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Editorial

Research on Micropollutants in Urban Water

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1. Introduction

To live in a safe and clean environment is a right of every human being. However, this is not a reality nowadays. According to UNICEF data [1], over two billion people still lack access to safe drinking water, and poorer communities are the most badly affected. Regarding a strategy to ameliorate this scenario, the 2030 Agenda for Sustainable Development has laid the groundwork for a sixth goal—"Ensure access to water and sanitation for all", which includes improving water quality by reducing pollution, eliminating dumping, mitigating the release of hazardous chemicals and materials, halving the proportion of untreated wastewater, and substantially increasing recycling and safe reuse globally [2]. With regard to this, the scientific community has been conducting joint efforts to meet these targets. A fact that hinders the adequate management of water resources nowadays is the presence of micropollutants in industrial and domestic wastewater, as many of these contaminants are not regulated and possess adverse effects on human health, which are barely known, thus waters containing them cannot simple be reused without previous analyses and adequate treatment [3]. These micropollutants include pharmaceuticals, personal care products, industrial chemicals, pesticides, fire retardants, and others, which are not completely removed by conventional water treatment technologies. Thus, they end up in the water and wastewater treatment plant effluents. Given that, there is an urgent need to understand how these pollutants occur and to develop effective technologies for removing them before their disposal.

The objective of this Special Issue is to gather the expertise of researchers investigating these questions and related topics so as to seek progress in this field and to implement practical solutions.

2. Invitation to Submit to This Special Issue

The call for papers for this Special Issue on "Research on micropollutants in Urban Water" sought contributions that reflect the advances in this area and related topics, thus seeking progress and suitable strategies for water pollution control.

The selected papers address the detection, persistence, and removal of micropollutants from waters through different approaches, such as:

- Novel materials as sustainable pollutant adsorbents or promoters of catalytic water treatment
- Computer modelling to understand the main micropollutants removal pathways
- Impact of the weather conditions regarding the performance of a municipal water treatment plant
- Advanced oxidation technologies for the removal of the most persistent micropollutants
- Economic study as a decision tool for the formulation of advanced water treatments

3. Topics Covered by Papers in This Special Issue

This Special Issue consists of eight papers related to the current advances regarding the research on micropollutants in water. The first paper in the collection provides

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an investigation comparing the efficacy of UVC radiation in the removal of five well known persistent pharmaceutical compounds in urban waters: acetaminophen, atenolol, bezafibrate, diclofenac, and ibuprofen [4] (https://www.mdpi.com/1872404, accessed on 18 January 2023). In this investigation, the authors realized that the mixture of the five pharmaceuticals became more toxic to aquatic organisms after UVC irradiation, meaning that the photolysis byproducts are even more toxic than the mother compounds, and they require stronger oxidants to promote further mineralization [4]. The removal of pharmaceuticals is a matter of major concern nowadays due to the environmental and public health impacts that this class of pollutants exerts when present in water bodies. Given this, the search for effective treatments for pharmaceutical removal triggers many investigations, such as one that can be found in the second paper of this Special Issue—"Removal of Amoxicillin from Processing Wastewater by Ozonation and UV-Aided Ozonation: Kinetic and Economic Comparative Study" [5] (https://www.mdpi.com/1877930, accessed on 18 January 2023). In this study, the authors compared the effectiveness and evaluated the costs of two ozone-mediated processes for the removal of amoxicillin (AMX), an antibiotic widely used to combat general bacterial infections. Its extensive worldwide usage and inappropriate disposal lead to AMX's constant presence in water bodies. This fact, combined with antibiotics' low biodegradability, make urgent the development of advanced technologies capable of removing said substances. Advanced oxidation technologies (AOTs) have been proven effective for such purposes, being that these employ strong oxidants, such as ozone, which attack the unsaturated hydrocarbon bonds in the antibiotics' structure, leading to their degradation. In this investigation, the authors achieved an effective AMX removal with ozone and verified that adding UV is not well compensated in terms of costs and benefits.

The third paper in this Special issue—"Performance of Micropollutant Removal during Wet-Weather Conditions in Advanced Treatment Stages on a Full-Scale WWTP" [6] (https://www.mdpi.com/1940932, accessed on 18 January 2023) by Johanna Neef, Dominik Leverenz, and Marie Alexandra Launay—assesses the influence of the weather conditions on the effectiveness of micropollutant removal in a German wastewater treatment plant (WTP). A total of 26 organic micropollutants (OMPs), including pharmaceuticals, corrosion inhibitors, industrial chemicals, flame-retardants, herbicides, insect repellents, and caffeine, were analysed in the secondary effluent of the WWTP during dry and wet weather seasons. The authors concluded that wet weather conditions greatly influence the removal of micropollutants, and this is related to and resultant regarding shortened hydraulic retention time (HRT) during rainy days.

The fourth paper—"Adsorptive Removal of Methylene Blue Dye Using Biodegradable Superabsorbent Hydrogel Polymer Composite Incorporated with Activated Charcoal" [7] (https://www.mdpi.com/1896200, accessed on 20 January 2023) deals with a novel material for pollutant removal from water, i.e., through adsorption. The authors studied the capacity of a composite combining hydrogel and activated carbon in the adsorption of methylene blue, a dye commonly applied in the textile industry, which represents considerable environmental concern due to its toxic effect on aquatic organisms. The material presented good activity and selectivity for dye removal and has the capacity for multi-fold adsorption and desorption cycles.

The fifth paper—"Environmental Persistence of the Antidepressant Fluoxetine and Its Pharmaceutical Alternative: Kinetics of Oxidation and Mathematical Simulations" [8] (https://www.mdpi.com/1925380, accessed on 20 January 2023) investigates the main removal pathways of the antidepressants fluoxetine and fluoxetine sulfate in sunlit environmental waters. The authors used a mathematical simulation tool called APEX (Aqueous Photochemistry of Environmentally Occurring Xenobiotics) to predict the half-life time of these pollutants, and this was based on experimental results and local measurements of insolation, seasonal weather conditions, and water quality parameters. Shorter half-lives were obtained for the pharmaceutical alternative of fluoxetine, and this was related to the

decay to half of the initial concentration in a timescale of hours, driven by direct photolysis, biodegradation, and interactions with reactive species present in the medium.

The sixth paper—"Synthesis, Characterization, and Application of Pt/PtO_2-TiO_2/SiO_2 Materials on a Continuous Flow Packed Bed Microreactor for Enhanced Photocatalytic Activity under Sunlight" [9] (https://www.mdpi.com/1971212, accessed on 23 January 2023) combines two approaches for intensity photolytic water treatment: the synthesis of a novel photocatalytic material and its application in a micro-sized reactor with a novel design beneficial for this kind of reaction. The authors verified an optimal content of Pt to be doped onto TiO_2, supported on silica, and they employed this optimized material in the photocatalysis of acetaminophen, a popular analgesic drug that is frequently detected in effluents and surface water bodies. Reactive oxygen species, such as superoxide radicals ($O_2^{\bullet -}$) and hydroxyl radicals ($HO^{\bullet}$), were proven to be involved in the degradation of the target pollutant, and the material can be reused for six cycles without activity loss, being attractive for solar-driven continuous reactions.

The seventh paper—"Occurrence and Removal of Priority Substances and Contaminants of Emerging Concern at the WWTP of Benidorm (Spain)" [10] (https://www.mdpi.com/2015410, accessed on 23 January 2023) investigates the appearance and elimination of 12 priority substances (EU) and 16 emerging pollutants (five of them are included in EU watch lists) in Spanish wastewater treatment plants (WWTPs) during a year of experimentation. The authors verified that the appearance of micropollutants in the WWTP effluents were not regular, i.e., they depended on the time of the year. Diuron and carbamazepine, a pesticide and an anti-epileptic drug, respectively, are compounds that presented 0% of removal, which indicates the need for complementary treatments able to reduce their concentrations in the WWTP effluent below the regulatory standards.

The eighth paper—"Experimental Design and Bioassays as Tools to Investigate the Impact of Anodic Oxidation on Progestins Degradation" [11] (https://www.mdpi.com/2027992, accessed on 23 January 2023) is a study employing an electrochemical advanced oxidation process (EAOP) to degrade hormones typically present in contraceptive pills: levonorgestrel (LNG) and gestodene (GES). These hormones are not fully metabolized by humans, being eliminated via urine and ending up in the environment. Their accumulation in the environment poses great concern given their endocrine disrupting activity upon several organisms, and they are extensively documented regarding their toxicicty towards aquatic organisms. The authors used an experimental design called "central composite design" to determine the EAOP experimental conditions, which simultaneously allow low energy consumption, high removal ($\geq$70%) of progestogens. and estrogenicity reduction in different water matrices. This study contributes important knowledge regarding the future application of such technologies at an industrial scale.

4. Conclusions

This Special Issue provides a collection of papers with updated information regarding micropollutant detection and the removal of the same from urban waters. The achievements presented in these papers can be of great utility in improving the water treatment procedures employed nowadays, or even to help environmental policy-making and regulation. From novel advanced water treatment techniques to practical information regarding the most frequently occurring micropollutants in urban waters, these papers provide direct and actionable links between scientific research and practice. However, it is important to bear in mind that new chemicals are being launched continuously to answer daily needs, which leads to a constant introduction of micropollutants into the environment. It is thus of extreme importance to ensure that continuous research is advancing in this field.

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References

1. UNICEF. Water Scarcity. Available online: https://www.unicef.org/wash/water-scarcity (accessed on 24 January 2023).
2. UN General Assembly. Transforming Our World: The 2030 Agenda for Sustainable Development, A/RES/70/1. 21 October 2015. Available online: https://www.refworld.org/docid/57b6e3e44.html (accessed on 25 January 2023).
3. Kamaz, M.; Wickramasinghe, S.R.; Eswaranandam, S.; Zhang, W.; Jones, S.M.; Watts, M.J.; Qian, X. Investigation into Micropollutant Removal from Wastewaters by a Membrane Bioreactor. *Int. J. Environ. Res. Public Health* **2019**, *16*, 1363. [CrossRef] [PubMed]
4. Katsumata, C.P.; Parizi, M.P.S.; Lastre-Acosta, A.M.; Teixeira, A.C.S.C. Low Pressure UV Photolysis of the Pharmaceutical Compounds Acetaminophen, Atenolol, Bezafibrate, Diclofenac and Ibuprofen. *Water* **2022**, *14*, 3165. [CrossRef]
5. Silva, B.S.; Ribeiro, M.C.B.; Ramos, B.; de Castro Peixoto, A.L. Removal of Amoxicillin from Processing Wastewater by Ozonation and UV-Aided Ozonation: Kinetic and Economic Comparative Study. *Water* **2022**, *14*, 3198. [CrossRef]
6. Neef, J.; Leverenz, D.; Launay, M.A. Performance of Micropollutant Removal during Wet-Weather Conditions in Advanced Treatment Stages on a Full-Scale WWTP. *Water* **2022**, *14*, 3281. [CrossRef]
7. Shah, S.S.; Ramos, B.; Teixeira, A.C.S.C. Adsorptive Removal of Methylene Blue Dye Using Biodegradable Superabsorbent Hydrogel Polymer Composite Incorporated with Activated Charcoal. *Water* **2022**, *14*, 3313. [CrossRef]
8. Souza, L.P.; Carneiro, J.G.M.; Lastre-Acosta, A.M.; Ramos, B.; Teixeira, A.C.S.C. Environmental Persistence of the Antidepressant Fluoxetine and Its Pharmaceutical Alternative: Kinetics of Oxidation and Mathematical Simulations. *Water* **2022**, *14*, 3536. [CrossRef]
9. Gusmão, C.d.A.; Borges, L.T.; Palharim, P.H.; Otubo, L.; Rodrigues, O.; Gouvea, D.; Ramos, B.; Teixeira, A.C.S.C. Synthesis, Characterization, and Application of Pt/PtO_2-TiO_2/SiO_2 Materials on a Continuous Flow Packed Bed Microreactor for Enhanced Photocatalytic Activity under Sunlight. *Water* **2022**, *14*, 3864. [CrossRef]
10. Alexa, E.T.; Bernal-Romero del Hombre Bueno, M.d.l.Á.; González, R.; Sánchez, A.V.; García, H.; Prats, D. Occurrence and Removal of Priority Substances and Contaminants of Emerging Concern at the WWTP of Benidorm (Spain). *Water* **2022**, *14*, 4129. [CrossRef]
11. de Jesus, J.M.S.; Argolo, A.d.S.; Tominaga, F.K.; Taqueda, M.E.; Bila, D.M.; Borrely, S.I.; Teixeira, A.C.S.C. Experimental Design and Bioassays as Tools to Investigate the Impact of Anodic Oxidation on Progestins Degradation. *Water* **2023**, *15*, 61. [CrossRef]