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The thermal regime of Alpine streams: natural controls and effect of hydroelectric power production

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Since the earliest studies water temperature was recognized as one of the most important drivers in stream ecosystems, shaping both biodiversity and ecosystem functioning. So, it was often included as a factor in stream classification systems. The temperature is critical to aquatic organisms through its effects on metabolic rates and thus on growth. Moreover, water temperature relates to the outbreaks of disease, to the toxicity of numerous substances, to the ability of fish to migrate and to many other ecosystem attributes.
Despite the recognized biological importance of water temperature, stream thermal regime alterations were rarely quantified in bioassessment programs and few quantitative information about the natural thermic conditions of Alpine streams are available. Besides, the ecological consequences of differences in the thermal regimes were highlighted to be important for many species of fish and invertebrates, but few studies focus on their consequences at community or ecosystem level which are the subject of bioassessment.
In the present study we monitored water temperature of streams belonging to the Alpine catchment of Serio River (Italy), in reaches selected as representative of different natural conditions and human alterations. The collected data, with air temperature, flow estimates and diversion rates of hydroelectric power plants, were used to produce quantitative models able to predict the temperature of stream water. Those models describe the effects of meteorological conditions on thermal regime for snow-melt/storm-water and groundwater fed streams. This is the basis for the evaluation of natural thermal regime, allowing to reconstruct temperature time series when only spot measurements are available. The developed models can also be used to evaluate the thermal alterations due to the presence and management of high altitude reservoirs and run-of-river hydroelectric power plants on snow-melt/storm-water fed streams.
High altitude reservoirs profoundly alter the thermal regime of streams both on daily and seasonally basis with potential implications for the overall ecosystem dynamics. Structural measures (e.g. multiple level outlets) can reduce the alteration to the downstream sectors while management action (e.g. residual flow) play only a minor role. On the other hand, the overall impact (from upstream the diversion to downstream the release) of run-of-river hydroelectric power plants on thermal regime is almost negligible. The key drivers of thermal alterations in the diverted stretches were the distance from the diversion and the residual flow.
The produced models, despite their simplicity, can be the basis to predict or describe the thermal alterations caused by hydroelectric power production in Alpine streams. Further research is needed to properly describe the relationships among selected characteristics of thermal regime and biological communities. Similarly to what was done in the last 10 years for the development of flow-ecology relationships, emphasis must be placed to the effects of thermal regime on the ecological parameters used for bioassessment. This kind of information will allow to predict or to describe changes within the biological communities and in ecosystem functions and ultimately to properly manage and conserve the Alpine stream ecosystems.