Abstract Volume
6th Swiss Geoscience Meeting

Lugano, 21st – 23rd November 2008

Apply! Geosciences
6th Swiss Geoscience Meeting 2008 - Lugano

sc | nat

Geosciences
Platform of the Swiss Academy of Sciences

SUPSI
University of Applied Sciences
of Southern Switzerland
Institute of Earth Sciences

10. Anthropogenic impacts on hydrological regime

Sandro Peduzzi, Andrea Salvetti

Swiss Society for Hydrology and Limnology (SGHL)
Swiss Hydrological Commission (CHy)

10.1

Evaluation of the hydraulic properties of constructed wetlands using geoelectric techniques

Mehdy Al-Zoubaidy*, Alessandro Brovelli*, Luca Rossi*, D. Andrew Barry*, and Klaus Holliger**

* *Ecological Engineering Laboratory, Environmental Sciences and Technologies Institute, EPFL, CH-1015 Lausanne*
** *Institute of Geophysics, University of Lausanne, CH-1015 Lausanne (klaus.holliger@unil.ch)*

Wastewater purification through massive horizontal and/or vertical filtering is increasingly applied throughout the world, albeit with varying success. Different types of systems, commonly referred to as "constructed wetlands" (CWs) can be used to treat wastewaters produced by individual houses, isolated settlements and even small towns provided that the surface area for the treatment is available (Brix, 1993). Among the key advantages of this technology is that CWs require only a small energy input, because they make use of natural biological processes for the degradation of pollutants. Despite their inherent simplicity, these systems are still poorly understood, particularly with regard to the processes responsible for the pollutant degradation and hence, there is significant potential for improving their performances by optimizing the individual subprocesses (Vymazal, 2007). To this end, a well-controlled and extensively instrumented model of a CW system was set up at the Ecological Engineering Laboratory of EPFL (for further information see http://ecol.epfl.ch/research/remieco).

A key prerequisite for studying and characterizing a CW system is to understand and control its hydraulic behavior. Preliminary tests conducted with saline tracers on our laboratory set-up indicated a complex flow field, possibly resulting from the coupled effects of the elevated density of the tracer plume and the inherently non-homogeneous distribution of the hydraulic properties. To investigate these aspects and in attempt to infer the 2D tracer distribution, a set of cross-hole geoelectric resistivity surveys is being conducted. Geoelectric techniques are commonly used to investigate the spatial variability of hydraulic properties and to monitor the evolution of saline plumes (e.g., Slater et al., 2000; Zhou and Greenhalgh, 2000). To obtain reliable and detailed resistivity measurements we constructed an ad hoc device consisting of 2 arrays containing 10 electrodes each. The vertical spacing between the electrodes is about 0.045 m.

The preliminary tests we conducted so far clearly illustrate the potential of the proposed methodology to characterize the hydraulic behavior of our CW model. The left-hand panel of Figure 1 depicts the quasi-1D evolution of apparent electrical resistivity, from time=0h (no tracer) to time=14h (peak of tracer observed in breakthrough curve, not shown). Due to the increased water density as a consequence of the dissolved tracer salt, the vertical profile is not homogeneous but the concentration tends to increase with the depth. The right panel of Figure 1 shows some preliminary 2D time-lapse results obtained by tomographically inverting the measured difference in apparent resistivity data measured at time=0h and time=14h. While the vertical stratification of the resistivity structure seen in the quasi-1D time-lapse profiles shown in the left-hand panel is clearly confirmed, the prominent resistivity anomaly at approximately 5 cm lateral distance and 33 cm depth could indeed be indicative of preferential flow phenomena related to the inherently hydraulic heterogeneity of the materials used to construct typical CWs.

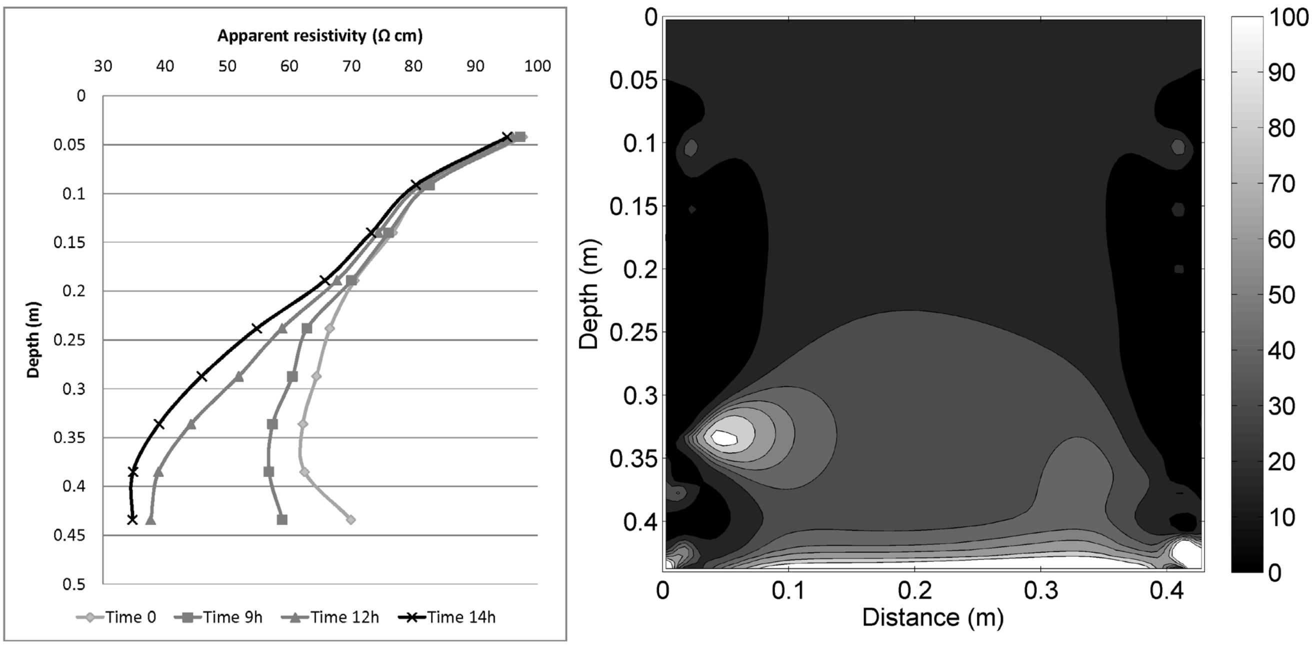


Figure 1. Left: evolution of the resistivity as a function of time and depth in a CW model system during a saline tracer experiment. Right: tomographic reconstruction of the change in resistivity between time=0h and time=14h. The grey-scale range of resistivity variations is given in Ωcm.

REFERENCES

Brix H. 1993: Wastewater treatment in constructed wetlands: system design, removal processes, and treatment performance. In: Moshiri GA, editor. Constructed wetlands for water quality improvement. CRC Press.

Vymazal J. 2007: Removal of nutrients in various types of constructed wetlands. Science of the total environment 380, 48-65.

Slater L., Binley, A.M., Daily, W. & Johnson, R. 2000: Cross-hole electrical imaging of a controlled saline tracer injection, Journal of Applied Geophysics, 44, 85-102.

Zhou B., & Greenhalgh S.A. 2000: Cross-hole resistivity tomography using different electrode configurations, Geophysical Prospecting, 48, 887-912.

10.2
Schwall/Sunk und Morphologie in Fliessgewässern

Peter Baumann

Limnex AG, Zürich

In den letzten Jahren sind die gewässerökologischen Auswirkungen des Schwallbetriebes aus Speicherkraftwerken auch in der Schweiz an einer zunehmenden Zahl von Flüssen untersucht worden. Unter dem Eindruck der so gewonnenen Erkenntnisse wird seit einiger Zeit auch an einer gesetzlichen Regelung dieser Problematik gearbeitet, steht Schwall/Sunk also auf der umweltpolitischen Traktandenliste. Dabei verlangen sowohl die Volksinitiative „Lebendiges Wasser" des Schweizerischen Fischerei-Verbandes als auch die parlamentarischen Initiative „Schutz und Nutzung der Gewässer" der Ständerätlichen Kommission für Umwelt, Raumplanung und Energie, die betroffen Gewässer seien hydrologisch und morphologisch aufzuwerten. Als wesentliche Massnahmen werden dabei, ebenfalls in beiden Fällen, die Revitalisierung der Gewässer, die Verminderung der negativen Auswirkungen von Schwall und Sunk sowie die Reaktivierung des Geschiebehaushaltes ausdrücklich verlangt.
Es stellt sich somit die Frage, wie sich der Schwallbetrieb und die Morphologie in Fliessgewässern gegenseitig beeinflussen. Die Wechselwirkungen von hydrologischen und morphologischen Eingriffen in die Gewässerökologie müssen bekannt sein, um die möglichen Aufwertungsmassnahmen besser aufeinander abstimmen zu können.
Im ersten Teil des vorliegenden Referates wird über die Ergebnisse aus verschiedenen Studien an schwallbeeinflussten Fliessgewässern berichtet und aufgezeigt, was diese Studien über den Zusammenhang zwischen Flussmorphologie und Schwall-Auswirkungen bisher ergeben haben.
In einem zweiten Teil des Referates wird an Beispielen untersucht, wie sich morphologische und/oder hydrologische Veränderungen in verschiedenen Indikatoren für die Beurteilung des Gewässerzustandes niederschlagen. An diesen Beispielen wird schliesslich auch geprüft, wie weit der ökologische Zustand bzw. die ökologische Qualität der untersuchten Schwallstrecken mit theoretischen Vorstellungen über die Auswirkungen von hydrologischen Störungen übereinstimmt.

10.3
Effects of pump storage operations on reservoir turbidity

Bonalumi Matteo*, Anselmetti Flavio*, Kägi Ralf**, Müller Beat*** & Wüest Alfred***

** Eawag, Swiss Federal Institute of Aquatic Science and Technology, Surface Waters – Research and Management, CH–8600 Dübendorf (matteo.bonalumi@eawag.ch)*
*** Eawag, Urban Water Management, CH–8600 Dübendorf*
**** Eawag, Surface Waters – Research and Management, CH–6047 Kastanienbaum*

Hydroelectric energy covers in Switzerland about 60 % of the energy requirement. To increase production and to better cover peak demand periods, pump storage operations are becoming more and more important. The effect of hydropower activities on light regime and on primary production in downstream lakes has been studied recently (Finger et al, 2007; Jaun et al., 2007). It is, however, not well understood, how such increased pump activities affect suspended particle load, particle characteristics and sedimentation processes, and whether they may affect also ecologic conditions in downstream areas.

Oberaarsee and Grimselsee, two reservoirs located in a glaciated catchment in the Central Alps, are since 1980 part of a pump storage operations scheme with annual water exchanges amounting to several times the lake volumes. We are currently analyzing this system with the aim to understand how pump storage and turbine operations may influence the water turbidity and sedimentation in the reservoirs. Investigations are undertaken seasonally in different locations and depths of both reservoirs. We determined suspended particle content, combined vertical profiles of temperature and turbidity using a CTD instrument, analyzed composition, number and grain size of particles and used SEM imagery to determine particle shapes. Furthermore, sediment cores provide seasonally-resolved time series of reservoir sedimentation.

For almost all the CTD profiles and analyses of suspended particles collected in Oberaarsee and Grimselsee, a positive correlation exists between turbidity, grain size distribution, particle number and mass concentration. The highest turbidity in both reservoirs occured in summer whereas the lowest was found at the end of winter, when no river inflows and the reservoirs are covered by ice. Moreover, vertical profiles have shown that turbidity generally increases with increasing reservoir depth.

In every season, specific features have been observed related to the annual cycles of climate, runoff and pump storage operations. In summer, when the hypolimnion is characterized by similar conditions in both reservoirs, the epilimnion of Oberaarsee is clearer and warmer in comparison with that of Grimselsee, indicating that a stronger thermal stratification in Oberaarsee may favor the settling of the suspended particles. In winter, higher turbidity has been measured specifically in in the Eastern basin of Grimselsee, where the power operations are continuously exchanging water between the two reservoirs. The decrease in water level of the reservoir causes the emersion of bedrock ridges that impede the flow of this more turbid water of the Eastern basin into the clearer Western part of the reservoir.

A recognized effect of both reservoirs is that they retain sediment that would normally be carried downstream by the River Aare (Anselmetti et al., 2007). Further investigations will try to deepen also the ecological impact down rivers of pump storage operations.

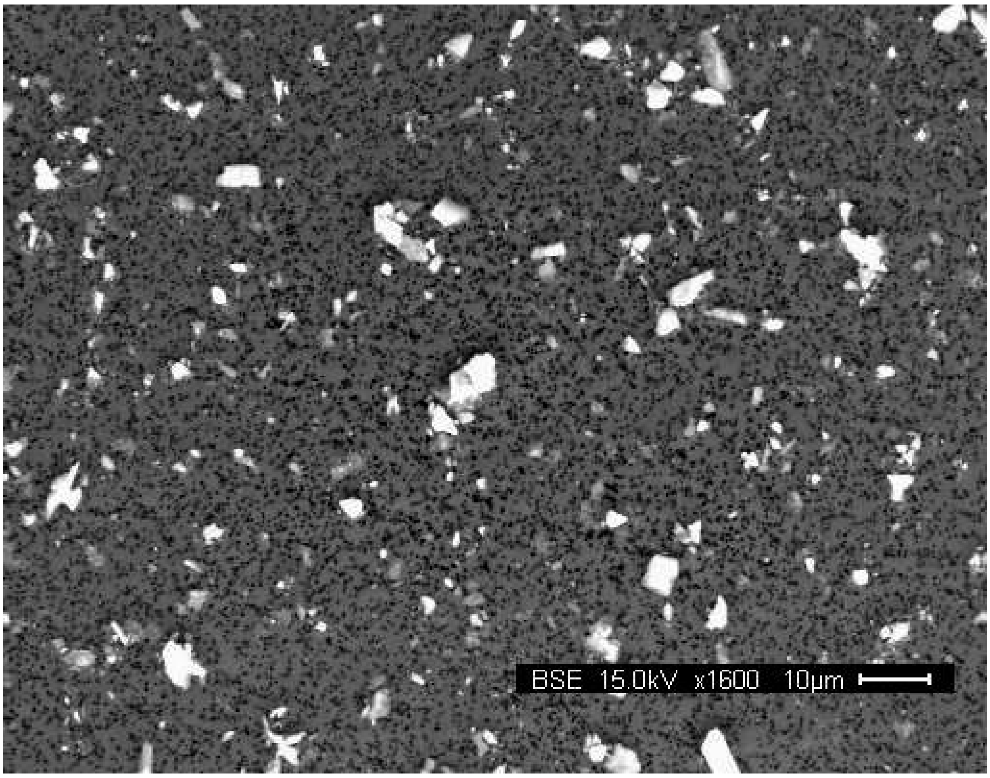


Figure 1. SEM backscattered electron image of clay minerals, feldspar and quartz particles from Grimselsee in 2008, July 28.

REFERENCES

Anselmetti, F. S., Bühler, R., Finger, D., Girardclos, A., Lancini, A., Rellstab, C. & Sturm, M. 2007: Effects of Alpine hydropower dams on particle transport and lacustrine sedimentation. Aquatic Sciences, 69, 179-198.

Finger, D., Bossard, P., Schmid, M., Jaun, L., Müller, B., Steiner, D., Schäffer, E., Zeh, M. & Wüest, A. 2007: Effects of alpine hydropower operations on primary production in a downstream lake. Aquatic Sciences, 69, 240-256

Jaun, L., Finger, D., Zeh, M., Schurter, M. & Wüest, A. 2007: Effects of upstream hydropower operation and oligotrophication on the light-regime of a turbid peri-alpine lake. Aquatic Sciences, 69, 212-226.

10.4

Urban storm water runoff impacts on receiving waters. On the use of continuous modelling and quantitative indicators.

Consuegra David*

Docteur ès Sciences Appliquées in Rural Engineering of the Swiss Federal Institute of Technology (EPF), Lausanne, CH. Currently scientific director at B+C Engineering SA, Montreux, CH.

It is widely recognised that urban storm runoff substantially modifies the natural hydrological regime of river systems. Special emphasis is normally given to qualitative impacts, a significant amount of publications deal with the assessment of pollution loads and the modelling of concentrations in storm runoff and receiving water bodies. The quantitative impacts of urbanization are also well documented and can always be summarized by more or less significant increases of runoff volumes and flood peaks and reductions of watershed response times. In urban runoff control studies the priority is normally given to the impacts on floods with moderate to high return periods. The impacts of urbanization on river flooding are normally documented by simple comparisons between present and future design floods and corresponding hydrographs. Most of these comparisons are based on single event modelling based on design storms and/or historical rainfalls selected from intensity-duration-frequency curves.

The increased environmental concern regarding the protection and the restoration of aquatic systems requires the analysis of urban runoff quantitative impacts to be extended to other processes such as river bed and bank erosion, rapid increases and decreases of water levels and velocities, seasonal shifting of flow occurrences as well as clogging of river substratum. The analysis of urban runoff impacts on these processes requires the whole hydrological regime to be assessed; this includes not only flood peaks but also low to medium average flow quantities as well as duration and seasonality.

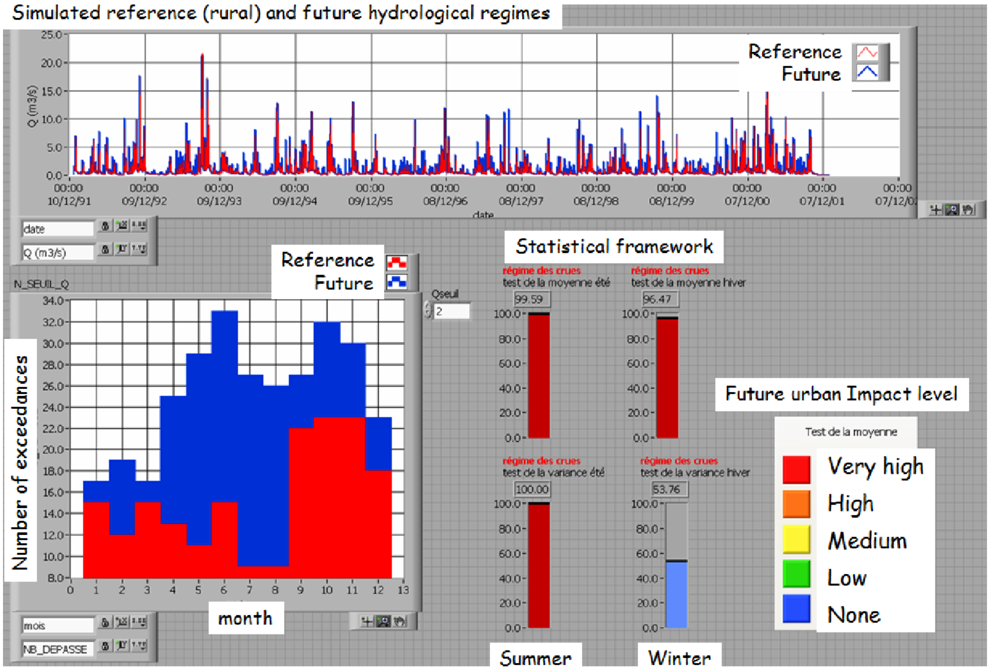
Simulation techniques need to be adapted to the analysis of the overall hydrological regime. Single event modelling is no longer applicable; long term continuous models have to be used instead. Continuous rainfall inputs must be considered. Suitable approaches to define representative rainfall series have to proposed and applied. Finally, new techniques have to be developed and tested to identify quantitative impacts of urban runoff on simulated hydrological regimes accounting for inter annual variability, climate sensitivity and land use changes.

In the framework of an overall and regional assessment of urban runoff impacts on river systems, the canton of Geneva developed a new methodological framework to describe and model the most determinant characteristics of hydrological regimes. The main features of this methodology include:

Define a global strategy to model hydrological regimes by an appropriate selection of modelling tools and an adequate strategy for model calibration and validation. This concerns both, urban and rural watersheds. The choice of the canton of Geneva refers to deterministic, conceptual and relatively detailed hydrological models.
Define adequate rainfall inputs made of long term continuous series. The canton of Geneva developed several stochastic continuous series; each one covers a period of 20 years with a 10 minutes time step. In conjunction with observed continuous records of precipitation, the rainfall series are used to generate at specific watershed locations several signatures of hydrological regimes. Every time three cases are considered, the first one produces a reference hydrological regime which does not have an urban runoff component while the other two describe the hydrological regime for present and future extents of urbanization.
The various hydrological regimes are analysed with quantitative indicators which are supposed to represent the variations of the most pertinent hydrological regime characteristic with respect to the river process that is analysed, for instance seasonality. Several indicators have been proposed. They are all accompanied with a statistical interpretation framework in order to assess the level of significance of the changes induced by urban runoff accounting for climate sensitivity and variability.

The figure below illustrates the flow series produced for the reference and the future urbanization extents for one of the studied rivers within the canton of Geneva. The analysed indicator is the monthly number of exceedances of a threshold flow value above which sediment transport may occur. The indicator clearly shows the seasonal shift between the reference (rural) hydrological regime and the future one. The statistical framework indicates that the changes are very significant for both the average and the standard deviation of the number of exceedances occurring during the summer period.

ACKNOWLEDGEMENTS
This work is the result of a group effort including the following Geneva cantonal authorities: P. Grandjean, E. Werlen and F. Pasquini from SECOE, A Wyss from SEVAC, F Bachman from SPDE and P. Nirel from former ECOTOX. All modeling developments have been made by D. Consuegra and Gaetan Seguin presently at B+C Ingénieurs, 1820 Montreux.



10.5

Schwall-Sunk in der Linth (GL) – ein neuer Ansatz zur Reduktion der Auswirkungen auf das Flussökosystem.

Arthur Kirchhofer, Martina Breitenstein

WFN – Wasser Fisch Natur/, Gümmenen.

Abstract

Die Linth im Kanton Glarus wird von den Kraftwerken Linth Limmern AG (KLL) und von einer grösseren Zahl Kleinwasserkraftwerke genutzt. Für die Anlagen der KLL wurde 2006 ein Gesuch mit UVB 1. Stufe zur vorzeitigen Neukonzessionierung eingereicht und im Juni 2007 mit einem Zusatzbericht zur Schwall-Sunk-Problematik in der Linth ergänzt. Dabei wurde festgestellt, dass mit dem Schwall-Sunk-Betrieb der KLL das Ökosystem der Linth und dessen Organismengemeinschaften negativ beeinflusst werden. Um diese Beeinträchtigungen soweit möglich zu reduzieren, wurden Vorschläge zur Anpassung des Schwall-Sunk-Regimes ausgearbeitet.

Grundlage dieser Vorschläge waren Erkenntnisse aus Untersuchungen der Wirbellosen- und der Fischfauna und umfangreichen hydraulischen Modellierungen der Linth. Es konnte aufgezeigt werden, dass bei jedem Schwall die Flusssohle zwischen Linthal und Schwanden in Bewegung gerät und eine „Katastrophendrift“ der aquatischen Wirbellosen stattfindet. Entsprechend gering sind Wirbellosenbiomasse, Fischbestand und fischereiliches Produktionsvermögen des Gewässers.
Die Variantenbeurteilung für einen zukünftigen Schwall-Sunk-Betrieb basierte auf den Habitatansprüchen und dem Flächenbedarf einer Fischpopulation in der Linth, die in etwa derjenigen eines hypothetischen, nicht von der KLL beeinflussten Ausgangszustandes entsprechen würde. Der Vergleich des Flächenbedarfs des aktuellen Fischbestandes mit dem Flächenangebot beim aktuellen Schwall-Sunk-Regime erlaubte die Folgerung, dass heute in erster Linie die für eine natürliche Fortpflanzung der Bachforelle geeigneten Flächen mit stabilem Sohlensubstrat den Fischbestand limitieren. Aufgrund der für die angestrebte Zielpopulation notwendigen Fläche mit stabilem Laichsubstrat wurde ein neues Schwall-Sunk-Regime definiert, das in die im Januar 2008 erteilte Neukonzession übernommen wurde.

10.6

Eco-hydrological impacts of hydropower production in the Adige river system

Maiolini Bruno*, Bruno Maria Cristina**, Carolli Mauro**, Silveri Luana**, Zolezzi Guido***, Bellin Alberto*** & Siviglia Annunziato***

** Museo Tridentino di Scienze Naturali, Via Calepina, 14, I-38100 Trento*
*** Fondazione E. Mach, Via E. Mach, 1, I-38010 S. Michele all'Adige (Trento)*
**** Department of Civil and Environmental Engineering, University of Trento, I-38100 Trento*

Most river systems worldwide suffer from loss of ecosystem connectivity, mainly due to dam building and water diversion (Nilsson et al., 2005). In the Alps, the longitudinal, lateral and vertical continuity of riverine ecosystems has been reduced by physical barriers such as dams, canalization, embankments. As a consequence, the disruption of the river continuum has severe effects on the ecological health of rivers and is a major cause of decline in freshwater biodiversity (Bunn & Arthington, 2002).
The historical alteration of the temporal dimension of rivers, i. e. changes of the flow regime at different time scales, has been little investigated. Most of the ecological alterations observed in Alpine rivers are due to hydroelectric power generation, which in the Alps has great economical relevance (Maiolini & Bruno, 2008). Hydropower is a strategic gas-free renewable energy and thus it should be maintained and possibly increased, but given its severe consequences on other benefits and goods deriving from freshwater ecosystems, eco-sustainable approaches to the management of the different phases of hydropower production should be explored.
Long-term changes in the hydrological regime were studied in the Adige River from 1923 to 2006, using different statistical approaches among which the Range of Variability Approach (RVA) (Richter et al., 1997). Severe changes occurred starting from the sixties, when most dams, diversion structures and associated power plants were built (Fig. 1). In more recent years changes in the timing of plant operation, dictated by the energy market, coupled with climate change and other uses such as artificial snow production, have worsened the effects of hydropeaking.
In order to assess in detail the effects of hydropeaking on the river communities, one single hydropeaking event was studied downstream of a representative Alpine power plant on the Noce River, a main tributary to the Adige River. Benthic fauna was affected by catastrophic drift for at least 8 km downstream of the power plant (Fig. 2). Our studies confirmed the well known effects of hydropeaking on the benthic community (i.e. Cereghino et al., 2002); in addition we explored the effects on the hyporheic habitat, where the ratio between stigobite and stigophile taxa was found to be severely affected downstream of the hydropower plant, due to clogging of the interstices.
Further research is being carried on using artificial flumes to analyse separately the physical, hydrological and chemical changes associated with the hydropeaking wave such as discharge, temperature and turbidity variations.

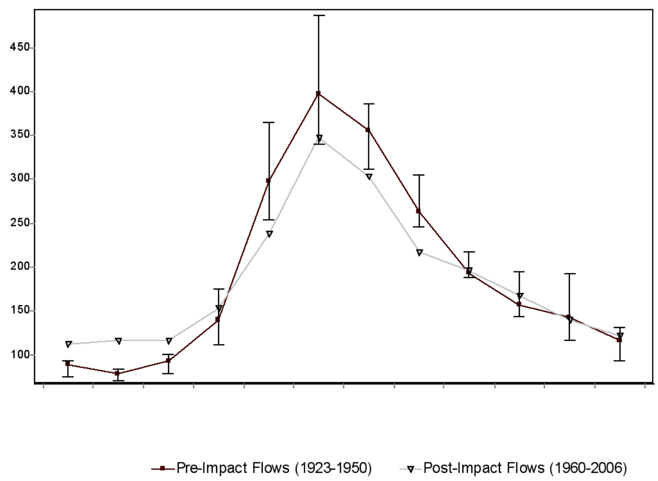


Figure 1. Results of RVA analysis: median monthly flow alterations of the Adige River for pre- and post-regulation periods, measured at Trento San Lorenzo gauging station. Vertical lines represent RVA category boundaries (i.e. the 34th and the 67th percentile of the pre-impact values) into which the post-regulation values should fall.

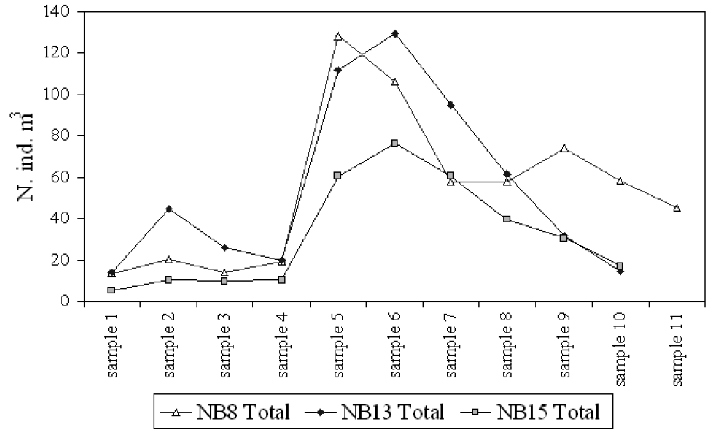


Figure 2. Densities of drifting invertebrates (n. ind./m³) collected at 5 minute intervals at stations NB8 (0.5 km downstream of the power plant), NB13 (6 km), NB15 (8 km). The water release started between sample 4 and 5.

REFERENCES

Bunn, S. E., and A. H. Arthington (2002), Basic principles and ecological consequences of altered flow regimes for aquatic biodiversity, Environ. Manage., 30(4), 492–507.

Céréghino, R., P. Cugny & P. Lavandier, 2002. Influence of intermittent hydropeaking on the longitudinal zonation patterns of benthic invertebrates in a mountain stream. International Review of Hydrobiology 87: 47–60.

Maiolini, B., and M. C. Bruno (2008), The River Continuum Concept revisited: lessons from the Alps. Alpine space - man & environment, vol. 3: The Water Balance of the Alps. Innsbruck University press, pp 21-30.

Nilsson, C., C. A. Reidy, M. Dynesius, and C. Revenga (2005), Fragmentation and Flow Regulation of the World's Large River Systems, Science 308, 405–408.

Richter, B. D., J. V. Baumgartner, J. Powell, and D. P. Braun (1996), A method for assessing hydrologic alteration within ecosystems, Conserv. Biol., 10, 1163–1174.

10.7

Module Hydrology: Assessing the natural status of the flow regime. Methodology and case study Brenno (TI)

Pfaundler Martin*, Salvetti Andrea**

** Bundesamt für Umwelt (BAFU), CH-3003 Bern (martin.pfaundler@bafu.admin.ch)*

*** Ufficio dei corsi d'acqua Cantone Ticino, Viale Stefano Franscini 17, CH-6500 Bellinzona (andrea.salvetti@ti.ch)*

The flow regime: the driving force of water dynamics

Next to water quality and the ecomorphological status of rivers, the flow regime is the third decisive abiotic influencing factor for the ecological status of watercourses. The "Guiding Principles for Swiss watercourses" (SAEFL and FOWG, 2003) therefore stipulate development goals of "sufficient water quality", "sufficient space for water courses" and "sufficient water flow".

The modular-stepwise-procedure (BUWAL, 1998) develops and provides Swiss-wide standardised methods to assess the ecological status of running waters. So far a module covering hydrological aspects has been missing to yield a comprehensive picture of a river's ecological status.

The Module Hydrology-flow regime (in short HYDMOD) has therefore been developed and conceived as an implementation aid for the Cantons for the above mentioned reasons and also with respect to the requirement of nature-like flow regime conditions as enacted in the federal water protection legislation.

HYDMOD starts with the inventory of water resources management related measures and interventions. Their impacts on the flow regime are evaluated. The result is a classification of the flow regime's natural status for a river system with individual river reaches as spatial reference objects. It is based on nine assessment indicators covering a wide variety of flow regime characteristics from the low flow, medium flow and high flow water regime.

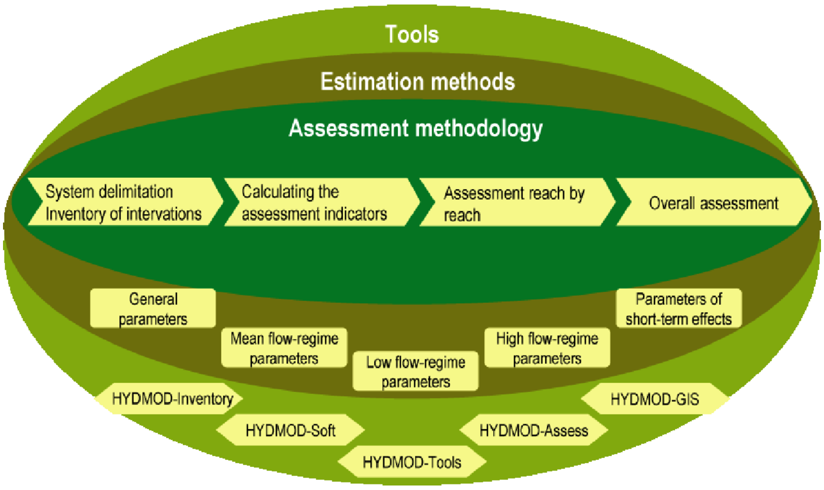


Figure 1. The "package" Module Hydrology – Flow Regime (HYDMOD)

Figure 1 schematically illustrates in the centre the single steps of the assessment method: from (1) inventorying the man-made interventions to (2) calculating the assessment indicators for the significant interventions, then (3) translating the point assessment at the intervention's location to the individual river reaches downstream and finally (4) aggregating the results for the individual indicators to a global classification.

As figure 1 also shows, HYDMOD comes as a package: the use of HYDMOD requires a number of hydrologic parameters. In many cases however, it can be assumed that the data available are scarce. For this reason, in parallel to the method development, a series of hydrologic fundamentals and estimation procedures were worked out that form part of HYDMOD. Finally, a few electronic tools were also developed which should make individual steps in the method's application easier for the user.

Case study Brenno

The method has been tested for the Brenno river basin in the Blenio valley (Canton Ticino) which is influenced by many interventions related to hydro-power exploitation (water abstraction, water deviations, reservoirs etc.). Figure 2 illustrates the cartographic results, left for one of the assessment indicators ("flood frequency"), right the global assessment (aggregation of the nine single indicators).

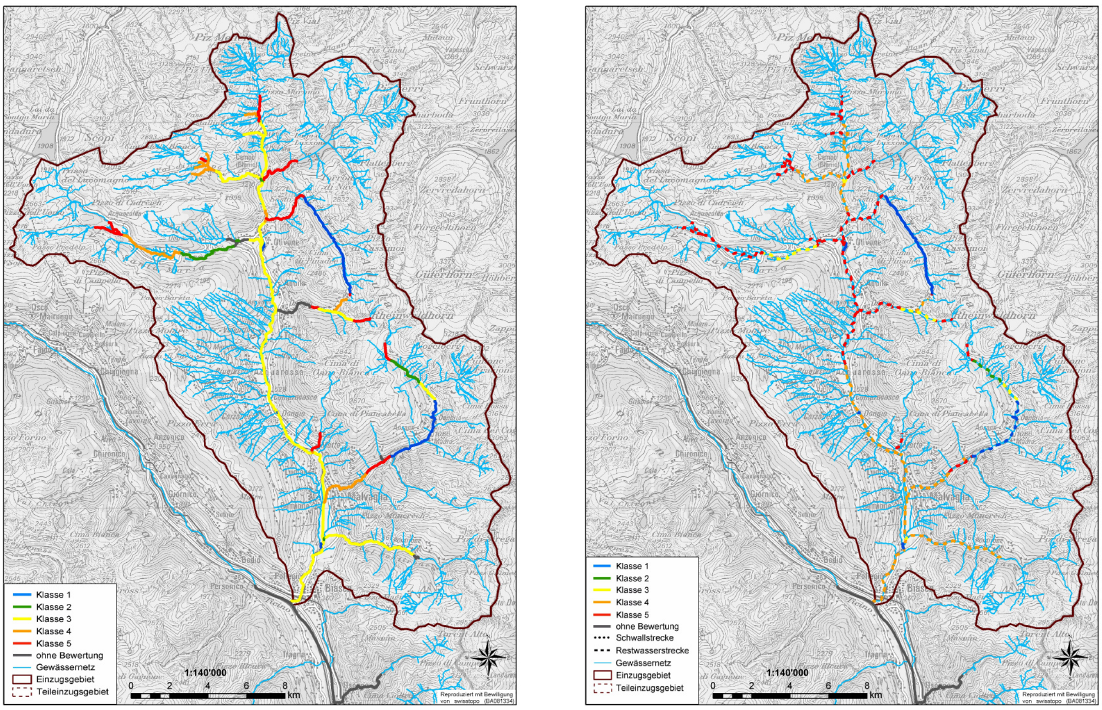


Figure 2. Cartographic results for the Brenno river basin case study. Left: classification for the indicator "flood frequency, right: global classification

The interested parties are invited to apply and test the draft of the method (Pfaundler et al. 2007) until the end of 2009. Based on the feedbacks from the experiences from practical applications, the method will be revised and published in its final version in 2010. The "side-products" and electronic tools developed for HYDMOD can be very useful also for other hydrological tasks. Together with the draft method, they can be ordered and downloaded free of charge via the following URL: http://www.modul-stufen-konzept.ch/e/hydro_startseite_e.htm

REFERENCES

BUWAL, 1998: Modul-Stufen-Konzept. Mitteilungen zum Gewässerschutz Nr. 26. Bundesamt für Umwelt, Wald und Landschaft, Bern. www.modulstufenkonzept.ch]

Pfaundler, M., Dübendorfer, C., Pfammatter, R. und Zysset, A., 2007: Methoden zur Untersuchung und Beurteilung der Fliessgewässer – Hydrologie-Abflussregime. Umwelt-Vollzug. Entwurf vom Oktober 2007. Bundesamt für Umwelt BAFU. Bern, 104 Seiten.

SAEFL/FOWG (Eds.), 2003: Guiding Principles for Swiss watercourses. Promoting sustainable watercourse management. Swiss Agency for the Environment, Forests and Landscapes (SAEFL) and Federal Office for Water and Geology (FOWG), Bern, 12 pp.

10.8

Hydropeaking on the Ticino River: Analysis, Impacts and Mitigation Strategies

Bruno Polli*, Luca Solcà**

* Ufficio caccia e pesca Cantone Ticino, Viale Stefano Franscini 17, CH-6500 Bellinzona, Switzerland (bruno.polli@ti.ch)
** CSD Tre Laghi Lugano, via Lucchini 12, CH-6900 Lugano, Switzerland (l.solca@csd.ch)

The problematic of irregular flow regime caused by the management of hydroelectric power plants has been not analysed at academic level in Switzerland up to the '90 of the last century.
In recent years several studies carried out in Switzerland demonstrate that the artificial variations of the flow regime significantly affect the aquatic biocenosis.
According to the result, the Ticino River is one on the most affected at national scale and, furthermore, a negative trend is observed during the last decades, where the influence of artificial regime is even more pronounced that before.
Starting from 1996 statistical data on the non-professional fishery are collected in Ticino and trends estimated from these data suggest a decrease of the caption in the lower part of the Ticino river.
The cantonal office for hunt and fishery (Ufficio caccia e pesca) decided to start a detailed research study in order to objectively evaluate the impact of hydropeaking activity on the aquatic biocenosis.

The study investigates the impact of anthropological alterations of the hydrological regime on the Ticino River ecosystem with both biological and ecomorphological approaches. The study area range from the embouchure in Lago Maggiore to the hydropower plant AET in Personico.
From a hydrological point of view, the statistical data provided by the Federal Office for the Environment (FOEN) will be completed with data coming from measurement stations specifically installed during this study. This will permit to figure out the hydrological characteristics of the river regime and to extrapolate the potentially alterations caused by the introduction of the "energy market". Physic-chemical parameters will be also collected by means of both punctual and continuous measurements.
Colmatation degree and mobilisation of the river bed during the daily peak of discharge will be studied with an experimental approach. Both phenomena have important influences on the success degree of the natural reproduction of fish populations.
The density and structure of fish populations will be investigated in a qualitative way by means of electrical fish. The target-species are trout (brown trout, lake trout and ev. marmorata) and grayling. In this way, natural reproduction will be quantified by comparing the results obtained before and after the spawn period.
Macro invertebrate populations will be characterized with the help of a biological index called IBGN. Additional collections have the goal to quantify the drift of macro invertebrates induced by the daily increase of the river discharge.
The results of all these activities will provide an exhaustive overview on the actual situation of the river ecosystem, which will allow identifying critical points and possible measures in order to improve the ecological state of the Ticino River.

10.9

Spatio-temporal effects of experimental floods on benthos, drift and seston below reservoirs

CT Robinson*, T Buser*, S Mannes*, D Kelly**, S Larned***

** Department of Aquatic Ecology, Eawag, 8600 Duebendorf, CH*
*** Department of Conservation, Christchurch, New Zealand*
**** NIWA, Christchurch, New Zealand.*

We examined the spatio-temporal effects of experimental floods on benthos, drift, and seston in rivers below reservoirs. Studies were conducted on the Spöl River, Switzerland and Opuha River, New Zealand. The flood in the Spöl increased discharge 28X, whereas discharge in the Opuha was increased fourfold. The duration of floods ranged from 4 to 8 hours depending on location along each river. Spatially, benthos was sampled from coarse-scale habitats along the Spöl. Drift and seston were sampled during each flood at sites longitudinally placed along each river. Coarse-scale benthic habitats all showed similar high losses of macroinvertebrates and periphyton regardless of location along the river. During each flood, peaks in drift occurred sooner than peaks in seston. All invertebrate taxa showed similar drift patterns during each flood, and drift density increased downstream during each flood. Seston showed two peaks in the Spöl as bed sediments became mobilized during the flood. Drift/seston displayed typical hysteresis curves during each flood. These data suggest that coarse-scale habitats do not provide refugia during large floods. The drift and seston data further indicate that invertebrates respond sooner to changes in flow than benthic sediments and organic matter, suggesting the role of behaviour in organism response to floods.

10.10

Thermopeaking from power plant releases in regulated Alpine stream

Siviglia Annunziato*, Salvaro Martino*, Zolezzi Guido*, Maiolini Bruno**, Carolli Mauro*** & Bruno Maria Cristina***

** Department of Civil and Environmental Engineering, University of Trento, I-38100 Trento*
*** Museo Tridentino di Scienze Naturali, Via Calepina, 14, I-38100 Trento*
**** Fondazione E. Mach, Via Mach, 1, I-38010 S. Michele all'Adige (TN)*

Rapid discharge variations due to hydropower releases are well known to be responsible for a strong impact on the ecological integrity of aquatic ecosystems. Such effect is not only related to sudden increases in water depth and velocity, that cause catastrophic drift and limit the availability of organic matter and refugia for the aquatic organisms. Especially in Alpine areas, in fact, hydropeaking is often associated with "thermopeaking", namely with sharp variations of water temperature induced by relevant temperature differences between the turbinated water and the recipient body.
Despite its ecological relevance, thermopeaking has not been quantified in detail in Alpine areas. A careful field study on the Noce River basin (NE Italy) allowed a first characterization of thermopeaking, providing the basis for the present study.
In order to develop sound mitigation strategies for hydro- and thermopeaking impacted river reaches, it is necessary to distinguish between anthropogenic and natural effects when analyzing the temperature time-series of a stream at a given cross section. This has been achieved through the comparison of temporal and spatial temperature variations due to natural channel confluences with those due to hydropower releases into the stream.
Assessment of existing impacts and of the feasible mitigation strategies requires:
1) quantifing the thermal fluctuations from field observations, and
2) predicting the effects of different release scenarios.

In this work we first quantify the thermopeaking extent in Alpine streams through the analysis of water temperature records and of the derivative of the recorded temperature signal. We compared water temperature regimes between thermopeaking-impacted and unimpacted rivers in order to distinguish daily natural cycles from thermopeaking fluctuations.
Figure 1 shows the marked seasonality of the thermopeaking processes, as a result of hydropower plants releasing cooler than natural water in summer periods, and causing reverse conditions during winter.
In order to predict the downstream effects of thermopeaking waves propagating along the stream a mathematical modelling

framework has been developed. It is a predictive tool based on a fully coupled 1D hydro-thermodynamic numerical model able to deal with natural, irregular geometries. The governing mathematical problem has been conveniently split into a convective problem and a diffusion problem in order to carefully describe rapid temperature and discharge variations. Application of the model can also be of interest to support planning of potential mitigating measures for thermal impacts on the recipient water body.

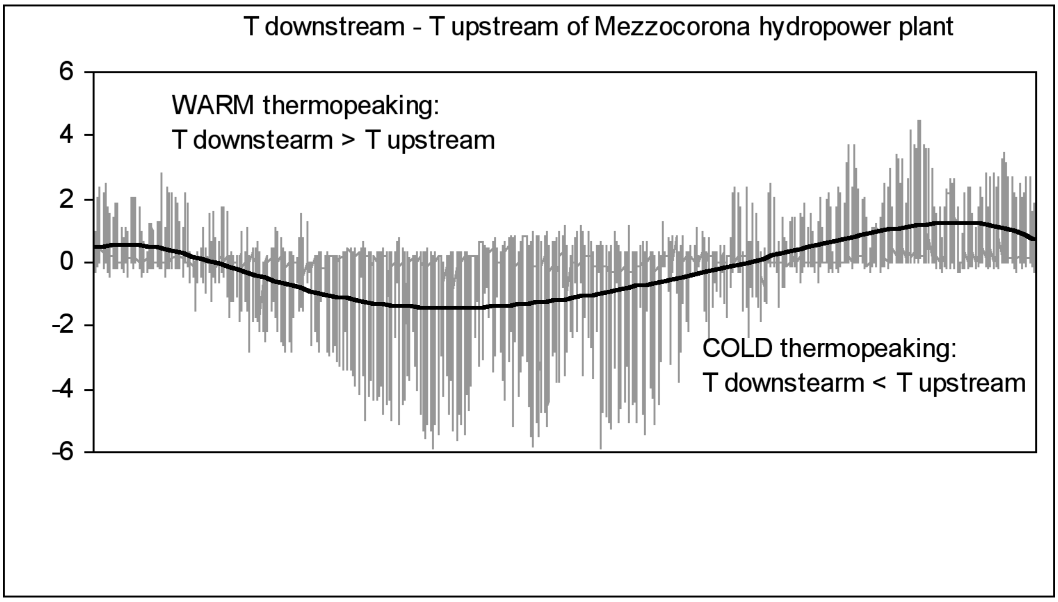


Figure 1. Cold and warm thermopeaking caused by the releases of turbinated water from the Mezzocorona hydropower plant in the Noce River (NE Italy) in the year 2007.