Streamlining Metaldehyde Removal from Wastewater: A Mini Review

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ABSTRACT

This mini review examines current methods and technology for effectively removing metaldehyde from wastewater, addressing its persistence and environmental effects. Adsorption advancements are evaluated for efficacy, cost-effectiveness, and environmental sustainability in this article. This analysis synthesizes recent research to optimize metaldehyde removal techniques and provides a comprehensive summary of viable wastewater treatment and environmental protection methods.

Keywords: Metaldehyde, wastewater treatment, adsorption, coagulation-flocculation biodegradation.

1. INTRODUCTION

Metaldehyde is a potent molluscicide and an active element in slug pellets used to protect crops, especially paddy. Its high solubility and low molecular weight make it highly mobile in the environment [1]. Metaldehyde primarily enters water sources as a diffuse contamination from agricultural areas [2]. However, metaldehyde in wastewater harms the ecosystem and must be removed. Metaldehyde pollutes water and causes drinking water compliance issues.

Metaldehyde is currently removed from wastewater by adsorption, biodegradation, improved oxidation techniques, and the use of nanoparticle catalysts [3]. However, these current techniques have limitations. To provide a detailed overview of efficient wastewater metaldehyde removal technologies, this study compared the removal methods, assessed their drawbacks, and discussed the most sustainable method. Using existing knowledge, this review intends to develop more sustainable and effective metaldehyde removal technologies from wastewater.

2. OVERVIEW OF METALDEHYDE CONTAMINATION IN WASTEWATER

Metaldehyde contamination in wastewater is significant because it may harm water quality and ecosystems. It can enter wastewater systems from agricultural runoff and domestic use. It is a persistent, mobile, and toxic (PMT) molecule due to its long-term environmental presence and ability to harm species [4].

Metaldehyde has been linked to animal poisonings and deaths, particularly in dogs [5]. Also explored were the effects of metaldehyde on non-target aquatic macroinvertebrates [6]. It has been demonstrated that metaldehyde reduces the survivability of macroinvertebrates through a combination of field and laboratory research. A previous study investigated the developmental toxicity of metaldehyde on Lymnaea stagnalis embryos [7]. It demonstrates that the non-targeted pond snails exposed to metaldehyde experience decreased hatching success and embryo growth.

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3. METALDEHYDE REMOVAL FROM WASTEWATER

Several effective methods can be used to remove metaldehyde from wastewater. Adsorption, coagulation-flocculation, and biological degradation through specific microorganisms or treatment systems are some viable options. Photocalysis, membrane treatment and Advanced oxidation processes (AOP) can also break down metaldehyde into less harmful substances.

3.1 Adsorption

Adsorption is a method of removing pollutants from wastewater using an adsorbent material. Adsorption of metaldehyde from wastewater is a promising way to reduce its content in water. A solid surface like activated carbon or biochar binds metaldehyde molecules, removing them from water [8]. Powdered activated carbon (PAC) has been proven to adsorb metaldehyde from water [9]. PAC adsorbs organic molecules like metaldehyde well due to its high surface area and abundance adsorption sites.

Adsorption is effective in removing a broad spectrum of pollutants, can be used with other treatment methods to maximize pollutant removal, and is the most cost-effective way for wastewater treatment, according to prior research [10]. However, saturation of the adsorbent may ensue, resulting in a decline in efficiency and it can be challenging to dispose the used adsorbent [11].

3.2 Coagulation-Flocculation

Coagulation-flocculation is a popular process for removing pollutants from wastewater, including metaldehyde. This technique involves the addition of coagulants and flocculants to destabilize and aggregate particles, enabling their removal via sedimentation or filtration. A study examines the use of coagulation and flocculation in the treatment of water and wastewater [12]. It emphasizes the significance of choosing coagulants and flocculants based on the features of the pollutants.

It has been shown that coagulation and flocculation can remove a lot of different pollutants [13]. This method is flexible and can be used with different kinds of wastewater [14]. Scientists have investigated using natural coagulants, like tannin and a coagulant made from Cassia fistula seeds. These are better for the environment than other coagulants [15]. However, chemical coagulants and flocculants are often added to the process, which can affect health and the environment. Coagulation-flocculation processes can make sludge, which needs to be treated and thrown away again, which makes the whole wastewater treatment process more complicated [16]. Using chemical coagulants and flocculants and managing the sludge that is produced can add to the overall costs of operating wastewater treatment plants [17].

3.3 Biodegradation

Biodegradation is a method of removing pollutants from wastewater using microorganisms. Previous studies on the engineering of biological metaldehyde removal have shown that some operational biofilters can get rid of metaldehyde through biodegradation and sorption processes [3].

Without the addition of chemicals, biodegradation occurs naturally [18]. Biodegradation is a viable approach that can be employed in conjunction with other treatment modalities to augment the efficacy of pollutant removal. Moreover, it boasts the capability to efficiently treat wastewater while being economically viable [18]. Unfortunately, biodegradation may generate environmentally hazardous byproducts, proceed at a sluggish rate, and fail to eliminate specific contaminants entirely.

3.4 Photocatalysis

Photocatalysis is a method of removing pollutants from wastewater using light and a photocatalyst. Utilizing photocatalysis is one method for eliminating metaldehyde from wastewater. In photocatalysis, a catalyst and light energy are utilized to initiate chemical reactions that destroy contaminants. Titanium dioxide (TiO_2) is often employed as the catalyst for metaldehyde. TiO_2 forms reactive oxygen species when exposed to ultraviolet (UV) radiation, which can oxidize and destroy metaldehyde molecules [19].

Previous research has established that photocatalysis, an environmentally friendly process that does not necessitate chemical additions, is capable to efficiently eliminating a diverse array of contaminants. By combining photocatalysis with additional treatment techniques, it is possible to augment the elimination of contaminants [20]. However, the process may be difficult to scale up, and the use of photocatalysis may generate environmentally hazardous byproducts.

3.5 Membrane Treatment

In recent years, membrane technologies have gained popularity for the treatment of wastewater due to their efficacy in eliminating contaminants [21]. Membrane treatment is a method of removing pollutants from wastewater using a membrane. A study proposes that nanofiltration membranes can be utilized for the removal of metaldehyde from wastewater [22].

In addition to being effective for the removal of a broad spectrum of contaminants, membrane treatment can be utilized in conjunction with other treatment techniques to improve the removal of contaminants [23]. However, membrane fouling may transpire, resulting in escalated operational expenses and diminished efficiency. Additionally, membrane treatment can generate waste streams that necessitate additional treatment, which can be energy-intensive.

3.6 Advanced Oxidation Processes

Advanced oxidation processes (AOPs) are a method of removing pollutants from wastewater using chemical reactions that produce highly reactive species such as hydroxyl radicals. AOPs generate extremely reactive hydroxyl radicals to oxidize and destroy organic pollutants. A study investigated the degradation of paracetamol utilizing AOPs such as electro-peroxone, ozone, goethite-catalyzed electro-Fenton, and electro-oxidation [24]. While the focus of the work was on paracetamol, it illustrates the potential for AOPs to degrade organic molecules in wastewater, including metaldehyde.

The efficacy of AOPs in eliminating a diverse array of contaminants is considerable. By combining AOPs with additional treatment techniques, the removal of contaminants can be enhanced [25]. Unfortunately, AOPs may consume a great deal of energy, high cost of operating and generate potentially hazardous byproducts.

4. ENHANCED ADSORPTION FOR METALDEHYDE REMOVAL

Adsorption is a good way to get rid of metaldehyde from wastewater because it is flexible, cheap, easy, and works with a lot of different adsorbent materials. Adsorption has drawbacks such as adsorbent saturation and spent carbon disposal. One method removes metaldehyde during regeneration using a novel combined adsorption and electrochemical destruction technique [26]. This is a significant advantage over adsorption-only procedures, which require the disposal of used adsorbent material, which is typically done in landfills.

An alternative approach entails employing a hybrid system comprising adsorption and biosorption [1]. This strategy may yield more metaldehyde sorption onto the biosorbents. In addition, biological activated carbon (BAC) and other alternative adsorbents have demonstrated efficacy in the removal of metaldehyde. For water treatment facilities, BAC filtration could be a viable alternative. Adjusting variables including pH, contact time, and the initial concentration of metaldehyde solution might ultimately increase the efficiency of the adsorption procedure.

5. CONCLUSION

This mini review underlines the need for sustainable metaldehyde pollution control in wastewater. Modern technology and methods could lessen metaldehyde's environmental impact, but most methods were too difficult to deploy widely. Metaldehyde removal from wastewater is promising with a combination of adsorption and other methods such as electrochemical destruction technique and biosorption. Further research and development in this integrated approach hold the key to advancing sustainable and effective solutions for the removal of metaldehyde, contributing to the protection of water ecosystems.

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