primary sources of microplastic contaminants in the underwater systems, it is absolutely important to have a full knowledge of how microplastics interact with the specific treatment techniques in WWTPs. In this academic paper, we discuss waste water treatment plant overviews and shed some light on wastewater treatment control strategies.*

**Keyword –** GHGs, WWTP, microplastics, micro-pollutants, control strategies

## I. Introduction

Pressure on wastewater handling facilities has risen dramatically as a result of the global modernization and growing populations. The vulnerability of the wastewater industry has also resulted in an increase in the global warming potential (GWP) due to greenhouse gas emissions, that elevates questions about the sustainability of this industry's growth. Additionally, the rapid rise in wastewater volume is going to cause a substantial release of Greenhouse gases from wastewater handling structures in addition to the procedure of wastewater treatment systems (WWTS). The development and operation of wastewater and/or sludge treatment units, obtaining or reusable water networks, etc., are some of the phases of wastewater handling frameworks that have drawn the attention of scientists from all over the world in terms of GHG emission [1].
Microplastics are produced from a variety land-based sources, just like all other anthropogenic contaminants, as well as they end up in wastewater treatment facilities that are thought to be the link among pollutants as well as the environment. In broad sense, manufactured microplastics are categorized as primary microplastics, whilst secondary microplastics are made from a distinct kind of physical, chemical, or biological deterioration [2].

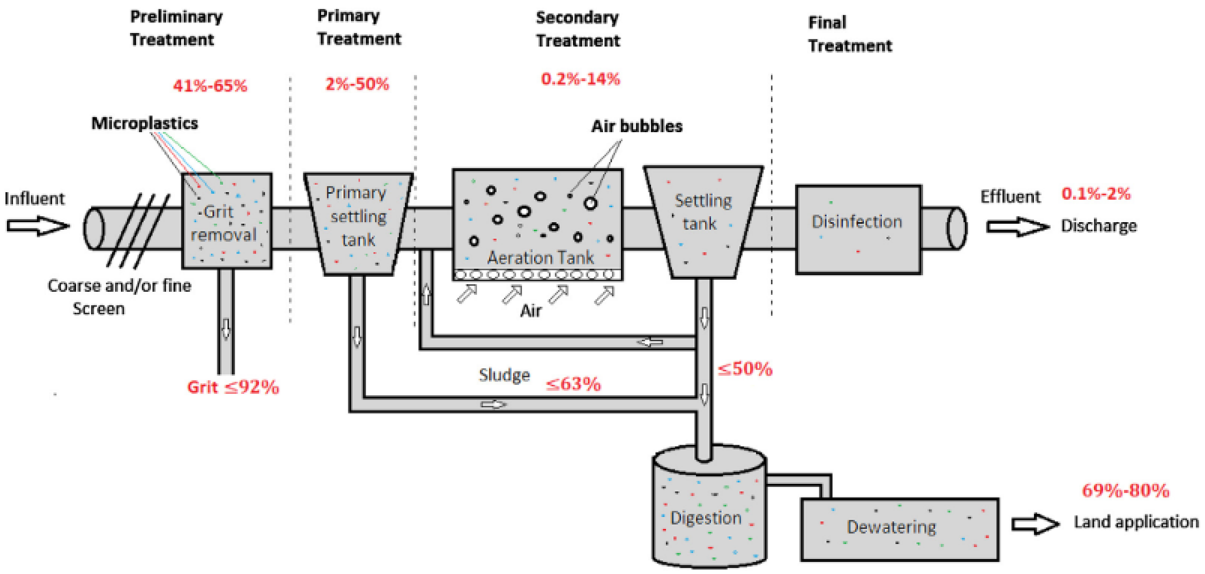


**Figure 1 General representation of a wastewater treatment plant**

The four phases of a general wastewater treatment procedure, shown in Fig. 1, are the preliminary, primary, secondary, as well as tertiary treatment. Inside the coarse screen, grit chambers, as well as sedimentation tanks of the preliminary and primary treatment, coarse particles like rocks, wood, and sand are eliminated. The organic matter massive amount in wastewater is eliminated in the subsequent stage by activated sludge procedures carried out in an aeration tank and a secondary sedimentation tank. Chlorine, ozone, and UV light are employed in the tertiary treatment to carry out the

disinfection process. After thickening, stabilizing, as well as dewatering, wastewater treatment culminates in the manufacturing of sludge, which would be typically recycled or dumped into water or onto land.
According to research findings, traditional treatment facilities do not totally eliminate plastics from sewage, as well as large amounts of MPs are released every day through the last treated effluents as well as sludge goods [3].

## II. CONTROL STRATEGIES IN COAGULANT DOSING

The implementation of the right quantity of chemicals is necessary in the coagulation procedure being used treat drinking water when the quality of the raw water frequently changes due to rain, agricultural activities, industrial waste discharge, etc. For procedures with significant inertia and dead times, such as DWT, the proportion dosing technique is appropriate. It entails dosing the coagulant into the raw water in a way that ensures the dosage rate, or the quantity of chemical needed for every cubic meter of raw water at a specific turbidity level, stays constant at all times. The proportional dosing system continuously modifies its flowrate to match the quantity and quality of the available raw water. [4].
Despite the current specified requirements for drinking water, the control strategy should be effective in preventing under- or over-dosing of coagulation chemicals and comply with regulations. An efficient control strategy must be used to address these identified operational challenges in order to get the plant's operations to respond as needed while incurring the fewest costs. Numerous studies have been done and can be broadly categorized as feedforward, feedback, and feedforward-feedback control strategies in the literary works. These are shown below:

A. FEEDFORWARD CONTROL STRATEGY

In a two-step process known as feedforward (FF) control, which is also known as predictive control, the load disturbance is measured as well as a control action is taken before it has an impact on the output. This method calculates the control action, u by combining the set point, r, and quantity of disturbance, d, as shown in figure 2 below.

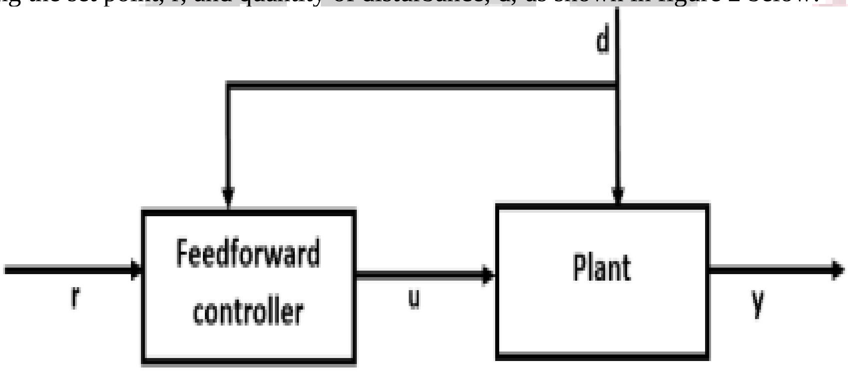


**Figure 2 Feedforward control strategy [4]**

B. FEEDBACK CONTROL STRATEGY

When using a feedback controller, the impact of disturbance (sudden changes) is not quickly neutralized; in other words, the control action, u, begins right away for changes in set points, e, but not for changes in disturbance, as depicted in figure 3 below. The corrective action won't be taken in time in the event of abrupt turbidity changes because the controller won't be capable of handling that until the controlled variable deviates. Simply because the process variable is governed by the addition of particular chemicals as well as a reaction time is permitted before the process variable can be sampled, water treatment procedures experience relatively lengthy transport delays. Therefore, allowing enough space between the chemical dosing as well as sampling points is becoming a necessity for layout, and the time delay is then dependent on both the water flow inside this space and the flow in the sample line [4]. Due to this procedure dead time, it is challenging to control water treatment plants utilizing traditional feedback methodologies since this control action requires some time to impact the controlled variable, and the control action that is implemented relying on the actual error attempts to fix a problem that started earlier in the procedure.

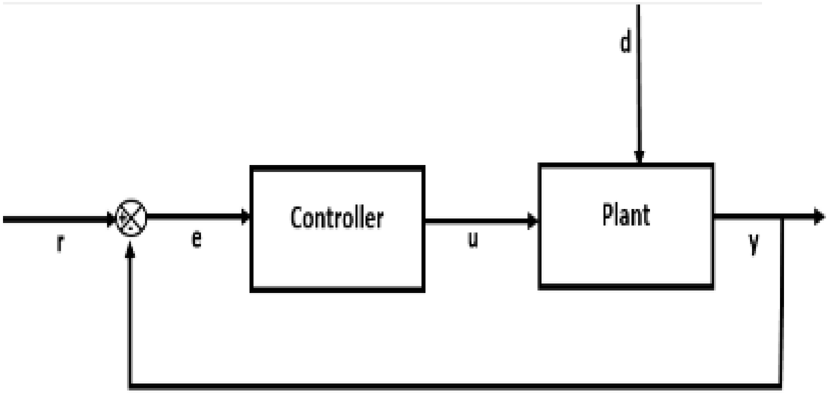


**Figure 3 Feedback control strategy [4]**

C. FEEDFORWARD-FEEDBACK CONTROL

The addition of a feedforward and including feedback aids in making up for modeling errors. A depiction of this plan is shown in Figure 4. To enable set point tracking, the feedback trim aids in the rejection of all other unquantified disturbances impacting the plant's operation as well as portions of the evaluated disturbance that pass through the feedforward element.

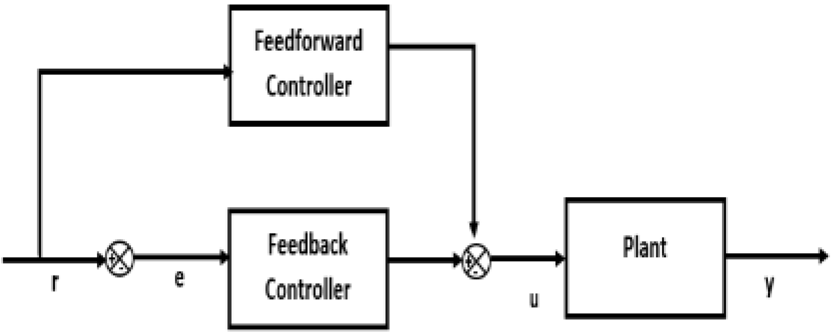


**Figure 4 Feedforward-feedback control [4]**

Because of the various types of microplastics found in the wastewater, traditional activated sludge processes' rates of microplastics removal varied greatly [5]. The study of microplastics/nanoplastics mitigation strategies in decentralized wastewater treatment procedures is still in its early stages, and the effects of operational conditions on their removal efficiencies have rarely been studied.

Physiochemical ammonium diagnosis techniques, including ion exchange, activated carbon, adsorption, chemical precipitation, air stripping, membrane filtration, break-point chlorination, as well as electrochemical methodology, are frequently employed in the water sector [6]. Although there are other treatments like biological methods, they are primarily employed in advanced countries. The perception that the latter treatment's use and the inclusion of microorganisms in the treatment had an impact on its effectiveness led to caution, particularly in the drinking water treatment industry. In biological treatment, bacteria are used to speed up the oxidation process that breaks down ammonia [7]. It doesn't produce any byproducts and doesn't need any additional processing. As a result, this operation is less expensive than physicochemical treatment.

## III. RELATED WORK

The main successes and drawbacks of using solar photocatalytic processes to remove antibiotic-resistant organisms (ARO) and antibiotic resistance genes (ARGs) from municipal wastewater treatment plant effluent (MWWTPE). The choice of solar photocatalytic processes was made with developing tropical nations in mind. ARB has been successfully removed from MWWTPE using one of these processes, solar photo-Fenton, at neutral pH in bench and pilot scales as well as under continuous stream. ARG removal, however, varies depending on the gene. For this reason, irradiation intensity and matrix composition are crucial factors in treatment effectiveness. For the removal of ARB and ARG, the use of sulfate radical in customized solar photo-Fenton is still in its infancy. Additional research must be done on the ARB resistance profile as well as horizontal gene transfer rates following solar photo-Fenton diagnosis. $TiO_2$ as well as $TiO_2$-composites tried to apply in suspension are the most frequently researched materials for the reduction of ARB as well as ARGs in solar heterogeneous photo catalysis. Treatment effectiveness is influenced by catalyst dosage, temperature, as well as irradiation intensity [8].

A review of the literature's references on the topic of disinfection and the simultaneous elimination of contaminants of emerging concern (CECs) in domestic wastewater matrices is provided in [9]. Since the withdrawal of CECs has garnered the majority of focus in the last ten years, these two responses are typically assessed separately. However, with the focus recently shifting to the removal of antibiotics and antibiotic-resistant bacteria, the simultaneous removal of CECs and pathogens from wastewater has come into focus. The creation of a bibliometric portfolio and systemic analysis were combined with peer-reviewed documents accepted for publication between 2008 and 2019 in five different databases in an effort to create a reproducible and impartial methodology. According to strict criteria, numerous keyword mixtures were required to produce a relevant portfolio.

The goal of task scheduling is to improve a system's efficiency by minimizing downtime, evenly loading machines, or increasing machine throughput. Additionally, employing the right scheduling algorithms frequently results in a decrease in the process's energy costs. Various industrial sectors experience task scheduling issues, and the severity of these issues varies greatly depending on the issue. The extent to which task scheduling techniques are used in business is demonstrated in [10]. The methods and algorithms for resolving task scheduling issues are presented in this paper. Additionally, it was examined whether task scheduling techniques could boost the effectiveness of biological wastewater treatment facilities. This strategy is predicated on the idea that multiple reactors will have a balanced workload.

Microplastics found in wastewater treatment plants can be sampled, prepared for analysis, and identified using methods described in [2]. There are significant environmental and ecological concerns as a result of the presence and deposition of microplastics in the environment. There are additional dangers that must be addressed due to wastewater treatment facilities' contribution to the spread of microplastics in the environment. The ability to detect microplastics at each stage of the treatment process and understanding their fate and occurrence in the wastewater treatment plant continue to be the main challenges. Thus, this review contributes to our understanding of the occurrence and fate of microplastics in wastewater treatment facilities. Additionally, it is structured to provide an overview of the methods for detecting microplastics, from sampling to identification.

The most cost-effective method is biological treatment because it only uses basic materials, uses no chemicals, and produces no harmful byproducts that would raise the cost of further treatment. Additionally, biological treatment is capable of producing highly treated drinking water that complies with industry standards. The purpose of [6] is to provide a summary of the use of biological treatment as a substitute treatment method for ammonia removal in water and wastewater treatment facilities. This overview discusses the comprehensive approach to biological treatment used in water and wastewater treatment facilities, the sources of ammonia pollution, the recommended maximum ammonia concentration to prevent hazards, reported incidents, and the most recent global ammonia pollution status. This overview also covers the use of artificial intelligence for model prediction and control techniques for water treatment..

The health as well as safety of people have been seriously threatened by the aerosols carrying viruses and microorganisms that have been released into the air from the wastewater system. Because of the numerous sources of aerosols and diverse germs and microorganisms, the wastewater systems, including toilets and wastewater treatment plants (WWTP), are the main sites of epidemic infectious diseases. The primary source of bioaerosols scattered in the air of the wastewater system is due to viruses and microorganisms that can travel from hospital and toilets into municipal pipes and then into the wastewater treatment plant. The generation, transmission, and diffusion of bioaerosols at toilet as well as WWTP were described in detail in [11].

Bioaerosols affiliated with wastewater treatment plants (WWTPs) have become one of the most important environmental indicators, safeguarding the health and well-being of societies and cities. This overview summarizes the different wastewater treatment techniques that have been investigated with a concentrate on bioaerosol emissions, potential emission stages, available sampling strategies, survival and dispersion factors, dominant microbial species in bioaerosols, and potential control methods in [12].

Ecosystems in both the water and on land are in danger from the release of microplastics into the environment. The threat to human health is also posed by their encroachment into the food chain. Wastewater treatment facilities can be thought of as the final line of defense against microplastics entering the environment. [15] review focuses on how waste treatment facilities affect the retention of microplastics. Wastewater treatment facilities themselves are viewed as point sources for the discharge of microplastics into the aquatic environment because studies show that no wastewater treatment method results in a complete retention of microplastics. The review also discusses issues with using sewage sludge that has been loaded with microplastics.

In-depth information more about structure as well as life cycle of MPs in both landfills and WWTPs is summarized in this review. Researchers also go over innovations that could be used in landfill leachate treatment facilities or WWTPs to collect MPs and possibly upcycle the polymers into products with added value. [16] also look at how difficult it will be to implement various technologies given current infrastructure and practices. Eventually, we point out the areas that require more research in order to develop comprehensive solutions to the persistent problem of plastic waste in waterways.

In order to identify cutting-edge technologies to remove microplastics from the water stream, this review is concentrated on comprehending the evolution as well as fate of microplastics throughout wastewater treatment processes. Bioremediation has been singled out as one of these, but it is still difficult to contain microorganisms inside the WWTP. Review of the potential for MP bioremediation in higher aquatic eukaryotes, which have low dispersion rates and are simple to contain[17] . Eco-ethical and biological concerns are taken into account when looking at animals, seagrasses, and macrophytes. The difficulties of necessary research have been noted.

In this article, sampling, sample pretreatment, as well as MP classification strategies for WWTPs and sewage sludge are reviewed. The effectiveness of WWTPs in removing microplastic particles will also be discussed, as well as their fate and repercussions as a source of toxic chemicals. Sewage sludge often contains the majority of the microplastics removed during wastewater treatment. As a result, implementations of sewage sludge release billions of MPs into the environment every year. [18] examines the removal and discharge of microplastics from WWTPs while taking into account their characteristics, methods of treatment, and interactions with other pollutants.

The purpose of this review is to summarize what is currently known about the effects and fate of nano- as well as microplastics in water and wastewater treatment facilities. The connections of nano/microplastics with water and wastewater treatment plant processes are related to their formation and fragmentation mechanisms, physical-chemical properties, and occurrence in water. Potential solutions to constrain these interactions are thoroughly reviewed. In order to maintain the required standards for water quality and lessen the risks to our ecosystems, this critical analysis proposes new methods for limiting the amount of nano/microplastics in water and wastewater.

With a focus on denitrification, this review article critically assesses the knowledge that has been acquired in the field over the past ten years, particularly in the microbiology, biochemistry, models, and mitigation techniques related to N2O production [18]. The understanding of the N2O generation mechanism has greatly advanced through previous research, but more work is still required because there is no standardized methodology for implementing N2O mitigation strategies in large-scale systems. This review suggests that one of the key opportunities to reduce N2O production is to transform the denitrification procedure from a net source of N2O into an efficient sink.

This review makes an effort to provide a general overview of the difficulties in using mainstream deammonification and to talk about the effects of unfavorable circumstances on key functional species. Additionally, a few cutting-edge control methods to keep desired species in their dominant positions were outlined. Researchers also looked at effective ways to resolve the conflict between NOB (Nitrite oxidizing bacteria) wash out and AnAOB (Anaerobic Ammonium-oxidizing Bacteria) biomass retention [19]. Finally, based on the metabolic diversity of AnAOB, researchers proposed additional research involving efficient improved methods that achieve combination of autotrophy and organotrophy species.

This paper examines OWT innovations that commonly use compact, mechanisation elements and reliant on preanoxic, postanoxic, or simultaneous nitrification-denitrification denitrification. The small footprint (required land area) of these small - scale applications, even so, presents significant opportunities for retrofitting OWTs on compact lots, in shoreline developments where land is at a premium, and where communities wish to foster as well as maintain compact, village advancements that reflect " smart growth" strategies [20]. These various techniques need more research and development, but they may provide an improvement over mechanized OWTs. To further quantify performance capabilities, more comparative studies of long-term operation of OWTs under field conditions in other parts of the world are required.

The benchmark model and LCA are both used in this study of a WWTP to determine the best possible treatment plan. LCA augments the existing criteria offered by such models by adding new criteria. For plant-wide models, including environmental evaluation, predicated on LCA, it is suggested as a complement to the cost/performance criteria, which offers a more comprehensive evaluation of WWTPs. It can record potential environmental effects as well as dynamic effects. An summary of the integration of plant-wide models and LCA is provided in this study [21].

## IV. Conclusion

The sudden growth in wastewater volume is also having an impact on the release of Greenhouse gases in the atmosphere from wastewater handling infrastructure facilities, in addition to the procedure of wastewater treatment systems (WWTS). In this paper, we discussed an overview of wastewater treatment facilities and shed light on various wastewater treatment control strategies, including feedforward, feed-backward, and forward-backward control strategies.

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