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SWEDISH ENVIRONMENTAL PROTECTION AGENCY

ISELAW

Integrated Studies of the Effects of Liming Acidified Waters

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Acidification and effects of liming as revealed by national lake surveys in Sweden

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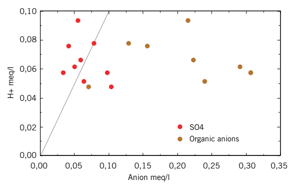
Lake surveys

Swedish national lake surveys have been performed seven times since 1972. The last two lake surveys, in 1995 and 2000 were executed in the same way. Acidification was one of the main objectives for both surveys. Based on a statistically stratified selection about 3000 lakes were sampled. This selection allows a destratification of the results describing the conditions for the entire Swedish lake population, which is about 100 000.

Possible sources of acidity

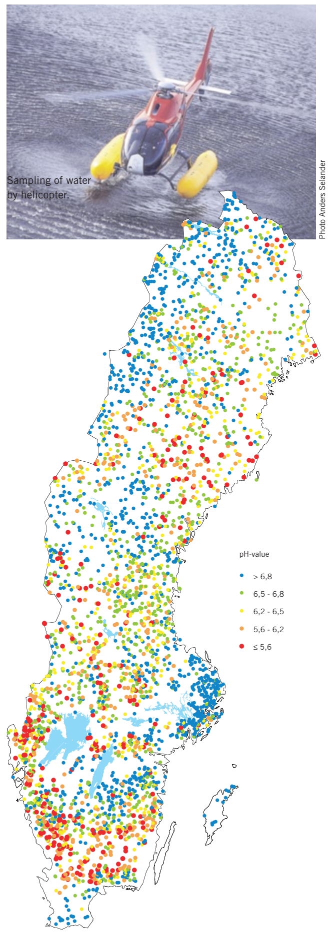
Both natural humic acids and anthropogenic sulphuric acid may contribute to the acidity of the lake. Swedish lakes are often quite humic; the median TOC concentration is 10 mg/l and the highest 50 mg/l. One way to reveal the importance of humic acids (organic anions) is to make a comparison with SO_4, which is at least partially of anthropogenic origin.



The relation between H+ and two anions which may contribute to the acidity. Organic anions indicate humic substances of natural origin, and SO_4 indicates anthropogenic acidification.

The H^+ concentration is used as an indicator of acidity. Concentrations of SO_4 and organic anions are used as indicators of the origin of acidity. In the most acid lake (highest H+) the concentration of organic anions is about 0.2 meq/l while the SO_4 concentration is only about 0.5 meq/l. Organic anion concentrations can explain the acidity of these lakes. However, concentration of SO_4 contributes as well.

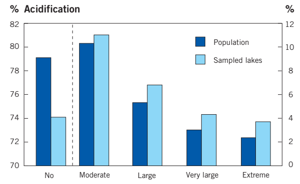
The graph describes a difference between acidity and acidification. But even a minor contribution of SO_4 can affect biota.



The map shows the pH-value of lakes sampled during the lake survey in the autumn 2000.

From 3 000 to 100 000

Stratified sampling with respect to lake size and acidity makes it possible to estimate conditions for the entire lake population. Acidification is estimated according the present Swedish Environmental Quality Criteria based on the Steady State Water Chemistry Model (SSWC).



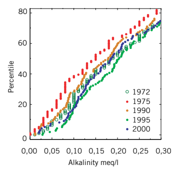
Acidification. Classification according to present Swedish Water Quality Criteria. For the sampled lakes and for the entire Swedish lake population.

The effect of the stratified sampling is indicated by the higher percentages of acidified, sampled lakes as compared to the entire lake population. Destratification indicates that 79 % of the Swedish lakes are not acidified.

The surveys also describe trends

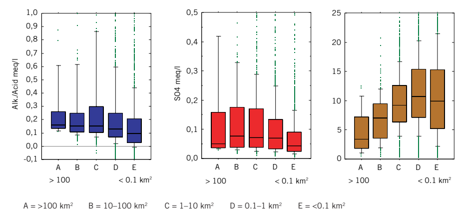
Five surveys have been performed since 1972. About 100 lakes are included in all of them. These are among the few lakes which have been sampled more or less frequently since then. Only pH and alkalinity values are available for all surveys.

Frequency distribution for alkalinity in lakes surveyed at all five lake surveys. The acidity situation in 1972 deteriorated to an even worse situation in 1975 and later surveys depict recovery leading to higher alkalinities.



Lake size is important

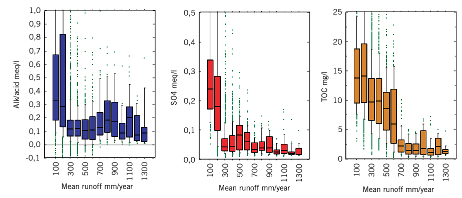
Small lakes are more acid than large lakes and have low alkalinity. The concentration of humic acids (TOC), which contributes to acidity, is higher in small lakes. However, SO_4 concentrations are comparatively low.



The importance of lake size for concentrations of alkalinity, sulphate and TOC.

Run-off is also important

Extremely dry areas in Sweden have the most acid (lowest alkalinities) lakes, even though the majority are alkaline. The acidity of these lakes is accompanied by high sulphate and high TOC. The areas with the highest run-off are generally located in the north, with less acid deposition.



The importance of run-off for concentrations of alkalinity, sulphate and TOC.

Mitigation by liming

About 3700 target lakes are directly limed to mitigate acidification. Another 4100 lakes are limed for the protection of downstream water bodies (depot liming); in total nearly 8% of all Swedish lakes are treated.

931 lakes in the 2000 lake survey were identified as limed or indirectly affected by liming.

Depot liming of lakes

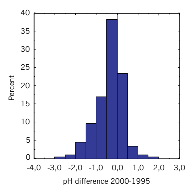
These lakes are intermittently limed; often the dose is high in order to achieve biologically acceptable conditions downstream.

Target liming of lakes

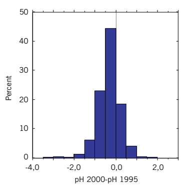
These lakes are monitored to regulate the pH-value by liming activities.

Between the surveys of 1995 and 2000, pH decreased in 76% of the target limed lakes as compared to 38% in the better-buffered storage lakes. This was mainly due to heavy rains in southern Sweden,

It is likely that large pH-variations may affect biota. Differences larger than 1 pH-unit were found for 6.9% of the target limed lakes and 9.0% for the depot limed lakes.



Depot limed lakes. Difference in pH-value between surveys 1995 and 2000.



Target limed lakes. Difference in pH-value between surveys 1995 and 2000.

Conclusions

– National, statistically stratified lake surveys enable estimations of conditions in the entire lake population. Of special value is that lakes of "less importance" are covered e.g. small lakes in northern Sweden and depot limed lakes.

– Based on the 2000 lake survey about 20% of Swedish lakes were acidified according to the Swedish Water Quality Criteria.

– Liming mitigates the conditions, but pH-fluctuations are sometimes very large.

References

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