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Proceedings of the 24th meeting of the ICP Waters Programme Task Force in Budapest, Hungary

October 6-8 2008

Photo: Ferenc Szilágyi, Hungary.

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

Convention on Long-Range Transboundary Air Pollution

Norwegian Institute for Water Research
– an institute in the Environmental Research Alliance of Norway

REPORT

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Abstract

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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 24th meeting of the ICP Waters Programme Task Force in Budapest, Hungary, October 6 - 8, 2008

Prepared at the ICP Waters Programme Centre
Norwegian Institute for Water Research
Oslo, Mars 2009

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 Center is hosted by the Norwegian Institute for Water Research (NIVA), while the Norwegian Pollution Control Authority (SFT) leads the programme. The Programme Centres work is supported financially by SFT.

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 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 24th Task Force meeting of the ICP Waters programme, held in Budapest, Hungary, October 6 - 8, 2008.

Brit Lise Skjelkvåle

Brit Lisa Skjelkvåle
ICP Waters Programme Centre

Oslo, February 2009

Contents

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 Budapest, Hungary in October 2008 are grouped thematically;

i. **National activities**
  - Ms Zsuzsa Steindl, the Ministry of Environment, Hungary; General overview over the main important characters of the Hungarian water protection policy
  - I. Lyulko et al; Report of National ICP Waters activities in Latvia, 2007/2008

ii. **Water chemistry – trends and status for S and N**
  - A. C. Legall; Effects of nitrogen nutrients on aquatic ecosystems: some examples from the WGE
  - G. Oelsner; Nitrate trends and patterns in Northeastern USA
  - N. Gashinka; Change in C, N and P content in Kola lakes through surveys 1995-2005

iii. **Biological response**
  - G.G. Raddum; Nitrogen leaching – some records on biology questions

iv. **Heavy metals and POP's**
  - B. L. Skjelkvåle; Results from the Norwegian Lake survey

v. **Dynamic modelling / Critical loads**
  - Duska Sasa; Calculating and mapping of critical loads on surface waters for selected sites from the Republic of Croatia

vi. **ICP-Waters and the EU Water Framework Directive**
  - G.G. Raddum; The biological database and its use for the Water Framework Directive
  - B. Wathne et al.; Position paper on links, complementarities and common interests between the LTRAP convention and the Water Framework Directive

2. Welcome

Dear Chairperson, dear Colleagues!

It is a great honour for Hungary that the International Co-operation Programme on Waters holds its 24th Task Force Meeting in Budapest.

Last November a reporter from a Hungarian electronic news agency asked our ministerial department about the present status of air born acidification in Hungary. He would like to know: is it true that the colour of some Hungarian surface waters will be brown due to the decreased acidification? He cited a part from a scientific paper published in the well known periodicals Nature. We reassured this journalist; in Hungary the air born acidification has not caused any serious water quality problems through the last forty years, so a decrease of acidification will not cause the colour change in our surface waters.

It is a great pleasure for me, that I may congratulate personally the authors of the mentioned Nature papers here in this Hall! This paper was an important evaluation of the 20 years activity of the International Co-operation Programme on Waters. The international activity to decrease the air born acidification was effective. This activity is a successful story in the history of general Environmental Protection field.

On behalf of the Ministry of Environment and Water of Hungary I wish you fruitful discussion, and I hope that beside the hard work you can find some free time to get familiar with and enjoy the attractions of Budapest and its surroundings.

Ms. Zsuzsa Steindl

Ministry of Environment, Hungary

Budapest, October 2008

3. General overview about the main important characters of the Hungarian water protection policy

Zsuzsa Steindl
Ministry of the Environment and Water, Hungary

The whole territory of Hungary is situated within in the lowest part of the Carpathian Basin, most of which comprises lowland plains. The entire territory contributes to the Danube Basin.
Due to the basin character of the country the annual average water-flow per capita (120 billion m³ p.a.) is one of the highest in the world. 96% of the surface water resources in Hungary originate beyond its frontiers. More than 90% of the water flowing through the country is concentrated in two main watercourses (the rivers Danube and Tisza).

As a consequence of this fact both the quality and quantity of the water is highly dependent on the waters arriving into our country from upstream neighbouring lands. It also means that without international cooperation our water policy could not be successful. The bilateral and multilateral water agreements are one of the most important fundaments of our national strategy as well. We are also active in the water related activities flowing under the umbrella of the different UN-ECE protocols and conventions, and the International Convention on the Protection of Danube River ensure frame and common platform for our national water protection activity together with the other 14 Danube countries.

In total, the water quality of our large rivers has improved during the last 10-15 years, and the quality is now generally acceptable. In accordance with their lower dilution capacity, the quality of smaller rivers is worse. (But from time to time the extremes occurring in the volume or quantity of the waters of large rivers can cause risks for a lot of settlements alongside the rivers. Extreme weather conditions occur more and more frequently. Varying water flow is typical mainly in the upper sections of the tributaries of Tisza.)

The pollutant load of human origin significantly influences the quality of surface waters.
The polluting substances, arriving to our watercourses originate;

- from abroad
- from point source discharges
- from diffuse pollution sources.

The yearly amount of waste water discharged into rivers is approximately 600-700 million m^3. From point sources approximately 70% of the waste waters discharged into the surface waters nationally are of municipal origin, 26% is industrial and 3% is of agricultural origin.

Often the diffuse pollution is dominated by agricultural fertilizers and pesticides and from the sewage disposal through infiltration where there are no sewage drains in the settlements. But the effects of diffuse pollution loads through other pathways become more and more important. Some model calculations show that the deposition from air is also a significant source mainly relating to the nitrogen compounds but also to different special micropollutants. It means that in the future we have to focus more intensively on this field as well.

As you know Hungary joined to the EU in 2004. This fact brought a lot of changes also in the environmental policy of our country.

In the first years of this century a very intensive legal harmonisation process was implemented. As a result of it Hungary's water legislation has been fully adapted to the Em's legislation. In harmony with the EU policy the basic element of the national water protection policy is the implementation of the Water Framework Directive.

In 2004 new priorities have been introduced by three government decrees in line with the Water Framework Directive. Accordingly, Hungary has to reach in all water bodies good water status (or good ecological potential, where relevant) by 2015. These goals have to be attained in river basin districts, through river basin management plans. According to the implementation program of the requirements of the Water Framework Directive overall water management plan has to be elaborated. The River Basin Management Plan will contain a water resource management strategy both for the qualitative and quantitative issues for all sub-basins. The first drafts of these plans have to be prepared by the end of 2008 and be finalised by the end of 2009.

As mentioned before the territory of Hungary is located in the "most international" catchments area of Europe, the Danube. Consequently, the implementation of the WFD is harmonised by the International Commission for the Protection of the Danube River (ICPDR) mainly focusing on characteristics and problems of basin-wide importance.

Since the Water Framework Directive entered into force, the typology of surface waters was established, the water bodies were determined and classified into water classes, their status revealed, the assessment of the human impacts on surface waters and their impact on the ecological condition took place, and the risk of water bodies were identified. During this those water bodies were classified as risky where the good status cannot be achieved until 2015.

Identification of risky surface water bodies took place according three pollutant groups: organic pollutions, plant nutrients and hazardous substances, and as fourth aspect from hydromorphological alterations.

Hungary identified 875 river water bodies along natural watercourses with catchments areas greater than 10 km^2 and classified them into 25 types. In addition 151 artificial (man-made) surface water bodies were also identified.

Altogether 100 natural lakes have been selected as water bodies. Beside our significant *lakes* (Lake Balaton, which is the largest lake in the Danube basin with its total surface area of 605 km^2, Lake Fertő, a transboundary lake shared with Austria - 75 km^2 surface in the Hungarian territory, and Lake Velence with its surface of 25 km^2) our list of water bodies includes 97 smaller lakes and wetlands over 50 hectares (all in the lowland region of the country). Among them are several very shallow alkaline-type lakes. 124 artificial standing waters (reservoirs for different purposes, fishponds, gravel pits) make the list complete.

One of the biggest challenges of implementation of the WFD is the determination of the reference conditions and, in close relation to this, the establishment of a classification system for ecological status. As a result of a research programme, Hungary has the referential description and an EQR-based classification system for all types and for all five biological quality elements (phytoplankton, phytobentos, macrophytes, macroinvertebrates, and fish). Both the reference conditions and the methodology of classification need further validation based on new biological monitoring data.

Hungarian water quality monitoring system was established at the end of '60-es. Taking into consideration that 96% of the total surface water resource is originated in abroad, the quasi-continuous control of surface water quality – mainly at the board section – was highly important. Near to 250 sampling sites were located in Hungary, and 12 laboratories were founded at regional water authorities. At the most important sites, the sampling is weakly, or in every fortnight, and in other cases monthly. Traditional analytical methods for oxygen household compounds, nitrogen components, phosphorous forms, salt content, pH, and so on were applied in the regional laboratories. Mainly because of the fact that that time these laboratories generally did not have appropriate laboratory equipments (for example atomic absorption spectrophotometer, gas-chromatograph and gas-chromatograph-mass spectrometer) the laboratories were not able to analyse systematically the wide range of micro-pollutants (for example heavy metals, pesticides, PAH and PCB compounds and so on). About 25 years later, in the middle of '90-es when the regional environmental inspectorates laboratories were supplied by modern analytical equipments started the systematic measurement of the main important micro-pollutant compounds (mainly heavy metals and basic organic compounds.)

Improvement and operation of the national network for monitoring surface water quality, including the assessment of the ecological status is one of the main important elements of the WFD implementation process. Although requirements of the Water Framework Directive concerning the water quality monitoring are similar to the previous Hungarian monitoring system, from 2007 some developments and changes were necessary in these networks. Primary task is the development of the biological monitoring to provide information for validating the reference conditions, the classification system and for applying the "direct" ecological status-assessment in the future as the basis for decisions on measures.

Another important area is the improvement of the special micro-pollutant analysis. The WFD requires the regular control of 34 so called priority substances. From these compounds there are some which can originate from air pollution sources.

Short overview over the investigation of air born acidification in Hungary:

Although, at the end of XIX. Century some scientists predicted the unpleasant effects of air born acidification, the systematic research works started in the '70-es only. Concerning this activity Hungary came in quite late, the first research works were provided in the middle '80-es by VITUKI (Water Resources Research Centre) and Budapest University of Technology. The hydro-geo-chemical condition of Hungary provides relatively high buffering capacity for surface and subsurface waters. It is the main reason that Hungarian natural waters are less sensitive on the air born acidification than for example the waters at Scandinavian Peninsula.

Concerning Hungarian research work, we may declare that the most sensitive waters in Hungary are situated at the North Hilly Region. In the Mátra Hills, water reservoirs for drinking water supply were established. In these reservoirs the water has the smallest buffering capacity in Hungary (0.5 – 1.5 milli-equivalent hydrogen-carbonate). It is clear that the sensitivity of Hungarian water reservoirs is not comparable to Scandinavian or Scottish surface waters.

Based on the existed Hungarian water quality monitoring system, it was impossible to valuate the effect of air born acidification on surface waters. Csórrét Reservoir was indicated as standard sampling site and study area for the investigation of acidification. Hungarian research activities have been concentrating on extreme meteorological events (heavy rain, rapid snow melting, long precipitation-less period) and the synergistic effect on drinking water quality (pH decreasing) of air born acidification and water treatment technology. On the bases of investigation of our experts, we may state that some extreme events are able to cause unacceptably low pH in the treated drinking water. The stopping of unpleasant change in water quality requires pH and buffering capacity control, which is rarely applied in Hungary.

Hungary has been participating in the work of the Task Force Group of International Co-operative Programme on Waters since the late '80-es. Although our role in the programme was not determining I hope our contribution should be used in the future activity of this international research programme too.

4. Report of National ICP Waters activities in Latvia, 2007/2008

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Sites and observations

In 2007/2008, the ICP Waters programme covered five sites: L. Jugla-Zaki, Amula-mouth, Tulija-Zoseni, Zvirbuli stream and Tervete – upstream Tervete (Figure 1).
The main activities focused on the QA/QC of sampling and analysis and performance of new measurements under the ICP Waters programme.

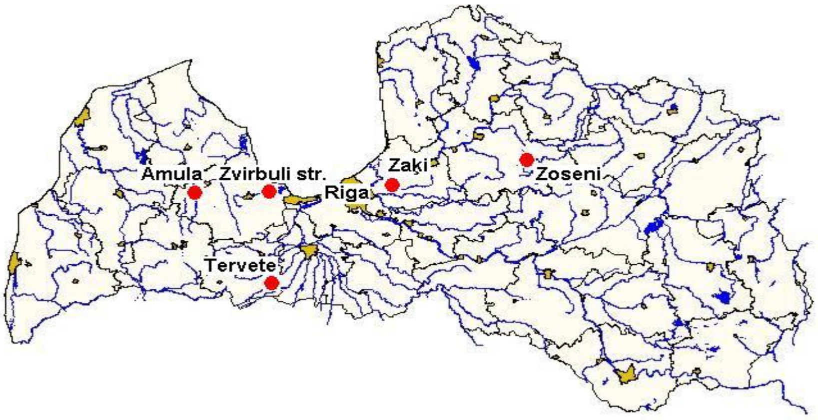


***Figure 1**. ICP Waters sites in Latvia*

Quality assurance and quality control

The agency's laboratory participated in a hydrochemical intercomparison exercise (072) held by ICP Waters and NIVA. A total of 85% of the results were within the general target accuracy of -/+20%. Measurements of alkalinity, Zn, and Pb (Figure 2) were unstable.

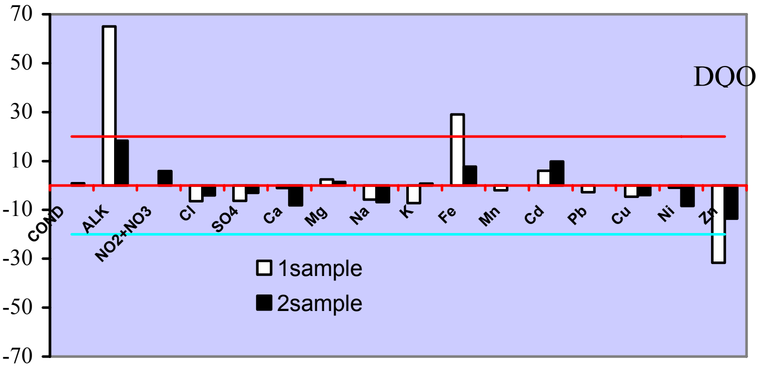


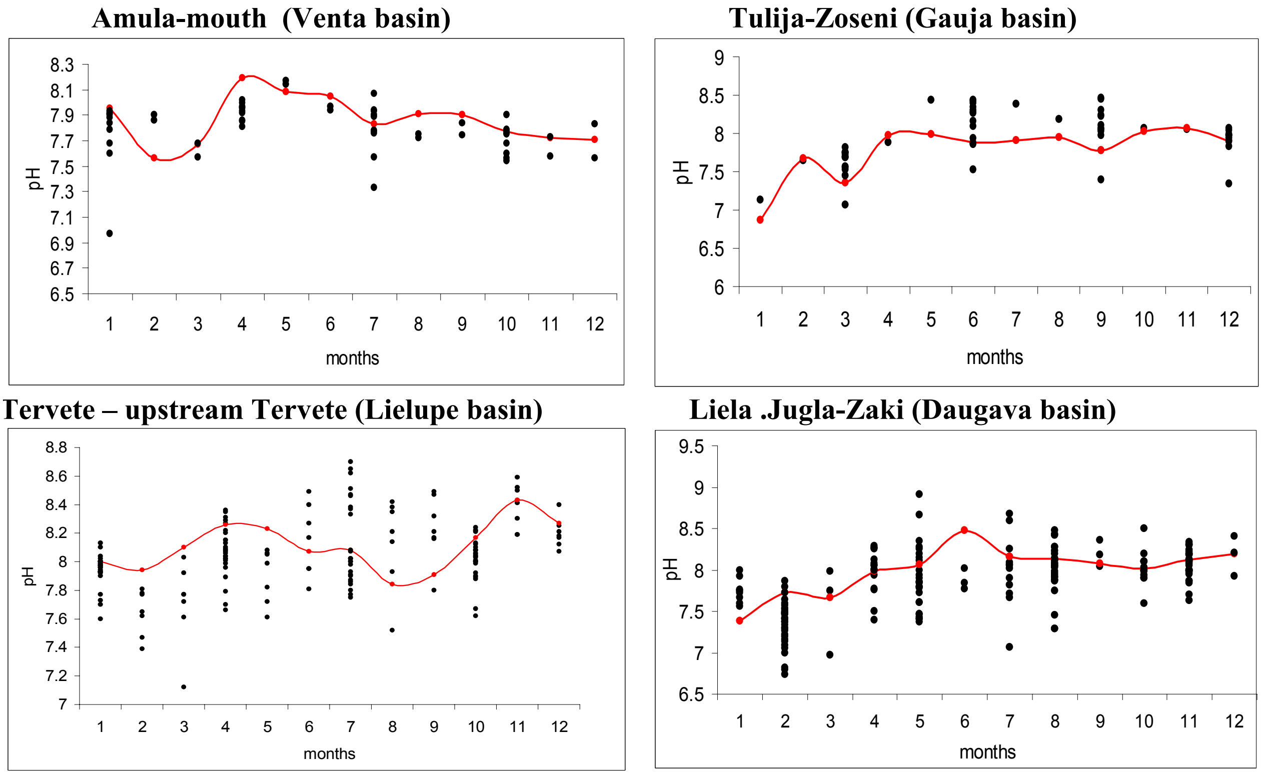
***Figure 2.** Results of the intercomparison exercise (072), %*

Comparison analysis of the 2007 water quality measurements from the ICP Waters sites (background stations) and the measurements from the water quality network operated under the Water Framework Directive

The analysis covered pH, NO_3N, Ntot, Pkop and Pb concentrations obtained at the ICP Waters sites and those from other stations located in these same river basins. The sampling frequency ranged between 4 and 12 times per year.

The comparison analysis showed that in 2007:

- pH of the water at the ICP Waters sites in the Amula (Venta River basin) and Liela Jugla (Daugava River basin) shifted to higher values throughout the year while in Tervete (Lielupe basin) higher values were obtained in the cold period of the year compared to those obtained from the river basins. The pH in Tulija (Gauja basin) was the lowest throughout the year against the whole of the basin and compared to other ICP Waters sites (Figure 3).
- the ICP Waters sites reported lowest tot-P concentrations compared to those obtained from the river basins (Figure 4).
- the distribution of nitrogen compounds (NO3-N and Ntot) in the ICP Waters sites was more sophisticated compared to the corresponding river basins. The Amula only reported lowest concentrations over the whole of the year (Figure 5).
- in the warm period of year, concentration maxima were found in the Tervete River that, as well as the whole of the River Lielupe basin, is situated within the territories sensitive to nitrate pollution. In the cold period, nitrates in the Tervete showed concentrations in excess of the threshold value of 11.3mgN/l under the Nitrate Directive.
- Pb concentrations in the Latvian ICP Waters sites has in general low values compared to data from the other basins, even though being highest in some months (Amula, October, December) (Figure 6).
- concentrations of organo-chlorine compounds were below the method detection limits (<0.2 ng/l: HHB, b-HCH, 2,4-DDE, 4,4-DDE, dieldrin, endrin,4,4-DDD, 2,4-DDT, 4,4-DDT, a-Endosulphane, b-Endosulphane; <0.3 ng/l Aldrin; <05 ng/l 2.4 DDD and <0.6 ng/l a-HCH) both in the ICP Waters sites and the water quality network operated under the Water Framework Directive.

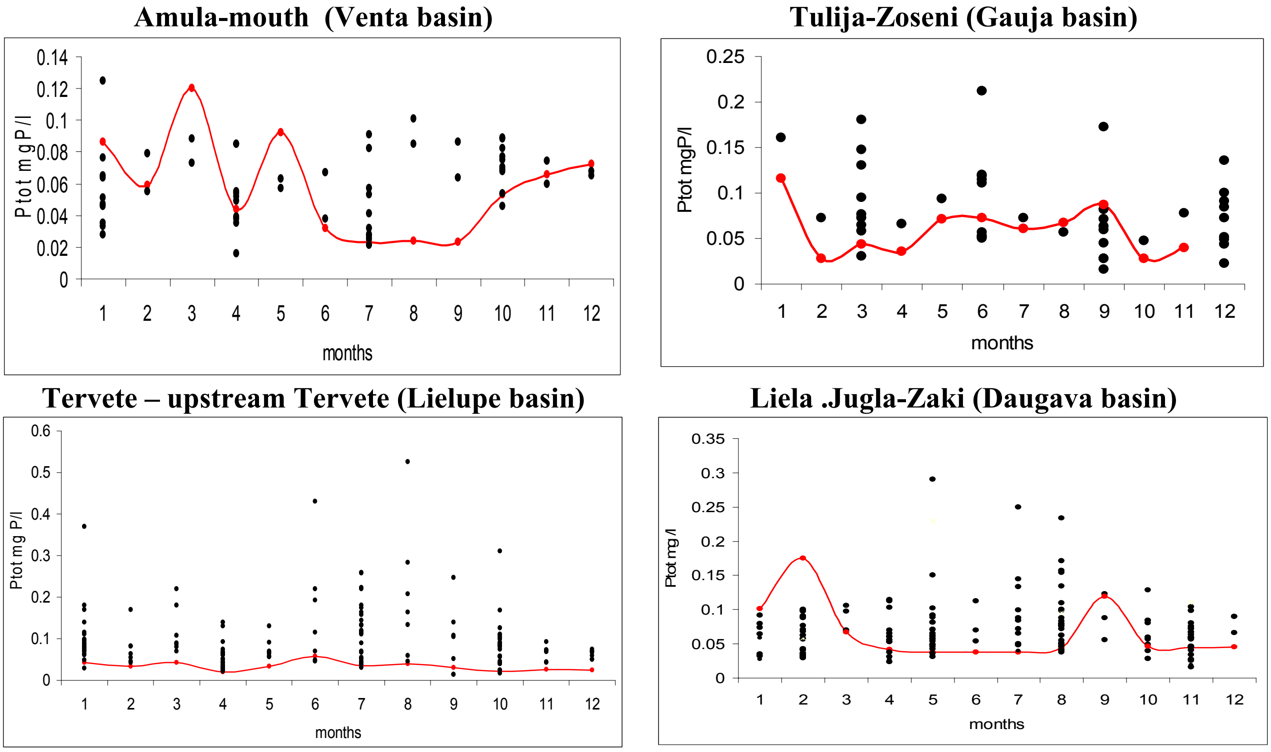

Amula-mouth (Venta basin)

Tulija-Zoseni (Gauja basin)

Tervete – upstream Tervete (Lielupe basin)

Liela .Jugla-Zaki (Daugava basin)

Figure 3. *PH values at ICP Waters sites (red) against other river basins (black), 2007.*


Amula-mouth (Venta basin)

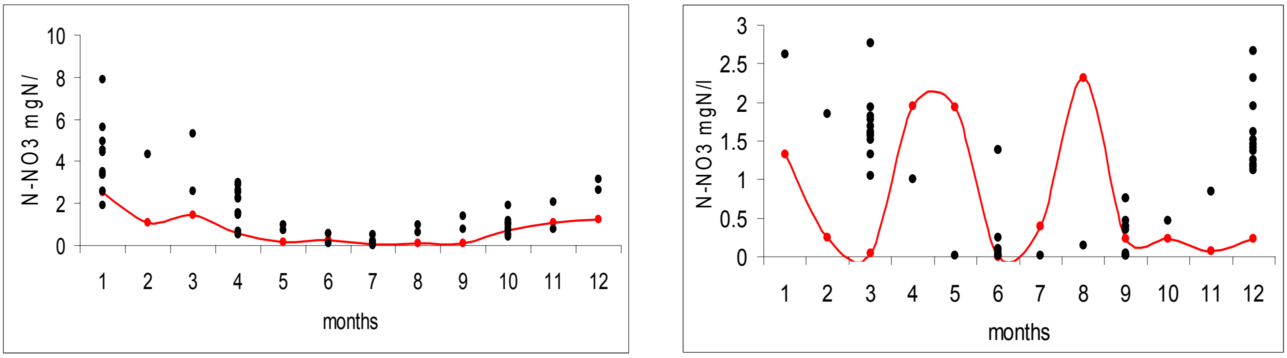
Tulija-Zoseni (Gauja basin)

Tervete – upstream Tervete (Lielupe basin)

Liela .Jugla-Zaki (Daugava basin)

Figure 4. *Ptot concentrations in ICP waters sites (red) against other river basins (black), 2007*

Amula-mouth (Venta basin) **Tulija-Zoseni (Gauja basin)**



Tervete – upstream Tervete(Lielupe basin) **Liela .Jugla-Zaki (Daugava basin)**

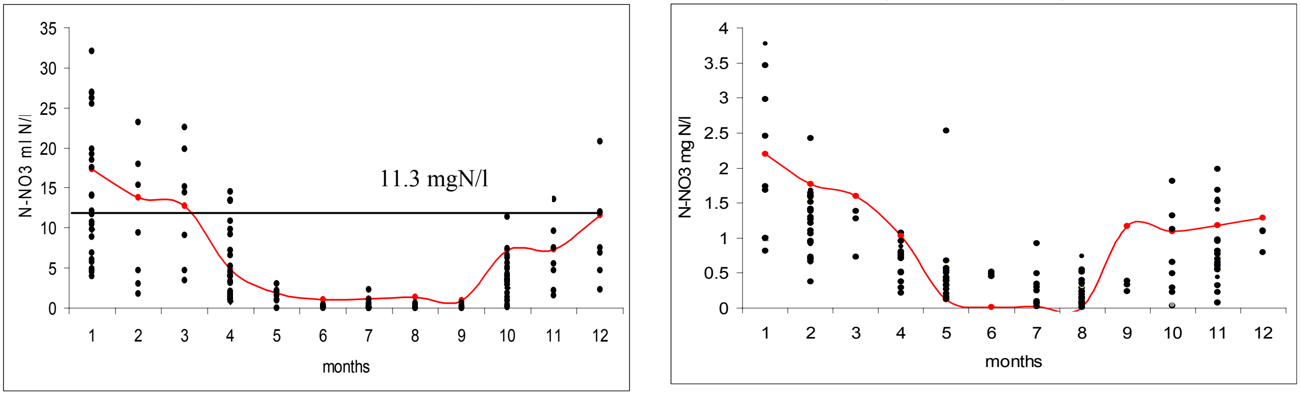
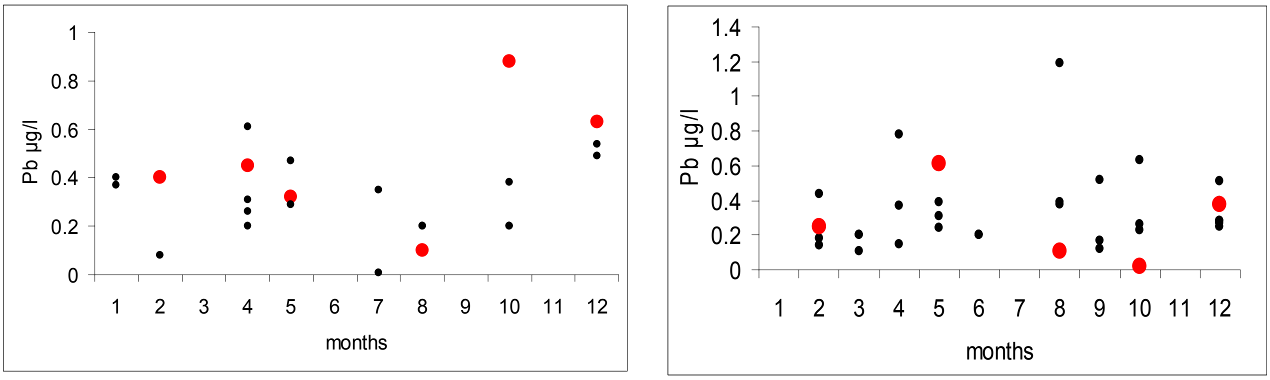


Figure 5 . *NO_3-N concentrations in ICP Waters sites(red) against other river basins (black), 2007*

Amula-mouth (Venta basin) **Tulija-Zoseni (Gauja basin)**



Tervete – upstream Tervete(Lielupe basin) **Liela .Jugla-Zaki (Daugava basin)**

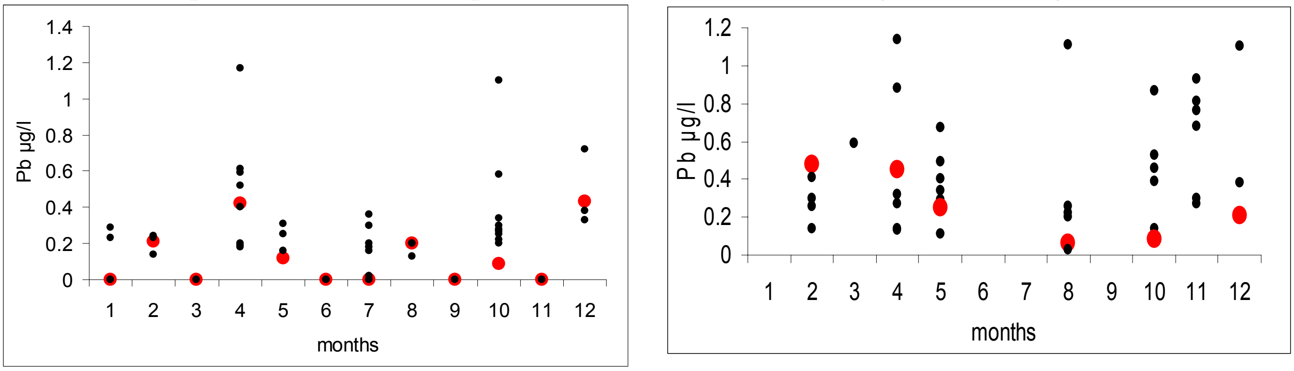


Figure 6 . *Pb concentrations in ICP Waters sites (red)against other river basins (black), 2007*

Surveys of sediments in Latvia’s rivers

In 2007, surveys to determine heavy metals (Cd, Ni, Pb, Cu, Zn, As, Hg), organo-chlorine pesticides (a-HCH, HHB, b-HCH, lindane, 2,4-DDE, 4,4-DDE, dieldrin, 2,4-DDD, endrin,4,4-DDD, 2,4-DDT, 4,4-DDT, aldrine, a-Endosulphane, b-Endosulphane) and oil products were carried out at 10 river stations situated in frontier areas, river mouths, within territories of high anthropogenic impact and in the ICP Waters sites Tulija and Liela Jugla.

Sediment samples were taken with Van Veen’s and Beeker’s samplers in the 0-20cm horizon to identify the distribution of pollutants in the upper layer of the sediments.

Analyses showed concentrations of Hg (< 0.08 mg/kg), Cd (< 0.70 mg/kg), Ni (< 2.0 mg/kg) and Pb (<4.0 mg/kg) below the method detection limits at all stations. Zn, Cu, and As concentrations at ICP Waters stations Liela Jugla and Tulija were within the range of values obtained from the territories under anthropogenic impact (basins of the Daugava and Gauja Rivers) (Figure 7).

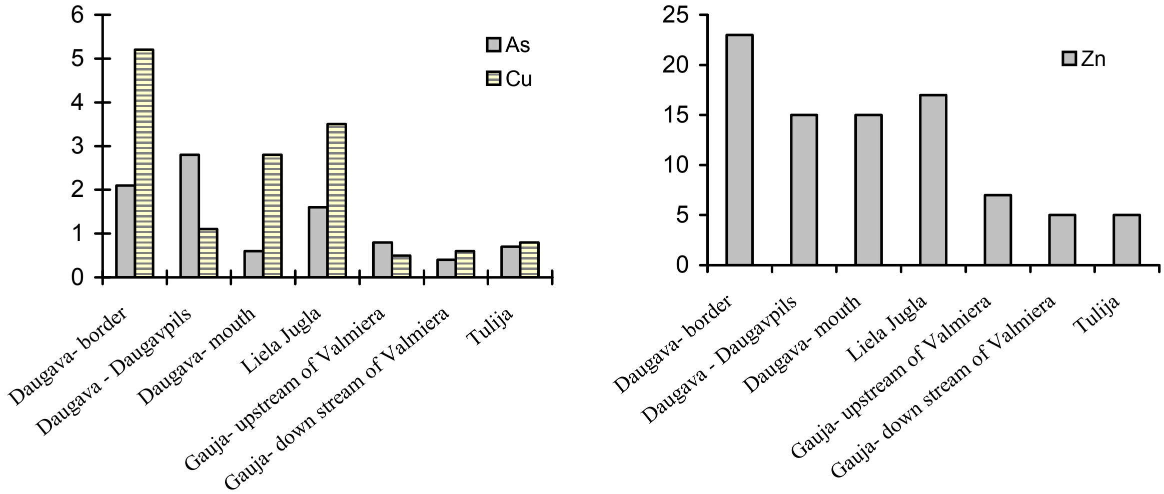


***Figure** 7. Zn, Cu and As concentrations (mg/kg) in river sediments, 2007*

Of the determined organo-chlorine pesticides, a HHB of 3.4 ug/kg was found in the sediments of the Liela Jugla; all the remaining values obtained were below the method detection limits.

Oil products in the sediments at the ICP Waters sites Tulija and Liela Jugla were below the method detection limit of 0.29 mg/kg.

Future activities

- 2007 data reported to the ICP Waters data base;
- participation in hydrochemical and hydrobiological intercomparison events;
- analysis of transboundary air pollution impacts on the ecosystem based on the 1994-2007 measurements from regional GAW/EMEP stations, observation sites under the ICP IM, ICP Waters, ICP Vegetation programmes, and from other relevant environmental stations;
- Participation in the work of the ICP Programme Centre to revise the ICP Waters Manual.

5. Effects of nitrogen nutrients on aquatic ecosystems: some examples from the WGE

Anne Christine Le Gall

INERIS, France

In less than a century, human activities have doubled the quantities of reactive nitrogen present in the biosphere. There are two main sources for this « new » reactive nitrogen: the fertilizers who have greatly increased the agriculture yields and the by-products of combustion processes from our industry and transport systems. Once released in the environment, reactive nitrogen cycles rapidly between its various chemical forms and between different environmental compartments (atmosphere, soil, water, and biota). Historically, nitrogen was a limiting nutrient for plants: the quantities available were less than the quantities plants could assimilate and a state of equilibrium had been reached. With the large quantities of new nitrogen introduced by human activities, this equilibrium is broken. The Working Group on Effects of the Convention on Long Range Transport of Atmospheric Pollution provides here some evidence of the effects the presence of this new nitrogen poses on ecosystems, with a focus on aquatic ecosystems.

Work reported at various ICPs meetings in the LRTAP Convention has shown that atmospheric deposition of nitrogen has a negative impact on the terrestrial ecosystem. Several examples are quoted:

- In Sweden, field experiments led to recommendations that the critical load for nutrient nitrogen in Swedish forest should be around 6 kg N ha^{-1} yr^{-1} to protect understorey vegetation. In experiments where 10 or 50 kg N ha^{-1} yr^{-1} where deposited on natural vegetation, blueberries were replaced by a vegetation dominated by common grass within less than 4 years (Nordin et al., 2005).
- In the Swiss Alps, in a area recently uncovered by a glacier, vegetation acclimated to nutrient poor conditions was overgrown within three years by a wide variety of plants when the soil was artificially fertilised. This implies a loss of ecological niche for vegetation with low nutrient requirements if these areas are fertilised by atmospheric deposition (Heer and Körner, 2002).
- Prairies in the US and the Netherlands lost a significant fraction of their species diversity when submitted to nitrogen input (Bobbink, 1991; Clark and Tilman, 2008). Countrywide surveys across the current deposition gradient in the UK showed a negative correlation between nitrogen deposition and species richness in grasslands (Stevens et al., 2004).
- Lichens and mosses were shown to be sensitive to nitrogen deposition at levels as low as 2 kg N ha^{-1} yr^{-1} in The Sierra Nevada range, California, and were seriously damaged when deposition reached 8-10 kg N ha^{-1} yr^{-1} in both California and the UK (Fenn et al., 2008; Sheppard et al., 2004).

Thus, there is an evidence-accumulation showing that the current deposition adversely affects terrestrial biodiversity, as was predicted by critical load models for Europe.
What effects does Nitrogen-deposition pose on aquatic ecosystems, then? Evidences of adverse effects comes both from water bodies subjected to direct inputs of nitrogen and from water bodies influenced only by atmospheric deposition.

In 2005, James et al. showed that a negative relationship exists between macrophyte diversity and winter nitrate concentrations in freshwater systems (James et al., 2005). Additionally, at levels set for human health protection (11 mg N L^{-1} = 50 mg NO_3 L^{-1}), most macrophyte species will have disappeared according to this study (Figure 1). This implies that the concentrations in the present legislation do not protect ecosystems from the adverse effects of nitrogen.

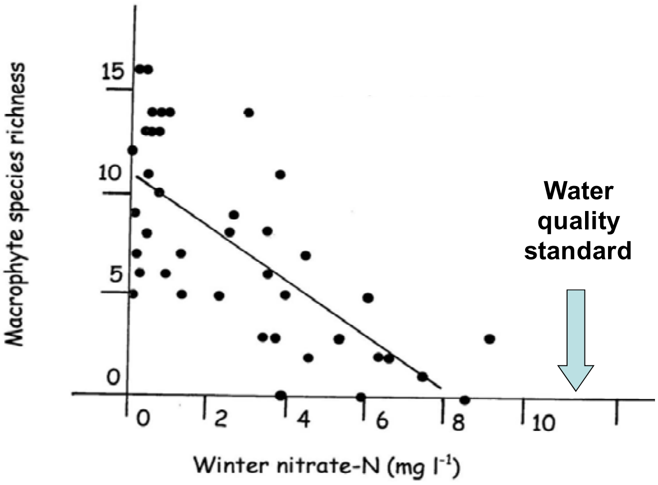


Figure 1. *Relationship between macrophyte diversity and winter nitrate concentrations in European freshwaters (adapted from James et al., 2005).*

More recently, studies have shown that freshwater ecosystem productivity could be nitrogen limited and not only phosphorous limited as previously believed. For instance, data compiled by Bergström and Jansson (2006) indicate that low productivity lakes were nitrogen limited in areas whit low nitrogen deposition, whereas they were phosphorous limited where nitrogen deposition was high (Figure 2). According to these authors, the majority of lakes in the northern hemisphere used to be nitrogen limited, until nitrogen deposition enriched them to saturation. Subsequently, phosphorous became the limiting nutrient.

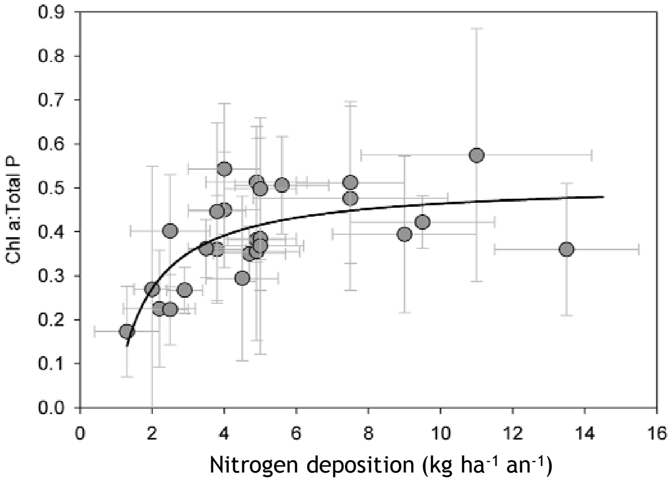


Figure 2. *Relation between nitrogen deposition and chlorophyll a / total phosphorous ratio (as a proxy of biomass productivity) in low productivity lakes in North America and Europe (adapted from Bergström and Jansson, 2006).*

Nitrogen present in water may originate from runoff from atmospheric deposition on land or from direct local inputs due to farming or urban and industrial discharges. Whatever the origins are, once in rivers nitrogen flows down to the coastal areas. A number of processes will decrease the total amount of Nitrogen reaching the sea (e.g. consumption by biomass, denitrification and emission to the atmosphere, trapping in sediment). Yet, the total amount that reaches the river mouth often causes eutrophication of marine areas. This can be illustrated in two ways:

- Satellite pictures show that around the European coastline chlorophyll a concentrations are high in spring and summer (Figure 3). Field observations have correlated these high concentrations to algal blooms and coastal water eutrophication. These algal blooms may occur in different forms depending on the local conditions (current, tide, temperature etc.). In the North Sea for example, foam caused by microalgae may accumulate at beaches (Figure 4).

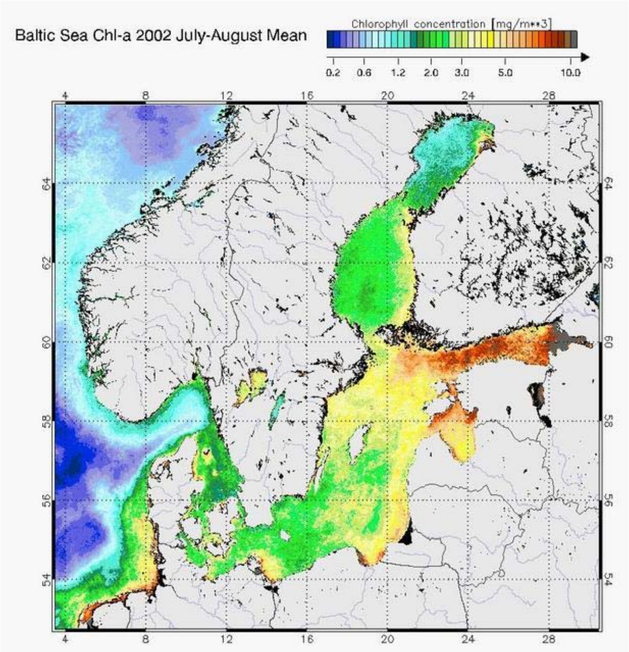


Figure 3. *Satellite picture of the Baltic Sea showing chlorophyll a concentrations (in mg.m^{-3}) in summer 2002 (Schrimpf et al., 2005).*

Figure 4. *Foams caused by the microalgae phaeocystis on North Sea beaches.*

- Diaz and Rosenberg (2008) have assembled literature references of coastal "dead zones" around the world (Figure 5). In these areas, eutrophication leads not only to large algae blooms but also to hypoxia in the bottom waters as these algae die and are broken down by microbial activity. In the most severe cases, fish and sediment dwellers die. Over 400 scientific literature references describing dead zones around the world since the beginning of the 20th century were found. The number has almost doubled every decade since the 1960s. In some areas, such as the Asian coastline, very few occurrences of eutrophication are indicated, probably because few studies have been carried out and reported in international scientific literature.

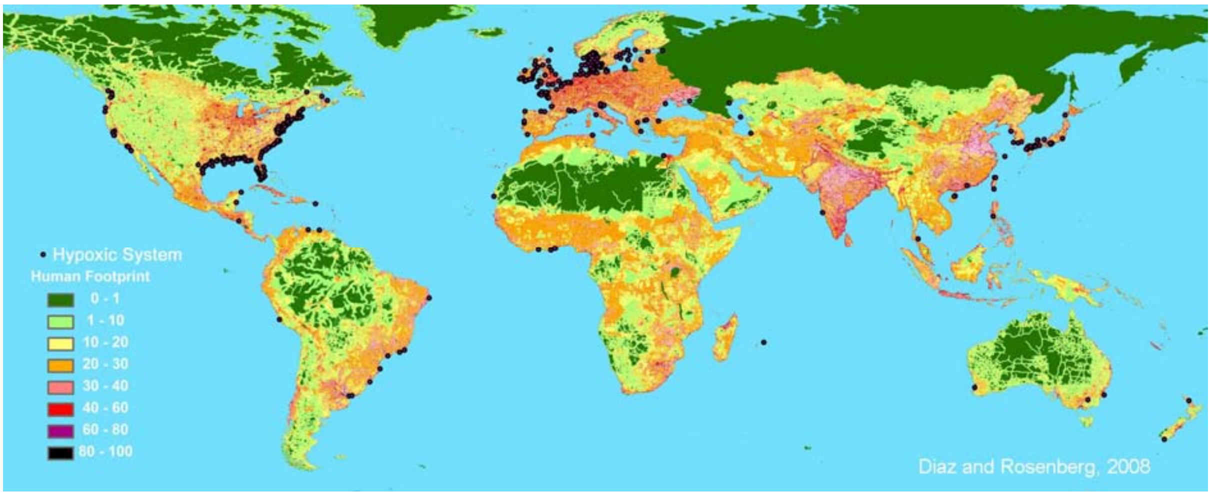


Figure 5. *Each black dot represents the 400 + dead zones listed by Diaz and Rosenberg (2008). The colour scale on the continental areas indicates human footprint (map from Diaz and Rosenberg, 2008).*

These few examples show that anthropogenic inputs of nitrogen have already modified aquatic ecosystems, causing serious damages to coastal environments. The present regulatory levels supposed to protect human health do not protect aquatic ecosystem as plant diversity will be suppressed below these concentrations. At the moment there are no regulations designed to protect aquatic ecosystems. Most of the studies related to nitrogen impacts on aquatic ecosystems have been carried out in the northern hemisphere, however nitrogen related problems are likely to occur in and around all densely populated areas in the world.

This short review shows that, whether nitrogen is introduced to water bodies via the atmosphere or through direct pathways, it will most likely impact freshwater and coastal ecosystems in most areas in the world. Yet, not much is known on this issue as until recently eutrophication of freshwaters was blamed mainly on phosphorous inputs. Further studies, and the ICP Waters activities, will help to increase the understanding and improve the management of nitrogen effected aquatic ecosystems.

Ackowledegments

Several persons from ICP Mapping and Modelling and from ICP Waters have made this presentation possible by providing documents. Graphs and photos presented here were made available by Brian Moss, John Stoddard, Ton de Nijs and Robert Diaz. All are sincerely thanked.

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6. Nitrate Trends in the Adirondack Mountains, Northeastern U.S., 1993 – 2007

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The Adirondack Mountains in New York State receive some of the highest rates of nitrogen deposition in the Northeastern U.S. Between 1993 and 2007, nitrogen deposition loads did not significantly change and average annual wet inorganic nitrogen deposition was 6 kg/ha (Figure 1). In general, nitrogen deposition is higher in southwest area of the park than in the northeast. To determine the effects of nitrogen deposition on surface water chemistry, the U.S. Environmental Protection Agency (EPA) has collected monthly samples from the outlets of 50 acid-sensitive lakes since 1993 (Figure 2). Nitrate trends were calculated for each lake using a linear regression model and monthly concentrations. Trend slopes with p-values less than 0.1 were considered significant. Although the lakes are located within the same geographic region and are all acid sensitive, they do not exhibit the same response to nitrogen deposition (Figure 2). Approximately half of the lakes (22/50) exhibited decreasing trends in nitrate concentrations while 4 lakes had increasing nitrate concentrations. No significant trend was observed for 24 lakes. We compared the nitrate trends to watershed characteristics including area, lake size, relief, elevation, percent wetland and forest cover and DOC trends to explain the spatial heterogeneity of the nitrate trends. No single watershed characteristic could account for the direction or magnitude of the nitrate trends (Figure 3). Trends in lake nitrate concentrations are likely due to multiple factors including watershed characteristics, soil chemistry and depth.

This is an abstract and does not necessarily reflect EPA policy. Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

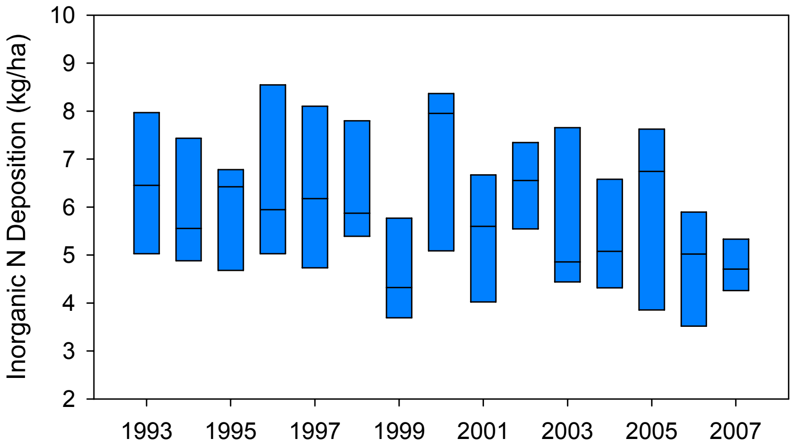

***Figure 1**. Inorganic nitrogen deposition loads in the Adirondack Park 1993 – 2007 from 5 monitoring stations.*

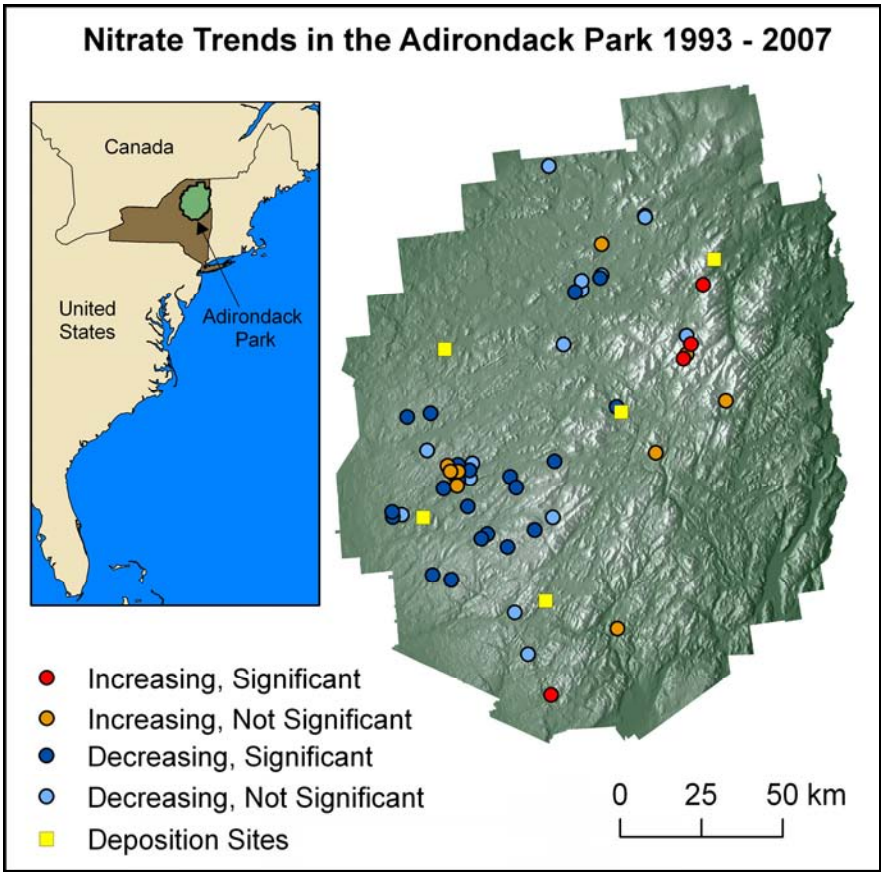

Figure 2*. Map of Adirondack Park showing monitoring lake locations and trends of nitrate concentrations in lake outlets 1993 – 2007.*

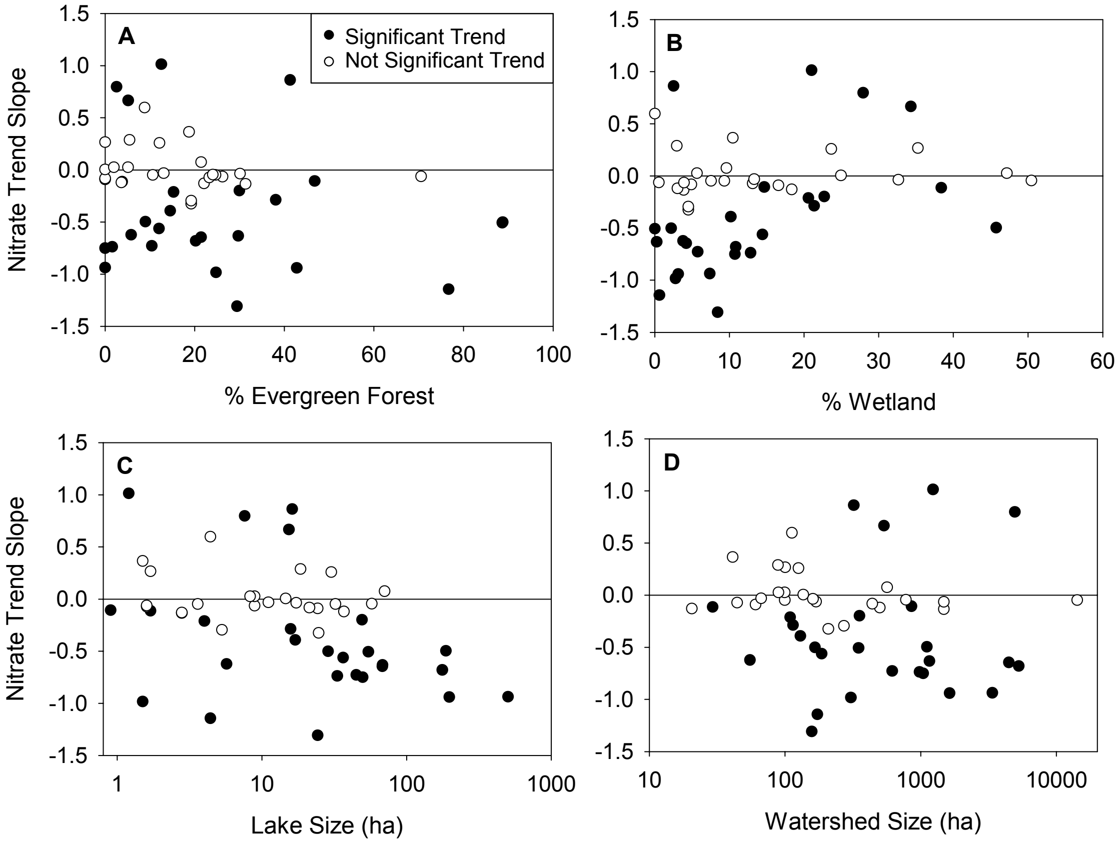

Figure 3. *Comparison of nitrate trends at individual Adirondack lakes with watershed properties. Land cover (% Evergreen Forest and % Wetland), lake size and watershed size were not correlated with the magnitude or direction of nitrate trend slopes.*

7. Change in C, N and P content in Kola lakes through surveys 1995-2005

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To describe the nutrient dynamics in Kola lakes, the results of the lake survey in 1995, 2000 and 2005 were used. In 1995 the research was carried out throughout the Kola North (460 lakes) as a part of the project “Nordic Lake Survey 1995” (Henriksen et al., 1998). In 2000 and 2005 partial monitoring of the Western part of the Kola North (100 lakes) was repeated; selection and sampling methods were met. Analytical methods were virtually identical throughout the study. Measurement accuracy of water chemistry is proved through international intercomparison (Hovind, 2001).

First of all it is worth mentioning about the increase in the total phosphorous concentration (TP). Phosphorous is used as a parameter of eutrophication (Figure 1a) and in particular organic phosphorous (Figure 1b). To estimate trophic state of the lakes the following classifications were used (OECD, 1982; Vollenweider, 1979): TP<4 mg/l – ultraoligotrophic lakes **UO**, TP 4-10 mg/l – oligotrophic lakes **O**, TP 10-35 mg/l – mesotrophic lakes **M**, TP 35-100 mg/l – eutrophic lakes **E** (mentioned abbreviation is applied in the figures). Thus, by using the same lake classifications from 1995 to 2005, a shift from ultraoligotrophic towards a mesotrophic and eutrophic state was observed (Figure 2a).

By 2005 the organic carbon and the nitrogen concentrations increased (Figure 1e, f) and their ratio (Figure 1g) as a parameter of the origin of the organic material shifted towards lower values which points to a rising quantity of autochthonous organic matter. The ammonium concentration showed an increase (Figure 1d), while at the same time the nitrate concentrations declined (Figure 1c). The organic nitrogen to ammonium ratio (Figure 1h) detects if there is an intensification of destruction processes.

The categories of lakes on humification grade on basis of color index were met (Håkanson, Boulion, 2001). The largest changes in the total phosphorous concentration (Figure 3a) and trophic state was observed in clear water and humic lakes (Figure 2c, d), where the change seems to be a combination of optimal supply, transformation and cycling of substances (Figure 2b, c, d). In polyhumic lakes organic matter was represented by more resistant allochthonous material (Figure 3d).

To compare chemical and biological processes in nitrate and ammonium repartition the hypothetic relationship was calculated. In the abstract under different pH-values, the content of nitrate and ammonium which amounts 100 percent is refractioned by reductive-oxidative reactions. In 2005 nitrates uptake and ammonium increased because organic matter destruction predominated over redox repartition, the more the higher the lake trophic state (fig. 4c). In 1995 and 2000 neither biological nor chemical processes compensated proportion in the several lakes (it is those that are located above the hypothetic line) (fig. 2a, b). The majority of the lakes are ultraologotrophic and oligotrophic, where a high level of nitrification is unlikely to occur, most likely external nitrate supply was higher than the possible utilization rate.

The question of algae nutrient demand and nutrient concentration becoming limiting is very disputable. However the concentrations can indicate a change in nutrient condition. Limiting concentrations as presented by G.F. Hutchinson (1967) may actually be a low level optimal condition.

There are many lakes in Kola North where phosphate concentration equal zero. Concentration of phosphate equal to 1 μg/l was tentatively admitted for severe limitation, according to a mass balance of 7 μg/l for nitrate. Kola lakes have in general very low supplies of nitrogen. The eutrophication of lakes observed in 2005 is probably due to phosphate. In the declining quantity of ultraoligotrophic lakes, almost half of the lakes had optimal phosphate concentrations (Table 1).

The nitrate to phosphate ratio serve as a good limiting parameter, but the lakes with phosphate concentration equal to zero are not accounted for in this ratio (Figure 3e). Judging by the nitrate to phosphate ratio in 2005 we can see a strong nitrogen deficiency, whereas in 1995 a simultaneous phosphorus and nitrogen deficiency. In 2000 there was a higher phosphorus deficiency especially in ultraoligotrophic lakes (Table 2). The total nitrogen to total phosphorus ratio are better indicators of trophic level and phosphorous accumulation in these ecosystems than nitrogen or phosphorous deficiency (Figure 3f).

During the thirty last years the temperature anomaly has been observed to rise 0.5 ^{o}C (Brohan et al., 2006). Maybe this is causing the intensified nutrient cycling both in the water and in the land ecosystems.

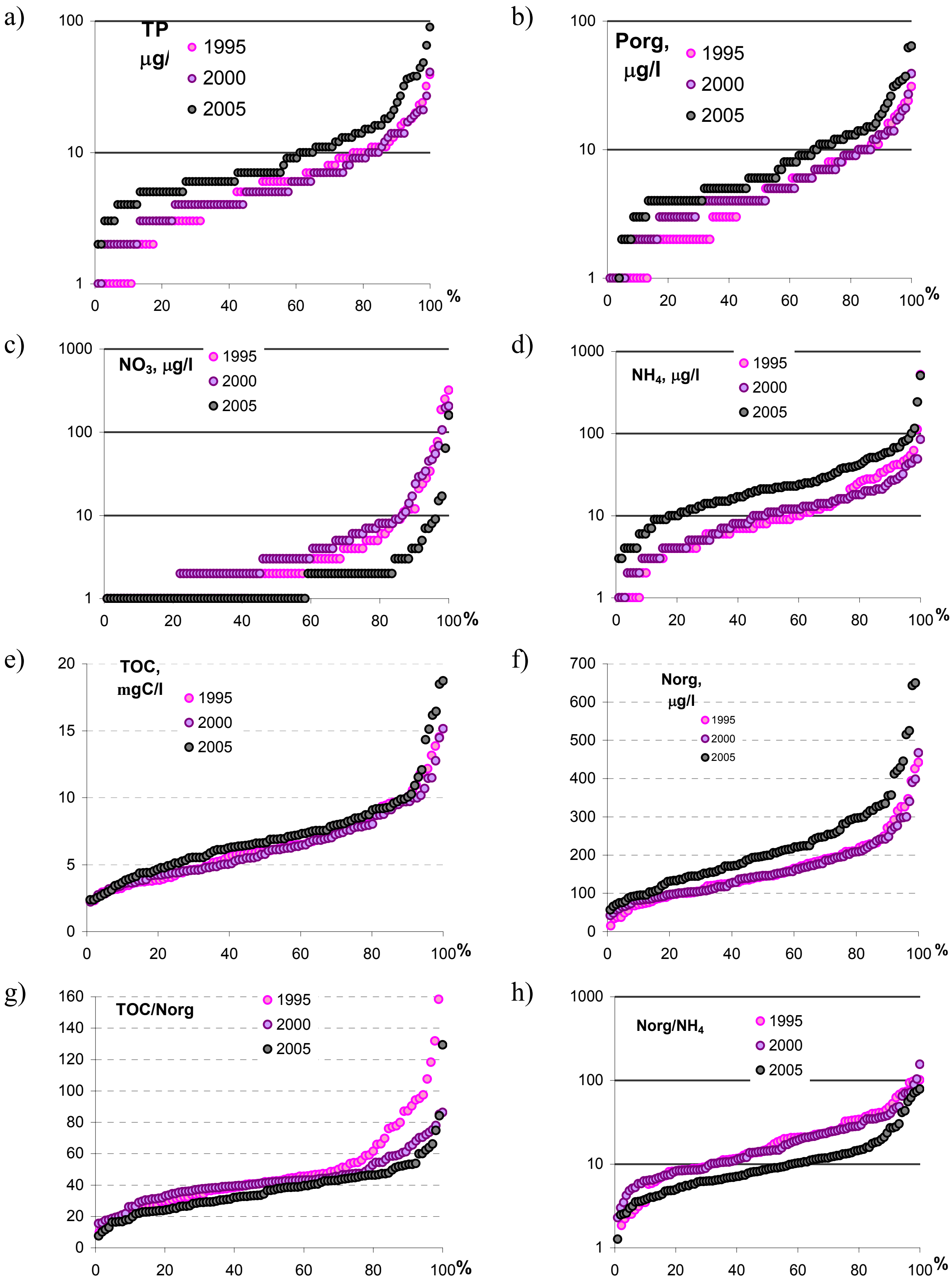

***Figure 1**. The percentage distribution of total and forms of phosphorous, nitrogen, carbon and some their ratios.*

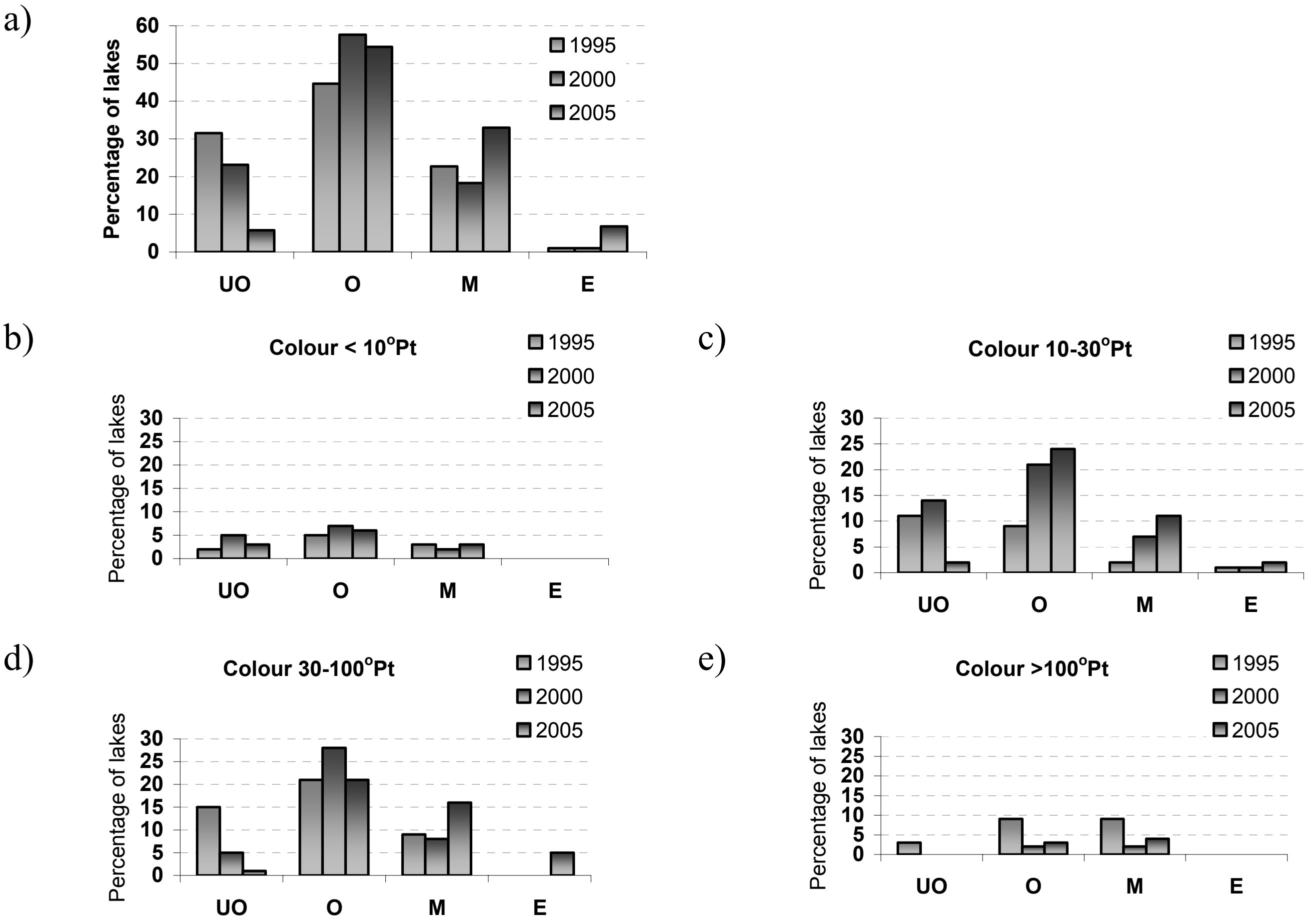

Figure 2. *The quantity of Kola lakes of different trophic state and humic content gradiation in 1995, 2000, 2005*

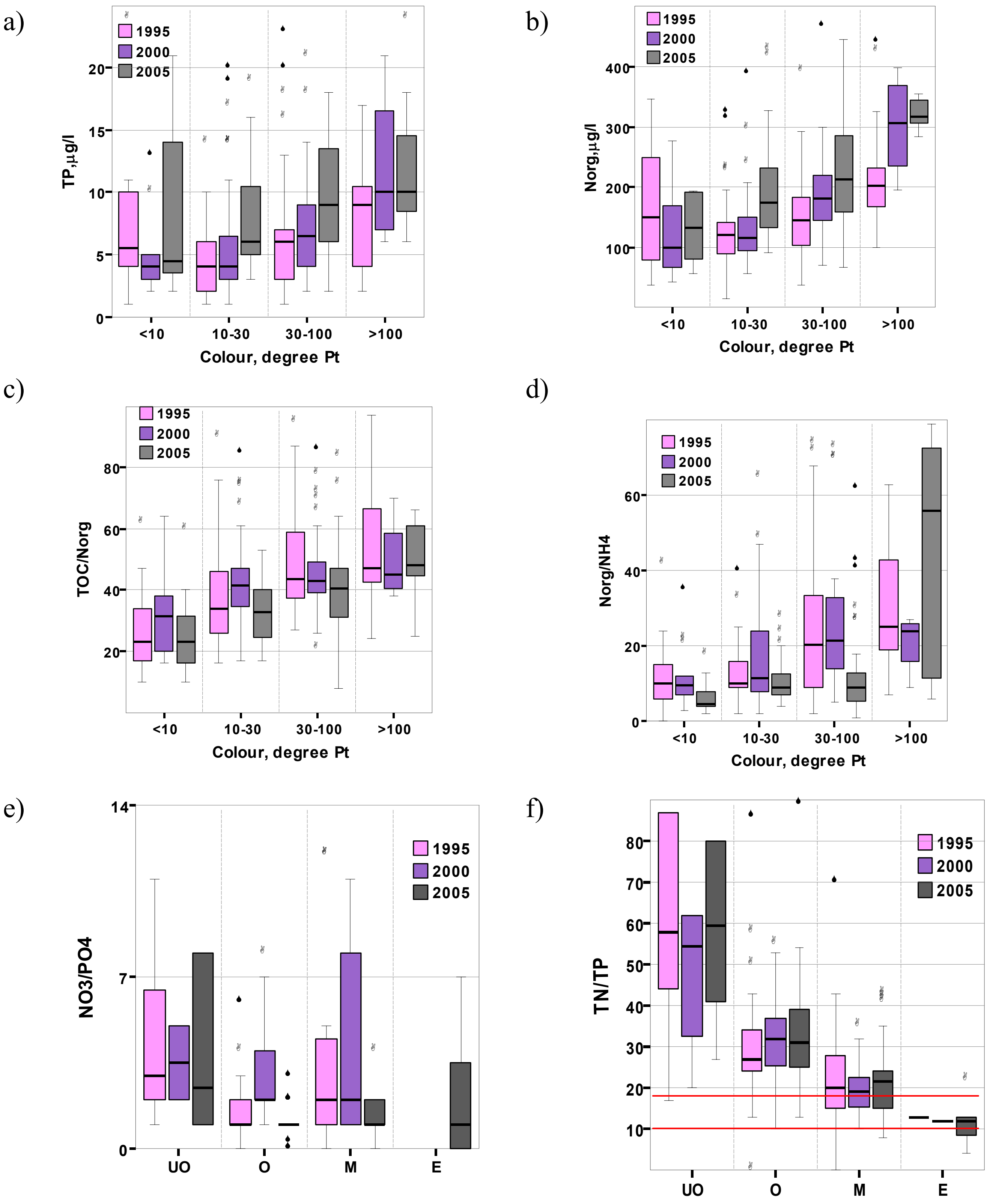

Figure 3. *The distribution of some parameters under humus content gradation and limiting parameters under different trophic states.*

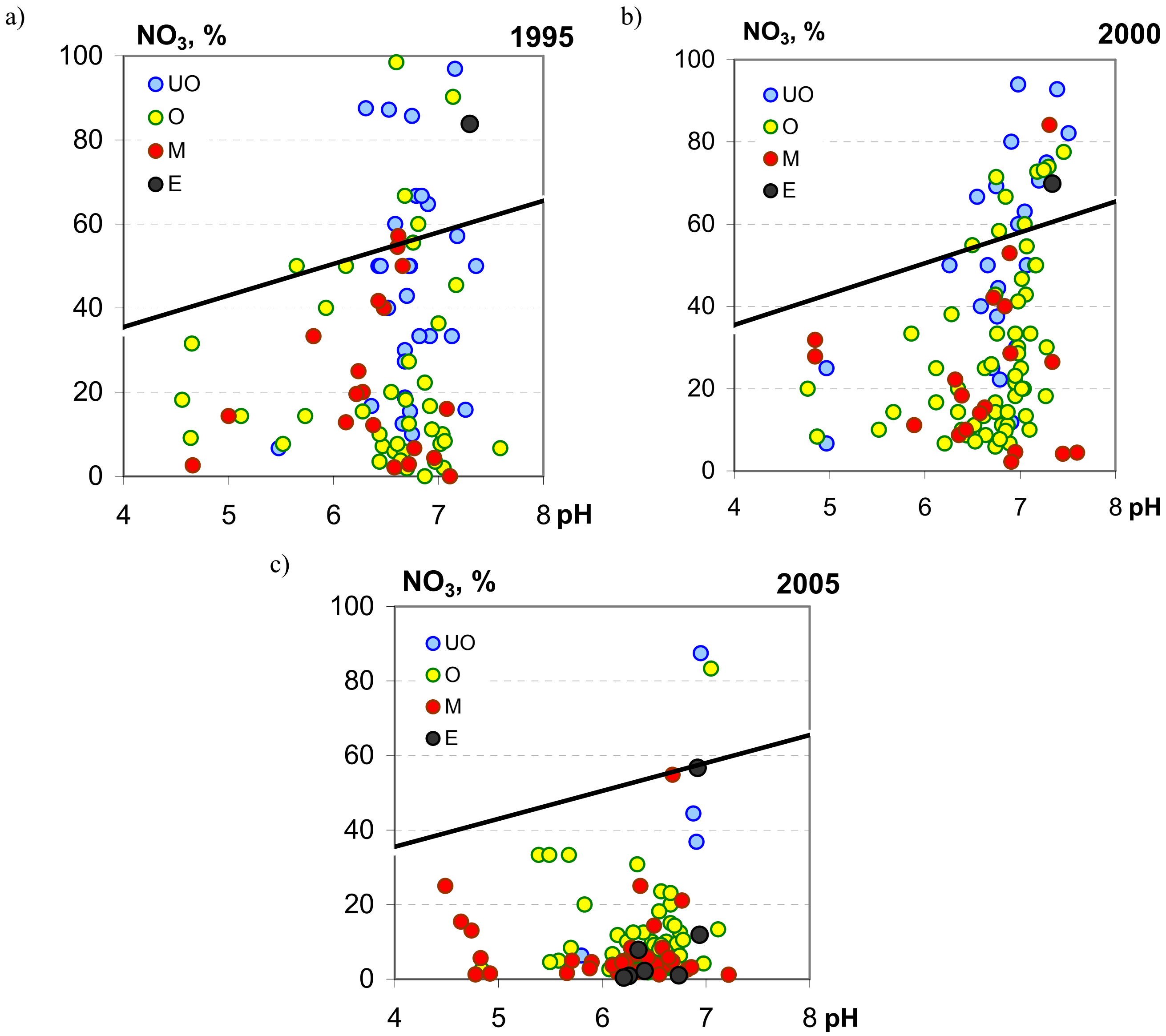

Figure 4. *The distribution of percentage nitrate in the inorganic nitrogen concentration in Kola lakes in 1995, 2000, 2005*

Table 1. *Distribution of percentage of the Kola lakes under different limitation level on phosphorus, nitrogen and silicon in 1995, 2000, 2005*

		PO_4		N		Si	
		<10 µg/l	<1 µg/l	<300 µg/l (sum NH_4 and NO_3)	<7 µg/l (NO_3)	<0,5 mg/l	<0,1 mg/l
		1	2	1	2	1	2
1995	All lakes	**90**	**30**	**98**	**81**	**14**	**4**
	Ultaoligotrophic	100	45	100	69	3	3
	Oligotrophic	80	23	100	95	18	8
	Mesotrophic	100	25	100	75	25	0
2000	All lakes	**100**	**61**	**100**	**75**	**14**	**5**
	Ultaoligotrophic	100	75	100	75	8	8
	Oligotrophic	100	62	100	80	12	3
	Mesotrophic	100	42	100	63	32	5
2005	All lakes	**97**	**17**	**99**	**93**	**21**	**9**
	Ultaoligotrophic	100	0	100	60	20	20
	Oligotrophic	100	20	100	98	13	5
	Mesotrophic	100	18	100	94	35	15
	Eutrophic	57	0	86	71	14	0

1 – limiting concentrations (low level of optimal condition) (Hutchinson, 1967)

2 – tentative concentration under which phytoplankton production cease

Table 2. *Distribution of percentage of the Kola lakes on NO3/ PO4 and TN/TP ratios in 1995, 2000, 2005*

		NO_3/ PO_4		TN/TP		
		<7	>7	<10	10-17	>17
1995	All lakes	**59**	**11/30***	**1**	**11**	**88**
	Ultaoligotrophic	41	14/45	0	3	97
	Oligotrophic	73	5/22	0	8	92
	Mesotrophic	60	15/25	5	25	70
2000	All lakes	**30**	**9/61**	**0**	**11**	**89**
	Ultaoligotrophic	21	4/75	0	0	100
	Oligotrophic	33	5/62	0	7	93
	Mesotrophic	37	21/42	0	37	63
2005	All lakes	**79**	**4/17**	**4**	**14**	**82**
	Ultaoligotrophic	80	20/0	0	0	100
	Oligotrophic	79	2/19	0	4	96
	Mesotrophic	79	3/18	3	26	71
	Eutrophic	86	14/0	43	43	14

* - denominator – percent of lake with PO4 concentration is equal 0

Conclusions

By 2005 biogeochemical processes in Kola lake ecosystems have changed.

The symptoms are:

- increase of TOC and the share of autochthonous organic matter judging from the TOC to organic nitrogen ratios
- intensification of nutrients cycling judging from the ammonium concentrations and the organic nitrogen to ammonium ratio as parameters of organic matter destruction
- increase of lake production judging from the total phosphorus concentration as a parameter of lake eutrophication

Possible causes of rising lake production:

- climate stimulation,
- increase of bioavailable forms of nutrients due to intensification of their cycling.

If in 1995 and 2000 the limiting factor of lake production was phosphorus in association with nitrogen, whereas in 2005 it was nitrogen.

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8. Nitrogen leaching – some records on biology questions

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Nitrogen ($NO^{3-} + NH^{4+}$), an important plant nutrition, can enhance or limit the growth of vegetation both in terrestrial and aquatic environments. Excess (leaching) of nitrogen (N) leads to acidification of streams and lakes. The nitrate concentration in runoff during the growing season depends on the uptake by forest and microbes and is the basis for stating the four saturation stages of N. The chance of N leaching (excess N) increases with increasing N-saturation stage. Growth of vegetation depends on temperature, light, and with the amount of nutrients such as inorganic N, P, Ca and K. Of these, nitrate and orthophosphate are the most common limiting factors for plant growth when other elements are sufficient. Lack of either phosphate or nitrate can limit plant growth and per definition influence the N saturation stage and the leaching of N.

Resent studies from Norway have shown:

- that nitrate increases in lake water by increasing altitude,
- that nitrate and organic carbon varies inversely,
- that nitrate varies negatively with increasing percent vegetation cover of the catchments and
- that high nitrate deposition in high and steep watersheds results in elevated nitrate concentrations in lake water

Nitrate is a fertilizer for vegetation, but can act on aquatic biota such as invertebrates through acidification. Studies have shown that nitrate can explain observed variations in cladocera, littoral invertebrates, chironomids, rotifers and planktonic crustaceans.

The reason is suggested to be a positive effect of nitrate on plant growth, which is food for these animals. High N-deposition is expected to reduce the degree of N-limitation of temperate forests and can change forests growth from N- to P- limitation. This can in turn decrease soil pH which can increased P-fixation and diminish the P-availability for plant growth.

Studies have shown that lakes receiving high deposition of N were forced towards extreme P-limitation and consequently low plant growth and high excess of nitrate (high N-saturation stage). To understand N-leaching better, limitation either by climate, N or P during the year should be stated before evaluation of the leaching. We should also put the catchments into categories like forest cover, open landscape, bogs and barren rocks and bring forward knowledge of water turnover rate and the steepness of the catchments. It is also suggested that high N-deposition in the long run will enhance P limitation and consequently increase N-leaching also at lower N deposition rates. The question is if increasing P-limitation can lead to oligotrophication both of terrestrial and aquatic environments – is it a self forcing process?

9. Norwegian lake survey 2004 – 2006; some results

Brit Lisa Skjelkvåle[1], Sigurd Rognerud[1], Guttorm Christensen[2], Eirik Fjeld[1] and Oddvar Røyset[1]

[1]NIVA and [2]Akvaplan-Niva

Introduction

Long-range transboundary air pollution (LRTAP) is the most important source of contaminants to the natural environment in Norway. Since the mid 1970s several large regional surveys on heavy metals in moss, soil, sediments and surface water have been conducted to give an estimate of their "natural" levels and the relative contributions from natural and anthropogenic sources.

In 2004 – 2006, a new national lake survey was conducted. In this survey, 316 lakes from all over the country, including lakes at Bjørnøya (Bear Island) and Spitsbergen, located in the Arctic, were investigated in order to monitor and map the level of acidification, nutrients and trace metals in the water, and trace metals and PAH and PCBs in lake sediments in the same lakes. POPs and metals were analyzed in 42 lakes and in eight fish populations in northern Norway and the Arctic.

Three reports have been published from this survey. The text in this paper is based on results from these reports.

- Skjelkvåle, B.L., S. Rognerud, G.N Christensen, E. Fjeld & O. Røyset. 2008. Nasjonal innsjøundersøkelse 2004-2006, DEL I: Vannkjemi. Status for forsuring, næringssalter og metaller (part I: Water chemistry. Status of acidification, nutrients and metals) NIVA-rapport; LNO-5548/2008, Statlig program for forurensningsovervåking, SPFO rapport; 1010/2008, SFT-rapport TA-2631/2008. Statens forurensningstilsyn (SFT), Oslo.
- Rognerud, S., E. Fjeld, B.L. Skjelkvåle, G.N. Christensen & O. Røyset. 2008. Nasjonal innsjøundersøkelse 2004–2006, DEL 2: Sedimenter. Forurensning av metaller, PAH og PCB.(PART II: Sediments. Pollution from metals, PAH and PCB). NIVA-rapport; LNO-5549/2008, Statlig program for forurensningsovervåking, SPFO rapport; 1011-2008, SFT-rapport TA-2632/2008. Statens forurensningstilsyn (SFT), Oslo. 77 pp.
- Christensen, G. N., Evenset, A., Rognerud, S., Skjelkvåle, B. L., Palerud, R., Fjeld, E., & Røyset, O. 2008. Coordinated national lake survey 2004 - 2006, Part III: Status of metals and environmental pollutants in lakes and fish from the Norwegian part of the AMAP region. Statlig program for forurensniningsovervåking, SPFO-rapport; 1013-2008. SFT-rapport TA 2363-2008. Statens forurensningstilsyn, Oslo.

Methods

316 lakes where sampled over three years (2204-2006), with approximately 100 lakes each year. Medium size of the lakes was 0.67 km^2, from the smallest at 0.04 km^2, to the largest at 21.7 km^2. Almost all the lakes had been sampled in previous surveys, although previous surveys not always included the same sampling programme and analytical variables as in the current survey. The lakes were originally selected to reflect influence from LRTAP, so lakes with local pollution sources were avoided. Most of the lakes were oligotrophic, nutrient poor lakes, sensitive to changes in air pollution.

Sampling was mostly done in autumn, after lake turnover, although this criterion had to be given up the third year due to bad weather conditions the autumn the second year of the survey. To secure sampling in northern Norway we had to start sampling in August. This does not influence the interpretation of metals in lake water or in the sediments, but it may influence the interpretation of the nutrient status and the acidification of lakes in northern Norway.

Field work were done with airplane and both water samples and sediment coring where done from the plane. Water chemical analysis was done at NIVA with regular methods, while metals and metalloids were analysed with HR-ICP-MS. PAH and PCBs were analysed at NIVA and at UNILAB in Tromsø. POPs were analysed at Typhoon lab in Obnisk, Russia.

Results

Acidification

The survey confirmed the results from the national acid rain monitoring programme (SFT, 2008). The most acid lakes with lowest pH and acid neutralizing capacity (ANC) (Figure 1) were found in the southernmost part of the country where we also find the highest deposition load of LRTAP. There was a significant decrease in sulphate and an increase in alkalinity, ANC and pH since the last survey in 1995, due to reduced acid rain in the period. There was also an increase in total organic carbon (TOC) in the eastern part of the country over the 10-year period, and in this area there had also been a decrease in pH, probably due to the increase in organic acids. The increase in TOC in connected to the decrease in sulphate (Monteith et al, 2007).

Nutrients

The survey is not at all representative of nutrient rich (eutrophic) lakes, but is very suitable for mapping the influence of eg., nitrogen (N) deposition to the lakes. The nitrate concentrations showed highest concentrations in south-eastern part of the country, where we also find the highest N-deposition load (Figure 1). This result is in line with previous surveys. Phosphorus (P) also showed the same low concentrations as in the previous survey with a median for total-P for the 316 lakes at 3 µg P/L.

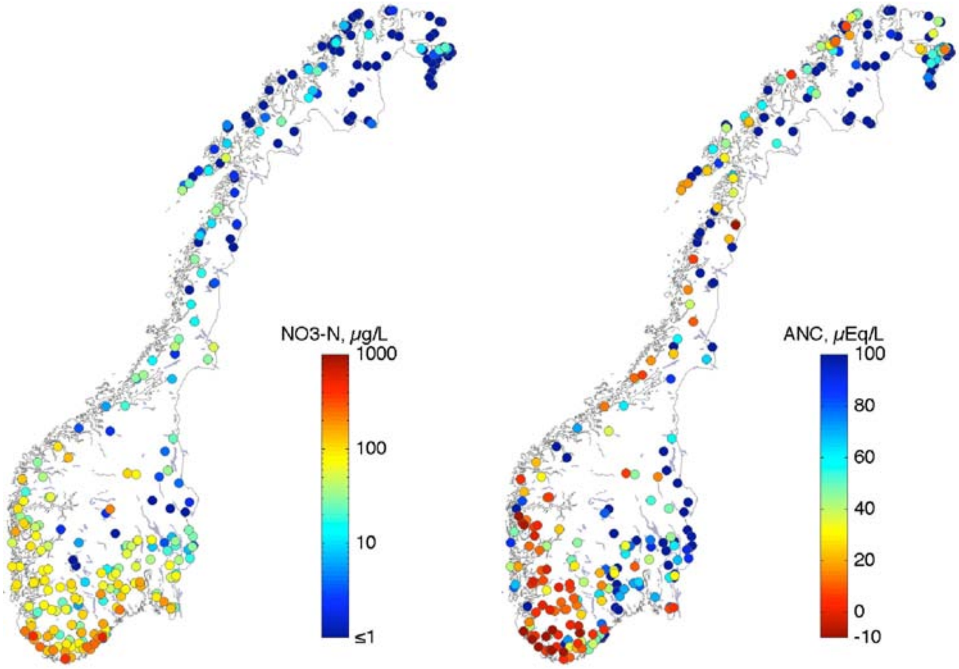

Figure 1. *Nitrate (NO3-N in µg N/L) and ANC (Acid neutralizing capacity µeq/L) in approx 300 lakes sampled from 2004 - 2006.(from Skjelkvåle et al. 2008)*

Metals in lake water

The concentration range and the median values of the analysed metals in the 316 lakes samples from 2004-06 where surprisingly similar to the approx. 1000 lakes investigated in 1995. Since most of the lakes were different between the two surveys, it is not possible to conclude anything about changes in concentration levels. But still it was clear that the concentration of lead (Pb) (Figure 2) had decrease in east- and southern Norway and that nickel (Ni) (Figure 2) had increased in eastern Finnmark close to the Russian border.

Many trace metals (Pb, cadmium (Cd), zinc (Zn), arsenic (As), tin (Sn), antimony (Sb), thallium (Tl) and bismuth (Bi)) showed a geographical pattern typical for pollutants where the sources are LRTAP, with the highest concentrations in southernmost parts of Norway, where also the deposition load from LRTAP is at the highest. This was also supported by statistical analysis.

The results showed that pollution from metals is probably a limited problem today in Norwegian lakes not influenced by local pollution, due to low concentrations of most analysed metals. Mercury was not analysed in water due to analytical challenges. In humic lakes in eastern Norway the concentrations in fish are so high that it is not recommended for consume, indicating that Hg is a large environmental problem in Norwegian lakes.

Southern and south-eastern part of Norway is most influenced from LRTAP; S and N, metals and other pollutants such as POPs. The combined effects of these pollutants on the aquatic biota are not assessed.

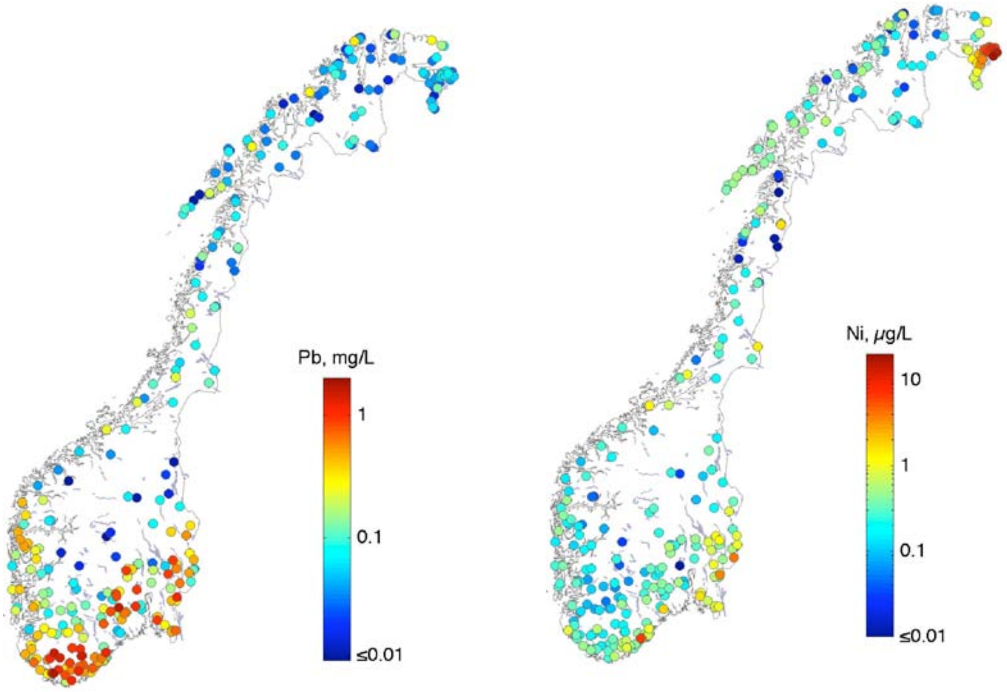

Figure 2. *Lead (Pb) and nickel (Ni) in approx 300 lakes sampled from 200 4- 2006.(from Skjelkvåle et al. 2008)*

Metals in lake sediments

The results from the lake sediment survey showed that a number of metals are quite common in Norwegian lakes, but also that the concentration levels are low. Elevated concentrations in lakes in southern part of Norway are attributable to LRTAP. In some cases local point sources or natural high concentrations in the bedrock or surface deposits may influence the concentration levels of some metals in the sediments. The highest metal concentrations were found in lakes in an approx 150 km wide belt along the coast form the Swedish boarder to western Norway. Also lakes along the coast of northern Norway showed somewhat higher concentrations than inland lakes in the area. The most important contributors to pollution of Norwegian lakes are LRTAP of Pb, As, Zn, Sn and Hg (Figure 3). Pollution of copper (Cu), Ni, chromium (Cr), cobalt (Co) is mostly due to emission from local industry.

The highest concentrations of Zn, Co, Cu and Ni were found in southern and south-eastern Norway but also in lakes in the eastern parts of Finnmark close to the Russian border. In southern parts of Norway there has been a significant decrease in Zn, Co, Cu and Ni while eastern Finnmark show an increase due to increased production at the smelter in Nikel, Russia.

In southernmost part of the country, most analysed elements show a decrease from the uppermost 0.5 cm sediment layer to the underlying 0.5 cm sediment layer, indicating reduced pollution load over the last 10-15 years. The exceptions are Sn, tellurium (Te) and wolfram (W) which show an increase in lake sediments in the southernmost part of Norway and Cu and Ni that increase in lake sediments in eastern Finnmark.

In the previous lake survey 1996/97 there was only documented reductions for Pb and Cd, while it is now clear that many metals decrease in lake sediments, including Hg. The increase in Sn, Te and W is probably due to an increase in emissions of these elements after 1940, due to more use of high technology equipment where these elements are used.

The increase in concentration from pre-industrial time to present is Pb>As>Bi>Sb>Hg.

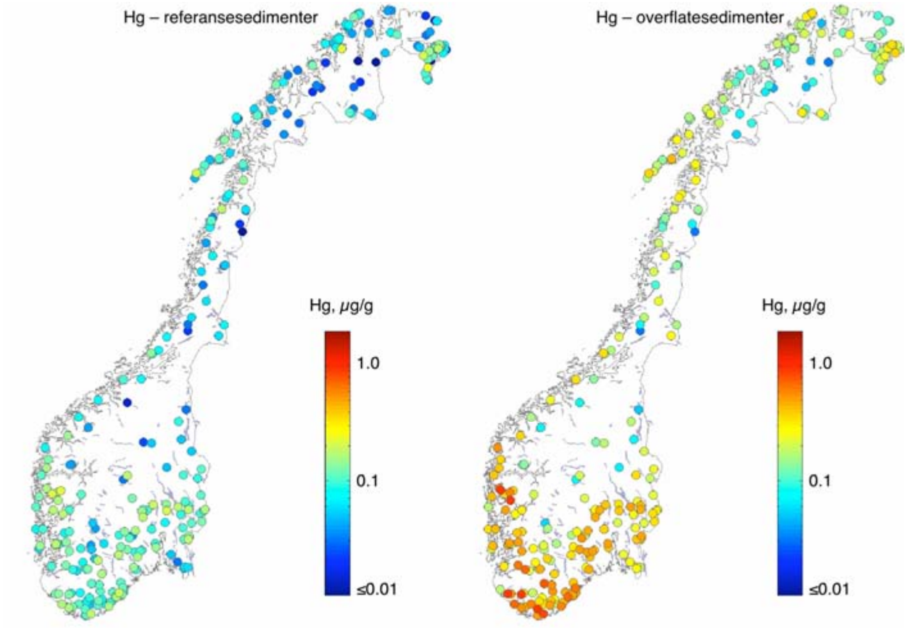

Figure 3. *Mercury (Hg) in reference layer of the sediment (pre industrial time)(left panel) and top sediment (right panel) in 300 lakes sampled from 2004 - 2006 (from Rognerud et al. 2008).*

PCB and PAH in sediments

PCB and PAH were only measured in lake sediments. The highest concentrations of PAH was found in lake sediments in southern Norway, but also lakes along the coast in northern Norway showed elevated concentrations (relative to reference sediments) (Figure 3). PAH is originating from LRTAP, but also ships, offshore activities and emissions from local sources contribute.

PCB showed low values in all lakes all over the country. The highest concentration levels of PCB (Figure 3) were found in lakes from southern Norway, with some few exceptions such as Lake Ellasjøen at Bear Island and Lake Kongressvatn at Spitsbergen (not shown on the map). In southern Norway the levels of PCB have decreased significant since the lake survey in 1995/96 while the levels in Northern Norway and Spitsbergen only were slightly lower compared to 1995/96.

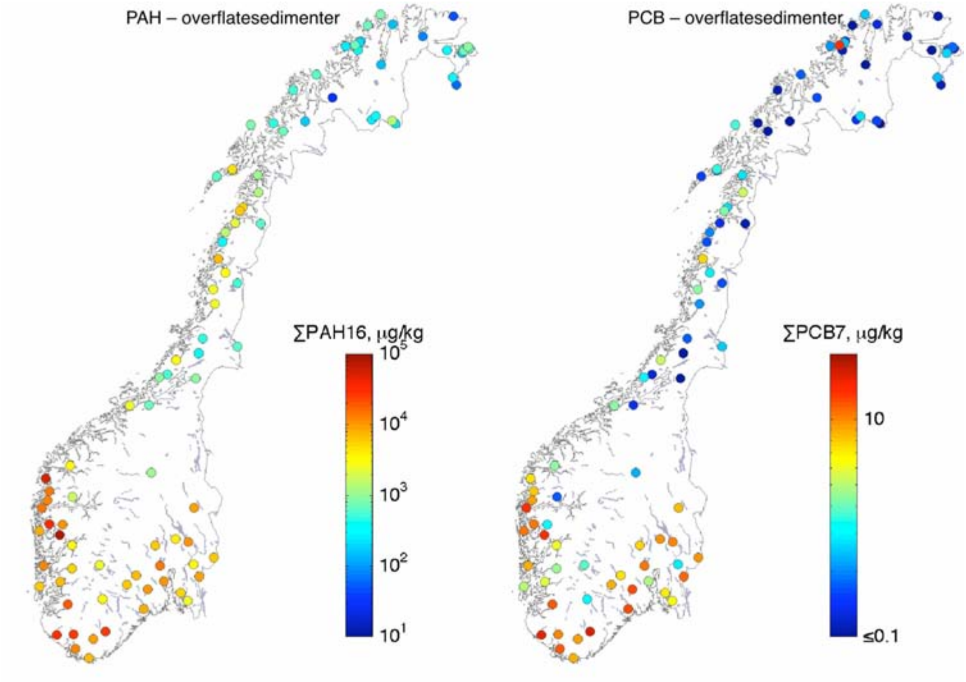

Figure 4. PAH and PCB in top sediments in approx 300 lakes sampled from 2004 – 2006 (from Rognerud et al. 2008).

POPs in sediments and fish Northern Norway and the Arctic

In Northern Norway it was in addition to PAH and PCB measured other environmental pollutants (POPs) in sediments in 42 lakes and in eight fish populations. The results showed that concentrations of most chlorinated pesticides were low. The highest concentrations were found in lakes at Bear Island and Spitsbergen. Concentration levels of DDT were the same as shown from other investigations in southern Norway. Polybrominated flame retardants (PBDE) was found in all the 42 investigated lakes, but he concentration levels were low.

The fish contained organic pollutants, although the concentration levels were low. The highest levels of pollutants were found in fish from lakes at Bear Island and Spitsbergen. The level of POPs in Arctic char in Lake Ellasjøen is some of the highest levels ever recorded in freshwater fish in the Arctic. The metal concentrations were low in fish samples from all lakes.

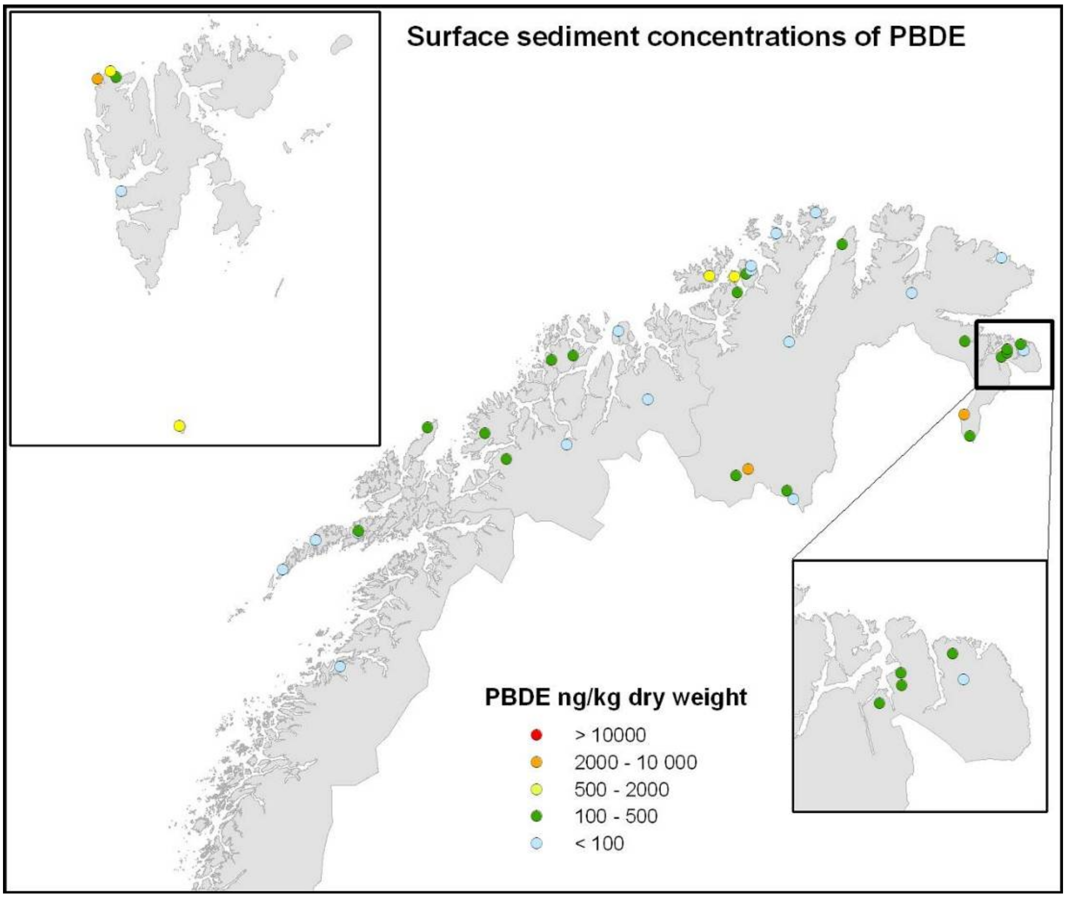

__Figure 5.__ Map illustrating concentrations of ∑PBDE in surface sediment (0 - 1 cm) from lakes on the mainland of Northern Norwegian and on Svalbard. (from Christensen et al. 2008).

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10. Calculating and mapping of critical loads on surface waters for selected sites in Republic of Croatia

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Introduction

The project '*Calculating and mapping of critical loads on surface waters for selected sites in Republic of Croatia'* started in late July 2007 and was finished in July 2008. The end-user of the project was the Croatian Environment Agency (CEA). The financial resources for the project execution were provided by the Swedish Institutional Support Fund in Republic of Croatia (SISF).

The Energy and Environmental Research Institute (EKONERG) was the lead contractor with two subcontractors – The Norwegian Institute for Water Research (NIVA) and the Faculty of Science, University of Zagreb. The main objective of this study was to assess the impact the deposition of acidifying compounds has on freshwater ecosystems in selected areas of Croatia.

Site selection

The selected approach is based upon two levels of selection, which represent logical sequence, and equally follow the requirements of the project tasks and the ICP Waters Programme Manual related to site selection procedures. On the basis of completed analyses, three sites were selected for programme implementation (Figure 1).

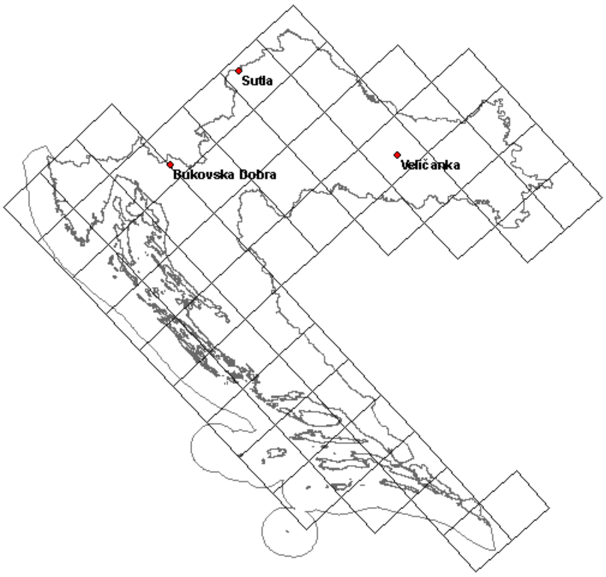

Figure 1. *Selected sites:*

Project conclusions

Chemical monitoring

- The majority of physical and chemical parameters recorded at all sites the four research periods belong to class I according to National Water Classification Regulations.
- Parameters related to acidification (especially pH and low alkalinity) show excellent condition in the examined sites.
- Higher nutrient classification (class II and III) was recorded, and could be explained by: influence of flow, increased nitrogen leaching due to natural seasonality and analytical error.
- Heavy metal analyses in water were obtained using ICP-MS methodology.
- Results show that there is a significant need for improvement in laboratory practice to narrow the differences between results and to avoid possible systematic errors.

Biological monitoring

- Highly acid sensitive organisms was present in all three watercourses (Veličanka, Bukovska Dobra and Sutla), the acidification score was thus calculated to 1 and the watercourses to category A (not threatened by acidification).
- Analyses of benthic invertebrate communities indicate that all three selected sites have in average a class I water quality according to Extended Biotic Index (EBI).
- Based on the composition of diatom indicator species and their population densities, the saprobic index (SWegl) was calculated. All sites were classified as having a water quality of class II, or being ß-mesosaprobic waters, which indicates a slight organic burden.
- High percentage of alkalibiontic and alkalyphilic diatom species in total also indicates non-acidified freshwaters.
- Increased nutrient concentrations at all three locations were confirmed using Trophic Diatom Index (TDI) while Generic Diatom Index (GDI) indicated higher eutrophication status for Sutla, minimal eutrophication at Veličanka and no eutrophication at Bukovska Dobra.
- Diatoms of genus Nitzschia were co dominant at Sutla and subdominant at Veličanka and Bukovska Dobra indicating higher abundance of organic matter in these watercourses.
- Fish community analyses indicate clean and unpolluted waters at Bukovska Dobra and Veličanka while Sutla was categorised as mostly clean and relatively unpolluted.
- The overall water quality status, on the basis of biological monitoring, indicates clean waters and undisturbed communities.

Modelling

Calculated critical loads of acidity (CL(A)) for all three selected sites are high. When comparing them with S and N deposition data, acquired from the document *Transboundary air pollution by main pollutants (S, N, O_3) and PM – Croatia,* it was obvious that CL(A) was not exceeded in any case (*see Figure 2*). Therefore, further modelling activities were not necessary.

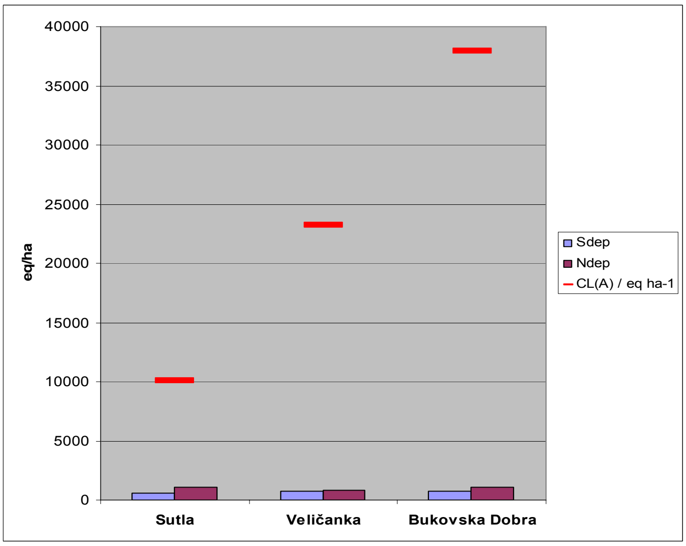

Figure 2. *Comparison of deposition and critical load of acidity data*

General conclusions

- Critical loads of acidity of all three sites selected are high
- Critical loads of acidity of all three sites are much higher than sulphur and nitrogen deposition; therefore there are no exceedances present
- Acidification of watercourses is not a distinct problem for Croatia

11. The biological database and its use for the Water Framework Directive

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A resent paper tested different acidification indices by use of multivariate statistical methods. The material consisted of monitoring data from Norway, UK and Sweden - all together 564 sites. The paper confirms earlier knowledge of sensitive and tolerant species and their thresholds with regard to pH. Development of metrics using proportional abundance showed, however, changes in species composition before extinction. Increase of DOC had a positive effect on sensitive species, as a higher number of species were found in humic lakes than in clear-water lakes at a given pH. The significant relationship between different invertebrate metrics and acidification showed a potential for further development of assessment systems for the ecological quality of lakes. The predictive power depends on harmonization, standardisation of sampling and taxa identification. Proposed method for evaluation of the ecological status of rivers for the Water Famework Direktive (WFD) regarding pollution is to use the British Monitoring Working Party (BMWP) score system. The BMWP is the sum of scores given for families of invertebrates recorded at a site. Families given high scores, > 7, indicate low pollution, while families representing low scores, < 5 indicate pollution or low ecological status. The average score per taxa, the ASPT score, indicate the ecological status of the site. Finally an ecological quality ratio, the EQR, can be calculated. This is the ASPT in relation to an original ASPT (an expert judgement of the site in an undisturbed situation). EQR will normally be < 1. The families giving a high BMWP score are normally very tolerant to acidification and vise versa. Examples of ecological status based on ASPT and by use of the Acidification index showed large discrepancies for most of the sites from the ICP water database. Most monitored sites in Norway had a high ASPT with low variation over time. High ecological status was the main trend. The same sites varied greatly regarding acidification. Some of them were strongly acidified, while other had low acid damage. Also improvement over time was observed. This variation in ecologic status regarding acidification was not detected by the ASPT. Sites in other countries demonstrated opposite situations with low ASPT and high Acidification index.

The biological data in the ICP Water database is well suited for evaluation of ecological status for the WFD. The database is well harmonised and quality controlled. The ICP Water data consists of long time series and some of them are unique. Evaluation of both organic pollution and acidification is needed for evaluation of the damage of an ecosystem. BMWP/ASPT does not take damages caused by acidification into account. The WFD must therefore include the acidification status separately. The goal is that both indices should indicate good ecological status. The long series of the ICP water database will be an important corrective for the WFD, and EQR can be calculated and compared over time. The database can put light on the distribution area of species that can be influenced by climate change. General long term biological changes are possible to analyse by use of this database. The River Basin Districts should use the information from ICP Water when there is an overlap between watersheds and “sites”.

12. Position paper on links, complementarities and common interests between LTRAP convention and the Water Framework Directive

Prepared by ICP Waters Programme Centre and discussed at the ICP Waters TF Meeting in Budapest 6.-8. October 2008.

Bente Wathne, Heleen de Wit, Merete Ulstein and Brit Lisa Skjelkvåle

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The aim of this position paper is to explore the links, complementarities and common interests between monitoring and assessing water quality under the LTRAP Convention and under the Water Framework Directive (WFD)

Procedures and methods under both legislations are not identical, but both aim at improving water quality and ecosystem conditions to achieve and maintain a healthy ecosystem structure in our surface waters. Within the WFD all parties involved within a river basin are obliged to take measures to improve the ecological status of the water bodies, while within the LTRAP convention the long range transport of chemicals between countries and over river basins is addressed.

We wish to draw attention to mutual benefits that can be drawn by both legislations by closer cooperation and integration of respective evidence bases. In particular we highlight advantages in the sharing of data and expertise with regard to assessment of ecological status of water bodies. This concord with a key objective of WFD that:” Member States will have to ensure that a co-ordinated approach is adopted for the achievement of the objectives of the WFD and for the implementation of programmes of measures for this purpose.*”*

The Water Framework Directive (WFD) has been developed to protect European waters and came into force on 22nd December 2000. Its overall, and very ambitious, goal is good ecological status in all water bodies within 2015. The work under the WFD is organized in River Basin Districts (RBD's). Integrated monitoring and management systems will be established for all waters within the RBD, to develop a dynamic programme of management measures within a River Basin Management Plan.

Central to the Water Framework Directive is a requirement for Member States to encourage the active involvement of all interested parties in its implementation.

The ICP Waters monitoring programme was initiated under the Convention on Long-Range Transboundary Air Pollution (CLTRAP). Its objectives are to assess the degree and geographic extent of effects of air-pollution on surface waters, collect information to evaluate dose/response relationships and define long-term trends and variations in aquatic chemistry and biota attributable to air pollution. This monitoring programme has been recognized over the years to be a strong tool for documenting long-term trends in water quality and for predicting future ecosystem changes occurring under different deposition scenarios.

Results from the ICP Waters monitoring programme are reported to the CLRTAP. The programme is based on data from national programmes that follow harmonized procedures. One of the major accomplishments of the ICP Waters collaboration is improved quality of biological and chemical methods, through yearly intercomparisons and intercalibrations. This is essential for the generation of reliable data that document the state of ecosystems as a basis for improved protection and management. A major achievement of the ICP Waters programme is high quality and long-term records in both biota and chemistry.

Complementary focus of monitoring under WFD and under CLTRAP

The WFD has as its main unit the River Basin District (RBD) where policies are implemented. This necessarily results in a focus on local ecological impacts rather than problems of a transboundary nature including air pollution. Consequently the WFD focuses on larger rivers and lakes where the effects of cultural eutrophication, other urban and industrial contamination, hydro-physical modification etc. are of major concern. For transboundary air pollution, emission abatement strategies are negotiated at CLRTAP, and concern is focused predominantly on the ecological health of headwater rivers and lakes that tend to be most sensitive to changes in the chemistry of deposition.

While this dichotomy of focus is understandable there are clear scientific and policy gains to be made by establishing better links between the two approaches. Headwater ecosystems can be considered early warning systems where changes in water quality related to climate and air pollution are observed earlier than in larger systems. Changes in headwater environments can have knock-on effects further down catchments. Changes in dissolved organic carbon concentration in headwater catchments, for example, can drive large increases in water colour and have significant ecological implications throughout an RBD. Headwater streams also serve as vital spawning habitats for migratory fish, one of the key target organisms under the WFD.

Thus, WFD and CLTRAP have both overlapping and complementary aims. The mutual benefits for coordination of monitoring programmes under both legislations relate to harmonization of monitoring strategies and data sharing**.** Monitoring results from the ICP Waters programme and the national headwater monitoring programmes that feed it, can be used to assess the ecological status of water bodies little affected by direct human activity, and could thus supplement WFD monitoring within RBDs, and improve comparability across geographical borders.

The WFD requires biological data and measurements, and in areas subjected to acid precipitation these data especially are of common interest, as ICP Waters needs them to improve the dose-relationship understanding.

Actions forward

It is the understanding of the ICP Waters Task Force meeting that initiatives should be taken on national level to approach river basin management/authorities and draw their attention to data availability on small water bodies in headwater ecosystems.

During accomplishment of a newly initiated upgrading of the ICP Waters Programme Manual, as well as through intercalbrations and intercomparisons exercises, it will be secured that the Programme activities shall be fully in harmony with guidelines given for monitoring under the WFD, to optimize comparability between the monitoring results from the ICP Waters and the WFD.

The scope of the WFD covers all human impacts on water bodies, including those pollutants that stem from transboundary air pollution. However, it is currently unclear how the detrimental effects on water bodies from long-range transported components will be addressed as the necessary countermeasures will fall primarily on regional to national governments, and thus outside the remit of local agencies with responsibility for RBDs. The WFD ought to utilise the resources and experience of the ICP Waters monitoring network and from the wider national programmes that support it.

We note also that the WFD includes targets also for hazardous substances and heavy metals, some of which have important deposition sources. Headwaters may serve as important conduits for more volatile toxins, and there is a clear need for further research and cooperation as general behavior across landscapes, and interactions with climate are currently poorly understood. As headwaters are mostly regarded as unpolluted under the WFD, with no upstream pollution sources, it is important that ICP Waters can stress the potential pollution through long-range transport and inclusion of measures within the RMP plans.

Stronger links between WFD and ICP Waters monitoring sites should support continuation of some of the world’s finest long-term national monitoring programmes. Long-term records from headwaters can provide valuable information on realistic “background levels“ for larger water bodies downstream and give a timely supplement to understand and follow long-term changes. These bodies will eventually also be indicators for climate change that are to be included in the revision of the present WFD guidelines.

Water Framework Directive

Key Objectives:

The WFD sets a framework for comprehensive management of water resources in the European Community, within a common approach and with common objectives, principles and basic measures. It addresses inland surface waters, estuarine and coastal waters and groundwater. The fundamental objective of the Water Framework Directive is to maintain “high status” of waters where it exists, prevent deterioration in the existing status of waters and achieve at least “good status” in relation to all waters by 2015. Member States will have to ensure that a co-ordinated approach is adopted for the achievement of the objectives of the WFD and for the implementation of programmes of measures for this purpose. The objectives of the WFD are:

- to protect and enhance the status of aquatic ecosystems (and terrestrial ecosystems and wetlands directly dependent on aquatic ecosystems)
- to promote sustainable water use based on long-term protection of available water resources
- to provide for sufficient supply of good quality surface water and groundwater as need for sustainable, balanced and equitable water use
- to provide for enhanced protection and improvement of the aquatic environment by reducing / phasing out of discharges, emissions and losses of priority substances
- to contribute to mitigating the effects of floods and droughts
- to protect territorial and marine waters
- to establish a register of 'protected areas' e.g. areas designated for protection of habitats or species.

The directive rationalises and updates existing water legislation by setting common EU wide objectives for water. It is very broad in its scope and relates to water quality in rivers, lakes, canals, groundwater, transitional (estuarine) waters and coastal waters out a distance of at least one nautical

13. Reports and publications from the ICP-Waters Programme

All reports from the ICP Waters programme from 1987 up to present are listed below. 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/

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