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LABORATOIRE NATIONAL DE MÉTROLOGIE ET D'ESSAIS



Review: What Has Been Achieved in Estimation and Applications of Uncertainty from Sampling (UfS)

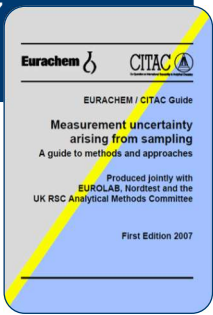
NATHALIE GUIGUES

Eurachem/CITAC Workshop
Quality in Analytical Measurement: Uncertainty Evaluation and Results interpretation
11 & 12 May 2026, Lisbon (PT)

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EURACHEM UfS

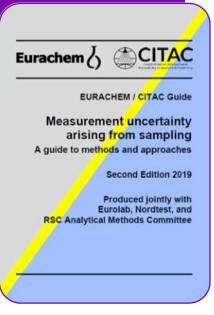
2007



Eurachem Workshop:
Uncertainty in Sampling and Compliance
(Berlin, April 2008)

AMC Technical Brief 31 (2008)

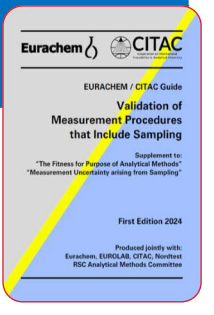
2019



Eurachem workshop:
Uncertainty from sampling and analysis for accredited laboratories
(Berlin, November 2019)

AMC Technical Brief 96 (2019)

2024



Leaflet:
Validation of Measurement Procedures that Include Sampling (2025)
Eurolab/Eurachem Webinar on 19th June
Video

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11 & 12 May 2026

Eurachem/CITAC Workshop: Quality in Analytical Measurement

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REVIEW

What has been published since the First Edition of UfS in 2007?

Review based on:

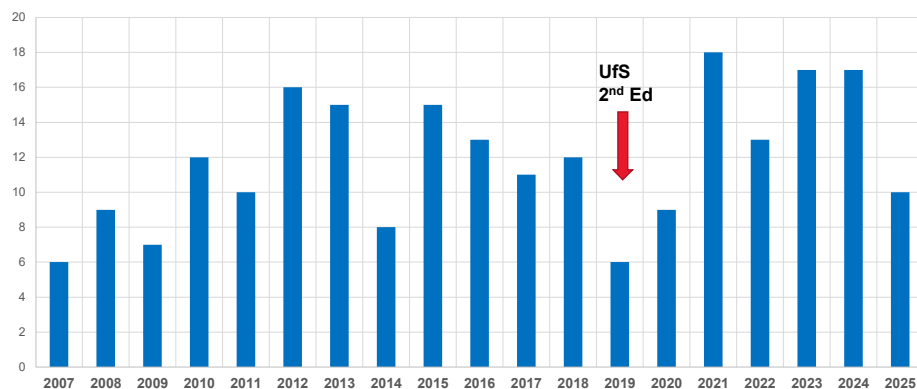
- Previous review presented by Ariadne Argyraki at the 2019 Eurachem UfS Workshop
- Scopus with keywords: Eurachem AND sampling AND uncertainty

=> 228 articles, book chapters, conference papers, technical brief

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REVIEW

Number of publications per year from 2007 to 2025



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REVIEW

Classification:

Approaches implemented to estimate UfS

General / concept
Top-down – Duplicate Method
Bottom-up – Theory of Sampling
Top-Down – Interlaboratory Comparison
Simulation – Monte Carlo, Bayes etc.
Use of Reference Sample
Uncertainty optimisation
Conformity assessment
Statistical method (other than Duplicate)
Other

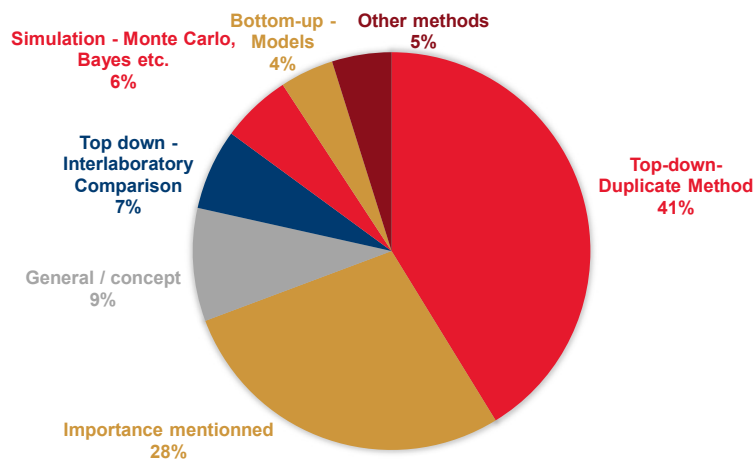
Application

Environment
Food & Feed
Human biomonitoring & clinical
Geochemistry & mining
Forensic
Industry
General / no specific application
Other

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REVIEW

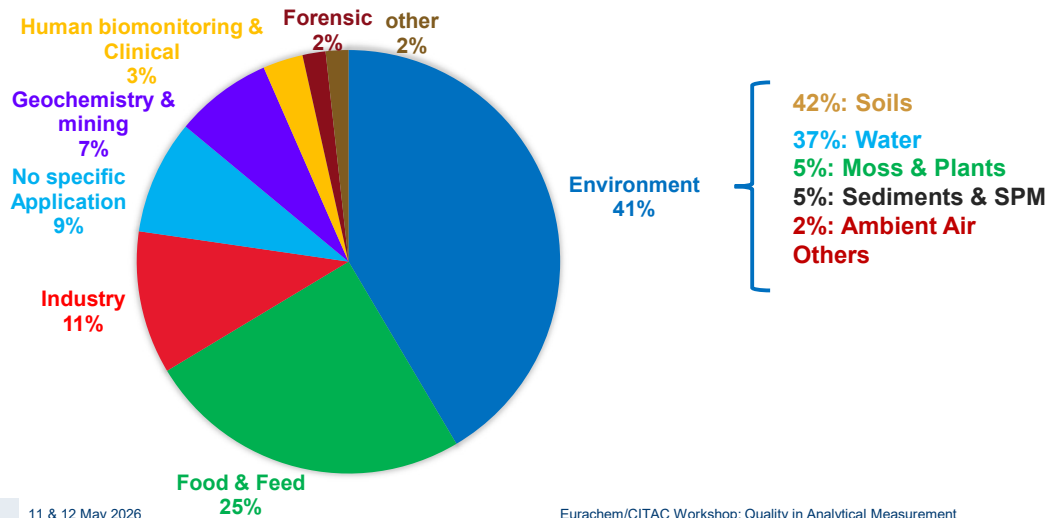
Approaches implemented to estimate UfS:



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REVIEW

Applications:



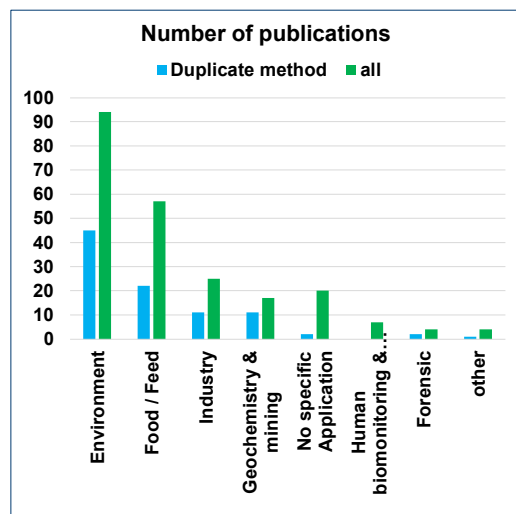
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DUPLICATE METHOD

- Relatively easy to implement
- Applicable to static and dynamic media
- No prior knowledge needed on the measurement process
- Optimisation of cost using unbalanced design
- Software available (RANOVA 4)



Most common used method to estimate uncertainty arising from sampling



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GENERAL CONCEPTS

❑ Feedback from Workshops

- 2008 & 2019 UfS workshops in Berlin

❑ RSC/AMC Technical briefs

❑ Literature reviews

❑ Technical topics such as:

- Uncertainty Factor
- Confidence intervals for robust estimates of U
- Role of Accreditation
- Sampling strategies and statistics
- Improved coverage factor
- Challenges for in situ measurements

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INTERLABORATORY COMPARISON - ILC

- ILC includes Collaborative Trial for Sampling (CTS) & Sampling Proficiency Tests (SPT)

▪ 15 papers

From 2008 to 2014 (2021)
Environment (n=10)
Food & Feed (n=5)



First ICL published
On-going ILC not often published

▪ Environment / Ambient Air (n=1)

Cipriano et al. (2021) Experimenting with odour proficiency tests implementation using synthetic bench loops



Test bench
Known concentration of specific compounds

FR: Air Quality and Industrial Emissions since 2015

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INTERLABORATORY COMPARISON - ILC

Environment / Water (n=4)

Gluschke (2008) Collaborative sampling trial in the context of quality assurance in the German marine monitoring programme for the North Sea and the Baltic Sea

Strub et al. (2009) Metrological aspects of collaborative field trials, including coping with unexpected events

Cotman and Pintar (2013) Sampling uncertainty of wastewater monitoring estimated in a collaborative field trial

Näykki et al. (2014) Proficiency test of pH, conductivity and dissolved oxygen concentration field measurements in river water



Sea water
Surface water
Wastewater



Regularly organised ILCs (FR, FI)



Examples
FR: Surface waters since 2018
and Urban Wastewaters since 2020

Focus on :

- in situ physico-chemical parameters (all)
- TSS, TOC, COD, BOD (wastewaters)
- Nutrients: NH_4 , NO_2 , NO_3 , PO_4 and SiO_4 (all)
- Other elements / species (e.g. Ba; DEHP) (surface waters)

EXAMPLES

Interlaboratory comparison and reference sites

Environment / Soil (n=5)

De Zorzi et al. (2008) A soil sampling reference site: The challenge in defining reference material for sampling

Kurfürst et al. (2011) Soil sampling uncertainty on arable fields estimated from reference sampling and a collaborative trial

Bucko et al. (2012) Assessment of sampling and analytical uncertainty of trace element contents in arable field soils

Bucko et al. (2012) Factors Affecting Sampling Error of Nutrient Element Contents of Arable Fields

Chelabi et al. (2016) Soil sample preparation techniques on routine analyses in Quebec affect lime and fertilizer recommendations



Main application : arable fields

Selection and characterisation of reference sites to conduct intercomparison

EXAMPLES

Interlaboratory comparison

▪ Food & Feed

Ámbrus (2009) Estimation of sampling uncertainty for determination of pesticide residues in plant commodities

Joebstl (2010) Identification of the geographical origin of pumpkin seed oil by the use of rare earth elements and discriminant analysis

Ramsey et al. (2011) Improved evaluation of measurement uncertainty from sampling by inclusion of between-sampler bias using sampling proficiency testing

Onori et al. (2013) Traceability of genetically modified Roundup Ready soybean: A case study on sampling and analytical uncertainty along processing chain

Wood et al. (2013) Breakfast cereal sampling study for nutritional elements



Butter
Vegetable oils
Crops
Vegetables and fruits
Breakfast cereals
Flour

Focus on

- **Water content (butter)**
- **Ca, Fe, Zn (cereals)**
- **REE (oils)**
- **Soyabean content (flour)**

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STANDARTISATION

Already published

- ISO 18400-104: 2018 - Soil quality - Sampling - Part 104: strategies

=> **Annex C: Assessment and modification of sampling uncertainty**

- NEN 7776: 2021 - Environment, food, feed, solid mineral fuels, and solid biofuels - **Contribution of sampling to measurement uncertainty**

- Air quality : integrated in each standard

Planned for 2026-2029:

- EN ISO 5667-14:2015 –Water quality — Sampling Part 14: Guidance on quality assurance and quality control of environmental water sampling and handling => **New Annex on estimating uncertainty arising from sampling using the duplicate method**

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CONCLUSION

Number of publications

- > 200

Most used method:

- Top-down - Duplicate Method

Interlaboratory comparison (CTS & SPT):

- Publication of the first ILC

Standardisation:

- Uncertainty arising from sampling included for solid matrices (soil, food, feed solid fuels ...)
- On-going for Water (ISO TC147/SC6)

THANK YOU FOR YOUR ATTENTION

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