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Working Group on Effects

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Recent results and updating of scientific and technical knowledge

Integrated monitoring

Report by the Programme Coordinating Centre of the International Cooperative Programme on Integrated Monitoring of Air Pollution Effects on Ecosystems

Summary

The present report presents the results of the activities undertaken since the previous report by the Programme Coordinating Centre for the International Cooperative Programme on Integrated Monitoring of Air Pollution Effects on Ecosystems. The activities and the report on them are in accordance with the request of the Executive Body to the Convention on Long-range Transboundary Air Pollution in its 2012–2013 workplan for the implementation of the Convention (ECE/EB.AIR/109/Add.2, items 3.1 (c) and 3.6). The report details, in particular, work on the relationships between critical load exceedances and empirical effect indicators (ground vegetation and surface waters) and the calculation of fluxes and trends of nitrogen and sulphur compounds.

I. Introduction

1. The work of the International Cooperative Programme on Integrated Monitoring of Air Pollution Effects on Ecosystems (ICP Integrated Monitoring) under the Working Group on Effects has recently focused particularly on the following key topics:

(a) Relationships between critical load exceedances and empirical effect indicators (ground vegetation and surface waters). Progress reports are included in ICP Integrated Monitoring's annual report 2012.[1] A scientific paper has also been accepted for publication;[2]

(b) Calculation of fluxes and trends of nitrogen and sulphur compounds. A progress report is included in the annual report 2012.[3]

II. Workplan items common to all programmes

A. Targets and ex post application

2. Data from the intensively monitored ICP Integrated Monitoring sites provide a connection between modelled critical thresholds and empirical observations, and thus an indication of the applicability of critical load estimates for natural ecosystems. Critical loads for acidification and eutrophication and their exceedances were determined for a selection of these ecosystem effects monitoring sites (18–37 sites, depending on method used). The level of protection of the sites with respect to acidifying and eutrophying deposition was estimated for the years 2000 and 2020. The deposition estimates were generated with the source-receptor matrices derived from the Cooperative Programme for Monitoring and Evaluation of the Long-range Transmission of Air Pollutants in Europe (EMEP)/Meteorological Synthesizing Centre-West (MSC-W) unified atmospheric dispersion model[4] used in integrated assessment. The NAT2000, COB2020, Low*2020, MID2020, High*2020 and the maximum technically feasible emission reductions (MFR2020) emission scenarios were used.[5]

3. In 2020 more sites were protected from acidification (67%) than in 2000 (61%). However, due to the sensitivity of the sites, even the MFR2020 scenario would not protect all sites from acidification. In 2000, around 20% of the ICP Integrated Monitoring sites were protected from eutrophication. In 2020, under reductions in accordance with current legislation, about one third of the sites would be protected, and at best, with the maximum technically feasible reductions, half of the sites would be protected from eutrophication.

4. Across the sites, there was good correlation between the exceedance of critical loads for acidification and key acidification parameters in run-off water, both with annual mean

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[1] S. Kleemola and M. Forsius (eds.), *21st annual report 2012: Convention on Long-Range Transboundary Air Pollution, International Cooperative Programme on Integrated Monitoring of Air Pollution Effects on Ecosystems*, The Finnish Environment series (Helsinki, Finnish Environment Institute, 2012) (in press).

[2] M. Holmberg et al., "Relationship between critical load exceedances and empirical impact indicators at Integrated Monitoring sites across Europe", *Ecological Indicators*, vol. 24 (2013), pp. 256–265 (in press).

[3] J. Vuorenmaa, S. Kleemola and M. Forsius, "Sulphur and nitrogen input-output budgets at ICP Integrated Monitoring sites in Europe".

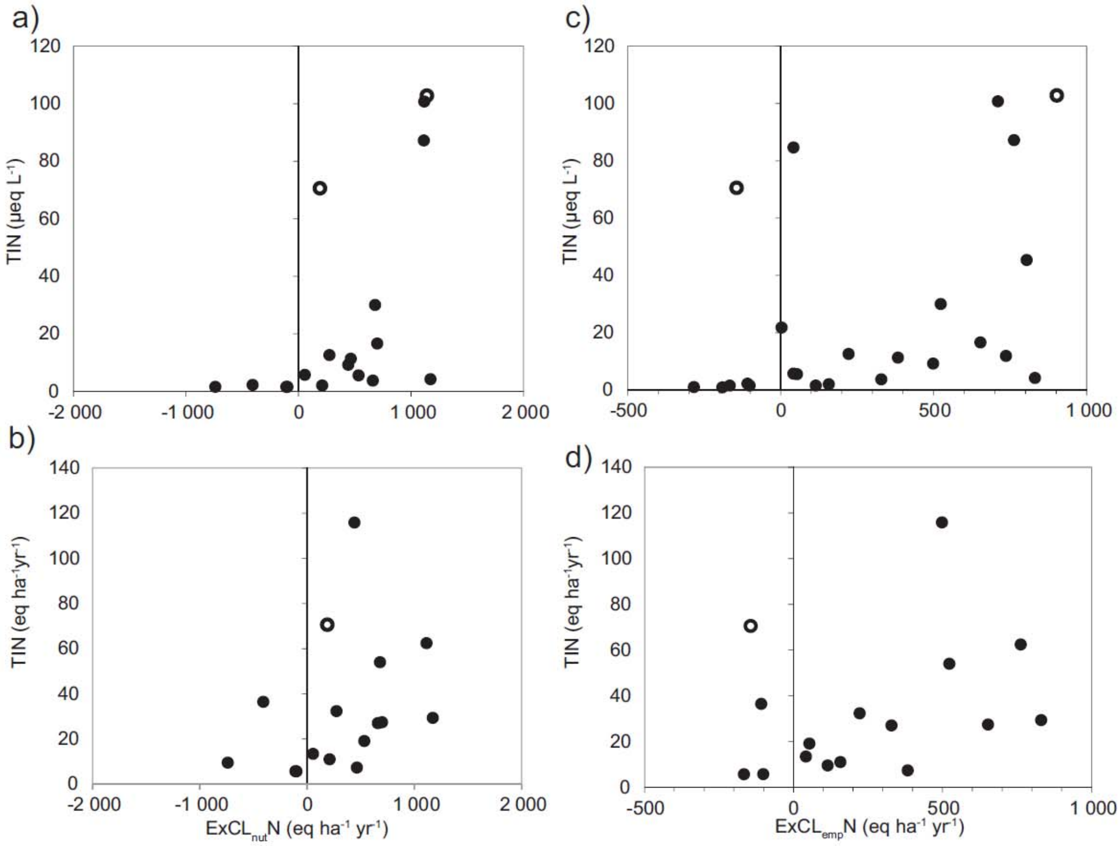
[4] Available from https://wiki.met.no/emep/page1/unimodopensource2011.

[5] Holmberg et al., 2013.

fluxes and concentrations. There was also evidence of a link between exceedances of critical loads of nutrient nitrogen and nitrogen leaching (figure 1). This increases confidence in the European-scale critical loads mapping used in integrated assessment modelling to support emission reduction agreements. Comparable work on critical loads, using ground vegetation responses as effect indicators, is currently in progress.

Figure 1

Eutrophication empirical impact indicators in relation to exceedance of critical loads of nitrogen at the ICP Integrated Monitoring sites



Source: Holmberg et al., 2013.

Notes: The x-axes show exceedances of mass balance critical loads of nutrient nitrogen (N) ($ExCL_{nut}N$, NAT2000 deposition, a and b) and exceedances of empirical critical loads of nutrient N ($ExCL_{emp}N$, NAT2000 deposition, c and d). The y-axes show annual mean concentrations (a and c) and fluxes (b and d) measured (2000–2002 average) of ammonium nitrate (TIN) (= nitrate (NO_3) + ammonia (NH_4)) in run-off. Negative exceedance values indicate that the critical loads are not exceeded. Open circles indicate catchments with inputs of N from sources other than deposition

B. Trends in selected monitored/modelled parameters

5. Annual input-output budgets for sulphur (S) and nitrogen (N) for the period 1990–2010 were calculated for a selection of 17 ICP Integrated Monitoring sites.[6] The

[6] ICP Integrated Monitoring *21st annual report 2012*.

selection of catchments was guided by the availability of deposition (bulk and throughfall) data and surface water chemistry and run-off volume data in the ICP Integrated Monitoring database. Output fluxes from the catchments were calculated as the product of measured catchment discharge and ion concentrations. Annual run-off water element fluxes were calculated by summing up mean monthly fluxes, obtained from monthly mean water flux and monthly mean solute concentration. In order to quantify retention/release of S and N in the catchment, a per cent net export (pne) was calculated. The per cent net export is defined as: pne = (output - deposition)100/deposition. Positive pne values indicate release and negative pne values indicate retention in the catchment.

6. Estimated sulphate (SO_4) budgets indicated a release of previously stored sulphate at most sites, particularly during the 2000s (figure 2). A net release of stored sulphate is considered to act as a hydron (H^+) source at many Integrated Monitoring sites.[7] These results are consistent with budget calculations for a number of other studies from European forested catchments. These results of the ICP Integrated Monitoring network thus indicate that forest soils are now releasing S that accumulated in the past. Decreasing trends in both S deposition and leaching are commonly observed at the ICP Integrated Monitoring sites.

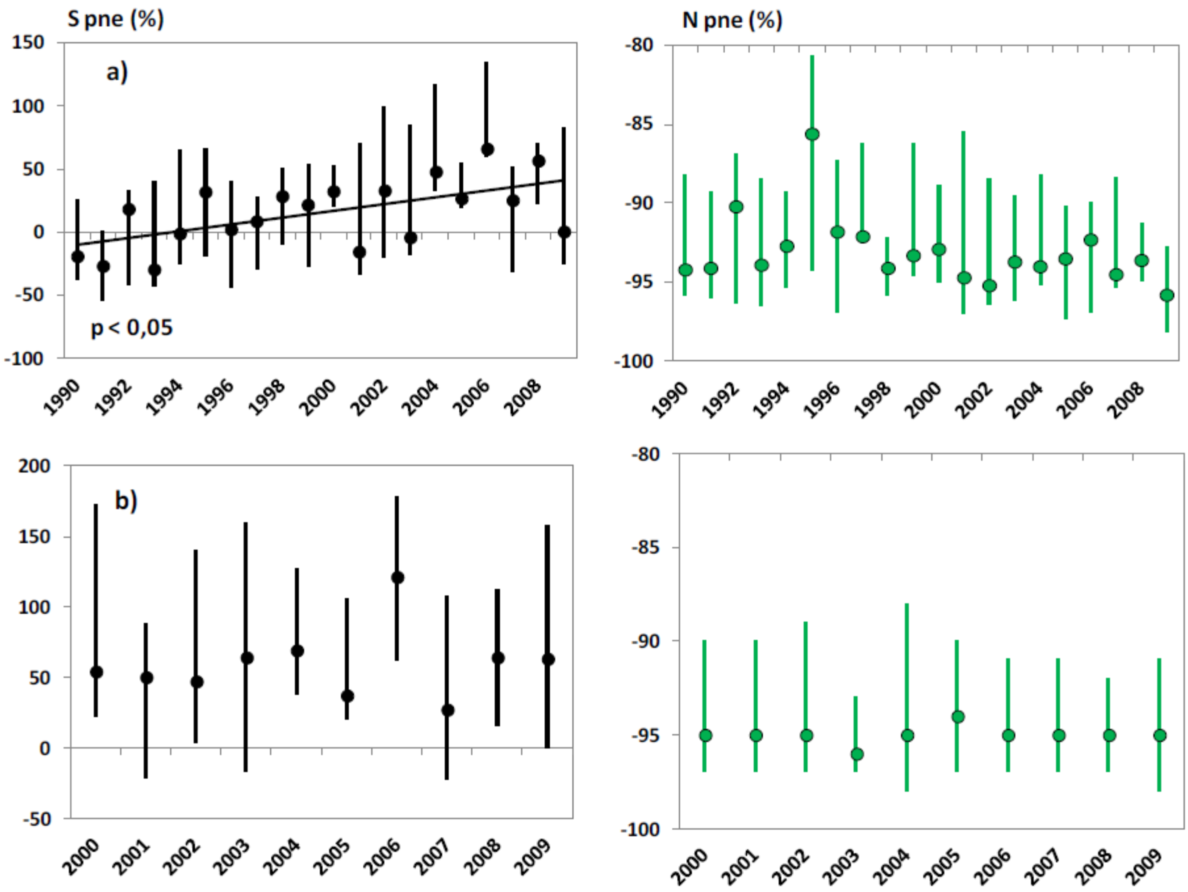
7. Nitrogen is generally the growth-limiting nutrient in forest ecosystems, and the uptake of available N compounds is efficient. In contrast to sulphur, nitrogen deposition is usually retained in boreal terrestrial ecosystems; typically < 10% is leached in run-off, mostly as nitrate (NO_3). Nitrate is a strong acid anion and so can acidify soil and water like SO_4. The pne of nitrogen has generally ranged between 97% and 90% at the Integrated Monitoring sites studied during the 2000s (figure 2), indicating a strong retention of N in the catchment. Although nitrogen has played a rather minor role in acidification in the past, its relative importance is increasing because N emissions have decreased much less than sulphur emissions. The role of nitrate as an acidifying agent may increase, when continued high nitrogen deposition may result in N-saturation of terrestrial ecosystems, and excess NO_3 leaching to surface waters.[8] Many of these S and N retention processes are also sensitive to changes in climatic variables, and would therefore be affected by future climate changes.

[7] M. Forsius, S. Kleemola, and M. Starr, “Proton budgets for a network of European forested catchments: Impacts of nitrogen and sulphur deposition”, *Ecological Indicators*, vol. 5 (2005), pp. 73–83.

[8] E.g., J. A. MacDonald et al, “Nitrogen input together with ecosystem nitrogen enrichment predict nitrate leaching from European forests”, *Global Change Biology*, vol. 8 (2002), pp. 1,028–1,033.

Figure 2

Percentiles (25%, median 50%, 75%) of pne of S and N for selected ICP Integrated Monitoring sites in 1990–2009 and in 200–2009



Source: S. Kleemola and M. Forsius (eds.), *21st annual report 2012*.

Notes: Figures in (a) are for sites CZ01, CZ02, FI01, FI03, NO01, NO02 and SE04 in 1990 2009; and figures in (b) are for sites CZ01, CZ02, EE02, FI01, FI03, IT01, LT01, LT03, LV01, LV02, NO01, NO02, SE04, SE14, SE15, SE16 in 2000 2009.

III. Acidification

8. The critical load exceedance calculations for ICP Integrated Monitoring sites indicate that even the MFR2020 scenario would not protect all sites from acidification (see above). The good agreement between the exceedance calculations and the measured impact indicators supports the use of the critical loads approach in the integrated assessment modelling. The input-output calculations at the sites indicate that forest soils are now releasing S that accumulated in the past. The relative importance of N emissions/deposition is increasing because N emissions have decreased much less than the S emissions.

IV. Nutrient nitrogen

9. Calculation of the exceedance of critical loads for nutrient nitrogen at the ICP Integrated Monitoring sites indicated continued high exceedances (see above). The sites at which the empirical critical load of nutrient nitrogen for terrestrial ecosystems was exceeded also exhibited higher nitrate concentrations and fluxes in run-off. Correspondingly, the leaching of nitrate increased with increasing exceedance of mass balance critical loads of nutrient nitrogen. The mass balance calculations indicated a strong retention of N in the catchments. Many of these S and N retention processes are sensitive to changes in climatic variables, and would therefore be affected by future climate changes.