NIVA

REPORT SNO. 6761-2014

ICP Waters Report 121/2014

Biological intercalibration: Invertebrates 1814

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

Convention on Long-Range Transboundary Air Pollution

LRTAP

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

REPORT

Main Office	NIVA Region South	NIVA Region East	NIVA Region West
Gaustadalléen 21	Jon Lilletuns vei 3	Sandvikaveien 59	Thormøhlens gate 53 D
NO-0349 Oslo, Norway	NO-4879 Grimstad, Norway	NO-2312 Ottestad, Norway	NO-5006 Bergen Norway
Phone (47) 22 18 51 00	Phone (47) 22 18 51 00	Phone (47) 22 18 51 00	Phone (47) 22 18 51 00
Telefax (47) 22 18 52 00	Telefax (47) 37 04 45 13	Telefax (47) 62 57 66 53	Telefax (47) 55 31 22 14
Internet: www.niva.no			

Title	Report No.	Date
Biological intercalibration: Invertebrates 1814	SNO 6761-2014 ICP Waters report 121/2014	Desember 2014
	Project No. 10300	Pages 24
Author(s)	**Topic group**	**Distribution**
Arne Fjellheim, Uni Research AS, Bergen, Norway *Arne Johannessen, Uni Research AS, Bergen, Norway* *Torunn Svanevik Landås, Uni Research AS, Bergen, Norway*	Acidification	Open
	Geographical area Europe	**Printed** NIVA

Client(s)	Client ref.
Norwegian Environment Agency United Nations Economic Commission for Europe (UNECE)	

Abstract

The 18th intercalibration of invertebrates in the ICP Waters programme had contribution from three laboratories. The laboratories identified a very high portion of the individuals in the test samples, > 95% of the total number of species. On the genus level, few faults were recorded. The mean Quality assurance index ranged between 96.0 and 97.1, well above the value 80 - indicating very good taxonomic work.

4 keywords, Norwegian	4 keywords, English
1. Interkalibrering	1. Intercalibration
2. Invertebrater	2. Invertebrates
3. Akvatisk fauna	3. Aquatic fauna
4. Overvåking	4. Monitoring

Heleen de Wit
Project manager

Claus Beier
Senior Adviser

ISBN 978-82-577-6496-8

CONVENTION ON LONG-RANGE TRANSBOUNDARY AIR POLLUTION

INTERNATIONAL COOPERATIVE PROGRAMME ON ASSESSMENT AND MONITORING OF ACIDIFICATION OF RIVERS AND LAKES

Biological intercalibration: Invertebrates 1814

ICP Waters Programme Subcentre
Uni Research AS, P.O.box 7810,
N-5020 Bergen, Norway

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 have 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 lead the programme. A programme subcentre is established at Uni Research, University of Bergen. The Programme Centre's work is supported financially by the Norwegian Environment Agency and from the UNECE LRTAP Trust Fund.

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.

The Programme objective is to establish and maintain an international network of surface water monitoring sites and promote international harmonisation of monitoring practices. A tool in this work is the inter-laboratory quality assurance tests. The bias between analyses carried out by the individual participants of the Programme has to be identified and controlled. The tests will also be a valuable tool in improving the taxonomic skill of the participating laboratories.

We here report the results from the 18th intercalibration on invertebrate fauna.

Bergen, November 2014

Arne Fjellheim
ICP Waters Programme Subcentre

Contents

Summary

The 18th intercalibration of invertebrates in the ICP Waters programme had contribution from three laboratories. The biological intercalibration is important for harmonising biological material/databases and will be of high value in programmes where community analyses is in focus or where the ecological status should be stated, like EU Water Framework Directive. The biological intercalibration under the ICP Waters programme is a unique test, as it operates on a species level.

The laboratories identified a very high portion of the individuals in the test samples, > 95 % of the total number of species. Few faults were recorded on genus level. The mean Quality assurance index ranged between 96.0 and 97.1, well above the value 80 - indicating acceptable taxonomic work. None of the participants did misidentifications that could result in a wrong acidity index, based on the Raddum score (Raddum et al., 1988).

1. Introduction

The purpose of the biological intercalibration is to evaluate the quality of the taxonomic work on the biological material delivered to the Programme centre. The quality can influence on the evaluation of the samples, which is based on the species and their tolerance (Raddum *et al.* 1988, Fjellheim and Raddum 1990, Raddum 1999). The control is therefore important for evaluation of the significance of trends in biotic indexes both for a specific site/watershed, as well as for comparisons of trends between different regions and countries. The material is also used for multivariate statistical analysis (Larsen *et al.* 1996, Skjelkvåle *et al.* 2000, Halvorsen *et al.* 2002, Velle *et al*., 2013). The results of this type of data treatment are especially sensitive to the quality of the species identification. The biological intercalibration focuses on the taxonomic skills of the participants and is a tool for improving the quality of work at the different laboratories as well as harmonisation of the biological database.

The methods for intercalibration of biological material were outlined in 1991 at the 7th ICP Waters Task Force meeting in Galway, Ireland. The different countries/laboratories have to know, first of all, their home fauna. Since the fauna in different geographical regions vary, it is necessary to prepare specific samples for each participating laboratory, based on their home fauna. It is a problem for the exercise of the intercalibration that it is not possible to use standardised samples for all participants. To solve this problem, each laboratory send identified samples of invertebrates from their own monitoring sites to the Programme centre. The Programme centre will additionally add species known to be present in the region of the specific laboratory. Based on this, each laboratory receives individual test samples composed of species representing their own monitoring region.

The taxonomic skill of the different participants is measured by using a quality assurance index, see Raddum (2005). This index evaluates the skill of identifying the species as well as the genus. It also takes into account the effort of identifying all specimens in the sample. The highest index score is 100, while a value of 80 is set as the limit of good taxonomic work.

2. Methods

Preparation of test-samples

Samples of identified invertebrates were received from all participating laboratories. These samples were used to compose test samples, with the addition of specimens from earlier exercises and from own stocks. The geographical distribution of species was checked by the use of the Fauna Europaea Web Service 2013 (http://www.faunaeur.org). This is a database of the scientific names and distribution of multicellular European land and fresh-water animals (see example in Figure 1).

Figure 1. *Geographical distribution of the mayfly* Baetis rhodani *in Europe. This is an example of a widely distributed freshwater species. The map is, however, slightly incorrect. According to the Estonian collaborators in ICP waters, B. rhodani is the most common mayfly in Estonia. Map after Fauna Europaea Web Service, http://www.faunaeur.org, Photo: Arne Fjellheim*

Identification

To minimise possible faults, the following procedure is used in preparing the test samples:

- The participating country has first identified the source material for the test samples. Two of us have verified the identification of the species/taxa as far as possible without damaging the individuals.
- The content of the two test samples for each laboratory, with respect to species and numbers, is listed in a table. Two persons control that the correct number and species is placed in the test samples according to the list.

Damages of the material

The quality of the test material may be reduced during handling and shipping. Taxonomically important parts of the body, as gills, legs, cerci, mouthparts etc., can be lost or destroyed in actions connected with identification, sample composition and transportation. Contamination of larvae may also occur during these processes as well as during the identification work at the participating laboratories. All mentioned possibilities for faults could influence on the results of the identifications and disturb the results in a negative way.

Evaluation

The results of the tests are sent to the laboratories for eventual comments before publishing the report. In this way, we can remove taxonomical biases - for example misidentified or destroyed test material. In cases of disagreement, material may be sent back to the programme subcentre for control. This procedure may act educational for both parts.

For calculation of faults (in percent), we must take into account possible destructions of the material as mentioned above. Further, a wrong identification of a species is one fault even if the sample contains many individuals of the species. We encourage the participants to give comments on matters that may impede the identification. For example, misidentification of species in cases where important taxonomic characters have been destroyed may be neglected, if this is pointed out by the participants.

We have discriminated between "short coming" identification, probably due to damaged material, and virtual fault (wrong species – or genus name). Due to this, some subjective evaluations of the results have to be made. The percent of faults is therefore not always the exact calculated percent of faults, but can be a modified value where some "expert judgement" is taken into account.

It is also of interest to know how many individuals that have been identified of the total number in the sample. This is named *percent identified*. A low percent means that many individuals were not identified and will consequently reduce the value of the taxonomic work.

Available material for making test samples varies. The number of individuals and number of species delivered will therefore differ. Normally each laboratory gets between 90 and 130 individual species in the two samples. Samples with low diversity will be easier to handle than samples with high diversity, see Appendix tables. This should also be kept in mind when the results are evaluated. Small samples should be avoided, as only a few misidentifications could result in a low score.

We have calculated the quality assurance index, Qi, for important groups of invertebrates as well as the mean index for each participant. The Qi integrates the separate levels of the identifications as follows:

Qi = % correct species/10 * % correct genus/10 * % identified individuals/100

Qi will be a number between 0 and 100. 100 is the highest score that can be obtained. A score ≥80 is regarded as acceptable taxonomical work.

Test of the subcentre

The ICP waters subcentre in Bergen, Norway was tested with the help from Sweden. The Swedish University of Agricultural Sciences in Uppsala prepares and evaluates the test of the subcentre. Methodology and implementation is otherwise identical to the other tests.

3. Results and discussion

Three laboratories participated in the intercalibration of invertebrates in 2012 (Appendix A). The content of species in the test samples delivered – and the results of the identification by the different laboratories are shown in Appendix Tables 1 – 3.

Mayflies

The identification of mayflies (Ephemeroptera) was generally very good (Figure 2, Appendix Table 1- 3). Laboratory 3 identified the mayflies without faults. The results from laboratory 1 and 2 was very good. The Qi was calculated to 92, 95 and 100. This indicates very high quality of work.

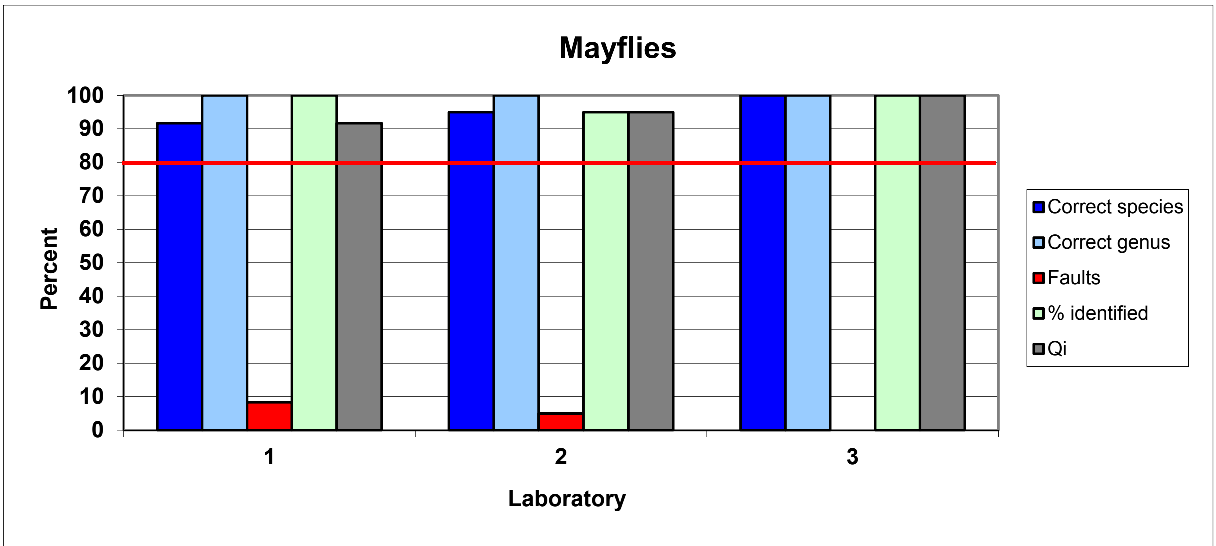

Figure 2. *Results of the identification of mayflies. The red line indicates the level of acceptance.*

Stoneflies

The identification of the stoneflies is presented in Figure 3 and Appendix tables 1 – 3. The results show a very good taxonomical knowledge of the group. The Qi was 96, 100 and 84 for laboratories 1, 2, 3, respectively, all above the limit of acceptance.

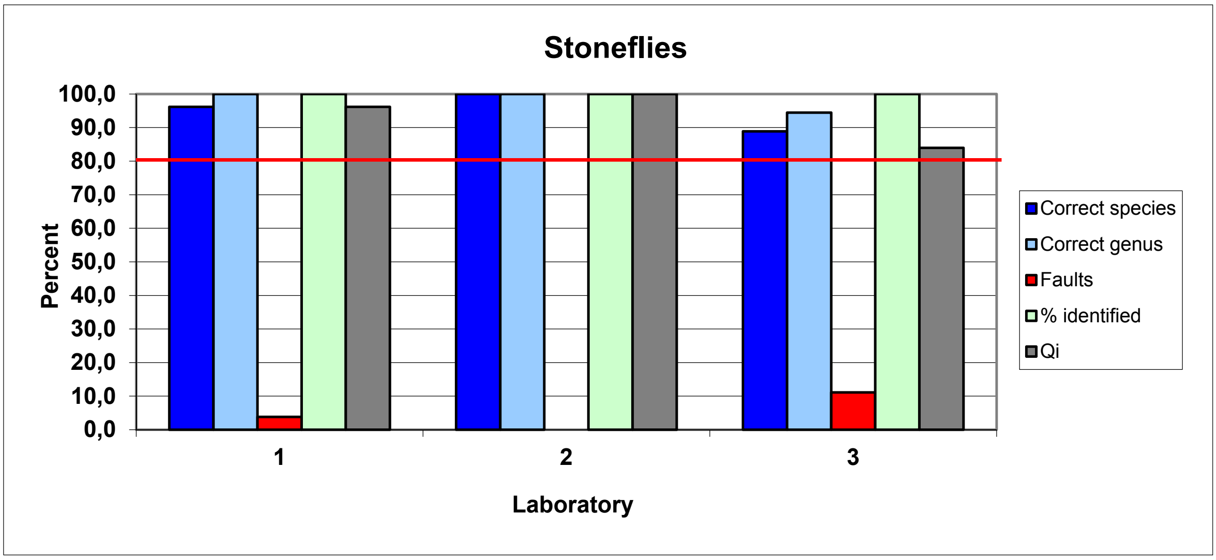

Figure 3. *Results of the identification of stoneflies. The red line indicates the level of acceptance.*

Caddisflies

The identification of caddisflies (Trichoptera) is presented in Figure 4 and Appendix tables 1 – 3. The quality of the identification was excellent for all laboratories, Qi values being 98, 100 and 100, for participants 1, 2 and 3, respectively.

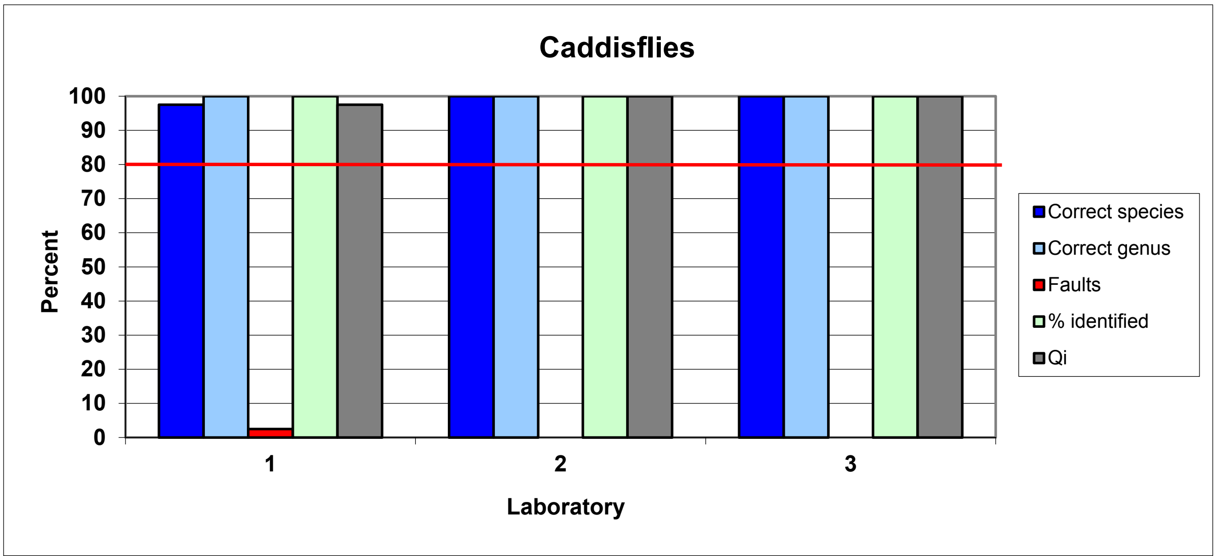

Figure 4. *Results of the identification of caddisflies. The red line indicates the level of acceptance.*

Other groups

In this intercalibration we have included water beetles (Coleoptera), larger crustaceans (Malacostraca), leeches (Hirudinea), molluscs (Gastropoda), alder-flies (Megaloptera), Diptera etc. Both larvae and imagines have been included for some of the groups. Leeches, molluscs and larger crustaceans are sensitive to acid water and important for the evaluation of acidification. The tolerance of the invertebrates among Coleoptera, Megaloptera, Diptera etc. is little known, but generally they are regarded as tolerant to acidic water and consequently have low importance for evaluation of acidity indices. However, all species will be important for invertebrate community analysis. Figure 5 and Appendix tables 1 – 3 shows the results of the identification of these groups. The identifications made by laboratory 1 and 3 were perfect with no faults. The result of Laboratory 2 was very good. The Qi score was 100, 93 and 100, for participants 1, 2, and 3, respectively.

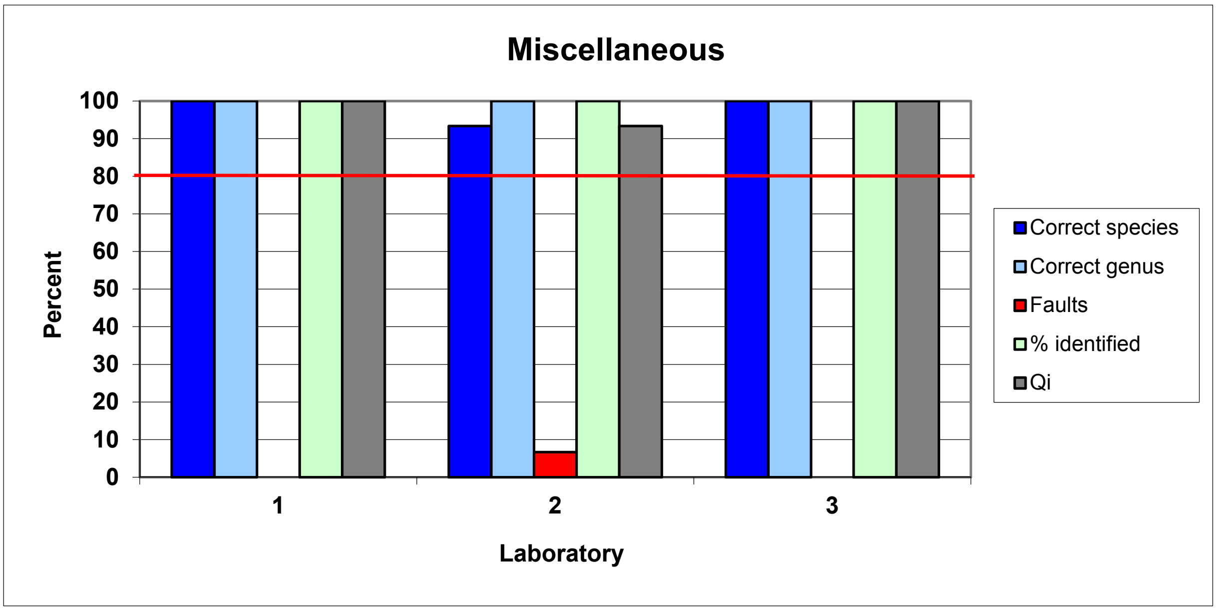

Figure 5. *Results of the identification of miscellaneous groups. The red line indicates the level of acceptance.*

Total number of species in the sample

There were generally low discrepancy between the number of individuals put into the samples and the reported number of larvae. A total of 328 individual specimens were sent to the different laboratories. Of these, 99.7 percent were reported back to the programme sub-centre.

4. Evaluation/conclusion

The laboratories generally identified a high portion of the total number of species in the test samples. The mean skill of identifying species, genus and Qi score per laboratory is shown in Figure 6. Laboratory 1 to 3 got a mean Qi score of 96, 97 and 96, respectively. This is characterized as excellent taxonomic work. The biological intercalibration is important for harmonising biological material/databases and will be of high value in programmes where community analyses is in focus or where the ecological status should be stated.

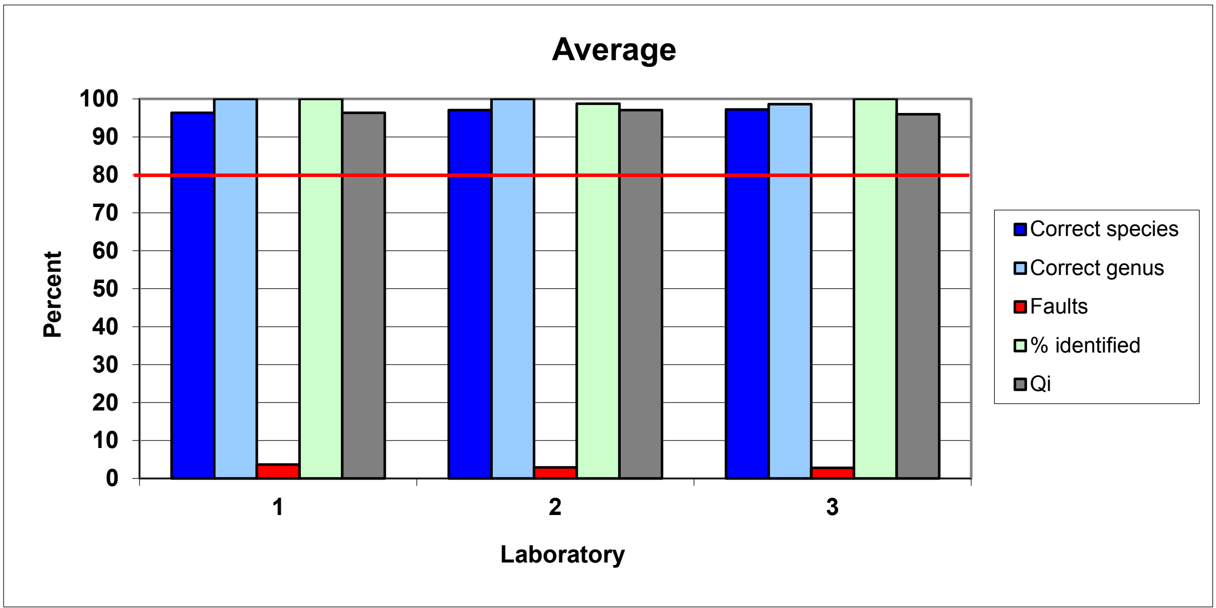

Figure 6. *Mean skill in percent of identifying species and genus and mean Qi for each laboratory. The red line indicates the level of acceptance.*

None of the participants did misidentifications that could result in a wrong acidity index, based on the Raddum score (Raddum et al., 1988).

The biological intercalibration under the ICP Waters programme was the first regular test aiming to test taxonomic skills of identifying benthic invertebrates. Today, similar tests are run by the North American Benthological Society (http://www.nabstcp.com) and by the Natural History museum, London (Identification Qualifications – IdQ test). The invertebrate groups covered in the latter test are those used in the BMWP water quality score system (Armitage et al., 1983) and include groups used for monitoring freshwater environments under the EU water framework directive (Schartau et al. 2008).

5. References

Armitage, P. D., D Moss, J. F. Wright and M. T. Furse, 1983. The performance of a new biological water quality score system based on macroinvertebrates over a wide range of unpolluted running-water sites. – Water Res. 17: 333–347.

Fauna Europaea Web Service (2013) Fauna Europaea version 2.6.2, Available online at http://www.faunaeur.org

Fjellheim, A. and G. G. Raddum, 1990. Acid precipitation: biological monitoring of streams and lakes. The Science of the Total Environment, 96, 57-66.

Halvorsen, G. A., E. Heegaard and G.G. Raddum, 2002. Tracing recovery from acidification – a multivariate approach. NIVA- Report SNO 4208/2000, ICP Waters Report 69/2002, 34 pp.

Larsen, J., H.J.B. Birks, G.G. Raddum & A. Fjellheim 1996. Quantitative relationships of invertebrates to pH in Norwegian river systems. Hydrobiologia 328: 57-74.

Raddum, G. G. 1999. Large scale monitoring of invertebrates: Aims, possibilities and acidification indexes. In Raddum, G. G., Rosseland, B. O. & Bowman, J. (eds.) Workshop on biological assessment and monitoring; evaluation of models. ICP-Waters Report 50/99, pp.7-16, NIVA, Oslo.

Raddum, G. G. 2005. Biological intercalibration: Invertebrates 0905. NIVA-report SNO 5067 2005, ICP Waters report 81/2005.

Raddum, G. G., A. Fjellheim and T. Hesthagen, 1988. Monitoring of acidification through the use of aquatic organisms. Verh. Int. Verein. Limnol. 23: 2291-2297.

Schartau, A.K., Moe, J., Sandin, L., McFarland, B. and Raddum, G. G. 2008. Macroinvertebrate indicators of lake acidification: analysis of monitoring data from UK, Norway and Sweden. Aquatic Ecology, 42: 293–305.

Skjelkvåle, B. L.; Andersen, T.; Halvorsen, G. A.; Raddum, G. G.; Heegaard, E.; Stoddard, J. and Wright, R. F. 2000. The 12-year report: Acidification of Surface Water in Europe and North America; Trends, biological recovery and heavy metals. ICP Waters report, nr. 52/2000. Oslo: Norwegian Institute for Water Research; 2000. 115 s.

Velle, G. 2013. Biodiversity in freshwaters: temporal trends and response to water chemistry. ICP Waters Report (in press).

Responsible laboratories

Each participating laboratory is identified by a number, which is identical with the table number. Laboratories participating in the intercalibration of invertebrates in 2011 and their code numbers are:

1. Swedish University of Agricultural Sciences, Dept. of Environmental Assessment, P.O. Box 7050, S-75007 Uppsala, Sweden. Responsible taxonomist: Magda-Lena Wiklund
2. Bayerisches Landesamt für Umwelt, Referat 83 - Ökologie der Fließgewässer, Hans Högn Straße 12, 95030 Hof. Responsible taxonomist: Astrid Weissbach
3. Uni Research AS, P.O.box 7810, N-5020 Bergen, Norway. Responsible taxonomists: Torunn Landås and Arne Johannessen

Appendix B. Results

Appendix table 1. Identified species/genus in sample 1 and 2 by Laboratory 1

Taxa:	Sample 1 Delivered	Sample 1 Identified	Sample 2 Delivered	Sample 2 Identified
Ephemeroptera				
Nigrobaetis digitatus	1	1	1	1
Seratella ignita	1	1	1	1
Heptagenia sulphurea	1	1	1	1
Ephemerella mucronata	1	1	1	1
Caenis luctuosa	1	1	1	1
Heptagenia dalecarlica	1		1	1
Ephemera danica	1	1		
Ephemera vulgata			1	1
Leptophlebia marginata	1			
Leptophlebia vespertina			1	1
Leptophlebia sp.		1		
Nigrobaetis niger	1	1		
Cloeon inscriptum	1		1	
Cloeon dipterum-gr.		1		1
Heptagenia fuscogrisea	1	2	1	1
Baetis rhodani	1	1	1	1
Ameletus inopinatus			1	1
Plecoptera				
Amphinemura sulcicollis	1	1	1	1
Ampinemura borealis	1	1	1	1
Nemurella pictetii	1	1	1	1
Capnopsis shilleri	1	1	1	1
Leuctra fusca	1	1	1	1
Nemoura cinerea	1	1	1	1
Protonemura meyeri	1	1	1	1
Capnia bifrons	1	1	1	1
Brachyptera risi	1	1	1	1
Isoperla grammatica	1	1	1	1
Nemoura flexuosa	1	1		
Nemoura dubitans			1	
Nemoura avicularis				1
Siphonoperla burmeisteri	1	1	1	1
Taeniopteryx nebulosa	1	1	1	1
Amphinemura sulcicollis	1	1	1	1
Ampinemura borealis	1	1	1	1
Nemurella pictetii	1	1	1	1
Capnopsis shilleri	1	1	1	1
Leuctra fusca	1	1	1	1
Nemoura cinerea	1	1	1	1
Protonemura meyeri	1	1	1	1

Trichoptera				
Rhyacophila nubila	1	1	1	1
Rhyacopila fasciata	1	1	1	1
Hydropsyche pellucidula	1	1	1	1
Lepidostoma hirtum	1	1	1	1
Sericostoma personatum	1	1	1	1
Micrasema gelidum	1	1	1	1
Tinodes waeneri	1	1	1	1
Chimarra marginata			1	1
Ecnomus tenellus			1	1
Philopotamus montanus	1	1		
Brachycentrus subnubilus	1	1		
Polycentropus flavomaculatus	1	1	1	1
Wormaldia subnigra	1	1		
Ceratopsyche silfvenii	1	1	1	1
Agapetus fuscipes	1	1		
Agapetus ochripes			1	1
Molanna angustata	1	1		
Arctopsyche ladogensis	1	1		
Glypotaelius pellucidus	1	1		
Ceraclea annulicornis	1	1	1	1
Athripsodes cinereus	1	1		
Athrispodes aterrimus			1	1
Cyrnus trimaculatus	1	1		
Cheumatopsyche lepida	1	1	1	1
Psychomyia pusilla			1	1
Hydropsyche angustipennis			1	
Hydropsyche saxonica				1
Nemotaulius punctatolineatus			1	1
Molannodes tinctus			1	1
Neureclipsis bimaculata			1	1
Miscellaneous				
Hirudinea				
Helobdella stagnalis	1	1		
Erpobdella octoculata			1	1
Diptera				
Chaoborus flavicans	1	1	1	1
Gastropoda				
Anisus vortex			1	1
Gyraulus (Planorbis) crista	1	1		
Gyraulus albus	1	1	1	1
Potamopyrgus antipodarum	1	1	1	1
Malacostrata				
Asellus aquaticus	1	1	1	1
Gammarus pulex	1	1	1	1
Coleoptera				
Platambus maculatus	1	1	1	1
Orectochilus villosus	1	1		

Hygrotus versicolor			1	1
Limnius volckmari	1	1	1	1
Elodes sp.	1	1	1	1
Nebriporus depressus			1	1
Odonata				
Erythroma najas	1	1		
Onychgomphus forcipatus			1	1
Corixidae				
Callicorixa praeusta	1	1		
Notonecta glauca			1	1
Heteroptera				
Velia caprai	1	1	1	1
Apheloceirus aestivalis			1	1

Appendix table 2. Identified species/genus in sample 1 and 2 by Laboratory 2

Taxa:	Sample 1 Delivered	Sample 1 Identified	Sample 2 Delivered	Sample 2 Identified
Ephemeroptera				
Ephemera danica	1	1	1	1
Ecdyonurus torrentis	1	1		
Rhitrogenia cf.semicolorata	1	1	1	1
Ephemerella major	1	1		
Ephemerella sp.			1	1
Ephemerella notata	1	1	1	1
Epeorus assimilis	1	1	1	1
Caenis luctuosa	1	1	1	1
Baetis rhodani	1	1	1	1
Potamanthus luteus	1	1	1	1
Alainites muticus	1		1	
Baetis sp.				1
Ephemerella ignita			1	1
Plecoptera				
Nemurella picteti	1	1	1	1
Dinocras sp.	1	1	1	1
Brachyptera risi	1	1	1	1
Amphinemura sp.	1	1		
Protonemura sp.	1	1	1	1
Taeniopteryx nebulosa	1	1	1	1
Leuctra nigra	1	1	1	1
Brachyptera seticornis	1	1		
Nemoura sp.			1	1
Siphonoperla sp.			1	1
Trichoptera				
Glossosoma intermedium	1	1	1	1
Hydropsyche pellucidula	1	1	1	1
Agapetus ochripes	1	1	2	2
Agapetus sp.	1	1		
Anomalopterygella chauviniana	1	1	1	1
Psychomyia pusilla	1	1	1	1
Neureclipsis bimaculata	1	1		
Odontocerum albicorne	1	1	1	1
Micrasema longulum	1	1	1	1
Lepidostoma hirtum	1	1	1	1
Hydropsyche siltalai	1	1	1	1
Athripsodes cinereus	1	1	1	1
Lype cf.reducta	1	1	1	1
Brachycentrus subnubilus	1	1	1	1
Ecclisopteryx guttulata	1	1	1	1
Hydropsyche saxonica	1	1	1	1
Goera pilosa	1	1	1	1
Philopotamus ludificatus	1	1	1	1
Polycentropus flavomaculatus			1	1

Miscellaneous				
Isopoda:				
Asellus aquaticus	1	1	1	1
Malacostraca:				
Gammarus roeselii	1	1		
Gammarus pulex			1	1
Gastropoda:				
Ancylus fluviatilis	1	1	1	1
Bithynia tentaculata	1	1	1	1
Hirudinea:				
Glossiphonia complanata	1	1	1	1
Dina punctata	1	1	1	1
Coleoptera:				
Platambus maculatus	1	1	1	1
Olimnius tuberculatus	1	1	1	
Olimnius rivularis				1
Limnius perrisi	1			
Limnius volckmari		1	1	1
Oreodytes sanmarkii	1	1	1	1
Brychius elevatus	1	1	1	1
Heteroptera:				
Aphelocheirus aestivalis	1	1	1	1
Megaloptera:				
Sialis lutaria	1	1		
Sialis fuliginosa			1	1
Diptera:				
Simulium (wilhelmia) lineatum	1	1	1	1
Atherix ibis	1	1	1	1

Appendix table 3. Identified species/genus in sample 1 and 2 by Laboratory 3

Taxa:	Sample 1 Delivered	Sample 1 Identified	Sample 2 Delivered	Sample 2 Identified
Ephemeroptera				
Heptagenia dalecarlica	1	1		
Heptagenia sulphurea			1	1
Kageronia fuscogrisea	1	1	1	1
Caenis luctuosa	1	1	1	1
Caenis horaria			1	1
Siphlonurus lacustris	1	1		
Ephemera vulgata	1	1	1	1
Ephemera danica			1	1
Ephemerella aurivilli			1	1
Ameletus inopinatus	1	1		
Alainites muticus	1	1	1	1
Nigrobaetis niger	1	1	1	1
Baetis rhodani	1	1	1	1
Leptophlebia vespertina	1	1		
Leptophlebia marginata			1	1
Plecoptera				
Diura nanseni	1	1		
Protonemura meyeri	1	1	1	1
Nemurella pictetii	1	1		1
Nemoura cinerea	1	1	1	
Nemoura avicularis			1	1
Nemoura sp.dubitans/flexuosa			1	1
Capnia pygmea	1	1		
Capnia sp.			1	1
Leuctra nigra	1	1	1	1
Amphinemura borealis	1		1	1
Amphinemura sulcicollis		1		
Brachyptera risi	1	1	1	1
Isoperla grammatica	1	1	1	1
Trichoptera				
Ithytrichia lamellaris	1	1		
Setodes argentipunctellus	1	1		
Atripsodes cinereus	1	1		
Athripsodes aterrimus			1	1
Mystacides longicornis			1	1
Lepidostoma hirtum	1	1	1	1
Micrasema gelidum			1	1
Holocentropus dubius	1	1	1	1
Neureclisis bimaculata	1	1	1	1
Silo pallipes			1	1
Cyrnus flavidus	1	1		
Polycentropus flavomaculatus	1	1	1	1
Sericostoma personatum	1	1		
Philopotamus montamus			1	1
Trianodes bicolor			1	1

Rhyacophila nubila	1	1	1	1
Glossosoma intermedium			1	1
Cyrnus trimaculatus	1	1	1	1
Ithytrichia lamellaris			1	1
Agapetus fuscipes			1	1
Chimarra marginata	1	1		
Cheumatopsyche lepida	1	1		
Hydropsyche pellucidula	1	1		
Hydropsyche angustipennis *Arctopsyche ladogensis*			1	1
Arctopsyche ladogensis			1	1
Halesus radiatus	1	1		
Agrypnia obsoleta	1	1		
Hydropsyche siltalai	1	1	1	1
Nemotaulius punctatolineatus			1	1
Miscellaneous				
Megaloptera:				
Sialis nigripes	1	1		
Sialis lutaria			1	1
Corixidae:				
Callicorixa praeusta	1	1		
Gastropoda:				
Gyraulus acronicus	1	1		
Radix baltica			1	1
Odonata:				
Onychgompus forcipatus	1	1		
Cordulia aenea	1	1		
Coleoptera:				
Olimnius tuberculatus	1	1		
Limnius volckmari			1	1
Elodes sp.	1	1	1	1
Elmis aenea	1	1	1	1
Platambus maculatus	1	1		
Haliplus sp.			1	1
Hirudinea:				
Helobdella stagnalis	1	1		
Piscicola geometra	1	1		
Erpobdella octoculata			1	1
Malacostraca:				
Gammarus lacustris	1	1		
Asellus aquaticus	1	1	2	2
Pontoporeia affinis			1	1

Appendix C

Reports and publications from ICP Waters

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/

Fjellheim, A., Johannessen, A. and Landås, T.S. 2014. Biological intercalibration: Invertebrates 1814. **ICP Waters Report 121/2014**

Escuedero-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**

Fjellheim, A., Johannessen, A. and Landås, T.S. 2013. Biological intercalibration: Invertebrates 1713. **ICP Waters Report 118/2014**

de Wit, H., Bente M. Wathne, B. M. and Hruška, J. (eds) 2014. Proceedings of the 29th Task Force meeting of the ICP Waters Programme in Český Krumlov, Czech Republic 1st –3rd October, 2013. **ICP Waters report 117/2014**

Escuedero-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 63/001**.

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.

NIVA: Norway's leading centre of competence in aquatic environments

NIVA provides government, business and the public with a basis for preferred water management through its contracted research, reports and development work. A characteristic of NIVA is its broad scope of professional disciplines and extensive contact network in Norway and abroad. Our solid professionalism, interdisciplinary working methods and holistic approach are key elements that make us an excellent advisor for government and society.

Norwegian Institute for Water Research

Gaustadalléen 21 • NO-0349 Oslo, Norway
Telephone: +47 22 18 51 00 • Fax: 22 18 52 00
www.niva.no • post@niva.no