Estimating critical phosphorus and nitrogen loading for good water quality in Finnish lakes with the model tool LLR

Anita Pätynen, Finnish Environment Institute, University of Jyväskylä, Finland

”Water quality models for WFD implementation in estimating target nutrient loads and lake monitoring (LakeState)” is a two year (2006-2008) project of the Finnish Environment Institute. One outcome of the project is the model tool LLR (Lake Load Response) that can be used when planning actions to achieve good water quality in lakes. For good water quality, the parameters here are total phosphorus, total nitrogen and chlorophyll a concentrations, and phytoplankton biomass. The aim has been to create an effective but easy-to-use tool that will soon be accessible through the Internet. LLR has already had some users within Finland's environmental administration and the feedback has been positive, so clearly there is a need for this kind of tool.

The basis of LLR is the LakeState (LS) model, that consists of three component models. One is Chapra’s model for retention of total phosphorus and nitrogen, with which it is possible to estimate the in-lake nutrient concentrations as a function of incoming loading and water flow. The model uses observations from the study lake for results, and Bayesian statistics with the Marcov chain Monte Carlo (MCMC) simulation method is used to get more reliable estimates.

The second model is the hierarchical, linear regression model for chlorophyll a. With this the concentration of chlorophyll a can be estimated from measured or estimated in-lake nutrient concentrations. The model is calibrated with observations from 2000 Finnish lakes, and Bayesian statistics and MCMC are also used in the estimation. Being hierarchical, the model uses information both from the study lake and from lakes of the same type when making estimations. Observations from the lake are weighted more but if the data are sparse, observations from similar lakes are also used. All Finnish lakes are divided into 13 different types according to some features like depth and the amount of humic substances in the water, and it is presumed that lakes within the same type are more similar.

The third model is a logistic regression model for phytoplankton biomass. This uses measured or estimated in-lake nutrient concentrations to estimate the probability with which the phytoplankton biomass will exceed the limit for good water quality. The model is calibrated with observations from 1200 Finnish and Norwegian lakes.

LLR is made to ease the use of the LS model. It works best for lakes with quite simple basin shapes and without internally nutrient loading. As input data the user gives the depth, volume and type of the lake, which for most Finnish lakes can be found from the LLR database by giving the name of the lake. For estimating how changes in loading influence the in-lake nutrient concentrations, prior observations about loading, concentrations and water outflow, averaged for the lake’s retention time, are needed. The biggest problems in the use often arise from inadequate loading data. For estimating changes in chlorophyll a concentration and phytoplankton biomass, the data needed come from the LLR database, if the study lake was found there when giving the basic lake information. If not, the user gives all chlorophyll a, total phosphorus and total nitrogen concentrations observed in the lake in July and August in different years.

After all the data has been input, LLR gives graphs and tables that show the present loading – water quality relations, and by how much the loading must be reduced to achieve good water quality with 50 % probability. The percentage can be raised, but this makes the limits for loading stricter and often harder to achieve. As lake management usually must balance between costs and effectiveness, LLR can be very helpful in realistic management planning by showing different possibilities.