



MULTIPLE DRIVERS SHAPE THE FUNCTIONAL STRUCTURE OF BENTHIC MACROINVERTEBRATE COMMUNITIES IN A SUBTROPICAL WATERSHED

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Freshwater ecosystems are increasingly affected by multiple anthropogenic stressors, including land-use change, nutrient enrichment, and microplastics (MPs). These stressors can alter the functional structure of benthic macroinvertebrate communities, affecting ecosystem functioning and resilience. Functional Redundancy (FR) and community-weighted means (CWMs) of functional feeding groups (FFGs) provide mechanistic insights into how environmental filters shape stream communities. However, the combined influence of land use, water quality, and MPs on functional structure remains poorly understood in subtropical watersheds. The study was conducted in the Lageado São José watershed, southern Brazil, across 30 stream sites sampled during spring 2022 and autumn 2023. Macroinvertebrates were classified into five FFGs: collector-gatherers, collector-filterers, shredders, scrapers, and predators. FR and CWMs indexes were calculated from abundance-weighted functional composition. Environmental predictors included land use, physicochemical variables, sediment grain-size composition, and MP quantity and size. Functional variation was evaluated using piecewise structural equation models (SEM). Functional structure did not differ significantly between seasons, indicating stronger spatial effects. Predators and collector-gatherers dominated throughout the watershed, whereas shredders and scrapers showed consistently low representation. Functional redundancy varied moderately among streams. SEM analyses revealed predominantly indirect effects of land use on functional structure mediated by water quality. Forest cover positively affected nitrate concentration and stream depth by preventing erosion and sustaining steady water flow, while turbidity negatively affected dissolved oxygen. MP size was associated with urbanization and MP quantity, but MPs showed limited direct effects on FR and most FFGs. Predator dominance increased with nitrate concentration, suggesting that nutrient enrichment may favor higher trophic levels. Land use and water quality were the main drivers of functional organization in subtropical streams, whereas MPs exerted comparatively weak direct effects at the community level. Trait-based approaches proved effective for detecting functional reorganization associated with anthropogenic environmental gradients.

Keywords: *Functional redundancy; Functional feeding groups; Community-weighted means; Multiple stressors; Freshwater ecology.*