The effects of POPs on Alpine organisms and ecosystems

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1. Abstract
A synthesis of the results of monitoring campaigns performed from 2000 to 2007 to measure POP concentrations in Alpine glacial streams is reported. Data are used to assess the potential risk for the aquatic communities. The results indicate that POPs may represent a threat for high mountain aquatic ecosystems.

2. Introduction

Persistent Organic Pollutants (POPs) are known to concentrate in cold environments as a result of volatilisation from warm regions and condensation in colder areas. The role of high mountains as cold condensers was hypothesized by Calamari *et al.* (1991) and confirmed by many authors (Blais *et al.,* 1998). In particular, Alpine glaciers are a sink for pollutants (Villa *et al.* 2003, 2006a) and ice layers deposited in the second half of the XX century contain high concentration of POPs (Fig. 1).
[FIGURE 1]

This burden of pollutants is known to be then released in streams as a result of glacial melting (Blais *et al.,* 2001a; Villa *et al.,* 2006b). As a consequence, it is possible to hypothesize a pollutants flow during summer that may represent a threat to the surrounding ecosystems.
Most POPs can produce adverse effects at very low concentration, acting as endocrine disrupting chemicals (Asplund *et al*., 1999) or as carcinogens (Ahlborg *et al*., 1995). Moreover, POPs have a high potential for secondary poisoning due to their biomagnification capability. Finally, biological communities of extreme ecosystems are particularly vulnerable, due to their relatively simple structure. Despite these evidences, a few studies have focused on high-altitude water samples (Vilanova *et al.,* 2001; Carrera *et al.,* 2001; Blais *et al.,* 2001a, 2001b, Lafreniere *et al.,* 2006).
In this paper the results of some monitorig campaigns in Alpine glacial streams are described, to assess the potential risk for aquatic comunities.

3. Materials and Methods

Since the year 2000, POP contamination in Alpine glacial streams was monitored. Five glacial streams were sampled in the Italian Alps (Fig. 2): Lys stream (Lys glacier, Monte Rosa massif, Western Alps); Frodolfo stream (Forni glacier, Ortles-Cevedale group, Central Alps); Dora di Veny stream (Miage glacier, Monte Bianco massif, Western Alp), Careser and Noce Bianco streams (Careser glacier and Col De La Mare glacier respectively, both in the Ortles-Cevedale group, Central Alps). Lys and Frodolfo streams were sampled in 2000, 2001 and 2002. In 2002 Dora di Veny, Careser and Noce Bianco were added.
[FIGURE 2]

In 2006 an intensive monitoring was performed on the Frodolfo stream for a more detailed assessment of temporal (daily and seasonal) trends and of transfer in aquatic trophic chains.
In 2007 a survey was performed on several glacial streams of Valtellina, in order to estimate the load to River Adda and Lake Como. Analyzed chemicals were DDT isomers and metabolites, HCB, α-, β-, γ-HCH and a selection of PCBs. Details on the monitoring plans and on the sampling and analytical procedures are described in the original papers (Villa *et al.,* 2006b; Bizzotto *et al.,* 2007).

3. Results and Discussion

A synthesis of the major results is reported below. More details on the results can be found in the already quoted original papers. In figure 3 the range of concentrations measured in glacial streams is reported for chlorinated pesticides (sum of DDTs, sum of HCHs and HCB). In Frodolfo and Lys, for which systematic samples are available, the range of concentrations of all chemicals is in good agreement. For Miage the difference is due to the sporadic sampling frequency, however, values fall within the range observed in the other streams. Same comments can be made for Careser and Noce Bianco, where data even more sporadic. In the same geographic areas, some non-glacial streams were also sampled. The concentrations of all chemicals were substantially lower (about one order of magnitude), confirming that the levels measured in glacial streams are a consequence of the accumulation in glaciers.
[FIGURE 3]

Different comments can be made on PCBs measured in the Frodolfo stream during 2006 (Fig. 4). Levels measured in May are low and comparable with those observed in other glacial streams. In June a concentration increase of about three orders of magnitude is observed. Than, concentration decreases, up to levels comparable to those measured in May. A comparable trend was observed in a non glacial stream sampled in the Frodolfo Valley.
[FIGURE 4]

A possible explanation of this trend could be a contamination due to snow melting and local emissions instead of long range transport and glacier accumulation. Possible sources of local emissions for PCBs could be hydroelectric power plants. Indeed, a small hydroelectric power plant is present in the Frodolfo Valley, close to sampling sites.
About the possibility of ecotoxicological risk, it is reasonable to suppose that the traditional risk assessment approaches, based on data on a few standard organisms and on traditional endpoints, are not suitable for assessing the risk on the Alpine communities due to POPs.
Species sensitivity distribution (SSD) has proved a useful approach to predict the sensitivity of entire communities (Posthuma *et al.,* 2002). The basic assumption is that the sensitivity of different species in a community toward a given stressor follows a normal distribution. According to this assumption, the number of species potentially affected by a given concentration of a toxic chemical can be statistically determined. According to the Dutch school, a concentration safe for 95% of the species of a community (HC5: Hazardous concentration 5%) could be assumed as suitable for protecting the ecosystem.
Major limitations for the application of SSD, in particular for POPs in Alpine ecosystems, are the following:

- due to the lack of information, SSD model are often based on acute toxicity data; chronic data are not frequently available for a large number of species; even less data are available for endocrine disruption endpoints;
- SSD does not take into account secondary poisoning, extremely relevant for POPs;
- no data are available for developing SSD models for species typical of Alpine ecosystems and nobody knows if they are more sensitive than traditional species.

In figure 5, an example of SSD curves, specific for fish and arthropods, is reported for DDT. The estimated HC5 is about two orders of magnitude higher than the upper limit of the range of concentrations measured in glacial streams. However, the value should be reduced by the application of four different security factors due to the difference between acute and chronic toxicity (in this case a factor of 10 is traditionally applied), secondary poisoning, endocrine disrupting effects, higher sensitivity of alpine communities. In particular, a reasonable value for the last two factors is totally unknown; however, it is highly probable that measured concentrations in glacial streams could overcome a threshold of risk for aquatic communities.

[FIGURE 5]

4. Conclusions

In synthesis, the following schematic conclusions can be drawn.

- Glacier melting mobilise POPs accumulated during the period of massive global use; therefore. POP concentrations in streams fed by glaciers is substantially higher than in non glacial streams. The pattern can be enhanced by global warming.
- Besides global long range transport, Alpine streams can be contaminated by local emissions followed by cold condensation and snow scavenging. In particular, local emissions are likely for PCBs due to the distribution of hydroelectric power plants in the Alpine territory.
- Nobody knows if there are significant differences of sensitivity between Alpine and low-land aquatic communities. However, risk from POPs is likely to occur in Alpine streams.

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