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Editorial: Legacy & emerging contaminants in the aquatic environment—bridging knowledge, policy, and future

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Editorial on the Research Topic
Legacy & emerging contaminants in the aquatic environment-bridging knowledge, policy, and future

1 Introduction

Aquatic ecosystems are increasingly under threat from a complex mixture of contaminants, including legacy and emerging. Historically, great focus has been given to legacy pollutants such as polychlorinated biphenyls (PCBs), dichlorodiphenyltrichloroethane (DDT), mercury, and heavy metals—substances known for their environmental persistence, bioaccumulative potential, and long-term ecological and human health impacts (Qadeer et al., 2020; Qadeer et al., 2019; Yang et al., 2019; Wang et al., 2018; Hoskins, 2003). Despite regulatory bans or restrictions in many regions (Gao, 2024; Zimmerman and Anastas, 2015; Qadeer et al., 2022a), these chemicals persist in sediments, biota, and water bodies due to their resistance to degradation, thereby causing lasting ecological disruption (Qadeer et al., 2019; Suedel et al., 1994; Streets et al., 2006; Huang et al., 2022; Coelho et al., 2016).

Concurrently, the scientific community is now contending with a new generation of pollutants, broadly referred to as emerging contaminants. These cover a vast number of chemicals, including but not limited to pharmaceuticals (Katsikaros and Chrysikopoulos, 2021), personal care products (Kachhawaha et al., 2021), microplastics (Biginagwa et al., 2016; Qadeer et al., 2021), plasticizers (Qadeer et al., 2022a; Qadeer et al., 2022b; Zhong et al., 2018), nanomaterials (Noguera-Oviedo and Aga, 2016; Li et al., 2021) and industrial additives such as per- and polyfluoroalkyl substances (PFAS) (Liu et al., 2023; Shen et al.,

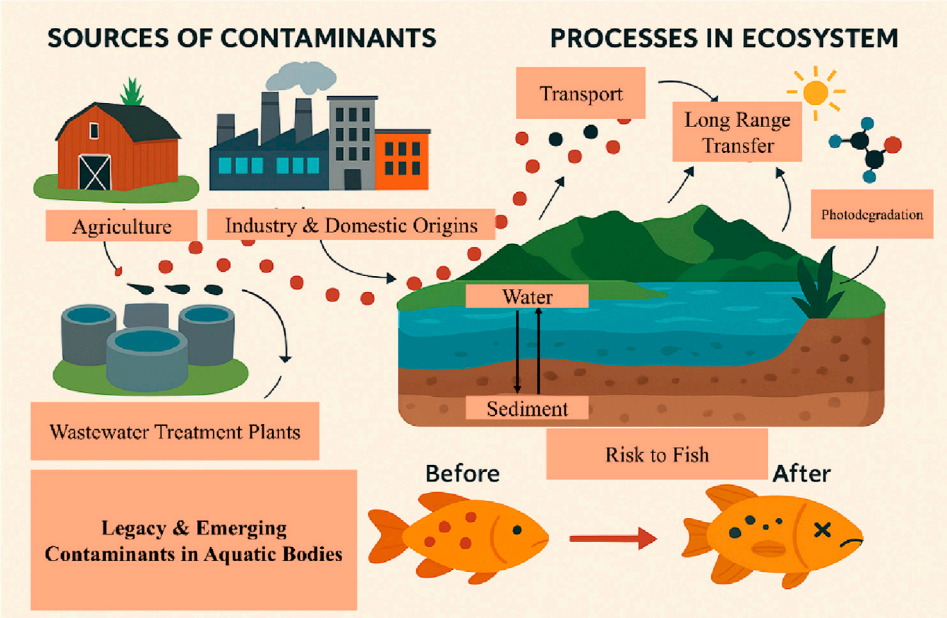

FIGURE 1
This is a general conceptual illustration of the sources, environmental processes, and ecological risks of legacy and emerging contaminants in aquatic ecosystems.

2018) and flame retardants (Noguera-Oviedo and Aga, 2016). Although these chemicals enter the environment through similar processes as legacy pollutants, they are, in general, more poorly monitored and largely unregulated. Our understanding of their long-term impacts remains limited, but growing evidence suggests they can induce sublethal toxicity, disrupt endocrine systems, impair reproduction, and interact synergistically with other stressors to amplify ecological harm (Qadeer et al., 2021; Zota et al., 2018; Folkerson et al., 2023; Ateia and Scheringer, 2024; Roepke and Sadlier, 2021). A general diagram of their sources, transport and risks of legacy and emerging contaminants is provided in Figure 1.

Together, legacy and emerging contaminants present a dual environmental threat to aquatic systems. Their co-occurrence and chemical mixture interactions necessitate urgent, coordinated efforts to reconsider and reshape traditional monitoring frameworks, risk assessment models, and management strategies. Addressing these interconnected challenges requires not only scientific advancement but also effective integration into environmental policy and on-the-ground practice.

2 Overview of the special issue

This Research Topic, "Legacy & Emerging Contaminants in the Aquatic Environment," features 11 original research articles, offering critical insights into the occurrence, fate, toxicity, and mitigation strategies of both legacy and emerging contaminants across diverse aquatic environments. This collective intellectual property represents efforts from a broad geographic and thematic scope, addressing both long-established and novel pollutants that are gaining increasing scientific and public attention.

Highlights include studies evaluating the impacts of microplastics on marine microbial communities, the toxicological effects of pesticide mixtures on zebrafish embryos, and spatial analyses of phosphorus distribution—linking land use to nutrient runoff. Innovative remediation approaches are also presented, such as the use of hydrothermal charcoals for uranium adsorption and salinity regulation techniques for controlling algal off-flavor compounds in aquaculture systems.

Other contributions examine the presence and distribution of chlorinated paraffins and dechloranes in subarctic lake sediments and biota, the vulnerability of karst aquifers to emerging organic pollutants, and the bioaccumulation of flame retardants in marine fish. A comprehensive assessment of agricultural pesticide residues in European surface waters further emphasizes the complexity of spatial variability and cumulative ecological risks. Collectively, these studies showcase the depth and breadth of current research and underscore the importance of bridging scientific findings with policy development and practical intervention.

3 Bridging science with policy and the future

Effectively addressing legacy and emerging contaminants requires not only scientific knowledge, progress, and breakthroughs but also their timely translation into actionable policy and environmental management strategies. Beyond significant advancements in detection techniques, monitoring, and risk assessment models, scientific findings should be more effectively integrated into regulatory frameworks. Bridging this gap calls for interdisciplinary collaboration among scientists, policymakers, industry professionals, and public health

authorities. By fostering evidence-based policymaking, encouraging stakeholder engagement, and integrating research into local and international regulations, we can enhance the real-world impact of environmental science and promote sustainable stewardship of aquatic ecosystems.

Although progress has been made, critical knowledge gaps still hinder comprehensive contaminant management. In particular, the effects of contaminant mixtures—often more complex and potent than individual compounds remain poorly understood, especially under realistic environmental conditions. There is also a shortage of long-term monitoring data for many emerging contaminants, limiting our ability to assess chronic exposure risks across trophic levels. Furthermore, the fate, transport, and transformation of emerging pollutants in aquatic systems are still largely uncharted.

To address these gaps, future research must prioritize developing integrated monitoring systems, advanced modeling tools, and high-resolution analytical techniques. Studies should also focus on the interactive and cumulative effects of chemical mixtures to reflect real-world exposure scenarios. Strengthening global research collaboration, harmonizing environmental standards, and promoting open-access data sharing will be essential for accelerating this progress. Additionally, engaging local communities, industry partners, and civil society will enhance the implementation of practical, context-specific solutions to aquatic pollution.

Author contributions

AQ: Conceptualization, Formal Analysis, Investigation, Software, Writing – original draft, Writing – review and editing. ML: Investigation, Validation, Writing – original draft, Writing – review and editing. SM: Investigation, Validation, Writing – review and editing. RL: Investigation, Validation, Writing – original draft, Writing – review and editing.

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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.

Generative AI statement

The authors declare that Generative AI was used in the creation of this manuscript. The English language was refined using Grammarly and ChatGPT, and Figure 1 was generated with the assistance of ChatGPT, but manually modified with PowerPiont. The authors take full responsibility for the content, which was carefully reviewed to ensure its accuracy and credibility.

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References

Ateia, M., and Scheringer, M. (2024). From "forever chemicals" to fluorine-free alternatives. *Science* 385 (6706), 256–258. doi:10.1126/SCIENCE.ADO5019

Biginagwa, F. J., Mayoma, B. S., Shashoua, Y., Syberg, K., and Khan, F. R. (2016). First evidence of microplastics in the african great lakes: recovery from lake victoria nile perch and nile Tilapia. *J. Gt. Lakes. Res.* 42 (1), 146–149. doi:10.1016/j.jglr.2015.10.012

Coelho, S. D., Sousa, A. C. A., Isobe, T., Kim, J. W., Kunisue, T., Nogueira, A. J. A., et al. (2016). Brominated, chlorinated and phosphate organic contaminants in house dust from Portugal. *Sci. Total Environ.* 569–570, 442–449. doi:10.1016/j.scitotenv.2016.06.137

Folkerson, A. P., Schneider, S. R., Abbatt, J. P. D., and Mabury, S. A. (2023). Avoiding regrettable replacements: can the introduction of novel functional groups move PFAS from recalcitrant to reactive? *Environ. Sci. Technol.* 57 (44), 17032–17041. doi:10.1021/acs.est.3c06232

Gao, P. (2024). Chasing "emerging" contaminants: an endless journey toward environmental health. *Environ. Sci. Technol.* 58 (4), 1790–1792. doi:10.1021/acs.est.3c10630

Hoskins, J. A. (2003). Health effects due to indoor air pollution. *Indoor Built Environ.* 12, 427–433. doi:10.1177/1420326x03037109

Huang, Z., Qadeer, A., Zheng, S., Ge, F., Zhang, K., Yin, D., et al. (2022). Fatty acid profile as an efficient bioindicator of PCB bioaccumulation in a freshwater lake food web: a stable isotope guided investigation. *J. Hazard. Mater.* 423, 127121. doi:10.1016/J.JHAZMAT.2021.127121

Kachhawaha, A. S., Nagarnaik, P. M., Labhasetwar, P. K., and Banerjee, K. (2021). Pharmaceuticals and personal care products in aqueous urban environment of western India. *Water Environ. J.* 35 (4), 1302–1312. doi:10.1111/WEJ.12720

Katsikaros, A. G., and Chrysikopoulos, C. V. (2021). Occurrence and distribution of pharmaceuticals and personal care products (PPCPs) detected in lakes around the world - a review. *Environ. Adv.* 6, 100131. doi:10.1016/J.ENVADV.2021.100131

Li, F., Meng, X., Wang, X., Ji, C., and Wu, H. (2021). Graphene-triphenyl phosphate (TPP) Co-exposure in the marine environment: interference with metabolism and immune regulation in mussel Mytilus galloprovincialis. *Ecotoxicol. Environ. Saf.* 227, 112904. doi:10.1016/j.ecoenv.2021.112904

Liu, M., Qadeer, A., Anis, M., Ajmal, Z., Bekele, T. G., Wang, S., et al. (2023). "Occurrence of per- and polyfluoroalkyl substances (PFAS): a special reference to their monitoring, distribution, and environmental fate," in *Emerging aquatic contaminants one health framework for risk assessment and remediation in the post COVID-19 anthropocene*, 173–202. doi:10.1016/B978-0-323-96002-1.00001-8

Noguera-Oviedo, K., and Aga, D. S. (2016). Lessons learned from more than two decades of research on emerging contaminants in the environment. *J. Hazard. Mater.* 316, 242–251. doi:10.1016/j.jhazmat.2016.04.058

Qadeer, A., Ajmal, Z., Usman, M., Zhao, X., and Chang, S. (2021). Agricultural plastic mulching as a potential key source of microplastic pollution in the terrestrial ecosystem and consequences. *Resour. Conserv. Recycl.* 175 (July), 105855. doi:10.1016/j.resconrec.2021.105855

Qadeer, A., Kirsten, K., Ajmal, Z., and Xingru, Z. (2022b). Rebuttal to comment on "alternative plasticizers as emerging global environmental and health threat: another regrettable substitution?" Focus on DINCH as an example. *Environ. Sci. Technol.* 56, 5294–5297. doi:10.1021/acs.est.2c01849

Qadeer, A., Kirsten, K. L., Ajmal, Z., Jiang, X., and Zhao, X. (2022a). Alternative plasticizers as emerging global environmental and health threat: another regrettable substitution? *Environ. Sci. Technol.* 56 (3), 1482–1488. doi:10.1021/acs.est.1c08365

Qadeer, A., Sai, L., Min, L., Liu, X., Ajmal, Z., Huang, Y., et al. (2019). Historically linked residues profile of OCPs and PCBs in surface sediments of typical urban river networks, Shanghai: ecotoxicological state and sources. *J. Clean. Prod.* 231, 1070–1078. doi:10.1016/j.jclepro.2019.05.203

Qadeer, A., Saqib, Z. A., Ajmal, Z., Xing, C., Khan Khalil, S., Usman, M., et al. (2020). Concentrations, pollution indices and health risk assessment of heavy metals in road dust from two urbanized cities of Pakistan: comparing two sampling methods for heavy metals concentration. *Sustain. Cities Soc.* 53, 101959. doi:10.1016/j.scs.2019.101959

Roepke, T. A., and Sadlier, N. C. (2021). Reproductive toxicology: impact of endocrine disruptors on neurons expressing GnRH or kisspeptin and pituitary gonadotropins. *Reproduction* 162 (5), F131–F145. doi:10.1530/REP-20-0612

Shen, A., Lee, S., Ra, K., Suk, D., and Moon, H. B. (2018). Historical trends of perfluoroalkyl substances (PFASs) in dated sediments from semi-enclosed bays of korea. *Mar. Pollut. Bull.* 128 (January), 287–294. doi:10.1016/j.marpolbul.2018.01.039

Streets, S. S., Henderson, S. A., Stoner, A. D., Carlson, D. L., Simcik, M. F., and Swackhamer, D. L. (2006). Partitioning and bioaccumulation of PBDEs and PCBs in lake Michigan. *Environ. Sci. Technol.* 40 (23), 7263–7269. doi:10.1021/es061337p

Suedel, B. C., Boraczek, J. A., Peddicord, R. K., Clifford, P. A., and Dillon, T. M. (1994). Trophic transfer and biomagnification potential of contaminants in aquatic ecosystems. *Rev. Environ. Contam. Toxicol.* 136, 21–89. doi:10.1007/978-1-4612-2656-7_2

Wang, D., Wang, Y., Singh, V. P., Zhu, J., Jiang, L., Zeng, D., et al. (2018). Ecological and health risk assessment of PAHs, OCPs, and PCBs in taihu lake basin. *Ecol. Indic.* 92, 171–180. doi:10.1016/j.ecolind.2017.06.038

Yang, J., Qadeer, A., Liu, M., Zhu, J., Huang, Y., Du, W., et al. (2019). Occurrence, source, and partition of PAHs, PCBs, and OCPs in the multiphase system of an urban lake, shanghai. *Appl. Geochem.* 106, 17–25. doi:10.1016/j.apgeochem.2019.04.023

Zhong, M., Wu, H., Mi, W., Li, F., Ji, C., Ebinghaus, R., et al. (2018). Occurrences and distribution characteristics of organophosphate ester flame retardants and plasticizers in the sediments of the bohai and yellow seas, China. *Sci. Total Environ.* 615, 1305–1311. doi:10.1016/j.scitotenv.2017.09.272

Zimmerman, J. B., and Anastas, P. T. (2015). Chemistry. Toward substitution with no regrets. *Science* 347 (6227), 1198–1199. doi:10.1126/science.aaa0812

Zota, A. R., Gellera, R. J., Romano, L. E., Coleman-Phox, K., Adler, N. E., Parry, E., et al. (2018). Association between persistent endocrine-disrupting chemicals (PBDEs, OH-PBDEs, PCBs, and PFASs) and biomarkers of inflammation and cellular aging during pregnancy and postpartum. *Environ. Int.* 115, 9–20. doi:10.1016/j.envint.2018.02.044