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Risk Assessment of Climate Change Impacts on Urban Discharge Fraction and Eutrophication in Large European River Networks

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Climate change impacts on natural environments and human-built landscapes have been extensively studied from the meteorological, hydrological, agricultural, and urban point of views. Embracing the inevitability of climate change, there is a need for investigating and establishing adaptation strategies to changing climate conditions in order to protect essential resources for the survival of humans and ecosystems. Especially for surface water resources, water quality in rivers is a sensitive aspect which might be affected by the impact of climate change on hydrological regimes along river networks.

In fact, with a grand target of achieving Good-Ecological-Status for all European surface water bodies, the implementation of the EU Water Framework Directive since year 2000 has facilitated remarkable reductions of point-source nutrient loads discharged from municipal wastewater treatment plants (WWTPs) into rivers. Nevertheless, satisfying the environmental regulations at the emission-pipe-end of individual WWTPs has not guaranteed a perfect resolution of river water quality problems (e.g., eutrophication) at the scale of entire river basins. This likely occurred because decisions concerning WWTPs size and location were mainly influenced by the scale and location of residential areas and driven by efficiency purposes. That is, the hydrological, biogeochemical, and ecological characteristics of river water bodies receiving the WWTPs emissions were less likely to be considered. Climate-change-driven shifts of hydrological regimes in rivers could exacerbate the current situation and accelerate the water quality degradation caused by the urban emissions.

To tackle this issue, this study aims to decipher the interplays between WWTPs discharges and hydrological regimes of the receiving river water bodies, and to assess water quality risks due to WWTPs emissions under climate-change-induced alteration of hydrologic regimes, by using systematic and general tools at the scale of entire river networks (e.g., combined dimensions of stream-orders and WWTP-sizes). To this end, we synthesize the EU-scale reliable dataset for river networks and WWTPs and the simulation results of the mesoscale hydrologic model under a climate change scenario. We focus on nutrient concentrations (NH4-N, total P) and urban discharge fraction from WWTPs (i.e., the fraction of treated wastewater in river flows), performing the risk assessments for three large European river basins. Our diagnostic results at the river-

network-scale could assist river basin managers and stakeholders to select WWTPs to be preferentially managed for minimizing water quality risks in the future under climate change. The presented concept here for the specific components is generally applicable to assess environmental risks and guide strategic management options for other pollutants in urban emissions (e.g., microplastics and pharmaceuticals).