Diverse ecological effects in Swedish lakes after termination of liming

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Background

Liming has for decades been applied at large scale to mitigate the effects of acidification in Swedish surface waters. Currently, 20000 lakes are main targets for lime treatment. However, since 2006 the number of limed lakes has decreased by 20%, a trend that is predicted to continue as acid deposition has decreased in the region.

Termination of liming may lead to reacidification but little is known about how limed and unlimed ecosystems will respond. Studies of the effects of reduced and terminated liming have therefore become a major theme within ISELAW, a Swedish national monitoring and research program. We present long-term integrated monitoring of data from four lakes situated in Tyresta National Park, Sweden, including one limed, one reference and two previously limed lakes (Fig. 1). Our objective is to determine how fast and to what extent the organism communities in previously limed lakes approach the situation in the reference lake.

Water chemistry (Fig. 2)

Acidity and alkalinity increased during the limed periods but varied much between the initially different regimes. After the last liming in pH and Al have decreased continuously; although more and faster in the small Lake Trehörningen, where pH reached the reference lake’s level after 15 years. Lake Längsjön had not reached the reference pH after 10 years. Both lakes have experienced acidic episodes with depleted alkalinity during the last decade.

Zooplankton (Fig. 2)

Zooplankton species richness decreased rapidly with reacidification in L. Trehörningen and leveled off at below the species richness in the reference lake. In contrast, the number of species has increased after termination of liming in L. Längsjön. Zooplankton increased also in the small L. Trehörningen. Most common plankton are known to be sensitive to low-oxygen conditions. The contribution of cladocerans to the species richness decreased after liming in L. Trehörningen but were unaffected by the decreasing pH and alkalinity in L. Längsjön.

Phytoplankton (Fig. 2)

Phytoplankton increased during the first few years after termination of liming in both lakes. Phytoplankton richness in L. Längsjön remained at levels comparable to the reference L. Stenö after an extended period, whereas the richness dropped in L. Trehörningen. During the last few years, there is a sign of decreasing species richness in both lakes, maybe as a result of more frequent acidic episodes.

Conclusion

The long-term effects of terminated liming on water quality and plankton were studied in two lakes, and on fish and benthic fauna in one lake. All variables were monitored in parallel in a limed lake and an untreated reference lake.

The rates of alkalinity and pH decline after termination of liming differed between the two lakes, which may be attributable to size, catchment and liming history.

The response on plankton differed greatly between the two lakes. In the more rapidly reacidifying lake, plankton composition approached the state of an acidified lake. The plankton communities in the other lake were not affected by termination of liming after 15 years.

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Observations on the state of fish communities were also made. Long-term monitoring showed that fish species richness was affected by the termination of liming, with a decrease in species richness in the limed lake compared to the reference lake. The fish communities in both lakes were affected by the termination of liming, with changes in species composition and abundance.

Fig. 3. Annual samples of Fish and Benthic Invertebrates

Fish (Fig. 3)

Fish abundance data is highly variable between years and trends must be assessed critically. The number of roach (Rutilus rutilus) and the relative species in these lakes, appears to have decreased in L. Längsjön during the last period, whereas it has become increasingly abundant.

However, roach has decreased only in the Längsjön lake making it difficult assess the cause. Changes in the mean body weight can indicate changes in recruitment but the data reveal no signs of depletion of smolts. There are not (yet) any evidence for reacidification effects on the roach population in L. Längsjön.

Benthic Invertebrates (Fig. 3)

The M&N index in L. Längsjön decreased sharply after 1998 and is approaching the index of the reference lake, while the index is stable in the Trehörningen. The benthic invertebrate community, in contrast to fish and plankton, thus indicates reacidification of Lake Längsjön.

In contrast, there is no clear effect of terminated liming on the benthic invertebrate diversity in none of the three studied habitats. However, in the L. Trehörningen, where we have the longest time series the profundal fauna shows a declining diversity.

Sampling

Monitoring of water chemistry and plankton started in 1970. Water chemistry was sampled during the May-October period. Phytoplankton and zooplankton were sampled bi-monthly during the summer months and monthly during the winter months. Fish were sampled using gill nets and trawls.

Annual sampling of fish (summer) and benthic invertebrates (fall) started in the late 1960s in Lake Strömsjön and even later in the other lakes. Monitoring of fish and benthic invertebrates has been ongoing since 1990s.