water

Editorial

Nature-Based Solutions for the Mitigation of Persistent and Emerging Contaminants

Pedro N. Carvalho [1,2,*] and Victor Matamoros [3,*]

1 Department of Environmental Science, Aarhus University, 4000 Roskilde, Denmark
2 WATEC—Centre for Water Technology, Aarhus University, 8000 Aarhus, Denmark
3 Department of Environmental Chemistry, Institute of Environmental Assessment and Water Research (IDAEA), Spanish National Research Council (CSIC), 08034 Barcelona, Spain
* Correspondence: pedro.carvalho@envs.au.dk (P.N.C.); victor.matamoros@cid.csic.es (V.M.)

check for updates

Citation: Carvalho, P.N.; Matamoros, V. Nature-Based Solutions for the Mitigation of Persistent and Emerging Contaminants. *Water* **2022**, *14*, 2105. https://doi.org/10.3390/w14132105

Received: 22 June 2022
Accepted: 23 June 2022
Published: 1 July 2022

Publisher's Note: MDPI stays neutral with regard to jurisdictional claims in published maps and institutional affiliations.

The Special Issue "Nature-Based Solutions for the Mitigation of Persistent and Emerging Contaminants" comprises seven papers, of which one is a review and six are full-research articles submitted by a diverse group of international colleagues.

Nature-based solutions (NBS) have been gaining attention in the recent years. Technologically, NBS can take different shapes and designs (e.g., natural and constructed wetlands, buffer strips, green walls, green roofs, or microalgae-based treatments), as well as a diversified range of applications. This Special Issue aimed at highlighting the latest findings in the application of NBS to control the water pollution of both persistent and emerging contaminants. In the end, the majority of the NBS covered by the current issue are constructed wetlands and biofilters.

Hexachlorocyclohexane (HCH, also known as lindane), despite being banned for several issues, still raises issues related to leaching form dump sites. Biochar amended biofilters have been proven to efficiently treat HCH and its transformation products in drainage water. Moreover, biodegradation functional genes for HCH isomers were confirmed in such systems [1], suggesting that biochar can be a good supporting material for removing persistent pollutants such as HCH in constructed wetlands.

At a time of concerns regarding climate change, the impact of desiccation and flooding extremes was studied for a unit process open water wetland designed for water treatment. A rehydrated biomat, which was naturally desiccated, re-established nitrate removal consistent with an undisrupted biomat demonstrating the resilience of such systems. However, sediment intrusion due to flooding had a negative impact on the biomat's photosynthetic activity and decreased its nitrate attenuation rates by nearly 50%. Overall, based on mechanistic inferences, the potential attenuation for trace organics was anticipated to follow similar trends to those of nitrate removal [2].

Vertical flow constructed wetlands showed a great potential for the removal of high concentrations of dimethyl phthalate, and potentially can be a good choice for the treatment of other phthalate esters released from plastics. An efficiency above 90% removal was observed, together with increased relative percentages of some microbial genera associated with nitrogen metabolism and the function of degrading aromatic hydrocarbons [3].

Vertical flow constructed wetland mesocosms showed a potential to treat wastewater contaminated with phenolic compounds. Nonylphenol and octylphenol were removed above 99%, while pentachlorophenol removal varied between 87% and 98%. The microbial richness, diversity, and dominance in the CWs substrate were generally not affected by phenolic compounds, and neither was the removal of organic matter and nutrients [4].

The resilience of an aerated horizontal subsurface flow treatment wetland was tested by simulating an aeration failure, while assessing the removal of emerging contaminants and the respective biological effects. During the interruption of the aeration, a deterioration in the water quality to a degree comparable to that of a conventional (non-aerated) horizontal subsurface flow wetland was observed. When the aeration was restarted, the performance of the system for removing pollutants recovered in a few days; however, not all bioassays have shown a full recovery [5].

To better understand the role of plant species in constructed wetlands towards treating carbamazepine, a hydroponic experiment was set up to study the capacity of the two ornamental plants, *Iris sibirica* and *Zantedeschia aethiopica*, for taking up, translocating, and accumulating this compound. The maximum tolerance threshold for carbamazepine for the two species was found to be 10 mg/L, while the compound accumulated mainly in the leaves of both species. Moreover, while 70% of the compound was removed from the solution, it was mostly metabolized by both species [6].

To close this special issue, a literature review focused on the state of the art of the attenuation of pesticides and antibiotics in wetland systems receiving non-point source runoff from urban and agricultural landscapes is included. The authors reviewed 181 primary studies, where the majority were related to pesticides (153) and only 29 to antibiotics. Fewer (16) studied influent mixtures of these compounds on nitrogen removal. Overall, large removal ranges have been reported for antibiotics (35–100%), pesticides (−619–100%), and nitrate–nitrogen (−113–100%). A significant knowledge gap remains concerning how wetland treatment systems are used to treat non-point source mixtures that contain nutrients, pesticides, and antibiotics [7].

Author Contributions: P.N.C. and V.M.: conceptualization, writing—original draft preparation, review, and editing. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Acknowledgments: We thank all authors for contributing to this Special Issue.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Amirbekov, A.; Mamirova, A.; Sevcu, A.; Spanek, R.; Hrabak, P. HCH Removal in a Biochar-Amended Biofilter. *Water* **2021**, *13*, 3396. [CrossRef]
2. Brady, A.R.; Vega, M.A.; Riddle, K.N.; Peel, H.F.; Lundeen, E.J.; Siegmund, J.G.; Sharp, J.O. Biomat Resilience to Desiccation and Flooding within a Shallow, Unit Process Open Water Engineered Wetland. *Water* **2021**, *13*, 815. [CrossRef]
3. Xu, Q.; Lu, S.; Yuan, T.; Zhang, F.; Wang, L.; Wang, P.; Wen, X.; Cui, L. Influences of Dimethyl Phthalate on Bacterial Community and Enzyme Activity in Vertical Flow Constructed Wetland. *Water* **2021**, *13*, 788. [CrossRef]
4. Montenegro, I.P.F.M.; Mucha, A.P.; Tomasino, M.P.; Gomes, C.R.; Almeida, C.M.R. Alkylphenols and Chlorophenols Remediation in Vertical Flow Constructed Wetlands: Removal Efficiency and Microbial Community Response. *Water* **2021**, *13*, 715. [CrossRef]
5. Sossalla, N.A.; Nivala, J.; Escher, B.I.; Reemtsma, T.; Schlichting, R.; van Afferden, M.; Müller, R.A. Resilience of Micropollutant and Biological Effect Removal in an Aerated Horizontal Flow Treatment Wetland. *Water* **2020**, *12*, 3050. [CrossRef]
6. Tejeda, A.; Zurita, F. Capacity of Two Ornamental Species (*Iris sibirica* and *Zantedeschia aethiopica*) to Take up, Translocate, and Accumulate Carbamazepine under Hydroponic Conditions. *Water* **2020**, *12*, 1272. [CrossRef]
7. Nottingham, E.R.; Messer, T.L. A Literature Review of Wetland Treatment Systems Used to Treat Runoff Mixtures Containing Antibiotics and Pesticides from Urban and Agricultural Landscapes. *Water* **2021**, *13*, 3631. [CrossRef]