Assessing runoff processes at different spatial and temporal scales in a glacierized Alpine watershed

1. INTRODUCTION

The Alps form Europe’s highest mountain range covering an area of 240,000 km²; around 10% of this is covered by glaciers. Many glaciers are retreating, reflecting a response to climate change and increased temperatures (Kaser et al., 2002) in some areas these responses are very rapid. Some of Europe’s largest river systems have their headwaters in the Alps and are fed by meltwaters from the mountain snowpack and valley glaciers. These melt waters have a major influence on the physical, chemical and ecological characteristics of the river systems they drain into.

2. OBJECTIVES

- To characterise the hydrology and tracer chemistry of the river – floodplain system at Lake Combal.
- To provide a preliminary, tracer-based conceptualization of the hydrological functioning.
- To upscale this hydrological process understanding to Alpine watersheds.

3. STUDY SITE

Dora di Veny – an important Alpine river system in the Aosta Valley (Italy). 90 km² catchment, mainly comprised of the southern slopes of Mont Blanc.
- Parts of the Dora di Veny’s headwaters form a relatively pristine, classic alpine braided river – the Lago Combal floodplain system (Figure 1).
- The study area is ca. 1 km² floodplain of a braided river (originally a lake created by the damming of the Dora di Veny river by the moraines of the Magie glacier) (Figure 2)
- Mainly fed by meltwaters from the Lex Blanche and Estellestes glaciers, snowmelt from the Lex Blanche stream and groundwater seepage from adjacent hillslopes (Figure 3).

4. DATA AND METHODS

- Spatial sampling of all major water courses in the floodplain.
- Electrical conductivity (µS cm⁻¹) as preliminary tool to differentiate contrasting source waters.
- Further samples analysed for dissolved oxygen (mg l⁻¹) using hand held probes and pH and Gran alkalinity (µEq l⁻¹) by acidimetric titration.

5. RESULTS

- Clear spatial organisation in hydrochemistry (Figure 4).
- Distinct temporal differences in terms of water source dynamics with lower conductivity in the river system in September.
- Early in the glacial melt season: significant groundwater contribution to flows.
- Groundwater appears to emerge from 3 distinct sources: high conductivity groundwater springs emerge from rock slopes on the northern edge of the floodplain; groundwater seepage on the southern side of the floodplain; groundwater springs re-emerge in the floodplain itself (see sample point 6).
- Low dissolved oxygen levels consistent with the more weatherable sediments indicating young residence times and strongly reducing conditions at a sampling point 6.7 and 8.
- At the downstream end of the floodplain: conductivities and alkalinites are closer to glacial inflow waters than groundwater.
- Hydrology is dominated by the melting of the high proportion of precipitation that falls as snow during winter, the steep terrain and geotectonic conditions of low permeability (Figure 5).
- Spring melt season (May – June) is characterised by floodhigh flows
- July – September: glacial melt sustains river flow.

6. DISCUSSION & IMPLICATIONS

- Development of a conceptual model of the hydrological functioning of the river floodplain system – quantitative assessment of contribution of different sources using end member mixing techniques.
- Response of alpine river systems to climate change is likely to have major implications for issues as water supply, hydropower production and flood management.
- Different source waters create diverse range of freshwater habitats in the river – floodplain systems.
- Alpine rivers, and their associated floodplains, form unique ecological habitats; and this major European, biodiversity resource will also adapt to climate change.

Table 1. Summarised range of selected determinands in different runoff sources at the Lago di Combal September 2004

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\begin{array}{lcccc}
\text{Runoff Source} & \text{Conductivity (µS cm} ^{-1} \text{)} & \text{Glacial melt-water} & \text{Groundwater} \\
\hline
\text{Dissolved Oxygen} & 236 - 1268 & 24 - 240 & 458 - 2054 \\
\text{pH} & 7.4 - 8.4 & 7.6 - 8.2 & 0.0 - 6.5 \\
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