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Editorial: Advances in ecotechnologies for the control of non-point source pollution in agricultural and urban watersheds

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Editorial on the Research Topic
Advances in ecotechnologies for the control of non-point source pollution in agricultural and urban watersheds

The rapid advancement of socio-economic development has led to a rapid increase in the transport of non-point source (NPS) inorganic contaminants, such as nitrogen, phosphorus, sediments, and metals, alongside organic pollutants like pesticides and pharmaceutical residues. NPS contaminants originate from both agricultural and urban sources, which in turn contaminate rivers, lakes, and reservoirs. In many areas around the world, these contaminants are directly discharged into aquatic ecosystems without undergoing treatment, primarily due to a lack of suitable treatment facilities. While both point source and NPS can impact river water quality, NPS are notably more challenging to manage and have emerged as the predominant contributors of pollutants in many water bodies (Kumwimba et al., 2018; Kumwimba et al., 2023a). NPS sources present greater complexity in control compared to point sources due to their reliance on catchment areas and environmental conditions. Recognizing the adverse effects of NPS in/organic contaminants on aquatic environments and human health, substantial efforts have been made to develop and implement strategies aimed at reducing NPS in/organic contamination in vital water resources.

This Research Topic comprises four articles. Kumwimba et al. synthesized current knowledge regarding key methods to address diffuse pollution stemming from agricultural and urban watersheds. They also delved into the primary purification mechanisms and influencing factors, facilitating a comprehensive and critical understanding of various control strategies to enhance diffuse pollution management. These authors discovered that the design of treatment systems, along with operational and environmental factors, plays a pivotal yet variable role in diffuse pollution treatment. Furthermore, the findings indicated that the combination or integration of constructed wetlands with other control technologies could augment the holistic purification of diffuse pollution compared to employing a singular method. The authors advocated for a systematic approach to diffuse pollution control, centered on three components: water, soil, and microbiota while maximizing the regulating services of agroecosystems via land use/cover types. They emphasized that future designs and management of plant-based water treatment systems should prioritize the provision of ecosystem services while balancing water pollutant retention and socio-economic benefits.

Amin et al. directed their focus towards the development of microextraction methods for the determination of sulfamethoxazole in water and biological samples. Their findings revealed that the extraction efficiency of sulfamethoxazole for both methods fell within the range of 92.44%–99.12%. These results indicate that the developed methods exhibit simplicity, sensitivity, and suitability for preconcentration of sulfamethoxazole in environmental water and biological samples.

In a study by Zúñiga-Estrada et al., the pollution removal performance of a field-scale bioretention cell constructed in a flood-prone urban semi-arid area was investigated. Initially, the researchers explored pollution sources at the site using hydrological modeling. Subsequently, they experimentally evaluated the elimination of pollutants in the bioretention cell during three actual storm events. Despite the bioretention cell showing poor removal of nitrates, its overall performance was comparable to or even better than the reports found in the literature. This observation underscores the potential of the proposed bioretention design for mitigating non-point pollution in semi-arid catchments, particularly during first-flush events, marking a significant achievement of the study.

Furthermore, within this Research Topic, Vaz et al. compiled bibliometric data concerning the utilization of phytoremediation as a strategy for treating fluoride-contaminated waters. Through their study, the bibliometric map illustrated the structured co-occurrence of terms into three major groups. These groups highlighted the investigation of using plants to remove fluoride from the environment from two perspectives: plant health and the search for tolerant and accumulator species, and sanitation, including public and environmental health. The authors also noted that certain macrophytes have been identified as accumulators, though consensus is lacking on specific physicochemical variables in the environment influencing the process of fluoride assimilation by these plants, including the impact of heavy metals. They further highlighted emerging approaches to optimize phytoremediation, such as utilizing phytohormones, growth-promoting bacteria, enriching the medium with sorptive materials like biochar, and genetic manipulation. Reports in the literature also mention combining the technique with filter media instead of solely relying on hydroponics, such as in constructed wetlands, which have shown promising results in terms of removal efficiency. Moreover, efforts should be directed towards improving biomass reuse in a safe and sustainable manner.

These collected papers presented new information contributing to our understanding of ecotechnologies in controlling the transport, transformation, and retention characteristics of NPS in/organic contaminants from agricultural and urban watersheds. Specifically, they advance our knowledge of the environmental drivers or factors influencing the removal of NPS in/organic contaminants, as well as management strategies.

Looking ahead, the future focus in this field is likely to center on several aspects. Firstly, examining the implications of plant-based water treatment system design and management while assessing their additional advantages and socioeconomic benefits alongside water pollution control. Secondly, although the studied treatment systems have demonstrated promising results in terms of pollutant removal at microcosm, mesocosm and field scales, studies in full-scale plant-based water treatment systems and long-term (e.g., 3–5 years) investigations remain limited. Further research in full-scale environments is crucial to enhancing treatment systems. Thirdly, efforts to improve system performance and sustainable operation at lower temperatures should delve into breeding cold-adapted biological populations (both macrophytes and microorganisms), integrating treatment systems with multiple strategies and/or other treatment processes, as well as employing rational design and operational approaches.

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