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ICP Waters Report 124/2015

Biological intercalibration: Invertebrates 1915

Nymph of the stonefly Dinocras cephalotes
Photo: T. Wiers, Uni Research

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

Convention on Long-Range Transboundary Air Pollution

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

REPORT

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Abstract

Six European laboratories participated in the 19th ICP Waters biological intercalibration, which took place in 2015. 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 was excellent, ranging between 95.4 and 98.5, well above the value 80 - indicating acceptable taxonomic work.

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CONVENTION ON LONG-RANGE TRANSBOUNDARY AIR POLLUTION

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

Biological intercalibration: Invertebrates 1915

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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 manages 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 19th intercalibration on invertebrate fauna.

Bergen, November 2015

Arne Fjellheim
ICP Waters Programme Subcentre

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Summary

The 19th intercalibration of invertebrates in the ICP Waters programme had contribution from six 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 95.4 and 98.5, 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 caddisfly* Rhyacophila nubila *in Europe. This species is widely distributed, but is absent from several West-European countries. 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. Normally each laboratory gets between 60 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.

According to Fauna Europaea, the total number of Europaean mayfly, stonefly and caddisfly species (per 2015) is 1814. However, the biodiversity differs between countries. Normally the

freshwater fauna gets poorer moving from South Europe towards the Northern countries. This is also a fact to bear in mind when judging taxonomical capacity. As an example of this, the freshwater fauna of Switerland is much richer than in Norway and Sweden – despite the fact that the area of Switerland is approximately 1/10 of the two Nordic countries (Figure 2).

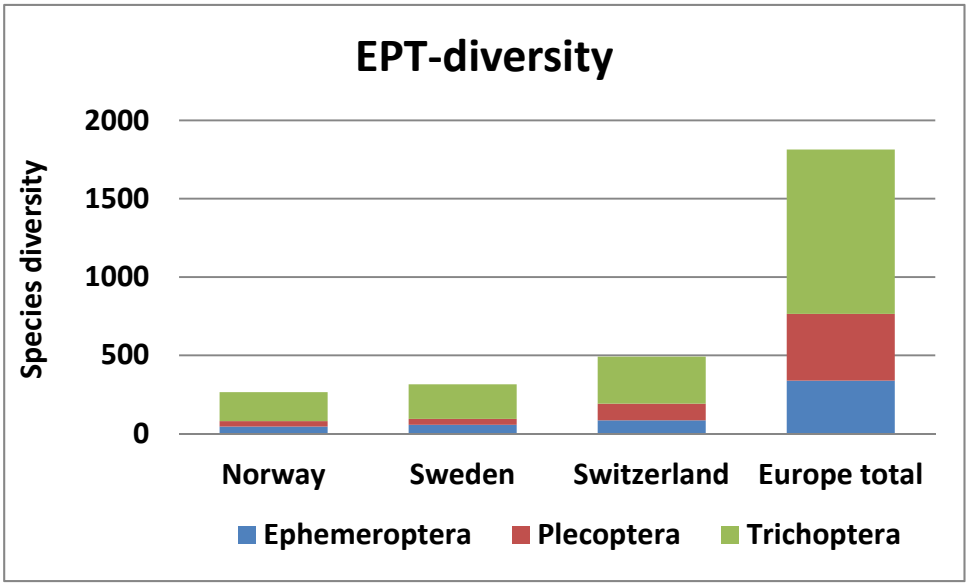

Figure 2. *Species (EPT) diversity of mayflies (Ephemeroptera), stoneflies (Plecoptera) and caddisflies (Trichoptera) in Norway, Sweden and Switzerland (after Fauna Europaea Web Service, http://www.faunaeur.org.*

Quality assurance index

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 are 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 is tested with the help from Sweden each second year (not in 2015). 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

A total of six laboratories participated in the intercalibration of invertebrates in 2015 (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 – 6.

Mayflies

The identification of mayflies (Ephemeroptera) was generally very good (Figure 3, Appendix Table 1- 3). Laboratories 1, 3 and 5 identified the mayflies without faults. The results from the other three laboratories were very good. The Qi was calculated to 100, 92.9, 100, 87.5, 100 and 92.9 for participants 1, 2, 3, 4, 5 and 6, respectively. This indicates very high quality of work.

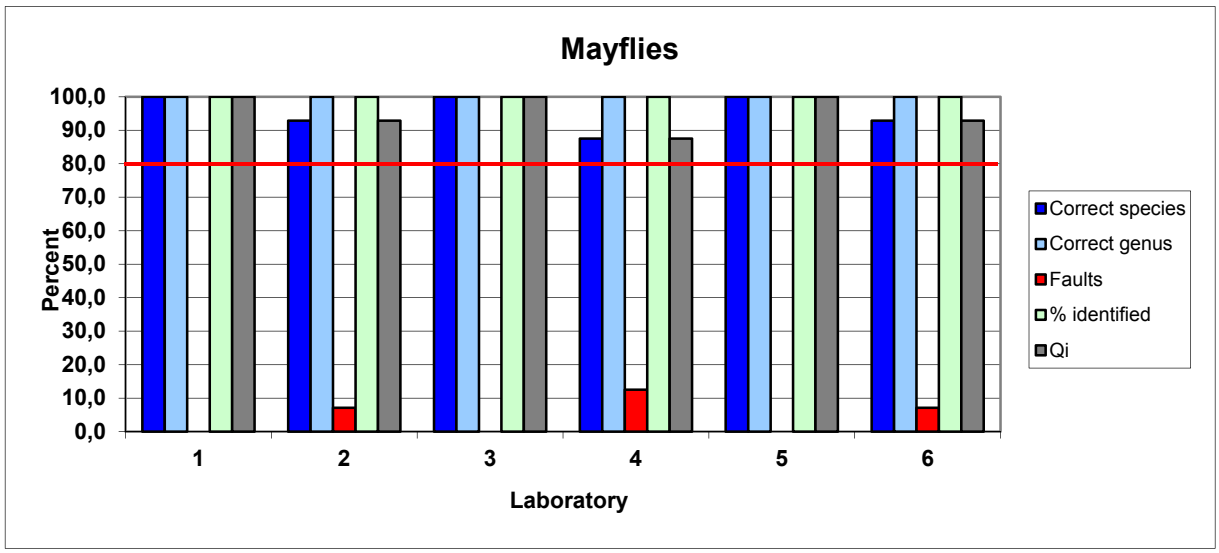

Figure 3. *Results of the identification of mayflies. The red line indicates the level of acceptance.*

Stoneflies

The identification of the stoneflies is presented in Figure 4 and Appendix tables 1 – 6. The results show a very good taxonomical knowledge of the group. Laboratories 2 and 4 identified the stoneflies without faults. The Qi was 81.6, 100, 94.1, 100, 90.7 and 92.9, all above the limit of acceptance.

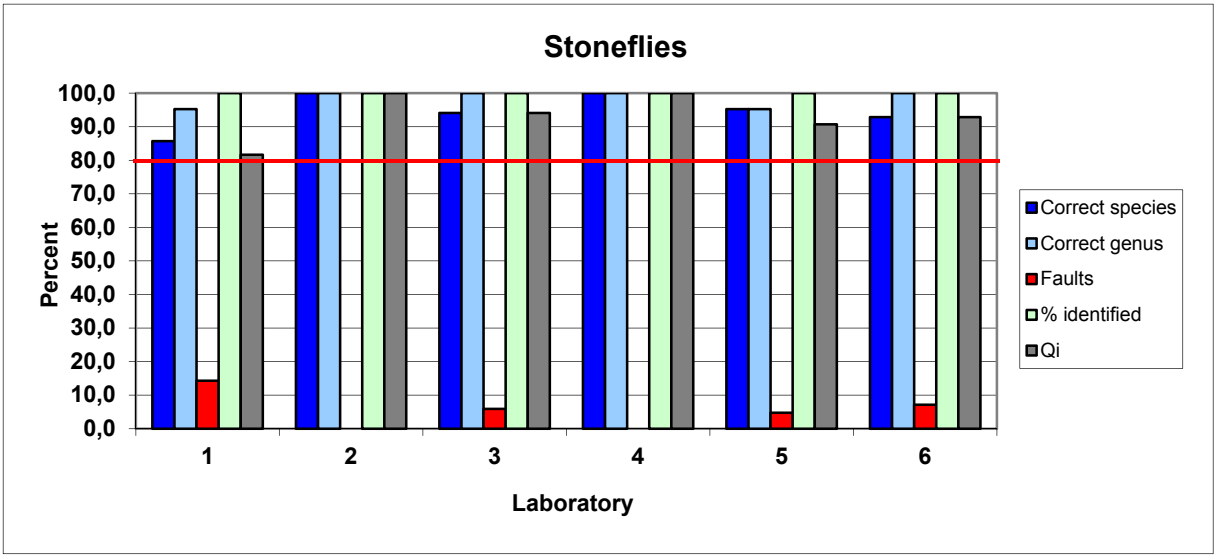

Figure 4. *Results of the identification of stoneflies. The red line indicates the level of acceptance.*

Caddisflies

The identification of caddisflies (Trichoptera) is presented in Figure 5 and Appendix tables 1 – 6. The quality of the identification was excellent for all laboratories, Qi values being 100, 93.3, 100, 100, 92.5 and 100, respectively.

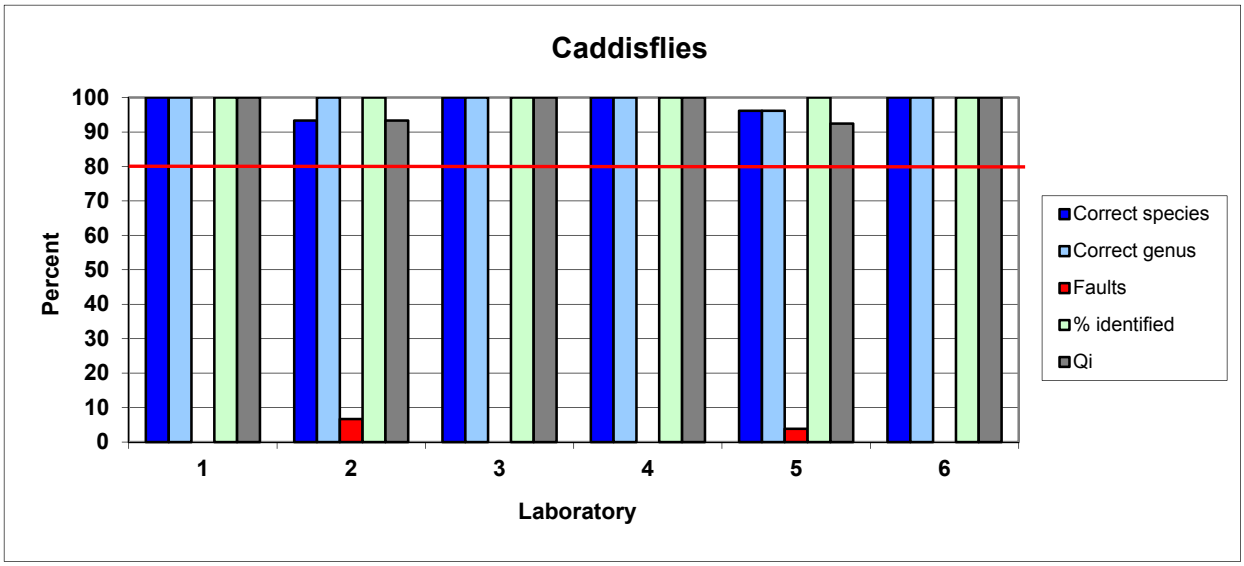

Figure 5. *Results of the identification of caddisflies. The red line indicates the level of acceptance.*

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 6 and Appendix tables 1 – 6 shows the results of the identification of these groups. The identifications made by laboratories 1, 3, 4 and 5 were perfect with no faults. The result of laboratories 2 and 6 were excellent. The Qi score was 100, 96.0, 100, 100, 100 and 96.9 for participants 1, 2, and 3, respectively.

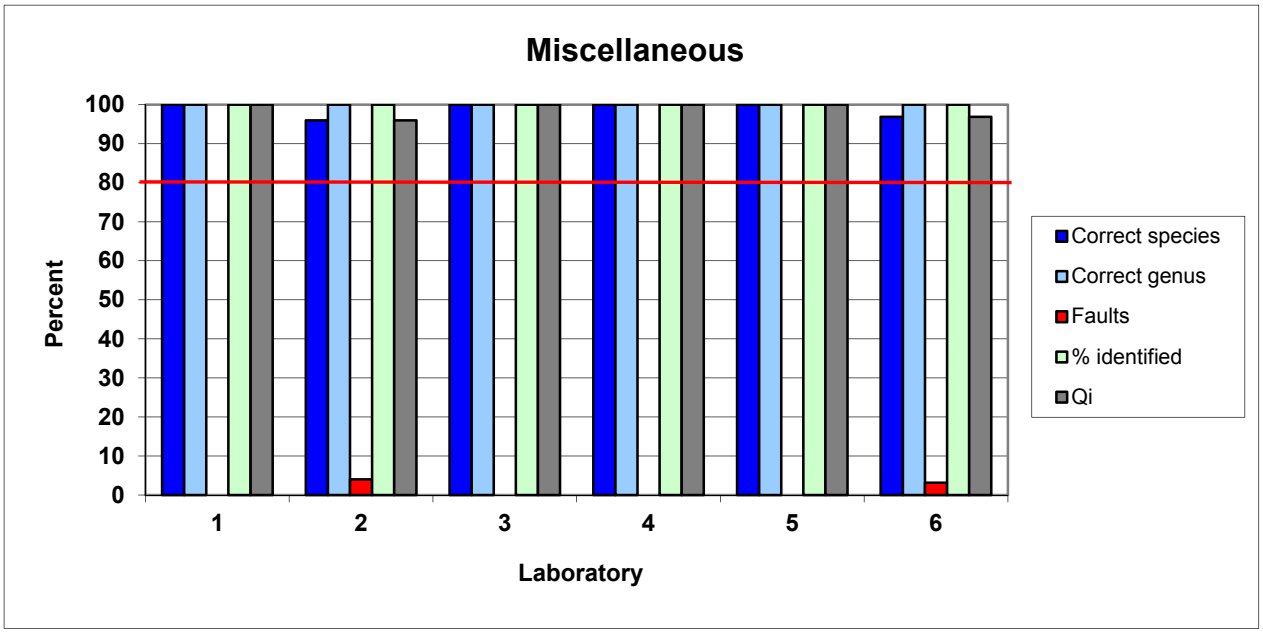

Figure 6. *Results of the identification of miscellaneous groups. The red line indicates the level of acceptance.*

Total number of species in the sample

There was no discrepancy between the number of individuals put into the samples and the reported number of larvae. A total of 494 individual specimens were sent to the different laboratories. Of these, 100 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 7. Laboratory 1 to 6 got a mean Qi score of 95.4, 95.5, 98.5, 96.9, 95.8 and 95.6 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 are in focus or where the ecological status should be stated.

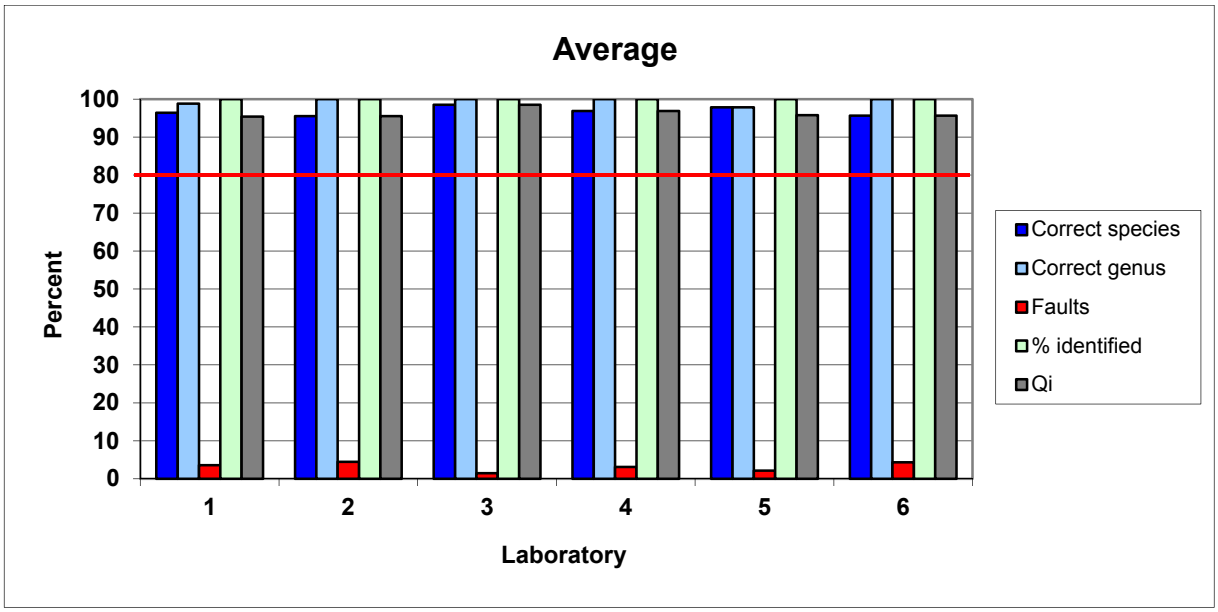

Figure 7. *Mean skill in percent of identifying species and genus and mean Qi for each laboratory. The red line indicates the level of acceptance.*

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).

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Appendix A. 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 2015 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: Dr. Magda-Lena Wiklund.
2. Landesamt für Natur, Umwelt und Verbraucherschutz NRW, FB 55: Ökologie und Chemie der Oberflächengewässer, Leibnizstraße 10, 45659 Recklinghausen Germany. Responsible taxonomist: Dr. Reinhold Ludwig.
3. Estonian Environmental Research Centre, Tartu branch, Vaksali 17a, 50410 Tartu, Estonia. Responsible taxonomist: Dr. Urmas Kruus.
4. School of Biological Sciences Queen Mary, University of London London E1 4NS, UK. Responsible taxonomist: Dr. Julie Winterbottom.
5. Bomio & Fürst SA, Via Pobbia 16, 6514 Sementina, Switzerland. Responsible taxonomist: Dr. Sebastiano Schneebeli.
6. Latvian Hydrometeorological Agency, EQOD , Environmental Quality Testing Laboratory, Riga, Latvia. Responsible taxonomist: Dr. Natalja Grudule.

Appendix B. Results

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

	Sample 1		Sample 2	
Taxa:	**Delivered**	**Identified**	**Delivered**	**Identified**
Ephemeroptera				
Nigrobaetis digitatus	1	1		
Baetis rhodani	1	1	1	1
Seratella ignita	1	1		
Leptophlebia marginata	1	1		
Caenis luctuosa	1	1		
Heptagenia dalecarlica	1	1	1	1
Ephemera vulgata	1	1		
Nigrobaetis niger	1	1		
Alainites muticus			1	1
Arthroplea congener			1	1
Caenis horaria			1	1
Ephemera danica			1	1
Ephemera aurivilli			1	1
Leptophlebia vespertina			1	1
Heptagenia sulphurea			1	1
Ephemerella mucronata	1	1		
Plecoptera				
Leuctra hippopus	1			
Leuctra fusca			1	
Leuctra digitata				1
Leuctra sp.		1		
Leuctra nigra	1	1	1	1
Taeniopteryx nebulosa	1	1	1	1
Amphinemura borealis	1	1	1	1
Diura nanseni	1	1	1	1
Nemoura avicularis	1	1	1	1
Capnia bifrons	1	1		
Siphonoperla burmeisteri	1	1	1	1
Dinocras cephalotes			1	1
Nemoura cinerea			1	1
Nemuoura cf viki		1		
Nemoura sp.	1	1		
Nemoura flexuosa			1	1
Nemurella pictetii	1		1	1
Trichoptera				
Mystacides azurea	1	1		
Setodes argentipunctellus	1	1		
Lepidostoma hirtum	1	1		
Rhyacophila fasciata	1	1		
Ceratopsyche silfvenii	1	1		
Ceratopsyche nevae			1	1
Ironoquia dubia	1	1		
Hydropsyche silatalai	1	1		
Philopotamus montanus	1	1		
Micrasema gelidum	1	1		
Neureclipsis bimaculata	1	1	1	1
Sericostoma personatum	1	1	1	1
Molanna angustata	1	1		
Apatania wallengreni	1			

Apatania sp.		1		
Agapetus ochripes	1	1		
Arthopsyche ladogensis			1	1
Brachycentrus subnubilus			1	1
Chimarra marginata			1	1
Cheumatopsyche lepida			1	1
Cyrnus flavidus			1	1
Cyrnus trimacualtus			1	1
Ecclisopteryx dalecarlica			1	1
Hydropsyche pellucidula			1	1
Molannodes tinctus			1	1
Phryganea grandis			1	1
Polycentropus flavomaculatus			1	1
Tinodes waeneri	1	1	1	1
Miscellaneous				
Megaloptera:				
Sialis lutaria			1	1
Corixidae:				
Notonecta glauca	1	1		
Gastropoda:				
Potamopyrgus antipodarum	1	1		
Bithynia tentaculata	1	1		
Acroloxus lacustris	1	1		
Gyraulus albus			1	1
Theodoxus fluviatilis			1	1
Radix baltica			1	1
Bivalvia:				
Sphaerium sp.			1	1
Odonata:				
Erythromma najas	1	1		
Onichogomphus forcipatus			1	1
Phyrrosoma sp.			1	1
Diptera				
Antocha vitripennis	1	1		
Pseudolimnophila sp.			1	
Limonidae				1
Tipula sp.			1	1
Coleoptera				
Elmis aenea	2	2		
Hydraena gracilis	1	1		
Orectochilus villosus			1	1
Limnius volckmari			1	1
Nebrioporus depressus			1	1
Elodes sp.	1	1		
Hirudinea:				
Erpobdella octoculata	1	1		
Helobdella stagnalis			1	1
Malacostraca:				
Gammarus lacustris	1	1		
Gammarus pulex			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				
Nigrobaetis niger	1	1		
Baetis alpinus	1	1		
Baetis rhodani	1	1	1	1
Baetis muticus			1	1
Epeorus assimilis	1	1		
Ephemera danica	1	1		1
Ephemera vulgata			1	
Leptophlebidae indet.	1	1		
Caenis horaria	1	1	1	1
Ephemerella notata			1	1
Ephemerella ignita			1	1
Plecoptera				
Perlodes microcephalus	1	1		
Siphonoperla sp.	1	1		
Nemoura sp.	1	1		
Nemurella pictetii	1	1		
Taeniopteryx nebulosa	1	1		
Leuctra nigra	1	1		
Brachyptera seticornis	1	1		
Nemurella pictetii			1	1
Leuctra nigra			1	1
Isoperla sp.			1	1
Brachyptera seticornia			1	1
Taeniopteryx nebulosa			1	1
Diura bicaudata			1	1
Dinocras cephalotes			1	1
Trichoptera				
Ecclisopteryx madida	1	1		
Brachycentrus montanus	1	1		
Hydatophylax infumatus	1	1		
Micrasema longulum	1	1		
Odontocerum albicorne	1	1		
Silo pallipes	1	1		
Hydropsyche fulvipes	1			
Hydropsyche tenius		1		
Hydropsyche silfvenii	1	1		
Sericostoma sp.			1	1
Philopotamus ludificatus			1	1
Drusus annulatus			1	1
Halesus sp.			1	1
Anomalopterygella chauviniana			1	1
Hydropsyche dinaria			1	1
Rhyacophila tristis			1	1

Miscellaneous				
Diptera				
Pedicia sp.	1	1		
Dixa sp.	1	1		
Simulium (Nevermannia) vernum	1	1		
Simulium monticoa	1	1		
Simulium argyreatum			1	1
Diamesa sp. (Chironomidae)			1	1
Anotcha sp.			1	1
Eloephila sp.(Limonidae)			1	1
Dicranota sp.			1	1
Oligochaeta				
Stylodrilus heringianus	1	1		
Turbellaria				
Polycelis sp.			1	1
Megaloptera				
Sialis fuliginosa			1	1
Coleoptera				
Olimnius tuberculatus	1	1		
Elmis aenea	1	1		
Elmis sp.	1	1		
Odeles marginata	1	1		
Limnius perrisi	1	1		
Hydraena gracilis	1	1		
Esolus sp.			1	1
Olimnius sp.			1	1

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

Taxa:	Sample 1 Delivered	Identified	Sample 2 Delivered	Identified
Ephemeroptera				
Baetis digitatus	1	1		
Baetis liebenauae	1	1		
Centroptilum luteolum	1	1		
Caenis luctuosa	1	1	1	1
Caenis rivulorum	1	1	1	1
Ephemerella mucronata	1	1	1	1
Ephemera lineata	1	1		
Kageronia fuscogrisea	1	1		
Leptophlebia marginata	1	1		
Potamanthus luteus	1	1	1	1
Ephemera vulgata			1	1
Alainites muticus			1	1
Nigrobaetis niger			1	1
Paraleptophlebia submarginata			1	1
Siphlonurus aestivalis	1	1	1	1
Plecoptera				
Nemoura avicularis	1	1	1	1
Capnopsis schilleri	1	1	1	1
Leuctra hippopus	1	1		
Amphinemura birealis	1	1		
Nemoura cinerea	1	1		
Nemurella pictetii	1	1	1	1
Isoperla grammatica	1	1	1	1
Brachyptera risi	1	1	1	1
Leuctra digitata			1	
Leuctra fusca				1
Nemoura flexuosa			1	1
Perlodes dispar			1	1
Taeniopteryx nebulosa	1	1	1	1
Trichoptera				
Beraeodes minutus	1	1	1	1
Ceraclea excisa	1	1		
Leptocerus tineiformis	1	1		
Oecetis notata	1	1	1	1
Anabolia laevis/furcata	1	1	1	1
Chaetopteryx villosa	1	1	1	1
Halesus radiatus	1	1		
Hydatophylax infumatus	1	1	1	1
Neunotaulius punctatolineatus	1	1		
Potamohylax cingulatus	1	1		
Molanna angustata	1	1	1	1
Odontocerum albicorne	1	1	1	1
Ceraclea annulicornis			1	1
Halesus tesselatus			1	1
Potamophylax latipennis			1	1
Polycentropus irroratus			1	1
Tinodes waeneri	1	1	1	1

Miscellaneous				
Malacostraca:				
Pontogammarus robustoides			1	1
Gammarus pulex	1	1		
Gastropoda:				
Acroloxus lacustris	1	1	1	1
Radix baltica	1	1	1	1
Planorbis planorbis	1	1		
Valvata crista	1	1		
Valvatia piscinalis			1	1
Hirudinea:				
Haemopsis sanguisuga	1	1		
Hemiclepsis marginata			1	1
Coleoptera:				
Oreodytes sanmarkii	1	1	1	1
Elmis aenea	1	1		
Olimnius tuberculatus	1	1		
Riolus cupreus	1	1		
Elmis maugetii			1	1
Normandia nitens			1	1
Riolus cupres			1	1
Odonata:				
Cordulegaster boltoni	1	1		
Libelulla quadrimaculata	1	1	1	1
Erythromma najas	1	1	1	1
Corixidae:				
Sigara fossarum	1	1	1	1
Lepidoptera:				
Cataclysta lemnata	1	1		
Eliophila nymphaeata			1	1

Appendix table 4. Identified species/genus in sample 1 and 2 by Laboratory 4

Taxa:	Sample 1 Delivered	Identified	Sample 2 Delivered	Identified
Ephemeroptera				
Baetis rhodani	1	1		
Siphlonurus lacustris	1	1		
Rhitrogena semicolorata	1	1		
Ephemera danica	1	1		
Caenis rivulorum	1	1		
Heptagenia sulphurea	1	1		
Caenis macura	1		1	1
Ecdynorus torrentis			1	1
Caenis luctuosa		1	1	1
Caenis robusta			1	1
Ephemera vulgata			1	1
Ephemera lineata			1	1
Potamanthus luteus			1	1
Baetis digitatus			1	
Centroptilum luteolum				1
Heptagenia fuscogrisea	1	1		
Plecoptera				
Chloroperla tripunctata	1	1		
Dinocras cephalotes	1	1		
Taeniopteryx nebulosa	1	1	1	1
Amphinemura sulcicollis	1	1		
Leuctra nigra	1	1		
Leuctra sp.			1	1
Nemurella pictetii			1	1
Nemoura avicularis			1	1
Leuctra hippopus			1	1
Isoperla sp.	1	1	1	1
Trichoptera				
Drusus annulatus	1	1		
Oecetis testacea	1	1		
Lepidostoma hirtum	1	1	1	1
Cyrnus flavidus	1	1		
Sericostoma personatum	1	1		
Neureclipsis bimaculata	1	1	1	1
Silo pallipes	1	1		
Hydropsyche pellucidula	1	1	1	1
Mystacides longicornis	1	1	1	1
Polycentropus flavomaculatus	1	1	1	1
Anabolia nervosa			1	1
Ecclisopteryx guttatus			1	1
Hydropsyche instabilis			1	1
Rhyacophila fasciata			1	1
Cheumatopsyche lepida			1	1
Athripsodes cinereus	1	1	1	1

Miscellaneous*:*				
Gastropoda:				
Radix baltica	1	1		
Bithynia tentaculata	1	1		
Theodoxus fluviatilis	1	1		
Viviparius viviparius	1	1		
Bathymophalus contortus	1	1		
Physa fontinalis			1	1
Ancylus fluviatilis			1	1
Acroloxus lacustris			1	1
Bithynia tentaclata			1	1
Valvata piscinalis	1	1		
Corixidae:				
Hespecorixa sahlbergi	1	1		
Cymatia bonsdorffi			1	1
Heteroptera:				
Apheloceirus aestivalis	1	1	1	1
Megaloptera:				
Sialis lutaria	1	1	1	1
Odonata:				
Erythromma najas	1	1		
Enalagma cyathigerum			1	1
Hirudinea:				
Helobdella stagnalis	1	1		
Erpobdella octoculata			1	1
Malacostraca:				
Gammarus pulex	1	1		
Gammarus lacustris			1	1
Coleoptera:				
Limnius volcmari	1	1		
Elmis aenea	1	1		
Oreodytes sanmarkii	1	1		
Olimnius tuberculatus			1	1
Nebrioporus griseostriatus			1	1
Esolus parallelepipedus			1	1
Ilybius fenestratus			1	1

Appendix table 5. Identified species/genus in sample 1 and 2 by Laboratory 5

Taxa:	Sample 1 Delivered	Identified	Sample 2 Delivered	Identified
Ephemeroptera				
Ecdyonurus pictetii	1	1	1	1*
Ecdynurus alpinus			1	1*
Epeorus alpicola	1	1	1	1
Rhithrogena sp.	1	1	1	1
Habroleptoidea confusa			1	1
Baetis alpinus	1	1	1	1
Baetis s latu (sp.)	1	1	1	1
Nigrobaetis niger	1	1	1	1
Baetis rhodani	2	2	2	1
Baetis sp.				1
Ephemera vulgata	1	1	1	1
Caenis luctuosa	1	1	1	1
Caenis horaria	1	1	1	1
* Identified to species				
Plecoptera				
Perla grandis	1	1		
Perlodes intricatus			1	1
Dinocras cephalotes	1	1	1	1
Isoperla rivulorum	1	1	1	1*
Brachyptera sp.	2	2		
Brachyptera risi	1	1	2	2
Amphinemura sulc./triangularis sulcicollis/triangularis	1	1	1	1*
Protonemura nimborum	1	1	1	1
Nemoura mortoni	1	1	1	1
Protonemura meyeri	1	1	1	1*
Nemurella pictetii	1	1	1	
Nemoura sp.				1
* Identified to species				
Trichoptera				
Hydropsyche modesta	1	1	1	1
Rhyacophila torrentium	1	1		
Rhyacophila (Hyporh.) pubecens			1	
Neureclipsis bimaculata				1
Limnephilidae indet.	1	1	1	1
Potamoph.nigricornis/pallidus			1	1
Plectrocnemia conspersa	1	1	1	1
Sericostoma personatum	1	1		
Sericostoma sp.			1	1
Itytrichia sp.			1	1
Philopotamus montanus	1	1		
Chimarra marginata			1	1
Stactobia moselyi (Hydroptila)	1	1		
Oligotricha striata (Phrygan.)	1	1		
Cheumatopsyche lepida	1	1	1	1

Lepidostoma hirtum	1	1	1	1
Hydropsyche angustipennis	1	1	1	1
Hydropsyche siltalai	1	1	1	1
Hydropsyche pellucidula	1	1	1	1
Miscellaneous				
Diptera:				
Atherix ibis	1	1	1	1
Hexatomia sp.	1	1	1	1
Coleoptera:				
Esolus sp.	1	1	1	1
Hydraen asp.			1	1
Agabus sp.	1	1		
Limnius volckmari	1	1	1	1
Odonata:				
Aeshna sp.	1	1		
Libellula indet.			1	1

Appendix table 6. Identified species/genus in sample 1 and 2 by Laboratory 6

Taxa:	Sample 1 Delivered	Identified	Sample 2 Delivered	Identified
Ephemeroptera				
Potamanthus luteus	1	1	1	1
Caenis robusta	1	1		
Caenis macura	1			
Caenis luctuosa		1		
Heptagenia sulphurea	1	1	1	1
Ephemera danica	1	1		
Ephemera vulgata	1	1	1	1
Ephemera lineata			1	1
Caenis horaria			1	1
Ephemerella notata			1	1
Ephemerella karelica	1	1	1	1
Plecoptera				
Taeniopteryx nebulosa	1	1	1	1
Brachyptera risi	1	1	1	1
Amphinemura borealis	1	1	1	1
Nemoura avicularis	1	1	1	1
Nemoura cinerea	1		1	1
Nemoura flexuosa		1		
Leuctra hippopus	1	1		
Leuctra nigra	1	1		
Protonemura meyeri	1	1	1	1
Trichoptera				
Sericostoma personatum	1	1	1	1
Cheumatopsyche lepida	1	1		
Hydropsyche pellucidula	1	1	1	1
Cyrnus flavidus	1	1		
Brachycentrus subnubilus	1	1		
Neureclipsis bimaculata	1	1	1	1
Mystacides azurea	1	1		
Molanna angustata	1	1		
Athripsodes cinereus	1	1		
Philopotamus montanus	1	1	1	1
Polycentropus flavomaculatus			1	1
Goera pilosa			1	1
Leptocerus tineformis			1	1
Hydropsyche siltalai			1	1
Lepidostoma hirtum			1	1
Athripsodes aterrimus			1	1
Mystacides longicornis			1	1
Cyrnus trimaculatus			1	1
Micrasema setiferum	1	1	1	1

Miscellaneous				
Malacostraca:				
Gammarus pulex	1	1	1	
Gammarus lacustris				1
Corixidae:				
Cymatia bonsdorffi	*1*	*1*	*1*	*1*
Sigara falleni			*1*	*1*
Heteroptera:				
Aphelocheirus aestivalis	1	1		
Ilyocoris cimicoides			1	1
Megaloptera:				
Sialis lutaria	1	1		
Sialis sordida			1	1
Coleoptera:				
Limnius volckmari	1	1	1	1
Olimnius tuberculatus	1	1		
Elmis aenea	1	1		
Haliplus sp.			1	1
Brychius elevatus	1	1	1	1
Hirudinea:				
Helobdella stagnalis	1	1		
Glossiphonia heteroclita			1	1
Diptera:				
Atherix ibis	1	1	1	1
Dicranota bimaculata			1	1
Gastropoda:				
Viviparius viviparius	1	1		
Ancylus fluviatilis	1	1		
Theodux fluviatilis	1	1		
Physa fontinalis	1	1		
Bithynia tentaculata	1	1		
Valvata piscinalis			1	1
Acroloxus lacustris			1	1
Bithynia leachi			1	1
Bathymophalus contortus			1	1
Dreissena polymorpha	1	1	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. 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**

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**

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 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.**

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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.**

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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.**

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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**

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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.**

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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.**

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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.**

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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.**

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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.

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