

Nitrogen – leaching - some records on biology - questions

Gunnar G. Raddum



Important statements of Nitrogen

- *Nitrogen* ($\text{NO}_3^- + \text{NH}_4^+$) is important plant nutrition and can enhance or limit the growth of vegetation both in terrestrial and aquatic environments
- Excess (leaching) of nitrogen leads to acidification of streams and lakes and has the same consequences for biology as deposition of sulphur.

Nitrogen can therefore act either as a fertilizer or as an acidification agent.

Saturation stages – excess of N

- The nitrate concentration in runoff during the **growing season** (uptake by forest and microbes) is the basis for stating the saturation stage. It has been distinguished between four main N saturation stages which can be expanded to seven, see Traaen and Stoddard (1995) and Stoddard et al. (2001).
- The chance of N leaching, nitrate acidification, increases with increasing saturation stage.

The measured nitrate in a water sample is the excess N at the spot when the sample is taken. It reflects the integrated results following all chemical and biological processes that have taken place both in the terrestrial and the aquatic environment.

Important growth limiting factors

Physical factors:

- Low temperature and reduced light. Regulates the seasonal pattern

Main chemical factors:

- Amount of inorganic N, P, Ca, K etc.

In undisturbed ecosystems nitrogen or phosphate are the most common plant growth limiting agents when other elements are sufficient. Both elements are the main drivers for eutrofication of aquatic ecosystems.

Lack of either phosphate or nitrate can limit plant growth and per definition influences the nitrogen saturation stage.

Records of Nitrogen in mountain lakes in Europe, the EMERGE study (Special issue; *Freshwater biology*, in press)

- Nitrate increases in lake water by increasing altitude.
- Nitrate and organic carbon varied inversely.
- Nitrate varied negatively with increasing percent vegetation cover of the catchments.
- High Nitrate deposition in high and steep watersheds resulted in elevated Nitrate concentrations in surface waters (Tatra Mountains).
- DOC concentrations are higher in northern lake districts than those in the Alps, eastern mountains and in the Pyrenean sites and is positive correlated with vegetation. (Nitrate concentrations are the opposite)

Biological effects of Nitrogen in oligotrophic mountain lakes in Europe, the EMERGE study (Special issue; *Freshwater biology*, in press)

- Nitrate has a direct effect on vegetation, but probably no direct effect on invertebrates, except through acidification.
- Nitrate explained variation in cladocera, littoral invertebrates, rotifers and planktonic crustaceans. The reason is suggested to be positive effect of nitrate on plant growth both in terrestrial and aquatic environments, increasing primary production and allochthonous material, food recourses for these invertebrates.

Other effects of Nitrogen on biology

- Plants with modest nitrogen requirements is replaced by species with higher demands when nitrogen increase (Henriksen & Hessen, 1997).
- High Nitrate concentration can reduce macrophyte species richness (James et al. 2005)
- Brodersen and Quinlan (2006) found a strong correlation between the trophic variables TN and TP and chironomid classification in low arctic West Greenland lakes. TN maintained its significant role in explaining the chironomid data also after taking out the effect of temperature.

The studies demonstrate that variation in nitrogen can be reflected in invertebrate communities through their food recourses.

Some observations of changes in N:P ratios

- High N deposition is expected to reduce the degree of N-limitation of temperate forests. Symptoms of N excess and decreased C:N ratio in soil is discussed in several papers.
- High N deposition can change forests growth from N to P- limitation. This is the conclusion from a study of sugar maple growth in Ontario (T. Gradowski & C. Thomas 2006).
- Decreased soil pH can result in increased P fixation and substantially diminish the P availability for plant growth.
- Lakes that received high deposition of N were forced towards extreme P-limitation (Bergstrøm et al. 2005)

Questions concerning nitrogen in the ICP water sites

- What is the importance of available P for plant growth, uptake of N and the saturation stage, in the sites?
- Can the spread in runoff data be better explained by putting the catchments into categories like forest cover, open landscape, bogs, barren rocks, etc ?
- Does the turnover rate of water, steep or flat catchments, help to explanation high or low N runoff ?

Deposition and leaching of inorganic N for ICP Waters sites – an unsolved riddle (from Skjelkvåle et al. 2008)

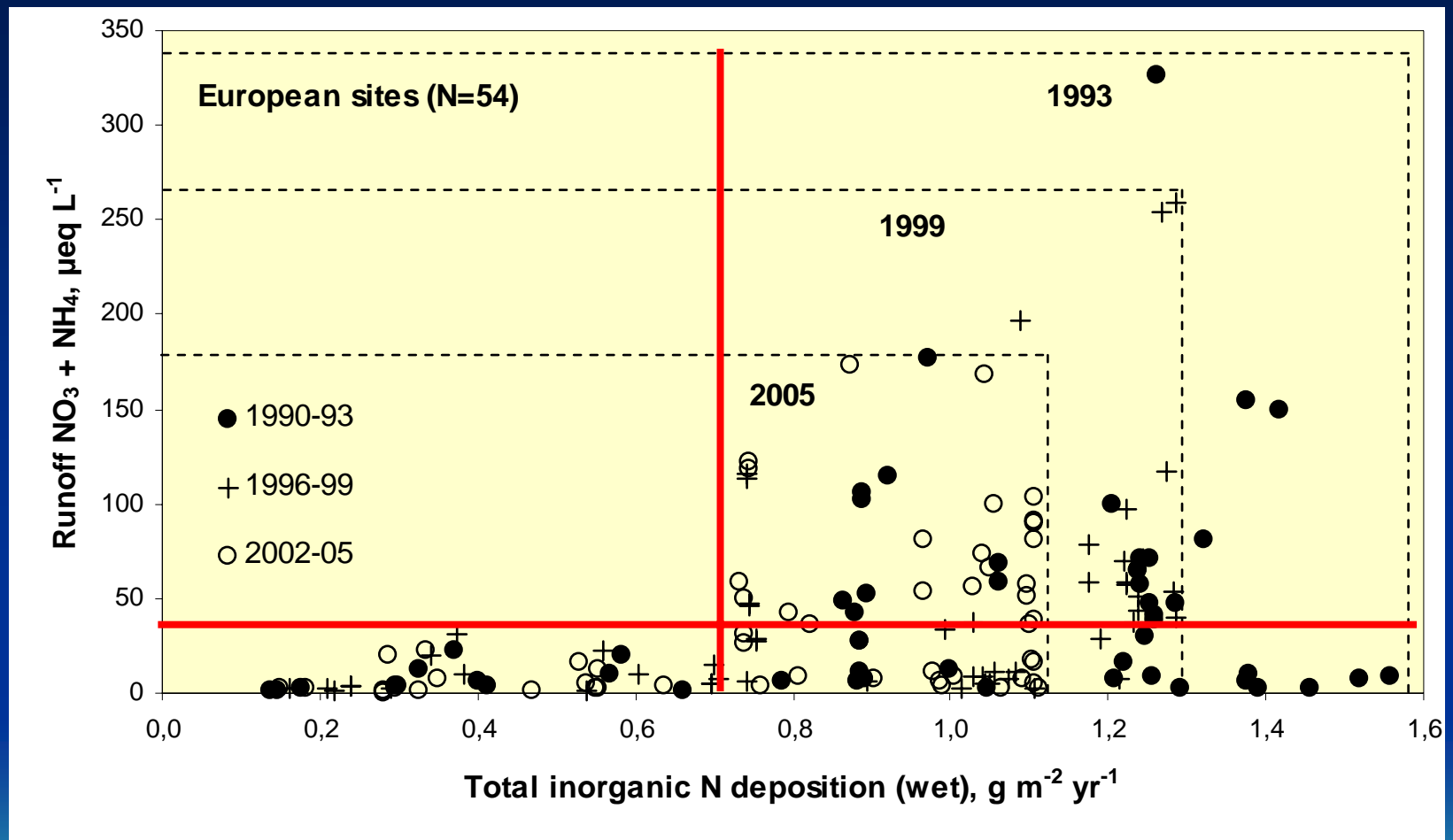


Fig. 1. Nitrogen ($\text{NO}_3^- + \text{NH}_4^+$) concentration in runoff and total inorganic N deposition for ICP Waters sites in 1990-93, 1996-99, and 2002-05.

Hypotheses that can be tested by the ICP Water sites

- Sites with runoff of NO_3 above the red line in Figure 1 are suggested to be more or less P limited
- High N deposition will over time enhance P limitation and consequently increase N leaching
- Leaching of NO_3 is suggested to occur at lower N deposition rates in the future than today. (This is also indicated by the vertical red line in Figure 1 which has move to the left, conf. the 1990-1993 data with the 1996-2005 data).



Summary

- Limitation either by climate, N or P during the year should be stated before evaluation of the N leaching
- Catchments characteristics should be evaluated in context with N cycling
- Can increasing P-limitation lead to oligotrophication both of terrestrial and aquatic environments, a self forcing process?

