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Emerging Industrial Pollutants in Aquatic Systems: Monitoring, Risk Evaluation, and Green Remediation Strategies

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Abstract

Aquatic ecosystems are increasingly threatened by the emergence of newly industrializing pollutants such as personal care products, pharmaceuticals, and endocrine-disrupting chemicals. The majority of these pollutants are not effectively removed by traditional wastewater treatment and accumulate in rivers, lakes, and coastal waters, posing gigantic threats to aquatic organisms and human health. This review addresses the monitoring of newly identified pollutants in aquatic environments, focusing on the use of advanced analytical techniques, such as liquid chromatography-mass spectrometry (LC-MS) and high-resolution mass spectrometry (HRMS), for the identification of trace concentrations. It also addresses the risk assessment of these contaminants, with emphasis on the challenges in assessing their long-term environmental and ecological impacts. Green remediation technologies, such as phytoremediation, bioremediation, and natural sorbents, offer green alternatives to chemical remediation. The overview presents a comprehensive overview of the effectiveness and limitations of these technologies, with focus on applicability for large-scale use in industrial settings. Furthermore, the application of bioindicators in assessing ecosystem health as well as pollutant bioaccumulation is addressed. This article ends by urging for holistic monitoring and remediation models that combine cutting-edge technologies with green approaches to address the new challenges posed by industrial contaminants in aquatic ecosystems.

Keywords: Industrial contaminants, aquatic ecosystems, monitoring, risk assessment, green remediation, bioindicators.

