



Methodological framework for the analysis of current and future nutrient and pollutant fluxes in the lowlands of Northeast Italy

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The European Water Framework Directive (WFD) 2000/60/EC is an important milestone for water management, aiming to achieve good chemical and ecological status for European water bodies. Achieving these goals requires a comprehensive understanding of nutrients and pollutants transfer through surface waters, especially in areas impacted by human activities. This study aims to develop a methodological framework for setting up numerical models at the Northeast Italian River district scale to analyze nutrients and pollutants transfer from agriculture, industrial production, and wastewater treatment. The research enhances knowledge on the distribution of priority substances, supporting effective water management strategies aligned with WFD objectives.

The study area covers about 12,000 km² across 11 river basins in Veneto and Friuli Venezia Giulia. Separate models were developed for each basin using the SWAT (Soil and Water Assessment Tool) model. The models focused on simulating river discharge, calibrated against observed data using the Nash-Sutcliffe Efficiency (NSE) coefficient, and estimating nutrient and phytochemical loads discharged to the sea, verified with literature and limited monitored data. Given the highly modified river network, simplifications were introduced. Irrigation diversions and channels were modeled as point sources, along with industrial and wastewater treatment discharges. To account for agricultural practices, a detailed land cover layer was created by integrating Corine Land Cover 2018 and EUCROP 2018 datasets. Fertilizer and phytochemical use were defined through specific scheduling for all major crops, covering up to 95% of the study area. Current climate conditions were simulated using observed data from 2001 to 2020. Future scenarios for Global Warming Levels of 2°C and 3°C were modeled using downscaled data from Regional Climate Models.

Results show a good reproduction of discharge rates across river basins, with monthly NSE of 0.5 or higher values. NSE values below 0.5 were observed in the Venice Lagoon basin, the most anthropized area, where tidal effects were not captured by SWAT. Nutrient loads of total nitrogen and total phosphorus discharged to the sea aligned with previous studies, highlighting key point and area sources within each basin. Under future climate scenarios, both annual flow and nutrient discharges are expected to slightly increase. The study results were used by the Northeast Italian River District Authority to develop recommendations for the improvement of surface water

monitoring and management strategies, so to contribute to an increasingly effective implementation of the WFD goals.