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From headwaters to lowlands: microplastic uptake in freshwater macroinvertebrates across European rivers

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Freshwater river ecosystems provide essential services including biodiversity support, water purification, and ecosystem functioning, yet they are increasingly affected by anthropogenic pollution, particularly microplastics (<5 mm). Within the European Biodiversa+ RIPARI-ANET project, this study investigates spatial patterns of microplastic contamination across European river networks and evaluates the suitability of macroinvertebrates as bioindicators of exposure. Macroinvertebrates representing different functional feeding groups, Baetidae (grazers), Simuliidae (filter feeders), and Chironomidae (generalists), were sampled together with water across five European rivers spanning broad climatic and land-use gradients: Sävar (Sweden), Queich (Germany), Noce and Tiber (Italy), and Cávado (Portugal). Sampling followed longitudinal gradients from headwaters to downstream reaches, capturing variation in anthropogenic pressure and environmental conditions. Results show a general accumulation of microplastics in both water and organisms across all rivers, with highest levels observed in Portugal and Italy. Macroinvertebrates from downstream and more impacted sites exhibited higher ingestion rates, supporting a river continuum pattern of contamination. Among functional groups, Chironomidae consistently showed the highest microplastic loads, highlighting their sensitivity and potential as reliable bioindicators. Interestingly, microplastic accumulation was more strongly associated with land-use than with population density. Urban land use was linked to higher concentrations in water, while agricultural catchments were associated with increased individual organism loads, suggesting distinct pathways of input, transport, and retention. These findings emphasize the combined influence of longitudinal river gradients, land-use pressures, and functional traits in shaping microplastic exposure.

The study strengthens the evidence for using benthic macroinvertebrates as bioindicators and supports more targeted management strategies for mitigating microplastic pollution in freshwater ecosystems.