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Special Issue

Predicting recovery of acidified freshwaters in Europe and Canada

Preface

Deposition of acidifying compounds from the atmosphere, acid rain, has been decreasing in Europe since the peak years of the late 1970s, because of reductions in emissions of sulphur (S) and nitrogen (N) gases to the atmosphere. These have come about largely from international agreements under the auspices of the United Nations Economic Commission for Europe (UN-ECE) Convention on Long-range Transboundary Air Pollution (LTRAP).

In response, acid-sensitive freshwater ecosystems have started to recover from the adverse effects of acidification. The first indications came in the 1980s when monitoring programmes, such as ICP-Waters (part of the LTRAP Convention), documented significant and widespread changes in water chemistry, including decreases in concentrations of sulphate, increases in pH, increases in acid neutralising capacity and decreases in toxic forms of aluminium. These trends continued through the 1990s in Europe, and similar trends have been observed in acidified waters of eastern North America.

Work within the Convention has become increasingly more complex during the past 20 years. The first agreements involved across-the-board cuts in emissions of S and later N compounds. In the 1990s, this approach was replaced by the critical load approach, an effect-based receptor concept that considered the natural spatial variations in acid sensitivity. The latest protocol, signed in 1999 (the Gothenburg protocol), further increased the complexity by considering multiple pollutants and multiple effects using the critical loads concept. Canada and the United States have as yet not taken the critical loads approach.

The critical load concept takes a static view, which assumes steady-state conditions between acid deposition, water chemistry and biological effects. In this sense it invokes the precautionary principle. In reality, of course, the response of water chemistry to changes in acid deposition is not instantaneous but, rather, entails lag times of years to decades, depending upon the processes involved and the natural characteristics of vegetation, soils and waters. Neither are the responses of biological components to changes in water chemistry instantaneous and, again, lag times of years to decades may be involved. For example, re-establishment of a damaged salmon or trout population may require several generation times, i.e. 10-20 years, once the chemical conditions again become suitable.

In the 1980s monitoring programmes in various countries and within the Convention were set up to document changes in ecosystem response to changes in acid deposition. Results from ICP Waters and national programmes have revealed substantial delays in response of water chemistry to decreased acid deposition. In Europe, for example, although S deposition has decreased by 50-60% during the period 1980-2000, the response in several chemical parameters has been more modest, and there have been only scattered reports of recovery of fish populations and other organisms.

The observed data thus do not answer questions such as whether the reductions in emissions of S and N compounds will be sufficient, and when the recovery of damaged ecosystems will occur. It may be politically unacceptable that steady-state conditions are first reached after many decades. Additional reductions in emissions may be necessary to speed up the recovery process.

Prediction of these lag times in the future acidification of freshwater ecosystems requires the use of models. Process-oriented models for acidification of soils and waters have been developed over the past 20 years and widely used to explain observed changes in water chemistry as well as to attempt to predict future changes in response to changes in acid deposition. These models are time dynamic, such that they can be used to estimate the lag time between changes in deposition and changes in water chemistry.

The RECOVER:2010 project is an EU research project focussed specifically on the recovery of surface waters in Europe from acidification. Waters characteristic of all the

acidified regions in Europe are included. The project first conducted a systematic analysis of existing long-term data sets for trends in deposition and surface water chemistry. The results of these were published in 2001 as a Special Issue of Hydrology and Earth Systems Sciences.

The project then calibrated dynamic models to the data and used these to predict future water chemistry given standard scenarios of future emissions of S and N compounds in Europe. Similar work was conducted in parallel in mountain lake regions in Europe (the EU project EMERGE) and in eastern Canada. The results of these predictions are found in this new Special Issue of Hydrology and Earth Systems Sciences.

Such predictions, of course, are inherently fraught with uncertainty. The uncertainty comes from the data used as inputs to the models, from the simplifications necessary in the models themselves, and from the confounding influence of other environmental factors. The future role of nitrogen in terrestrial ecosystems has long been a major source of concern. If ecosystems become nitrogen saturated, then nitrogen leached from catchments can cause significant acidification in the future, and thus offset or delay recovery. Future climate change is another such confounding factor. Work in Canada shows, for example, that drought events can delay recovery.

Results of the RECOVER:2010 project have helped point the way forward for work within the Convention, and provide a starting point for time-dynamic assessments that can form the basis for new protocols for emissions of air pollutants in Europe and North America. The models can now be used to calculate target loads; i.e. to what level and when must deposition of S and N be reduced to allow recovery of freshwaters by a given year in the future. Further the results can be used to evaluate the future ecological status of acid-sensitive surface waters, as mandated by the EU Water Framework Directive. The project offers a prime example of the fruitful cross-fertilisation between environmental monitoring, research and policy.

Richard F. Wright
Oslo and Skåtøy,
Norway