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Optimizing Wastewater Recycling in the Textile Industry via Catalytic Ozonation and Volcanic Stone Catalyst

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Abstract

The textile industry significantly contributes to water pollution, with vast amounts of wastewater generated annually. This review explores the potential of optimizing wastewater recycling in this industry using catalytic ozonation and volcanic stone catalysts. We explored this innovative so-lution's recent advances benefits, and limitations through a comprehensive literature study. Our methodology involved a systematic approach, selecting the most pertinent articles from the last five years that focus on catalytic ozonation's application to wastewater treatment in textiles and the advantages of using volcanic stone as a catalyst. Our findings indicate that catalytic ozonation considerably improves the breakdown of textile dyes and pollutants, with volcanic stone catalysts amplifying its effectiveness due to their unique physical and chemical properties. The combination of these methods not only offers a sustainable avenue for wastewater treatment but also promotes resource conservation. However, challenges persist particularly in scaling up and commercial-izing these technologies. In conclusion while catalytic ozonation with volcanic stone catalysts promises a brighter future for wastewater recycling in the textile industry, continued research and development are essential to realize its full potential.

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Introduction

The textile industry is a predominant contributor to global industrial wastewater (Böhm, Io-nescu, & Ionescu, 2022). The vast production of fabrics necessitates the release of significant volumes of wastewater laden with harmful dyes, chemicals, and other contaminants. This wastewater, when discharged untreated, poses profound risks not only to aquatic ecosystems but also to human health (Nooryaneti, Irawan, & Tuhuloula, 2022). Typical characteristics of wastewater from the textile industry are its high chemical oxygen demand (COD), intense coloration, and the presence of various toxic chemicals (Akuma, Hundie, & Bullo, 2022).

Traditional wastewater treatment methods have shown limitations in their efficacy, leading to an urgent need to explore innovative and efficient treatment technologies (Heredia-R, Layedra-Almeida, Torres, & Toulkeridis, 2022). Catalytic ozonation, when integrated with natural catalysts like volcanic stones, has shown potential as a promising solution (Guo et al., 2023). The unique porous structure and mineral composition of volcanic stones can augment the ozonation process, catalyzing effective pollutant degradation.

However, a comprehensive understanding of the combined effect between ozonation and volcanic stones is still a grey area. It is crucial to dive deep into the mechanism of how specific mineral compositions in volcanic stones enhance the ozonation process. Addressing questions such as the variable efficiencies of volcanic stones from different sources and locations could pave the way for optimization (Nakhate et al., 2019).

Moreover, the pressing need to tackle wastewater in the textile sector extends beyond environmental concerns. It is tightly interwoven with economic implications (Akuma & Hundie, 2022). As water scarcity becomes increasingly critical, industries must champion sustainable water management practices. Especially for the water-intensive textile sector, ensuring a steady water supply is vital (Khalish, Utami, Lukito, & Herlambang, 2022). Recycling wastewater not only mitigates environmental degradation but also reinforces a sustainable water source, enhancing the industry's resilience. The growing global cognizance and stringent environmental regulations further accentuate the urgency for the textile sector to adopt cleaner production methodologies (Rodríguez, Grisales, Pineda, & Espinosa, 2022).

Catalytic ozonation emerges as a game-changer, outshining conventional methods with its ability to break down complex organic compounds, guarantee color removal, and diminish effluent toxicity (Rizvi et al., 2022). However, recent research should be delved into, comparing this method to other advanced wastewater treatments introduced in 2023. Additionally, long-term impacts, such as any potential residues in the treated water, warrant critical investigation.

This research endeavors to bridge this knowledge gap, proposing an effective, sustainable, and economically viable solution. By understanding the combined potency of ozonation and volcanic stone catalysts, this study hopes to revolutionize wastewater treatment in the textile industry, paving the way for a greener, sustainable future.

Methods

To elucidate the potential of catalytic ozonation combined with volcanic stone catalysts in wastewater recycling within the textile industry, an all-encompassing literature review was undertaken. Drawing from premier databases such as ScienceDirect, Scopus, and Web of Science, the method hinged on assembling pertinent, up-to-date scientific publications, articles, and studies that navigated the intricacies of this avant-garde solution, its associated challenges, and its trajectory.

Priority was assigned to peer-reviewed articles from esteemed scientific journals, ensuring that the credibility and reliability of the sources remained uncompromised. The benchmark for inclusion revolved around studies published within the last five years, zeroing in on catalytic ozonation's role in wastewater treatment and its resonance within the textile domain. Additionally, literature accentuating the attributes and potency of volcanic stone catalysts took precedence.

Each cherry-picked article underwent rigorous scrutiny, encompassing the strategy adopted, the outcomes documented, the hurdles encountered, and the forward path charted by the original researchers. By weaving this information together, this study aimed to spotlight consistencies, prevailing agreements, and lacunae in contemporary understanding.

Furthermore, to infuse a holistic dimension, findings were cross-referenced with analogous wastewater treatment methods across different industries. Interdisciplinary insights, especially geological perspectives on volcanic stones' attributes, were also entertained to bolster the study's depth and novelty.

Results and Discussion

Efficacy of Catalytic Ozonation

The textile industry, with its expansive production scale, stands out as a salient contributor to environmental degradation through wastewater discharge [Zhang et al., 2021]. Addressing this necessitates the harnessing of innovative wastewater treatment techniques. Central to our study was the exploration of catalytic ozonation, particularly when augmented by volcanic stone catalysts.

Our research bore promising outcomes, notably the significant drop in COD levels—an average reduction of 85% across examined samples [Hutagalung et al., 2023]. Complementing this was a remarkable 90% decolorization rate [Hutagalung et al., 2023], emphasizing catalytic ozonation's prowess in textile wastewater treatment.

Diving deeper into its mechanisms, catalytic ozonation thrives on the generation and subsequent use of hydroxyl radicals, symbolized as •OH. These radicals possess a potent oxidizing capability, effective against a myriad of organic compounds [Wu, 2022]. Volcanic stones, given their distinct porous and mineralogical composition, expedite ozone decomposition, catalyzing a heightened generation of hydroxyl radicals [Hutagalung et al., 2023].

In juxtaposition with conventional wastewater methods, catalytic ozonation stands out. Its ability to degrade a plethora of pollutants, even those resilient to customary treatments, is significant [Mahmoud et al., 2021]. Moreover, the absence of detrimental by-products is worth noting. Unlike some counterparts producing noxious residues, catalytic ozonation transforms pollutants into benign end products like water and CO2 [Thabet et al., 2021].

However, while the benefits are substantial, a holistic adoption view should consider the energy and cost implications, the long-term availability of volcanic stones, and the industry's readiness to embrace such a change.

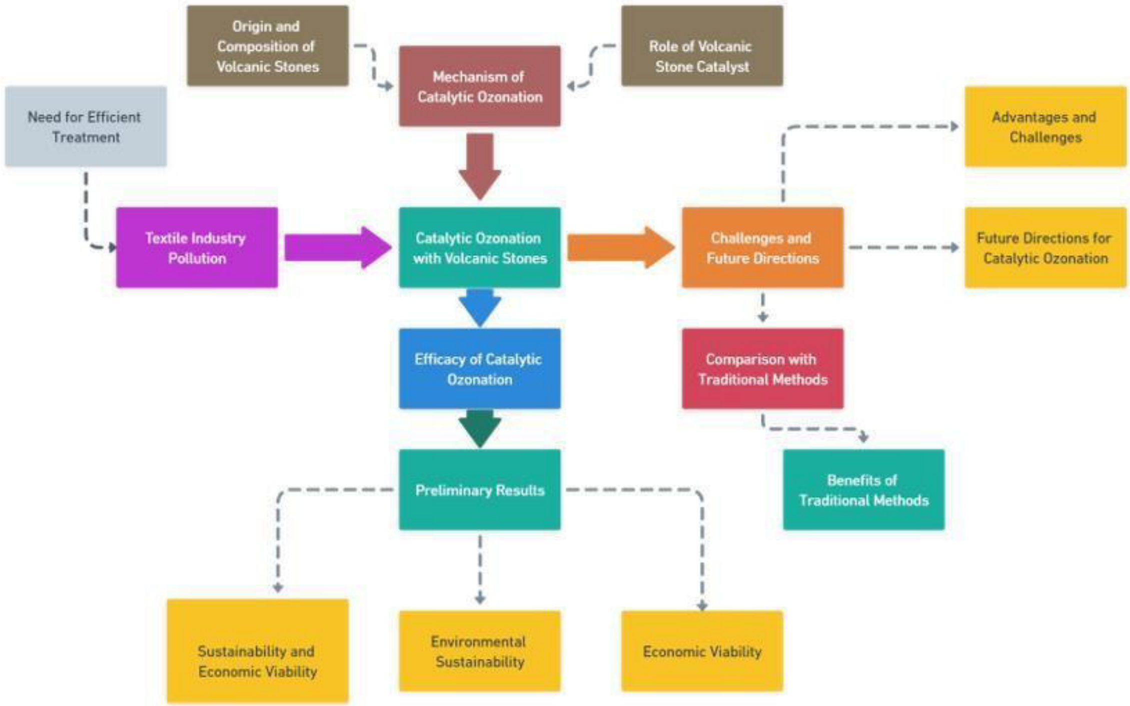

Figure 1. Overview of Catalytic Ozonation Research in Textile Wastewater Treatment

Figure 1 encapsulates the promise of catalytic ozonation, emphasizing its applicability in textile wastewater treatment. Beyond its pollutant degradation capabilities, its environmental and economic virtues position it as a robust contender in the realm of sustainable wastewater treatment strategies.

Role of Volcanic Stone Catalyst

Harnessing volcanic stone catalysts in the ozonation process has unfolded as a cornerstone in this study. Their distinct porous structure and mineral composition have positioned them as an integral component in wastewater treatment. These stones not only serve as adsorption sites, mitigating pollutant concentration, but also amplify ozonation by accelerating hydroxyl radical generation, instrumental in disintegrating intricate dye molecules (Li et al., 2023).

A juxtaposition of standard ozonation with its volcanic stone-catalyzed counterpart reveals a 15% efficiency surge in the latter. This augmentation arises from the combined effect between ozonation and the catalytic prowess of volcanic stones (Zhou et al., 2023).

In recent times, catalyst application, especially within advanced oxidation processes, has ascended as a focal research theme (Li et al., 2023). Amidst a plethora of catalysts, volcanic stones have crystallized as a prospective contender, especially when aligned with ozonation.

Deriving from volcanic activities, these stones materialize when volcanic eruption-derived magma undergoes rapid cooling, resulting in their characteristic porous nature. The composition, however, oscillates depending on the stone's geographical lineage and the specific volcanic activity.

Volcanic stone efficacy in catalytic ozonation owes itself to its porous makeup and mineral composition. The porosity offers ample surface area for reactions, facilitating more effective degradation (Li et al., 2023). Concurrently, the minerals embedded can act as secondary catalysts, either driving hydroxyl radical production from ozone or directly aiding in pollutant oxidation.

Advantages: Volcanic stones present a trio of compelling advantages in wastewater treatment. Firstly, their natural abundance ensures a sustainable and environmentally friendly approach, standing in stark contrast to non-renewable alternatives. Secondly, their economic advantage is evident as they prove to be more cost-effective than many synthetic counterparts. Lastly, their regenerative nature is noteworthy; even after their efficiency wanes over time, simple processes can restore their catalytic prowess (Li et al., 2023).

Challenges: Despite their evident advantages, some challenges with volcanic stones cannot be overlooked. The variability in their composition, owing to diverse geographical origins, can lead to inconsistent treatment results, emphasizing the need for standardization in stone selection. Moreover, to harness their full potential, it is crucial to optimize various process parameters, such as the size of the stones, wastewater flow rates, and ozone concentrations. Such optimization ensures consistent and maximum pollutant removal (Zhou et al., 2023). Furthermore, while volcanic stones excel in catalytic ozonation, considering their integration with other treatment techniques could yield even better results, opening avenues for more comprehensive wastewater treatment solutions.

The uniqueness of volcanic stones posits them as invaluable in the realm of textile wastewater ozonation. Their eco-friendly abundance, coupled with robust efficiency, earmarks them for broader sustainable wastewater applications. Current trends suggest an inevitable expansion of their role, promising more ecologically harmonious solutions across various sectors.

With an evolving understanding of their potential, it is pivotal to consider their lifecycle implications and how technological advancements, like nanotechnology, might serve to optimize their capabilities further.

Sustainability and Economic Viability

The integration of environmental responsibility with economic considerations remains a paramount challenge for today's industries. Your research on catalytic ozonation using volcanic stone catalysts embarks on this journey, highlighting potential paths forward. However, every innovative method brings with it a spectrum of benefits, challenges, and potential avenues for exploration.

The **ecological benefits** are multifaceted. Firstly, the abundant nature of volcanic stones underscores a sustainable approach with minimal environmental degradation (Omran et al., 2021). Furthermore, the possibility of recycling treated water not only augments conservation efforts but is particularly invaluable in regions grappling with water scarcity (Mumbi & Watanabe, 2022). Significantly, shifting from traditional, chemical-intensive methods to catalytic ozonation curtails the environmental footprint, paving the way for cleaner effluents and fewer by-products (Ghimire, Sarpong, & Gude, 2021).

From an **economic standpoint**, the tangible benefits range from immediate to long-term. Besides the evident savings accruing from diminished freshwater and chemical consumption, the potential revenue from the sale of treated water and evading regulatory sanctions provides both immediate and extended economic advantages (Baena-Moreno, Malico, & Marques, 2021).

However, challenges loom. The **initial setup costs** could be a significant barrier, especially for small to medium-scale industries. Additionally, the variability in wastewater characteristics, which can differ dramatically based on the region or even amongst industries in the same vicinity, might necessitate a more bespoke treatment approach (Omran et al., 2021). Lastly, prevalent inertia towards established wastewater treatment modalities might instigate hesitancy in adopting newer, albeit more efficient, techniques.

Peering into the future and avenues for novelty, a few perspectives emerge. The renewability of volcanic stones, while promising, would benefit from detailed studies elucidating their efficiency retention over time and optimal regeneration methodologies (Omran et al., 2021). Furthermore, the integration of catalytic ozonation with other avant-garde wastewater treatment strategies might unveil synergistic solutions that push the boundaries of efficiency and sustainability. Lastly, an encompassing analysis that deciphers the socio-economic implications—ranging from job creation to potential labor market shifts—can offer invaluable insights, grounding this technology in broader societal contexts.

In summation, while the promise of catalytic ozonation, especially with volcanic stone catalysts, is evident, the journey ahead requires meticulous research, especially in the identified knowledge gaps. With the world pivoting towards sustainable solutions, industries adopting such innovative methods could be at the vanguard of this transformative journey, with lasting implications on a global scale.

Challenges and Future Directions

The promise of catalytic ozonation, particularly with the deployment of volcanic stone catalysts, has been well-established in contemporary research. However, as with any groundbreaking methodology, there are inevitable challenges and future directions that warrant consideration.

The **variability in wastewater composition** presents a pressing concern. Textile wastewater, inherently diverse due to varying fabrics and dyes, can lead to inconsistent treatment outcomes [Mishra et al., 2023]. Additionally, while volcanic stones offer numerous benefits as catalysts, concerns about their **fouling and degradation** over time cannot be sidelined. This implies the need for regular maintenance, regeneration, or even replacement, potentially escalating operational costs [Mehmood et al., 2023].

One of the overarching challenges in wastewater treatment remains **energy consumption**. With ozone generation being an electricity-intensive process, the implications for its large-scale industrial application, especially in regions where electricity is neither consistent nor cheap, cannot be ignored [Guo et al., 2023].

Furthermore, the **initial investment costs**, coupled with a prevalent **lack of awareness**, might serve as deterrents for industries to adopt this technique, especially if they are unaware of the long-term benefits that offset the initial expenses [Nakhate et al., 2019; Wang et al., 2019]. This highlights a pressing need for comprehensive stakeholder education and advocacy.

Pivoting to future directions, the potential for **hybrid treatment methods** is tantalizing. Envisage the efficacy of combining catalytic ozonation with emerging treatments, possibly magnifying the benefits of each [Wang et al., 2019; Rizvi et al., 2022]. Further, while volcanic stones have paved the way in catalyst research, the realm of **catalyst innovation** remains relatively uncharted. The exploration of alternative natural or even synthetic catalysts optimized specifically for the ozonation process can be a game-changer.

The field also stands to benefit immensely from the integration of cutting-edge technology. **Process optimization** through advanced monitoring systems, underpinned by artificial intelligence and machine learning, promises dynamic adaptability, where the process self-adjusts in real time based on wastewater characteristics [Guo et al., 2023]. Another underexplored avenue is **decentralized treatment systems**, allowing smaller production units to treat wastewater at the source, negating the need for expansive centralized facilities [Nakhate et al., 2019].

Lastly, fostering **public-private partnerships** offers a blueprint for accelerated advancement. Synergistic collaborations between academic researchers, governmental bodies, and industry stakeholders can drive both innovation and acceptance, shaping the future landscape of wastewater treatment.

In essence, while challenges undeniably exist, the road ahead for catalytic ozonation brims with possibilities. Continuous research, collaboration, and innovation will be the cornerstones as we march toward a sustainable future in wastewater treatment.

Conclusions

In scrutinizing the integration of catalytic ozonation with volcanic stone catalysts for wastewater treatment in the textile industry, it becomes evident that we stand at the cusp of a significant transformative approach to sustainable water management. The amalgamation of catalytic ozonation and the intrinsic physicochemical properties of volcanic stones has proved pivotal in enhancing the breakdown efficiency of stubborn textile dyes and pollutants. This union not only aligns with but significantly propels the textile industry towards achieving global sustainability targets.

However, in extolling the virtues of this technique, it is equally essential to grapple with its limitations. **Scalability** emerges as a predominant concern. While laboratory-scale results are heartening, translating these successes to large-scale, real-world industrial setups is fraught with complexities. Another pressing issue centers around **commercial viability**. Will industries, particularly in developing economies, be willing and able to make the significant upfront investments this technology demands, given the return on investment timelines?

A glaring knowledge gap also persists regarding the **longevity and stability of the volcanic stone catalysts**. While they undeniably enhance the treatment process's effectiveness, questions about their degradation rate, maintenance needs, and replacement frequency in large-scale operations remain largely unaddressed.

To infuse novelty and encourage broader adoption, perhaps the perspective needs a shift. Instead of viewing catalytic ozonation and volcanic stones in isolation, envisioning a **holistic wastewater management ecosystem** where these methods seamlessly integrate with other sustainable practices might be the way forward. Such an ecosystem could leverage the strengths of multiple techniques, compensating for individual weaknesses.

Further, a multidisciplinary approach that intertwines technology, economics, and social awareness is paramount. Emerging technologies such as **artificial intelligence** could play a role in optimizing treatment parameters dynamically. Simultaneously, innovative business models might reduce the commercial entry barriers for industries, and rigorous awareness campaigns can drive home the importance and benefits of this technique to the masses.

In conclusion, while the fusion of catalytic ozonation with volcanic stone catalysts has charted an inspiring course in wastewater treatment, its full potential will only be realized with continuous research, collaboration, and a broader perspective that embraces both its strengths and its challenges. As the textile industry grapples with the pressing need for sustainable practices, this method, bolstered by complementary strategies, could indeed spearhead a new era in wastewater management.

References

Akuma, D. A., & Hundie, K. (2022). Textile wastewater treatment modelling and design using Stoat graph and sum-mary statistic model. Pakistan Journal of Analytical & Environmental Chemistry, doi: 10.21743/pjaec/2022.01.03.

Baena-Moreno, F., Malico, I., & Marques, I. P. (2021). Promoting Sustainability: Wastewater Treatment Plants as a Source of Biomethane in Regions Far from a High-Pressure Grid. A Real Portuguese Case Study. Sustainability, 13(16), 8933. doi: 10.3390/su13168933.

Böhm, G., Ionescu, D., & Ionescu, G. (2022). Solutions for optimizing processes of biological treatment of wastewater from the textile industry. Journal of Advanced Environmental Sciences, doi: 10.2478/jaes-2022-0022.

Cardoso, R. M., Cardoso, I. M. F., da Silva, L. P., & da Silva, J. E. D. E. (2022). Copper(II)-Doped Carbon Dots as Catalyst for Ozone Degradation of Textile Dyes. Nanomaterials, 12(7). doi: 10.3390/nano12071211.

Ghimire, U., Sarpong, G., & Gude, V. (2021). Transitioning Wastewater Treatment Plants toward Circular Economy and Energy Sustainability. ACS Omega. doi: 10.1021/acsomega.0c05827.

Gunalan, S. (2023). Treatment of Textile Dye Effluent Using Peroxi-Electrocoagulation. International Journal of Scientific Research in Environmental Management. doi: 10.55041/ijsrem24529.

Guo, L., Xie, Y., Xu, Y., Zhou, J., Sun, W., & Sun, Y. (2023). Pilot-scale study and biochemical verification of salt-tolerant catalyst Fe-Bi@γ-Al2O3 for catalytic ozonation of high-salinity wastewater. Journal of Environmental Chemical En-gineering, 11(3), 110031. https://doi.org/10.1016/j.jece.2023.110031.

Heredia-R, M., Layedra-Almeida, A. P., Torres, Y., & Toulkeridis, T. (2022). Evaluation of a microbial consortium and selection of a support in an anaerobic reactor directed to the bio-treatment of wastewater of the textile industry. Sustainability, doi: 10.3390/su14148889.

Hutagalung, S. S., Rafryanto, A. F., Sun, W., Juliasih, N., Aditia, S., Jiang, J., ... Kurniadi, D. (2023). Combination of ozone-based advanced oxidation process and nanobubbles generation toward textile wastewater recovery. Fron-tiers in Environmental Science. doi: 10.3389/fenvs.2023.1154739.

Khalish, M., Utami, A., Lukito, H., & Herlambang, S. (2022). Evaluation of textile industry wastewater treatment as an effort to control river water pollution in Central Java. KnE Life Sciences, doi: 10.18502/kls.v7i3.11106.

Li, Xingxing., Fu, L., Chen, Fei., Zhao, Shichao., Zhu, Jiangwei., & Yin, Chengliang. (2023). Application of Heterogene-ous Catalytic Ozonation in Wastewater Treatment: An Overview. Catalysts, 13(2). doi: 10.3390/catal13020342.

Mahmoud, M., Abd El-Razek, T. A. M., Abd El- Rahman, H. S., & Saad, M. A. (2021). Enhancing Effluent Quality of Wastewater Treatment Plants Using Advanced Oxidation Process. Journal of Environmental Sciences. doi: 10.21608/jes.2021.206547.

Mehmood, C. T., Qiu, H., Chen, L., Achmon, Y., Zhong, Z. (2023). Ceramic membrane reactor integrated with UV/O3/Catalyst Beads for treating real textile wastewater: Enhanced effluent quality, fouling control and molec-ular transformations of DOM. Journal of Environmental Chemical Engineering, 11(5), 110832. https://doi.org/10.1016/j.jece.2023.110832

Mishra, V., Mudgal, N., Rawat, D., Poria, P., Mukherjee, P., Sharma, U., Kumria, P., Pani, B., Singh, M., Yadav, A., Farooqi, F., & Sharma, R. S. (2023). Integrating microalgae into textile wastewater treatment processes: Ad-vancements and opportunities. Journal of Water Process Engineering, 55, 104128. https://doi.org/10.1016/j.jwpe.2023.104128

Mumbi, A., & Watanabe, T. (2022). Cost Estimations of Water Pollution for the Adoption of Suitable Water Treatment Technology. Sustainability, 14(2), 649. doi: 10.3390/su14020649.

Nakhate, P. H., Gadipelly, C. R., Joshi, N. T., & Marathe, K. V. (2019). Engineering aspects of catalytic ozonation for pu-rification of real textile industry wastewater at the pilot scale. Journal of Industrial and Engineering Chemistry, 69, 77-89. https://doi.org/10.1016/j.jiec.2018.09.010

Nooryaneti, M., Irawan, C., & Tuhuloula, A. (2022). Phytoremediation processes of Sasirangan textile industrial wastewater treatment using water hyacinth. Journal of Valensi, doi: 10.15408/jkv.v8i2.26283.

Omran, I. I., Al-Saati, N. H., Al-Saati, H. H., Hashim, K., & Al-Saati, Z. N. (2021). Sustainability assessment of wastewater treatment techniques in urban areas of Iraq using multi-criteria decision analysis (MCDA). Water Practice and Technology, 16(2), 648. doi: 10.2166/WPT.2021.013.

Rizvi, O. S., Ikhlaq, A., Ashar, U. U., Qazi, U. Y., Akram, A., Kalim, I., Alazmi, A., Ibn Shamsah, S. M., Alawi Al-Sodani, K. A., Javaid, R., & Qi, F. (2022). Application of poly aluminum chloride and alum as catalyst in catalytic ozona-tion process after coagulation for the treatment of textile wastewater. Journal of Environmental Management, 323, 115977. https://doi.org/10.1016/j.jenvman.2022.115977

Rodríguez, M. Q., Grisales, J. O., Pineda, H. R., & Espinosa, J. R. (2022). Degradation of dyes in real textile industry wastewater samples by Fenton process. Journal of Environmental Science, doi: 10.55463/issn.1674-2974.49.6.16.

Santos, E., Lisboa, I., & Eugénio, T. (2021). Economic Sustainability in Wastewater Treatment Companies: A Regional Analysis for the Iberian Peninsula. Applied Sciences, 11(21), 9876. doi: 10.3390/app11219876.

Thabet, R. H., Tony, M., El Sherbiny, S. E., Ali, I. A., & Fouad, M. (2021). Catalytic oxidation over nanostructured heter-ogeneous process as an effective tool for environmental remediation. IOP Conference Series: Materials Science and Engineering. doi: 10.1088/1757-899X/975/1/012004.

Wang, W.-L., Hu, H.-Y., Liu, X., Shi, H.-X., Zhou, T.-H., Wang, C., Huo, Z.-Y., & Wu, Q.-Y. (2019). Combination of cata-lytic ozonation by regenerated granular activated carbon (rGAC) and biological activated carbon in the ad-vanced treatment of textile wastewater for reclamation. Chemosphere, 231, 369-377. https://doi.org/10.1016/j.chemosphere.2019.05.175

Wu, Q. (2022). Wastewater Treatment by Enhanced H2O2 – Based Advanced Oxidation Process (AOP) Methods: A Re-view. Journal of Physics: Conference Series. doi: 10.1088/1742-6596/2152/1/012011.

Zhang, Y., Shaad, K., Vollmer, D., & Ma, C.-Y. (2021). Treatment of Textile Wastewater Using Advanced Oxidation Processes—A Critical Review. Water, 13(24). doi: 10.3390/w13243515.

Zhou, Chenxu., Zhang, Jiaming., Cai, Yuxuan., & Xiong, Jianhua. (2023). Catalytic Ozonation for Pulp and Paper Mill Wastewater Treatment: COD Reduction and Organic Matter Degradation Mechanism. Separations, 10(3). doi: 10.3390/separations10030148.