Energy
National Research Programmes 70 and 71

Project

Aquatic ecosystem

Healthier mountain rivers despite more hydropower

Healthier mountain rivers despite more hydropower

By law, a body of water may never be completely dried up for hydropower – a minimum flow rate must always be ensured. According to the result of this research project, however, this residual flow provision does too little to protect the biodiversity of our mountain rivers.

Wonderful but not untouched – the alluvial zones of the Maggia are greatly impacted by hydropower. *Source:* AdobeStock

At a glance

- Constant minimum flow rates are not enough to create near-natural conditions that protect biodiversity in mountain rivers and ensure groundwater recharging.
- Variable residual flow rates are required to imitate the natural conditions in rivers and thus enhance the river habitat without greatly restricting the use of hydropower.
- In rivers found in the high mountains, the sediment load caused by the flushing of water extraction points plays a greater role in environmental quality than residual flow rates.

As an important cornerstone of Energy Strategy 2050, hydropower is to be expanded further in future. However, to ensure that the habitats of the affected rivers do not suffer excessively, the impact of hydropower use must be cushioned to the greatest extent possible. To this end, the Waters Protection Act stipulates that rivers must still exhibit a minimum flow rate even after the extraction of water. This so-called residual flow rate, which is set individually depending on the river in question, can be increased by the authorities if this appears necessary in order to safeguard the water quality, preserve groundwater resources, the bedload balance and habitats or allow for fish migrations.

Researchers from ETH Zurich, the Swiss Federal Institute of Technology Lausanne (EPF Lausanne), the Swiss Federal Institute of Aquatic Science and Technology (EAWAG) and the University of Lausanne have investigated how effective this approach is for preserving the environmental value of mountain rivers. Their finding is clear – a constant minimum flow rate as stipulated by the applicable legislation does not provide sustainable protection for the biodiversity found in many rivers and alluvial zones.

Far removed from natural conditions

An exemplary case is the Maggia in Ticino, a little gem of national importance. However, the idyll is deceptive. This is because the lion's share of the natural discharge from this mountain river's catchment area is redirected into a system of reservoirs and passes through turbines and pressure pipes rather than picturesque alluvial landscapes. Only the residual water volume required by law remains in the riverbed – apart from the contribution of small tributaries that are not utilised for hydropower. In the event of severe storms, however, it can also be the case that major discharge peaks are diverted into the river to ensure that the infrastructures used for hydropower are not overloaded. In the river, a gap exists between these extremes. In natural rivers, smaller floods continuously reshape the riverbed and also create connections, for example, across the course of a river. This gives rise to a large number of niches for various fauna and flora. The naturally occurring floods are also important for recharging groundwater reserves – the heightened water level brings about an exchange between the surface water and groundwater.

The researchers from ETH Zurich wanted to obtain a better understanding of how the absence of natural flow dynamics impacts the habitat of the Maggia and similar rivers. Their computer simulations revealed that a simple increase in current residual flow rates could absolutely lead to a slight improvement in environmentally relevant variables. For example, the decline in the groundwater level would not be as marked, while the river would run quicker and achieve greater water depths. Nevertheless, the achieved values would still fall far short of creating the characteristics of a free-flowing natural river.

The species composition found on the Maggia is also far removed from what would be expected under natural conditions, as shown by another study conducted by the EAWAG team. The researchers investigated the life in pools left in the riverbed by a flood. If such pools continue to exist detached from the river flow over an extended period, they increasingly become inhabited by flies, mosquitoes and beetles as time passes, i.e. by insect species that love standing waters. In contrast, young pools are primarily home to stoneflies, mayflies and caddisflies, in other words species that are actually typical of a fast-flowing, cold and oxygen-rich river such as the Maggia. Periodically occurring floods flush out older pools once more and reset the environmental clock. Fluctuations in the water level are therefore necessary in order to preserve habitat diversity.

Imitate nature

These findings give rise to an obvious solution: rather than continuous residual flow rates, it should be attempted to replicate the constant ups and downs observed in nature. It was precisely this idea that was investigated by researchers from the EPFL Lausanne. Using computer simulations of possible discharge patterns, they were able to show that many parameters of environmental water quality can be improved markedly – and without considerable losses in terms of electricity production. The key here is the clever use of storage basins. Instead of completely filling reservoirs, the scientists propose leaving room in order to cushion flood peaks. This would mean more water is available for controlled discharge. Not only would this benefit nature and the hydropower sector, but it is also more efficient overall.

The near-natural management of residual flow rates could therefore considerably enhance rivers such as the Maggia. However, this measure would also not provide a universal remedy. For example, mountain streams situated at 2,000 metres above sea level require a different formula, as researchers from the University of Lausanne discovered. They tested their hypotheses with an intensive observation of the Borgne d'Arolla mountain river in the canton of Valais.

A hostile environment

High Alpine waters such as this are naturally characterised by harsh living conditions – especially when they are fed by very cold and murky glacial water as is the case with the Borgne d'Arolla. The channelling off of glacial water for hydropower does not necessarily make this habitat more inhospitable. On the other hand, however, the benefit of adding residual water is also unclear. The operation of water extraction points, in contrast, has a major influence. These regularly have to be freed of sediment – often several times a day during the summer months. A surge of sand and gravel then spills into the streams and decimates the insects living there. According to the researchers, it will only be possible to revitalise these mountain rivers if the frequency of this flushing process is reduced.

A need for legislative change

The significance of variable flow rates is not taken into account in the applicable Waters Protection Act. And the conventional method used for the environmental assessment of watercourses is unsuitable for ascertaining the impact of sediment flushing on high-mountain rivers. The researchers believe that the legal provisions governing these points need to be revised in order also ensure the protection of nature in the event of greater hydropower use. As all rivers are not the same, however, the project also calls for the authorities to require that hydropower operators provide a precise clarification of the environmental impacts. The required tools are available – namely the computer models with which the researchers are investigating how the rivers respond to interventions in the water balance. The models allow for experiments that are not possible in the field to be conducted on a virtual basis – in order to better understand and better protect our waters.

Produkte aus diesem Projekt

Contact & Team

Prof. Dr. Paolo Burlando
Institut für Umweltingenieurwissenschaften
HIL D 22.3
Stefano-Franscini-Platz 5
8093 Zürich

+41 44 633 38 12
paolo.burlando@ifu.baug.ethz.ch

Paolo Burlando
Projektleiter

Tom Battin

Gianluca Bergami

Pierre Chanut

Chrystelle Gabbud

Stuart Lane

Peter Molnar

Amin Niayifar

Paolo Perona

Chris Robinson

All information provided on these pages corresponds to the status of knowledge as of 10.05.2019.