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Editorial

Editorial: thematic issue on microbial ecotoxicology

Imagine you are a microbe and you are exposed to chemical contamination. Will you be at risk? How will you react, and by which means? Just die? Express some form of adaptation using specific resistance mechanisms? Reduce toxicity of chemicals by degrading them, or by negative tactic movement? Tolerate their presence thanks to emergent properties of your surrounding microbial community? Express some other form of resilience and wait for better times, to return to a functional state after a more or less long period, depending on the intensity and toxicity of the contamination?

Alongside these questions that microbial ecotoxicologists are eager to answer, the question "Why do we need to preserve and monitor the integrity of environmental microbes and the communities they form?" has been at the core of the emerging multidisciplinary field of microbial ecotoxicology. Over the last decade, microbial ecotoxicologists have organized through the international EcotoxicoMic network (https://ecotoxicomic.org), which now counts 282 members from 46 countries. With three international conferences in 2017 (Lyon, France), 2020 (online due to the COVID pandemic), and 2022 (Montpellier, France), the network has addressed the interactions, effects, and risks of chemical exposure on microbial and environmental systems and generated new research perspectives. A forthcoming fourth international EcotoxicoMic conference will take place in Gothenburg (Sweden) on 12–14 November 2024 (https://ecotoxicomic.org/ecotoxicomic-2024).

Microorganisms have now become appreciated as keystone contributors in numerous ecosystemic processes (Cavicchioli et al. 2019), including but not limited to (i) cycling of carbon, nitrogen, phosphorus, iron, and sulfur; (ii) biological control of pathogens; (iii) attenuation of chemical pollution; (iv) production and consumption of greenhouse gases; (v) contribution to soil structure; and (vi) biomass nutrients for higher trophic levels. Microbial communities also constitute the richest genetic pool, which can be harnessed by biotechnology. All this very much speaks in favor of the fundamental role that microbial ecotoxicology can play in ecosystem preservation and functioning today.

Indeed, the high diversity, genetic plasticity, adaptability, and responses of microbes to chemical pollution provides a unique opportunity to discover and quantify chemical effects and associated risks to microbial communities and their crucial ecosystem functions, and to explore the responses of the microbial world, their impact on contaminant eco-dynamics, and associated risks to ecosystems and human health (Fig. 1). Thanks to the experimental approaches and technologies available today, current research ranges from laboratory studies of the detailed mechanisms of microbial gene expression linked to exposure to contaminants and their toxic effects in model organisms, to integrative studies of the complex responses of environmental microbial communities at field scales.

Given the high complexity of the investigated interactions, increasingly in-depth and integrative exploration of microbial responses is now clearly warranted and will contribute to the further development of the field of microbial ecotoxicology. The present thematic issue of *FEMS Microbiology Ecology* brings together a selection of three review articles and 12 original research papers representative of the research questions and experimental approaches that microbial ecologists develop in the broad field of microbial ecotoxicology today, as presented in part at the EcotoxicoMic 2022 Conference. The review articles provide a general overview of the field of the microbial ecotoxicology and its perspectives for development today (Hellal et al. 2023), as well as two more thematically focused contributions on the specific topics of microbial ecology-driven sustainable agriculture (Vermeire et al. 2024) and microbial treatment of wastewater from an industrial process (Reis et al. 2023). Several of the experimental papers deal with microbial transformation of contaminants, both organic (Bertrans-Tubau et al. 2023, Laffet et al. 2023, Paris et al. 2023, Vogel et al. 2024) and inorganic (Diaz-Vanegas et al. 2023, Glodowska et al. 2023, Laroche et al. 2023). One publication makes use of laboratory microcosms to investigate community-level resilience (eco-restoration) following chemical treatment to eliminate species-specific algal blooms (Cai et al. 2022). Another series of papers illustrates the diverse ways by which the response of microbial strains and communities to chemicals can be used for bioindication (Narciso et al. 2023), as well as for toxicological risk assessment for individual species (Helander et al. 2023) and higher-level biomes, e.g. microbial–plant interactions (Gkimprixi et al. 2023, Gréau et al. 2023).

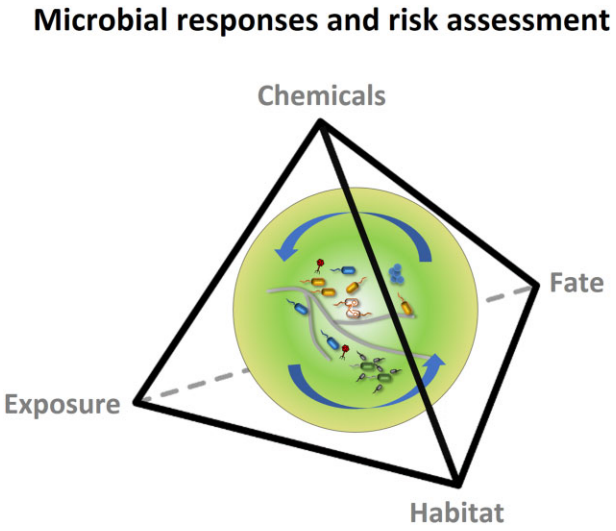

Figure 1. The microbial ecotoxicology tetrahedron for risk assessment of chemical pollution. Risks associated with chemical contamination can be assessed basing on the complex interplay of exposure of microorganisms and microbial communities to chemicals, contaminant bioavailability and toxicity, contaminant fate including the role of microbial transformation, and environmental conditions.

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Overall, this collection of articles provides a timely snapshot of current research in this dynamic and expanding field, and an exciting foretaste of the upcoming fourth EcotoxicoMic Network International Conference in Gothenburg in November 2024.

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