Impacts of climate change on the biological quality of Hessian streams

Dr. Sonja Jähnig, PD Dr. Peter Haase, Sami Domisch, Denise Früh, Dr. Andrea Sundermann

It is widely assumed that the water quality as an important water management parameter will be changed by climate change and its associated temperature and precipitation changes. However, little is known on particular and regional effects, regarding specific catchments. According to the Water Framework Directive (WFD) a quantitative estimation on climate change effects is required for subsequent river basin management plans (Common implementation strategy for the WFD, EC 2009). To comply with this requirement the present study on "climate change effects on biological quality of streams and rivers in Hesse" was conducted. Regional knowledge about interdependency between climate change and river water quality was compiled and specified. The project consisted of two parts (1) a literature review and (2) analysis and evaluation of the literature reviews result. The project had the following objectives:

- search and compile published and unpublished studies relevant for southern Germany, particulary for Hesse, regarding all WFD relevant organism groups;
- regionalize and specify large scale relationships between climate change and river water quality for the area of Hesse, based on cause-effect-chains;
- display already occurring and expected river water quality changes;
- estimate vulnerability of aquatic communities and defined stream types;
- define knowledge gaps and future research demands.

The literature review included nationally and internationally published literature, as well as unpublished "grey" literature from PhD, master / diploma thesis, or reports. Altogether 228 references were regarded as relevant for the region. Most references documented already occurring climate change effects, while only few documented modeling results; model results were largely available for the period beyond the year 2050, thus being less relevant for the WFD-time frame (up to 2027). Only little specific information was available on ecological effects, the probability of occurrence or degree of expected changes. Thus the literature review was useful to identify general mechanisms, but not to describe particular cause-effect-chains related to specific organism groups.

Based on the literature review, cause-effect-chains for three river regions (upper (head water), middle and lower reaches) were extracted and described. Varying uncertainties for the three regions were discussed.

Due to the present uncertainties, a conceptional model was developed estimating climate change effects and its consequences on WFD assessment results for four different organism groups (fish, benthic invertebrates, submergent macrophytes, diatoms, and phytoplankton). For fish, benthic invertebrates and macrophytes the projected temperature changes were considered as most relevant; furthermore no suitable information and data were available to consider other parameters such as hydrological changes. For diatoms and phytoplankton, changes in nutrient conditions were considered. Taxa lists were modified according to relevant ecological trait distributions within the communities. Analysis were conducted for 54 "best of" sites (at least one organism group was assessed as "high ecological status") and 47 sites within the course of the Fulda, a major river in Hesse.

Overall 36% of the sites experienced a deterioration of ecological status by one class. Diatom assessment results were changed most often, referring to all other groups, about 20% of the sites experienced such a change. Changes occurred mostly from high to good status or from moderate to poor status; this pattern is most likely due to the asymmetric distribution of original data (“best of” sites). Most sites did not experience a change in ecological status.

Many factors like seasonality, discharge, continuity, or ecological aspects such as rheophily, egg lying behavior or food webs could not be considered in this approach. However, a methodological concept has been developed to estimate consequences for ecological assessment results due to climate change impacts. In the future more differentiated prognoses might be achieved by enhancing and further developing this approach.

Concluding, the estimation of ecological changes and their extent due to climate change is still facing many uncertainties. Only few relationships are actually documented and quantified, and many aspects like food webs are not well researched (at least for the region of interest here).

A list of (potentially) invasive species (benthic invertebrates, fish, submergent macrophytes) was compiled, including information on their dispersal status. Finally, knowledge gaps and data deficiencies are shown and future research demand is defined.