Historical channel adjustment in the Ahr river (Italian Alps) and ecological effects of restoration

Ajustement du canal historique sur la rivière Ahr (Alpes italiennes) et ses répercussions écologiques

Daniela Campana[1]; Francesco Comiti[1]; Giustino Tonon[1], Francesco Giammarchi[1] and Thomas Kiebacher[2]

[1]Faculty of Science and Technology, Free University of Bozen-Bolzano, Universitätsplatz 5 – piazza Università 5, 39100 Bozen-Bolzano, Italy (corresponding author: daniela.campana@natec.unibz.it). [2]Biological laboratory of the Provincial Agency for the Environment, via Sottomonte 2, 39055 Laives, Italy.

RÉSUMÉ

La plupart des rivières alpines présentent des conditions hydromorphologiques très altérées à cause de la production d'énergie hydroélectrique ainsi que des mesures de protection contre les crues. La rivière Ahr/Aurino (Alpes italiennes) était caractérisée jusqu'à la moitié du 20e siècle par un cours sinueux/anastomosé, avec de bandes riveraines larges. A partir des années 70 son cours a fait l'objet d'importantes modifications suite à l'activité locale d'extraction de gravier et à la rétention de sédiments par un barrage d'hydroélectricité et plusieurs barrages de consolidation le long de ses affluents. L'incision du lit et les travaux nécessaires à la stabilisation des berges ont séparé hydrauliquement et morphologiquement la forêt riveraine de la plaine alluviale, en affectant ainsi la croissance et les dynamiques des forêts d'aulnes. Le rétrécissement et l'approfondissement de sa section ont entraîné le pavage naturel du fond du lit et la réduction de la diversité morphologique dans le lit de hautes eaux, avec des répercussions sur l'habitat aquatique. Des travaux de renaturation (élargissement et surélévation du lit) ont été effectués dans plusieurs cours de la rivière Ahr entre 2003 et 2011. Les effets écologiques des interventions de réhabilitation sont présentement contrôlés par le biais d'une analyse des macrobenthos et de la population piscicole, ainsi que de la présence de végétation et la croissance d'arbres.

ABSTRACT

Most Alpine rivers feature highly altered hydromorphological conditions due to hydropower production and flood mitigation purposes. The river Ahr/Aurino (Italian Alps) was characterized until mid 20th century by a meandering/anastomosed pattern, with large riparian areas. Starting from the 1970s, it underwent intense channel adjustments as a result of local gravel mining and of the sediment retention by a hydropower dam and several check-dams along its tributaries. Bed incision and the following bank stabilization works disconnected hydraulically and morphologically the floodplain woodlands, thus affecting growth and dynamics of the alder woodlands. Cross-section narrowing and deepening brought about bed armouring and reduction of in-channel morphological diversity, with consequences for aquatic habitats. Restoration works (channel widening and bed raising) were carried out in different reaches of the river Ahr from 2003 to 2011. The ecological effects of restoration interventions are being monitored by analyzing macrobenthos and fish populations as well as vegetation establishment and tree growth.

KEYWORDS

Ecological assessment, macrobenthos, riparian vegetation, river restoration monitoring.

1 INTRODUCTION

Most Alpine rivers feature highly impacted hydromorphological conditions due to hydropower production and flood mitigation purposes. Few former floodplain areas still host riparian woodlands as a consequence of deforestation and land reclamation schemes to favor agricultural production. Changes in river morphology (pattern, substrate, floodplain characteristics) have determined sharp modifications of aquatic and riparian habitats and of the associated biotic community. In order to recover or at least to improve the ecological characteristics of degraded river systems, river restoration projects have begun to spread worldwide over the last two decades. Most river restoration projects in the Alps focus on channel widening, on reconnection and reconstruction of former secondary channels, on favoring bank erosion and bedload supply processes (Habersack and Piegay 2007). However, there isn't yet a clear understanding of how hydromorphological characteristics affect biotic elements and river ecological functioning. A multi-disciplinary approach relating ecological, hydrological and morphological characteristics is needed to understand how different biological parameters respond to hydromorphological degradation, which is a pre-requisite for the comprehension of the biotic response to restoration. The aim of the present research is to analyze the recent channel adjustments occurred in the river Ahr/Aurino (Italian Alps) and to assess the ecological effects associated to restoration interventions carried out in the period 2003 to 2011.

2 METHODS

2.1 Study area

The Ahr/Aurino river (basin drainage area of about 630 km^2) lies in South Tyrol (Italian Alps). The maximum elevation of the basin is 3498 m a.s.l., the minimum 810 m a.s.l. The lower valley features the typical U-shaped section carved by glaciers, which now cover an area of about 25 km^2, strongly influencing the flow regime (nivo-glacial). The Ahr valley is at places very wide (up to 900m), with an average channel slope of about 0.4%. Maps from 19th century illustrate an anastomosed system with several meandering channels (Fig. 1).

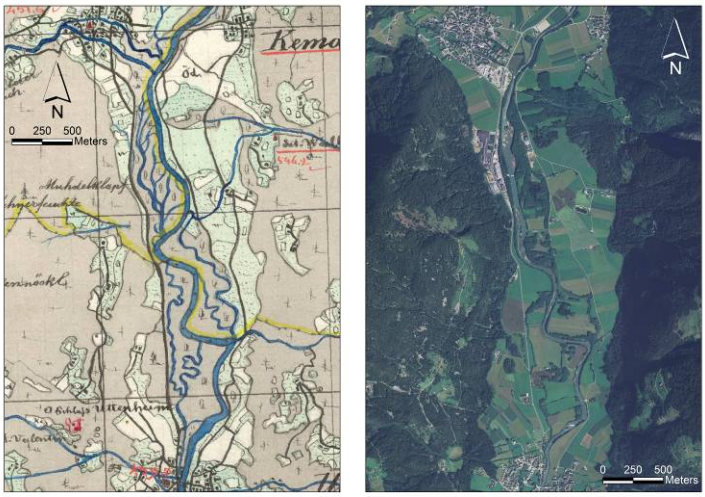

Figure 1 - The Ahr river in the analyzed reach: anastomosed conditions in 1858 (left) and the present (2006) artificially fixed meandering pattern (right)

At present, the river presents a single-thread, sinuous to meandering channel fixed by bank protections, with former floodplain areas no longer inundated even for 30-50 yr recurrence interval events. Such dramatic variations have most likely occurred in response to the combination of both intense sediment mining in the reach from the 1970s to the 1980s, and to the reduced sediment supply from the upstream basin determined by a hydropower dam (trapping roughly a basin area of 100 km^2) and by hundreds of control works (retention check-dams and grade-control structures) along the tributaries. Starting in 2003, the Department of Hydraulic Engineering of the Autonomous Province of Bolzano has undertaken a program of river restoration, mainly aimed at re-establishing adequate conditions of soil moisture for the remnants of the riparian woodlands present on the valley bottom. In fact, bed incision has led to a marked lowering of the groundwater table, not suitable for the survival of the riparian stands dominated by alder (*Alnus incana*). Restoration actions included channel widening by removal of ripraps coupled to channel bed filling and raising, mid-channel bar creation and bed stabilization by ramps (Fig. 2).

Figure 2 – One of the restored reach of the river Ahr in before (left) and after (right) the restoration works. The gravel mining site is clearly visible (courtesy of the Rip. Opere Idrauliche, Autonomous Province of Bolzano).

2.2 Materials and methods

Planimetric adjustments of the river Ahr have been analyzed by interpretation of historical maps and orthophotos, whereas the vertical variations have been inferred from a LiDAR DTM. The recent morphological changes following the restoration works have been evaluated by aerial photos and cross-sections surveys. Present habitat and hydromorphological characteristics quality have been assessed by IQM (Rinaldi et al, 2011) and CARAVAGGIO (Buffagni et al, 2005) methods. The ecological effects of restoration interventions are being monitored by analyzing macrobenthos and fish populations as well as vegetation establishment and tree growth. Macrobenthos samples are available from 2008 (on May, July and October) and since May 2011 sampling is carried out monthly at two different sites. Fish sampling has been carried out by the Province of Bolzano in 2003, 2004, 2007 and 2011. Composition and size of woody vegetation growing on bars has been surveyed in summer 2011, and 14 tree cores from the mature alder (*Alnus incana*) stand were taken in fall 2011 to test the potential for a dendrochronological analysis aiming at evaluating effects of groundwater variations on alder growth.

3 RESULTS AND CONCLUSIONS

After the severe morphological degradation (i.e., disappearance of gravel bars and of secondary channels, channel narrowing and bed incision) still present in year 2003, restoration interventions have increased habitat diversity and morphological dynamics of the river bed. A preliminary analysis of macrobenthos and fish samples suggest how their response to interventions are not major, but more analysis are needed to attain a statistical evidence.
A preliminary analysis of the tree cores showed that the dominant alder trees are about 40-50 yr old even though their diameter is < 30 cm, and point to the impact of bed incision on water availability. A wider tree sampling will be carried out in fall 2012 to detect if increase of tree growth occurred following the bed raising.

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