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Human activities through agricultural, urbanized, and industrial regions in a catchment produce anthropogenic nutrient releases into the aquatic environment. The human-induced nutrient sources are discharged toward receiving water bodies (e.g., rivers, lakes, and oceans) via diffuse or point pathways. Although travel time-scales are different between diffuse and point sources, they have significant potentials to impair the health of lotic and lentic ecosystems. In case of point sources, they are dominantly discharged from urban wastewater treatment plants (UWWTPs) under regulations to protect water-quality and aquatic ecosystems. While UWWTPs sizes are designed to meet the regulations and constrained by physical conditions (e.g., economy of scales), their locations within a catchment are not always determined to satisfy integrated viewpoints for environmental protection. Thus, unexpected adverse effects at a catchment scale are often observed in many catchments (e.g., algal blooms due to eutrophication).

Against this background, our research aims to explore how the specific loadings and location of UWWTPs are distributed along river networks, and to investigate which parts of a catchment are ecologically vulnerable due to nutrient (nitrogen and phosphorous) loads discharged from UWWTPs. To this end, we have analyzed country-scale data of 8,927 UWWTPs in Germany, and examine the size and location distributions not only for UWWTPs themselves, but also for individual nutrients loads, their superposition and spiraling length. Based on these results we developed a parsimonious model that can be used for assessing the ecological vulnerability of river networks to point sources nutrient loading in a spatially explicit way and for entire river networks.