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Do river garbage patches exist?

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Main

Ocean garbage patches (OGPs) are the most evident example of artificial litter accumulation hotspots on the ocean's surface (e.g., Lebreton et al., 2018), presenting a unique opportunity for the effective removal of floating litter from the marine environment (Galgani et al., 2022). Recent evidence suggests that litter accumulation hotspots can also form on the water, in the sediments and in the vegetation of riverine ecosystems (Gallitelli and Scalici, 2023, 2024; Liro et al., 2022; Van Emmerik et al., 2022; Tasseron et al., 2024). These hotspots can form because rivers act both as carriers of land-produced litter to the sea and as long-term sinks for it (Liro et al., 2020; Gallitelli and Scalici, 2022; Van Emmerik et al., 2022). This trapped litter poses numerous risks to ecosystem functioning and human health (Galgani et al., 2022; Gallitelli and Scalici, 2023).

To stimulate future discussion on river garbage patches (RGPs), defined here as a concentrated accumulation of floating or surface-stored artificial litter in rivers, we outlined their key characteristics in comparison to OGPs (Figure 1). The key difference between these two types of garbage patches is that individual RGPs cover areas that are several orders of magnitude smaller than OGPs, yet they provide plastic abundances several orders higher.

For example, the plastic concentration in the Great Pacific Garbage Patch (GPGP), which is considered the oceanic garbage patch with the highest concentration of plastics, reaches ~70 kg/km^2 (0.07 g/m^2) and ~700,000 items/km (0.7 items/m^2) (Table 2 in Lebreton et al., (2018)). In contrast, hotspots of plastic accumulation in rivers (RGPs), especially in river channels and on riverbanks, exhibit values at least two orders of magnitude higher (e.g., Liro et al., 2022; Tasseron et al., 2024). For instance, the amount of macroplastic stored in wood jams in moderately polluted mountain rivers averages 9.5 items and 113 g per m^2 (Liro et al., 2022). Although this is a rough estimation, we should consider that it is likely an underestimation of macrolitter in rivers as very few studies currently address this issue (Liro et al., 2020; Van Emmerik et al., 2022). Most existing field and modeling works focus on plastic transport from rivers to oceans (Meijer et al., 2021; UNEP, 2020; González-Fernández et al., 2023; Morales-Caselles et al., 2021). Future research should focus on gathering more data on plastic abundance in river accumulation areas (RGPs) and estimating their global extent, ultimately enabling comparisons between the amount of plastic stored in RGPs and OGPs.

River ecosystems are recently hypothesized to function as litter sinks most of the time when large floods are not occurring (Liro et al., 2020; Van Emmerik et al., 2022; Gallitelli and Scalici, 2024); such events can lead to massive erosion of RGPs, resulting in plastic mobilization (Liro et al., 2020), fragmentation, and downstream transport (Van Emmerik et al., 2022). This ultimately contributes to the downstream dispersal of macroplastic (Liro et al., 2020; Van Emmerik et al., 2022) and production of secondary microplastic (Liro et al., 2023), increasing the related risks to biota and human health. It is important to notice that OGPs may not be fueled by riverine inputs to the ocean and only receive a small portion of land-based plastics (Lebreton et al., 2018; Morales-Caselles et al., 2021), given that most

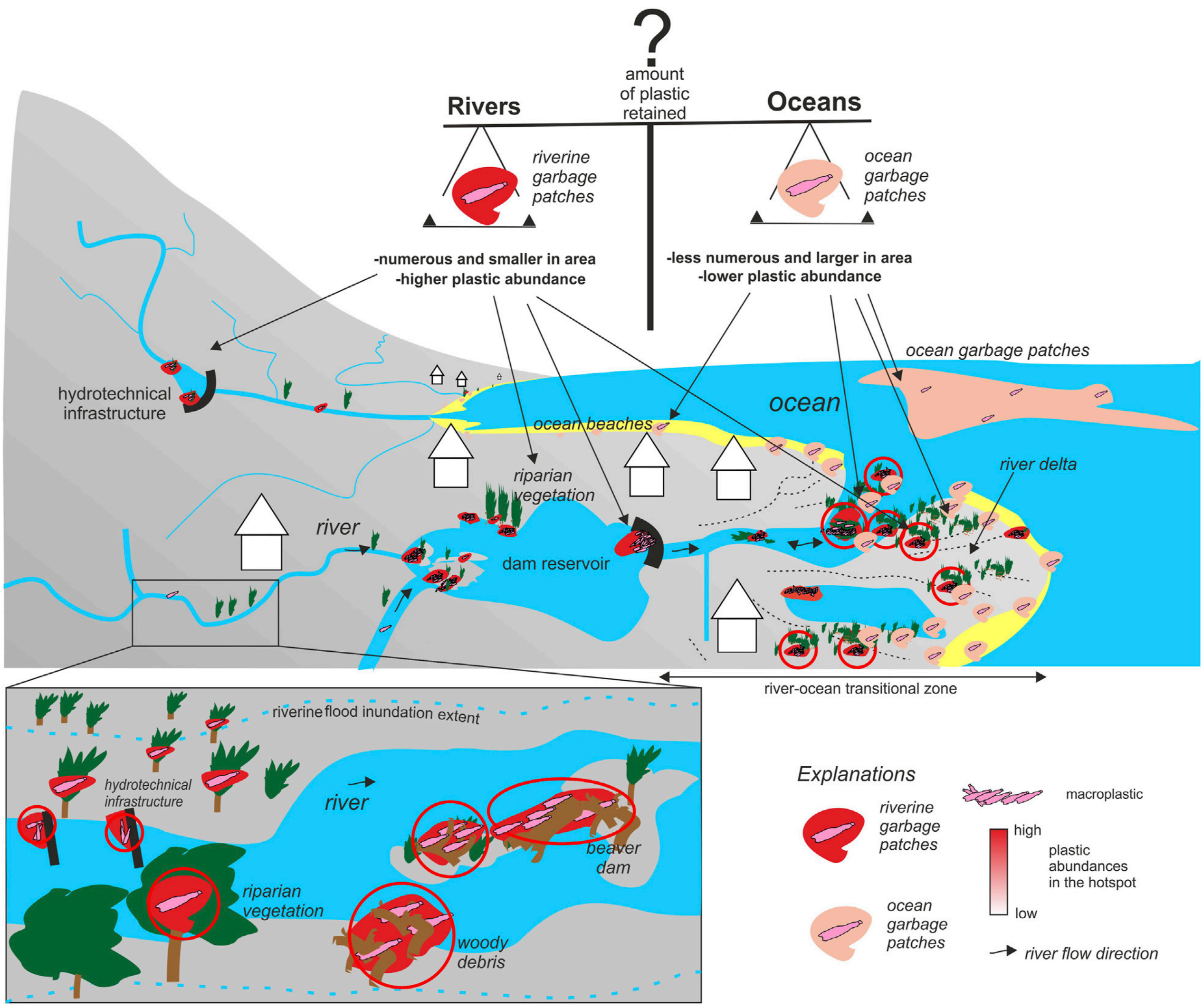

FIGURE 1
Plastic garbage patches in rivers and oceans. In the larger panel, from left to right, rivers flow through dam reservoirs and river deltas to the oceans. Most plastics remain within rivers, a situation further explained in the smaller panel on the left. In this panel, groynes, riparian vegetation, woody debris, and beaver dams are illustrated as potential local-scale sinks for macroplastics in rivers. During floods, rising water levels transport macroplastics out of the river channel, depositing them along the riverbanks and interacting with these elements.

land-based litter is trapped nearshore areas and only small fragments might reach the open ocean, apart from the sea-based sources (Morales-Caselles et al., 2021) (Figure 1).

Recent studies indicated that RGPs can vary considerably depending on the river characteristics (Tasseron et al., 2024). Due to complex hydromorphological and land cover patterns in riverine ecosystems, even at the local scale of an individual landscape or geomorphological unit, river garbage patches tend to be more localized and concentrated in specific areas within rivers (see e.g., Liro et al., 2022). This contrasts with ocean garbage patches, which are often large and widespread (Lebreton et al., 2018; Galgani et al., 2022). OGPs are typically surrounded by large areas of open water, while rivers in populated areas are enclosed by land with easier access for transportation. This increases the potential for removing litter hotspots through cleanup efforts or the implementation of engineering infrastructure. OGPs have a significantly larger surface area compared to individual river garbage patches (RGPs), and their size and location can shift over time, making their removal more challenging and costly. In contrast, RGPs generally remain stable throughout most of their existence, except during rare periods of mobilization caused by major floods (Liro et al., 2020; Van Emmerik et al., 2022; Gallitelli and Scalici, 2024).

Future outlook

Comparing the total amount of plastic in oceanic garbage patches to that in riverine patches is challenging due to the limited and often heterogeneous data available. Here, we highlight the specific features of these two types of plastic accumulation hotspots, suggesting potentially different opportunities and challenges for their removal from the environment. Since RGPs are more abundant in plastic, more widespread, accessible, scattered, and substantially smaller than OGPs, clean-up efforts through citizen science initiatives may be more effective for RGPs. Evaluating the cost-effectiveness of clean-up activities in both oceanic and riverine hotspots could be a crucial step in mitigating and addressing plastic pollution.

Author contributions

LG: conceptualization, investigation, project administration, software, supervision, validation, visualization, writing–original draft, and writing–review and editing. ML: conceptualization, funding acquisition, investigation, project administration, supervision, validation, visualization, writing–original draft, and writing–review and editing.

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Conflict of interest

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