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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

REPORT

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Summary

Proceedings of the 33rd Task Force meeting of the ICP Waters Programme in Uppsala, May 9-11, 2017. National contributions from Russia, Switzerland, and Moldova.

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1. Monitoring	1. Overvåking
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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 33rd Task Force meeting of the ICP Waters Programme in Uppsala May 9-11, 2017

Prepared at the ICP Waters Programme Centre
Norwegian Institute for Water Research
Oslo, October 2017

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 25 years) for many sites. The programme conducts annual chemical intercomparison and biological intercalibration exercises.

At the annual Programme Task Force, national ongoing activities in many countries are presented. This report presents national contributions from the 33rd Task Force meeting of the ICP Waters Programme, held in Uppsala, Sweden, May 9-11, 2017.

Heleen de Wit
ICP Waters Programme Centre

Oslo, October 2017

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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 Uppsala, Sweden, May 9-11, 2017 were grouped thematically. A short summary of each presentation is given in the Minutes (Chapter 4). Selected presentations are reported more extensively in the Proceedings.

Acidification and recovery

- Potential impact of forest biomass harvest on the acidity of Swedish surface waters*. Stefan Löfgren, Sweden.*
- Trends in S and N budgets of Swiss high-altitude mountain lakes (see Chapter 3)*. Steingruber Sandra, Switzerland.*
- Air and Surface Water Quality Monitoring System in Moldova*. Natalia Zgircu, Moldova.*
- Report on activities in CLRTAP*, Anna Engleryd, Chair EB.*
- The regional assessment on surface water acidification status*. Kari Austnes, ICP Waters Programme Centre.*
- A statistical method for detecting artefacts in time series*. Jens Fölster, Sweden.*
- DOC trends in Europe and North America*, Heleen de Wit, ICP Waters Programme Centre.*
- NEC directive - information and discussion on implication for national monitoring and international cooperation*. Anna Engleryd, Chair EB.*
- Integrated Monitoring Network in Poland - current status and future perspectives*. Tomasz Pecka, Poland.*

Heavy metals

- Heavy metal concentrations in terrestrial compartments and runoff across European IM sites. *Staffan Åkerblom, Sweden.*
- Spatial and temporal trends of mercury in freshwater fish in Fennoscandia. *Hans Fredrik Veiteberg Braaten, ICP Waters Programme Centre.*

Biology responses to air pollution

- Environmental drivers of leaf litter decomposition in streams, *Andreas Bruder and Julien Cornut, Switzerland*
- Species sensitivity to acidification in highly endemic regions of South Africa. *Londiwe M Khuzwayo, South Africa.*

- Nitrogen deposition impacts in the Austrian IM site Zöbelboden – long-term observations and future research directions. *Ika Djukic, Austria.*
- Gas supersaturation may cause effects on the biota comparable to acidification. *Gaute Velle, ICP Waters Programme Sub-centre*
- Co-analysis of coniferous forest state parameters and atmospheric deposition data series obtained by ICP IM and EMEP at European part of Russia. *Ekaterina Pozdnyakova, Russia*
- Recovery of benthic algal assemblages from acidification: how long does it take, and is there a link to eutrophication? *Jakub Hruška, Czech Republic.*

Critical loads/dynamic modelling

- Soil modelling study VSD+. *Maria Holmberg, ICP IM Programme Centre.*
- Acidification and Critical Loads of Surface Waters: European Territory of Russia and Western Siberia (see Chapter 2). *Marina Dinu/Tatyana Moiseenko,Russia.*
- Relationships between critical load exceedances and empirical impact indicators - Update of N assessment. *Jussi Vuorenmaa, ICP IM Programme Centre.*

2. Acidification of Surface Waters: European Territory of Russia and Western Siberia

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In the middle of the last century the use of fossil fuels has led to the acid rain and the acidification of water in some regions of Europe and North America (Henriksen et al., 1992; Driscoll et al. 2003). In the past two decades, sulfur dioxide emissions declined in Europe and North America, as well as in Russia and some authors have reported trends of lakes and rivers recovery (Stoddard et al.; 1999; Evans et al. 2001; Skelkvale et al., 2005; Garmo et. al. 2014; Moiseenko et al., 2013). In present times, SO_2 and NOx emissions are still high, especially in developing countries such as China and same country of South America (Kuylenstierna, 2001)**.** Therefore, the problem of water acidification is still the actual problem in the current century (Reitzel, 2013, Li, 1998).

Research of waters acidification in Russia has been neglected. It is connected with the system monitoring only for assessment of the large lakes and rivers water quality. One of the first methodologically correct territorial surveys of lakes in Russia was performed in the Kola North (international project «Survey lakes») (Moiseenko et al., 2013; Henriksen et al., 1992). Anthropogenic water acidification is developed by sulfur dioxide emissions from the local copper-nickel smelter. The anthropogenic acidification lakes in some other regions of Russia such as Karelia, Arkhangelsk and Vologda (Moiseenko et al., 2013) were found later.

Study area and water sampling. European Russia (ER) is located from the north of the Kola Peninsula to the Caspian depression (East European Plain), average elevation is 170 m a.s.l., some hills rising to 300–400 m a.s.l. or more. In the northern part of the plain (in the Kola Peninsula and Karelia) the crystalline Archean and Lower-Proterozoic outcrops form the Baltic Shield, whereas the southern part of the plain is covered by thick Upper-Proterozoic and Phanerozoic sedimentary rock. A total of 201 small lakes in European Russia along a transect from the Kola Peninsula (tundra and taiga zones) to the Caspian Lowland (arid zone) were sampled from 2000 to 2005 using the same methods employed in the 1995–1996 Northern European lake survey (Henriksen et al. 1992) (Fig.1).

Western Siberia (WS) is located from the tundra of the Yamal Peninsula to the steppe zone of the Kurgan Region (from north to south). The area consists of monomineral Quaternary deposits with a predominance of quartz sand and loose silicate rocks. Permafrost is widespread in tundra and taiga zones of WS. Rainfall is dominated over evaporation and coefficient of humidification is more than 1.2. The extensive development of the wetland is a feature of WS. The percentage of swamp watersheds of taiga lakes may be 70-90%. Wetland waters entering the lakes have a natural acidic (pH ≤5) and high color (> 100 °Pt/Co). The watersheds in southern regions are characterized by naturally salinization (Starikov, Tul'kova, 2010). 166 lakes samples in WS from the Yamal and the Gydan Peninsulas to the Kurgan Region forest-step were collected in 2011-2014 using the same methods (**Figure 1**).

The selected lakes ranged from 0.4 km^2 to 20 km^2 in surface area and don't have direct sources of anthropogenic pollution in their catchments. Water samples were collected in plastic bottles without sorbing properties. In the field, the bottles were rinsed twice with lake water, and placed into dark containers and cooled to 4 ^{0}C. Water samples were transported to the laboratory as soon as possible (within 5-15 days). The sampling was carried out during autumn turnover (from late September for tundra lakes to late November for lakes on the steppe) to minimize the effect of interannual and seasonal variations.

Chemical analyses were carried out using techniques outlined in the Standard Methods for the Examination of Water and Wastewater (Eaton et al., 1992). Methodology Research was unified in three laboratories and analyzes were carried out by one method recommended in the user manual ICP Waters Programme Manual 2010 (report NIVA 105/2010): in the Laboratory of the Institute of North Industrial Ecology Problems, Kola Science Centre (INEP RSC RAS), Laboratory of water quality, ecosystem sustainability and ecotoxicology Tyumen University and the Laboratory of Institute of Water Problems of RAS. The quality of the analytical results of INEP RSC RAS was repeatedly tested by intercomparisons in frame of "International Cooperative Programme on Assessment and Monitoring of Acidification of Rivers and Lakes" (Intercomparisons, 2005-2010).

Results and discussion. The acidification of water and soil in acid-sensitive areas of Russia has not been thoroughly investigated. Therefore, we have researched acidification of lake water in European Russia (from the Kola Peninsula to the Caspian lowlands) and in Western Siberia (from the Yamal Peninsula to the forest-steppe Kurgan region).
Large areas have been investigated and despite the different periods of the research our results are quite comparable, due to the absence of radical changes of anthropogenic activities in the investigated regions. The chemical composition of water ER and WS are shown in **Table 1**. and **Table 2**.

The main feature of both regions is an increase of cation concentrations and alkalinity in water towards the south. In both regions, there is an increase in the content of mineral salts: for ER - 50-55 °, for WS - 57-62 ° Norse latitude due to geological factors. The low salinity and oligotrophic nature of the lakes in the tundra and forest–tundra, northern and middle taiga region of ER and WS connect also with the features of geology. In humid regions, there are lakes vulnerable to acid deposition due to the low content of calcium and alkalinity.

Figure 1. Map showing location of the sampled waters.

High temperatures in the southern region promote intensive evaporation and high concentration of salts in the waters. We can conclude the lakes of forest-steppe zones in ER and WS are highly resistant to acidification based on **Table 1**. and **Table 2**. Therefore, further discussion of these lakes was excluded.

Deposition of anthropogenic sulfur in the European Russia is estimated at 0.8-1.5 gS/m2yr and nitrogen at 0.1-0.6 gN/m2yr (EMEP, 2010). The acid deposition in Western Siberia is 0.1 - 0.5 keq/ha yr (Semenov, 2002). Over the last decade the amount of depositions has not changed (EMEP, 2014). In the northwest of Russia, in the central regions and the south of European Russia, in the Urals region, in the center of Western Siberia, in the south of Eastern Siberia, as well as the northern coast the precipitation with high acidity (pH<4) is observed. According to Protasov et al. (2000), the frequency of precipitation with a pH <5 is 30-80% depending on the season and the region. **Figure 2** shows the deposition of acids in the regions studied.

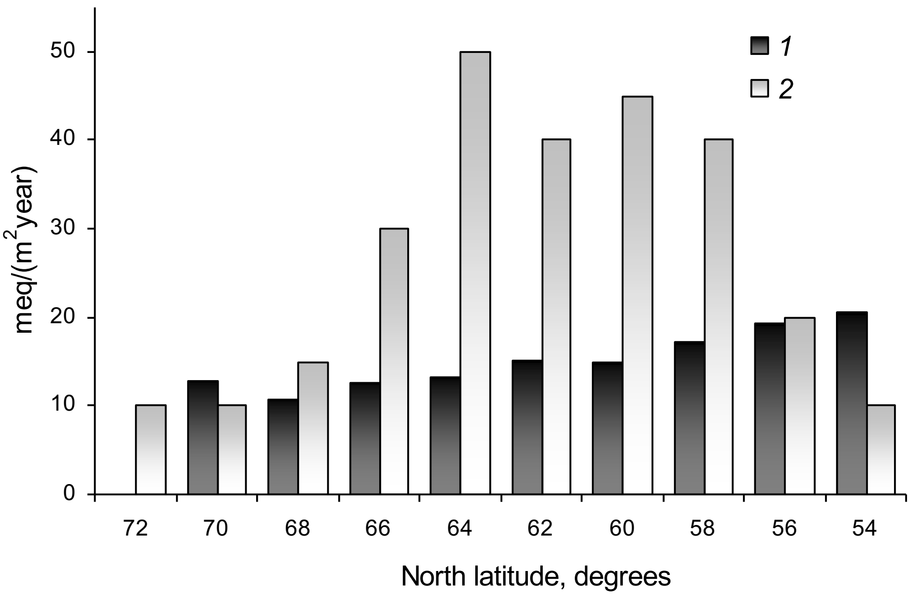

Figure 2. Deposition of strong acids by the latitudinal gradient in the European territory of Russia - 1 (EMEP, 2000) and in Western Siberia -. 2 (Semenov, 2002)

Table 1. Hydrochemical characteristics of lakes of different natural zones European Russia (the numerator - the median (bold), the denominator - the limits of contents).

Element	Natural zones				
	Tundra and forest tundra n=35	Northern taiga n=73	Middle taiga n=97	Mixed forests n=53	Forest-steppe and steppe n=20
pH	**6.36** 4.65-6.86	**6.61** 4.49-7.51	**6.72** 4.41-7.74	**7.49** 4.72-8.82	**8.11** 6.78-9.66
Color, ^{0}Pt-Co	**20** 5-69	**34** 0-125	**52** 4-202	**45** 8-156	**23** 10-120
Ca, mg/l	**1.08** 0.44-2.11	**2.24** 0.18-5.85	**2.87** 0.91-9.58	**21.2** 3.31-50.0	**43.9** 14-132
Mg, mg/l	**0.73** 0.40-1.39	**0.66** 0.06-5.23	**1.10** 0.92-4.20	**3.75** 0.60-15.6	**15** 1.2-74
K, mg/l	**0.34** 0.15-0.80	**0.41** 0.05-2.27	**0.64** 0.10-3.67	**0.77** 0.10-8.10	**15** 1.3-23
Na, mg/l	**3.54** 2.18-9.52	**1.6** 0.43-10.2	**1.8** 0.5-11.9	**1.90** 0.4-14.1	**50.5** 1.4-115
NH_4^+, µgN/l	**16** 1.0-60	**21** 1-509	**24** 1-690	**170** 1-5440	**580** 180-1610
Alk, µeq/l	**70** 0-135	**161** 0-839	**175** 15-839	**1239** 50-2900	**2400** 500-8500
SO_4^{2-}, mg/l	**2.37** 1.03-6.16	**2.06** 0.72-5.50	**3.58** 0.87-12.78	**5.01** 0.53-42.20	**24.25** 10.00-259.00
Cl^-, mg/l	**5.33** 2.95-15.40	**1.08** 0.40-9.35	**1.22** 0.39-14.90	**2.13** 0.44-24.00	**34.50** 0-119.00
NO^-_3+NO^-_2, µgN/l	**1** 1-15	**2** 1-480	**4** 1-595	**86** 1-840	**120** 20-220
A^-, µeq/l	**18** 6-49	**30** 1-89	**38** 7-117	**44** 15-151	**32** 7-271
Al, µg/l	**53.8** 15.5-180.0	**54.2** 8.9-808.0	**70.0** 2.4-672.0	**15** 0-700	**8.8** 0.1-35.8
Fe, µg/l	**66.7** 13.7-710.0	**100** 3-3160	**197** 9-3300	**92** 0-1100	**5.0** 0.1-204.0
Mn, µg/l	**1.5** 0.2-18.0	**3.8** 0.3-37.8	**15.0** 1.3-94.0	**12.3** 0.1-144.0	**1.24** 3.06-17.70

Table 2. Hydrochemical characteristics of lakes of different natural zones Western Siberia (the numerator - the median (bold), the denominator - the limits of contents)

Element	Natural zones				
	Tundra and forest tundra n=57	Northern taiga n=35	Middle taiga n=74	South taiga n=11	Forest-steppe n=11
pH	**6.29** 4.81-7.71	**5.38** 4.54-7.17	**5.70** 4.50-7.74	**7.13** 6.50-7.63	**7.92** 7.47-8.75
Color, ^{0}Pt-Co	**22** 1-355	**51** 5-198	**58** 7-149	**107** 17-166	**34** 29-89
Ca, mg/l	**2.85** 0.72-5.74	**1.88** 0.86-3.55	**2.06** 0.94-18.15	**25.53** 3.54-72.19	**28.31** 0.84-33.06
Mg, mg/l	**1.11** 0.24-2.25	**0.59** 0.25-1.48	**0.56** 0.19-5.24	**9.85** 1.09-17.26	**0.41** 0.12-41.60
K, mg/l	**0.99** 0.20-4.04	**0.56** 0.17-2.66	**0.82** 0.18-2.25	**2.34** 0.83-4.53	**0.16** 0.03-14.00
Na, mg/l	**1.89** 0.60-5.87	**1.72** 0.70-9.51	**4.34** 0.92-20.62	**11.11** 2.47-24.81	**0.39** 0.15-70.02
NH_4^+, µgN/l	**170.3** 10.2-1114.3	**45.6** 7.2-1529.9	**57.8** 6.3-1228.6	**27.9** 10.7-730.3	**648.3** 10.8-2578.0
Alk, µeq/l	**182** 10-1502	**112** 0-306	**99** 0-1350	**2814.9** 217-5210	**6730** 5790-12300
SO_4^{2-}, mg/l	**0.64** 0.22-2.79	**0.48** 0-2.50	**1.42** 0.59-16.00	**0.88** 0.58-3.55	**0.67** 0.16-6.11
Cl, mg/l	**2.02** 0.61-11.54	**1.00** 0.34-13.16	**3.07** 0.55-24.40	**13.58** 1.20-17.94	**0.35** 0.09-26.39
NO_3+NO_2, µgN/l	**220** 1-2022	**177** 5-530	**21** 0-1546	**498** 4-3873	**60** 3-829
A^-, µeq/l	**16.72** 0.1-81	**50** 3-116	**69.67** 0.75-187	**66.98** 28.1-97.3	**125** 89-185
Al, µg/l	**12.6** 1.9-109.0	**46.9** 0.7-204	**32.4** 7.3-534.5	**13** 5-499	**24.7** 10.6-78.4
Fe, µg/l	**389** 76-2328	**374** 0-1457	**433** 11-4186	**139** 64-1394	**248** 16-1820
Mn, µg/l	**3.06** 0.13-8.46	**0.93** 0-8.46	**5.68** 1.98-29.7	**4.70** 2.13-30.0	**4.72** 1.10-24.00

The main differences in the chemical composition of the waters of the lakes investigated regions are found. The lakes in the both humid regions have pH value from 4.5 to 7.0. However, the median pH of waters in the WS is considerably lower than in waters from the ER (more than 1.0); especially in lakes that are naturally acidic due to a high content of organic matter in the waters. Number of lakes with an extremely low pH (<5) in WS less than in ER as were found. There are also a large number of lakes with very low alkalinity (<50 µeq/L) in ER compared with the lakes in WS. The most significant differences between the lakes water chemistry in ER and WS are observed in the content of basic anions. The higher concentration of sulfate due to the development of metallurgical industry was found in ER region.
The majority of investigated lakes of ER and WS are characterized by pH near 7.00 and color from 10 to 100 ° Pt-Co. In humid areas of both regions the lakes with high water color and the large concentrations of humic acids are distributed. Natural processes of humic acids leaching (allochthonic organic matter) from wetlands watersheds to water provide a natural low pH waters.
In same lakes with low pH and high water transparency the strong acid (sulfates, nitrates and chlorides) in the anionic composition are dominated. In the tundra and the taiga zones of ER the lakes with pH <6 and color of waters <10 oPt/Co are 4.4%, in WS are 8.2%. The lakes with color less than 30 oPt-Co and pH <6 in ER is 6.9%, in WS are 17.2%. The part of highly acidified lakes with pH <5 and color <30 oPt-Co in ER is 2.0%, while in WS is 5.0%. The lakes with low pH and low color are more likely point to anthropogenic acidification.

Conclusion. Water chemistry of the lakes ER and WS are determined by cumulative effect of the natural and the anthropogenic factors. Waters of small lakes (without a direct source of pollution) reflects of zonal, regional and local characteristics, as well as the contributions of pollutant atmospheric deposition. The main air pollution is determined by emissions of the ferrous and non-ferrous metallurgy (ER); the flaring of gas (WS). The geographic gradients increased the concentration of cations and alkalinity from the north to the south in waters. In the southern regions (forest-step) the lakes are resistant to acidification due to high content of base cations.
In humid areas of ER and WS the acidic lakes both natural and anthropogenic origin are identified. The processes of natural acidification associated with a high content of humus acids, especially in the waters of the lakes WS. The anthropogenic acidification of the lakes with high transparency of water (with a pH <5 and color <30 oPt-Co) is 2% in ER, and 5% in WS; with pH less than 6 is 4.4% in ER and 8.2% in WS (the tundra and the taiga regions).
In strongly acidified waters of lakes (pH <5) the dominate anions are sulfates (ER) and chlorides, sulfates and organic acids (WS). In the waters of WS the higher concentrations of the organic matter and nitrates connect with the extensive development of wetlands. Additionally, flaring of gas increases the level of nitrate and nitrite in the water of lakes. High chloride content connects with geological factors, but oil and gas fields can increase the chloride content around production sites too.

Reference.

1. Driscoll C.T., Driscoll K.M., Roy K.M., Mitchell M.J. 2003. Chemical response of lakes in the Adirondack Region of New York to declines in acidic deposition. Environmental Science and Technology 37. 10, 2036-2042. DOI: 10.1021/es020924h
2. Evans C.D., Cullen J.M., Alewell C., Kopacek J., Marchetto A., Moldan F., Prechtel A., Rogora M. 2001. Recovery from acidification in European surface waters. Hydrology and Earth System Sciences 5. 3, 283-298. DOI: hal-00304608
3. Garmo A., Skjelkvele B., de Wit A., at. al. 2014. Trends in Surface Water Chemistry in Acidified Areas in Europe and North America from 1990 to 2008. Water Air Soil Pollut. 225.3, 1880-94. DOI 10.1007/s11270-014-1880-6
4. Henriksen A., Kämäri I., Posh M., and Wilander A. 1992. Critical loads of acidity: Nordic surface waters. AMBIO 21, 356-363. DOI: 10.1139/er-2016-0054
5. Kvaeven B., Ulstein M.J., Skjelkvåle B.L. 2001. ICP Waters - An international program for surface

water monitoring. Water Air Soil Pollut. 130, 775-780. DOI:10.1023/A:1013802122401
6. Li J., Tang H. 1998. Acidification capacity model: formulation and application. Water Research. 32. 11, 3378-3386. DOI: 10.1016/S0043-1354(98)00101-8
7. Moiseenko T.I., Skjelkvale B.L., Gashkina N.A., et al. 2013. Water chemistry in small lakes along a transect from boreal to arid ecoregions in European Russia: Effects of air pollution and climate change. Applied Geochemistry 28, 69-79. DOI:10.1016/j.apgeochem.2012.10.019
8. Monteith D.T., Stoddard J.L., Evans C.D. et al. 2007. Dissolved organic carbon trends resulting from changes in atmospheric deposition chemistry. Nature 450, 537-539. DOI:10.1038/nature06316
9. National Atlas of Russia. Moscow: University Press; 2007.
10. National Soil Atlas of Russia. Moscow: University Press; 2011.
11. Reitzel K., Jensen H.S., Egemose S. 2013. pH dependent dissolution of sediment aluminium in six Danish lakes treated with Al. Water research 47, 1409-1420.
12. Semenov M.Yu. 2002 Acid deposition in Siberia. Novosibirsk: The science 143 p.
13. Skelkvale B.L., Stoddard J.L., Jeffries D.S., Torseth K., Hogasen T.J. et al. 2005. Regional scale evidence for improvements in surface water chemistry 1990-2001. Environmental Pollution 137. 1, 165-176. DOI: 10.1016/j.envpol.2004.12.023
14. Starikov V.D., Tul'kova L.A. 2010. Geology, topography, minerals of Tyumen Region, Tyumen: Tyumen Printing House 352.

3. Trends in input-output budgets of S and N in Swiss high-altitude lakes

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Introduction

Because of its proximity to the emission rich Po Plain and its generally abundant precipitations (Spinedi et al. 2012), Southern Switzerland is particularly exposed to deposition of anthropogenic pollutants. In fact, wet deposition in Southern Switzerland is mainly determined by warm, humid air masses originating from the Mediterranean Sea, passing over the Po Plain and colliding with the Alps. In addition, because of the dominance of base-poor rocks with low buffering capacity, in Southern Switzerland many high altitude-soils and freshwaters are sensitive to acidification (Zobrist and Denver 1990). For this reasons at the beginning of the 1980s the Canton of Ticino started to monitor wet deposition and water chemistry of high-altitude lakes.
As a consequence of decreased emissions, depositions of sulphate decreased at all monitored sites particularly before 2000. After 2000, depositions of nitrate also decreased significantly at most sites while the decrease in depositions of ammonium is still low and restricted to few sites. It followed a significant decrease in deposition of acidity at all sites (Rogora et al. 2016, Steingruber 2015a, Steingruber 2017). In agreement with trends in depositions, from the 1980s until present, concentrations of sulphate and nitrate decreased in most studied high altitude Alpine lakes, leading to an increase of alkalinity and pH (Rogora et al. 2013, Steingruber 2017).
This study is a first attempt to combine data from monitoring of deposition and high-altitude lake water chemistry to calculate input-output budgets of sulphur (S) and nitrogen (N) for high-altitude Alpine lake's catchments in Southern Switzerland.

Methods and study site

Water chemistry of 20 high-altitude lakes has been studied since the 1980s. They all belong to the Lago Maggiore watershed (**Feil! Fant ikke referansekilden.**). The lakes are small (0.3–16.9 ha), their watershed areas vary between 23 and 294 ha and consist mainly of bare rocks, with vegetation generally confined to small areas of alpine meadow. All the watersheds are dominated by acidic rocks (ortho- and paragneiss), amphibolites are present locally and carbonates are rare. In most cases soils are absent or very thin. At the study site, during the monitoring period, wet deposition has been sampled and analyzed at 11 sites: 5 of them are situated in Italy and data were provided by the Institute of Ecosystem Study in Pallanza, the other 6 are situated in Switzerland. For more details regarding the studied sites and methods for sampling and analysis see Rogora et al. (2016), Steingruber (2015) and Steingruber (2017).

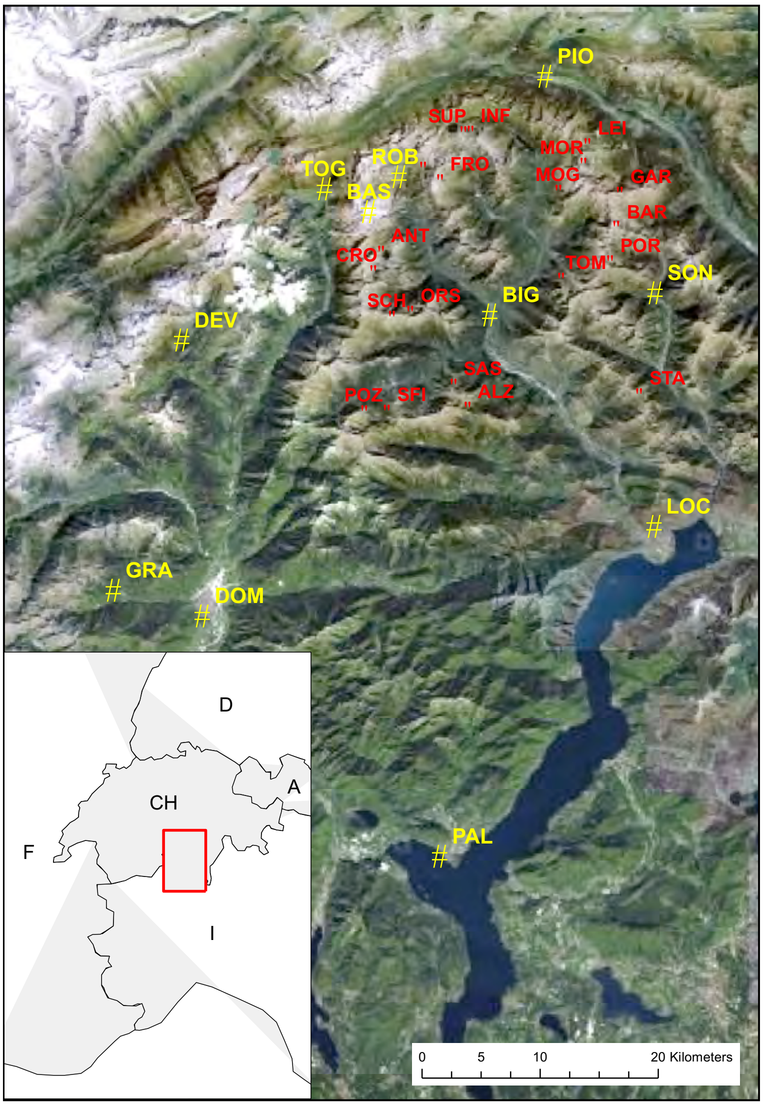

Figure 3. Study area. Yellow: wet deposition sampling sites, red: lakes

Total inputs of S, N and base cations (BC) to the lake catchments were calculated multiplying annual mean rainwater concentrations with yearly precipitation and adding dry deposition. Annual mean rainwater concentrations at each lake catchment has been estimated from the closest wet deposition sampling site situated at Robiei (ROB) and considering a time dependent altitude gradient that was calculated considering data from wet deposition sampling sites above 900 m a.s.l. (BAS, BIG, DEV, GRA, PIO, ROB, SON, TOG). The amount of yearly precipitation at each catchment has been calculated by multiplying the yearly rainwater volume measured at Robiei by the Federal Office of Meteorology and Climatology (MeteoSwiss) with a catchment specific factor, derived from 5-years average precipitation maps (1 km x 1 km), that were provided together with dry deposition maps (1 km x 1 km) by the company Meteotest. Yearly mean output of sulphate, total nitrogen (TN) and base cations (BC) were calculated by multiplying lake surface water autumn concentrations with the yearly mean outflow estimated by subtracting evapotranspiration (ET) from annual mean precipitation. Catchment specific evaporation/precipitation ratios were extracted from long-term evaporation (1973-1992, Menzel et al. 1999) and precipitation maps (1971-1990, Schwarb et al. 2001). To reduce temporal variability yearly net release of S and BC (output-input) and net retention of N (input-output) were calculated as the difference between 3-years moving means of input and output fluxes.

Results and discussion

S budgets

At the beginning of the monitoring period, during the 1980s, when depositions of S reached maximum values, lake catchments output and input fluxes were almost the same, suggesting absence of immobilization, reduction and uptake of sulphate. In most lake catchments (12 out of 20), afterwards (1980s-2016) output fluxes decreased with almost the same rate as input fluxes showing that these systems are close to steady state as regards S and that desorption is almost inexistent. Differently, output fluxes of the remaining 8 lakes decreased at a lower rate than input fluxes or in some cases did even increase with time. Interestingly, the resulting net release of S (S_{rel}) increased at all catchments (**Figure 4**) after 2000. Similar results are described for other catchments in Europe and North America (Forsius et al. 2005, Löfgren et al. 2001, Mitchell et al. 2013, Prechtel et al. 2001, Vuorenmaa et al. 2017, Watmough et al. 2005) and are generally ascribed to mobilization of S, that was accumulated in the watersheds during times of higher atmospheric deposition, causing a delay of the response of aquatic ecosystems to decreased S depositions. However, since retention of S in high-altitude lake catchments has most probably always been very small (see above) and the soil layer is very thin, release of high amounts of previously stored S is unlikely. High S_{ret} values, an extreme example is Lago Leit with present day output fluxes that are twice as input fluxes during the 1980s, must be explained otherwise. Since in terms of depositions, geology, soil depth, land-use, the studied lake catchments do not differ greatly, the existence of high S_{rel} values in some lakes and not in others suggests a source of S that does not depend on these variables.

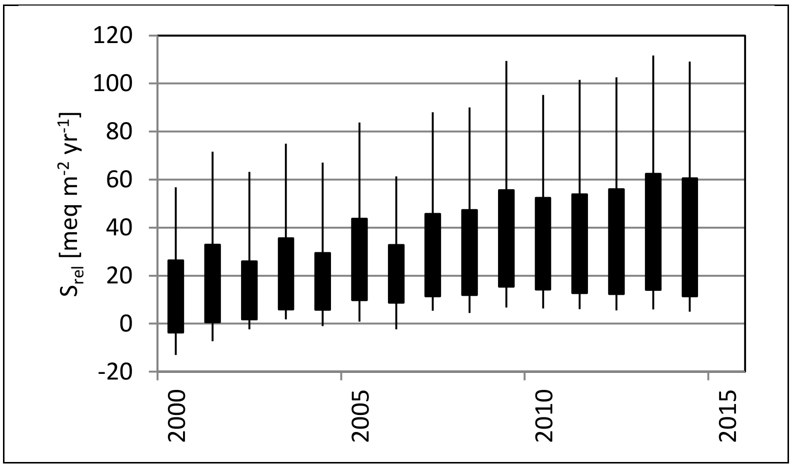

Figure 4. Percentiles (10%, 25%, 75%, 90%) of S release from lake catchments

Figure 5 shows that high fluxes and high increasing rates of S_{rel} are restricted to catchments with average altitudes > 2400 m a.s.l., indicating that the process that releases high amounts of S occurs only at high altitudes. Melting of permafrost is a recent phenomenon restricted to high altitudes. Since the real extent of permafrost in the catchments is not known, modelled data have to be used to test this hypothesis. The Alpine Permafrost Index Map (APIM) is publicly available from the University of Zürich (https://www.geo.uzh.ch/microsite/cryodata/PF_map_explanation.html) and indicates with an index that ranges from 0 to 1 the likelihood of occurrence of permafrost in the Alpine Region. The model is used for debris and bedrock and its explanatory variables are annual mean temperatures, potential incoming of solar radiation and precipitation. Offset terms were applied to make predictions for topographic and geomorphic conditions that differ from the terrain feature (Boeckli et al. 2012). Comparing the average S_{rel} of 2000-2015 and its temporal increase with the percent catchment area with and Alpine Permafrost Index > 0.9, a good correlation can be found (**Figure 6**). Only S_{rel} of Lago Porchieirsc (empty symbol) can not be explained by the permafrost model. With an average altitude of 2357 m a.s.l. its catchment is situated at the lower limit above which permafrost might occur. The lake is situated at the base of a steep talus slope. It is reported that in the lower section of talus slopes, temperatures might be lower than more above (Boeckli et al. 2012) increasing the chance to find permafrost even at altitudes were normally they don't occur. It's therefore probable that in the catchment of Lago Porchieirsc permafrost exists, even if the model does not predict it.

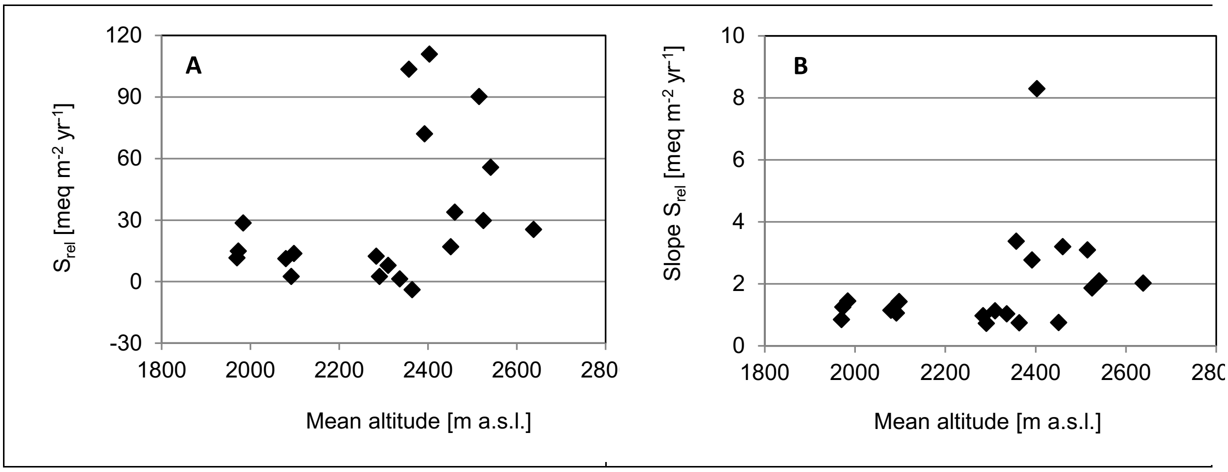

Figure 5. Correlation between the release of S (A) and the its temporal change (B) with altitude

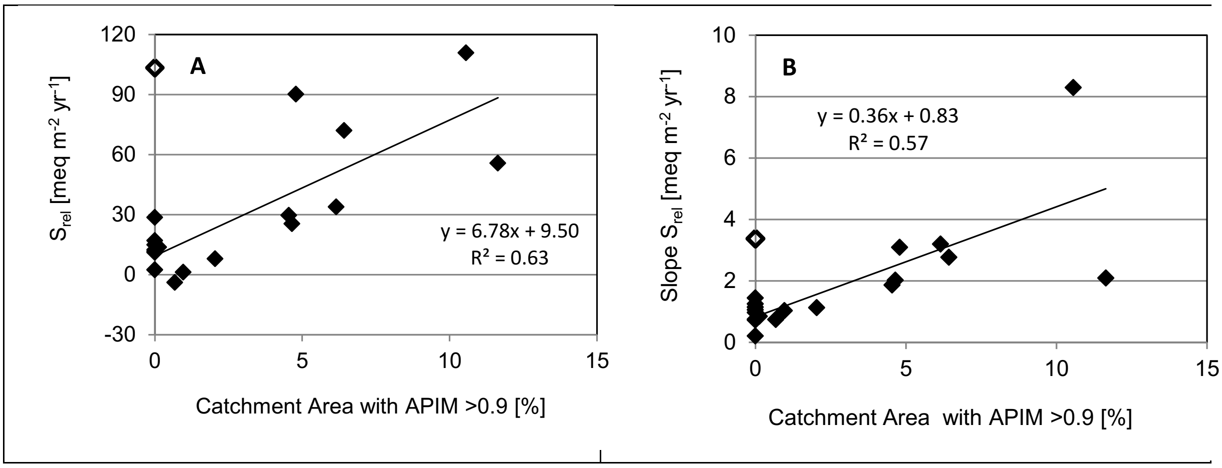

Figure 6. Correlation between the release of S (A) and the its temporal change (B) with the percent area of the catchment with a permafrost index > 0.9

We now showed that melting of permafrost is most probable responsible for causing observed high rates of S_{rel}. But where does S come from? Old atmospheric S from periods with higher S depositions, would hardly explain present day output fluxes twice as high as input fluxes in the 1980s. It's true that the available geological maps don't indicate the presence of S containing rocks in the catchments, but this does not exclude the presence of small spots of S containing minerals. It is possible that ice contained in permafrost has been enriched with time by the surrounding minerals and flows now out of the catchment or more likely rocks and minerals that in the presence of permafrost were somehow "protected" from weathering, after thawing are suddenly exposed and weathered at rates that are most probably higher than normally typical for these catchments.

What about the consequences of permafrost caused S release? Other studies reported huge export rates of metals from thawing rock glaciers (Thies et al. 2007). In this study among the measured metals (Al, Cu, Zn, Pb, Cd) concentrations of only aluminum slightly increased only in Lago Leit (among all lakes the most influenced by permafrost thawing) from about 1 to 5 µg l^{-1} (soluble aluminum). Watmough et al. (2001) warned that a net release of S from forested catchments may cause a delay of chemical recovery from acidification. In this study, most S_{rel} is compensated by a net release of BC (**Figure 7**) and since trends of measured Gran alkalinity between 2000 and 2016 (Steingruber 2017) are still either positive or not significant, the excess release of S (compared to BC) is at present most probably still compensated by decreasing S and N depositions.

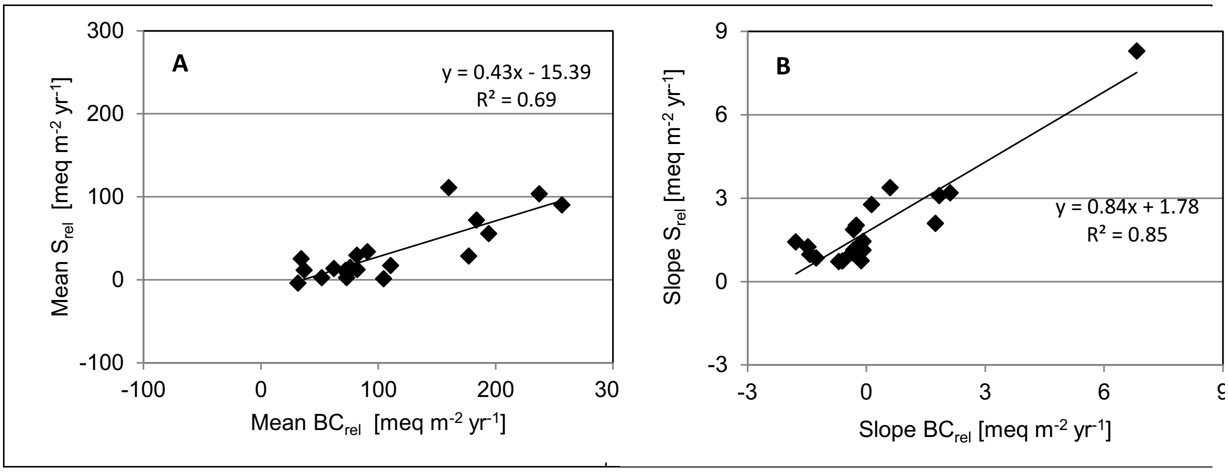

Figure 7. Correlation between the release of S with the release of BC (A) and the temporal change of the release of S with the temporal change of the release of BC (B)

N budget

As TN input and output fluxes decreased during the monitoring period, TN retention also decreased. However, the relative net retention (rel_TN_{ret}) remained fairly constant after 2000 (**Figure 8**) and varied among lake catchments between 45% and 81% and was on average 63%.

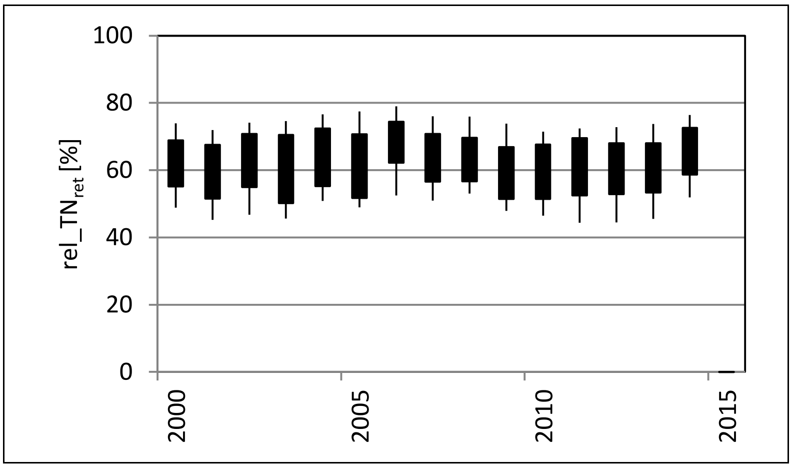

Figure 8. Percentiles (10%, 25%, 75%, 90%) of TN retention in lake catchments

The Pearson correlation coefficient between rel_TN_{ret} and the environmental variables mean catchment altitude, catchment area, mean precipitation, percent cover vegetation, percent cover vegetation plus lake area, mean areal lake outflow (=average depth/average retention time), mean catchment slope was significant only for the last two with a coefficient of -0.473 for the mean areal outflow and of -0.629 for the average slope. This result indicates that lakes probably play an important role in the retention of N in high-altitude lake catchments and that average slope may explain well differences of rel_TN_{ret} among these catchments. The most plausible explanation for the good correlation between rel_TN_{ret} and mean slope is that, similar to the mean areal outflow that describes the "velocity" water flows through a lake basin (Kaste and Dillon 2003, Kelly et al. 1987; Seitzinger et al. 2006), average catchment slope may acts as a surrogate for the "velocity" water flows through the entire catchment.

In order to estimate the proportions of N that are retained in the terrestrial part of the catchment ($rel\_terr\_TN_{ret}$), that are retained in the lake itself ($rel\_lak\_TN_{ret}$) and that flows out of the lake (rel_TN_{out}), two approaches were used. The first approach (top-down) estimated first $terr\_TN_{ret}$ as described in Posch et al. (2007) from landuse data (percent area with forest, grassland, bare land, lake) and landuse specific N uptake, N immobilization and denitrification values and then lak_TN_{ret} as the difference between N that flows out of the terrestrial part and out of the lake. Land-use data were estimated combining data from the Swiss Areal Statistics (resolution 100 m x 100 m) supplied by the Federal Office for Statistics and a vegetation cover map (resolution of about 20 m x 30 m) provided by the University of Zürich together with the Alpine Permafrost Index Map (https://www.geo.uzh.ch/microsite/cryodata/PF_map_explanation.html). The second approach (bottom-up) estimated first lak_TN_{ret} from the relationship between the ratio of total nitrogen in-lake retention (lak_TN_{ret}) and dissolved nitrogen load to the lake (lak_DIN_{in}) to the areal lake outflow (q) and then $terr\_TN_{ret}$ as the difference between N deposition and N that flows into the lake. The $lak\_TN_{ret}/lak\_DIN_{in}$ vs q relationship was estimated from literature data (Ahlgren et al. 1994, Andersen 1974, Gibson et al. 1992, Hayward et al. 1993, Jensen et al. 1992, Molot and Dillon 1993, Serruya 1975, Steingruber 2001): $(lak\_TN_{ret}/lak\_DIN_{in}) = 27.2 / (27.2 + q)$, with q expressed in m $yr^{-1}a$. The reason for using this relation instead of the often used lak_TN_{ret}/lak_TN_{in} vs q (Seitzinger et al. 2006) or $lak\_DIN_{ret}/lak\_DIN_{in}$ vs q (Kaste and Dillon 2003, Kelly et al. 1987; with DIN = dissolved inorganic nitrogen) is that the here proposed relation gives a much smaller spreading of the measured values from model. A publication on this subject is planned.
The two approaches gave values for $rel\_terr\_TN_{ret}$ and $rel\_lak\_TN_{ret}$ that were in the same order of magnitude (**Figure 9**). Mean $rel\_terr\_TN_{ret}$ was 22±9% with the top-down and 32±18% with the bottom-up approach, while mean $rel\_lak\_TN_{ret}$ was 40±10% with the top-down and 30±16% with the bottom-up approach. Considering an underestimation of the output flux, because of the not considered increased N export after snow melt (Rogora et al. 2013), results from the two approaches were even more similar (top-down: mean $rel\_terr\_TN_{ret}$ = 22±9%, mean $rel\_lak\_TN_{ret}$ = 32±11%; bottom-up: mean $rel\_terr\_TN_{ret}$ = 19±22%, mean $rel\_lak\_TN_{ret}$ = 35±19%). That means that although lake surfaces are small compared to the surfaces of the entire catchment (1-18%), their importance in retaining TN is equal or even higher than that of the terrestrial compartment of the catchments and are therefore important N buffers.

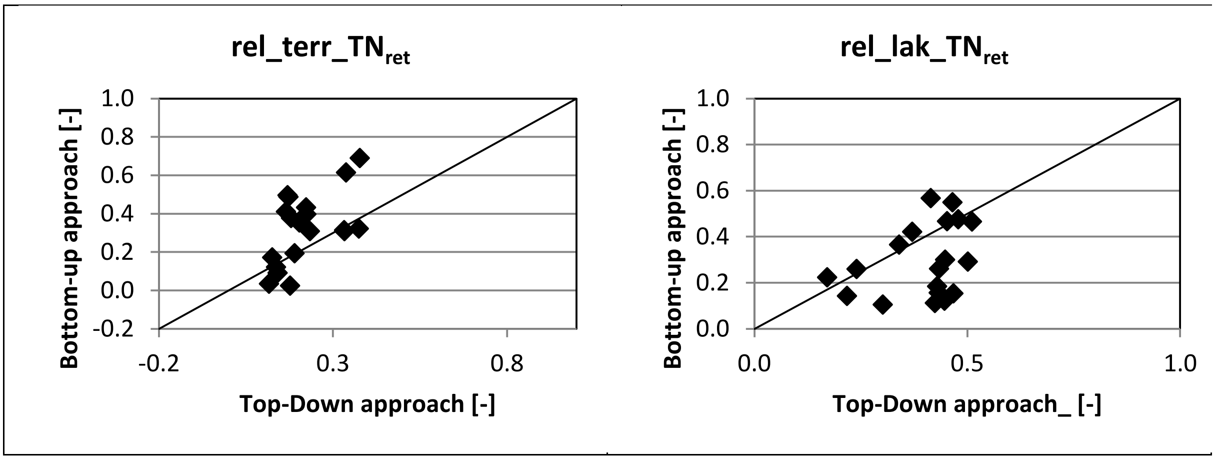

Figure 9. Relative retention of TN in the terrestrial and in the lake compartment of the catchments

Acknowledgements

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References

Ahlgren I., Sörensson F., Waara T. and Vrede K. 1994. Nitrogen budget in relation to microbial transformations in lakes. Ambio 23(6): 367-377.

Andersen J. M. 1974. Nitrogen and phosphorus budgets and the role of sediments in six shallow Danisch lakes. Arch. Hydrobiol. 74(4): 528-550.

Boeckli L., Brenning A., Gruber S. and Noetzli J. 2012. Permafrost distribution in the European Alps: calculation and evaluation of an index map and summary statistics. The Cryosphere 6: 807–820.

Gibson C.E., Smith R.V. and Steward D.A. 1992. The nitrogen cycle in Lough Neagh, N. Ireland 1975 to 1987. Int. Revue ges. Hydrobiol. 77: 73-83.

Hayward J., Foy R.H. and Gibson C.E. Nitrogen and phosphorus budgets in the Erne system, 1974-89. Proc. R. Ir. Acad. 93B(1): 33-44.

Jensen J.P., Jeppesen E., Kristensen E., Christensen P.B. and Søndergaard M. 1992. Nitrogen loss and denitrification as studied in relation to reductions in nitrogen loading in a shallow, hypertrophic lake (Lake Søbygård, Denmark). Int. Revue ges. Hydrobiol. 77(1): 29-42.

Kaste Ø. And Dillon P.J. 2003. Inorganic nitrogen retention in acid-sensitive lakes in southern Norway and southern Ontario - a comparision of mass balance data with an empirical N retention model. Hydrol. Pürocess. 17: 2393-2407.

Kelly C.A., Rudd J.W.M., Hesslein R.H., Schindler D.W., Dillon P.J., Driscoll C.T., Gherini S.A. and Hecky R.E. 1987. Prediction of biological acid neutralization in acid sensitive lakes. Biogeochemistry 3: 129-140.

Forsius M., Kleemola S. and Starr M. 2005. Proton budgets for a monitoring network of European forested catchments: impacts of nitrogen and sulphur deposition. Ecol. Indic. 5, 73–83.

Löfgren S., Aastrup M., Bringmark L., Hultberg H., Lewin-Pihlblad L., Lundin L., Karlsson G.P. and Thunholm B. 2011. Recovery of soil water, groundwater, and streamwater from acidification at the Swedish integrated monitoring catchments. Ambio 40, 836–856.

Mitchell M.J., Driscoll C.T., McHale P.J., Roy K.M. and Dong Z. 2013. Lake/watershed sulfur budgets and their response to decreases in atmospheric sulfur deposition: watershed and climate controls. Hydrol. Process. 27: 710-720.

Menzel L., Lan, H. and Rohmann M. 1999. Mean annual actual evaporation. In: Geographical Institute of the University Bern (Ed.), Hydrological Atlas of Switzerland. National Hydrological Survey, Bern, Switzerland.

Molot L. A and Dillon P.J. 1993. Nitrogen mass balances and denitrification rates in central Ontario Lakes. Biogeochemistry 20: 195-212.

Posch M., Eggenberger U., Kurz D. and Rihm B. 2007. Critical Loads of Acidity for Alpine Lakes. A Weathering Rate Calculation Model and the Generalized First-Order Acidity Balance (FAB) Model Applied to Alpine Lake Catchments. Environmental Studies: 0709. Federal Office for the Environment, Berne, Switzerland.

Prechtel A., Alewell C., Armbruster M., Bittersohl J., Cullen J.M., Evans C.D., Helliwell R., Kopácek J., Marchetto A., Matzner E., Meesenburg H., Moldan F., Moritz K., Veselý J. and Wright R.F. 2001. Responses of sulphur dynamics in European catchments to decreasing sulphate deposition. Hydrol. Earth Syst. Sci. 5(3): 311-325.

Rogora M., Colombo L., Lepori F., Marchetto A., Steingruber S. and Tornimbeni O., 2013. Thirty years of chemical changes in Alpine acid-sensitive lakes in the Alps. Water Air Soil Pollut. 224: 1746.

Rogora M., Colombo L., Marchetto A., Mosello R. and Steingruber S. 2016. Temporal and spartial patterns in the chemistry of wet deposition in Southern Alps. Atmos. Environ. 146: 44-54.

Schwarb M., Frei C., Schär C. and Daly C. 2001. Mean annual precipitation throughout the European Alps 1971-1990. In: Geographical Institute of the University Bern (Ed.), Hydrological Atlas of Switzerland, National Hydrological Survey, Bern, Switzerland.

Seitzinger S., Harrison J.A., Böhlke J.K., Bouwman A.F., Lowrance R., Peterson B., Tobias C. and Van Drecht G. 2006. Denitrification across landscapes and waterscapes: a synthesis. Ecol. Appl. 16(6): 2064-2090.

Serruya C. 1975. Nitrogen and phosphorus balances and load-biomass relationship in Lake Kinneret (Israel). Verh. Internat. Verein. Limnol. 19: 1357-1369.

Spinedi F., Scherrer S., Schlegel T., Begert M., Rigi G., Isotta F., Bader Stephan and Gaia M. 2012. Rapporto sul clima – Cantone Ticino 2012. Rapporto di lavoro MeteoSvizzera no. 239. MeteoSwiss, Locarno Monti, Switzerland.

Steingruber S. 2017. Results from the participation of Switzerland to the International Cooperative Programme on Assessment and Monitoring Effects of Air Pollution on Rivers and Lakes (ICP Waters). Annual report 2016. Dipartimento del territorio del Canton Ticino, Bellinzona, Switzerland.

Steingruber S. 2015. Deposition of acidifying and eutrophying pollutants in Southern Switzerland from 1988 to 2013. Boll. Soc. Tic. Sc. Nat. 103: 29-37.

Steingruber S.M. 2015. Nutrient transformations in a wetland pond. Diss ETH No 13939. Zürich, Switzerland.

Thies H., U. Nickus, V. Mair, R. Tessadri, D. Tait, B. Thaler and R. Psenner. 2007. Unexpected response of high Alpine lake waters to climate warming. Environ. Sci. Technol. 41: 7424-7429.

Vuorenmaa J., Augustaitis A., Beudert B., Clarke N., de Wit H.A., Dirnböck T., Frey J., Forsius M., Indriksone I., Kleemola S., Kobler J., Krám P., Lindroos A.-J., Lundin L., Ruoho-Airola T., Ukonmaanaho L. and Váňa M. 2017. Long-term sulphate and inorganic nitrogen mass balance budgets in European IP Integrated Monitoring catchments (1990-2012). Ecol. Indic. 76: 15-29.

Watmough S.A., Aherne J., Alewell C., Arp P., Bailey S., Clair T., Dillon P., Duchesne L., Eimers C., Fernandez I., Foster N., Larssen T., Miller E., Mitchell M. and Page S. 2005. Sulphate, nitrogen and base cation budgets at 21 forested catchments in Canada, the United States and Europe. Environ. Monit. Assess. 109: 1–36.

Zobrist J. and Denver J.I. 1990. Weathering processes in Alpine watersheds sensitive to acidification.In: Johanessen M., Mosello R. and Barth H. (eds), Acidification Processes in Remote Mountain Lake, CEC, Brussels: 149-161.

4. Air and Water Quality Monitoring in Republic of Moldova

Environmental Quality Monitoring Department (EQMD) within the State Hydrometeorological Service performs systematic ecological monitoring of the quality of environmental components (surface water, air, soil, sediments, atmospheric precipitations, γ-radiation etc.) according to a monitoring network throughout the entire territory of the Republic of Moldova.

The national monitoring system regarding environmental quality was established in the sixth decade of the last century, but systematic observations started in 1980 currently having as priority objectives:

- monitoring of the environmental quality and determining the pollution level;
- detection of extremely high pollution of surface water, air and soil;
- prevention and mitigation of negative effects on environment and population;
- emergency warning about extremely high pollution of environmental components;
- informing systematically the public about environmental quality.

Being provided with adequate human and technical potential, as well as holding the Accreditation Certificate Nr. LÎ - 023 (previous nr. LÎ 01 220) of 21st of February 2014 according to international standard ISO/CEI 17025, the EQMD includes 7 subdivisions:

- Expedition Group (EG);
- Surface Water Quality Monitoring Centre (SWQMC);
- Soil Quality Monitoring Centre (SQMC);
- Ambient Air Quality Monitoring and Radioactive Background Level Centre (AAQMRBLC);
- Ambient Air Quality Monitoring Division Balti city (AAQMD);
- Chemical and Physical Analysis Center (CPAC);
- Centre on Integrated Ecological Monitoring and Informational Management (CIEMIM).

At present the national monitoring system contributes to solving some of the most important problems related to environmental quality, integration of environmental issues in the economic sector, as well as, promotion of sustainable development.

The subdivisions of EQMD are active in the frame of:

- Danube River Protection Convention;
- Stockholm Convention on Persistent Organic Pollutants;
- Convention on the Transboundary Effects of Industrial Accidents;
- Convention on Long-range Transboundary Air Pollution;
- Convention on the Transboundary Effects of Industrial Accidents;
- as well as according to other national and regional bilateral and multilateral agreements between Republic of Moldova and neighbouring countries.

Ambient Air Quality Monitoring and Radioactive Background Level Center (AAQMRBLC) was established in 1969 and operates the monitoring network consisting of 17 stationary stations. Samples are collected 3 times per day (7oo, 13oo, 19oo) and analyzed by main parameters (solid substances, sulphur oxide, carbon oxide, nitrogen dioxide) and by specific parameters (soluble sulphur, nitrogen oxide, formaldehyde, phenol and benzapirene) in 5 industrial regions (Chişinău – 6 posts, Bălţi – 2 posts, Benderi – 4 posts, Tiraspol – 3 posts, Rîbniţa – 2 posts).

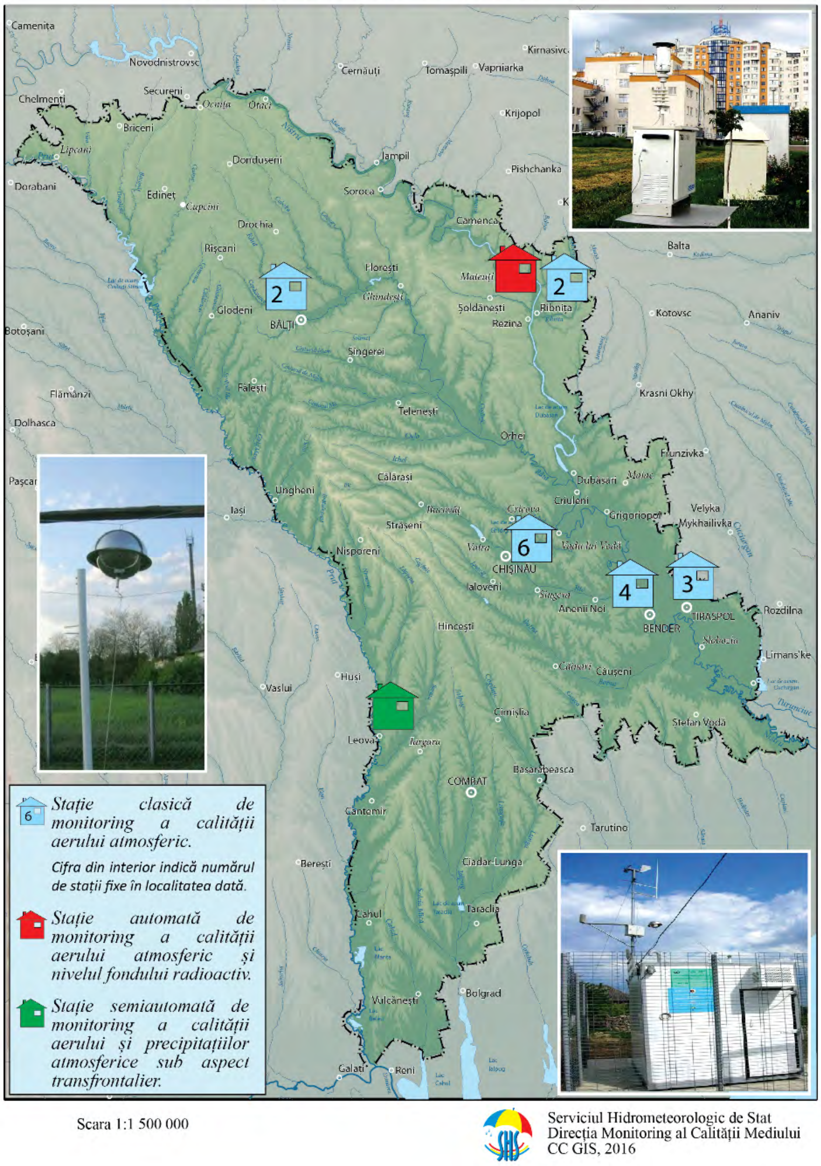

Figure 10. Air quality monitoring network in Republic of Moldova.

In order to carry out a more efficient monitoring of the atmospheric air quality, activities of real time monitoring were initiated on the first of April 2007 by installing an automatic control station in Mateuţi village Rezina district. The station automatically monitors 17 parameters (with the exception of total solid suspensions, that are collected manually) of which 12 on atmospheric pollutants (nitrogen oxides (NO, NO_2, NO_x's), sulphur dioxide (SO_2)), hydrogen sulphide (H_2S), ammonium (NH_3), carbon oxide (CO), sum of the aromatic hydrocarbons (∑CH), troposphere ozone (O_3), total solid suspensions, as well as those with 10mkm fraction (PM_{10}), the exposure to gamma rays and 5 meteorological parameters (temperature and air humidity, atmospheric pressure, direction and speed of the wind). This station is the only one of such kind in the Eastern Europe as it performs online continuous automatic monitoring on 12 atmospheric pollutants, thus completing the national and international monitoring network.

In 1992 the Republican monitoring network of atmospheric precipitation chemistry was established on a basis of 8 weather stations on 6 indices: SO stations on 6 indices: $SO_{2\text{-}4}$, Cl^-, HCO^-_3, Ca^{2+}, Mg^{2+}, NH_4^+ and the active reaction of the hydrogen ions concentration (pH) was determined.

In order to meet the commitments of the UNECE Convention on Long-range Transboundary Air Pollution, (Geneva,1979), in 2007 the transboundary pollution control station from Leova city was re-established and provided with modern equipment and it started to carry out atmospheric air quality observations according to EMEP Programme (European Monitoring and Evaluation Programme): level I (no organic compounds in precipitations: SO_4^{--}, NO_3^-, NH_4^+, H+ (pH), Na^+, K^+, Ca^{++}, Mg^{++}, Cl; no organic compounds in the atmospheric air: SO_2, SO_{4}-, NO_{3}-, HNO_3, NH_4+, NH_3, (NO_3, NH_4), HCl, Na^+, K^+, Ca^{++}, Mg^{++}; NO_2; troposphere O_3; PM_{10}; gas phase particles: NH_3, NH_4^+, HCl, HNO_3, NO_3^-) and level II (persistent organic pollutants (POPs) and heavy metals in precipitations).

To ensure the authenticity of obtained data, the centre yearly participates in the international extern laboratory control (EMEP) in cooperation with Norwegian Institute for Air Research (NILU), thus increasing the qualification of specialists from the local laboratories.

For the assessment of the radioactive state of the environment, starting with 1978, systematic observations on the level of exposure of the γ-irradiation are carried out twice per day (7oo and 20oo) at 18 weather stations (in the northern part – 7, in the central part – 7, in the southern - 4), as well as on-line at the Mateuţi automatic station.

The centre also takes additional observations on anthropogenic radionuclides 137Cs, 90Sr (cesium-137, strontium-90), summarily activity γ-β in the atmospheric deposits, as well as determining of the telluric radionuclide composition in the soil ^{226}Ra, ^{232}Th, ^{40}K (radium-226, torium-232, calium-40). Also, since 2009 the investigation of radioactive aerosols in the ambient air was initiated by installing a station (ASS-500) in Chişinău.

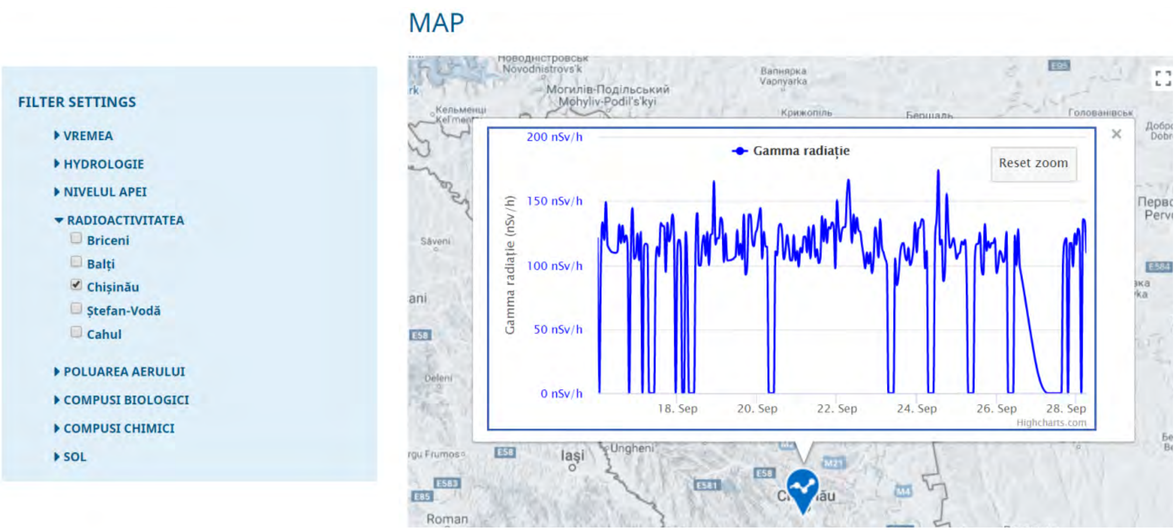

Figure 11. Gamma dose-rate in Chisinau city during September 2017.

According to the Agreement of Cooperation between the State Hydrometeorological Service and Roshydromet, as well as in the frame of the information exchange, for the development on the yearbook “Radioactive situation on the territory of Russian Federation and neighbouring countries”, AAQMRBLC is providing annual investigations results on the radioactive situation in the Republic of Moldova.

Starting with 2007 AAQMRBLC is cooperating with the International Atomic Energy Agency in the frame of the IAEA-WMO program on global network for determining the isotope compounds in precipitations (GNIP) and especially of the stable isotopes Oxygen-18 and Deuterium (Hydrogen-2) as well as of the radioactive isotope Tritium (Hydrogen-3).

Surface Water Quality Monitoring Centre (SWQMC)

Surface water quality monitoring of chemical parameters in the Republic of Moldova began in the 60’s of the last century, but systematic and comprehensive character has been acquired only in the 80’s, with an emphasis on the monitoring of transboundary rivers: Nistru and Prut. Ever since the main purpose of monitoring was to determine the level of contamination of surface waters, to identify cases of very high pollution, to monitor pollution sources, as well as to send timely notifications to local and central authorities authorized to take decisions for the elimination or mitigation of the effects.

The hydrobiological monitoring of surface water on the territory of the republic was initiated in the frame of the State Hydrometeorological Service since 1976. Over a period of 34 years the Hydrobiological Group has carried out observations and calculations in parallel with laboratory analysis. The results are assessed and included in the Yearbook of Surface Water Quality. A special feature of the bio-monitoring is the possibility to quickly provide relevant information using a minimum of resources.

Surface water quality monitoring at national level is carried out on the basis of legal acts, among which the most important are the Laws of the Republic of Moldova:

- Water Law, nr. 272 of 23.12.2011;
- Law on Environmental Protection nr. 1515-XII, June 16th 1993;
- Law on Protection Zones and Strips of water, rivers and reservoirs, nr. 440-XIII from April 27, 1995;
- Law on Natural Resources, nr. 1102-XIII from 6 February 1997;
- Law on drinking water, nr. 272-XIV of 10 February 1999;

and Governmental decrees:

- Regulation on monitoring systematic evidence of the surface and ground waters’ status (GD 932 of 20.11.2013);
- Regulation on surface water environmental quality requirements (GD 890 of 12.11.2013).

At present the activity of the SWQMC has extended and now it carries out systematic observations on surface water quality in 67 monitoring sections set up on 32 rivers, 6 reservoirs and 2 natural lakes, analysing 72 hydrochemical indicators and 5 hydrobiological elements (**Figure 13**).

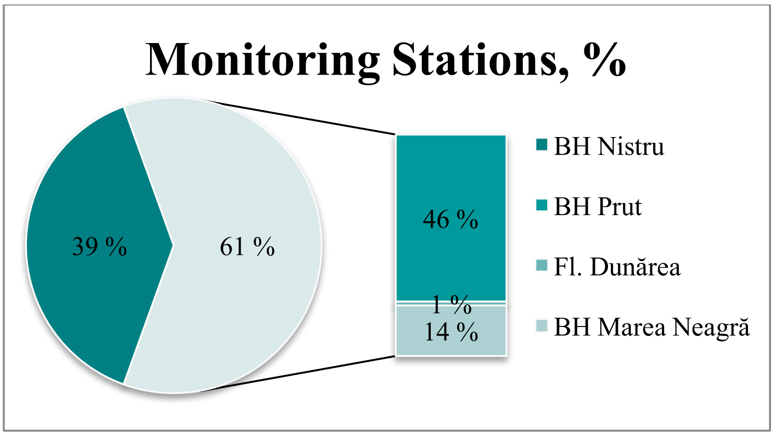

Figure 12. Monitoring stations located in Nistru Hydrographical District and in Prut, Danube and Black Sea Hydrographical District

Physico-chemical monitoring in RM includes the following indicators: temperature, pH, conductivity, transparency, turbidity, coloration, content of dissolved oxygen, saturation, biochemical oxygen demand, chemical oxygen demand with bichromate, chemical oxygen demand with manganese, total suspensions, mineralization, ammonium nitrogen, nitrate nitrogen, nitrite nitrogen, mineral nitrogen, mineral phosphorus, total phosphorus, chloride ions, sulphate ions, total iron, phenols, petroleum, anion active detergents, alkalinity, calcium ions, magnesium ions, total hardness, sodium ions, potassium ions, the amount of ions, silicon, coloration, detergents, heavy metals (copper, zinc, nickel, lead and cadmium), polyaromatic hydrocarbons, and organochlorine pesticides.

Biological quality elements assessed in RM include: Bacterioplancton, Phytoplancton, Chlorophyll a, Zooplancton, Macroinvertebrates, Phytobenthos and Macrophytes.

Figure 13. Surface Water Quality monitoring network in Republic of Moldova

Transboundary monitoring on the Prut River with Romania is conducted according with the Regulation of bilateral cooperation with the National Administration "Apele Române" and Basin Department Prut-Bârlad (Iasi) in seven monitoring points:

- joint monthly monitoring sampling and equivalent exchange of information with experts from Romania is being conducted at the following sections: Ungeni Town, Valea Mare and Giurgiulesti villages;
- quarterly sampling monitoring and equivalent exchange of information with experts from Romania is being conducted at sections: Sirauti, Costesti, Leova, Cahul.

Also the in the frame of the Bilateral Cooperation Agreement between Republic of Moldova and Ukraine joint sampling and exchange of information and data on water quality of the Nistru and Prut rivers in the transboundary sections is being conducted quarterly.

In the frame of Danube Convention, surface water monitoring is carried out in 5 sections of the TransNational Monitoring Network (TNMN), analyzing 72 hydrochemical quality indicators and 5 hydrobiological elements indicators.

According to the Bilateral Cooperation Agreement between Republic of Moldova and Romania ("Regia Apelor Române" concern, Iaşi branch), SWQMC is investigating the water quality of the Prut river in 7 jointly established monitoring sections, analyzing 39 hydrochemical parameters and 3 groups of hydrobiological elements.

Each year SWQMC participates in the external international laboratory control (Qualco Danube) in cooperation with the WESSLING International Educational Research Center, Hungary. This activity contributes to increasing of the reliability of the analyses carried out in the laboratories of the Department.

5. Minutes of the 33rd Task Force meeting of the ICP Waters programme held in Uppsala, Sweden, May 9-11 2017

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 33rd meeting of the Programme Task Force
the Joint ICP IM and ICP Waters TF meeting in Uppsala 9-11 May 2017

KEY MESSAGES OF ICP WATERS 2017 TASK FORCE MEETING

Policy developments regarding air pollution: The EU NEC Directive

In the updated EU National Emission Ceilings (NEC) Directive, monitoring effects of air pollution on freshwaters, semi-natural habitats and forest ecosystems is made mandatory (Article 9). Bodies under the WGE have been contacted by the European Commission to contribute to implementation of the NEC Directive, because of the suitability of existing monitoring networks under the LRTAP Convention. National focal centres that currently contribute to ICP Waters are advised to make themselves acquainted with national activities for implementation of the NEC Directive. ICP Waters will contribute to preparation of guidelines for monitoring effects on surface waters under the NEC Directive and will highlight the relevance and value of the ICP Waters network and expertise developed since the 1980s.

Mercury

Emissions of the pollutant mercury (Hg) are regulated and included in old and new international conventions and agreements (e.g. Minamata convention on mercury, WFD, Artic Council). Documentation of spatial patterns and temporal trends in Hg levels in ecosystems is therefore highly opportune. The database on Hg in fish in Finland, Sweden and Norway, with some data from the Kola Peninsula, consists of over 50 000 observations of Hg in fish covering the period 1965 to 2015. The database is the most extensive database of its kind. Lakes with known local pollution sources and lakes with only air pollution as source of Hg were treated separately. More than 40% of the almost 2800 lakes in the database have fish Hg levels that exceed 0.5 mg/kg, which is often used as a criteria to classify the suitability of fish for human consumption. There were no uniform changes observed for temporal trends in fish Hg concentrations from lakes with sufficient historical records (> 5 years of data). The report will be delivered by September 2017.

Climate change: Melting permafrost affects recovery from acidification

A study of high altitude lakes in the southern Alps in Switzerland demonstrated that water chemistry (sulfate, nitrate) in most lakes reflects precipitation chemistry and show strong signs of chemical recovery. However, there were deviating patterns in the lakes at highest elevation. Release of sulphur and base cations from melting permafrost appeared to be the best explanation for the deviating patterns. Similar observations have been done in high altitude lakes in North America, which were also explained by melting permafrost. High altitude lakes in permafrost areas function as early warning systems for ecosystem impacts of climate change.

Current status of ICP Waters Monitoring network

The ICP Waters Monitoring network is tailored to document responses in water chemistry to changes in atmospheric loads of air pollution. New countries start to contribute (Moldova, EECCA country) while several countries re-initiate their participation (Poland, Spain, Ireland). Collaboration within the Convention has intensified through organization of joint meetings with ICP Integrating Monitoring. Reports and results that are delivered continue to be of relevance under the LTRAP Convention, and outside, for instance for the Minamata Convention on Mercury, and for the EU NEC Directive.

1. The meeting of the International Cooperative Programme on Assessment and Monitoring of the Effects of Air Pollution on Rivers and Lakes (ICP Waters) organized jointly with International Cooperative Programme on Assessment and Monitoring of the Effects of Air Pollution Ecosystems (ICP Integrated Monitoring) was attended by 50 experts from the following 16 Parties to the Convention on Long-range Transboundary Air Pollution (CLRTAP): Armenia, Austria, Canada, the Czech Republic, Finland, Germany, Ireland Italy, Moldova, the Norway, Poland, Russia, Spain, Sweden, Switzerland, and the United States of America. In addition, the Chair of the Executive Body of the Convention and the Chair of the Working Group of Effects (WGE) of the Convention attended. A representative from South Africa also attended. A complete list of participants can be found **Annex I.**

Introductions

2. Mr. Lars Lundin, Chair of ICP IM, opened the meeting.

3. Mr. Kevin Bishop, Pro Vice-Chancellor at the Agricultural University in Uppsala (SLU), welcomed the parties to SLU. He gave a brief introduction to the history of the institution and emphasized its special dual role as a university and as an institute for monitoring and assessment. He went on to describe the CLRTAP as a success story of how interplay between science and policy can provide a better environment.

4. Mr. Björn Risinger, Director General of the Swedish Environmental Protection Agency (EPA), welcomed all participants to Sweden and spoke about the long tradition in monitoring of ecosystems and surface waters in Sweden. He announced that 2017 was a year to celebrate. It is now 50 years since Svante Odén's famous paper "The Acidification of Air and Precipitation and its Consequences", which recognized the need for larger scale monitoring. Year 2017 is also the 50th anniversary of the Swedish EPA. He suggested that this makes it the oldest EPA in the world. He went on to describe monitoring in Sweden and its importance for decision making. He described objectives of Swedish environmental regulation and Sweden's role in ICP IM and ICP Waters. Air pollution is still a threat, but solutions are available. He ended by wishing the attendants a successful meeting.

5. Mr. Lars Lundin (Chair ICP IM) thanked the speakers for their welcoming speeches. The agenda was adopted (**Annex II**).

6. Mr. Jens Fölster (Sweden), the local organizer, provided general information about the meeting and the excursion.

7. Ms. Isaura Rábago (Chair WGE) presented information on common issues and reporting from the WGE. She provided news from CLRTAP, emphasizing the launch of the scientific assessment report "Towards cleaner air". The EB and the Working Group on Strategy and Review (WGSR) recommend further integration of activities under EMEP and WGE. An issue of concern is the funding situation of the Coordination Centre for Effects (CCE), as the Netherlands have announced to finish their financial support for the CCE in 2017. A solution is yet to be found. She reminded the Task Force that activities under the CLTRAP are policy relevant and that products and data produced have high visibility. The Policy Review Group (PRG) recommends enhanced efforts to combine (or connect) effects and concentration/deposition monitoring, increase cooperation between EMEP and WGE groups. Ms. Rábago also mentioned the annual reporting routines to the WGE and the update of the mandates of the bodies under the WGE, which will focus on main objectives and activities rather than activities that are repeated annually. She then moved on to the EU National Emission Ceilings (NEC) Directive, specifically Article 9 and Annex V. Article 9 is the legal basis for monitoring of negative impacts of air pollution, based on a network of monitoring sites. Annex V describes optional indicators for monitoring air pollution impacts. The bodies under the WGE are now involved in NEC Directive work, as the monitoring under the LTRAP Convention is tailored to assess effects of air pollution. The EU prefers a cost-effective approach for the monitoring reporting under the NEC Directive, and here using existing expertise will be very important.

8. Mr. Gunnar Skotte (Chair ICP Waters) introduced current issues for ICP Waters. He thanked ICP IM and the Focal centre in Sweden for organizing the Task Force meeting. Also, he thanked Mr. Risinger and Mr. Bishop for the warm and welcoming words and mentioned that the ICPs highly appreciate the attendance of Ms. Rábago, Chair of the WGE, and Ms. Engleryd, Chair of the EB, to the meeting. Mr. Skotte mentioned recent ICP Waters reports and the recent assessment report 'Towards clean air' as well as the updated ICP Waters homepage, with the opportunity to explore data. The upcoming mercury report was mentioned as well as its relevance for the Minimata convention. He mentioned the NEC Directive and its potential importance for sustaining effect-related work under the CLRTAP. He encouraged parties to contact their national authorities to inform and be informed. The next thematic report for ICP Waters will be a regional acidification assessment. It is intended as a supplement to maps displaying exceedance of critical loads, i.e. to assess the current extent of acidification. Mr. Skotte concluded that the work of ICP Waters is increasingly relevant also for initiatives outside the convention.

9. Mr. Lars Lundin (Chair ICP IM) presented current issues for ICP IM. Priority work is: Biodiversity indicators. Work on heavy metals baseline, budgets and critical loads. Mass balances of S and N. Collaboration with EU projects. He went through planned ICP IM work and reports. ICP IM emphasizes collaboration with other ICPs and EU projects. He specifically mentioned the elTER project.

Acidification and recovery

10. Mr. Stefan Löfgren, (Sweden) gave a talk entitled "Potential impact of forest biomass harvest on the acidity of Swedish surface waters". He presented monitoring and modelling results comparing conventional harvest and whole tree harvest. Harvesting appears to have little effect on pH in soil solution, but appreciable effect on calcium. There is apparently little effect on runoff because of restricted amounts of mobile anions. Some effect is seen in certain soil horizons, but little in runoff. The impact of more intensive harvesting was not large enough to prevent recovery from historic acidification Still, base cation stores were affected.

11. Ms. Sandra Steingruber (Switzerland) presented trends in S and N budgets of Swiss high-altitude mountain lakes. These lakes have been impacted by air pollution from Italian sources. Deposition was modelled for each lake. There are rainwater and lake water decreases in SO_4, NO_3 and base cations and increase in alkalinity and pH. In some lakes, the outputs of sulphur exceeded inputs and the release of sulphur was increasing, a pattern which appeared to be correlated with release of base cations. A further data exploration showed that this mainly concerned lakes between 2400 and 2700 mas., an elevation range with melting permafrost. Data from the Alpine Permafrost Index supported this hypothesis. With regard to nitrogen, all lake catchment lakes showed considerable retention of N, which was on average circa 60 %, with some variation between lakes. Catchment slope was the best single predictor of relative N retention. It was estimated how much N was retained by the catchments and how much by the lake. Lakes, despite having a relatively small area compared to catchments, are of similar importance as the terrestrial part of catchments for N retention. High altitude lakes are important N buffers and are impacted by climate warming

12. Mr. Stoddard (USA) said that high release of S had also been observed at high altitude lakes in the Rocky Mountains and asked if there was pyrite in the bedrock. Ms. Steingruber answered affirmatively and pointed out that melting of permafrost promote enhanced weathering of such minerals, with likely effects on lake water chemistry.

13. Ms. Natalia Zgircu, (Moldova) presented the Air and Surface Water Quality Monitoring System in Moldova. The State Hydro-meteorological Service is responsible for monitoring. She described the role of this institution. Monitoring of highly polluted water, air and soil has been undertaken since the 1980s. She went through regulation applying to the environment in Moldova (national and international). There are 17 stations in 5 industrial regions for monitoring air pollution. She presented results from ambient air pollution level in Moldova. Radioactivity in air, soil and water is subject to monitoring. The results are reported annually in a bulletin. She went on to describe the surface water quality monitoring of 6 dams, 2 lakes and 29 rivers, and the parameters monitored. She mentioned that Moldova cooperates with Ukraine and Romania on monitoring of transboundary rivers. She presented results for pH, ammonium and nitrates in the two stations proposed for the ICP Waters database.

14. Mr. Rosseland (Norway) asked if there was any monitoring of fish. Ms. Zgircu answered no, but that there might be in the future.

15. Ms. de Wit (ICP Waters Programme Centre) thanked Ms. Zgircu for the presentation and commented that the monitoring system in Moldova is extensive and has a good design. While the surface waters do not appear to be acidified, there would be a potential to monitor other air pollution impacts.

16. Ms. Anna Engleryd, (Chair EB) reported on recent developments under the Convention, specifically how the assessment report 'Towards cleaner air' will be used. She praised the report and reminded the Task Force that we have a well-functioning science-policy network. She mentioned that an *ad hoc* group who will work on how findings in the assessment report can be translated into future policy, has been created. The group has 4 themes: Science and monitoring gaps, policy gaps, protocol impact, improving cooperation and outreach. This will be further treated at the WGE/EMEP session in September. Examples of follow-up issues are: What is the next generation of policy instruments? New substances to be monitored? Black carbon, mercury? New conventions? Ratification and implementation of protocols: Heavy metals, the protocol on POP, the Gothenburg protocol. All three revised protocols may enter into force in 2018. She then mentioned that there will be a new Saltsjøbaden meeting, which is a workshop on air pollution issues where future air pollution policies and issues are discussed in a structured way but in a more informal setting than in the Geneva meetings. She invited ICPs and Task Force participants to provide feedback on the work of the EB.

17. Ms. de Wit (ICP Waters Programme Centre) thanked for the presentation and mentioned that it would also be useful to get feedback on how ICPs can become (even) more policy relevant.

18. Ms. Anna Engleryd mentioned that the EB Bureau might be a better group than the EB to give feedback on work done under the ICPs, and mentioned that the EB Bureau meetings are open for presentations from ICPs.

19. Ms. Kari Austnes, (ICP Waters Programme Centre) presented work on the upcoming ICP Waters report on regional assessment of surface water acidification. The report is intended as a policy-friendly product which will have supplementary information to maps showing exceedance of critical loads. ICP Waters sites are suitable for temporal trend analysis, but have limited spatial coverage. She went through various data sources on surface water quality and their strengths and weaknesses. The aim is to assess the current extent of surface water acidification with output that is relevant on a nationwide-scale. An enquiry was sent to NFCs, to which 11 NFCs had answered. The following issues were addressed: 1. Identification of acid-sensitive areas. Most NFCs suggest using geological maps and additional information. 2. Which acidification criteria to use? Various methods were suggested. 3. Overlap with WFD reporting. In total 8 NFCs are reporting to the WFD, and WFD data have some potential for this assessment. Ms. Austnes gave the tentative outline for the report. Call for data June 15, with deadline for contribution on November 1.

20. Ms. De Wit asked if ICP IM sees possibilities to collaborate with ICP Waters on this report. Mr. Lundin answered that this needed further discussion, but that ICP IM does not have a spatially extensive network.

21. Mr. Löfgren (Sweden) expressed surprise over the lack of international agreement on a definition on what acidified water is. Ms. Austnes described various practices from different countries. Mr. Fölster (Sweden) also commented on various options. Mr. Aherne (Canada) asked when it would be clear what data or response were requested and informed that Canada intends to help with the report, depending on capacity.

22. Mr. Jens Fölster (Sweden) gave a talk entitled “A statistical method for detecting artefacts in time series”. Sweden has 50 years of freshwater monitoring and he gave examples of suspected artifacts and how they were identified. Case studies described were a change in method for Tot-N, effect of change in laboratories, and malfunction of equipment for determination of TotP. With Generalized Additive Models, it is possible to test step-changes in environmental time series.

23. Mr. Sample (ICP Waters Programme Centre) asked if it was necessary to define possible break points *a priori*. Mr. Fölster confirmed this.

24. Ms. Heleen de Wit (ICP Waters Programme Centre) gave an update on the work with DOC trends in Europe and North America. Both air pollution and climate change affect DOC trends, but air pollution remains the dominating driver. There are some interesting patterns in levelling out and strengthening of DOC trends in the 2000s, which so far cannot be explained by a single factor.

25. Ms. Anna Engleryd (Chair EB) gave a background on air pollution policy in the EU, and mentioned the thematic strategy on Air pollution and the new NEC Directive 2016/2284. The NEC Directive entered into force in December 2016. Emission reduction commitments for EU 28 for 2005-2030 are considerable: SO2 by 79%, NOx by 63%, NMVOC by 40%, NH3 by 19%, PM2 by 49%. Interim ceilings are set for 2025. Article 9 states that Member States shall ensure monitoring and shall report by 2018 and every 4th year thereafter. ICPs were invited to a meeting in Brussels in April to inform about their effect-based monitoring and its possible use for the NEC Directive. From this meeting, it appears that MS are positive to using existing networks to perform the monitoring that the NEQ Directive requires. However, it is necessary to develop a guidance document on how to select stations and ensure representatively. It is likely that NFCs can play an active role in each Member State to help implement the NEC Directive on a national basis. With regard to international collaboration, it is possible that the EU will support the existing infrastructures under the CLTRAP, but this is still open. More cooperation between the ICPs and further presentation of the WGE as a single monitoring network would be helpful.

26. Ms. Engleryd's presentation inspired a lively discussion. Mr. Lundin (Chair ICP IM) asked if an implication of the NEC Directive was that new countries would be included under the ICPs Ms. de Wit (ICP Waters Programme Centre) asked the NFCs if they had heard about the NEC Directive and the possible role for ICPs and national monitoring programmes. The response was that many had heard of the Directive but did not know many details, but certain NFCs were well-informed. Mr. Cummings (Ireland) commented that this was the best news for effect-based monitoring he had heard in a good while.

27. Ms. Engleryd encouraged the Task Force to discuss how we can help the Commission with implementation of the Directive.

28. Ms. Rogora (Italy) asked how non-compliance with the directive would be sanctioned. Ms. Engleryd replied that this would be fines.

29. Ms. Engleryd offered to provide a list of people involved in the various Member States.

30. Ms. Rábago (Chair WGE) explained that the NEC Directive's Article 9 states that monitoring is mandatory, and that its Annex V is not binding.

31. Mr. Tomasz Pecka (Poland) presented the Integrated Monitoring Network in Poland - current status and future perspectives. Poland has more than 20 years of monitoring records. Monitoring is funded for 5 years at a time. He described the location of the 9 proposed IM stations. Atmospheric S deposition is decreasing at most stations, but not all. The nitrate/sulphate ratio in deposition is increasing. Both decreasing and increasing trends of sulphate are observed in runoff. Puszcza Borecka is an IM "super station". Many parameters are determined and used extensively for testing of various models. There are differences between typical ICP IM stations and proposed stations in Poland with respect to catchment sizes, framework rules, methodology, and assessment period.

32. Mr. Pavel Kram (Czech Republic) asked why there was no station in the Southwest, which is very acid-sensitive. Mr. Pecka answered that there is one ICP Waters station, but it is not operational.

Heavy metals and POPs

33. Mr. Staffan Åkerblom (ICP IM) Presented heavy metal (HM) concentrations in terrestrial compartments and runoff across European IM sites, specifically Cd, Pb, Hg, Cu, and Zn. There is spatial variation in HM levels in forest compartments. Levels have decreased, but trends are levelling off. Asia is increasing its emissions of Hg, while they are decreasing in Europe and North America. There is high retention of HM in the terrestrial compartment. He displayed maps showing precipitation, through-fall, runoff and litterfall. He concluded that data are important for evaluating responses to changes in air pollution. What about POPs? Mr. Åkerblom also mentioned a submitted manuscript on air transported PFAS (per- and polyfluoroalkyl substances) in Perch across a gradient of pristine Swedish lakes (Åkerblom et al. STOTen, accepted).

34. Mr. Aherne (Ireland) asked if the data could be compared with those from ICP Vegetation's moss survey. Mr. Åkerblom answered that this was not planned.

35. Ms. de Wit mentioned that the data that were presented were not all data she was familiar with, and suggested that a Call for data would be helpful. Mr. Åkerblom answered that data would be very welcome.

36. Mr. Vuorenmaa (ICP IM Programme centre) mentioned that Finland also had data that could be useful.

37. Mr. Hans Fredrik Veiteberg Braaten, (ICP Waters Programme Centre) presented the report in progress, which considers spatial and temporal trends of mercury in freshwater fish in Fennoscandia. The report will be ready to be presented at the next WGE-EMEP meeting in September. The aim was to collect all data on mercury in fish in Scandinavia in order to assess trends and effects of long-range transported air pollution. Mercury is included in old and new international regulation and agreements (e.g. Minimata convention, WFD) and their effects need to be assessed. Increasing as well as decreasing trends of mercury in fish are reported in the literature. The database used in the present work holds data Hg data on 66 456 fish specimens collected between 1965 and 2015. Age, growth, species and trophic status are important factors affecting mercury levels in fish. The overall level, considering all the data, is apparently declining. Bias owing to spatial representation can, however, not yet be ruled out. Lakes were categorized according to the likelihood that they had been affected by local point sources of mercury. Temporal trends in individual lake records did not show uniform patterns. Long time series from individual lakes that are exclusively affected by air pollution will be given further attention. There is a large potential for further study in the database compiled in this work.

Biology responses to air pollution

38. Mr. Andreas Bruder (Switzerland) presented environmental drivers of leaf litter decomposition in streams. He described the food web of forested streams. The main decomposers are fungi and shredders who break litter down to smaller fractions. Decomposition depends on several biotic and abiotic factors such as temperature, chemicals, pollution, flow velocity, litter characteristics, biodiversity community composition, and also pH He concluded that litter decomposition is sensitive to environmental conditions, and that part of ecological variation could be reduced using standardized substrate.

39. Ms. Londiwe M Khuzwayo (South Africa) gave a presentation entitled species sensitivity to acidification in highly endemic regions of South Africa. South Africa is building new coal power stations, and in certain regions there is high deposition of S and N with potential effects on aquatic biota. It was difficult to find suitable EPT indicator species because the species are highly endemic. She found indications that *Baetida spp* in the region with highest deposition had changed since the 60s, but waters were not acid sensitive. Water chemistry data were still being analysed.

40. Ms. Ika Djukic, (Austria) gave a presentation entitled "Nitrogen deposition impacts in the Austrian IM site Zöbelboden – long-term observations and future research directions". Highest deposition is found in the northern limestone alps, exceeding critical loads. Negative effects on biodiversity are observed in the lichen community. Climate events drive nitrate loss to groundwater, not average conditions. Forest disturbance (e.g. insect attack) strongly reduces N retention. She suggested that future reduction in N deposition and climate change will cause higher N retention.

41. Mr. Gaute Velle (ICP Waters Programme Sub-centre) gave a presentation entitled "Gas supersaturation may cause effects on the biota comparable to acidification". Gas supersaturation occurs both naturally and as a man-made phenomenon caused by hydropower plants. He presented a study from the River Otra. Effects can be traced up to 30 km from the outlet of a not optimally designed power plant. He presented findings suggesting that gas supersaturation has a strong effect on invertebrates and fish for a stretch of up to 30 km of the river. The effects are such that they could be mistaken for acidification effects.

42. The presentation inspired the following questions and comments. Mr. Rosseland (Norway) commented that gas supersaturation is a major problem in aquaculture. Mr. Bruder asked whether it is possible to find a specific indicator for gas super saturation. Mr. Velle answered that this would be useful. Ms. de Wit asked whether the ICP Waters data could be affected by such problems. Mr. Velle did not suspect that it was a major problem.

43. Ms. Ekaterina Pozdnyakova (Russia) gave a presentation entitled "Co-analysis of coniferous forest state parameters and atmospheric deposition data series obtained by ICP IM and EMEP at the European part of Russia". Trends were observed at two stations. Correlations with deposition of SO4, NO3, NH4, Na, Mg, Ca, Cl and K were observed. It was suggested that the effect was due to fertilization. Coniferous forests in the north were found to be more sensitive. The results could be used for testing models.

44. Mr. Lundin asked whether climate change effects like droughts were considered. Ms. Pozdnyakova answered that this had not yet been done, but hopefully in the future. Mr. Lundin mentioned that insects and fungi also could affect forest.

45. Mr. Jakub Hruška (Czech Republic) gave a presentation entitled "Recovery of benthic algal assemblages from acidification: how long does it take, and is there a link to eutrophication?". He started by showing a map indicating the acidified areas of Czech Republic. Only about 5 % of the area affected. He showed trends of acidification parameters. He concluded that episodic low pH appears to be an important pressure for the community. Acidification is a more important driver than eutrophication in these areas. Episodes are more important than means.

Critical loads/Dynamic modelling

46. Ms. Maria Holmberg, (ICP IM Programme Centre) gave a talk entitled "Soil modelling study VSD+". The aim was to study impacts of N deposition and climate change on vegetation. The simulated responses with respect to carbon/nitrogen ratios were very variable. The next step is going to be the use of the vegetation module of the model.

47. Ms. Tatyana Moiseenko (Russia) gave a presentation entitled "Acidification and Critical Loads of Surface Waters: European Territory of Russia and Western Siberia". Monitoring has traditionally been focused on large water bodies and not acid sensitive waters. She presented results from investigations of about 270 lakes in transects in the European part Russia and about the same number of lakes in Siberian Russia. There are different types of emissions in the two areas and a strong north south gradient in deposition. European lakes were more acid sensitive than Siberian lakes. She asked the audience about how one should include organic acids in the assessment of acidification. CL was set to ANC = 50 µEq/L. She showed a map with future scenarios in the Kola peninsula, displaying mixed responses.

48. Ms. de Wit asked about expectations for future extraction of oil and gas in Western Siberia. Ms. Moiseenko answered that increases are expected, but she did not have data on this.

49. Mr. Jussi Vuorenmaa (ICP IM Programme Centre) gave a presentation entitled "Relationships between critical load exceedances and empirical impact indicators - Update of N assessment". Previous work indicated good agreement between CL calculations and empirical indicators. The conclusion holds also for this new investigation. Improvement is visible. There is a shift towards less exceedance. There are plans to extend empirical indicators to include vegetation.

50. Mr. Löfgren commented that two of the sites with very high concentrations were in karst areas. It was suggested that agricultural influence could be a factor. Mr. Löfgren questioned the representatively of these two sites. Mr. Vuorenmaa said that the sites might be excluded from the analysis.

51. Ms. de Wit asked how the exceedance was calculated, e.g. biological background. Mr. Vuorenmaa answered that the critical loads were calculated from mass balance.

52. Mr. Lundin asked what happens with the organic nitrogen. Mr. Vuorenmaa commented that only the inorganic N was considered in this exercise.

Issues common for both ICPs

53. Mr. Øyvind Garmo (ICP Waters Programme Centre) gave a presentation on the annual chemical intercomparison. The work is done by his colleague Carlos Escudero. 35 laboratories from 20 countries participated. The report is published and can be obtained from them ICP Waters web page. Mr. Garmo described how the test was done, described the samples and outlined the results. pH and alkalinity are typically the parameters with the worst performance. This is partly because laboratories have different ways of measuring pH (stirring, non-stirring, etc.) and alkalinity (different types of titrations). This year total concentration off phosphorous will be included as a parameter. Contact carlos.escudero@niva.no before May 24 if you are interested in participation.

54. Mr. Löfgren suggested adding 'air-equilibrated pH' as a parameter (diurnal variation in CO2 might affect pH). It was stated that results for pH would improve if one used more acidic samples. However, this would have the opposite effect on alkalinity. Moreover, the acidity should reflect the waters that we monitor in ICP Waters. HM levels in the test samples should be lowered somewhat.

55. Mr. Lundin, Mr. Skotte and Ms. de Wit described the plan for the separate sessions of the ICPs.

Separate ICP Waters TF meetings

56. Ms. Kari Austnes (ICP Waters Programme Centre) provided more detail about the regional assessment on surface water acidification status. Major discussion points were: How to produce consistent overview and how to distribute work between the Programme centre and Focal centres. Different countries have different methods for assessing acid-sensitivity. National maps can be provided in individual chapters but one map for the ECE countries, made with consistent data, would also be useful. It was commented that geological nomenclature is not uniform in all regions, which might pose challenges for using only one data source. It was highlighted that such maps would be very useful given the recent needs of implementation of monitoring networks for the NEC Directive, to document where stations are lacking. Ms. Austnes asked about the availability of maps for N America. Mr. Stoddard (USA) replied that US and Canada have separate maps but they could be used together. Ms. de Wit (ICP Waters Programme Centre) suggested that the work with these maps will have a high priority. Ms. Engleryd (Chair EB) informed that the EU commission suggests a kick off meeting to prepare for the NEC Directive already before the summer, and that follow-up meetings in the autumn must be expected. The NEC Directive needs guidance documents and first versions should be produced, which can be revised later. The monitoring site selection must be ready by July 1, 2018. Ms. de Wit suggested that the ICPs are likely to have the best information on the location of such stations and all NFCs should consider how to start the work with this topic.

57. Mr. Skotte (Chair ICP Waters) added that it would also be good to produce maps (geology) for EECCA countries in addition to Europe and North America. This will give useful information in order to identify the most relevant EECCA countries to include in the ICP Waters monitoring network.

58. Ms. Austnes presented different sources of information on surface water acidification status, such as critical load maps and data reported under the WFD. It was pointed out that definition of water body types (with regard to size) could lead to underestimation of the extent of acidification, and that this should be clear in the report. Also, it was pointed out that the WFD data suggested that certain countries do not have acidification issues, which is wrong. The question was raised how information would be obtained from countries that are not involved in ICP Waters. The NEC Directive presents an obligation for all member states, and it is possible that more countries will participate.

59. Ms. Austnes moved on to present the reported data availability from the NFCs that have responded and various methods for spatial extrapolation of limited datasets to the country-level, or the level of acid-sensitive regions. Ms. Austnes identified the challenge of consistency between countries. Mr. Stoddard commented that uncertainty will vary from country to country, but that this is not unusual and that there are methods, for instance from IPCC, to show how the uncertainty varies. Also, it was pointed out that relevant dataseries, which can be sent to ICP Waters, are not necessarily time series and thus do not require extensive quality assurance. Ms. de Wit asked if it is an aim to calculate the proportion of lakes or rivers that are acidified, or if the absolute number can be estimated. Ms. Rogora (Italy), Ms. Steingruber (Switzerland) and Mr. Ulańczyk (Poland) answered that sensitive areas in their countries were small and the selection of lakes was representative of these areas. Ms. Moiseenko and Ms. Dinu (Russian Federation) commented that it would be difficult to cover the whole of Russia.

60. Ms. Austnes raised the next issue, i.e. How to define what constitutes acidified waters? Several NFCs explained their national approaches. Mr. Stoddard said that in US they used DOC to define whether a lake was naturally acidic or acidified. Mr. Stoddard commented that for the global overview it was important to use consistent methods (e.g. ANCorg). In the national chapter it could be described how it is actually done.

61. Ms. de Wit complimented Ms. Austnes with the work done so far and said that the report will be very relevant, also with regard to the current developments of the NEC Directive.

62. A reference group for the regional acidification report is needed, which will be established in 2017.

63. Mr. Sample (ICP Waters Programme Centre) gave an update on the status of the database. The quality of site meta data has been improved. The biggest remaining challenge is duplication of sites. He described what he would like to do before uploading the most recent data. He gave a short description of the new web page. Ms. de Wit asked if it was OK to show raw data instead of annual means, and there were no objections. Ms. de Wit asked what the NFCs thought about rendering their data open access on the ICP Waters site. Mr. Fölster replied that it would be advisable to refer people to the original database because the original data providers will always be able to provide the latest quality-assured data. Ms. De Wit said that the tendency in society in general is moving towards open access. Mr. Sample rounded off by encouraging the NFC to send him references to reports and publications.

64. Mr. Godtfred Anker Halvorsen (ICP Waters Programme Sub-centre) presented the ICP Waters Biological Intercalibration 2016. The aim is to promote international harmonization of monitoring practices and evaluate quality of taxonomic work. Mr. Anker described how the samples are produced, and how the quality of the work is assessed. The results were good, but just two labs, one from Norway and one from Sweden, participated. There will be more participants in the coming Intercalibrations. UK has unfortunately lost funding and finished monitoring invertebrates in 2015.

65. Ms. de Wit (ICP Waters Programme Centre) presented the status of the participation in various activities under ICP Waters (**Annex III**) and went through the workplan for 2017-2019 (**Annex IV**). She repeated the recommmendations of the ICP review, as well as past and current reports since 2010. Two potential topics for the 2019 report was presented. Ms.de Wit suggested to take up nitrogen again, and evaluate how nitrogen species have changed, specifically with compared to phosphorous. This might be interesting for a number of issues, including productivity. Mr. Gaute Velle (ICP Waters Programme Sub-centre) presented an idea considering the functional diversity of macro invertebrates in relation to air pollution. The different options were discussed and both received support. With regard to the nitrogen topic, it was highlighted that nitrogen is an issue not just for the CLRTAP but also for marine eutrophication, where contribution from nitrogen deposition is not well understood. Also, the issue is relevant for the WFD. In addition, it presents possibilities to collaborate with ICP IM. With regard to functional diversity, the question of policy-relevance was raised. Ms. de Wit concluded that there seemed to be most interest in the nitrogen topic, and we will explore this further.

66. Ms. de Wit asked about the experience with joint meetings with ICP IM. Most NFCs were positive. The topic of having a full day excursion before the meeting instead of half a day during the meeting came up. Mr Lundin said that this the host organization should be involved in that decision.

67. Mr. Ulańczyk and Mr Pecka announced that they on behalf of the Polish Ministry of Environment invited us to Warszawa for the 2018 joint TF meeting. This was very well received by the attendants.

Common Task Force meeting

68. Outcome of relevant discussions at the separate meetings were summarized.

69. Mr. Lundin said that ICP IM had questions regarding the acidification report. He said that ICP IM were interested in contributing if this was considered useful. Ms. de Wit proposed that ICP IM could contribute by having representatives in the reference group for the report. Mr. Lundin passed the message to Mr. Vuorenmaa who would take it back to the Programme Centre of ICP IM.

70. Mr. Lundin asked whether ICP Waters is going to continue working with mercury. Ms. de Wit said that a scientific paper would be written in the wake of the report.

71. Next, the NEC Directive. Mr. Lundin said that all ICP IM feedback would be going through Ms. Rábago. Ms. de Wit said that ICP Waters in addition would emphasize contact between NFCs and local representatives involved in the NEC Directive.

72. Mr. Lundin thanked for a fruitful meeting and announced that he would retire as Chair of ICP IM. New Chair is Mr Grandin with co-chair Mr. Valinia will take over.

73. Mr. Skotte thanked Mr. Lundin for his efforts and service, and wished him good luck in the future.

74. Mr. Fölster thanked Naturvårdsverket and SLU for financially supporting the meeting.

75. Closing of the meeting.

6. Annex I: Participants at the ICP Waters 33rd Task Force meeting

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7. Annex II: Agenda for the 33rd Task Force ICP Waters May 9-11, 2017

Venue: Ulltuna, Uppsala, Sweden

Introductions

- Opening words, *Lars Lundin, Chair ICP IM*
- Welcome to SLU, *Kevin Bishop, Pro Vice-Chancellor at SLU*
- Ecosystem and water environments in Sweden: *Björn Risinger, Director General of the Swedish EPA*
- Adoption of the agenda*, Lars Lundin, Chair ICP IM*
- General information about the meeting and excursion*, Jens Fölster, local host*
- WGE Common issues and reporting*, Isaura Rábago, Chair WGE*
- Current issues ICP Waters*, Gunnar Skotte, Chair ICP Waters*
- Current issues ICP IM*, Lars Lundin, Sweden, Chair ICP IM*

Acidification and recovery

- Potential impact of forest biomass harvest on the acidity of Swedish surface waters*. Stefan Löfgren, Sweden*
- Trends in S and N budgets of Swiss high-altitude mountain lakes*. Steingruber Sandra, Switzerland*
- Air and Surface Water Quality Monitoring System in Moldova*. Natalia Zgircu, Moldova.*
- Report on activities in CLRTAP*, Anna Engleryd, Chair EB*
- The regional assessment on surface water acidification status*. Kari Austnes, ICP Waters Programme Centre*
- A statistical method for detecting artefacts in time series*. Jens Fölster, Sweden*
- DOC trends in Europe and North America*, Heleen de Wit, ICP Waters Programme Centre*
- NEC directive - information and discussion on implication for national monitoring and international cooperation*. Anna Engleryd, Chair EB*
- Integrated Monitoring Network in Poland - current status and future perspectives*. Tomasz Pecka, Poland.*

Heavy metals

- Heavy metal concentrations in terrestrial compartments and runoff across European IM sites. *Staffan Åkerblom, Sweden*
- Spatial and temporal trends of mercury in freshwater fish in Fennoscandia. *Hans Fredrik Veiteberg Braaten, ICP Waters Programme Centre*

Biology responses to air pollution

- Environmental drivers of leaf litter decomposition in streams, *Andreas Bruder and Julien Cornut, Switzerland*
- Species sensitivity to acidification in highly endemic regions of South Africa. *Londiwe M Khuzwayo, South Africa.*
- Nitrogen deposition impacts in the Austrian IM site Zöbelboden – long-term observations and future research directions. *Ika Djukic, Austria.*
- Gas supersaturation may cause effects on the biota comparable to acidification. *Gaute Velle, ICP Waters Programme Sub-centre*
- Co-analysis of coniferous forest state parameters and atmospheric deposition data series obtained by ICP IM and EMEP at European part of Russia. *Ekaterina Pozdnyakova, Russia*
- Recovery of benthic algal assemblages from acidification: how long does it take, and is there a link to eutrophication? *Jakub Hruška, Czech Republic*

Critical loads/Dynamic modelling

- Soil modelling study VSD+. *Maria Holmberg, ICP IM Programme Centre*
- Acidification and Critical Loads of Surface Waters: European Territory of Russia and Western Siberia. *Marina Dinu/ Tatyana Moiseenko,Russia.*
- Relationships between critical load exceedances and empirical impact indicators - Update of N assessment. *Jussi Vuorenmaa, ICP IM Programme Centre*

Common Task Force meeting for both ICPs

- Chemical intercomparison, Øyvind Garmo, Norway, ICP Waters Programme Centre

Separate ICP Waters and ICP IM Task Force Meetings

- ICP Waters
    - The regional assessment on surface water acidification status – *Kari Austnes, ICP Waters Programme Centre*
    - ICP Waters Biological Intercalibration 2016. *Godtfred Anker Halvorsen, ICP Waters Programme Sub-centre*
    - Workplan
- ICP IM
    - Common WGE issues, database, Workplan

Common Task Force meeting

- Conclusions and closing of meeting

8. Annex III: Status participation in the ICP Waters programme as of September 2017

	Chemical data	Biological data	Participation in TF meetings 2013-2017	Participation in chemical intercomparison 2014-2016	Participation in biological intercalibration 2014-2016
Armenia	2012		•		
Austria	2015		•	•	
Belarus	2015				
Belgium				•	
Canada	2015			•	
Croatia					
Czech Rep.	2016	2011	•	•	
Estonia	2016		•	•	•
Finland	2016		•	•	
France				•	
Germany	2016	2015	•	•	•
Ireland	2012		•	•	
Italy	2016		•	•	
Latvia	2016	2014		•	•
Lithuania				•	
Moldova	2016		•		
Montenegro	2012				
Netherlands	2016		•	•	
Norway	2016	2015	•	•	•
Poland	2013		•	•	
Russia	2016		•	•	
Serbia				•	
South Africa			•		
Spain	2014		•	•	
Sweden	2016	2014	•	•	•
Switzerland	2016	2015	•	•	•
UK	2015	2013	•	•	•
USA	2016		•	•	
Total	**21**	**7**	**18**	**22**	**7**

9. Annex IV: ICP Waters workplan for 2017 – 2019

2017

- Arrange thirty-third meeting of the Programme Task Force in spring of 2017, joint with ICP Integrated Monitoring, scheduled to be held in Uppsala, Sweden, May 8 to 10.
- Prepare proceedings from the 33rd Task Force meeting
  - abstracts (2-6 pages) by **Aug 1 2017** to oyvind.garmo@niva.no
  - Report delivered in **September 2017**
- Finalize mercury report
  - The draft report will be ready for review by **June 23 2017**
  - Comments to draft report are expected by **August 16 2017**
  - Special reviewers are Staffan Åkerblom, Matti Rask, Heleen de Wit
  - The report will be finalized **by September 1 2017**
- Write draft report on regional assessment of surface water acidification, with possible contributions from ICP M&M and ICP IM, and with a timeline that will make the report relevant for the implementation of the EU NEC Directive
  - Results from an enquiry to NFCs on data availability will be presented at the Task Force meeting in **May 2017**
  - A second call for contributions from NFCs will be sent by **June 15,** with deadline on **November 1st**.
  - An outline of the report will be presented on the WGE meeting in **September 2017**
  - Final report in print and to be presented at the **Task Force meeting 2018**
- Arrange and report chemical intercomparison 1731
  - in collaboration with all participating ICPs
  - Invitations will be sent in **March 2017**
  - Samples will be sent by **May 20 2017**
  - Report delivered in **September 2017**
  - Responsible person: Carlos Escudero
  - Laboratories that analyse samples for national monitoring programs and laboratories in EECCA countries will not pay a fee
- Arrange and report biological intercalibration 2017
  - in collaboration with participating ICPs
  - Send out invitations by **1 May 2017**
  - Report delivered in **November 2017**
  - Responsible person: Godtfred Anker Halvorsen
- Contribute to a DOC trend analyses, resulting in a submitted manuscript in **2017**
- Run the Programme Centre in Oslo and the Subcentre in Bergen, including:
  - maintenance of web-pages
  - Increase visibility of databases on the web-page
  - maintenance of database of chemical and biological data
  - Report to UNECE
- Submission of data to the Programme Centre by all Focal centres**.**
  - Responsible: James Sample
  - Call for data: **June 15 2017**
  - Submission by **August 15 2017**

- Participation in meetings of relevance for the ICP Waters programme
    - Contribute to implementation of NEC Directive, together with other bodies under WGE
    - Cooperation with other bodies within and outside the Convention
- Consider availability other water databases and cooperation with other water monitoring programmes (UNEP, GEMS, EEA, WFD)
- Cooperation with EECCA countries (Eastern Europe, Caucasus and Central Asian countries)

2018

- Arrange thirty-fourth meeting of the Programme Task Force in spring of 2018
- Prepare proceedings from the 34th Task Force meeting
- Finalize report on regional assessment of surface water acidification, with possible contributions from ICP M&M and ICP IM at the Task Force meeting in **spring 2018**
- Arrange and report chemical intercomparison 1832
- Arrange and report biological intercalibration 2218
- Prepare new thematic report for 2019 (suggested topic, to be decided on 2018 TF meeting: retention and effects of reactive nitrogen in surface waters), with possible contributions from other bodies under the Convention
- Run the Programme Centre in Oslo and the Subcentre in Bergen, including:
    - maintenance of web-pages
    - An overview of the layout and functioning of the web page, including publication list
    - Increase visibility of activity of Focal Centres on the web-page
    - maintenance of database of chemical and biological data
    - Report to UNECE
- Submission of data to the Programme Centre by all Focal centres.
- Participation in meetings of relevance for the ICP Waters Programme Contribute to implementation of NEC Directive, together with other bodies under WGE
- 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)

2019

- Arrange thirty-fifth meeting of the Programme Task Force in spring of 2019
- Write new thematic report (proposed topic: reactive nitrogen, to be discussed at the 2018 Task Force meeting)

10. 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/

Braaten, H.F.V., Åkerblom, S., de Wit, H.A., Skotte, G., Rask, M., Vuorenmaa, J., Kahilainen, K.K., Malinen, T., Rognerud, S., Lydersen, E., Amundsen, P.A., Kashulin, N., Kashulina, T., Terentyev, P., Christensen, G., Jackson-Blake, L., Lund, E., Rosseland, B.O. 2017. Spatial and temporal trends of mercury in freshwater fish in Fennoscandia (1965-2015). **ICP Waters report 132/2017**

Garmo, Ø., de Wit, H., Fölster, J. (editors). Proceedings of the 33rd Task Force meeting of the ICP Waters Programme in Uppsala, May 9-11, 2017. **ICP Waters report 131/2017**

Anker Halvorsen, G., Johannessen, A., Svanevik Landås, T. 2016. Biological intercalibration: Invertebrates 2016. **ICP Waters report 130/2016.**

Escudero-Oñate, C. 2016. Intercomparison 1630: pH, Conductivity, Alkalinity, NO3-N, Cl, SO4, Ca, Mg, Na, K, TOC, Al, Fe, Mn, Cd, Pb, Cu, Ni and Zn. **ICP Waters report 129/2016**.

De Wit, H., Valinia, S. (editors). 2016. Proceedings of the 32st Task Force meeting of the ICP Waters Programme in Asker, Oslo, May 24-26, 2016. **ICP Waters report 128/2016**.

Gaute Velle, Shad Mahlum, Don T. Monteith, Heleen de Wit, Jens Arle, Lars Eriksson, Arne Fjellheim, Marina Frolova, Jens Fölster, Natalja Grudule, Godtfred A. Halvorsen, Alan Hildrew, Jakub Hruška, Iveta Indriksone, Lenka Kamasová, Jiří Kopáček, Pavel Krám, Stuart Orton, Takaaki Senoo, Ewan M. Shilland, Evžen Stuchlík, Richard J. Telford, Lenka Ungermanová, Magda-Lena Wiklund, Richard F. Wright. 2016. Biodiversity of macro-invertebrates in acid-sensitive waters: trends and relations to water chemistry and climate. **ICP Waters report 127/2016**

De Wit, H., Valinia, S. and Steingruber, S. Proceedings of the 31st Task Force meeting of the ICP Waters Programme in Monte Verità, Switzerland 6th –8th October, 2015. **ICP Waters report 126/2015**

De Wit, H., Hettelingh, J.P. and Harmens, H. 2015. Trends in ecosystem and health responses to long-range transported atmospheric pollutants. **ICP Waters report 125/2015**

Fjellheim, A., Johannessen, A. and Landås, T.S. 2015. Biological intercalibration: Invertebrates 1915. **ICP Waters report 124/2015**

Escudero-Oñate, C. 2015 Intercomparison 1529: pH, Conductivity, Alkalinity, NO3-N, Cl, SO4, Ca, Mg, Na, K, TOC, Al, Fe, Mn, Cd, Pb, Cu, Ni, and Zn. **ICP Waters report 123/2015**

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. Intercom¬parison 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**

De Wit, H. A., Garmo Ø. A. and Fjellheim A. Chemical and biological recovery in acid-sensitive waters: trends and prognosis. **ICP Waters Report 119/2014**

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 Hruśka, 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., Indriksone 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., Skjelkvaale 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**

Dahl, I. 2012. Intercomparison 1226: pH, Conductivity, Alkalinity, NO3-N, Cl, SO4, Ca, Mg, Na, K, TOC, Al, Fe, Mn, Cd, Pb, Cu, Ni and Zn. **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, HCO_3, NO_3-N, Cl, SO_4, 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 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, HCO_3, NO_3-N, Cl, SO_4, Ca, Mg, Na, K, TOC, Al, Fe, Mn, Cd, Pb, Cu, Ni, and Zn. NIVA-report SNO 5845-2009. **ICP Waters report 98/2009**

Ranneklev, 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, HCO_3, NO_3-N, Cl, SO_4, 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, $NO_3 + NO_2$, Cl, SO_4, 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 Wrigth 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, Heergaard, 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, K_{25}, HCO_3, $NO_3 + NO_2$, Cl, SO_4, 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, K_{25}, HCO_3, $NO_3 + NO_2$, Cl, SO_4, 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 63/2001**

Raddum.G.G. 2000. Intercalibration 0005: Invertebrate fauna. NIVA-report SNO4384-2001. **ICP Waters report 62/2001**

Raddum, G.G. and Skjekvåle 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, K_{25}, $NO_3 + NO_2$, Cl, SO_4, 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, K_{25}, HCO_3, $NO_3 + NO_2$, Cl, SO_4, 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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