Assessing floodplain restoration potential through the re-use of hydropower peaking waves into nearby agricultural ditch networks

M. Cristina Bruno[1]*, Bruno Maiolini[1], Mauro Carolli[1], Elisa Varolo[1], Martino Salvaro[2], Elisabeth Slomp[2], Guido Zolezzi[2]

[1] Centro Ricerca e Innovazione, Fondazione E. Mach, Via E. Mach 1, S. Michele all'Adige (TN), I-38010 Italy. * cristina.bruno@iasma.it

[2] Department of Civil and Environmental Engineering, University of Trento, Italy

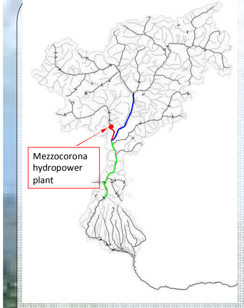


Fig. 1. The Adige River watershed

Problem 1: daily hydropeaks of 10 x baseflow (10 $m^3 s^{-1}$ of water released from Mezzocorona hydropower plant during production, Fig. 1 and 2), propagating to the Adige River downstream of the junction with the Noce River

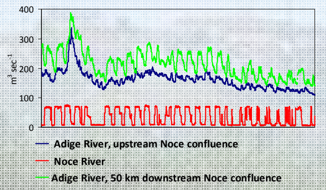


Fig. 2. Discharge measured in three sites near the study area (color codes as in Fig. 1), showing the hydopeaking impacts caused by Mezzocorona HPP

Problem 2: the ROTALIANA PLAIN is the agricultural floodplain located between the Noce and Adige Rivers, downstream of Mezzocorona hydropower plant. The Rotaliana Plain is intensively occupied by vineyards (production of quality wines) and to a lesser extent by apple orchards. Natural freshwater habitats have been sacrificed to agriculture.

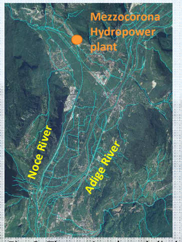


Fig. 3. The agricultural ditch network in the Rotaliana Plain

Consequences: high nitrate input to the rivers, lowering of the water-table for increasing irrigation demands.

An agricultural ditch network (Fig. 3) extends in the Piana Rotaliana for approximately 50 km over a 26 km² area. Most of the ditches are abandoned and dismissed. Part of the ditches are fed by natural springs and water discharge intake from the Noce River (Fig. 4) and used for flood protection during heavy rain.

(Partial) solution: reuse of hydropeaking water **to restore freshwater habitats** in the Rotaliana agricultural land by connecting the extended ditch network to the water discharged by the power plant.

How? **Raise the height of the intake sluice gate (Fig. 4), thus doubling the existing discharge into the ditches, but ONLY during the hydropeaking events, in order not to alter the Minimum Vital Flow released mandatorily into the Noce River.**

MAIN EXPECTED ECOSYSTEM BENEFITS (while maintaining HP production):

1. partial reduction of hydropeaking
2. transition from agricultural land to agro-ecosystem
3. increased water quality in the agricultural ditches (dilution, denitrification, phytodepuration)
4. increased biodiversity in the area and in adjacent protected wetlands
5. increased groundwater recharge

Fig. 4. Inlet from the Noce stream to the ditch network

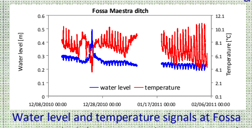
What has been done: Hydraulic characterization

STEP 1: characterization of the present state of the ditches network.

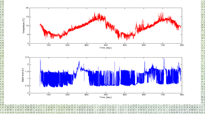
Collection of historical topography and hydraulic data (from 1906)

Update of historical data: GPS RTK survey of the ditches network

Hydraulic characterization: water level and temperature time series in selected ditches



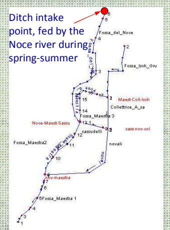
Water level and temperature signals at Fossa Maestra ditch (approximately 2 months at 2' intervals)



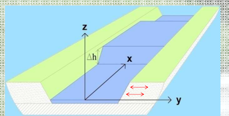
Temperature and water level of the Noce River downstream Mezzocorona HPP (Dec. 2008 – Dec 2010)

STEP 2: Quantification the hydraulic benefits of possible hydropeaking water re-use: water resilience time in the ditch network, water/aquifer exchange.

Developed an unsteady hydraulic model for hydropeaking wave propagation in the ditches network (1D free surface flow)



Developed a symplified 1D model to simulate the propagation of discharge and thermal waves in the riparian area

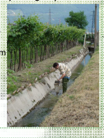


What has been done: Ecological characterization

29 stations along 12 ditches sampled in June and September 2010: physico-chemical variables, macrophytes and benthic community surveys.

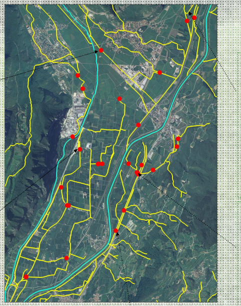
Fossa di Mezzocorona: example of group B

June	September
Flow: 0.02 m³/s	Flow: 0.09 m³/s
pH: 8.79	pH: 8,65
Cond: 195.7 µS/cm	Cond: 214 µS/cm
O_2%: 109	O_2%: 108
V AVG: 0,3 m/s	V AVG: 1.2 m/s
Tmax: 16.9 °C	Tmax: 15. 4 °C
ΔT: 4.7 °C	ΔT: 2 °C



Fosso Rotaliano: example of group B

June	September
Flow: 0.06 m³/s	Flow: 0.11 m³/s
pH: 8.66	pH: 8.12
Cond: 217 µS/cm	Cond: 203 µS/cm
O_2%: 112	O_2%: 105.8
V AVG: 0.4 m/s	V AVG: 0.7 m/s
Tmax: 16.8 °C	Tmax: 15.5 °C
ΔT: 3.2 °C	ΔT: 3.1 °C



Fossa di Caldaro: example of group D

June	September
Flow: 2.1 m³/s	Flow: 2.1 m³/s
pH: 7.82	pH: 8.11
Cond: 628 µS/cm	Cond: 620 µS/cm
O_2%: 55.2	O_2%: 68.9
V AVG: 0.1 m/s	V AVG: 0.1 m/s
Tmax: 26.4 °C	Tmax: 21.7 °C
ΔT: 2.8 °C	ΔT: 2.8 °C

Fossa minore: example of group C

June	September
Flow: 0.28 m³/s	Flow: 0
pH: 7.42	
Cond: 943 µS/cm	
O_2%: 4	
V AVG: 0.1 m/s	
Tmax: 19.5 °C	
ΔT: 7.7 °C	

Fosso Rotaliano: example of group D

June	September
Flow: 0.38 m³/s	Flow: 0.58 m³/s
pH: 7.84	pH: 8.86
Cond: 508 µS/cm	Cond: 340 µS/cm
O_2%: 135.3	O_2%: 167.8
V AVG: 0.2 m/s	V AVG: 0.3 m/s
Tmax: 20.2 °C	Tmax: 17.8 °C
ΔT: 3 °C	ΔT: 4.1 °C

Fossa di Lavis: example of group E

June	September
Flow: 0,28 m³/s	Flow: 0,84 m³/s
pH: 8.3	pH: 8,2
Cond: 535 µS/cm	Cond: 482 µS/cm
O_2%:135	O_2%: 112.5
V AVG: 0.1 m/s	V AVG:0.3 m/s
Tmax: 18.5 °C	Tmax:15.5 °C
ΔT: 6.2 °C	ΔT:3.3 °C

Physical-chemical variables divided the ditches in 4 groups.

- A: lentic, highest T mean value, low dissolved O_2 and low or null velocity.
- B: fastest flow, high pH and dissolved O_2 values, narrow and shallow ditch profile, concrete bottom.
- C: intermediate values between B and D, stations closest to the source.
- D: largest and deepest ditches, slowest flow, low pH and highest O_2 values.
- Macrophytes: 36 taxa in total. Taxa richness per site: 1-11. Taxa composition differs within the 4 groups of ditches.
- Benthic invertebrates: 29 taxa in total. Taxa richness per site: 1-12.

The statistical analysis did not identify clear and well-separated patterns in macrophytic or benthic community composition.

Conclusions: The ditch network represents a largely variable range of aquatic habitats on a relatively small spatial scale. Their restoration would enhance biodiversity in highly anthropic areas, at the same time efficiently storing water resources which otherwise would be quickly withdrawn from the system.

An ecological management of the ditches would restore the hydraulic connectivity with the surrounding territory; the increased inflow would reduced abrupt variations of the physico-chemical parameters, allowing the permanence of more diverse and structured aquatic communities. Such communities would provide ecosystems benefits typical of floodplain wetlands.

A fraction of the water delivered by each hydropeak would be absorbed from the ditch network, reducing the hydrological and ecological alterations downstream.

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.