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EDITORIAL
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Editorial: Highlighting the Role of Microbes in Greener Wastewater Treatment

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Editorial on the Research Topic

Microbial Biotechnology for Wastewater Treatment

Large-scale industrialization around the world has resulted in the contaminations of natural waterways with heavy metals, polycyclic aromatic hydrocarbons (PAHs), and many other wastes that threaten drinking water supplies, poison the agricultural food chain, and are detrimental to the ecosystem health. Although physical and chemical technologies provide services to remediate polluted water, biotechnology can present green alternatives to wastewater treatment and water resource management. Much attention has been given to the use of microorganisms for detoxification of water and soil contaminated with USEPA priority list pollutants and other contaminants. By using microbial biotechnology, concentrations of oxidized water contaminants (e.g., perchlorates, heavy metals, nitrates, and chlorinated solvents) can be reduced while cogenerating methane, hydrogen, and electricity. Microbial communities need to be managed to ensure that they provide the desired service of waste reduction. Waste management goals can be achieved through coupling of the microorganisms with modern materials and physical and chemical processes.

This Research Topic entitled "*Microbial biotechnology for wastewater treatment*," contains four articles in total, including a paper review and three original research articles that describe advances in "green" wastewater treatment through biotechnological applications that include bioremediation, phytoremediation, and biomineralization.

The rapid growth of the aquaculture industry over recent decades has resulted in a significant increase in saline wastewater, which contains high concentrations of nutrients, organic compounds, and total nitrogen, requiring significant treatment prior to discharge to meet environmental regulations. Biological treatment approaches such as bioaugmentation are attractive candidates for implementation due to their lower infrastructure and running costs relative to physicochemical treatment approaches. The present review by Anh et al. identified the major biodegradable components in saline fish wastewater that may result in deleterious effects upon discharge. The review discussed the current methods used in aquaculture for the treatment of wastewater processes, and identified the opportunities for improved processes to be utilized and knowledge gaps that require further attention.

Nitrogen pollution is a global problem and innovative mechanisms to treat wastewater are required to be developed. Removal of nitrogen as hydroxylamine could effectively improve wastewater treatment efficiency. In the study of Wang et al., the authors describe the isolation of a novel alkali-tolerant bacterium *Bacillus thuringiensis* EM-A1 and its ability to remove

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hydroxylamine through a hybrid heterotrophic nitrification-aerobic denitrification pathway was evaluated. Ultimately, the author demonstrated ammonium was completely consumed by strain EM-A1, and the removal efficiencies of NO_2^--N and NO_3^--N by strain EM-A1 were 100% and 76.67%, respectively. These results indicated that *B. thuringiensis* EM-A1 is a promising candidate for bioremediation of inorganic nitrogen from wastewater.

The aerobic granular sludge (AGS) process is widely applied for wastewater treatment. In the original research of Paulo et al., fish canning wastewater was treated by an AGS process after removing salinity and fat content from the raw fish canning wastewater. The authors investigated organic loading rate, C/N ratio were investigated under three different phases. The treatment efficiency was assessed by measuring biochemical characteristics (COD, ammonia, total nitrogen, total organic carbon, carbon to nitrogen ratio and salinity) in the three different phases. The morphological and structural changes in the granules were analyzed by quantitative image analysis and principle component analysis (PCA). The microbial community and its diversity in the three different phases were identified through genomic DNA extraction, next-generation sequencing and microbial metabolic function prediction. The authors found a remarkable resiliency of AGS community composition and the capacity of nitrification activity to adjust in response to the varied operational conditions.

The use of low-cost bioaugmented biochar in wastewater treatment to enhance the removal and degradation of emerging contaminants has been receiving attention in recent years. The study by Limbergen et al. describes the potential of three types of biochar—coffee bean husks, wood waste mix, and date palm fiber wood, produced at four different temperatures (350°C, 450°C, 500°C, and 550°C)—with regard to the adsorption and degradation of pesticides (thiacloprid, primicarb) and pharmaceuticals (diclofenac, ibuprofen). Their work shows that selected wood-waste feedstocks and low pyrolysis temperature can produce environmentally-safe biochars that have suitable characteristics to sorb emergent pollutants from water. These materials could be further studied in multi-pollution sorption/competition experiments, and in larger environmental wastewater treatment systems.

Overall, biological treatment has become one of the main strategies in wastewater remediation because of its unique advantages, such as the safety and reusability of remediation materials. With the rapid development of sequencing and mass spectrometry technologies, meta-omics is adopted in wastewater bio-treatment to reveal the structure and function traits of key microbial community, as well as detect various contaminants and their transmission mechanism. In practical use, it is still difficult to treat polluted water simply by biological treatment. Research work needs to be done on the cultivation and domestication of microorganisms as well as the mechanism of waste reduction. In future practice, integrating microorganisms with modern materials and physiochemical processes is expected to improve treatment efficiency.

AUTHOR CONTRIBUTIONS

LW and XL drafted the manuscript. NK and MC made the edition. All authors approved the final version.

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