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Editorial

Soluble Microbial Products and Perfluorinated Compounds in Wastewater Treatment

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Water is vital for all living organisms and many manufacturing industries. Water demand is rising due to changes in climate, population growth, industrialization, and the destruction of the environment. To meet the water demands, wastewater must be treated and reused. The treatment process is a method in which water polluted by individuals or industrial processes is recovered to an acceptable standard [1]. In recent years, pollutants such as antibiotics, microplastics, and fluorinated organic compounds have been frequently detected in water, and research shows that they pose potential risks to public health and aquatic ecology [2]. Research on pollution control has received significant attention and importance. At the same time, due to the rapid development of the economy and the diversification of people's needs, different types of chemicals are produced and used in large quantities, and pollutants are increasingly becoming harmful substances that threaten human health and the environment [3]. Therefore, research on wastewater treatment must explore a set of efficient and economical governance methods.

Per- and polyfluoroalkyl substances (PFASs) are synthetic fluorinated surfactants composed of a carbon backbone and a charged functional group. Their unique chemical structure provides hydrophobicity, oil repellency, high temperature resistance, and a significant reduction in water surface tension properties, making them widely used in pesticides, medicines, cosmetics, and clothes [4]. However, some studies have shown that PFASs exhibit potential hepatotoxicity, neurotoxicity, and reproductive toxicity. Other pollutant antibiotics are widely used in medicine, agriculture, forestry, animal husbandry, and other fields, resulting in a continuous increase in antibiotic content in the water environment [5]. Therefore, environmental safety poses significant challenges. Antibiotics remaining in effluents from sewage treatment plants also enter natural water bodies. Antibiotics enter the human body via drugs and drinking water and accumulate, posing a serious threat to human health [6]. In addition, in recent years, microplastics have also caused great harm to the environment. As an emerging pollutant, in addition to toxic substances such as phthalates it contains, it can absorb organic pollutants, heavy metals, antibiotics, etc. Under the influence of nature, these harmful substances migrate to soil and water bodies [7]. Existing research shows that microplastics are widely present in oceans, lakes, and even drinking water, and their content and distribution characteristics are affected by the natural environment and human factors, exhibiting certain differences [8]. Microplastics accumulate in animals and humans via the food chain, posing a serious threat to organisms and the ecological environment [9].

To solve these water pollution problems, the use of modern treatment technology to compensate for the shortcomings of traditional wastewater treatment methods has become a current research hotspot. Conventional wastewater treatment approaches include a mixture of physical, chemical, and biological procedures, including sewage removal activities to eliminate soluble pollutants [10]. Different techniques have been established to extract these pollutants, including adsorption, membrane technology, advanced oxidation processes, biological methods, and wetlands [11].

Citation: Li, C. Soluble Microbial Products and Perfluorinated Compounds in Wastewater Treatment. *Water* **2023**, *15*, 4216. https://doi.org/10.3390/w15244216

Received: 4 December 2023
Revised: 5 December 2023
Accepted: 5 December 2023
Published: 7 December 2023

This Editorial refers to the Special Issue "Soluble Microbial Products and Perfluorinated Compounds in Wastewater Treatment". This Special Issue highlights new opportunities and challenges for treating the pollutants in water, focusing on technological advancements and method innovation by considering sustainability and harmlessness.

A large number of manuscripts were submitted for consideration for this Special Issue, all of which were subject to a rigorous water review process. In total, ten papers were finally accepted for publication and inclusion in this Special Issue (two articles and eight reviews). The contributions are listed below:

Contribution 1: In response to the frequent occurrence of Harmful Algal Blooms (HABs) caused by *Heterosigma akashiwo* in coastal waters, which presents risks to marine ecosystems and processes like desalination, Jianwei Zeng investigates the efficacy of UV-assisted permanganate oxidation (UV/$KMnO_4$) as an innovative advanced oxidation process. This research demonstrates the successful disintegration of *H. akashiwo* cells into fragments via UV/$KMnO_4$ treatment, accompanied by the degradation of photosynthetic pigments, membrane lipid peroxidation, and the induction of severe oxidative stress. Demonstrating an impressive 80.2% removal efficiency within 20 min of UV/$KMnO_4$ oxidation, using a $KMnO_4$ dosage of 5 mg L^{-1}, highlights its potential as a robust method to combat harmful marine algae. The UV/$KMnO_4{}^-$induced fragmentation not only enhances cell settleability but also reduces UV254, thereby offering prospects for minimizing disinfection byproduct formation and membrane fouling in downstream water treatment processes. This study highlights the UV/$KMnO_4$ process as an efficient and environmentally sound technique to treat harmful marine algae and presents its implications for enclosed aquaculture systems, seawater desalination, and ship ballast water management.

Contribution 2: This study delves into the challenges associated with azo dye wastewater, focusing particularly on Acid Orange 7 (AO7). Using wood chips as biological templates, Qijia Zhu developed an eco-friendly, reusable adsorbent and catalytic material—Fe_3O_4@BC. This study thoroughly examines the adsorption kinetics and isotherms of Fe_3O_4@BC on AO7, providing insights into the proposed adsorption mechanism. Additionally, it assesses the persulfate activation to facilitate AO7 degradation and investigates the catalytic performance of Fe_3O_4@BC by considering various parameters. Key findings underscore the exceptional adsorption capacity of Fe_3O_4@BC, and the suggested mechanism identifies –N=N– and sulfonic acid groups in AO7 molecules as primary sites for chemical reactions. The Fe_3O_4@BC/PS system achieves an impressive 90% removal rate of AO7 after 20 min under specific conditions. In conclusion, Qijia Zhu's study highlights the promising potential of Fe_3O_4@BC in activating PS advanced oxidation for degrading water pollutants, offering unique advantages in treating refractory organic pollutants like AO7.

Contribution 3: In this review, Sha Jin addresses the prevalent issue of odorous substances in urban drainage pipelines, which is a source of growing complaints from residents. In addition to causing pipeline corrosion and erosion, these substances pose health and environmental risks. This review categorizes in situ deodorization techniques, focusing on the main odorous substances, their sources, and formation mechanisms. These techniques include pipeline condition optimization, odor source control, and chemical and biological approaches. The conclusion emphasizes the urgency for effective odor control and proposes future research directions, emphasizing the need for innovative, field-applicable solutions.

Contribution 4: The review by Jianping Yu explores the eco-friendly water treatment potential of Ferrate(VI). This green agent, valued for oxidation, disinfection, and adsorption flocculation, outshines traditional methods. This paper delves into three preparation techniques that emphasize the removal, adsorption, and control of pollutants. While Ferrate(VI) boasts efficient pollutant removal, its selectivity and instability require attention. This review introduces hyphenated techniques, including the Ferrate(VI)–PMS and Ferrate(VI)–PAA synergies, adding depth to their applications. Addressing preservation challenges and combining Ferrate(VI) with other technologies are crucial for advancing its water treatment capabilities.

Contribution 5: Yong Wang's review delves into the global concern of Perfluorinated Compounds (PFCs), emphasizing their environmental persistence and biotoxicity. This paper covers the hazardous effects, detection technologies, and treatment methods for PFCs. It highlights their widespread presence in water, air, soil, and organisms, detailing toxic effects such as hepatotoxicity and neurotoxicity. This review provides insights into sample pretreatment techniques, detection assays, and various treatment approaches, offering support and suggestions for PFC pollution control technologies. This conclusion stresses the need for continued optimization of detection methods and improvement in PFC treatment technologies.

Contribution 6: The influx of MPs into water bodies is of significant concern for aquatic ecosystems and human health. Cong Li and Bo Jiang provide a comprehensive review of the aging process of microplastics (MPs) in aquatic environments. They address the environmental challenges posed by plastic waste and the transformation of plastics into MPs via oxidation, weathering, and fragmentation. This review covers the aging pathways of MPs, changes in their physicochemical properties, potential compound effects of other pollutants, and the formation of environmentally persistent free radicals (EPFRs) during photoaging. The authors also propose the feasibility of using photoaged MPs as photosensitizers to catalyze the photoreactive degradation of organic pollutants. This comprehensive evaluation contributes valuable insights into the behavior of MPs in aquatic environments.

Contribution 7: The misuse of antibiotics has led to the enrichment of ARGs, raising concerns regarding their spread into the global ocean. Jiaqi Guo conducted a comprehensive review of the distribution and influence of antibiotic resistance genes (ARGs) in ballast water, emphasizing the global transfer of bacteria and genes through this mobile carrier. It covers the current state of ARGs in ballast water from various sea areas, delving into the factors influencing their distribution, and explores the impact of differential disinfection technologies (chlorination, ultraviolet, ozone, and free radical technology) on ARGs. The author also explores the potential risks of ARG transfer in ballast water after disinfection and suggests considerations for establishing reasonable ballast water discharge standards. Overall, this review aims to guide future research, offering valuable insights into ARG pollution and the risk of vertical and horizontal ARG transfer in ballast water.

Contribution 8: Saikai Huang delves into the critical issue of antibiotic contamination in water and presents a comprehensive review of methods to address this problem. Antibiotics, essential for medical, aquaculture, and animal husbandry purposes, find their way into water bodies, posing threats to both human health and the environment. This paper thoroughly examines biological, physical, and chemical approaches, along with combined processes, for antibiotic pollution control. It provides detailed insights into the degradation mechanisms, removal efficiencies, influencing factors, and technical characteristics of different antibiotics, offering a valuable resource for future research and development of antibiotic removal technology. This review emphasizes the significance of combating antibiotic contamination, assesses the advantages and drawbacks of various treatment methods, and advocates the advancement of combined processes to optimize antibiotic pollution control in water environments.

Contribution 9: Perfluorinated Compounds (PFCs), particularly Perfluorooctanoate (PFOA) and Perfluorooctane Sulfonate (PFOS), have garnered significant attention due to their persistent environmental pollution, bioaccumulation, and biotoxicity. Kai Zhang provides a thorough examination of PFC pollution and distribution in aquatic environments globally. It focuses on the latest advancements in processing technologies for PFOA and PFOS, particularly on physical techniques like adsorption and flocculation. This review emphasizes the crucial role of adsorbents with high specific surface areas and hydrophobic interactions in PFC enrichment and removal. Additionally, this paper explores Advanced Oxidation Processes (AOPs) based on radical decomposition, including photocatalysis, electrochemical processes, ozone, the Fenton process, and ultrasound. The conclusion outlines the benefits and limitations of various PFC treatment methods, providing insights into their efficacy and discussing future developments in PFC elimination technologies for water treatment.

Contribution 10: The escalating concern over water and wastewater contamination by organic pollutants has spurred interest in various advanced oxidation processes (AOPs). Peroxyacetic acid (PAA), an emerging oxidant, has garnered attention due to its low or negligible number of toxic by-products. However, its widespread application faces constraints due to unclear activation mechanisms and intricate preparation processes. A review by Changjie Shi consolidates the research findings on organic pollutant removal through PAA-based AOPs. It elucidates the preparation methods, characteristics, activation mechanisms, and reactivity of PAA, focusing on both the free radical and non-radical pathways. This paper explores the influencing factors and introduces novel non-radical activation methods discovered in recent years. In conclusion, this review identifies the current limitations, analyzes the development of PAA-based AOPs, and offers insights for future advancements. This comprehensive review serves as a valuable reference for the practical application of activated PAA technology in organic pollutant treatment.

The articles in this Special Issue are mainly reviews that discuss the treatment of pollutants, such as algae, dyes, Perfluorinated Compounds, microplastics, and antibiotics, which cause great harm to human health, and cover high-tech treatment technologies such as advanced oxidation, electrochemistry, and adsorption materials. Each article serves as a unique thread, ranging from nanomaterial applications to cutting-edge oxidative processes, which shows the dynamic landscape of contemporary solutions addressing water-related challenges. Contributions 1, 3, 4, 6, 8, and 10 describe and compare different AOPs to remove organic pollutants. Contribution 2 describes the effect of Fe_3O_4@BC combined with the adsorption and oxidation methods to remove the dye. Contributions 5 and 9 investigate the removal methods for Perfluorinated Compounds. Contribution 7 investigates the distribution and influence of antibiotic resistance genes (ARGs) in ballast water. Generally, these papers investigate the removal of organic pollutants and Perfluorinated Compounds using physical, chemical oxidation, and biological methods.

Upon collective reflection on these articles, it is evident that our strides in water treatment are commendable, but the path forward requires further exploration. The issues of accessibility, environmental impact, and scalability loom large, necessitating interdisciplinary efforts. Bridging the gap between research excellence and on-the-ground implementation is the next frontier.

Acknowledgments: For their contribution to the Special Issue "Soluble Microbial Products and Perfluorinated Compounds in Wastewater Treatment", I would like to express my deep appreciation to all authors and my postgraduate student, Shanshan Li, whose valuable work was published in this issue and thus contributed to the success of the edition.

Conflicts of Interest: The author declares no conflict of interest.

List of Contributions

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