MUkit – A practical free software to calculate measurement uncertainty

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MUkit – measurement uncertainty software

- Mainly based on the
  - Nordtest TR 537 *(Handbook for Calculation of Measurement Uncertainty in Environmental Laboratories)* and on the
  - standard ISO 11352 *(Water quality -- Estimation of measurement uncertainty based on validation and quality control data)*.
- Using the program, the laboratories can easily calculate measurement uncertainties using
  - Quality control samples,
  - Repeated results from routine samples,
  - Results from proficiency tests and
  - Results from recovery tests

ENVICAL MUkit

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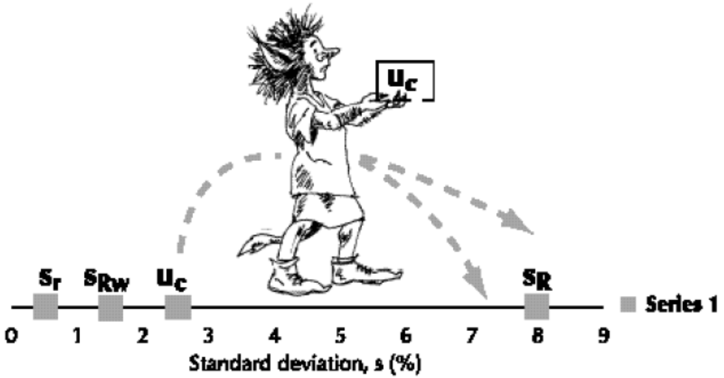
NORDTEST NT TR 537 edition 4 2017:11

Handbook for Calculation of Measurement Uncertainty in Environmental Laboratories



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New version 4 available at www.nordtest.info

Estimation of measurement uncertainty

- In chemical laboratories, the most common way to estimate measurement uncertainty is using the results of **laboratory validation** and **quality assurance/quality control** (QA/QC):
  - Synthetic samples or reference materials (X-chart)
  - Routine samples, duplicates (r%-chart)

- By using an existing and experimentally determined results of the QC samples and the results from method validation, the probability that all uncertainty components are included in the estimation can be maximized.

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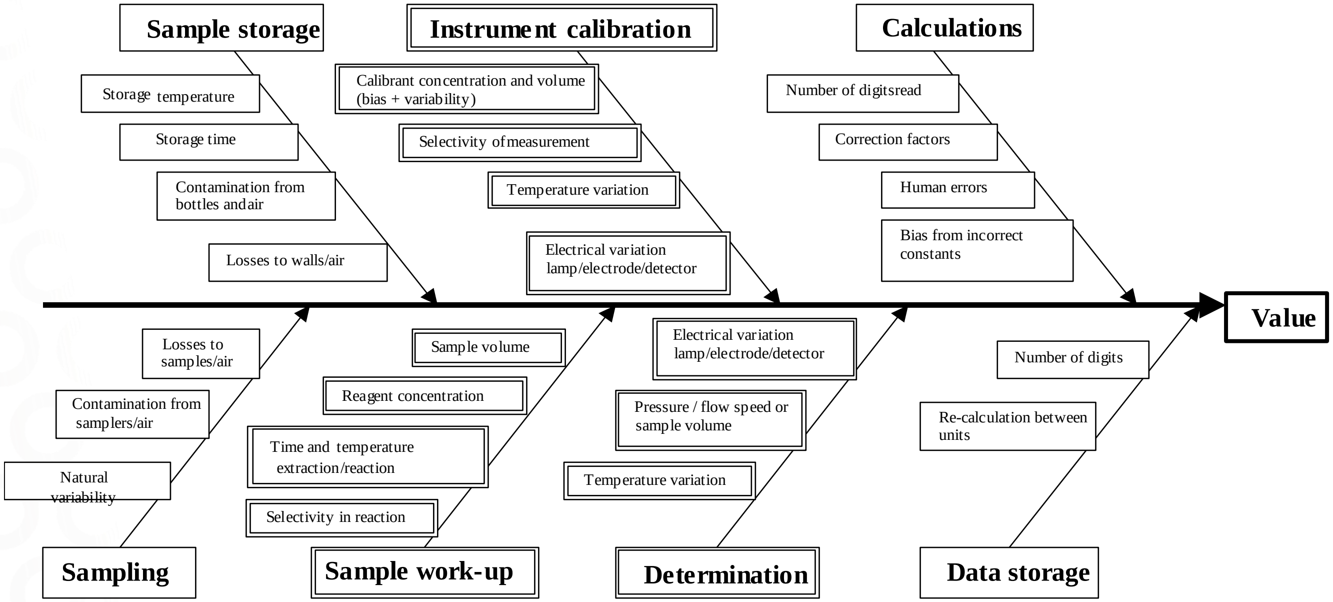
To look at details

- **Full fish-bone diagram, showing all contributions to the measurement uncertainty**



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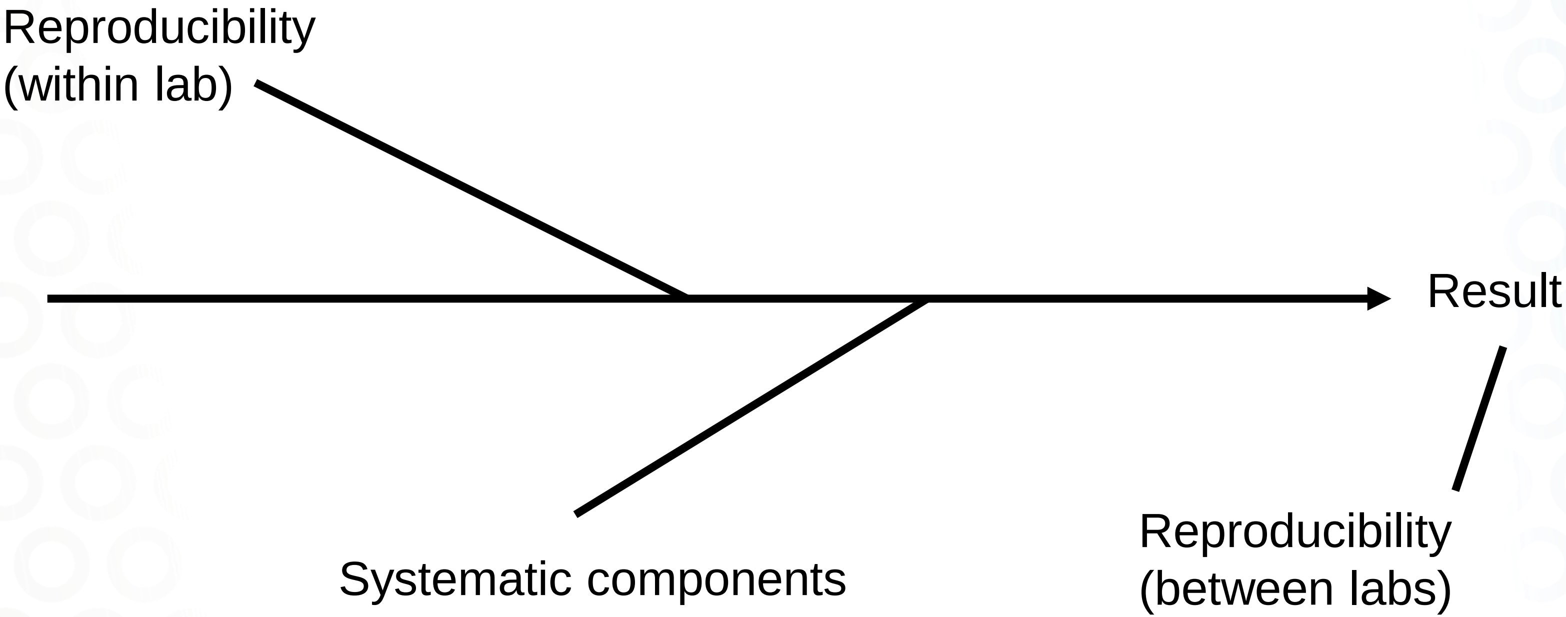
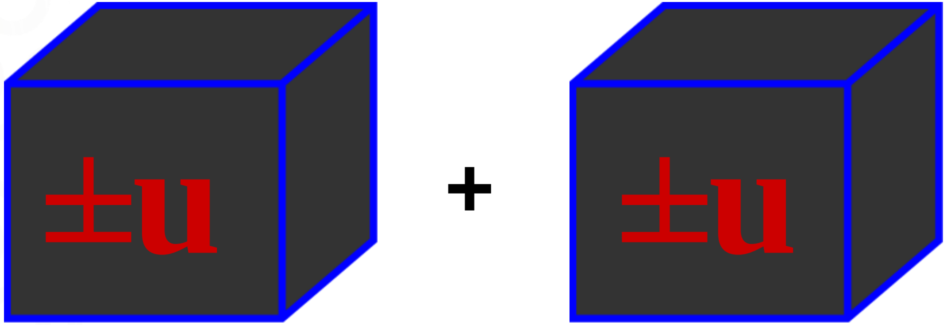
Fish-bone diagram of Nordtest TR 537



This is a ”black-box” model

Reproducibility(within lab)   Systematic components



e.g. from control charts   From CRM or proficiency tests

= **Estimate of measurement uncertainty**

To open the black boxes, consult the e.g. Eurachem guide

The 6 steps to be followed

1. Specify measurand
2. Quantify reproducibility (Black box 1; R_w)
   - Routine sample replicates in different concentration levels (R-chart, r%-chart)
   - Repetitons of the validation measurements
   - Certified Reference Material or other synthetic sample (X-chart)
3. Quantify systematic components (Black box 2; bias)
   - Certified Reference Material or other synthetic sample (X-chart)
   - Recovery tests
   - Proficiency tests
4. Convert components to standard uncertainties $u(R_w)$ and u(bias)
5. Calculate combined standard uncertainty
6. Calculate expanded uncertainty

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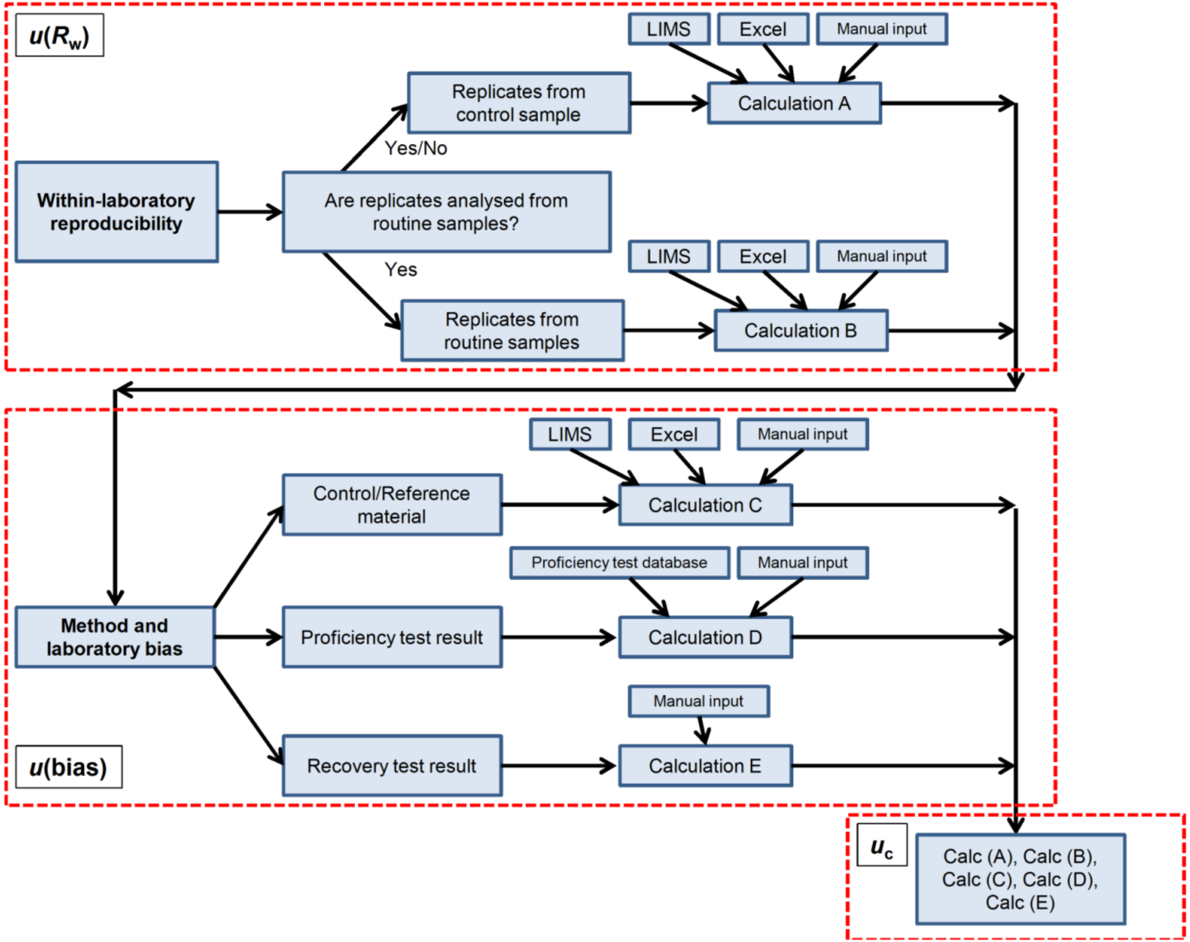
Flowchart for MUkit operation



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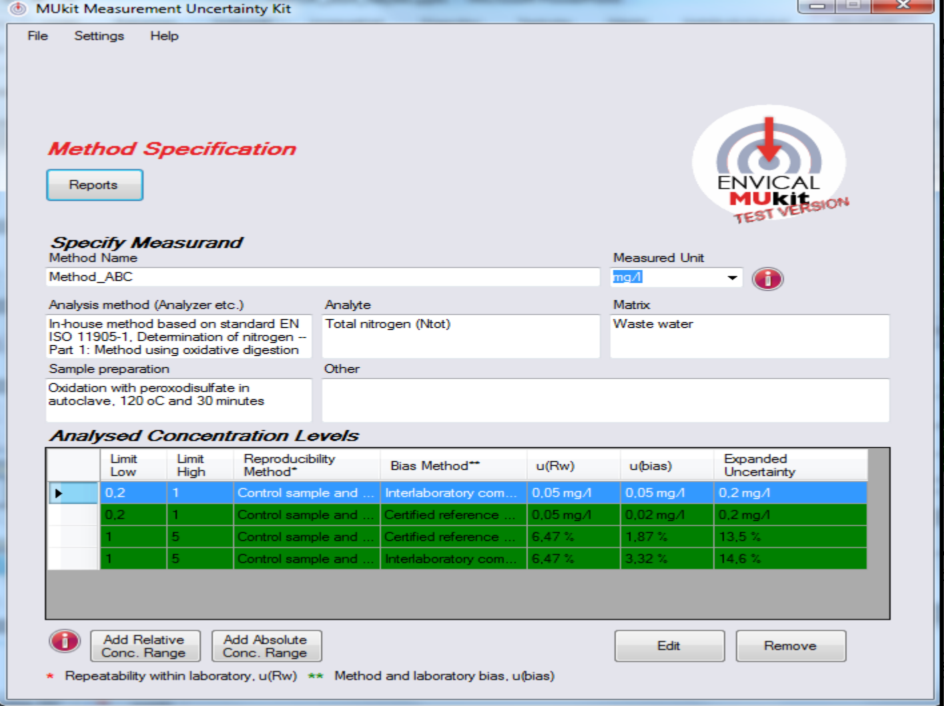

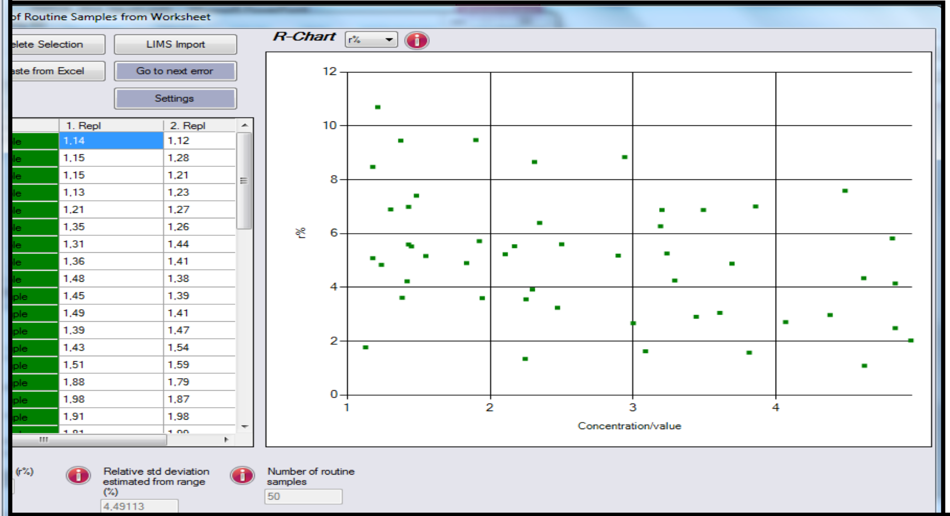

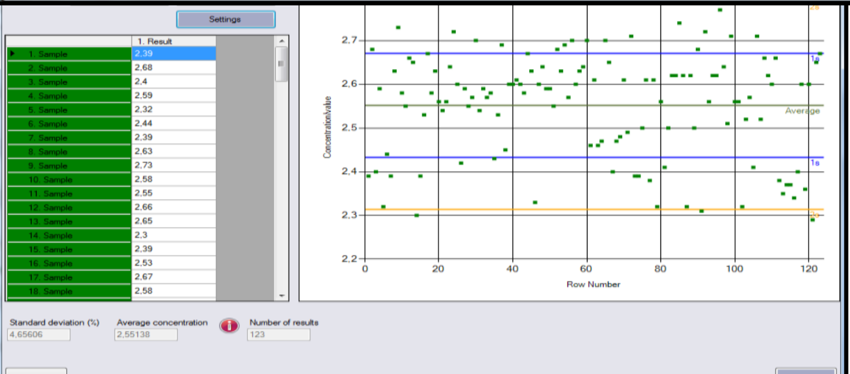

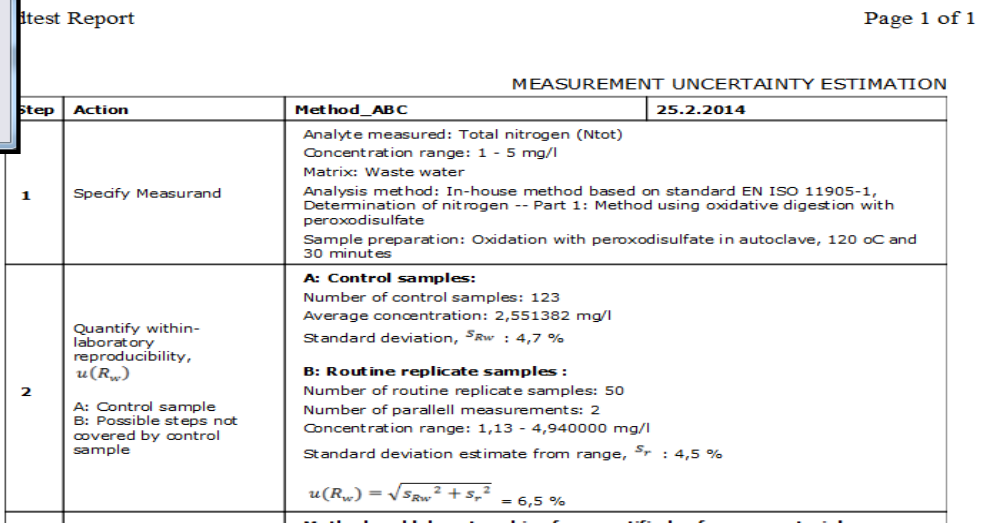

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MEASUREMENT UNCERTAINTY ESTIMATION

Step	Action	Method_ABC	25.2.2014
1	Specify Measurand	Analyte measured: Total nitrogen (Ntot) Concentration range: 1 - 5 mg/l Matrix: Waste water Analysis method: In-house method based on standard EN ISO 11905-1, Determination of nitrogen -- Part 1: Method using oxidative digestion with peroxodisulfate Sample preparation: Oxidation with peroxodisulfate in autoclave, 120 oC and 30 minutes	
2	Quantify within-laboratory reproducibility, $u(R_w)$ A: Control sample B: Possible steps not covered by control sample	**A: Control samples:** Number of control samples: 123 Average concentration: 2,551382 mg/l Standard deviation, s_{Rw} : 4,7 % **B: Routine replicate samples :** Number of routine replicate samples: 50 Number of parallell measurements: 2 Concentration range: 1,13 - 4,940000 mg/l Standard deviation estimate from range, s_r : 4,5 % $u(R_w) = \sqrt{s_{Rw}^2 + s_r^2}$ = 6,5 %	

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› MUkit - Measurement Uncertainty Kit
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About the program

MUkit (Measurement Uncertainty Kit) is a measurement uncertainty software application, where calculations are based on the Nordtest TR 537 report. By introducing the MUkit software, ENVICAL SYKE presents for chemical laboratories a user-friendly tool, which can be utilized for measurement uncertainty estimations often appearing to be a laborious task to perform. The traceability and comparability of analytical results require knowledge of the measurement uncertainty associated with a result. A uniform procedure for the estimation of measurement uncertainty is expected to improve the comparability of analysis results between laboratories.

The work also supports the goals of the Finnish energy and environment cluster's (CLEEN Ltd) programme for Measurement, Monitoring, and Environmental Efficiency Assessment (MMEA) especially in developing the MMEA platform for environmental data.

The software allows laboratories to easily evaluate the measurement uncertainties utilizing:

- Results of control samples
- Routine sample replicates
- Results of inter-laboratory comparison tests
- Results of the recovery tests

MUkit measurement uncertainty software, including the source code, is available for download free of charge from the links below. The program has been implemented in Finnish, English and Russian.

System requirements

MUkit requires to be installed on a computer with Microsoft Windows, which can run the Microsoft .NET Framework 4.0 Client Profile

RELATED LINKS

Nordtest TR 537 article
MMEA research program

http://www.syke.fi/envical/en

Available for free of charge

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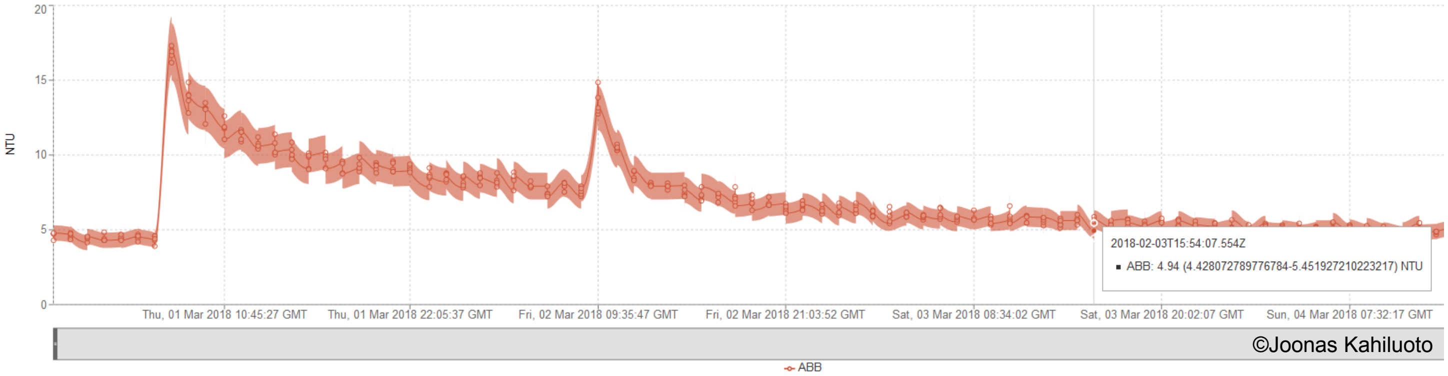
Under development: SYKE EnviCal Manager

- Control and management of data of on-line water quality field measuring devices
- Automated data analysis

→Real-time measurement uncertainty using AutoMUkit



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Accred Qual Assur (2012) 17:603–612
DOI 10.1007/s00769-012-0932-0

PRACTITIONER'S REPORT

Software support for the Nordtest method of measurement uncertainty evaluation

Teemu Näykki · Atte Virtanen · Ivo Leito

Received: 6 June 2012 / Accepted: 4 October 2012 / Published online: 23 Octo

Abstract Software support for the Nordtest method of measurement uncertainty evaluation is described. According to the Nordtest approach, the combined measurement uncertainty is broken down into two main components—the within-laboratory reproducibility (intermediate precision) s_{Rw} and the uncertainty due to possible laboratory bias u(bias). Both of these can be conveniently estimated from validation and quality control data, thus significantly reducing the need for performing dedicated experiments for estimating detailed uncertainty contributions and thereby making uncertainty estimation easier for routine laboratories. An additional merit of this uncertainty estimation approach is that it reduces the danger of underestimating the uncertainty, which continues to be a problem at routine laboratories. The described software tool—MUkit (measurement uncertainty kit)—fully reflects the versatility of the Nordtest approach: it enables estimating the uncertainty components from different types of data, and the data can be imported using a variety of means such as different laboratory data systems and a dedicated

Environ Monit Assess (2015) 187: 630
DOI 10.1007/s10661-015-4856-0

CrossMark

Application of the Nordtest method for "real-time" uncertainty estimation of on-line field measurement

Teemu Näykki · Atte Virtanen · Lari Kaukonen · Bertil Magnusson · Tero Väisänen · Ivo Leito

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Abstract Field sensor measurements are becoming more common for environmental monitoring. Solutions for enhancing reliability, i.e. knowledge of the measurement uncertainty of field measurements, are urgently needed. Real-time estimations of measurement uncertainty for field measurement have not previously been published, and in this paper, a novel approach to the automated turbidity measuring system with an application for "real-time" uncertainty estimation is outlined based on the Nordtest handbook's

Electronic supplementary material The online version of this article (doi:10.1007/s10661-015-4856-0) contains supplementary

ORIGINAL ARTICLE

A C G publications

J. Chem. Metrol. 8:1 (2014) 1-12

journal of chemical metrology

Comparison of measurement uncertainty estimates using quality control and validation data

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Abstract: A study was organised where consistency of measurement uncertainty estimations between laboratories in Finland, Sweden and Estonia was surveyed. For all laboratories a file was delivered containing the same set of fictional quality control and validation results for the measurement of total nitrogen in waste water. The laboratories were asked to evaluate the measurement uncertainty using quality control and validation data with the Nordtest approach, using the free MUkit software for measurement uncertainty estimation developed by SYKE. A total of 21 laboratories participated in the survey.

Attention was paid to handling of the data, e.g. selecting the concentration ranges for uncertainty estimation, choosing the appropriate approach among those proposed in the Nordtest guide used for uncertainty estimation, choosing the way in which the uncertainty was reported (absolute or relative) and the outcomes of the measurement uncertainty estimations. Most of the laboratories estimated measurement uncertainty for more than one concentration range. The majority also reported measurement uncertainty in relative numbers, even in the low concentration range, where it is advised for most instrumental methods to perform calculation with absolute values. As measurement uncertainty was reported as relative values, it was heavily underestimated at the lowest concentration levels.

However, the measurement uncertainty estimates were consistent between the laboratories, and variability of relative uncertainty estimates was small (within ± 2% units from the average value). This indicates that with the same data and with the unified uncertainty estimation approach, laboratories are able to achieve the same

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Thank you for your attention

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