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Editorial: Emerging challenges and solutions for plastic pollution

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Editorial on the Research Topic
Emerging challenges and solutions for plastic pollution

1 Introduction

Without a change in policy and management, plastic waste is modeled to triple by 2060 compared to 2019 (OECD, 2022). Even with far-reaching actions, 710 million metric tons of plastic waste will enter environments between 2016-2040 (Lau et al., 2020). In this special issue, "Emerging Challenges and Solutions for Plastic Pollution," we invited articles exploring plastic pollution issues and hypothesizing solutions. The topic was broad to include diverse approaches as contributions from all stakeholders are needed to provide a full perspective on the plastic waste problem (Jambeck et al., 2015; Borrelle et al., 2020; Lau et al., 2020). The special issue is a transdisciplinary collection of articles from academia, nongovernmental organizations, and industry: (Diana et al., Fürst and Feng, Grabiel et al., Koongolla et al., Lauer and Nowlin, Morrison et al., Murphy et al., Stolte et al., 2022; and Alnahdi et al., Karasik et al., 2023).

2 Harm posed by plastic pollution to marine animals

Plastic pollution can harm marine animals through entanglement, ingestion, and additive leaching. For example, ninety-four percent of fish (n = 271) from the Beibu Gulf, South China Sea, had microplastics (< 5 mm) in the gill and gut (Koongolla et al., 2022). Microplastics may be consumed unintentionally as prey or intentionally *via* active feeding (Savoca et al., 2016; Allen et al., 2017; Savoca et al., 2017), exposing animals to plastic additives (Turner, 2018; Diana et al., 2020). Plastic exposure can induce the production of reactive oxygen species and result in gastrointestinal obstruction, translocation, and trophic

transfer among marine animals (Morrison et al., 2022; Yip et al., 2022a). Plastic leachates can be acutely toxic to aquatic animals (*e.g.*, barnacle larvae, *Ceriodaphnia dubia*) (Li et al., 2016; Thaysen et al., 2018).

3 Does plastic pollution harm human health?

Human plastic exposure is ubiquitous; however, health effects are poorly understood. Laboratory and occupational epidemiology studies link plastic exposure to respiratory irritation, cardiovascular disease, gut disturbance, inflammation, oxidative stress, and cancer (Morrison et al., 2022; World Health Organization (WHO), 2022). Human cells exposed to nanoplastics showed significant toxicity (Yong et al., 2020; Danopoulos et al., 2021; Mahadevan and Valiyaveettil, 2021). However, microplastics are diverse in their polymer type, shape, source, and chemical composition (Rochman et al., 2019), so laboratory studies greatly simplify real-world exposures, often by testing only one polymer type (World Health Organization (WHO), 2022). Plastics are associated with over 10,000 compounds, at least 2,400 of which have known toxicity issues (Hahladakis et al., 2018; Groh et al., 2019; Wiesinger et al., 2021). Though endocrine-disrupting Bisphenol-A and phthalates are frequently studied (Morrison et al., 2022), the health impacts of other plastic additives/mixtures are not well understood.

Plastics inequitably impact marginalized, low-income communities worldwide (Karasik et al., 2023; UNEP, 2021a). Plastic creates economic benefits and human health burdens across all lifecycle stages (Karasik et al., 2023). Benefits and burdens are intertwined: petrochemical industries provide convenient lifestyle support, economic benefits, and air and environmental pollution (Karasik et al., 2023). Diana et al. (2022) support Persson et al. (2022)'s assessment that plastics have crossed planetary boundaries; thus, society is beyond the "safe operating space" in which human activities can occur (Steffen et al., 2015; Persson et al., 2022).

4 Solutions

To address the harms to human and environmental health posed by plastic pollution (*e.g.*, Yong et al., 2020; Yip et al., 2022b), it is necessary to involve all stakeholders and utilize a variety of approaches (Worm et al., 2017; Lau et al., 2020), including policy-focused (Fürst and Feng, 2022; Grabiel et al., 2022; Lauer and Nowlin, 2022), technological (Morrison et al., 2022; Stolte et al., 2022; Alnahdi et al., 2023), industry-focused (Diana et al., 2022), and theoretical (Diana et al., 2022; Morrison et al., 2022; Murphy et al., 2022) responses (Figure 1).

Strong theoretical underpinnings support effective solutions to plastic pollution. A seascape ecology (SE) theoretical framework is recommended for examining spatially-explicit plastic pollution questions (Murphy et al., 2022). SE is transdisciplinary, multi-scale, and incorporates "governance systems, human actors, and ecological components … that contribute to patterns of plastic production, use, and pollution…" (quoted in Murphy et al., 2022). Diana et al. (2022) applied the four pathways to global sustainability, created by Folke et al. (2021), to plastic pollution interventions.

Governments worldwide have adopted policies to reduce plastic pollution (Xanthos and Walker, 2017; Schnurr et al., 2018; Karasik et al., 2020; Diana et al., 2022b). The United Nations Environment Assembly is drafting a legally-binding global treaty to reduce plastic pollution by 2024 (Simon et al., 2021). Researchers suggest using the Montreal Protocol as a model for the treaty, which includes fact-finding (*i.e.*, plastic production reporting, licensing, setting baselines) and policymaking stages (*i.e.*, phased decreases, production caps, independent assessments, exemptions for essential plastics) (Grabiel et al., 2022).

Consistent with global trends (Xanthos and Walker, 2017; Schnurr et al., 2018; Karasik et al., 2020; Diana et al., 2022b), Chinese governments adopted and implemented plastic pollution policies from January 2000 and June 2021, increasing 925% (Fürst and Feng, 2022). Policies frequently employed regulatory (*e.g.*, bans, limits) and information instruments (*e.g.*, education and outreach,

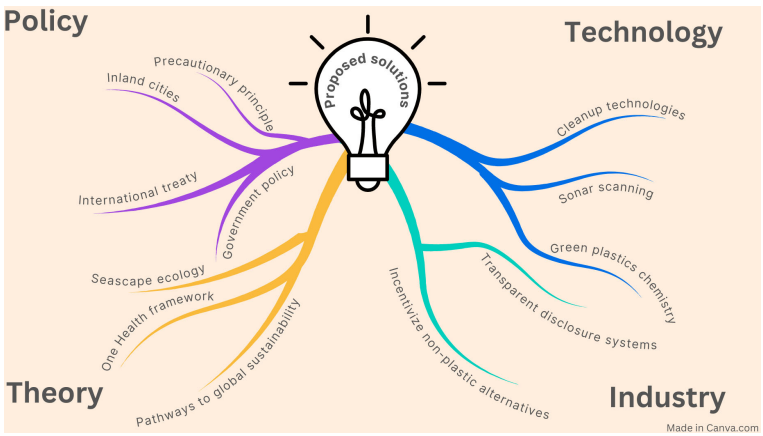

FIGURE 1
Proposed solutions to address plastic pollution.

campaigns) to target plastic waste and bags, but not plastic production (Fürst and Feng, 2022).

All stakeholders have an important role in reducing marine debris, as pollution generated inland can be transported to the ocean *via* rivers or the wind (Meijer et al., 2021; Napper et al., 2021; Youngblood et al., 2022). City governments, managers, and community groups may 1) collect data on dominant plastic litter or waste to understand the magnitude of the problem, 2) develop policies that reduce plastic consumption and waste, and 3) utilize controls (*e.g.*, stormwater covers, riverine booms) to capture and prevent pollution (Lauer and Nowlin, 2022). To be equitable, plastic bag fees should exempt low-income residents and distribute free reusable items (*e.g.*, cotton reusable bags, takeout containers) (Lauer and Nowlin, 2022).

Cleanup/bioremediation technologies and developing circularity concepts (Sheth et al., 2019; Schmaltz et al., 2020; Alnahdi et al., 2023) complement policies to reduce plastic pollution (Morrison et al., 2022; Stolte et al., 2022);. Compared to previous methods, the sonar approach led by Stolte et al. (2022) has greater success in removing lost fishing gear and is less destructive to seafloor ecosystems. Alnahdi et al. (2023) suggest developing a marine-microbial ecosystem to degrade microplastics, nanoplastics, and additives. Such plastic clean-up and bioremediation efforts may be incentivized; however, efforts to reduce plastic upstream need to be prioritized, such as eliminating unnecessary plastics production (UNEP, 2021b; Bergmann et al., 2022) and incentivizing reusable alternatives (Amon et al., 2022; Moss et al., 2022; Diana et al., 2022a). For those plastics that are necessary, further efforts should be made to produce fully recyclable plastics, have half-lives similar to the usage period, and incorporate biologically-compatible additives (Diana et al., 2022).

5 Conclusions

This special issue focused on articles related to plastic pollution issues and proposed potential solutions. Further research is needed to characterize human co-exposure to plastic chemical mixtures over time (Morrison et al., 2022) and develop sustainable plastic chemistry (Diana et al., 2022). Despite unknowns, researchers recommend applying the precautionary principle by regulating plastics (Karasik et al., 2023). Diverse stakeholder inputs are needed to reduce plastic pollution and reverse deleterious environmental and human health effects.

Author contributions

ZD provided the first draft of the manuscript. All authors reviewed and revised the manuscript. All authors contributed to the article and approved the submitted version.

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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.

Publisher's note

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