Global warming effects on macrophytes' role in lowland rivers

Agricultural landscapes dominate across Europe and, therefore, agricultural practices and related water management measures influence the hydrological cycle and associated processes responsible for the persistence of aquatic ecosystems in a major part of the continent. The overall goals of the European Common Agricultural Policy are oriented at increasing the sustainable use of resources and mitigating the negative influence of agriculture on the environment, making it more climate-resilient. Forecasts indicate that climate change may cause the decline of food security worldwide in the next decades. Problems related to climate extremes, and the consequent water and soil degradation, must be all considered as a priority, since they are part of a dramatically dynamic and evolving scenario that could severely test the stability of our cropping system. Depending on the scenario and climate models, the average air temperature is expected to rise from 1.8°C to 4.0°C by 2100, with a consequent increase in water temperatures. Riverine water temperature and its fluctuations are one of the main factors determining physical, chemical and biological processes in water, regulating the functioning of aquatic ecosystems. The increase in temperature in water will affect changes for all living organisms inhabiting aquatic ecosystems, and of special concern will be primary producers (macrophytes, phytoplankton, phytobenthos. Being a key controlling factor of stream ecosystem metabolism, water temperature increase is predicted by the metabolic theory of ecology.

Like a large part of Europe, Poland and Austria are dominated by lowland intensively-used landscapes, and the majority of watercourses crossing such type of environment are small low-dynamic rivers. Their characteristic feature is an intensive overgrowth of emergent aquatic macrophytes both along the banks and submerged plants in the main channel. However, the influence of these morphological groups of aquatic macrophytes on water temperature and stream metabolism in small low-dynamic rivers received less attention. Managing these rivers is of critical importance for local biodiversity and novel tools are required to describe elements of these ecosystems for future management setup.

The project will investigate the influence of aquatic macrophytes on water temperature in small lowland rivers in intensively used landscapes by integrating monitoring information with modelling results.

The project is based on the following research hypotheses:

- water temperature and its variations at multiple timescales can be more adequately predicted using statistical models, which are determined by key independent variables stemming from the meteorological, hydro-morphological and aquatic vegetation factors;
- river hydraulics and aquatic macrophyte characteristics (e.g., biomass, shading, blocking) influence seasonal water temperatures and can reduce the amplitude of temperature fluctuations at different temporal scales, leading to a reduced fluctuation of temperature in macrophyte-dominated stretches;
- the effect of higher temperature maxima in macrophyte-free sections affects ecosystem metabolism and changes the dominance of algal groups;
- in river sections with patches of macrophytes, the spatial thermal heterogeneity is increased, affecting the diversity and ecosystem function of other primary producers.

We will address these hypotheses by:

- examining the temporal (annual, seasonal, daily - with and without vegetation) and spatial (along the river course considering macrophyte patches and different vegetation conditions) heterogeneity of water temperature through automatic monitoring;
- creating a dataset of predictors related to hydro-morphological, meteorological and aquatic macrophytes as a result of automatic monitoring and field surveys;
- employing the hierarchical regression methodology to find key predictors;
- developing regression models to account for the spatio-temporal variations in water temperature;
- modelling the observed dynamics via a 1-D numerical model, accounting for the presence/absence of in-stream and riparian vegetation and its influence on the river hydraulics.
- using the Before-After Control-Impact (BACI) design to study in-situ the effect of water temperature fluctuations and the buffering capacity macrophytes on ecosystem functions (metabolism). We will use the daily and stochastic temperature variability of the system and evaluate the buffer effect of the temperature variance by comparing macrophyte and macrophyte-free sections;
- applying a mesocosms approach to investigate the effect of varying temperature fluctuations on macrophytes and their interactions with other organism groups (phytoplankton, phytobenthos, macroinvertebrates)
- study differentially affected diversity of ecological groups of algae, functional traits of algae, functional groups of phytoplankton and phytobenthos and their relationship with temperature;
- use advanced modeling approaches to examine the multitrophic interactions and ecological feedbacks driven by macrophyte-induced temperature changes.