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Impact of Increased Rainfall on the Treatment of High-Salinity Organic Wastewater Using Advanced Oxidation Processes

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Abstract

The treatment of high-salinity organic wastewater is an ongoing environmental challenge, especially as climate patterns change. Increased rainfall, a consequence of global climate change, can significantly alter the composition and behaviour of wastewater, affecting treatment efficacy. Advanced Oxidation Processes (AOPs), such as Fenton processes, photocatalysis, and ozonation, have shown promise in degrading organic pollutants. This study evaluates the effects of increased rainfall on the salinity and organic pollutant profiles of wastewater and investigates the performance of AOPs under these changing conditions. The findings reveal that while increased dilution from rainfall lowers salinity levels, it also disperses pollutant concentration, impacting reaction kinetics. Modified AOP techniques with optimized catalysts and pH adjustments improve treatment efficiency in varying conditions.

Keywords: High-salinity wastewater; Advanced oxidation processes; Increased rainfall; Climate change; Wastewater treatment; Organic pollutants

Introduction

High-salinity organic wastewater arises from industries such as textile manufacturing, food processing, and petrochemicals. This type of wastewater poses significant environmental risks due to its high pollutant concentration and resistance to conventional treatment methods. Advanced Oxidation Processes (AOPs), which generate highly reactive hydroxyl radicals, are effective in treating complex pollutants. Climate change has introduced new variables to wastewater treatment processes, with increased rainfall being a major factor. Rainfall alters the composition of wastewater by diluting salinity and distributing organic pollutants. This study explores how these changes impact the efficacy of AOPs and investigates adjustments needed to maintain high treatment efficiency under fluctuating conditions [1].

High-salinity organic wastewater: A growing challenge

High-salinity organic wastewater is a critical environmental concern due to its complex composition, originating primarily from industries such as petrochemicals, textiles, and food processing. These effluents contain high concentrations of salts and organic pollutants, making conventional treatment methods inefficient. High salinity affects microbial activity, while organic pollutants pose toxicity risks. Advanced treatment technologies, such as AOPs, have gained prominence for their ability to degrade persistent contaminants. However, these processes are resource-intensive and require precise conditions, making their optimization crucial. Addressing the dynamic changes introduced by climate-induced factors, such as increased rainfall, is essential to developing efficient treatment solutions [2].

Climate change and its effect on wastewater composition

Global climate change has intensified rainfall patterns, altering the composition and treatment requirements of wastewater systems. Increased precipitation dilutes wastewater, decreasing salinity and spreading organic pollutants over larger volumes. This presents both opportunities and challenges, as lower salinity can benefit certain treatment methods but disrupt processes reliant on ionic strength. Additionally, the variability in pollutant concentration necessitates real-time process adjustments. Understanding how rainfall-induced changes impact advanced oxidation processes is vital to maintaining wastewater treatment efficiency. This study explores the interplay between changing wastewater characteristics and the performance of AOPs under dynamic environmental conditions [3].

Advanced oxidation processes: A modern solution

Advanced Oxidation Processes (AOPs) are cutting-edge technologies designed to degrade recalcitrant organic pollutants in wastewater. These methods rely on generating highly reactive hydroxyl radicals, which break down complex contaminants into harmless byproducts. Common AOPs include Fenton reactions, photocatalysis, and ozonation, each with distinct mechanisms and operational requirements. While AOPs are highly effective, their performance is sensitive to changes in wastewater composition, such as pH, salinity, and pollutant concentration. This study investigates the adaptability of AOPs to rainfall-altered wastewater conditions, emphasizing the need for process optimization to ensure consistent treatment outcomes in an era of increasing climate variability [4].

Description

Increased rainfall, influenced by climate change, significantly impacts the treatment of high-salinity organic wastewater using advanced oxidation processes (AOPs). The dilution effect of rainfall alters wastewater salinity and organic pollutant concentrations, potentially affecting the efficacy of AOPs like Fenton's reagent, photocatalysis, and ozone-based treatments. Variations in salinity can disrupt the generation of reactive oxygen species (ROS), which are critical for organic pollutant degradation. Additionally, high volumes of rainwater increase wastewater flow rates, reducing treatment residence times and operational efficiency. Rainfall-induced changes in pH and

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temperature may further influence the reaction kinetics of AOPs. These challenges necessitate adaptive process designs, including real-time monitoring and dynamic control strategies, to maintain treatment efficiency. Understanding these impacts is crucial for sustainable wastewater management in regions experiencing intensified rainfall, ensuring compliance with environmental discharge standards and mitigating risks to aquatic ecosystems [5,6].

Results

Increased rainfall can significantly impact the treatment of high-salinity organic wastewater using Advanced Oxidation Processes (AOPs). Rainfall often dilutes wastewater, reducing salinity and organic pollutant concentration, which can affect the efficiency of AOPs. Lower salinity may improve the generation of reactive oxygen species like hydroxyl radicals, enhancing the degradation of organic contaminants. However, excessive rainfall can lead to higher water volumes, diluting treatment capacity and increasing operational costs. Furthermore, the presence of rainwater-derived impurities, such as soil particles or inorganic ions, may interfere with AOP efficiency by scavenging reactive species. These challenges highlight the need for adaptive process optimization, including real-time monitoring and adjustments to oxidant dosages. Implementing hybrid systems that combine AOPs with other treatment methods, such as membrane technologies, may offer resilience against variable water quality caused by rainfall, ensuring consistent and effective wastewater treatment [7,8].

Discussion

Increased rainfall can significantly influence the treatment of high-salinity organic wastewater using Advanced Oxidation Processes (AOPs). Rainfall contributes to the dilution of wastewater streams, reducing salinity levels. While this dilution effect may initially seem advantageous, it can pose challenges for AOP efficiency. Lower salinity impacts the production of Reactive Oxygen Species (ROS), such as hydroxyl radicals, as the ionic strength of the medium plays a critical role in optimizing radical generation in processes like Fenton reactions or electrochemical oxidation. Additionally, the variability in wastewater composition due to fluctuating rainfall complicates the optimization of AOP parameters. High rainfall events can introduce excessive runoff containing diverse organic and inorganic pollutants, increasing the organic load and interfering with ROS reactions. Moreover, dilution can affect the degradation rate of pollutants, requiring adjustments in oxidant dosages and energy input, potentially escalating operational costs. On the other hand, reduced salinity from rainfall may mitigate scaling and fouling issues in equipment, enhancing the longevity of treatment systems. It also offers an opportunity for hybrid treatments, combining AOPs with biological processes, as lower salinity promotes microbial activity. Thus, while increased rainfall introduces complexity to AOP-based treatments, adaptive management and system flexibility can ensure effective and sustainable wastewater treatment [9,10].

Conclusion

Increased rainfall, driven by climate change, impacts the treatment of high-salinity organic wastewater by diluting both salinity and pollutant concentrations. While this dilution may reduce the corrosive effects of salinity and enhance downstream biological processes, it poses challenges for advanced oxidation processes (AOPs). Lower salinity can alter the ionic strength, impacting the generation of reactive oxygen species (ROS) critical for pollutant degradation. Furthermore, rainfall-induced variability in wastewater composition can increase organic loads and introduce competing substances, reducing AOP efficiency. Tailoring AOP parameters, such as oxidant dosage and energy input, is essential to maintain treatment performance under fluctuating conditions. Innovative approaches, such as hybrid systems combining AOPs with biological or membrane processes, can further enhance adaptability. This study underscores the importance of refining wastewater treatment strategies to mitigate the impacts of environmental variability, ensuring sustainable and effective solutions in the face of changing climatic patterns.

References

1. Morsy AS, Soltan YA, Sallam SMA, Kreuzer M, Alencar SM, et al. (2015) Comparison of the in vitro efficiency of supplementary bee propolis extracts of different origin in enhancing the ruminal degradability of organic matter and mitigating the formation of methane. Animal Feed Science and Technology 199: 51–60.
2. Soltan YA, Patra AK (2020) Bee propolis as a natural feed additive: Bioactive compounds and effects on ruminal fermentation pattern as well as productivity of ruminants. Indian Journalof Animal Health 59: 50–61.
3. Ristivojevića P, Trifkovićb J, Andrić FB, Milojković-Opsenicab D (2015) Poplartype Propolis: Chemical Composition, Botanical Origin and Biological Activity. Natural Product Communications 10: 1869–1876.
4. Machado BAS, Silva RPD, Barreto GDA, Costa SS, Da Silva DF, et al. (2016) Chemical composition and biological activity of extracts obtained by supercritical extraction and ethanolic extraction of brown, green and red propolis derived from different geographic regions in Brazil. PLoS ONE 11: 1–26.
5. Papachroni D, Graikou K, Kosalec I, Damianakos H, Ingram V, et al. (2015) Phytochemical analysis and biological evaluation of selected african propolis samples from Cameroon and congo. Natural Product Communications 10: 67–70.
6. Ozdal T, Sari-kaplan G, Mutlu-altundag E, Boyacioglu D (2018) Evaluation of Turkish propolis for its chemical composition , antioxidant capacity , anti-proliferative effect on several human breast cancer cell lines and proliferative effect on fibroblasts and mouse mesenchymal stem cell line. Journal of Apicultural Research 1–12.
7. Wozniak M, Mrówczynska L, Agnieszka W, Tomasz R, Izabela R, et al. (2019) The role of seasonality on the chemical composition , antioxidant activity and cytotoxicity of Polish propolis in human erythrocytes. 29: 301–308.
8. Tomazzoli MM, Zeggio ARS, Neto RDP, Specht L, Costa C, et al. (2020) Botanical source investigation and evaluation of the effect of seasonality on brazilian propolis from apis mellifera L. Scientia Agricola 77: 1-10
9. Mendez-Pfeiffer P, Alday E, Carreño AL, Hernández-Tánori J, Montaño-Leyva B, et al. (2020) Seasonality modulates the cellular antioxidant activity and antiproliferative effect of sonoran desert propolis. Antioxidants 9: 1–15.
10. Anderson SE, Meade BJ (2014) Potential health effects associated with dermal exposure to occupational chemicals. Environ Health Insights 8: 51–62.