Editorial

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Editorial: Assessment of environmental risk and challenges in addressing emerging pollutants: current and future perspectives

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Editorial on the Research Topic
Assessment of environmental risk and challenges in addressing emerging pollutants: current and future perspectives

Industrial wastewater is a pressing issue due to significant water and chemical usage in production, leading to the discharge of harmful micropollutants, toxins, and lethal substances into the environment without proper treatment. Employing eco-friendly biological treatment systems involving microorganisms like bacteria, fungi, and enzymes is crucial for detoxifying such contaminated water. Hence, urgent measures are needed to develop sustainable methods for treating emerging pollutants in wastewater to safeguard the environment. The toxicity of emerging pollutants poses a global environmental concern, including rare Earth elements, micro/nano plastics, antibiotics, and pharmaceuticals. Inadequate treatment systems discharge many of these hazardous compounds, challenging their detection due to their adverse effects even at low concentrations. Nano/micro-scale physical pollutants add complexity, while the fate, transport, and toxicity of these contaminants remain unclear. Understanding their behaviours and advancing remediation techniques is critical to mitigating the ecosystem exposure risks.

Emerging pollutants, largely unregulated, are found in drainage systems, medication residues, household products, and agricultural runoff. Predominantly organic compounds, their fate, toxicity, and mitigation strategies remain ambiguous. Research aimed to uncover the occurrence, sources, and treatment of emerging pollutants in industrial wastewater through conventional and advanced technologies. Five state-of-the-art publications were generated under this flagship.

Gao et al., reported the presence of pharmaceuticals in the aqueous environment has had adverse effects on both human health and the balance of ecosystems. Removing

pharmaceutical contaminants using conventional treatment technologies has proven challenging. To effectively degrade carbamazepine (CBZ), a common antiepileptic drug, three plasma discharge modes were investigated: liquid-phase discharge, air gas-liquid jet, and dielectric barrier discharge. Their results showed the highest levels of degradation efficiency and energy yield (0.11 g/kWh), achieved while operating at 225 W input power under liquid-phase discharge, surpassing the other discharge modes. In this research article, parameters such as concentration, electrode distance, volume, input power, and discharge frequency were systematically evaluated and optimized. Plasma emission spectroscopy revealed that the degradation process is primarily attributed to reactive oxygen species (ROS), with the role of reactive nitrogen species being insignificant. The potential degradation intermediates and pathways of CBZ were investigated and analysed using liquid chromatography-mass spectrometry (LC-MS). Considering aspects such as cleanliness, degradation efficiency, and application feasibility, the liquid-phase discharge treatment emerges as a promising technology for water treatment. Their comprehensive approach highlights the potential of this method for effectively addressing pharmaceutical contamination in aquatic environments.

Wang et al., further reported the contamination of per- and polyfluoroalkyl substances (PFAS) in the rivers of Shandong, China. They investigated the spatiotemporal variations, mass discharges, and ecological risks of PFAS by collecting surface waters seasonally at the estuaries of 13 major rivers in Shandong. Among the compounds that were studied, two novel perfluoroalkyl ether carboxylic acids, hexafluoropropylene oxide-dimer acid (HFPO-DA) and hexafluoropropylene oxide-trimer acid (HFPO-TA), along with 10 legacy PFAS. All were detectable, and their total concentrations (∑PFAS) exhibited a wide range from 23 to 25,400 ng/L. Elevated levels of all target compounds were notably observed in the Xiaoqing River, although the Majia and Jiaolai Rivers also raised concerns. Perfluorooctanoic acid (PFOA) stood out as dominant across all rivers, with its concentration in the Xiaoqing River estuary exhibiting a six-fold increase from 2011 to 2014 and stabilizing during 2014–2020. The absence of significant seasonality in PFAS concentrations in rivers with seasonal flows in their study suggests different emission patterns, possibly higher emissions during the wet season and lower emissions during the dry season. A proposed parameter, the ratio of maximum to minimum concentration (C_{max}/C_{min}), aimed to characterize the influence of local point sources, with a wide range observed from 10 to 14,000. The Xiaoqing and Yellow Rivers were identified as discharging approximately 98% of the ∑PFAS flux into the sea, estimated at 28.0 tons in 2020. Their study highlighted the need to focus on industrial emission patterns of PFAS and emphasizes the necessity for further investigations with higher time resolution to comprehend the emission dynamics of PFAS in Shandong.

Li et al., highlighted the viability of immobilized microbial technology in combatting water pollution. They stressed the importance of understanding microorganisms in immobilized biochar for effective contaminant removal. Several challenges were identified, including microporous structure blockage hindering microbe-pollutant contact, unstable microbial loading, and extended cycle times. Their study focused on *A. faecalis* immobilization on rice hull biochar for phenol degradation. *A. faecalis* JH1 effectively removed 300 mg/L of phenol in 24 h. Phenol adsorption by rice husk biochar increased with higher pyrolysis temperatures (700°C > 500°C > 300°C). Using 700°C biochar, JH1 achieved 249.45 nmol P/g of immobilized biomass. Remarkably, JH1 consistently eliminated 300 mg/L of phenol within 12 h after six cycles. Bacterial growth formed a robust biofilm, accelerating phenol removal. Their study emphasized the strong adherence of *A. faecalis* to rice hull biochar and its efficient phenol degradation. Overall, their findings demonstrate *A. faecalis* potential for effective, durable phenol removal when immobilized on rice hull biochar.

Rana et al., used nuclear and conventional methods to analyse metal pollutants in Islamabad-Rawalpindi's groundwater (the "twin cities"). Of the 122 samples they have studied, most met aesthetic and WHO/PSQCA standards for parameters like pH, copper, and zinc. However, elevated electrical conductivity and dissolved solids made 9.83% and 4.09% of samples unsuitable for drinking. Lead and iron exceeded safe limits. Anthropogenic and geogenic factors, like waste disposal and over abstraction, contributed to metal presence. The water quality index revealed poor groundwater quality due to high metal levels. Isotopic data highlighted vulnerability to various sources. This underscores the impact of urbanization, waste mismanagement, and lack of water policies on groundwater quality. Regulating abstraction and improving treatment systems are urgent. Their findings aid in strategizing to improve water quality in the "twin cities."

Ibrahim presented a review elaborating on how the COVID-19 pandemic has significantly affected public health, economies, social life, and the environment worldwide. While much research has focused on medications like antivirals and vaccines, studies on their environmental impact, especially in the water sector, are limited. The review provided a comprehensive summary of COVID-19's effects on water, covering detection methods, virus presence in wastewater, transmission probabilities, variant detection, and both positive and negative impacts on the water sector. It offers recommendations for governments, policymakers, water treatment plants, the public, and researchers to minimize its effects and prepare for future pandemics. They aim is to highlight the pandemic's various aspects and suggest measures to reduce its impact and that of potential future pandemics.

Overall, this Research Topic provided valuable insights into environmental challenges stemming from industrial wastewater, emphasizing the urgency of sustainable treatment methods for emerging pollutants. The focus on the COVID-19 pandemic highlighted its multifaceted impact on public health, the economy, and the environment, particularly in the water sector. Additionally, it delved into research concerning microbial technology in water pollution mitigation and the need for a holistic approach to understand and address environmental concerns. Overall, these Research Topic underscore the significance of proactive measures, interdisciplinary research, and innovative solutions to tackle contemporary global challenges.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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