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Proceedings of the 30th Task Force meeting of
the ICP Waters Programme in Grimstad, Norway
14th –16th October, 2014



International Cooperative Programme on Assessment
and Monitoring Effects of Air Pollution on Rivers and Lakes

Convention on Long-Range Transboundary Air Pollution



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CONVENTION ON LONG-RANGE
TRANSBOUNDARY AIR POLLUTION

INTERNATIONAL COOPERATIVE PROGRAMME ON
ASSESSMENT AND MONITORING EFFECTS OF AIR
POLLUTION ON RIVERS AND LAKES

**Proceedings of the 30th Task Force meeting of the ICP
Waters Programme in Grimstad, Norway,
October 14 – 16, 2014**

Prepared at the ICP Waters Programme Centre
Norwegian Institute for Water Research
Oslo, February 2015

Preface

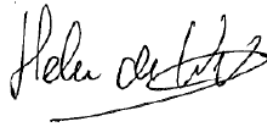
The international cooperative programme on assessment and monitoring of air pollution on rivers and lakes (ICP Waters) was established under the Executive Body of the UNECE Convention on Long-range Transboundary Air Pollution (LRTAP) in July 1985. Since then ICP Waters has been an important contributor to document the effects of implementing the Protocols under the Convention. Numerous assessments, workshops, reports and publications covering the effects of long-range transported air pollution has been published over the years.

The ICP Waters Programme Centre is hosted by the Norwegian Institute for Water Research (NIVA), while the Norwegian Environment Agency leads the programme. The Programme Centre's work is supported financially by the Norwegian Environment Agency.

The main aim of the ICP Waters Programme is to assess, on a regional basis, the degree and geographical extent of the impact of atmospheric pollution, in particular acidification, on surface waters. More than 20 countries in Europe and North America participate in the programme on a regular basis.

ICP Waters is based on existing surface water monitoring programmes in the participating countries, implemented by voluntary contributions. The ICP Waters site network is geographically extensive and includes long-term data series (more than 20 years) for many sites. The programme yearly conducts chemical and biological intercalibrations.

At the annual Programme Task Force, national ongoing activities in many countries are presented. This report presents national contributions from the 30th Task Force meeting of the ICP Waters programme, held in Grimstad, Norway, October 14 – 16, 2014.



Heleen de Wit
ICP Waters Programme Centre

Oslo, February 2015

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1. Introduction

The International Cooperative Programme on Assessment and Monitoring of Rivers and Lakes (ICP Waters) is a programme under the Executive Body of the Convention on Long-Range Transboundary Air Pollution. The main aims of the programme are:

- *To assess the degree and geographic extent of the impact of atmospheric pollution, in particular acidification, on surface waters;*
- *To collect information to evaluate dose/response relationships;*
- *To describe and evaluate long-term trends and variation in aquatic chemistry and biota attributable to atmospheric pollution.*

The national contributions on ongoing activities that were presented during the ICP Waters Task Force meeting in Grimstad, Norway, October 14 – 16, 2014 were grouped thematically. A short summary of each presentation is given in the Minutes (Chapter 7). Selected presentations are reported more extensively in the Proceedings.

Water chemistry

- Natural and anthropogenic acidification of waters: mechanisms and specification in European Russia and Western Siberia, *Tatyana Moyseenko and Marina Dinu, Russia*
- Increasing phosphorus concentrations in lakes and streams across the U.S.: evidence from national surveys, and a possible role for atmospheric deposition, *John Stoddard, US*

Biological response

- Responses to changes in air pollution and climate in Valkea-Kotinen ICP IM catchment – key findings over a 20 year period, *Jussi Vuorenmaa, Finland*
- Recovery of water chemistry and biology in the UK: latest status and emerging issues, *Don Monteith, UK*
- Recovery of Aurora Trout in a low calcium environment in Ontario, Canada, *John Gunn, Canada and Bjørn Olav Rosseland, Programme Centre*
- It's getting better all the time but I can't get no satisfaction - 25 years of recovery in Sweden from a roach's perspective, *Jens Fölster, Sweden*

Water chemistry – dissolved organic carbon

- A simple model to estimate historical and recent changes of TOC concentrations in lakes, *Salar Valinia, Sweden.*
- Changes in soil dissolved organic carbon affect reconstructed history and projected future trends in surface water acidification, *Jakub Hruška, Czech republic*
- Trends and spatial variation in DOC – proposed follow-up of DOC trend paper in 2007, *Don Monteith, UK*

Critical Loads

- National and EMEP deposition data give different areas with critical loads exceedance, *Kari Austnes, ICP Modelling and Mapping*

2. Acidification of water in humid regions of Russia: case study European Russia and Western Siberia

Moiseenko T., Dinu M. Kremleva T.A., Gushkina N.A

V.I.Vernadsky Institute of Geochemistry and Analytical Chemistry RAS

1. Introduction

In North America and Europe SO₂ emissions began to decrease in the mid 80s of the last century. Surface waters began recovering from acidification in many acid-sensitive areas as response to reduced SO₂ emissions (Skelkvale et al., 2005). However, water chemistry responses are not always proportionate to reductions in sulfate flow. There are three scenarios of water chemical changes: i) further water acidification is progressing, ii) pH and alkalinity levels remain the same; iii) lake's water chemistry recovery.

In Russia, for many years the problems of acidification small lakes have been neglected. Only scientific research of the late 20th century devoted to the problem of anthropogenic acidification of small lakes. It should be noted that in addition to anthropogenic sources of natural water acidification of small lakes, a large influence on the pH have the specifics zonal area and especially in chemistry of water.

2. Discussion

The European Russia is a region with substantial industrial emissions of sulphur. Large copper-nickel smelting plants, “Pechenganikel” and “Severonikel” (Fig. 1), situated at the western part of the Kola Peninsula, have been emitting sulfur dioxide and metals for more than 50 years. In the central part of EP are concentrated metallurgical productions. This has resulted in high concentrations of anthropogenic sulphate and an increase in the prevalence of acidification as well as a rise in metal concentrations in the lakes of North Kola. However, over the last 30 years, sulfur emissions in Kola North have decreased substantially.



Fig. 1 Large copper-nickel smelting plants, “Pechenganikel” and “Severonikel”

Western Siberia (WS) maintains the leading position among Russian regions for the oil and gas extraction: more than 6% of the world's oil production is concentrated in this region. Gas flaring during of oil production in Western Siberia (Fig. 2) leads to air pollution by oxides of nitrogen, sulfur, chlorine, that can form acid rain (Moiseenko, 2001)

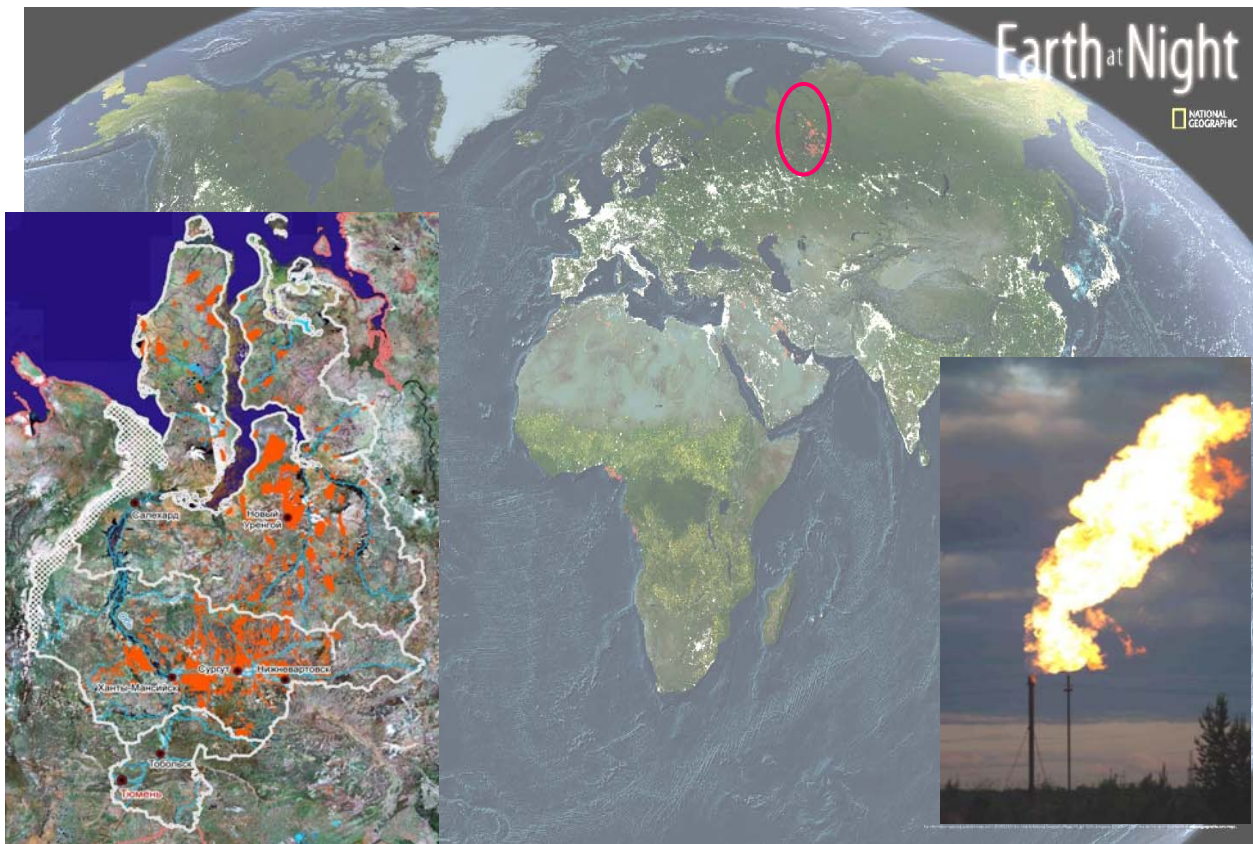


Fig. 2 Location gas flares (points in the center of red circle) and the deposits in Western Siberia (orange dots, lower left picture)

Both considered acidification source can affect the pH reduction system, including the expense and differences in the chemical composition of natural waters. In lakes in European Russia (ER) the dominant ion is SO_4 (fig. 3).

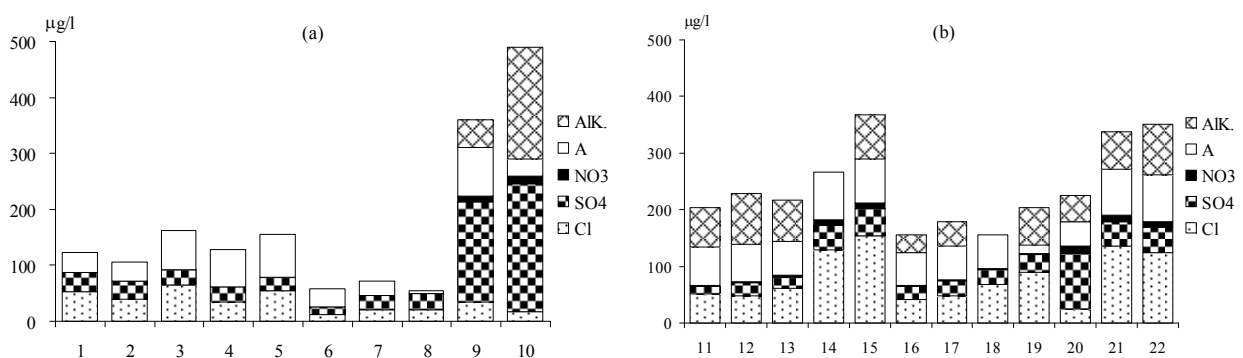


Fig. 3 Examples of the anionic composition of the waters lakes with pH < 5 European part of Russia (a) (1 - in the forest, 2-8 - in the northern taiga, 9 - in the middle of the forest, 10 - in the mixed forests) and West Siberia (b) (11 -13 in the tundra, 14-15 - in the northern taiga, 16-22 - in the middle taiga)

The mechanism of water acidification anthropogenic sulfate is widely known and is associated with the displacement of weak acids (hydrocarbons) by sulfate. In lakes of WS there is a contribution of different factors - dominated by Cl, NO₃ and A-.

Receipt of these elements in the water of WS associated with natural and anthropogenic sources, which in combination give the effect of acidification with all its attendant adverse effects.

Another zonal feature that affects the acidification of natural waters in Western Siberia is oil deposits. Biochemical transformation and expansion of the oil under the influence of biological organisms may contribute to the formation of humus substances. The most important stage of the formation humus substances (HS), including fulvic and humic acids, is the polycondensation of hydroxycarboxylic acids and amino acids with different structures, depending on the ratio of the variation which may molar ratio C: N as part of HS.

For waters of lakes in Western Siberia, a correlation with $R^2 = 0.63$ was observed between the content of organic nitrogen and organic carbon content with a ratio of around 0.0497 mgN / 1mgS (Fig. 4), which corresponds to a molar ratio C: N = 23,4: 1 consisting of water-soluble organic matter.

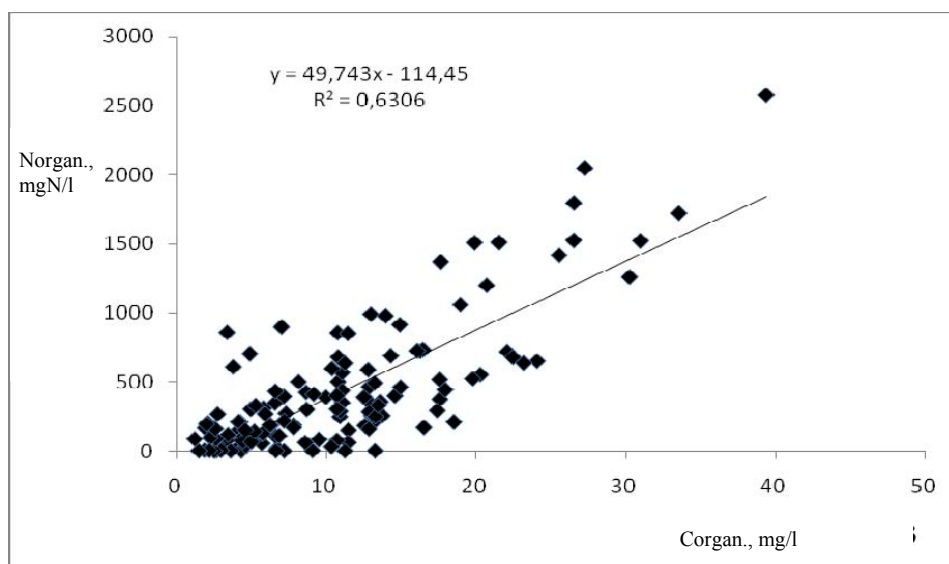


Fig.4 The content of organic nitrogen (Norg), depending on the content of organic carbon (TOC) in the lakes of the WS.

It should be noted that the processes that biodegrade oil catalyze different biochemical processes. Biodegradation of petroleum hydrocarbons in the northern regions is in the direction of humification, in the southern regions - mineralization. Humification process accompanied by the formation of humic acids, as well as products of biodegradation of oils - nitrates, chlorides and sulfates. Humic acid at a particular point of their decomposition are capable of producing in the water protons, which in combination can enhance the acidic properties of water in vulnerable regions.

3. The main conclusions

- Most of the lakes investigated in ER and WS showed near neutral pH values and Color from 10 to 100°Pt–Co scale and higher. Low pH values do not always indicate the anthropogenic acidification of water. They may be related to the natural acidification of waters owing to the abundance of humus acids. Lakes with low Color and pH values are anthropogenic acidified. In the tundra–taiga regions, 10.6% of lakes in ER and 14.8% of lakes in WS can be regarded as anthropogenically acidified. In the ER forests, the occurrence frequency of anthropogenically acidified lakes is 7.2%, whereas such lakes were not detected in the

southern taiga of WS. The absence of acidified lakes in the arid and steppe zones is due to the high buffer capacity of water.

- Flue emissions from metallurgical plants and cross-boundary transport of air masses from Europe and the flaring of gas at oil production, as well as natural processes of emission of chlorine species and humification of petroleum hydrocarbons in a cold climate - are the main factors causing acidification.
- In acidified lakes of tundra and taiga ER'ecoregions, the low cation contents and high level of accumulation of anthropogenic sulfates, which dominate anion compositions. In the humid zone of WS, the influence of sulfates on water acidification is much weaker, whereas the contribution of the input of nitrates and chlorides from the catchment to water acidification is higher than in ER waters.
- The influence of organic anions on the acidity of WS waters is very high owing to the high wetland of the catchments, especially for waters with Color > 100°Pt–Co. Taking into account recent investigations of the role of organic matter in water formation, it can be concluded that natural humic substances enhance the acidic properties of waters in case influence of strong anthropogenic acids. It was demonstrated that the mechanism of acidification in WS regions is controlled by several factors, the most important among which could be organic anions, nitrates, and ion exchange transformation of NaCl to hydrochloric acid.
- Water acidification is a complex process. Along with the decrease in water pH, direct and indirect influences of acid rain precipitating entail a complex of adverse phenomena. The deposition of strong acid on catchments of humid ecoregions of Russia led to direct and indirect effects on aquatic systems, causing changes in water quality and ecosystems.
- In recent decades, a tendency toward their recovery from acidification has been revealed in water systems of north part of ER. Calculations of critical loads and their exceedances show restoration of acidified lakes in the 20th century as a result of the introduction of environmental technologies.

References

- Skelkvale, B.L., J.L. Stoddard, D.S. Jeffries, K. Torseth, T. Hogasen, J. Bowman, L. Mannio, Monteith, D.T., et al. 2005. Regional scale evidence for improvements in surface water chemistry 1990-2001. *Environmental Pollution* 137(1): 165-176.
- Moiseenko, T., L. Kudrjavzeva, I. Rodyshkin. 2001. The episodic acidification of small streams in the spring flood period of industrial polar region, Russia. *Chemosphere* 362: 45-50.

3. Integrated Monitoring in the Valkea-Kotinen Catchment during 1990–2009: Abiotic and Biotic Responses to Changes in Air Pollution and Climate

Jussi Vuorenmaa¹, Martti Rask², Lauri Arvola³, Martin Forsius¹, Maria Holmberg¹, Kirsti Jylhä⁴, Anja Lehtovaara³ and Tuija Ruoho-Airola⁴

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1. Introduction

Lake Valkea-Kotinen Integrated Monitoring (UNECE IM) catchment is one of the three active IM sites in Finland. The lake is also included in to ICP Waters programme. As a consequence of the comprehensive long-term environmental monitoring together with diverse terrestrial and aquatic ecological research, the Valkea-Kotinen site has grown into a major Finnish research infrastructure and data source for environmental modelling. The Valkea-Kotinen IM catchment is also part of the Finnish Long-Term Socio-Ecological Research network (FinLTSER).

This report summarizes the main results of the Integrated Monitoring of the Valkea-Kotinen catchment over a 20-year period (1990–2009) published in the special issue of Boreal Environment Research. The seven papers included provide findings on the climate variability and trends (Jylhä *et al.* 2014), development in bulk deposition and atmospheric concentration of acidifying compounds and trace elements (Ruoho-Airola *et al.* 2014), long-term water quality trends in Lake Valkea-Kotinen (Vuorenmaa *et al.* 2014), and modelling of climate change effects on the hydrology and carbon processes of Valkea-Kotinen catchment (Holmberg *et al.* 2014). The remaining three papers present long-term biological responses to environmental changes in Lake Valkea-Kotinen, including plankton metabolism and sedimentation (Arvola *et al.* 2014), zooplankton community patterns (Lehtovaara *et al.* 2014), and perch (*Perca fluviatilis*) population dynamics (Rask *et al.* 2014b).

Rask, M., Arvola, L., Forsius & Vuorenmaa, J. 2014a: Preface to the Special Issue "Integrated Monitoring in the Valkea-Kotinen Catchment during 1990–2009: Abiotic and Biotic Responses to Changes in Air Pollution and Climate". *Boreal Env. Res.* 19 (suppl A): 1–3.

2. Study area

The study site, Lake Valkea-Kotinen (0.042 km²), is a boreal, polyhumic (water colour > 100 mg Pt l⁻¹), shallow (max. depth 6.5 m) headwater lake with a small pristine catchment area (0.22 km²) in southern Finland (Fig. 1). Its bedrock is acid-sensitive, dominated by slow-weathering granitoids and gneisses. The forest mainly consists of the old-growth Norway spruce (*Picea abies*), with the Scots pine (*Pinus sylvestris*), the aspen (*Populus tremula*) and the birch (*Betula* spp.). The catchment is located inside a conservation area and has been intact for over 100 years. There is no local pollution, and therefore long-range transported air pollutants and climate change are the only external disturbances. For 1990–2009, the mean annual air temperature, precipitation and runoff are 4.6 °C, 628 mm and 196 mm, respectively.

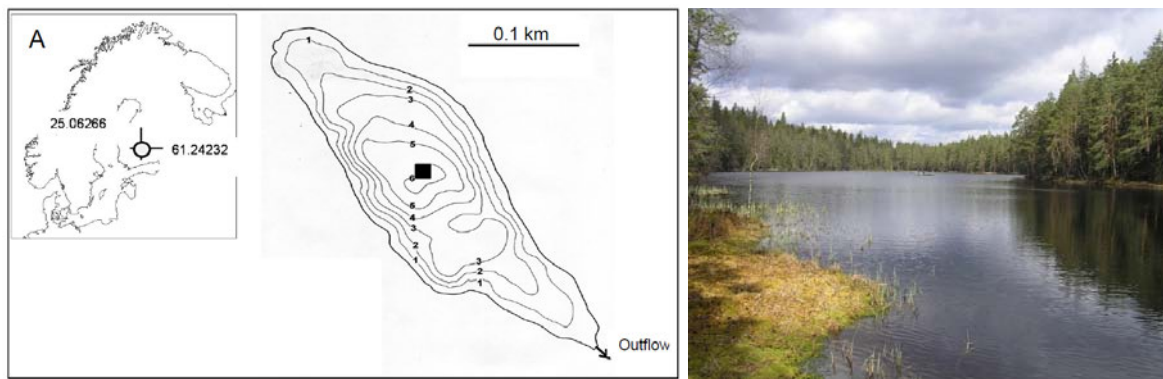


Fig. 1. Bathymetric map and location of Lake Valkea-Kotinen. Black box indicates the sampling point of the water chemistry.

3. Climate variability and trends in the Valkea-Kotinen region

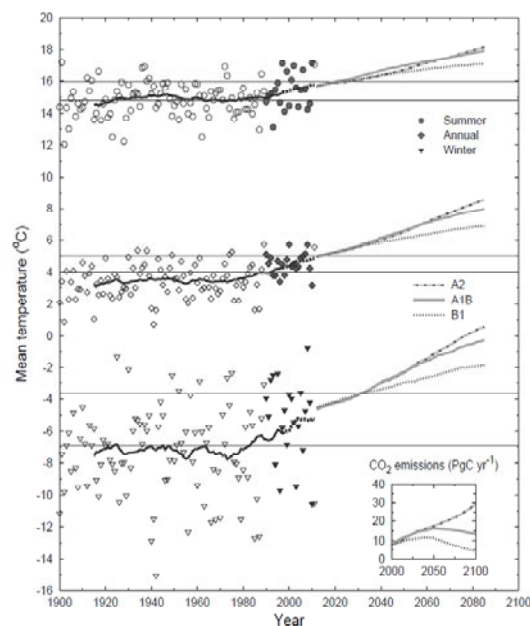
Climatic conditions in the Valkea-Kotinen region during 1990–2010 were compared with the preceding climate based on observations and with the projected future climate based on climate model simulations. The focus was on describing variations and potential trends in climatic variables relevant for aquatic and terrestrial ecosystems, i.e., air temperature, precipitation, snow depth, lake ice cover, wind speed and solar radiation. The incorporation of both climate observations and scenarios allowed to see the modelled future changes in the perspective of already-observed trends and also to use the range of recently-observed temporal variability to assess the significance of the modelled trends. The goal was to address the question of how rapidly climate will change in the future as compared with what the ecosystems in the Valkea-Kotinen region have recently experienced. The future projections considered in this study are based on the CMIP3 global climate models and the SRES emission scenarios that have been widely utilized in climate-change impact, adaptation and vulnerability studies.

The observed increases in annual and spring mean temperature of 0.4 °C, a thinning of the annual mean snow depth by slightly above 1 cm, a shortening of the lake-ice season by 17 days and an advance of its end by six days, all given per decade, are already currently statistically significant, and these trends are also likely to continue in the future. Moreover, in addition to the changes in the ice-cover period, significant increases in epilimnetic water temperatures and thermal stability were been found in Lake Valkea-Kotinen in the same period.

For a few climatic variables, previous statistically-significant trends are levelling out. These include mean wind speed as well as autumn solar radiation. The projected future increases in autumn solar radiation are small in comparison with the past increases during the European scale “brightening” episode. Instead of the weakening that has occurred at the considered weather station in the past, the wind speed is projected to undergo slight increase

For the majority of the climatic variables, the changes experienced so far have been relatively modest compared to recent inter-annual variations. Already during the next three decades, however, increases in winter, summer and autumn temperatures (Fig. 2), increases in annual precipitation, decreases in winter mean snow depth and decreases in winter mean incident solar radiation are projected to emerge from the background of observed inter-annual variability. Based on the rates of changes presented by Räisänen and Eklund (2012), decreases in spring and autumn mean snow depth might already be significant at that stage, but at the latest some decades afterwards. Decreases in spring solar radiation and increases in annual and seasonal mean precipitation sums are also projected to be strong enough to surpass the limit of statistical significance by the 2080s. As an exception, the projected changes in summer precipitation are small and unclear in sign. This applies to summer solar radiation as well.

Fig. 2. Observed and projected mean temperatures in the Valkea-Kotinen region in summer (June–August; top part), whole year (middle part) and winter (December–February; bottom part) in 1900–2085. The black solid lines depict observed 30-year running means. The horizontal lines indicate 95% confidence intervals $\Delta 95_{(obs)}$ for the differences in climatological means (see Jylhä *et al.* 2014 for details).



Jylhä, K., Laapas, M., Ruosteenoja, K., Arvola, L., Drebs, A., Kersalo, J., Saku, S., Gregow, H., Hannula, H.-R. & Pirinen, P. 2014: Climate variability and trends in the Valkea-Kotinen region, southern Finland: comparisons between the past, current and projected climates. *Boreal Env. Res.* 19 (suppl.A):4–30.

4. Temporal trends in the bulk deposition and atmospheric concentration of acidifying compounds and trace elements

This study aimed to present the atmospheric bulk depositions of the main ions affecting acidification and also of trace elements, as well as gaseous compounds (SO_2 and NO_2) measured at Valkea-Kotinen, and to provide an overview of the development in the time series (1988–2011).

The total monitoring periods for the main anions and cations and most trace elements covered 24 and 22 years, respectively. The annual deposition levels of the components were evaluated from 10-year mean values, which filtered away the less interesting short-term variation in the time series. The averaged periods always overlapped by five years: 1988–1997, 1993–2002, 1998–2007 and 2003–2011 (the last period covered only nine years). This procedure enabled changes in the average level of the annual deposition to be followed in five-year steps.

For all the main anions and cations, the deposition was highest during the first period from 1988 to 1997 (Fig. 3). A significant downward trend in bulk depositions of all main ions at Valkea-Kotinen was detected in the period 1988–1997. Moreover, for all trace elements except Cd and Hg tot, bulk deposition declined during the first ten years of measurement. Depending on the component, the monitoring of trace elements began between 1990 and 1995, and for Al and Co in 2003. In the other periods, only a few significant trends were detected in the time series of the components. However, significant downward trends were recorded during the entire measurement period for SO_4 , H^+ , Pb, As, Ni and V, which provides positive evidence of successful emission reductions for these elements or their precursors. In addition to these changes, NH_4 and Ca deposition declined during 1998–2007 and Mg during 2003–2011.

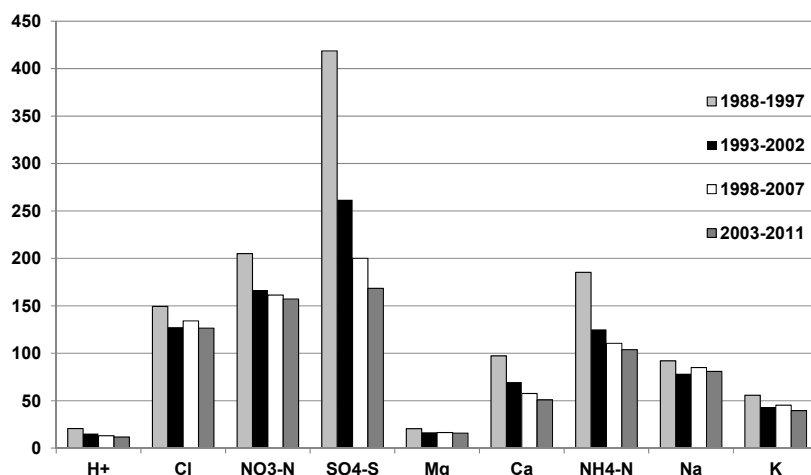


Fig. 3. Ten-year annual mean values for the bulk deposition of the main anions and cations at Valkea-Kotinen. Deposition (mmol m^{-2} for H^+ , mg m^{-2} for other compounds).

In recent years, the N cycle in the environment has attracted increasing interest, one reason being the slower decline in N emissions as compared with that in S emissions. In contrast to the general decreasing trend for acidifying compounds, bulk deposition of NO_3 increased during 2002–2008 at Valkea-Kotinen. Further studies might reveal whether the situation is similar at other background stations in Finland, and confirm our assumption that this negative development has resulted from increased Russian emissions, ship traffic emissions in the Baltic Sea and unchanged NO_x emissions in the EMEP domain in 2002–2008.

Bulk deposition of Cd increased by 2% annually between 1996 and 2005, after which no further significant changes were detected. An increase in Cd deposition was also detected at other Finnish background stations and in Russia in 2000–2005. Even though the levels measured at Valkea-Kotinen are low as compared with those in areas in central Europe, the element is highly enriched in the environment and harmful to ecosystems.

Ruoho-Airola, T., Hatakka, T., Kyllönen, K., Makkonen, U. & Porvari, P. 2014: Temporal trends in the bulk deposition and atmospheric concentration of acidifying compounds and trace elements in the Finnish Integrated Monitoring catchment Valkea-Kotinen during 1988–2011. *Boreal Env. Res.* 19 (suppl. A): 31–46.

5. Long-term changes in water chemistry in 1990–2009

Sulphur deposition declined in south Finland by about 60%–70% since the late 1980s, while the decline in the nitrogen deposition was about 30%–40% (Vuorenmaa 2007, Ruoho-Airola *et al.* 2014). In line with a recovery of small headwater lakes from acidification in Finland (e.g. Mannio 2001a, Vuorenmaa & Forsius 2008) and elsewhere in Europe and North America with decreasing concentrations of sulphate and a subsequent increase in alkalinity (e.g. Garmo *et al.* 2014), the acidification reversal was also recorded in Lake Valkea-Kotinen. The decrease in sulfate (xSO_4) concentrations exceeded that in base cation (xBC) concentrations, indicating the improved acid-base status of soils, and led to increased buffering capacity and pH in runoff and lake water (Fig. 4). However, a clear decrease in sulfate and increase in alkalinity took place in early 2000s, about 5–10 years later than observed in clear water lakes in south Finland. This may be due to retention and release processes of sulfate in peaty soils of the catchment that may have affected the recovery processes in the lake. Effects of episodic organic acidity may have also delayed the recovery of buffering capacity in the highly humic lake.

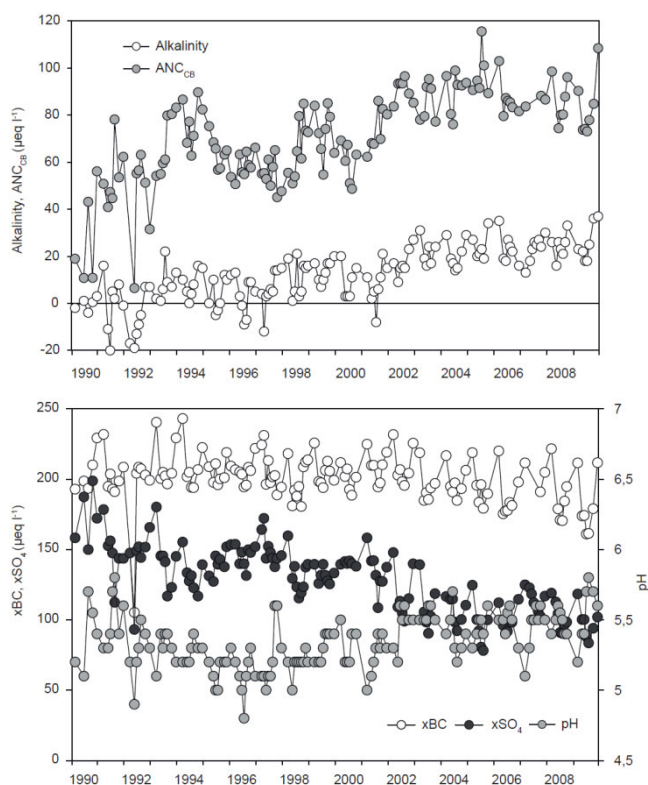


Fig. 4. Alkalinity (measured) and charge-balance acid neutralising capacity (ANCCB, calculated) (upper), and non-marine base cations (xBC) and sulphate (xSO₄) concentrations and pH (lower) at the depth of 1 m in Lake Valkea-Kotinen in 1990–2009.

There were no significant long-term trends in trace metal concentrations from 1994 to 2009, except for total aluminium with a significant increase. For Pb and Ni, however, the median concentrations decreased by 10%–20%, and maximum concentrations (as expressed by 90th percentile) by 20%–50% between the periods 1994–1999 and 2000–2009. Correspondingly, the maximum concentrations for Zn and Cu also decreased, by 30%–60%, between these two decades. Cd concentration was mostly below the detection limits ($\leq 0.03 \mu\text{g l}^{-1}$ in 1994–2004 and $\leq 0.01 \mu\text{g l}^{-1}$ in 2005–2009). The retention of total atmospheric deposition of Pb, Cd, Cu and Zn in the catchment was $\geq 77\%$, and only 3%–26% accounted for the lake sediment (Ukonmaanaho *et al.* 2001). The accumulation of trace metals in the lake sediments, particularly of Hg, Pb, Cd and As, declined in recent decades, presumably reflecting the decrease in the atmospheric loading and catchment supply (Mannio 2001b, Ukonmaanaho *et al.* 2001).

In Lake Valkea-Kotinen, both dissolved organic carbon (DOC) and water colour significantly increased, particularly during the 2000s (Fig. 5). Recovery from acidification may be probably an important driver behind the long-term increase, but short-term fluctuations in runoff have modified the load of organic matter to the lake. Increase in DOC may also be related to increased air temperature.

The increase in inorganic nitrogen ($\text{NO}_3\text{-N} + \text{NH}_4\text{-N}$) concentrations was one of the most consistent changes during the study period, taking place since the early 1990s (Fig. 5). This trend was unlikely to have been dominated by soil N status and N deposition, but it was more related to in-lake processes and hydrology.

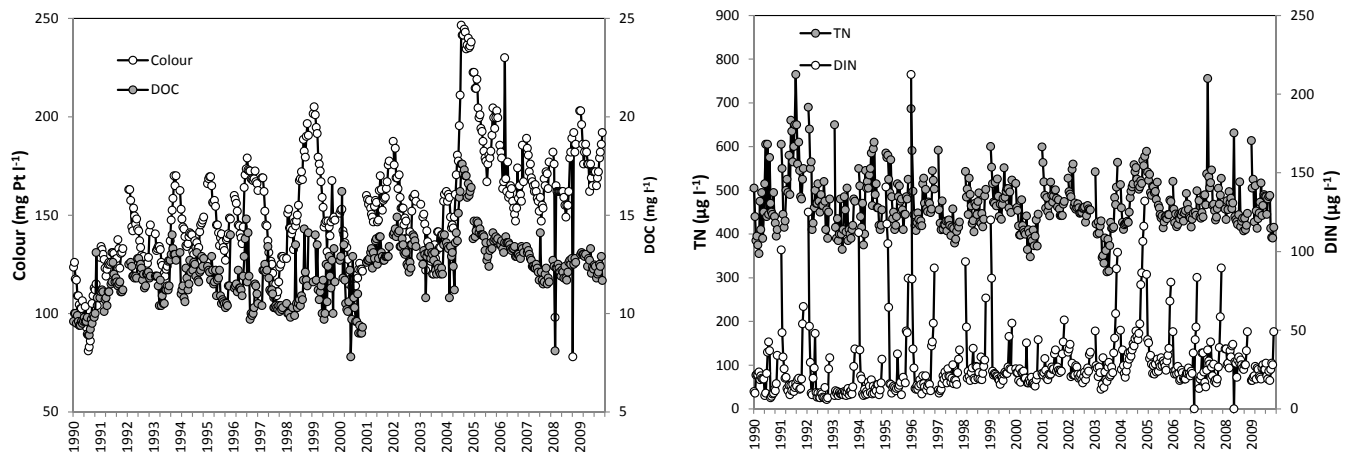


Fig. 5. Water colour and dissolved organic carbon (DOC) concentration (left) and total nitrogen (TN) and dissolved inorganic nitrogen (DIN = $\text{NO}_3\text{-N} + \text{NH}_4\text{-N}$) (right) at the depth of 0–1 m in Lake Valkea-Kotinen in 1990–2009.

Vuorenmaa, J., Salonen, K., Arvola, L., Mannio, J., Rask, M. & Horppila, P. 2014: Water quality of a small headwater lake reflects long-term variations in deposition, climate and in-lake processes. *Boreal Env. Res.* 19 (suppl. A): 47–65.

6. Effects of a changing climate on the hydrology of a boreal catchment and lake DOC-probabilistic assessment of a dynamic model chain

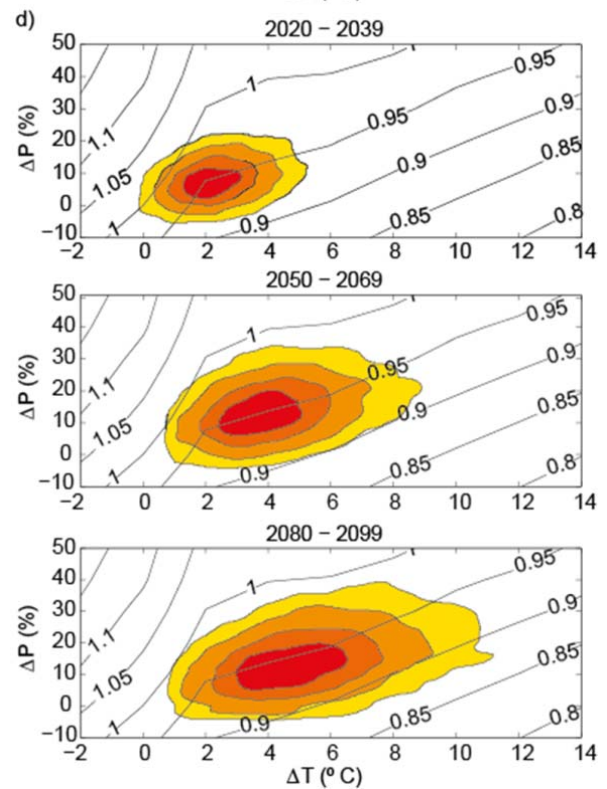
The purpose of this study was to apply the impact response surface analysis to quantify the likelihood of climate change induced hydrological responses in Valkea-Kotinen IM catchment. In this study, a novel model chain was reported using HBV, INCA-C and MyLake to simulate runoff, snow dynamics, ice cover, soil moisture, lake thermal stratification and in-lake DOC concentrations in Valkea-Kotinen. Using the period 1990–2005 as a reference conditions, impact response surfaces (IRSs) were constructed with modelled results of 63 combinations and 10 000 probabilistic projections of changes in temperature ($-2\text{ }^{\circ}\text{C}$ to $+14\text{ }^{\circ}\text{C}$) and precipitation (-10% to $+50\%$) in 2080–2099.

There is a clear seasonal pattern in the response of evapotranspiration and runoff to climate change. Superimposing probabilistic projections of climate change onto the IRSs, the uncertainty in impacts under projected climate change was illustrated. Soil moisture deficit is sensitive to both temperature and precipitation change, and 12% to 25% drier soils are projected in response to the changing climate by the end of the century. The runoff from catchment to the lake is decreasing for some simulations and increasing in others. A larger decrease in runoff than -10% is unlikely, while it is likely that the increase is at most 5%. In the modelling analysis, drying soils were found to lead to slightly decreasing DOC concentrations in the uppermost layer (0–1 m) of the lake, at least by 5% from reference 14.3 mg C l^{-1} (Fig. 6).

It is also likely that lake ice cover will continue to shorten, with a likely rate of about 1.5 days per year. The onset of lake stratification is likely to happen earlier, by 23 April, as compared with 12 May in reference conditions. The length of the stratified period is becoming longer, at a likely rate of about 0.5 days per year.

Fig. 6.

Impact response surfaces (IRS) depicting the sensitivity to climate change of impact model results: (d) DOC concentrations in lake. The IRSs, drawn as labelled contour lines, represent the responses of the impact model chain to perturbations of temperature (T) and precipitation (P). The impact model results are expressed as standardized values where value 1 for no change in climate from 1961–1990 is the reference value for each variable; values larger than 1 mean an increase, and smaller than 1 a decrease in the model response; 90% of the climate change projections are within the outermost filled contour, 75% and 50% within the intermediate, and 25% within the innermost filled contour (see Holmberg *et al.* 2014 for details).



Holmberg, M., Futter, M. N., Kotamäki, N., Fronzek, S., Forsius, M., Kiuru, P., Pirttioja, N., Rasmus, K., Starr, M. & Vuorenmaa, J. 2014: Effects of changing climate on the hydrology of a boreal catchment and lake DOC — probabilistic assessment of a dynamic model chain. *Boreal Env. Res.* 19 (suppl. A): 66–82.

7. Long-term changes in plankton metabolism and sedimentation

The aim of this study was to assess the variability and long-term trends of the metabolic processes of plankton, such as primary production (PP), chlorophyll a (Chl) and respiration (R), and the causal connections between these processes and abiotic factors. The analysis was focused on the uppermost, shallow water layer with most intense plankton biomass and metabolism.

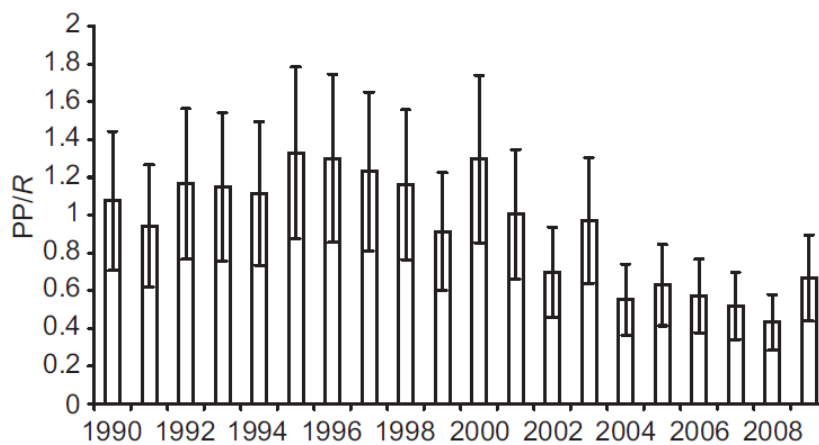


Fig. 7. The ratio between mean annual primary production and respiration (PP/R) of plankton in Lake Valkea-Kotinen in 1990–2009. The bars indicate standard deviations of the means.

The phytoplankton production and sedimentation of organic matter were significantly decreased during the 20-year study period (1990–2009) (Fig. 7) while no consistent long-term trend was found for Chl and *R*. Availability of light and nutrients and water temperature were among the key abiotic factors regulating the changes in metabolic processes in the lake. The decline in PP was due to light limitation following increased water colour during the second half of the study period. Climatic forcing and consequent hydrological conditions determined the nutrient and DOC loading to the lake, and finally affected the metabolic processes of plankton and sedimentation patterns.

Arvola, L., Salonen, K., Keskitalo, J., Tulonen, T., Järvinen, M. & Huotari, J. 2014: Plankton metabolism and sedimentation in a small boreal lake — a long-term perspective. *Boreal Env. Res.* 19 (suppl. A): 83–96.

8. Zooplankton – seasonal patterns and long-term trends

In this study, patterns in the dynamics and composition of the zooplankton community as related to long-term environmental changes were presented. On the basis of the entire 20-year data set, a clear seasonal pattern was recorded for the main taxonomic groups of zooplankton. The protozoans had their highest densities typically in early June, followed by rotifers in June–July, cladocerans in July and copepods in late July and August.

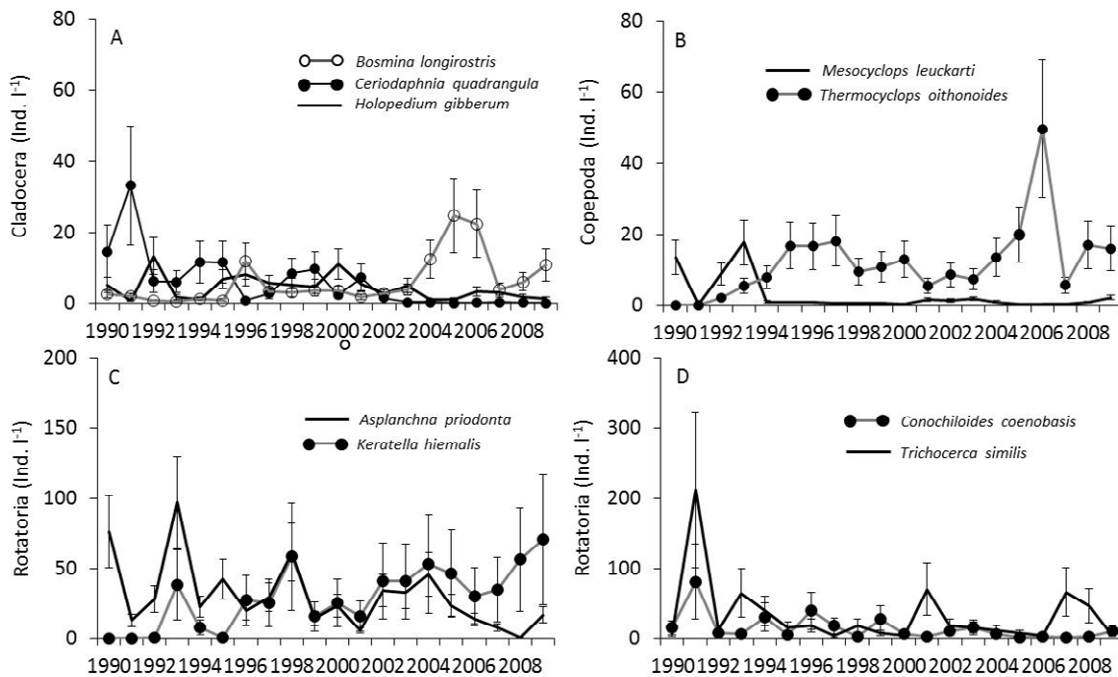


Fig. 8. June–August mean densities (\pm SD) of the major cladoceran, copepod and rotifer species in Lake Valkea- Kotinen during 1990–2009.

There were significant long-term changes in the abundance of dominating crustacean species but not of rotifers species (Fig. 8). According to the redundancy analysis (RDA), increasing organic carbon and the subsequent increase in water colour, increasing alkalinity and phosphorus affected the crustacean zooplankton in Lake Valkea-Kotinen strongly. In the early 1990s, the zooplankton community as a whole was closely associated with total phosphorus and primary production of phytoplankton but during the latest years of the study period with water colour and alkalinity. Rotifers were also affected by both cladocerans and copepods, suggesting competitive and/or predatory interactions. Instead, climate change, if temperature alone is considered, seemed less important. Changes in acidity of water i.e. recovery from acidification explain poorly observed changes, because most of the dominating species, present in the community over the 20 year period, are acid-tolerant. On the other hand, quantitative relations of the dominating species in the lake over 20 years may indicate the proceeding recovery process in the lake.

Lehtovaara, A., Arvola, L., Keskitalo, J., Olin, M., Rask, M., Salonen, K., Sarvala, J., Tulonen, T. & Vuorenmaa, J. 2014: Responses of zooplankton to long-term environmental changes in a small boreal lake. *Boreal Env. Res.* 19 (suppl. A): 97–111.

9. Population dynamics of perch

In this study, changes in perch population dynamics and growth were related to the environmental trends recorded in the lake during the 20-year study period to compare the impact of each stressor on perch. Both environmental and biological factors were included to evaluate their relative importance.

The 20-year data from Lake Valkea-Kotinen revealed that the size of the perch population and the occurrence of strong year classes were only weakly associated with the environmental and biological factors considered, and were regulated more through intraspecific processes. The lake had never acidified to critical levels for perch reproduction in humic waters, as indicated by the occurrence of strong year-classes of perch during the “acidification years” of the 1990s, before the onset of pronounced chemical recovery of the lake around the year 2000 (Vuorenmaa *et al.* 2014). In the first half of the monitoring period, the fluctuation of the perch population size followed the occurrence of strong year-classes that were born at 4-year intervals until the early 2000s. In the latter part of the monitoring period, since the early years of the 2000s, no really strong or weak year-classes occurred and the population was dominated by small individuals.

During the study period, a significant decreasing trend in perch growth was recorded in their first summer and slowing growth also during the 2nd and 3rd summers (Fig. 9), which were more closely related to the trends in environmental factors. The main factor affecting the early growth of perch appeared to be the organic carbon load, resulting in darker water, and decreased light, which would outweigh the expected positive effect of increasing temperature on the growth of young perch (Jeppesen *et al.* 2012). Perch is a visually-oriented fish species and further brownification may have affected — at least partly — to early growth of perch. An important factor causing the decreased early growth of perch is also a general decrease in the biological production of the lake, also related to the increased water colour (Arvola *et al.* 2014). Densities of important food items for small perch, such as cladoceran zooplankton and Chaoborus larvae were also decreased (Lehtovaara *et al.* 2014), thus affecting perch growth.

Rask, M., Sairanen, S., Vesala, S., Arvola, L., Estlander, S. & Olin, M. 2014b: Population dynamics and growth of perch in a small, humic lake over a 20-year period — importance of abiotic and biotic factors. *Boreal Env. Res.* 19 (suppl. A): 112–123.

10. Concluding remarks

- The present results from Valkea-Kotinen ICP IM catchment / ICP Waters lake highlight the value of protected head water catchments for environmental monitoring.
- In such sensitive sites 20 years may be a sufficient time period to show abiotic and biotic responses to air pollution and climatic change.
- The results clearly demonstrate the complexity of boreal nature and the interactions within and between the aquatic and terrestrial ecosystems and atmosphere.
- Further, these studies strongly emphasize the importance of integrated long-term monitoring of physical, chemical and biological variables for detecting the variety of impacts of changing environmental conditions on ecosystems.

References

- Garmo, Ø.A., Skjelkvåle, B.-L., de Wit, H.A., Colombo, L., Curtis, C., Fölster, J., Hoffmann, A., Hruška, J., Høgåsen, T., Jeffries, D.S., Keller, W.B., Krám, P., Majer, V., Monteith, D.T., Paterson, A.M., Rogora, M., Rzychon, D., Steingruber, S., Stoddard, J.L., Vuorenmaa, J., Worsztynowicz, A. 2014. Trends in Surface Water Chemistry in Acidified Areas in Europe and North America from 1990 to 2008. *Water Air Soil Pollut.* 225:1880.
- Jeppesen, E., Mehner T., Winfield, I.J., Kangur, K., Sarvala, J., Gerdeaux, D., Rask, M., Malmquist, H.J., Holmgren, K., Volta, P., Romo, S., Eckmann, R., Sandström, A., Blanco, S., Kangur, A., Ragnarsson, Stabo H., Meerhoff, M., Ventelä, A.-M., Søndergaard, M. & Lauridsen, T.L. 2012. Impacts of climate warming on lake fish assemblages: evidence from 24 European long-term data series. *Hydrobiologia* 694: 1–39.
- Mannio, J. 2001a. Recovery pattern from acidification of headwater lakes in Finland. *Water Air Soil Pollut.* 130: 1427–1432.
- Mannio, J. 2001b. Responses of headwater lakes to air pollution changes in Finland. *Monographs of the Boreal Environment Research* 18: 1–48.
- Räisänen, J. & Eklund, J. 2012. 21st century changes in snow climate in Northern Europe: a high-resolution view from ENSEMBLES regional climate models. *Clim Dyn.* 38: 2575–2591.
- Ukonmaanaho, L., Starr, M., Mannio, J. & Ruoho-Airola, T. 2001. Heavy metal budgets for two headwater forested catchments in background areas of Finland. *Environ. Pollut.* 114: 63–75.
- Vuorenmaa, J. 2007. Recovery responses of acidified Finnish lakes under declining acid deposition. *Monographs of the Boreal Environment Research* 30: 1–64.
- Vuorenmaa, J. & Forsius, M. 2008. Recovery of acidified Finnish lakes: trends, patterns and dependence of catchment characteristics. *Hydrol. Earth Syst. Sci.* 12: 465–478.

4. Recovery of the Aurora Trout (*Salvelinus fontinalis*) in a Low Calcium Environment in Ontario, Canada

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The Aurora trout is a rare race or colour strain of the brook trout (*Salvelinus fontinalis*) that existed in only two lakes in the world, Whirligig (11 ha) and Whitepine (77 ha) lakes, located 110 km north of Sudbury, Canada. These lakes were highly sensitive to the damaging effects of acid rain and the Aurora trout became an iconic species (strain) in the North American battle against acid rain in the 1980s and beyond. Aurora trout were eliminated from their home range by acidification in the late 1950s or early 1960s (Keller 1978), but were preserved through a captive breeding program by the Ontario Ministry of Natural Resources and Forestry staff (program continues to this day). Aurora trout were successfully returned to their home lakes, but only after whole lake and watershed liming efforts in 1989, 1992 and 1993 (Snucins et al. 1995). The first naturally reproduced Aurora trout was captured in 1992 and the population rapidly expanded to reach expected standing crop biomass by the late 1990s (Snucins et al. 1995).

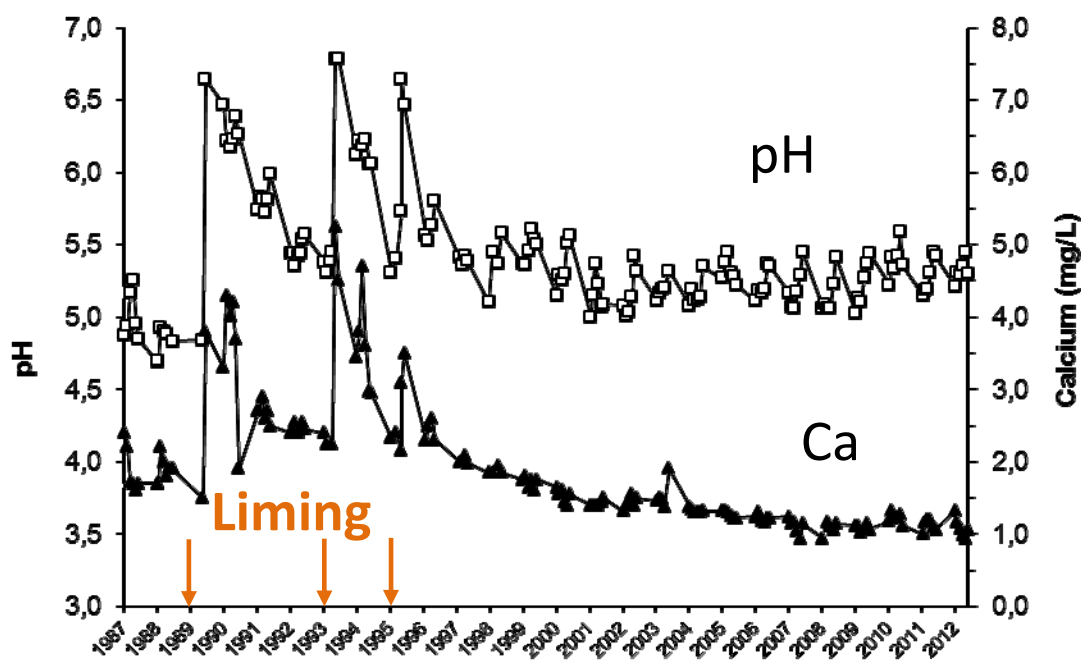


Figure 1. Monitoring of the water chemistry in Lake Whirligig (WG) from 1976 to 2012. Data from OMOE monitoring program provided by J. Bailey and J. Heneberry.

Initially we had great concerns that the pH would not hold above the lethal level for reproducing populations (pH 5.0, Beggs and Gunn 1986) without further liming treatments. However in recent decades, with massive regulated acid rain reductions in North America, the pH has remained above pH 5.0 (see Figure 1), and now appears to be slowly rising to the pre-industrial level of pH 5.4-5.7, estimated by paleolimnological methods (Dixit et al. 1996).

We conducted a physiological and contaminant study of the effects of Ca decline and contaminant deposition during Sept 3-6, 2013 on aurora trout in Whirligig Lake. This initial report is a brief description of the sampling methods and early results.

Material and methods

A total of 20 specimen were collected. Except for two younger Aurora trout caught in a trapnet, the other 18 fish were caught by angling. The fish varied in sizes between 16-39 cm and 44 to 690 g, respectively (Figure 2).

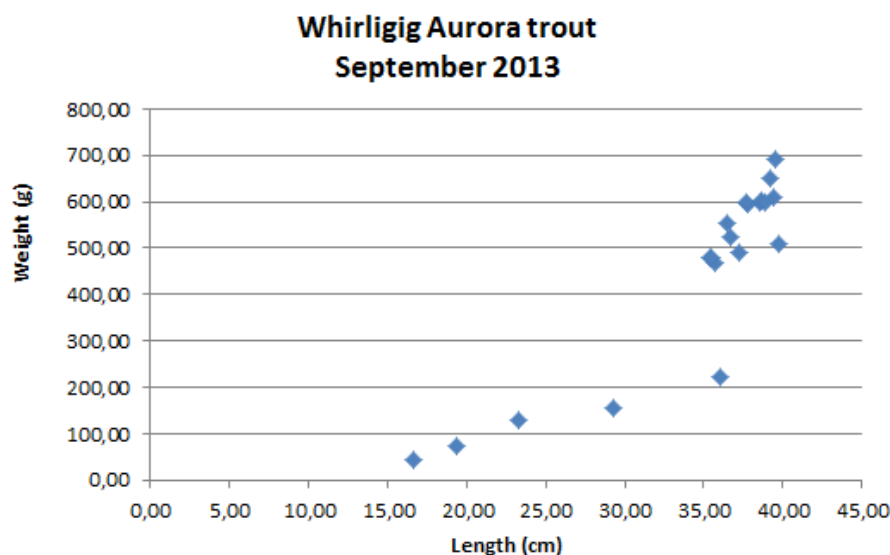


Figure 2. Length (cm) and weight (g) of the 20 Aurora trout caught in Lake Whirligig in the period September 3-6, 2013.

After catch, the fish was brought immediately back to the field laboratory in a temporary shelter on the edge of the lake. The fish dissection followed the EMERGE SAMPLING MANUAL FOR LIVE FISH (<http://www.mountain-lakes.org/emerge/methods/29.pdf>), (Rosseland et al. 2001) and the UNECE ICP Waters Manual for fish sampling (<http://www.icp-waters.no/Manual/11TracemetalsandPOPsinfish/tabid/140/Default.aspx>) according to the instruction video (<http://www3.laurentian.ca/livingwithlakes/research/instructional-videos/>).

Except for three fish (No 13, 14 and 19), the remaining were analysed in minutes after catch, and brought alive to the laboratory in a bucket. The fish was killed with a blow to the head, and blood was sampled immediately. In the case of 3 fish sampling was delayed and some additional handling stress was noted. Fish no 13 and 14 were sampled by small mesh trapnet set overnight, and fish no 19 was captured by angling but placed in a white keepnet for 2 hours while waiting to be sampled. Only two of these 3 delayed-sampling individuals provided blood sample, but both exhibited slightly higher stress value than the other specimen, measured in blood glucose (suggesting that fish are generally fine but can handle very little extra stress).

Samples for analyses of chemistry and contamination levels (metals, persistent organic pollutants (POPs) and radioactive isotopes) were taken from; blood, gill, liver, kidney, muscle and spine. Scales and otoliths were sampled for ageing. Muscle samples, as well as aquatic mosses, periphyton and zooplankton were sampled for analyses of stable isotopes of N and C to determine the individual fish and their place in the food chain ($\delta^{15}\text{N}$), and where they got their carbon from ($\delta^{13}\text{C}$). The periphyton, moss and zooplankton analysis are used for base line correction of the SI data from the fish tissue.

Blood analyses

Blood was sampled from the caudal aorta/vein in a 5 ml syringe without use of heparin, and transferred immediately to a EC8+ cassette for analyses in a portable I-STAT clinical analyser (Abbot)

to determine plasma Na^+ , K^+ , Cl^- , glucose, pCO_2 , HCO_3^- and pH in whole-blood. pH, pCO_2 and HCO_3^- values will be corrected for the temperature difference between ambient water temperature (18°C) and the temperature-adjusted (37°C) values displayed by the instrument in accordance with the I-STAT procedure (Eliason et al. 2007).

Data on blood plasma ions demonstrated clearly that the fish were able to osmoregulate in the lake at the time of sampling, and that except for the three fish kept for prolonged holding periods in traps, the level of blood glucose showed no-stress values, $5, 4 \pm 1, 6$ mM (Table 1). The values are in accordance with background data from non-stressed Atlantic salmon (*Salmo salar*) from three rivers in Norway (Table 2). The glucose values of the trapped fish No. 14 and 19 were 8.9 and 9.7 mM Glucose, respectively, indicating a slight stress from confinement.

Table 1. Some of the data from the analyses of Aurora trout in Lake Whirligig sampled on September 3-6, 2013. Blood ($N=16$) were analysed in situ by an Abbot I-STAT analyser, using EC8+ cartridges.

	Na^+	K^+	Cl^-	Glucose (mM)	Hct (%)
Mean	147,4	5,3	136,5	5,4	24,9
SD	4,5	0,9	4,9	1,6	5,3

Table 2. Physiological parameters in whole blood samples from Atlantic salmon smolts from River Lygna (Southern Norway, $N=14$) and River Stjørdalselva (Central Norway, $N=35$) analysed in-situ using I-stat clinical analyser and EC8+ cartridges. Values are mean \pm SD. Values not connected by similar letter are significantly different at $p=0,05$ (Student's *t*). From: Kristensen, 2013.

Location	Na^+	K^+	Cl^-	Glu (mM)	Hct (%)	pH	pCO_2 (mmHg)	HCO_3^- (mM)
R Lygna	153 ± 4 a	$3,9 \pm 0,7$ a	134 ± 3	$5,3 \pm 1,1$	27 ± 6	$6,956 \pm 0,130$ b	$5,2 \pm 1,4$	$1,20 \pm 0,5$ a
R Stjørdalselva	144 ± 5 b	$4,8 \pm 0,6$ b	135 ± 6	$6,3 \pm 2,4$	27 ± 3	$7,224 \pm 0,136$ a	$4,7 \pm 0,8$	$2,00 \pm 0,8$ b
Total	146 ± 6	$4,5 \pm 0,8$	135 ± 5	$6,1 \pm 2,2$	27 ± 4	$7,147 \pm 0,181$	$4,8 \pm 1,0$	$1,80 \pm 0,8$

Sex and maturation

The two sexes were relatively well represented in the samples, with 8 females and 12 males. Six fish were immature, an 8 fish were post-spawners, of which 3 were females having unshed eggs from last year spawning in the gut (Figure 3).



Figure 3. Aurora trout with unshed eggs from last year spawning, together with stage 4-5 egg for spawning within the next two months. Fish No 5 (left) and No 20 (right). Photo: B.O. Rosseland.

In the UN-ECE ICP Waters definition of a “recovered” fish population which earlier have been suffering from acidification, is the presence of natural and expected year classes relative to the geographical location of the lake, and that the lake contain young year classes as a result of successive spawning as well as surviving spawners, represented as post-spawners. The most studied acidified lake in Norway, Lake Saudlandsvatn, still shows under-representation of post-spawners, where the lake had up to a 16 years period no post-spawners surviving (Hesthagen et al. 2011).

Based on the Un-ECE ICP Waters definition, the population of Aurora trout in Lake Whirligig Lake in Canada should be characterized as recovered from acidification at the time of sampling in 2013.

Water chemistry of concern

The phenomenon of reduced calcium concentration observed in Canada as well as in Europe, is a defined challenge for organism living in freshwater. Fish in alpine areas with low ion content seem to face a critical minimum level for Ca to be able to breed, as well as to survive due to osmoregulation problems (Rosseland et al. 2003, Massabua et al. 2013). Lake Whirligig seems to be in this same process of reduced Ca level, Figure 1. With a pH around 5.2 and Ca around 1 mg/L, the future of this reproducing Aurora trout population is therefore uncertain.

Upcoming analyses and conclusions.

The sampling of brown trout (*Salmo trutta*) from Lochnager, Scotland, a moderately acidified lake within the Balmoral Estate, belonging to the Duke of Edinburgh, also showed a fairly sound population structure, although the blood ionic composition demonstrated an osmotic stress. However, this lake came up as the most polluted lake in a series of lakes from Arctic and Alpine areas of Europe, Rosseland et al. 2007. The parameters analysed from the fish in that study were i.e.; blood chemistry, gill metal concentrations, POPs (the “black list” from WHO included brominated flame retardants (PBDEs)) in liver and muscle, liver histology, liver tissue anti-oxidant status, kidney metal concentrations and mercury and stable isotopes in muscle. All the samples to enable analyses of these parameters, except liver histology and anti-oxidant status, have been sampled from the Aurora trout. It is therefore of utmost importance to be able to analyse the same parameters in the organs of fish from Lake Whirligig as in Lochnagar, in order to establish their present status and hopefully be able to foresee future need of monitoring and sampling. With the continuous reductions in Ca, a new field study should therefore be planned to take place in near future, and the water monitoring must continue on a regular basis.

Acknowledgement

Thank you to Jocelyne Heneberry and Matt Heerschap with OMOE at the Co-op Unit at Laurentian for all the help in the field; to Michelle Gillespie for lab preparation; and to John Bailey with OMOE who provided data and supported travel costs.

References

- Beggs, G.L. and Gunn, J.M. 1986. Response of Lake Trout (*Salvelinus namaycush*) and Brook Trout (*S. fontinalis*) to surface water acidification in Ontario. *Water, Air, and Soil Pollution* 30, 711-718.
- Dixit, A.S., Dixit, S.S. and Smol, J.P. 1996. Long-term trends in limnological characteristics in the Aurora Trout lakes, Sudbury, Canada. *Hydrobiologia* 335, 171-181.
- Eliason, E.J., Kiessling, A., Karlsson, A. Djordjevic, B. and Farrell, A.P. 2007. Validation of the hepatic portal vein cannulation using Atlantic salmon (*Salmo salar* L.). *J. Fish Biol.* 71, 290-297.
- Grimalt, J.O., Fernandez, P., Berdie, L., Vilanova, R., Catalan, J., Psenner, R., Hofer, R., Appleby, P.G., Rosseland, B.O., Lien, L., Massabuau, J.C. & Battarbee, R.W. 2001. Selective Trapping of Organochlorine Compounds in Mountain Lakes of temperate areas. *Environmental Science and Technology* 35: 2690 - 2697.
- Hesthagen, T., Fjellheim, A., Schartau, A. K., Wright, R. F., Saksgård, R. and Rosseland, B.O. 2011. Chemical and biological recovery of Lake Saudlandsvatn, a highly acidified lake in southernmost Norway, in response to decreased acid deposition. *Science of the Total Environment* 409, 2908-2916.

- Jeziorski, A., Yan, N., Paterson, A., DeSellas, A., Turner, M., Jeffries, D., Keller, W., Weeber, R., McNicol, D., Palmer, M., McIver, K., Arseneau, K., Ginn, B. Cumming, B. and Smol, J. 2008. The widespread threat of calcium decline in freshwaters. *Science* (Washington, D.C.), 322, 1374-1377.
- Keller, W. 1978. Limnological observations on the Aurora Trout lakes. Technical Report Ontario Ministry of the Environment, Sudbury, Ontario, Canada
- Keller, W. 2009. Limnology in northeastern Ontario: from acidification to multiple stressors. *Can. J. Fish. Aquat. Sci.* 66, 1189-1198.
- Kristensen, T. 2013. Water quality in commercial Atlantic salmon smolt production: Effects on fish performance and welfare with special emphasis on hyperoxia. PhD thesis. Norwegian University of Life Sciences, Aas, Norway. Hesis no: 2013:59, ISBN 978-82-575-1159-3.
- Massabuau, J.-C., B.O. Rosseland, P. Laurent, R. Lackner, S. Rognerud, M. Ventura, L. Encina, A. Probst, G. Durrieu. 2013. Climate change, surface-water mineralization and fish limits of life in remote mountain lakes. Manuscript.
- Rognerud, S., Grimalt, J.O, Rosseland, B.O., Fernandez, P., Hofer, R., Lackner, R., Lauritzen, B., Lien, L., Massabuau, J.C. & Vilanova, R. 2002. Mercury and organochlorine contamination in brown trout (*Salmo trutta*) and Arctic charr (*Salvelinus alpinus*) from high mountain lakes in Europe and the Svalbard archipelago. *Water, Air, and Soil Pollut. Focus* Vol 2: 209-232.
- Rosseland B.O., Massabuau J-C., Grimalt J., Hofer R., Lackner R., Raddum G., Rognerud S., Vives I. 2001. Fish ecotoxicology, The EMERGE fish sampling manual for live fish. The EMERGE Project (European Mountain lake Ecosystems: Regionalisation, diaGnostic and socio-economic valuation). (<http://www.mountain-lakes.org/emerge/methods/29.pdf>)
- Rosseland, B.O., Massabuau, J-C., Grimalt, J., Rognerud, S., Hofer, R., Lackner R., Vives, I., Ventura, M., Stuchlik, E., Harriman, R., Collen, P. Raddum, G.G., Fjellheim, A., and Trichkova, T. 2003. Fish Ecotoxicology. In: Patrick, S. (Ed.) EMERGE Final Report, February 2000 – January 2003. Contract EVK1-CT-1999-00032, PP. 41-50.
- Rosseland, B.O., Rognerud, S., Collen, P., Grimalt, J., Vives, I., Massabuau, J-C., Hofer, R., Lackner, R., Fjellheim, A., Harriman, R., and Pina, B. 2007. Brown trout in Lochngar. Population and contamination by metals and organic micropollutants. In: Rose, N. (Ed.): Lochngar: The Natural History of a Mountain Lake. *Developments in Paleoenvironmental Research (DPER) Volume 12*, page 247 – 279. ISBN 1-4020-3900-X, 2007.
- Snucins, E.J., Gunn, J.M. and Keller, W. 1995. Restoration of the Aurora Trout to its acid-damaged native habitat. *Conservation Biology* 9, 1307-1311.

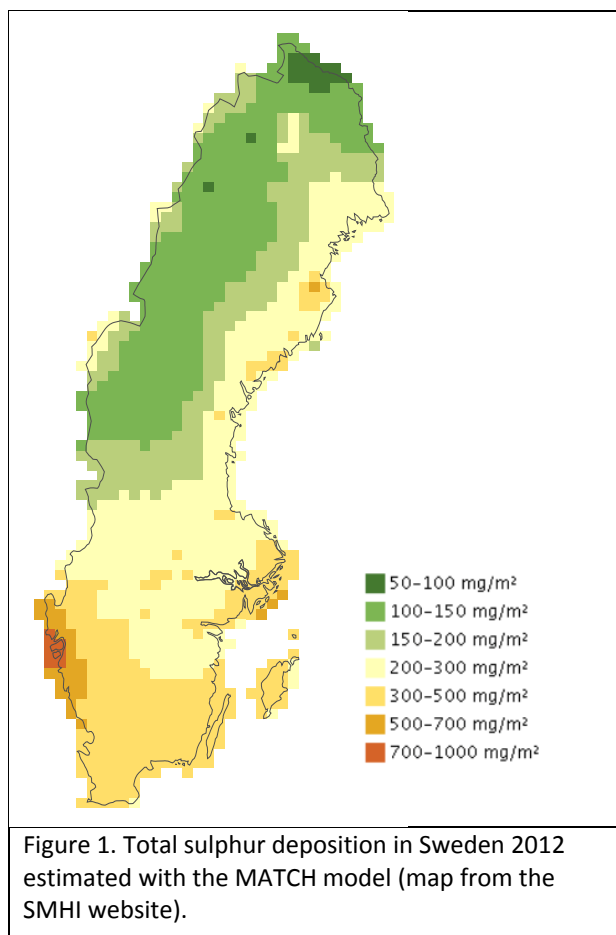
5. Swedish contribution to the ICP-waters trend report for 2015

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Introduction

The Swedish national freshwater monitoring programme has been going on since 1965 (Fölster et al. 2014a). The program started with a focus on eutrophication of large lakes and nutrient loads to the sea. Monitoring of smaller acid sensitive lakes and streams was first included in the program in the 1980s. Since then, more than a hundred soft water lakes have been monitored on a seasonal basis. This, together with surveys including thousands of randomly selected lakes ensures that the Swedish monitoring program has a good possibility to follow the spatiotemporal trends in impacts from transboundary pollution.



Sweden experiences a strong gradient in increasing sulphur deposition from south to north (50 – 1000 mgS/m²). In the southern region, there is increasing deposition from west to east, whereas in the northern region the longitudinal gradient is opposite (Figure 1). Acid sensitive till soils covers most of the country with exceptions of smaller regions with well buffered sediment soils and small areas of calcareous soils, primarily on Gotland. This results in a concentration of acidified lakes clustered along an arc from south–southwest to east-central Sweden (Figure 5). A part of the country was submerged by the sea after the last glaciation, and especially along the northern east coast this has

resulted in naturally sulphur rich sediment soils. The sulphur deposition has declined by 90 % since the peak around 1980 and is now at the same level as around 100 years ago (data from EMEP). In this report we present regional average trends for water chemistry of acid sensitive lakes from the national monitoring program. We also present estimates of the fraction of acidified lakes according to the national ecological status classification scheme as well as the change in number of acidified lakes over time according to MAGIC model simulations. The report is based on a report for the Swedish EPA (Fölster et al. 2014b) and peer-reviewed scientific publications (Futter et al. 2014).

Study sites

The lake dataset includes 95 acid sensitive lakes (mean ANC < 0.3 meq/l) with seasonal samples of water chemistry between 1988 and 2013 (four samples a year) (Figure 2). The lakes are well distributed over southern Sweden, but in the northern part fewer lakes are included, especially in inland areas. The lakes were originally monitored as part of a reference program for limed lakes. Hence they represent a rather homogenous set of small to medium size lakes in the forest landscape of the regions with the highest acidification pressure. The lakes are not impacted by larger point sources or intensive land use.

The description of the acidification status of all lakes in Sweden is based on the national lake survey performed between 2007-2012 including 5084 lakes that were selected by a stratified random selection from all 96 690 lakes > 1 ha within the national lakes register (Fölster et al. 2014a).

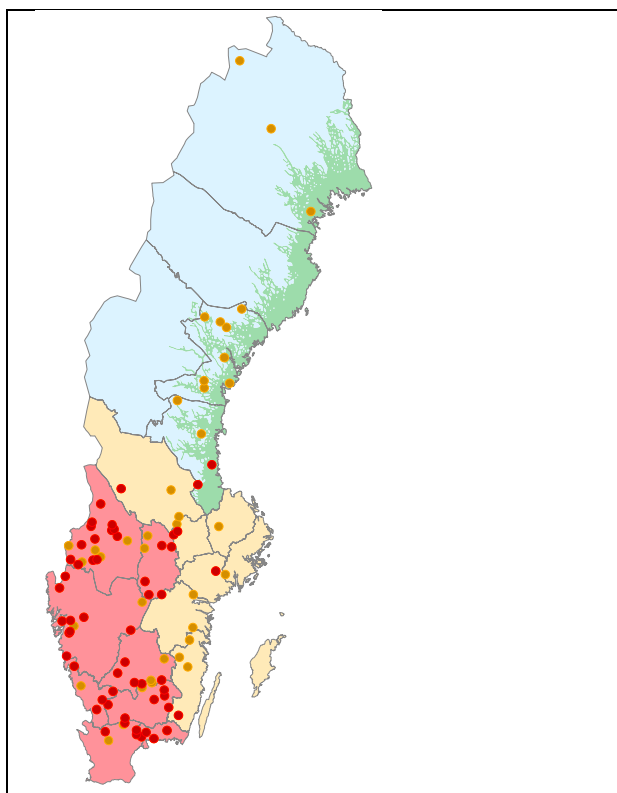


Figure 2. 95 acid sensitive lakes (mean ANC < 0.3 meq/l) with seasonal water chemistry 1988-2013. Red symbols denotes lakes with at least one pH measurement ≤ 5.6 . The background colours of the land area are regions based on acidification pressure and county borders. The northern region is divided into areas above and below the highest coast line.

The stratification is based on regions used in national environmental reports and is consistent with county borders and acidification pressure. The northern region is divided along the highest coastline since the last glaciation.

Methods

The regional trends are based on the annual medians of all lakes or streams within each region. ANC (Acid neutralizing capacity) is calculated as:

$$\text{ANC} = (\text{Ca} + \text{Mg} + \text{Na} + \text{K}) - (\text{SO}_4 + \text{Cl} + \text{NO}_3)$$

with all concentrations in meq/l. Statistical significance of trends was estimated using the non-parametric Mann-Kendall test. Acidification was defined as a pH change > 0.4 units in relation to preindustrial concentrations as estimated by the MAGIC_{library} according to the Swedish national ecological quality criteria (Fölster et al. 2007; SEPA 2007; Moldan et al. 2013).

Results and discussion

Trends in lake chemistry

The most obvious response to the decline in sulphur deposition was the decline in surface water sulphate concentrations in all four regions by more than 50 % between 1988 and 2013 (Table 1, Figure 3a). The decline is still less than the 90 % decline in sulphur deposition, and while the deposition levelled out after year 2000, the sulphate concentration is still declining. The delay in response to the deposition decline is due to hydrological, chemical and biological processes contributing to sulphate retention in catchment soils. The delay, however, varies between lakes, and for individual lakes the sulphate concentrations have levelled out (data not shown). A further decline in sulphate concentration is expected, both due to further reductions in emissions and to the observed lag in response to the deposition decline.

In the two southern regions with the highest impact from acid deposition, there were significant trends in non-marine base cations (BC*) (Table 1, Figure 3b). Sulphate declines are often followed by declines in base cations due to a reduction in ionic exchange in catchment soils (Stoddard et al. 1999). In the northern regions of Sweden where the deposition level is lower, temporal variation in BC-concentrations is controlled by natural climatic variation (Lucas et al. 2013).

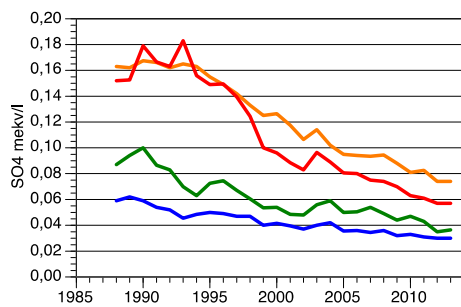
Table 1. Statistical decreasing ("–") and increasing ("+") trends in annual medians of water chemistry in 95 lakes with ANC < 0.3 meq/l 1988-2013 divided in four regions, the northern inland above the highest coastline (NI), the northern coast below the historical highest coastline (NC), the eastern and central region and the south west region (SW) (Mann-Kendall two-sided test, p<0.05).

Parameter	NI	NC	EC	SW
SO ₄ ²⁻	-	-	-	-
BC*			-	-
ANC	+	+	+	+
TOC		+	+	+
pH	+			+

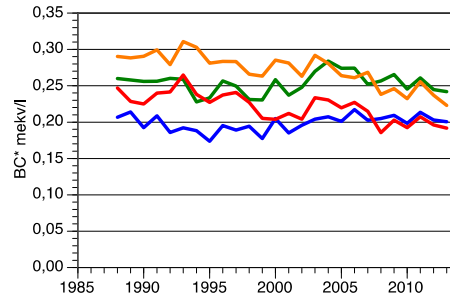
The sulphate decline results in statistically significant ANC increases in all four regions (Table 1, Figure 3c). In the two southern regions, the ANC-increase was dampened by the decrease in BC*. Chloride concentrations peaked during the 1990-ies, indicating impact from an elevated deposition of sea salt (Figure 3c) (Franzén 1990). The chloride concentration has stayed at a constant level over the last ten years. Since the chloride concentrations show pronounced non-monotonic patterns over time, no statistical trend tests were performed.

The concentrations of natural organic matter measured as total organic carbon (TOC) increased in all regions except in northern sites above the highest coastline (Table 1, Figure 3d). The increases follows a pattern of increasing TOC in regions with declines in acid deposition (Monteith et al. 2007). In the south western region the decline in deposition has resulted in a statistically significant increase in pH (Table 1, Figure 3f). The increase in pH in the low deposition northern inland region above the highest coastline is probably due to natural variation.

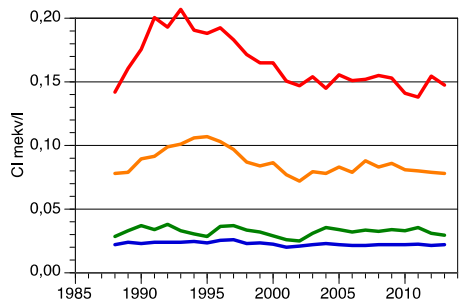
a. SO_4^{2-}



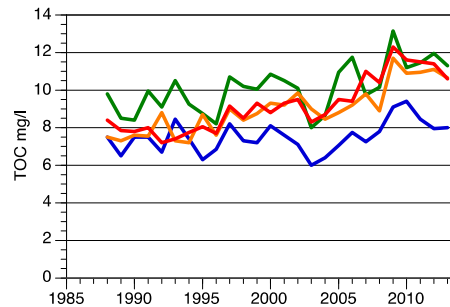
b. BC (non-marine)



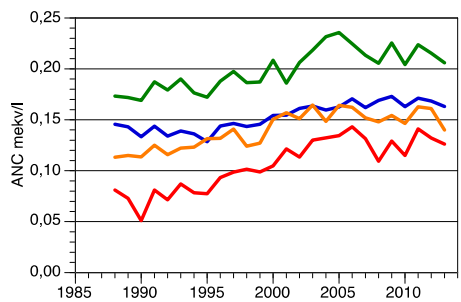
c. Cl^-



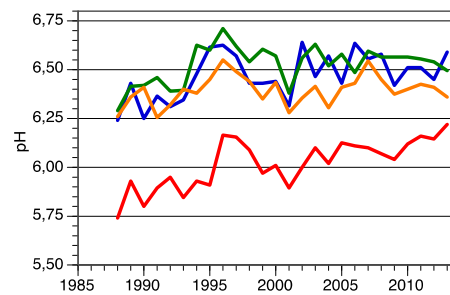
d. TOC



e. ANC



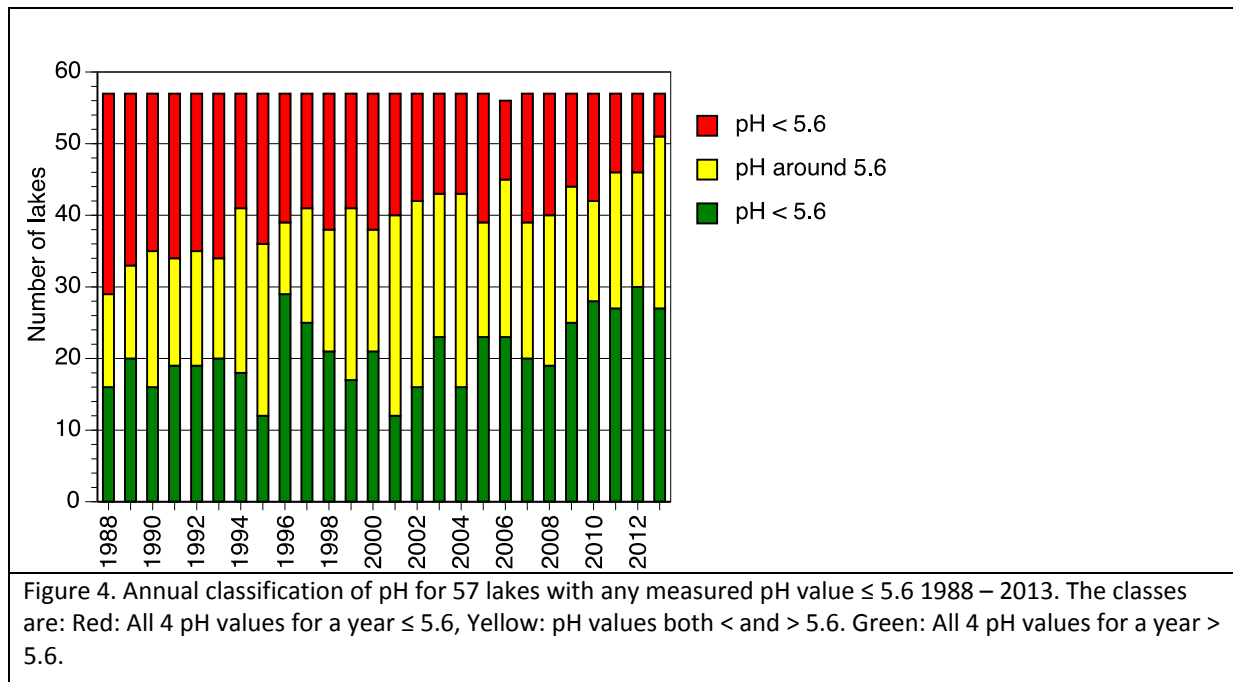
f. pH



Figur 3. Annual regional medians of waterchemistry 1988 - 2013 in 95 Swedish lakes with mean ANC < 0.3 meq/l.

In Sweden, where there is a large gradient of natural organic matter concentrations in surface waters, (Fölster et al. 2014a) pH was found to be the acidity parameter best correlated to biota (Fölster et al. 2007). Critical values of pH for acid sensitive organisms like roach are between 5 and 6. To determine whether or not the observed increase in pH can potentially have resulted in a biological recovery, we determined the number of pH values above 5.6 annually for each lake in a subset of 57 lakes with any measured pH value in the time series below 5.6. The lakes were then classified for each year according

to if all, some or no pH values were below 5.6. The analysis shows that the number of lakes with all measured pH values above 5.6 increased over time. The number of lakes with all measured pH values below 5.6 decreased over time. As a consequence, the chemical recovery has led to conditions suitable for biological recovery.



Fraction of acidified lakes in Sweden

Lakes with an estimated change in pH of > 0.4 units since 1860 based on results from the MAGIC_{library} are classified as acidified and not achieving good ecological status according the Swedish implementation of the Water Framework Directive. In 2010, 10 % of all 96 690 lakes $> 0,01 \text{ km}^2$ in Sweden were classed as acidified. This is a decline from the 17% of lakes which were classified as acidified in 1990. Most acidified lakes were found in the south western region where 47 % of the lakes were acidified (Figure 5). In the three regions with the lowest impact of acidification as many as half of the historically acidified lakes have recovered sufficiently so as to no longer be classified as acidified. In the south west region with the highest degree of acidification, there have certainly been large improvements in water chemistry as shown by the trends presented above, but since the acidification was so severe, the improvements are not yet enough for a full recovery of most acidified lakes. Projections made using MAGIC suggest that any further recovery will be very modest.

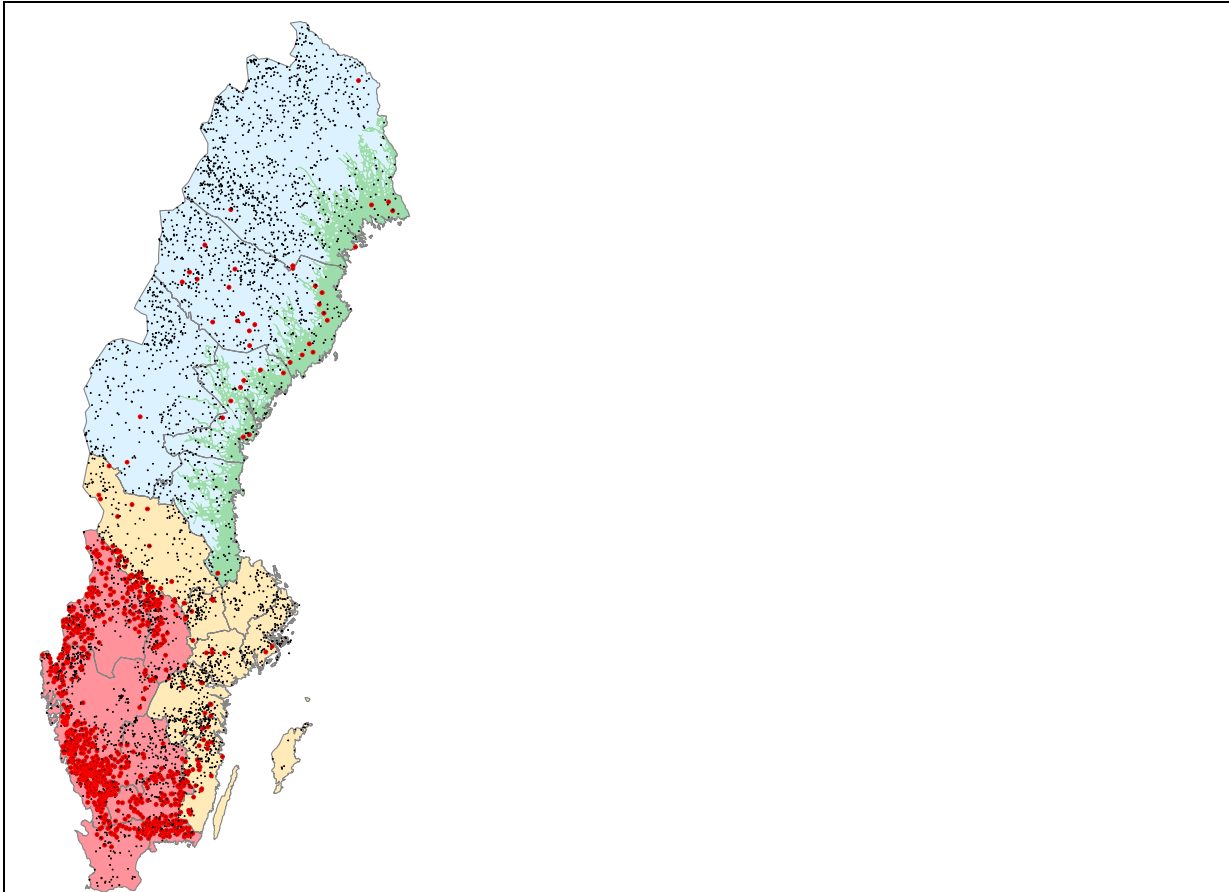


Figure 5. Acidified (red) and non acidified (black) lakes in the national lake survey 2007-2012 (n=5084) according to the MAGIC_{library} (Moldan et al. 2013). The background colours of the land area are regions based on acidification pressure and county borders. The northern region is divided into inland and coastal regions according to the highest coast line.

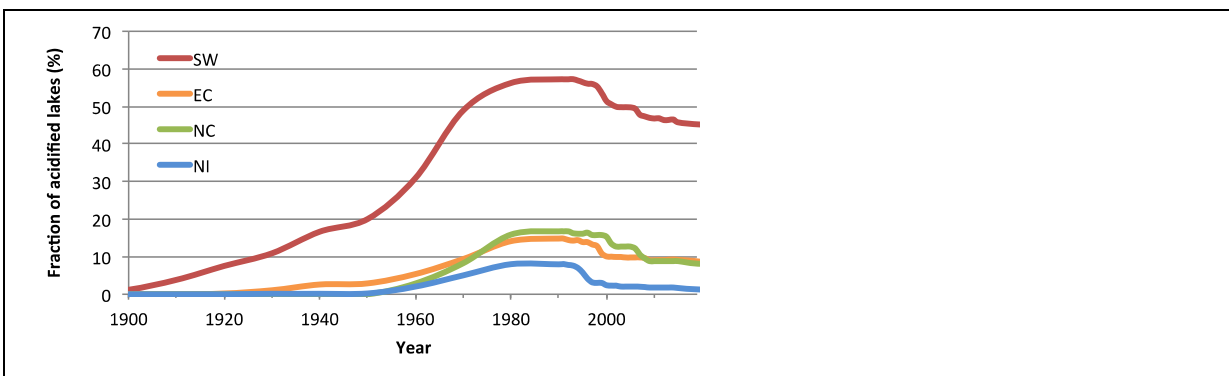


Figure 6. Temporal trends in the fraction of acidified lakes in Sweden 1900-2020 based on the national lake survey and the MAGIC_{library}.

References

- Franzén, L.G. 1990. Transport, deposition and distribution of marine aerosols over southern Sweden during dry westerly storms. *Ambio* 19: 180-188.
- Futter, M.N., A. Valinia, S. Löfgren, S.L. Köhler, and J. Fölster. 2014. Long term (1987-2012) trends in water chemistry of acid sensitive Swedish lakes show slow recovery from historic acidification. *Ambio*. doi:10.1007/s13280-011-0208-7.

- Fölster, J., R.K. Johnson, M.N. Futter, and A. Wilander. 2014a. The Swedish monitoring of surface waters: 50 Years of adaptive monitoring. *Ambio*: 1-13. doi:DOI 10.1007/s13280-014-0558-z.
- Fölster, J., S. Valinia, L. Sandin, and M.N. Futter. 2014b. "För var dag blir det bättre men bra lär det aldrig bli".
- Försurning i sjöar och vattendrag 2014. SLU, Vatten och miljö: Rapport 2014:20
- Fölster, J., C. Andrén, K. Bishop, I. Buffam, N. Cory, W. Goedkoop, K. Holmgren, R. Johnson, et al. 2007. A Novel Environmental Quality Criterion for Acidification in Swedish Lakes – An Application of Studies on the Relationship Between Biota and Water Chemistry. *Water, Air, & Soil Pollution: Focus* 7: 331-338.
- Lucas, R.W., R.A. Sponseller, and H. Laudon. 2013. Controls Over Base Cation Concentrations in Stream and River Waters: A Long-Term Analysis on the Role of Deposition and Climate. *Ecosystems* 16: 707-721. doi:10.1007/s10021-013-9641-8.
- Moldan, F., B. Cosby, and R. Wright. 2013. Modeling Past and Future Acidification of Swedish Lakes. *Ambio* 42: 577-586. doi:10.1007/s13280-012-0360-8.
- Monteith, D.T., J.L. Stoddard, C.D. Evans, H.A. de Wit, M. Forsius, T. Hogasen, A. Wilander, B.L. Skjelkvale, et al. 2007. Dissolved organic carbon trends resulting from changes in atmospheric deposition chemistry. *Nature* 450: 537-U539. doi:10.1038/nature06316.
- SEPA. 2007. Handbook 2007:4 Status, potential and quality requirements for lakes, watercourses, coastal and transitional waters.
- Stoddard, J.L., D.S. Jeffries, A. Lukewille, T.A. Clair, P.J. Dillon, C.T. Driscoll, M. Forsius, M. Johannessen, et al. 1999. Regional trends in aquatic recovery from acidification in North America and Europe. *Nature* 401: 575-578.

6. Exceedance of critical loads in Norway in 2020 – Comparing CCE and NIVA calculations

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In September 2013, the document *Guidance document on health and environmental improvements using new knowledge, methods and data*¹ (hereafter called the Guidance document) presented exceedance of critical loads for acidification of surface waters in Europe. The calculations were done by the Coordination Centre for Effects (CCE)² and the results were presented as percentages of the ecosystem areas where the critical load for acidification is exceeded. The Norwegian exceedances were estimated to 8% in 2005 and 2% in 2020.

As National Focal Centre under the UNECE International Cooperative Programme on Modelling and Mapping of Critical Loads & Levels and Air Pollution Effects, Risks and Trends (ICP M&M), the Norwegian Institute for Water Research (NIVA) has calculated Norwegian exceedances of critical loads for many years³. The calculations have been based on empirical deposition data estimated by the Norwegian Institute for Air Research (NILU)⁴. NIVA has also calculated future exceedances, combining the NILU estimates and deposition scenarios modelled by the European Monitoring and Evaluation Programme (EMEP)⁵.

In the present work, we have compared calculations of exceedances of critical loads of acidification, applying the approach used by CCE in the Guidance document and the approach normally used by NIVA.

Methods

Exceedance of critical loads occurs when the deposition of acidifying substances in an area is higher than the critical load in that area. The critical load is based on the buffer production (weathering) and an extra buffer to protect sensitive biota^{6,7}. In Norway, critical loads for acidification of surface waters are targeted at protecting healthy populations of brown trout.

Two major models are used when calculating critical loads:

1. The Steady-State Water Chemistry (SSWC)
2. The First-order Acidity Balance (FAB)

The main difference between the models is the assumptions regarding long-term assimilation of nitrogen. The SSWC model assumes that the proportion of nitrogen that is leached is the same in the future as it is now (i.e. as observed from measurements), while the FAB model assumes a situation of future nitrogen saturation, and thus a higher leaching of nitrogen (that will contribute to the acidification).

In the NIVA reports on exceedances of critical loads³, exceedances are estimated using both SSWC and FAB critical loads. However, only FAB critical loads are delivered to CCE from Norway, so this is what is used in the current comparison of exceedance calculations. With this common model basis, the difference between the approach used in the Guidance document and the one normally applied by NIVA is in the deposition data used: While CCE uses EMEP modelled deposition data only, NIVA uses empirical deposition data from NILU for past and present deposition, and EMEP data only to estimate the future relative change in deposition. The UNECE Convention on Long-Range Transboundary Pollutants (LRTAP)⁸ does not allow the CCE to use national deposition data.

EMEP and NILU deposition data

The EMEP deposition data applied in the Guidance document calculations were the model outputs GP_2005 and GP_2020 (called EMEP 2005 and EMEP 2020), which are based on emissions in the base year 2005 and the projected baseline emissions in 2020 according to the revised Gothenburg Protocol¹, respectively. Values for sulphur and nitrogen deposition are given for a 0.5 longitude*0.25 latitude grid, and the cell average values were used (labelled _a).

The NILU deposition data are based on monitoring and statistical interpolation, and are available as five year averages at a 50km*50 km grid⁴. The five year average for 2002-2006 was used to represent 2005 (NILU 2005). To estimate “NILU” deposition in 2020, the GP_2020 deposition was divided by the GP_2005 deposition for each grid cell to find factors that describe the change in modelled deposition between the two years. These factors were then multiplied by the NILU deposition average for 2002–2006 to give the estimated NILU 2020 deposition (NILU 2020 est).

Calculating exceedances using EMEP and NILU deposition data

The critical loads used were the most recently submitted to CCE, with FAB critical loads assigned to a 5km*5km EMEP grid. Each cell was assigned EMEP and NILU depositions of sulphur and nitrogen (nitrate+ammonia) for 2005 and 2020. To calculate FAB exceedance in the same way as CCE did for the Guidance document, we used the routine described in the Mapping Manual⁷, chapter 7, to decide if the critical load was exceeded or not in each cell. The total area of exceeded cells was then divided by the total area of all cells to give the percentage of the area with exceedance of critical loads.

Results and discussion

The deposition data (Figure 1) clearly show that the NILU deposition estimates are far higher than the EMEP simulated deposition. The difference is largest for nitrogen. The area-weighted average NILU 2005 deposition is 69% and 98% higher than the EMEP 2005 deposition for sulphur and nitrogen, respectively. The difference is maintained for 2020, as the deposition increases by the same factors.

Given the differences in deposition, the critical load exceedance estimates using the two different deposition datasets are markedly different (Figure 2). Applying the EMEP deposition, the exceedances are the same as in the Guidance document, i.e. 8% for 2005 and 2% for 2020. The corresponding numbers using NILU deposition are 18.5 and 9.5% (Table 1).

Identifying the causes of the differences between the deposition datasets requires further investigations. The two approaches are very different, with EMEP using emission data, meteorology and a chemical transport model to estimate deposition, while NILU uses measured concentrations in precipitation and air, precipitation amounts and statistical interpolation. On a European scale the EMEP model generally performs well, but for single monitoring stations there may be large deviations (see e.g. the supplementary material to the EMEP Status Report 1/2014⁹). Possible sources of underestimation of the sulphur and nitrogen deposition in Norway may be too low estimated emissions from nearby sources, especially for nitrogen, or failure to capture the effects of local topography, giving too low precipitation, in particular along the coast. However, station density and representativity is always an issue, and may be a source of inaccuracy in the NILU deposition data, although it is not likely to give a consistent overestimation of the wet deposition. The dry deposition estimates may be overestimated, but the contribution of dry deposition to the total deposition is relatively low.

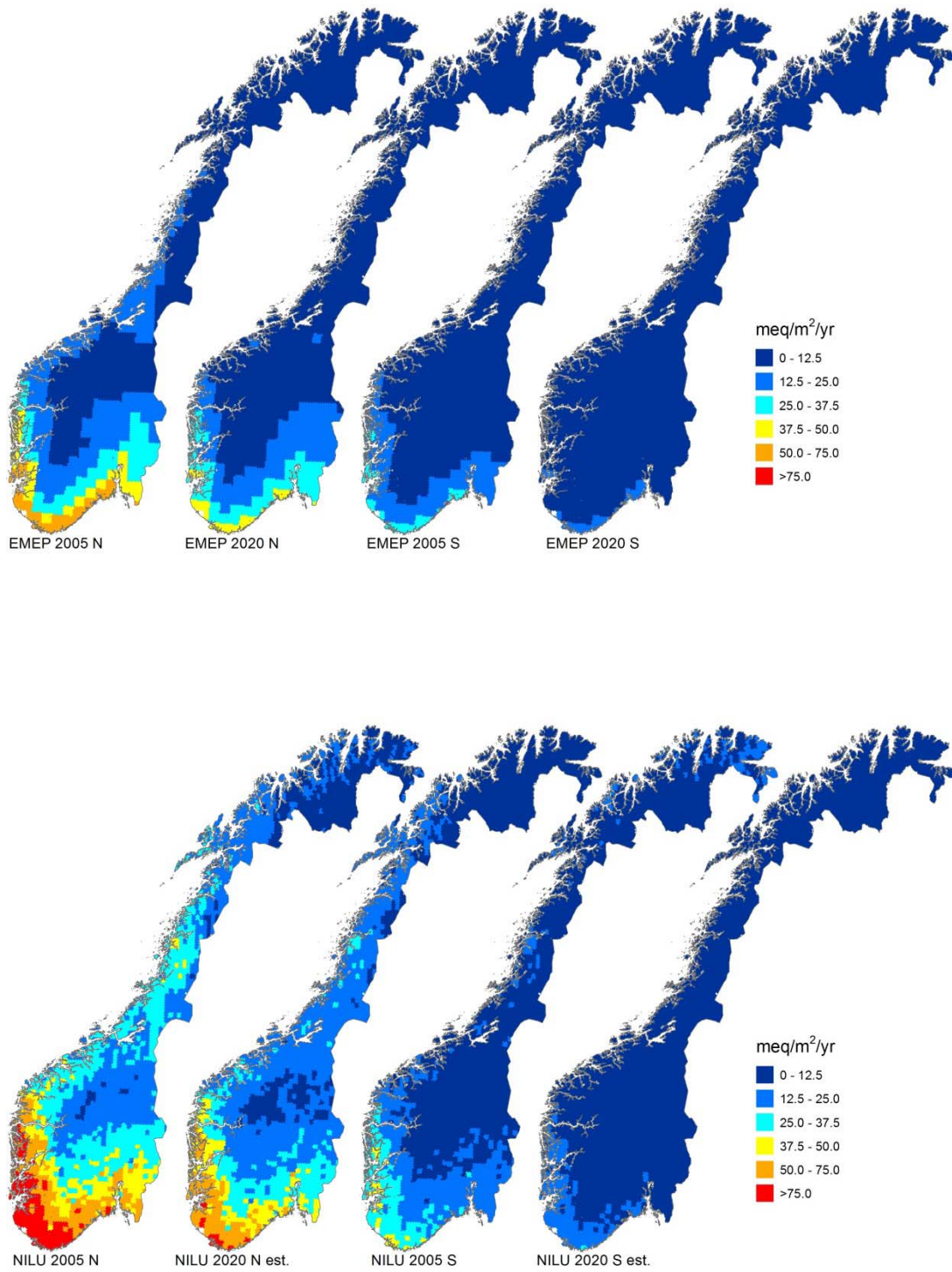


Figure 1. Nitrogen (N) and sulphur (S) deposition according to EMEP (top) and NILU (bottom)

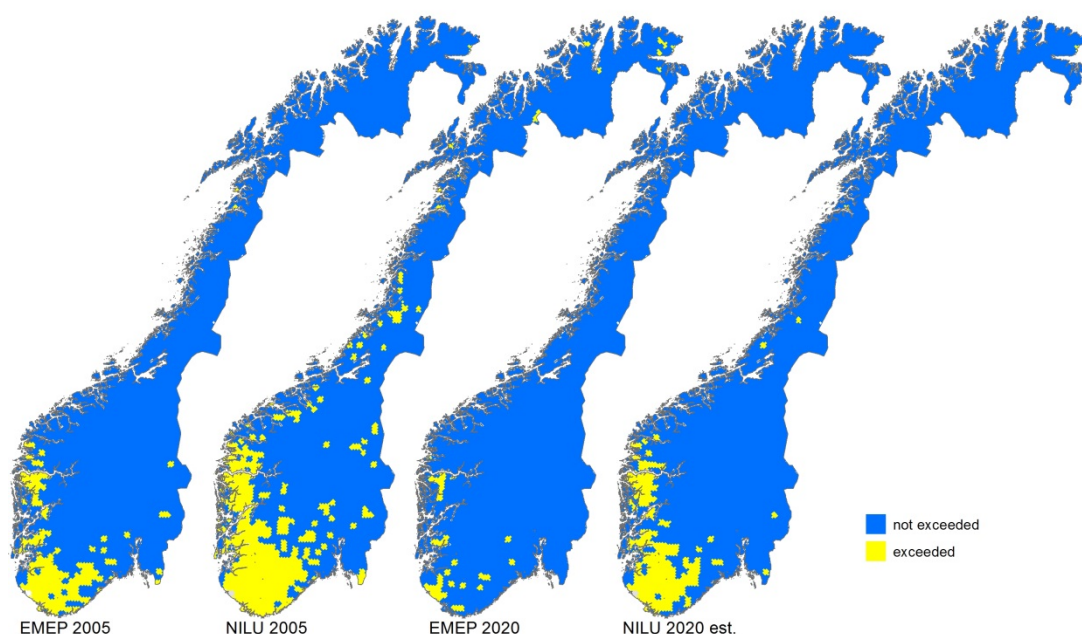


Figure 2. Exceedance of critical loads for acidification of surface waters in Norway using EMEP and NILU deposition.

Table 1. Percentage of the area of Norway with exceedance of critical loads in 2005 and 2020, using different deposition data.

Deposition data	FAB exceedance (%)
NILU 2005	18.5
EMEP 2005	8.1
NILU 2020 est	9.5
EMEP 2020	2.0

Conclusions

A comparison of exceedances of critical loads of acidification has been made, applying the approach used by CCE in the Guidance document and the approach normally used by NIVA. In the former approach, the modelled EMEP deposition is used directly. In the latter, NILU deposition (based on measurements) is used directly for 2005, while for 2020 deposition is estimated based on NILU 2005 deposition and the relative change in EMEP deposition.

For 2005, the NILU deposition was 69% higher for sulphur and 98% higher for nitrogen than the EMEP deposition. The lower EMEP deposition compared to the NILU deposition gave a considerably lower percentage of the Norwegian area with exceedance of critical loads of acidification. In European overviews based on EMEP deposition, this means that the situation in Norway looks better than it most likely is. This may be the case also for other countries. EMEP should look into the causes of the

deviations, with the aim to improve the deposition estimates in the regions with large discrepancies between modelled and measured data.

References

1. ECE/EB.AIR/2013/8:
http://www.unece.org/fileadmin/DAM/env/documents/2013/air/eb/ECE_EB.AIR_2013_8_E.pdf
2. <http://wge-cce.org/>
3. Lund, E., W. Aas, T. Høgåsen and T. Larssen, 2012. Overskridelser av tålegrenser for forsuring og nitrogen for Norge – oppdatering med perioden 2007–2011. NIVA 6448-2012.
4. Aas, W., A. Hjellbrekke, L. Hole and K. Tørseth, K., 2012. Deposition of major inorganic compounds in Norway 2007-2011. Kjeller, NILU. Statlig program for forurensningsovervåking. Report nr. 1136/2012 (NILU OR, 41/2012).
5. <http://www.emep.int/>
6. Henriksen, A. and M. Posch, 2001. Steady-state models for calculating critical loads of acidity for surface waters. *Water, Air, and Soil Pollution: Focus* 1: 375–398.
7. UBA, 2004. Manual on methodologies and criteria for modelling and mapping critical loads and levels, and air pollution effects, risks and trends. Umweltbundesamt, Berlin.
http://www.icpmapping.org/Mapping_Manual
8. <http://www.unece.org/env/lrtap/welcome.html>
9. Gauss, M., S. Tsyro, B. M. Steensen and A.-G. Hjellbrekke, 2014. EMEP/MSC-W model performance for acidifying and eutrophying components, photo-oxidants and particulate matter in 2012. Supplementary material to EMEP Status Report 1/2014.
http://emep.int/publ/reports/2014/sup_Status_Report_1_2014.pdf

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**7. Task Force minutes of the thirtieth meeting of
the Programme Task Force held in Grimstad,
Norway, October 14-16, 2014**

**CONVENTION ON LONG-RANGE TRANSBOUNDARY AIR
POLLUTION**

Working Group on Effects

**International Cooperative Programme
on Assessment and Monitoring of the Effects of Air
Pollution on Rivers and Lakes**

MINUTES

**of the 30th meeting of the Programme Task Force
held in Grimstad, Norway, October 14-16, 2014**

Key messages from the Task Force meeting

Salmon populations in Norway returned to a large extent as result of common efforts of international, regional and local policy Salmon populations became extinct in southern Norway in the 1960s because of toxicity in surface waters resulting from acid deposition. International policy for abatement of atmospheric emissions went hand-in-hand with national and regional policy which resulted in a return of Atlantic salmon to rivers in South Norway. National and local policy consisted of liming to improve water quality, and stocking of water bodies with salmon. Local stakeholders stimulated positive developments of fish stocks by promoting awareness in the public and in politics.

Chemical recovery Long-term records of water chemistry of surface waters in Finland, Sweden, Canada and the UK demonstrate chemical recovery as a response to reduction in acid deposition. The long-term trends also demonstrate variation in water chemistry related to climate episodes with the potential to delay or set back chemical recovery. In many regions, the status of acidified sites is far from background water chemistry.

Biological recovery Long-term records of aquatic organisms in acid-sensitive waters with chemical recovery show mixed biological responses to improved water chemistry. In some water bodies, catchment-specific factors appear to dominate how biology responds. In general, biological recovery is much slower than chemical recovery.

Dynamic modeling Acidification history and recovery of acidified streams in the Czech Republic were shown to depend on model assumptions for leaching of dissolved organic carbon (DOC). Less recovery is predicted when taking into account increasing trends in DOC. Increased DOC has been demonstrated for most ICP Waters sites.

EECCA countries Acidified waters in the northern parts of the Kola Peninsula in Russia have recently shown chemical recovery owing to reduced atmospheric emissions of acidifying components. Dissolved organic carbon (DOC) (humic substances) strongly affects the acidification/recovery process, especially in catchments with a high proportion of wetlands.

Critical loads Discrepancies between S and N deposition modelled by EMEP and national estimates of deposition in Norway, lead to a significant difference in estimated area exceeded by critical loads. Investigating causes for these discrepancies and increasing awareness about possible biases in EMEP deposition is important for effect-based work under the LTRAP Convention.

1. The meeting of the International Cooperative Programme on Assessment and Monitoring of the Effects of Air Pollution on Rivers and Lakes (ICP Waters) was attended by 30 experts from the following Parties to the Convention on Long-range Transboundary Air Pollution (CLRTAP): Armenia, Canada, the Czech Republic, Estonia, Finland, Italy, Latvia, Norway, Russian Federation, Sweden, Switzerland, the United Kingdom of Great Britain and Northern Ireland and the United States of America. In addition a representative for ICP Integrated Monitoring, ICP Forests and the Convention Secretariat participated. The list of participants is attached as **Annex I**.

Introductions

2. Mr. Øystein Djupedal, Governor of Aust-Agder County in Norway, welcomed all participants to the ICP Waters meeting in Grimstad. Mr. Djupedal gave an introduction to the history, geography, literature, economic development and academic institutions of the county of Aust

Agder. He presented the history of the acid rain problem in the region, the mitigation measures to counter its effect, and the subsequent return of the salmon. He emphasized that the acid rain story is an excellent example of successful cooperation between science and policy.

3. Mr. Gunnar Skotte (Norway), Chair of the Programme Task Force, thanked Mr. Djupedal for opening the meeting and the warm welcoming words. He thanked Ms. de Wit (Norway) and the organizers for inviting us and hosting the meeting. Then he welcomed all participants to the 30th Task Force Meeting of ICP Waters in Grimstad, especially the representatives from ICP Forests, ICP IM and the secretariat.
4. The Task Force adopted the agenda of the meeting (**Annex II**).
5. Ms. de Wit (Programme Centre) welcomed all participants to Grimstad, thanked the local hosts (Ms. Mette Cecilie Lie and Ms. Liv Bente Skancke) and gave general information on the meeting and the excursion.
6. Mr. Frode Kroglund (Norway) then presented a success story from southern Norway where international and local policies informed by science, have enabled restoration of salmon populations. He showed how the salmon population decreased as acid rain increased, and how liming mitigated the negative effects of acidification of surface waters. About 15 % of all wild salmon in Norway is now caught in the southern part of Norway. He explained how methods and water chemistry targets for liming were developed in order to detoxify aluminium in fresh and estuarine water. He also explained how the salmon is exposed to threats posed by hydropower plants and aquaculture (escapees, lice), the latter prevalent in other parts of Norway. Mr. Kroglund also suggested how fish kills in power plants could be reduced. He held that more streams should be limed to secure recruitment areas. He provided ample suggestions as to how fish stocks (salmon, sea trout, pike, eel) could be managed better. He raised the question of whether eel, which is considered mildly acid tolerant, have benefited from liming.
7. The presentation inspired a lively discussion of the points raised by Mr. Kroglund.
8. Mr. Krzysztof Olendrzyński of the UNECE Secretariat, reported from the Working Group on Effects (WGE). He gave an update on the activities under the Convention. He described the process from negotiation to implementation of the three latest protocols (1. Heavy metals, 2. Acidification, eutrophication and ground-level ozone (Gothenburg), and 3. POPs). Capacity building in the EECCA region is a priority. He then presented news from the WGE and other relevant bodies (EMEP, EB, WHO, UNEP). A recent development of particular interest to ICP Waters is the WGE response to the ICP review, suggesting that data access should be improved and that a single WGE website/portal with further links like EMEP home page and thematic reports/workshops should be created. Mr. Olendrzyński also mentioned that EMEP modelled deposition estimates appear to be underestimated in some parts in Europe, a problem that poses challenges for several ICPs.
9. In the subsequent discussion, Mr. Wright asked if there would be a new protocol for sulphur and nitrogen. Mr. Olendrzyński responded that no new protocols are expected in the near future. Mr. Velle asked if standardization of biodiversity indicators was a priority. Mr. Olendrzyński answered that efforts were ongoing. Ms. De Wit asked if capacity building was relevant for the work on effects. Mr. Olendrzyński answered that it was a challenge to get national administrations in the EECCA region to give this issue a priority.
10. Mr. Skotte introduced emerging issues from the WGE. He started with the general recommendations from the review of the ICPs and went on to describe the recommendations for ICP Waters. These include shifting the focus from acidification to a more comprehensive assessment of impacts from nitrogen, heavy metals and POPs. Periodic trend assessments should still be conducted. Interaction with other international waters monitoring programmes (e.g. UNEP, GEMS) should be pursued. Links with the river sites monitored as part of ICP Integrated Monitoring should be considered. Relevant workplan items include a common WGE trend report for all the ICPs and an EMEP/WGE assessment report.

11. Mr. Jussi Vuorenmaa (Finland) reported from the ICP Integrated Monitoring Programme (ICP IM). He described the purpose, extent and priorities of the programme. He then presented ongoing work and highlights from reports and scientific papers, and planned cooperation with other ICPs.
12. Ms. Alexa Michel (Germany) reported from the ICP Forests Programme. She described the purpose, extent and priorities of the programme. ICP Forest now includes 42 countries and is the biggest ICP. She described the activities and priorities of the programme for 2013/2014. She presented the levels (different scales) of monitoring that ICP forests undertake and proposed ideas for cooperation. She did not go into detail about recent papers and reports, but provided a broad overview of the programme. Detailed results or the data management in ICP Forests could be presented at the next ICP Waters TF meeting if deemed desirable. The next ICP Forest meeting will be in Ljubljana.
13. Mr. Stoddard (USA) asked about the involvement of North America in ICP Forest. Ms. Michel's answer was that it is not extensive.

Reports from the ICP Waters Programme activities 2013/2014

14. Ms. Heleen de Wit (Norway) from the Programme centre reported on the status of the ICP Waters programme and on common work for effect-oriented programmes under the WGE. She emphasised that ICP Waters should produce policy-relevant results. "Hot" issues under the convention include: health effects of particulate matter, hemispheric transport of air pollution, POPs, ozone, mercury, active involvement of EECCA countries, climate, nitrogen, and black carbon but not acidification. She went through the aims of the programme and the main areas of our activity. The state of the water chemistry and biology data base and number of participants at the TF meeting was presented (Annex III). The status is considered to be good, but continued monitoring is vulnerable because of the dependence on national funding.
15. Ms. Heleen de Wit (Norway) reported on representation of ICP Waters in other bodies/meetings under the Convention. ICP Waters was represented at the following meetings:
 - Oct 13: JEG-meeting, Sitges, Spain
 - Mar 14: WGE, WGE Extended Bureau, Joint meeting EMEP SB Extended Bureau/WGE Extended Bureau/ EB Bureau, Geneva
 - April 14: CCE WS, Roma
 - May 14: ICP IM, Westport
 - Sept 14: WGE, WGE Extended Bureau, Joint meeting WGE/EMEP Steering Body, Geneva
16. Ms. Heleen de Wit (Norway) presented new reports, papers and writings from ICP Waters. These are:
 - ICP Waters report 120/2014 Chemical intercomparison 1428
 - ICP Waters report 118/2014 Biological intercomparison 1713
 - ICP Waters report 117/2014 Proceedings Task Force meeting 2013
 - Garmo et al. 2014. Trends in surface water chemistry in acidified areas in Europe and North America from 1990 to 2008. Water Air Soil Pollut 225, 1-14
 - Reporting to WGE and revision of manual from ICP Modelling and mapping.
17. Ms. Heleen de Wit (Norway) outlined current work. This can be summarised as follows:
 - Trend assessment of water chemistry
 - Trend assessment of biodiversity and climate

- WGE trend assessment – common report from all ICPs (edited by Ms. de Wit)
- EMEP/WGE Assessment report

Presentation of ICP Waters reports in progress

18. Mr. Øyvind Garmo (Norway) from the Programme Centre gave a presentation on results of the analysis of long term trends in surface water chemistry and the prognosis of water chemistry for 2020. He used the SSWC model, EMEP deposition data, 30-year discharge and a deposition scenario for 2020 to produce a steady-state prediction of water chemistry in circa 60 European ICP Waters sites. The relative change in deposition between 2005 and 2020 was used as EMEP deposition deviates from site-specific deposition. SO₄ deposition was assumed equal to SO₄ outflow in 2005. The modelled estimates of water chemistry for 2000-2012 described observed trends and mean water chemistry in a satisfying manner, but observed water chemistry showed considerable more variation than modelled water chemistry. This is related to variations in annual climate and deposition. The improvements in water chemistry in 2020 were marginal compared with measured water chemistry in 2012, despite a considerable reduction in deposition. In the debate that followed, several suggestions were made with regard to interpretation of the results, the importance of climate for water chemistry and on whether to include some examples of trends going back to 1990 or earlier. The Task Force meeting applauded the presentation of the preliminary results and concluded that this report is likely to produce important results documenting relations between deposition, climate and expected chemical recovery of surface waters.
19. Mr. Gaute Velle (Norway) from the Programme subcentre presented the outline for the 2015 ICP Waters report on biodiversity and climate. The aim of the analysis is to tease out effects of acidification and climate change, i.e. increased temperature and precipitation, on biodiversity. A preliminary analysis indicates that diversity may be limited at very low pH, while at higher pH more variation is found. Such relations might be useful for documentation of how biodiversity relates to water chemistry. The presentation inspired a lively debate on how to proceed with the analysis of the available datasets. The discussion was primarily about ways to categorize the data, statistical techniques, and definition of reference sites. There was also a discussion about how the work can be made as policy relevant as possible. A challenge is that there are many ways to quantify changes in biodiversity. The Task Force was content with the presentation of the outline and acknowledged the unique database. The Task Force concluded that quantification of relationships between water chemistry and biodiversity will be an important contribution from ICP Waters to the work under the Convention. The Task Force also expressed the opinion separating the effects of deposition and climate is a challenging task.

Water chemistry

20. Ms. Marina Dinu (Russia) presented case studies from European Russia and Siberia of acidification in humid regions. The presentation focused on mechanisms of surface water acidification. She also gave an assessment of the degree and geographic extent of acidification. Some acidified waters in the northern parts of the Kola Peninsula have recently recovered somewhat chemically (as manifested by increased alkalinity and pH), owing to reduced emissions of strong acids. Further south there are lakes that have become more acidic. Natural organic acids (humic substances) strongly affect the acidification/recovery process, especially in catchments with a high proportion of wetlands.

21. Mr. John Stoddard (USA) reported on increasing phosphorus concentrations in lakes and streams across the U.S. He presented evidence from national surveys and suggested a possible role for atmospheric deposition. He outlined the extent and frequency of monitoring. Other possible explanations such as increased fertilizer inputs, change in field methods, laboratory procedures, and hydrology does not seem to hold up. There is strong evidence that P is increasing in both lotic and lentic systems. The increase is most pronounced in reference sites. Increased atmospheric deposition could explain the results, although the mechanism behind is elusive.

Biological responses to air pollution

22. Mr. Vuorenmaa (Finland) presented responses to changes in air pollution and climate in the ICP-IM catchment Valkea-Kotinen and key findings over a 20 year period. Observations include increased air temperature, reduced snow depth, and shortening of lake ice season. The temperature is expected to continue to increase. A significant decrease in deposition of major ions and nitrate was associated with a decrease in lake water sulphate concentration and increase in alkalinity in the early 2000s. DOC and colour have increased between 1990 and 2009. There has been an increase in dissolved inorganic nitrogen in lake water. Effects of a changing climate on the hydrology of a boreal catchment and lake DOC, assessed with a dynamic model, was presented. The model predicts that DOC concentration will be lower in the future. Trends in zooplankton and fish were also presented. The results demonstrate the value of monitoring protected headwater catchments.
23. Mr. Don Monteith (UK) presented recovery of water chemistry and biology in the UK. He also accounted for the latest status and emerging issues. He went through trends in water chemistry parameters. There has been a decrease in NAO and chloride during the last 25 years. This has contributed to the increase in ANC. If chloride should increase to the levels of 25 years ago it would mean significant decreases in ANC. Trends in biological recovery were mixed. Changes are subtle and difficult to interpret.
24. Mr. Bjørn Olav Rosseland (Norway) from the Programme centre and Mr. John Gunn (Canada) reported on the recovery of Aurora Trout, a formerly endangered species, in a low calcium environment in Ontario, near Sudbury, Canada. The calcium level has dropped to about 1 mg/l. This could be close to the tolerance level at the present aluminium levels, but the population meets the requirements, as defined in the ICP Waters manual, for full recovery.
25. Mr. Jens Fölster (Sweden) gave a presentation entitled “It’s getting better all the time but I can’t get no satisfaction - 25 years of recovery in Sweden from a roach’s perspective”. He presented the Swedish monitoring activities for acid sensitive waters and chemistry results for the time span 1988-2013. The chemistry has recovered to a large extent and is still improving. Biological recovery is lake specific, i.e. it appears to be dependent on other factors as well as water chemistry. It seems that many lakes will never reach a “pre-industrial” state, e.g. because of changes in land use. Finally he raised the question of whether the target for recovery should be redefined. This sparked some discussion, but no consensus was reached by the Task Force.

Water chemistry – Dissolved organic carbon

26. Mr. Salar Valinia (Sweden) presented a simple model to estimate historical and recent changes of TOC concentrations in lakes. The model is based on using the technique of near visible infrared spectra on sediment cores to estimate historical TOC levels. The results suggest that TOC levels are reaching a pre-industrial state, and that acidification will not much longer be a driver for TOC change (although there could be other drivers for change). This has implications for e.g. implication of WFD and for water treatment works.
27. Mr. Jakub Hruška (Czech Republic) gave a presentation on how changes in soil DOC can affect reconstructed history and projected future trends in surface water acidification. The presentation is based on work in the Lysina catchment, which is an ICP Waters station. In recent years the sulphate concentration has dropped more than expected. The DOC

concentration has increased both in surface and soil water. MAGIC model hindcasts (for a preindustrial state) and forecasts are strongly dependent on where the surface water DOC is assumed to come from, i.e. riparian zone only or also soil water from the rest of the catchment.

28. Mr. Monteith (UK) announced plans for a follow-up of the 2007 paper on trends and spatial variation in DOC. There is still considerable interest in DOC trends in the UK, particularly from water managers. What levels of DOC should we expect for a given water body in the future? In British sites, the proportion of wetland soil in the catchment, effective precipitation, altitude, sulphate and a few other variables can predict spatial variation in DOC to a remarkably high degree. To separately assess the significance of e.g. factors like temperature and altitude there is a need for greater spatial cover (here ICP Waters data could be useful). For a follow up, focal centres consent to using the original data set from 2007. Involvement in providing additional information on sites and provision of updates for chemistry is also needed. The Task Force is content with a renewed focus on DOC trends and applauds a follow-up of the 2007 Nature paper. Focal centres from USA, Sweden, the Czech Republic and Norway expressed their support for such an analysis, and indicated that many of the necessary data were already available.

Critical loads

29. Ms. Kari Austnes (Norway) showed in a modelling exercise to quantify exceedance of critical loads (CLs) in Norway, that using national estimates or EMEP-produced estimates of S and N deposition results in different areas with CL exceedance. Area exceeding CL is much lower (3%, 2020) when calculations are based on EMEP simulations instead of calculated deposition from NILU (about 9 % of area exceeded in 2020). She presented possible reasons explaining this discrepancy: Empirical estimates for deposition may be too high, both may be wrong, or EMEP predicted deposition may be too low. The latter appears to be likely, as comparison between modelled and measured deposition for Norwegian stations show. She suggested that EMEP data should not be used directly in modelling without prior comparison of EMEP vs local estimates. Using EMEP or local (national) deposition data is important for the conclusion that is drawn with regard to the state of the acidification problem. The Task Force agreed that the conclusions of this presentation should be conveyed to EMEP and urge EMEP to consider how to address uncertainties and biases in EMEP deposition. In the following discussion it was stressed that non-exceedance of CLs does not indicate that acidification is no longer causing damage, but rather that sometime in the future, acidification will no longer be a problem.
30. Mr. Krzysztof Olendrzyński (UNECE Secretariat) commented that decreasing exceedances of CLs do not provide adequate information on the actual chemical and biological recovery recovery. There is a need for a quantitative measure of recovery (biological and chemical) that can be easily grasped by laymen and policymakers, and he encouraged the TF to consider how this need can be met.

Intercalibration/intercomparison

31. Mr. Carlos Escudero (Norway) from the Programme centre presented the results from the chemical intercomparison. 33 laboratories from 12 countries participated, which is lower than previously. This is due to a number of reasons, among which the fee asked for participation for those laboratories that do NOT contribute to monitoring dataserries. Next year, a somewhat higher number of laboratories is expected. All the usual variables were included, and also aluminium and TOC. On average, 76% of results were acceptable. For pH (68 %), nitrate (14%) and alkalinity (26%) the fraction of laboratories achieving acceptable results was low. Mr. Escudero asked the Task Force whether spiking levels were appropriate, whether aluminium fractionation and total phosphorus should be included as variables. The Task Force agreed that spiking levels were fine and approved of including total phosphorous in the intercomparison. No agreement was reached with regard to aluminium fractionation. Furthermore, in order to find out if the poor results for nitrate were caused by analytical problems or instability of samples, the TF would like to have a control sample shipped to

(some of) the participating laboratories with subsequent return to NIVA for analysis. For alkalinity and pH the methods are different, and this should be kept in mind when interpreting the results. The results could perhaps be split down to methods.

32. Mr. Arne Fjellheim (Norway) from the Programme subcentre presented the results from the 18th biological intercomparison. Test samples normally contain about 50 different species of macroinvertebrates from different countries. Three laboratories (from Norway, Sweden and Germany) participated in the biological intercalibration 2014. The laboratories identified a high portion of the individuals in the test samples. The quality of the identification of the different groups was above the level of acceptance for all laboratories. The taxonomic quality was sufficient for stating the acidity index. The average quality assurance index ranged between 88.3 and 96.3, well above the accepted criteria of 80 % - indicating good taxonomic work. The TF meeting encourage more laboratories, preferably those who already contribute with data, to participate in the intercalibration.
33. The Task Force meeting was content with the good results for the chemical intercomparison and the biological intercalibration and thanks the Programme Centre and Subcentre for their efforts.

Current issues and workplan

34. Ms. Brit Lisa Skjelkvåle (Norway) from the programme centre reported from the Saltsjöbaden workshop: “Taking international air pollution policies to the future”. There were 7 different topics discussed, some of them relevant for effects in water. An important conclusion in the meeting was that EB and CLRTAP should try to improve their communication with politicians and the public. Capacity-building was also a major focus. Regarding POPs and heavy metals, CLRTAP should initiate cooperation with other conventions. In the discussion it was pointed out that CLRTAP should list concrete suggestions for cooperation with other conventions.
35. Ms. de Wit (Norway) announced current issues that have emerged from the WGE (see below), the first of which was the recommendation to reduce focus on acidification and increase focus to more comprehensive assessments of the impacts of nitrogen, heavy metals and POPs. She mentioned that ICP Waters does not include POPs in the database, even though some focal centres have access to data on POPs in fish tissue. Usually, however, those data are scarce and can often be below detection limit. Few monitoring programmes collect such data in a systematic way for headwater sites, only affected by air pollution. A previous ICP Waters report on POPs concluded that comparison between sites is hampered by methodological differences. She also mentioned that more data exist on mercury in aquatic environments that are affected by air pollution. The Task Force agreed that mercury appears to be a more promising topic for a comprehensive ICP Waters assessment than POPs, also because it has potential for collaboration with ICP Integrated Monitoring. It was also pointed out by the Task Force meeting that acidification and recovery from acidification remains an important issue.
36. Ms. de Wit also mentioned another recommendation, that ICP Waters should pursue interaction with other international waters monitoring programmes, e.g., UNEP, GEMS. The Task Force reminded that ICP Waters in fact already has contributed to AMAP (the arctic acidification assessment), although perhaps not under an ICP Waters flag. Such contributions would be valuable to be pointed out in communications to the WGE and in reports from Task Force meetings. There was a suggestion that ICP Waters could use resources to contribute to common assessments rather than producing its own report on various subjects.
37. Ms. de Wit presented arguments for and against common meetings between ICP Waters and ICP Integrated Monitoring. A common meeting would imply moving the ICP Waters Task Force meeting from October to May, in addition to having joint a scientific workshop and joint excursions. Several positive points included the thematic overlap between the programmes, reduced meeting activities for some representatives (one instead of two meetings), and potentially more interaction between the programmes. On the other hand, the

meeting would be bigger and require more organising. Merging of the meetings should not end up shifting more work from focal centres to programme centre. The Task Force was positive to the idea of having a joint meeting with ICP IM and did not see any problems with moving the TF meeting to the spring. The Task Force agreed that a joint meeting with ICP IM can be attempted.

38. One of the recommendations for all ICPs is to build a common data portal. The TF agreed that focal centres which already have data portals (6 focal centres have this) will send the links to the programme centre for publication on ICP Waters' web site. Ms. de Wit asked NFCs about their position on making data publicly available, and no NFC had any objections.
39. The recommendation that focal centres should be more involved in the writing of reports and other work that the programme centre does was discussed, but no conclusion was reached. Current practice is therefore likely to continue.
40. Ms. de Wit described the workplan for 2015-2016 (see annex IV). It includes finalising the trend report with data up to 2011 both on chemistry and biology. A report on biodiversity and climate is also on the workplan and should be ready before the next TF meeting. Reference groups/reviewers for the reports were nominated. Mr. Jussi Vuorenmaa, Mr. Jakub Hruška and Ms. Sandra Steingruber will be special reviewers for the trend report. The reference group for the report on biodiversity and climate will consist of Mr. Don Monteith and Ms. Heleen de Wit. A WGE trend report is also on the work plan. Suggestions for further work/reports were discussed. One suggestion was to report trends in POPs or mercury. Several countries have data on mercury in fish and other media (Sweden, Norway, Canada, Finland, Russian Federation, UK). This could be a good topic for 2016. A report on policy indicators was suggested, but no conclusion was reached. Regular activities will be conducted as usual. Focal centres should send links to publications, reports etc., where ICP Waters is acknowledged.

Other business

41. Ms. Sandra Steingruber (Switzerland) announced that the TF meeting 2015 will be held in Monte Verita in Ascona, Switzerland, from October 6 to 8.
42. Mr. Gunnar Skotte (Norway) thanked the local hosts at NIVA Sørlandet, especially Ms. Mette Cecilie Lie and Liv Bente Skancke, for splendid organisation of the Task Force meeting, including the excursion. He also expressed warm gratitude towards the Programme Centre, especially Ms. Heleen de Wit, for managing the technical or scientific part of the meeting. All participants were thanked for attending the meeting and contributing to the discussions.
43. The Task Force expressed its appreciation to the Programme Centre for its scientific and coordinating work and acknowledged its important contribution to the programme's successful implementation. Finally, the Task Force recognises that the contributions of the National Focal Centres and cooperating institutes are essential for the high quality output from the programme.

Adoption of the minutes

44. The decisions in the ICP Waters meeting as written in the minutes were adopted by the Task Force.

Annex I: Participants at the ICP Waters 30th Task Force meeting

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Annex II: Agenda for the 30th Task Force ICP Waters October 14-16, 2014

Introductions

- Meeting welcome: *Øystein Djupedal, County Governor of Aust-Agder county, Norway*
- Adoption of the agenda, *Gunnar Skotte, ICP Waters Chairperson*
- General information about the meeting and excursion, *Heleen de Wit, local host*
- A success story from southern Norway: international and local science-based policy went hand in hand to restore salmon populations, *Frode Kroglund, Norway*
- Update on the activities under the Convention, *Krzysztof Olendrzyński, Secretariat UNECE*
- Introduction to emerging issues from WGE, *Gunnar Skotte, ICP Waters Chairperson*
- Report from ICP Integrated Monitoring, *Jussi Vuorenmaa, Finland*
- Report from ICP Forests, *Alexa Michel, Germany*

Reports from the ICP Waters Programme activities 2013/2014

- Status of the ICP Waters programme, and report on common work for effect-oriented programmes under the Working Group on Effects, *Heleen de Wit, Programme centre*

Presentation of ICP Waters reports

- Long term trends in surface water chemistry; trend analysis up to 2012 – results, *Øyvind Garmo, Programme centre*
- The 2015 ICP Waters report: Biodiversity and climate - outline and first results, *Gaute Velle, Programme subcentre*

Water chemistry

- Natural and anthropogenic acidification of waters: mechanisms and specification in European Russia and Western Siberia, *Tatyana Moyseenko and Marina Dinu, Russia*
- Increasing phosphorus concentrations in lakes and streams across the U.S.: evidence from national surveys, and a possible role for atmospheric deposition, *John Stoddard, US*

Biological responses to air pollution

- Responses to changes in air pollution and climate in Valkea-Kotinen ICP IM catchment – key findings over a 20 year period, *Jussi Vuorenmaa, Finland*
- Recovery of water chemistry and biology in the UK: latest status and emerging issues, *Don Monteith, UK*
- Recovery of Aurora Trout in a low calcium environment in Ontario, Canada, *John Gunn, Canada and Bjørn Olav Rosseland, Programme Centre*
- It's getting better all the time but I can't get no satisfaction - 25 years of recovery in Sweden from a roach's perspective, *Jens Fölster, Sweden*

Water chemistry – dissolved organic carbon

- A simple model to estimate historical and recent changes of TOC concentrations in lakes, *Salar Valinia, Sweden*.
- Changes in soil dissolved organic carbon affect reconstructed history and projected future trends in surface water acidification, *Jakub Hruška, Czech republic*

- Trends and spatial variation in DOC – proposed follow-up of DOC trend paper in 2007, *Don Monteith, UK*

Critical loads

- National and EMEP deposition data give different areas with critical loads exceedance, *Kari Austnes, ICP Modelling and Mapping*

Intercalibration/intercomparison

- Chemical intercomparison, *Carlos Escudero, Programme centre*
- Biological intercalibration, *Arne Fjellheim, Programme subcentre*

Current issues and workplan

- A report from the Saltsjöbaden workshop, *Brit Lisa Skjelkvåle, Programme centre*
- Current issues that have emerged from WGE: joint meetings, data portal, open data access, *Heleen de Wit, Programme centre*
- Draft 2014-2015 Workplan, *Heleen de Wit, Programme centre*

Other Business

- TF meeting 2015

Adoption of the minutes

Time schedule

Tuesday October 14

09.00 - 09.30 Registration
 09.30 - 12.00 Task Force meeting
 12.00 - 13.00 Lunch
 13.00 - 17.00 Task Force meeting
 Coffee break 10.30-11.00 and 15.30-16.00

Wednesday October 15

09.00 - 11.45 Task Force meeting
 11.45 - 12.30 Lunch
 12.30 - 18:30 Field trip to Birkenes, Tovdal river and Boen Gård
 18:30 – 22:30 Conference dinner in Boen Gård
 Coffee break 10.00-10.30

Thursday October 16

09.00 - 12.00 Task Force meeting
 12.00 - 13.00 Lunch
 Coffee break 10.30-11.00

Annex III: Status participation in the ICP Waters programme as of October 2014

	Chemical data	Biological data	Participation in TF meetings 2012-2014	Participating in chemical intercomparison 2012-2014	Participating in biological intercalibration 2012-2014
Armenia	2013		•		
Austria	2014		•	•	
Belarus	2014				
Canada	2013		•	•	
Croatia			•		
Czech Rep.	2014	2011	•	•	•
Estonia	2014		•	•	•
Finland	2014		•	•	
France				•	
Germany	2014	2013		•	•
Ireland	2012		•	•	
Italy	2014		•	•	
Latvia	2014	2012	•	•	•
Montenegro	2013				
Netherlands				•	
Norway	2014	2013	•	•	•
Poland	2013		•	•	
Russia			•	•	
Spain	2014			•	
Sweden	2014	2013	•	•	•
Switzerland	2014	2013	•	•	•
UK	2014	2010	•	•	•
USA	2013		•	•	
Total	19	7	17	19	8

Belgium				•	
Iceland				•	
Lithuania				•	
Portugal				•	
Romania				•	
Serbia				•	
Slovenia				•	
Total				26	

Annex IV: ICP Waters workplan for 2015–2016

2014

- Prepare proceedings from the 30th Task Force meeting
 - abstracts (2-6 pages) by **December 1 2014** to **Bente.Wathne@niva.no**
- Send out trend report on surface water chemistry for review
 - Reviewers and all other TF members to receive draft report by **December 15 2014**

2015

- Finalize the trend report on surface water chemistry and biology up to 2012
 - A chapter on trends in biology will include voluntary contribution from focal centres, for which the deadline for submission is **December 1 2014**
 - The full report will be sent out for review to all Focal Centres by **December 15 2014**.
 - Reviewers for a detailed review who volunteered at the Task Force meeting are Jussi Vuorenmaa, Jakub Hruska and Sandra Steingruber
 - The review comments must be sent by **January 15 2015**
 - Print trend report in **February 2015**
- Finalize report on Biodiversity and climate
 - A reference group for feedback and discussion during the data analysis will consist of Don Monteith, John Gunn and Heleen de Wit
 - The draft report will be ready for review by **June 30 2015**
 - Comments to draft report are expected by **August 15 2015**
 - The report will be finalized in **September 2015**
 - The report will be presented on the WGE meeting in **September 2015**
 - Final report to be presented at the **Task Force meeting 2015**
- Arrange and report chemical intercomparison 1529
 - in collaboration with all participating ICPs.
 - Invitations will be sent in **March 2015**
 - Samples will be sent by **May 15 2015**
 - Responsible person: Carlos Escudero
 - Laboratories that analyse samples for national monitoring programs and laboratories in EECCA countries will not pay a fee
 - We will aim for a good distribution across countries
- Arrange and report biological intercalibration 1814
 - in collaboration with participating ICPs.
 - Send out invitations by **1 May 2015**.
 - Responsible person: Arne Fjellheim
- Contribute to a DOC trend analyses, resulting in a submitted manuscript in **2015**
- Arrange thirty-first meeting of the Programme Task Force, scheduled to be held in Switzerland in Ascona, on October 4 to 6 2015.

- Run the Programme Centre in Oslo and the Subcentre in Bergen, including:
 - maintenance of web-pages
 - All papers using data from ICP Waters sites shall be listed on our web on your request; one limitation: the word ICP Waters has to be mentioned in the paper somewhere.
 - Increase visibility of activity of Focal Centres on the web-page
 - maintenance of database of chemical and biological data
- Submission of data to the Programme Centre by all Focal centres.
 - Call for data: **June 15 2015**
 - Submission by **August 15 2015**
- Participation in meetings of relevance for the ICP Waters programme
 - Report to WGE
 - Contribute to the common trend report of Working Group on Effects, to be finished in **September 2015**
 - Contribute to assessment report EMEP-WGE, which will be **finished in 2016**
 - Other possible items to be announced
 - Cooperation with other bodies within and outside the Convention
- Consider availability other water databases and cooperation with other water monitoring programmes (UNEP, GEMS, EEA)
- Cooperation with ECCCA countries (East Central Caucasus and Central Asian countries)
- **2016**
 - New topic for a report, suggested to be “mercury in the aquatic environment”
 - The following will be considered: cooperation with ICP IM, the possibility for a trend analysis, and cooperation with AMAP and UNEP.
 - Contribute to assessment report EMEP-WGE, which will be **finished in 2016**

8 Reports and publications from the ICP Waters Programme

All reports from the ICP Waters programme from 2000 up to present are listed below. Reports before year 2000 can be listed on request. All reports are available from the Programme Centre. Reports and recent publications are also accessible through the ICP-Waters website; <http://www.icp-waters.no/>

- de Wit, H., Wathne, B. M. (eds) 2015. Proceedings of the 30th Task Force meeting of the ICP Waters Programme in Grimstad, Norway 14th–16th October, 2014. **ICP Waters report 122/2015**
- Fjellheim, A., Johannessen, A. and Landås, T.S. 2014. Biological intercalibration: Invertebrates 1814. **ICP Waters Report 121/2014**
- Escudero-Oñate. 2014. Intercomparison 1428: pH, Conductivity, Alkalinity, NO₃-N, Cl, SO₄, Ca, Mg, Na, K, TOC, Al, Fe, Mn, Cd, Pb, Cu, Ni, and Zn. **ICP Waters Report 120/2014**
- Fjellheim, A., Johannessen, A. and Landås, T.S. 2013. Biological intercalibration: Invertebrates 1713. **ICP Waters Report 118/2014**
- de Wit, H., Bente M. Wathne, B. M. and Hruška, J. (eds) 2014. Proceedings of the 29th Task Force meeting of the ICP Waters Programme in Český Krumlov, Czech Republic 1st–3rd October, 2013. **ICP Waters report 117/2014**
- Escudero-Oñate, C. Intercomparison 1327: pH, Conductivity, Alkalinity, NO₃-N, Cl, SO₄, Ca, Mg, Na, K, TOC, Al, Fe, Mn, Cd, Pb, Cu, Ni and Zn. **ICP Waters Report 116/2013**
- Holen, S., R.F. Wright, I. Seifert. 2013. - Effects of long-range transported air pollution (LTRAP) on freshwater ecosystem services. **ICP Waters Report 115/2013**
- Velle, G., Telford, R.J., Curtis, C., Eriksson, L., Fjellheim, A., Frolova, M., Fölster J., Grudule N., Halvorsen G.A., Hildrew A., Hoffmann A., Indrikson I., Kamasová L., Kopáček J., Orton S., Krám P., Monteith D.T., Senoo T., Shilland E.M., Stuchlík E., Wiklund M.L., de Wit, H., Skjelkvåle B.L. 2013. Biodiversity in freshwaters. Temporal trends and response to water chemistry. **ICP Waters Report 114/2013**
- Fjellheim, A., Johannessen, A. and Landås, T.S. 2013. Biological intercalibration: Invertebrates 1612. **ICP Waters Report 113/2013**
- Skjelkvåle, B.L., Wathne, B.M., de Wit, H. and Michela Rogora (eds.) 2013. Proceedings of the 28th Task Force meeting of the ICP Waters Programme in Verbania Pallanza, Italy, October 8 – 10, 2012. **ICP Waters Report 112/2013**
- Fjellheim, A., Johannessen, A., Svanevik Landås, T. 2012. Biological intercalibration: Invertebrates 1612. NIVA-report SNO 6454-2012, **ICP Waters report 111/2012.**
- Skjelkvåle, B.L., Wathne B. M. and Moiseenko, T. (eds.) 2010. Proceedings of the 27th meeting of the ICP Waters Programme Task Force in Sochi, Russia, October 19 – 21, 2011. **ICP Waters report 110/2012**
- Fjellheim, A., Johannessen, A., Svanevik Landås, T. 2011. Biological intercalibration: Invertebrates 1511. NIVA-report SNO 6264-2011, **ICP Waters report 109/2011.**
- Wright, R.F., Helliwell, R., Hruska, J., Larssen, T., Rogora, M., Rzychoń, D., Skjelkvåle, B.L. and Worsztynowicz, A. 2011. Impacts of Air Pollution on Freshwater Acidification under Future Emission Reduction Scenarios; ICP Waters contribution to WGE report. NIVA-report SNO 6243-2011. **ICP Waters report 108/2011.**
- Dahl, I and Hagebø, E. 2011. Intercomparison 1125: pH, Cond, HCO₃, NO₃-N, Cl, SO₄, Ca, Mg, Na, K, TOC, Al, Fe, Mn, Cd, Pb, Cu, Ni, and Zn. NIVA-report SNO 6222-2011. **ICP Waters report 107/2011.**
- Skjelkvåle B.L. and de Wit, H. (Eds). 2011. Trends in precipitation chemistry, surface water chemistry and aquatic biota in acidified areas in Europe and North America from 1990 to 2008. NIVA-report SNO 6218-2011 **ICP Waters report 106/2011.**
- ICP Waters Programme Centre 2010. ICP Waters Programme manual. NIVA SNO 6074-2010. **ICP Waters report 105/2010.** 91 s. ISBN 978-82-577-5953-7,
- Skjelkvåle, B.L., Wathne B. M. and Vuorenmaa J. (eds.) 2010. Proceedings of the 26th meeting of the ICP Waters Programme Task Force in Helsinki, Finland, October 4 – 6, 2010. **ICP Waters report 104/2010**
- Fjellheim, A. 2010. Biological intercalibration: Invertebrates 1410. NIVA-report SNO 6087-2010, **ICP Waters report 103/2010.**
- Hovind, H. 2010. Intercomparison 1024: pH, Cond, HCO₃, NO₃-N, Cl, SO₄, Ca, Mg, Na, K, TOC, Al, Fe, Mn, Cd, Pb, Cu, Ni, and Zn. NIVA-report SNO 6029-2010. **ICP Waters report 102/2010.**
- De Wit, H. A. and Lindholm M., 2010. Nutrient enrichment effects of atmospheric N deposition on biology in oligotrophic surface waters – a review. NIVA-report SNO 6007 - 2010. **ICP Waters report 101/2010**
- Skjelkvåle, B.L., De Wit, H and Jeffries, D. (eds.) 2010. Proceedings of presentations of national activities to the 25th meeting of the ICP Waters Programme Task Force in Burlington, Canada, October 19-21 2009. NIVA-report SNO 5995 - 2010. **ICP Waters report 100/2010.**

- Fjellheim, A. 2009. Biological intercalibration: Invertebrates 1309. NIVA-report SNO 5883-2009, **ICP Waters report 99/2009.**
- Hovind, H. 2009. Intercomparison 0923: pH, Cond, HCO₃, NO₃-N, Cl, SO₄, Ca, Mg, Na, K, TOC, Al, Fe, Mn, Cd, Pb, Cu, Ni, and Zn. NIVA-report SNO 5845-2009. **ICP Waters report 98/2009.**
- Rannekleiv, S.B., De Wit, H., Jenssen, M. T. S. and Skjelkvåle, B.L., 2009. An assessment of Hg in the freshwater aquatic environment related to long-range transported air pollution in Europe and North America. NIVA-report SNO 5844-2009. **ICP Waters report 97/2009.**
- Skjelkvåle, B.L., Jenssen, M. T. S. and De Wit, H (eds.) 2009. Proceedings of the 24th meeting of the ICP Waters Programme Task Force in Budapest, Hungary, October 6 – 8, 2008. NIVA-report SNO 5770-2009. **ICP Waters report 96/2008.**
- Fjellheim, A and Raddum, G.G. 2008. Biological intercalibration: Invertebrates 1208. NIVA-report SNO 5706-2008, **ICP Waters report 95/2008**
- Skjelkvåle, B.L., and De Wit, H. (eds.) 2008. ICP Waters 20 year with monitoring effects of long-range transboundary air pollution on surface waters in Europe and North-America. NIVA-report SNO 5684-2008. **ICP Waters report 94/2008.**
- Hovind, H. 2008. Intercomparison 0822: pH, Cond, HCO₃, NO₃-N, Cl, SO₄, Ca, Mg, Na, K, Fe, Mn, Cd, Pb, Cu, Ni, and Zn. NIVA-report SNO 5660-2008. **ICP Waters report 93/2008.**
- De Wit, H. Jenssen, M. T. S. and Skjelkvåle, B.L. (eds.) 2008. Proceedings of the 23rd meeting of the ICP Waters Programme Task Force in Nancy, France, October 8 – 10 , 2007. NIVA-report SNO 5567-2008. **ICP Waters report 92/2008.**
- Fjellheim, A and Raddum, G.G. 2008. Biological intercalibration: Invertebrates 1107. NIVA-report SNO 5551 – 2008, **ICP Waters report 91/2008**
- Hovind, H. 2007. Intercomparison 0721: pH, Cond, HCO₃, NO₃-N, Cl, SO₄, Ca, Mg, Na, K, Fe, Mn, Cd, Pb, Cu, Ni, and Zn. NIVA-report SNO 5486-2007. **ICP Waters report 90/2007**
- Wright, R.F., Posch, M., Cosby, B. J., Forsius, M., and Skjelkvåle, B. L. 2007. Review of the Gothenburg Protocol: Chemical and biological responses in surface waters and soils. NIVA-report SNO 5475-2007. **ICP Waters report 89/2007**
- Skjelkvåle, B.L., Forsius, M., Wright, R.F., de Wit, H., Raddum, G.G., and Sjøeng, A.S.M. 2006. Joint Workshop on Confounding Factors in Recovery from Acid Deposition in Surface Waters, 9-10 October 2006, Bergen, Norway; Summary and Abstracts. NIVA-report SNO 5310-2006. **ICP Waters report 88/2006.**
- De Wit, H. and Skjelkvåle, B.L. (eds). 2007. Trends in surface water chemistry and biota; The importance of confounding factors. NIVA-report SNO 5385-2007. **ICP Waters report 87/2007.**
- Hovind, H. 2006. Intercomparison 0620. pH, K₂₅, HCO₃, NO₃ + NO₂, Cl, SO₄, Ca, Mg, Na, K, total aluminium, aluminium - reactive and nonlabile, TOC, COD-Mn. Fe, Mn, Cd, Pb, Cu, Ni and Zn. NIVA-report SNO 5285-2006. **ICP Waters report 86/2006.**
- Raddum, G.G. and Fjellheim, A. 2006. Biological intercalibration 1006: Invertebrate fauna. NIVA-report SNO 5314-2006, **ICP Waters report 85/2006.**
- De Wit, H. and Skjelkvåle, B.L. (eds.) 2006. Proceedings of the 21th meeting of the ICP Waters Programme Task Force in Tallinn, Estonia, October 17-19, 2005. NIVA-report SNO 5204-2006, **ICP Waters report 84/2006.**
- Wright, R.F., Cosby, B.J., Høgåsen, T., Larssen, T., Posch, M. 2005. Critical Loads, Target Load Functions and Dynamic Modelling for Surface Waters and ICP Waters Sites. NIVA-report SNO 5166-2005. **ICP Waters report 83/2006.**
- Hovind, H. 2005. Intercomparison 0317. pH, K₂₅, HCO₃, NO₃ + NO₂, Cl, SO₄, Ca, Mg, Na, K, total aluminium, aluminium - reactive and nonlabile, TOC, COD-Mn. Fe, Mn, Cd, Pb, Cu, Ni and Zn. NIVA-report SNO 5068-2005. **ICP Waters report 82/2005**
- Raddum, G.G. 2005. Intercalibration 0307: Invertebrate fauna. NIVA-report SNO 5067-2005. **ICP Waters report 81/2005**
- De Wit, H. and Skjelkvåle, B.L (eds.). 2005. Proceedings of the 20th meeting of the ICP Waters Programme Task Force in Falun, Sweden, October 18-20, 2004. NIVA-report SNO 5018-2005, **ICP Waters report 80/2005.**
- Fjeld, E., Le Gall, A.-C. and Skjelkvåle, B.L. 2005. An assessment of POPs related to long-range air pollution in the aquatic environment. NIVA-report SNO 5107-2005, **ICP Waters report 79/2005.**
- Skjelkvåle et al 2005. Regional scale evidence for improvements in surface water chemistry 1990-2001. *Environmental Pollution*, 137: 165-176
- Hovind, H. 2004. Intercomparison 0418. pH, K₂₅, HCO₃, NO₃ + NO₂, Cl, SO₄, Ca, Mg, Na, K, Fe, Mn, Cd, Pb, Cu, Ni and Zn. NIVA-report SNO 4875-2004, **ICP Waters report 78/2004.**
- Raddum, G.G. 2004. Intercalibration: Invertebrate fauna 09/04. NIVA-report SNO 4863-2004, **ICP Waters report 77/2004.**
- Skjelkvåle, B.L. (ed). Proceedings of the 19th meeting of the ICP Waters Programme Task Force in Lugano, Switzerland, October 18-20, 2003. NIVA-report SNO 4858-2004, **ICP Waters report 76/2004.**
- Raddum, G.G, *et al.* 2004. Recovery from acidification of invertebrate fauna in ICP Water sites in Europe and North America. NIVA-report SNO 4864-2004, **ICP Waters report 75/2004.**
- Hovind, 2003. Intercomparison 0317. pH, K₂₅, HCO₃, NO₃ + NO₂, Cl, SO₄, Ca, Mg, Na, K, total aluminium, aluminium - reactive and nonlabile, TOC, COD-Mn. Fe, Mn, Cd, Pb, Cu, Ni and Zn. NIVA-report SNO 4715-2003, **ICP Waters report 74/2003.**

- Skjelkvåle, B.L. (ed). 2003. The 15-year report: Assessment and monitoring of surface waters in Europe and North America; acidification and recovery, dynamic modelling and heavy metals. NIVA-report SNO 4716-2003, **ICP Waters report 73/2003**.
- Raddum, G.G. 2003. Intercalibration 0307: Invertebrate fauna. NIVA-report SNO-4659-2003, **ICP Waters report 72/2003**.
- Skjelkvåle, B.L. (ed.). 2003. Proceedings of the 18th meeting of the ICP Waters Programme Task Force in Moscow, October 7-9, 2002. NIVA-report SNO 4658-2003, **ICP Waters report 71/2002**.
- Wright, R.F and Lie, M.C. 2002. Workshop on models for Biological Recovery from Acidification in a Changing Climate. 9-11 september 2002 in Grimstad, Norway. Workshop report. NIVA-report 4589-2002.
- Jenkins, A. Larssen, Th., Moldan, F., Posch, M. and Wright R.F. 2002. Dynamic Modelling of Surface Waters: Impact of emission reduction - possibilities and limitations. NIVA-report SNO 4598-2002, **ICP Waters report 70/2002**.
- Halvorsen, G.A, Heegaard, E. and Raddum, G.G. 2002. Tracing recovery from acidification - a multivariate approach. NIVA-report SNO 4564-2002, **ICP Waters report 69/2002**.
- Hovind, H. 2002. Intercomparison 0216. pH, K₂₅, HCO₃, NO₃ + NO₂, Cl, SO₄, Ca, Mg, Na, K, total aluminium, aluminium - reactive and nonlabile, TOC, COD-Mn. Fe, Mn, Cd, Pb, Cu, Ni and Zn. NIVA-Report SNO 4558-2002, **ICP Waters Report 68/2002**.
- Skjelkvåle, B.L. and Ulstein, M. (eds). 2002. Proceedings from the Workshop on Heavy Metals (Pb, Cd and Hg) in Surface Waters; Monitoring and Biological Impact. March 18-20, 2002, Lillehammer, Norway. NIVA-report SNO-4563-2002, **ICP Waters report 67/2002**.
- Raddum, G.G. 2002. Intercalibration 0206: Invertebrate fauna. NIVA-report SNO-4494-2002, **ICP Waters report 66/2002**.
- Bull, K.R. Achermann, B., Bashkin, V., Chrast, R. Fenech, G., Forsius, M., Gregor H.-D., Guardans, R., Haussmann, T., Hayes, F., Hettelingh, J.-P., Johannessen, T., Kryzanowski, M., Kucera, V., Kvaeven, B., Lorenz, M., Lundin, L., Mills, G., Posch, M., Skjelkvåle, B.L. and Ulstein, M.J. 2001. Coordinated Effects Monitoring and Modelling for Developing and Supporting International Air Pollution Control Agreements. *Water Air Soil Poll.* **130**:119-130.
- Hovind, H. 2001. pH, K₂₅, HCO₃, NO₃ + NO₂, Cl, SO₄, Ca, Mg, Na, K, total aluminium, aluminium - reactive and nonlabile, TOC, COD-Mn. Fe, Mn, Cd, Pb, Cu, Ni and Zn. NIVA-Report SNO 4416-2002, **ICP Waters report 64/2001**.
- Lyulko, I. Berg, P. and Skjelkvåle, B.L. (eds.) 2001. National presentations from the 16th meeting of the ICP Waters Programme task Force in Riga, Latvia, October 18-20, 2000. NIVA-report SNO 4411-2001. **ICP Waters report 63/001**.
- Raddum, G.G. 2000. Intercalibration 0005: Invertebrate fauna. NIVA-report SNO4384-2001, **ICP Waters report 62/2001**.
- Raddum, G.G. and Skjelkvåle B.L. 2000. Critical Load of Acidifying Compounds to Invertebrates In Different Ecoregions of Europe. *Water Air Soil Poll.* **130**:825-830.
- Stoddard, J. Traaen, T and Skjelkvåle, B.L. 2001. Assessment of Nitrogen leaching at ICP-Waters sites (Europe and North America). *Water Air Soil Poll.* **130**:825-830.
- Skjelkvåle, B.L. Stoddard J.L. and Andersen, T. 2001. Trends in surface waters acidification in Europe and North America (1989-1998). *Water Air Soil Poll.* **130**:781-786.
- Kvaeven, B. Ulstein, M.J., Skjelkvåle, B.L., Raddum, G.G. and Hovind, H. 2001. ICP Waters – An international programme for surface water monitoring. *Water Air Soil Poll.* **130**:775-780.
- Wright, R.F. 2001. Note on: Effect of year-to-year variations in climate on trends in acidification. NIVA-report SNO 4328-2001, **ICP Waters report 57/2001**.
- Hovind, H. 2000. Trends in intercomparisons 8701-9812: pH, K₂₅, NO₃ + NO₂, Cl, SO₄, Ca, Mg, Na, K and aluminium - reactive and nonlabile, TOC, COD-Mn. NIVA-Report SNO 4281-2000, **ICP Waters Report 56/2000**.
- Hovind, H. 2000. Intercomparison 0014. pH, K₂₅, HCO₃, NO₃ + NO₂, Cl, SO₄, Ca, Mg, Na, K, total aluminium, aluminium - reactive and nonlabile, TOC, COD-Mn. Fe, Mn, Cd, Pb, Cu, Ni and Zn. NIVA-Report SNO 4281-2000, **ICP Waters Report 55/2000**.
- Skjelkvåle, B.L., Olendrzynski, K., Stoddard, J., Traaen, T.S, Tarrason, L., Tørseth, K., Windjusveen, S. and Wright, R.F. 2001. Assessment of trends and leaching in Nitrogen at ICP Waters Sites (Europe And North America). NIVA-report SNO 4383-2001, **ICP Waters report 54/2001**.
- Stoddard, J. L., Jeffries, D. S., Lükewille, A., Clair, T. A., Dillon, P. J., Driscoll, C. T., Forsius, M., Johannessen, M., Kahl, J. S., Kellogg, J. H., Kemp, A., Mannio, J., Monteith, D., Murdoch, P. S., Patrick, S., Rebsdorf, A., Skjelkvåle, B. L., Stainton, M. P., Traaen, T. S., van Dam, H., Webster, K. E., Wieting, J., and Wilander, A. 1999. Regional trends in aquatic recovery from acidification in North America and Europe 1980-95. *Nature* 401:575- 578.
- Skjelkvåle, B. L., Andersen, T., Halvorsen, G. A., Raddum, G.G., Heegaard, E., Stoddard, J. L., and Wright, R. F. 2000. The 12-year report; Acidification of Surface Water in Europe and North America; Trends, biological recovery and heavy metals. NIVA-Report SNO 4208/2000, **ICP Waters report 52/2000**.

Reports before year 2000 can be listed on request.

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