Effects on the benthic community of hydropower-induced flow regime alteration

Bruno Maiolini*, M. Cristina Bruno, Luana Silveri, Mauro Carolli, Elisa Varolo
Centro Ricerca e Innovazione, Fondazione E. Mach, Via E. Mach 1, S. Michele all'Adige (TN), I-38010 Italy. *bruno.maiolini@iasma.it

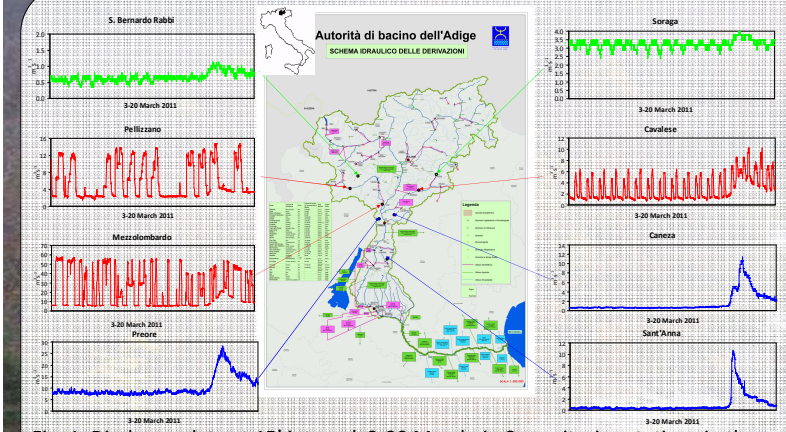

Fig. 1. Discharge data at 15' interval, 3-30 March, in 8 monitoring stations in the Adige River watershed (NE Italy). Measurement period characterized by: low T (no snowmelt), no rainfall for the first 13 days, and strong rainfall starting March 16.

Problem

Flow regime is widely considered as a main driver of the ecological condition of rivers. In Alpine streams the main alterations are due to hydropeaking downstream of hydropower plants (red, Fig. 1), and to constant regime following application of minimum vital flows below dams and water abstraction structures (green, Fig. 1).In the Adige watershed, very few reaches remain with a natural flow regime (blue, Fig. 1).

Methods

In order to assess the effects of natural, hydropeaking, and constant regimes on the same benthic community, we collected samples in three sites (Figs. 2, 3) : i) a pristine Alpine steam (natural flow, NFR); ii) a set of five 20 m long, 0.3 m wide and 0.3 m tall artificial flumes directly fed by the same stream (constant flow, CF); iii) an hydropower-impacted reach of the same stream, 200 meters downstream of the flumes (HP). Five stations were selected in the natural flow reach of the stream, five in the hydropeaking-impacted reach and five in the flumes (i.e. one for each of the five flumes).

Each station was sampled biweekly from mid-February to the end of July 2010 using a Hess bottom sampler and a set of three Hester-Dandy artificial substrates (Fig. 4). A total of about 65000 invertebrates were collected and identified to the lowest possible taxonomic level.

Figs. 2, 3. Experimental flumes on the Fersina Stream, Adige watershed, with the three flow conditions

Fig. 4. Set of substrates at the NFR station, Hess sampler, artificial substrate

Results

The physical-chemical parameters (Fig. 5) varied more in the hydropeaking impacted reach, where thermal alterations associated to the pulsing release of colder water are apparent.

The benthic communities differed in response to the different flow regimes (Fig. 6). The community assessed with the Hess method was slightly more abundant as mean ind m^{-2} in the station at constant flow than in the station from the natural flow reach, while the hydropeaking reach hosted a much poorer community, both in abundance and diversity. Similar results were obtained for the community assessed with the artificial substrates, where the hydropeaking sites had a very low abundance of individuals and where the number of taxa differed less, with the lowest values recorded at the natural flow regime station.
Differences were due to the accumulation of particulate organic matter in the sediment of the flumes due to the constant flow and, as a consequence, they selected a higher relative abundance of gatherers and shredders. In the natural flow reach, predators were relatively more abundant.
The two sampling methods selected for different taxa, i.e., more gatherers were present in the artificial substrates, which collected more matter, and black flies were almost exclusively collected there, favored by the smooth plastic substrate.

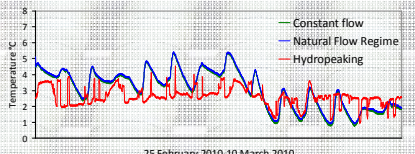

Fig. 5. Physical-chemical parameters at different flow regimes. Top: temperature variations at 10' interval, over a two-week period. Bottom: median values calculated over the entire sampling period.

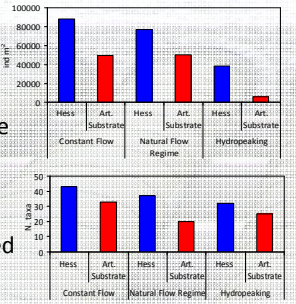

Fig. 6 Mean abundance and total number of taxa for the two sampling methods and for each flow regime.

Conclusions

This experiment represents a first tentative to assess the effects on a small spatial scale of flow alterations on comparable benthic communities. Notwithstanding the possibility of faunal exchange between the three sites through drift downstream of larval stages, or fly upstream of adults to lay their eggs, thee different flow regimes appeared to have a selective effect on benthic community structure.

The hydropeaking reach appeared as the most impacted, with reduced richness and abundance. The constant regime favored collector, scraper and grazer taxa, due to accumulation of organic matter and development of periphyton. Furthermore several taxa anticipated emergence and in some cases a second generation appeared, in contrast with the same taxa in the natural flow reaches and in the hydropeaking ones.

Results suggest possible remediation strategies in streams impacted by the operation of hydropower plants, i.e. programmed flash floods in imposed constant flow reaches and diversion for re-use of hydropeaking waves wherever possible.

Acknowledgements:
The present research was conducted within the framework of the Interreg IVB project ALP WATER SCARCE - Water Management Strategies against Water Scarcity in the Alps. Discharge data provided by Servizio Opere Idrauliche - Provincia Autonoma di Trento.