

## Conclusions and perspectives

Surface waters in many areas of Europe with sensitive geology suffered severe anthropogenic acidification during the last century, among them also water ecosystems in remote mountain areas, which are extremely sensitive to global changes. The lake district of the Tatra Mountains on the Slovak-Polish border, as well as lakes in the Šumava Mountains and reservoirs in the Jizera Mountains (Bohemia, Czech Republic), were strongly acidified.

The reasons for acidification were elevated sulphur and nitrogen emissions, transported long distances in the atmosphere. The contribution of nitrogen to acidification was always very high (up to 40%) on the territory of the Czech and Slovak Republics, compared to other acidification areas within Europe. However, the size and character of a watershed (namely the geology and vegetation cover) and forest management in the watersheds were important factors influencing the sensitivity of waters to acidification, the extent of damage, and the dynamics of the acid-driven processes.

The man-made acidification may be combined with a natural acidity (dystrophy) in some waters, caused by a high amount of organic acids.

Acidification led to a change in the water chemistry (a decrease in pH and alkalinity, and an increase in concentrations of sulphate and nitrate), and to a reduction of biodiversity in freshwater ecosystems. Fish and planktonic Crustacea disappeared from many lakes. Acidification-induced oligotrophication, eutrophication, and toxicity of aluminium were recognized as key mechanisms of the effect of anthropogenic acidification on biota. In the areas studied, the consequences of acidification were more drastic than in other mountain areas of the world.

Since the beginning of the 1990s, the water ecosystems in all the areas studied have been rapidly recovering from acidification due to a strong reduction of both sulphur and nitrogen deposition. Recovery of water chemistry from acidification started immediately after the socio-economic changes in Central Europe in 1989, but has been delayed by a hysteresis of pH and elevated concentrations of aluminium in some watersheds (Kopáček *et al.*, 2002). The past water chemistry in these and many other studied areas, as well as predictions for the

future, have been extensively modelled using the MAGIC model. Thus, there are different recovery scenarios for areas reforested with Norway spruce monoculture and those planted with a mixed forest, with a tree species composition close to the original forest, and for lakes in the alpine zone (Křeček & Hořická, 2001; Kopáček *et al.*, 2004; Hardekopf *et al.*, *submitted*).

It is much harder, though, to predict the biological recovery. It often followed the changes in water chemistry, but, in general, it was delayed because of the considerable complexity of these processes. The survival of re-stocked salmonid fish (*Salvelinus fontinalis*, *Salmo trutta morpha fario*) is determined by water pH and concentration of aluminium, the food supply, and the lake – tributaries system, which enables the survival of fish in periods of snowmelt or flood flows, accompanied with a drop in water pH (Hořická *et al.*, 2005). In planktonic and littoral Cladocera, so far we have seen that in addition to the return of original species to lake ecosystems, we must expect a period of an unstable dynamics in the species composition, where the trophic status of a lake, water temperature and acidity, quality and quantity of food, and predation by fish and invertebrates (e.g. *Notonecta*) will be determining factors in the post-acidification succession (Hořická, 2005; Sacherová *et al.*, 2005). In the first phase of the recovery of biota, we expect small species with a short turnover time, the “right” life strategy, and a high adaptability to win in competition. For many species now missing, like rotifers or planktonic Copepoda, we do not know whether their return is possible (Kohout & Fott, *in press*). The dispersal of water organisms is a stochastic process, especially in isolated and remote from each other environments. While the fish can be re-stocked by man, the ways and mechanisms of water animals' transport are much more complicated and partly still unknown.