INTERNATIONAL ATOMIC ENERGY AGENCY
DEPARTMENT OF NUCLEAR SCIENCES AND APPLICATIONS

Improving Analytical Capabilities and Quality of Measurement Results for Mercury Monitoring in the Marine Environment

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" Expert Consultations Meeting on Mercury Monitoring on Soil and Biota", 13 and 14 of May 2019, Monaco

The only Environment Laboratory in UN System

IAEA

1961 - Laboratory established in the Oceanographic Museum

1988 -Temporary facilities in the Louis II Football Stadium

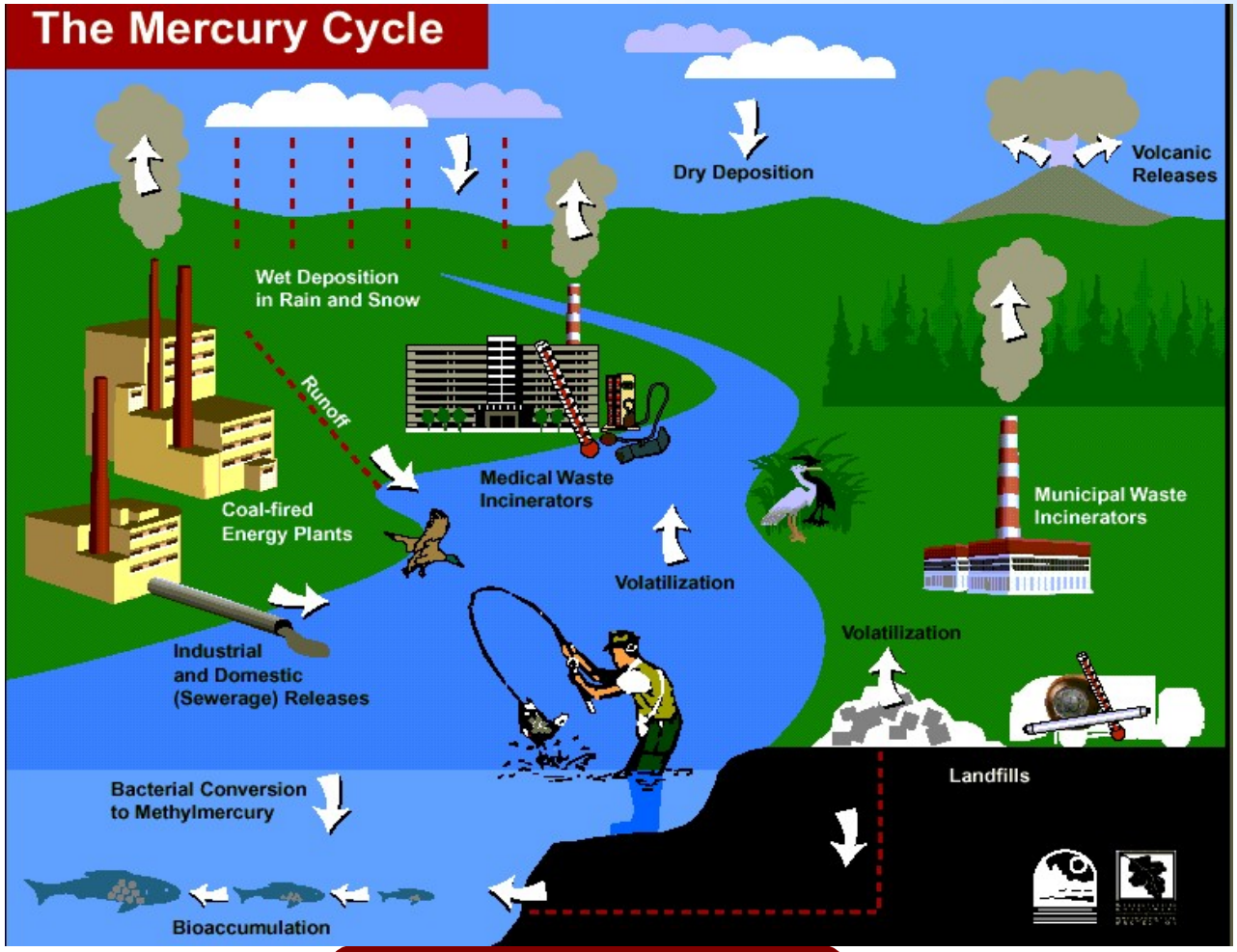
1998 - Permanent facilities on the Port of Monaco

IAEA Environment Laboratories

The primary goal of the International Atomic Energy Agency's Environment Laboratories (IAEA EL) in Monaco is to help Member States to understand, monitor and protect the marine environment.

Among its multiple tasks, IAEA - EL in Monaco acts as the analytical support centre for IAEA Member States laboratories and is the pillar of the Quality assurance program for the determination of nuclear and non nuclear pollutants including mercury and methylmercury in the marine environment.

The Mercury cycle



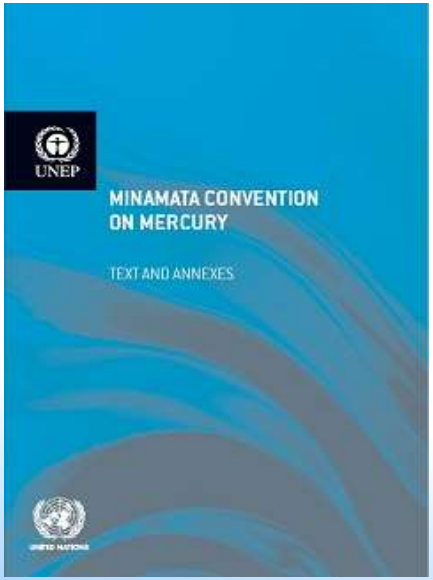
Atmospheric transport

Deposition to land and ocean

Revolatilization

Why mercury is a subject of concern?

- Hg is a global pollutant with high toxicity and possible bioaccumulation.
- Mercury concentrations in the oceans and in marine biota have risen due to anthropogenic emissions.
- Global climate change may complicate the response of global ecosystems to mercury emission reductions.



UNEP report "Mercury as a global pollutant "2013

Member Nations now needs to establish/strengthen monitoring efforts in order to assess mercury contamination in the environment

Quality assurance of the monitoring data, is essential for their effective use for environmental assessments and decision making

Why is harmonised knowledge on mercury monitoring so important ?

- Comparability of monitoring data
- Accurate environmental assessments
- Effectiveness of mercury pollution control

NAEL activities improving MSs capabilities for mercury monitoring

Build the technical capacity of the national and regional laboratories for assessing mercury pollution by:

- ✓ Organisation of global ILC and targeted proficiency tests
- ✓ Production of matrix certified reference materials
- ✓ Developing fit-for-purpose recommended analytical procedures
- ✓ Reference measurements
- ✓ Training of laboratory practitioners from laboratories of IAEA Member States.

ILC for Trace Elements including Mercury and MeHg

Number of participating laboratories	Number of Member States	Sample Type	OPEN to	Year
81	**48**	Marine Sediment	All member states	2018
49	**32**	Fish tissue	All member states (Non EU)	2017
30	**19**	Marine biota-Oyster	Participants with demonstrated capabilities	2016
108	**52**	Marine biota-Clams	All member states	2013
23	**15**	Marine Sediment *(No MeHg)*	Participants with demonstrated capabilities	2012
72	**38**	Marine Sediment *(No MeHg)*	All member states	2011
35	**19**	Marine Sediment	Participants with demonstrated capabilities	2010
143	**59**	Marine biota-scallop	All member states	2010

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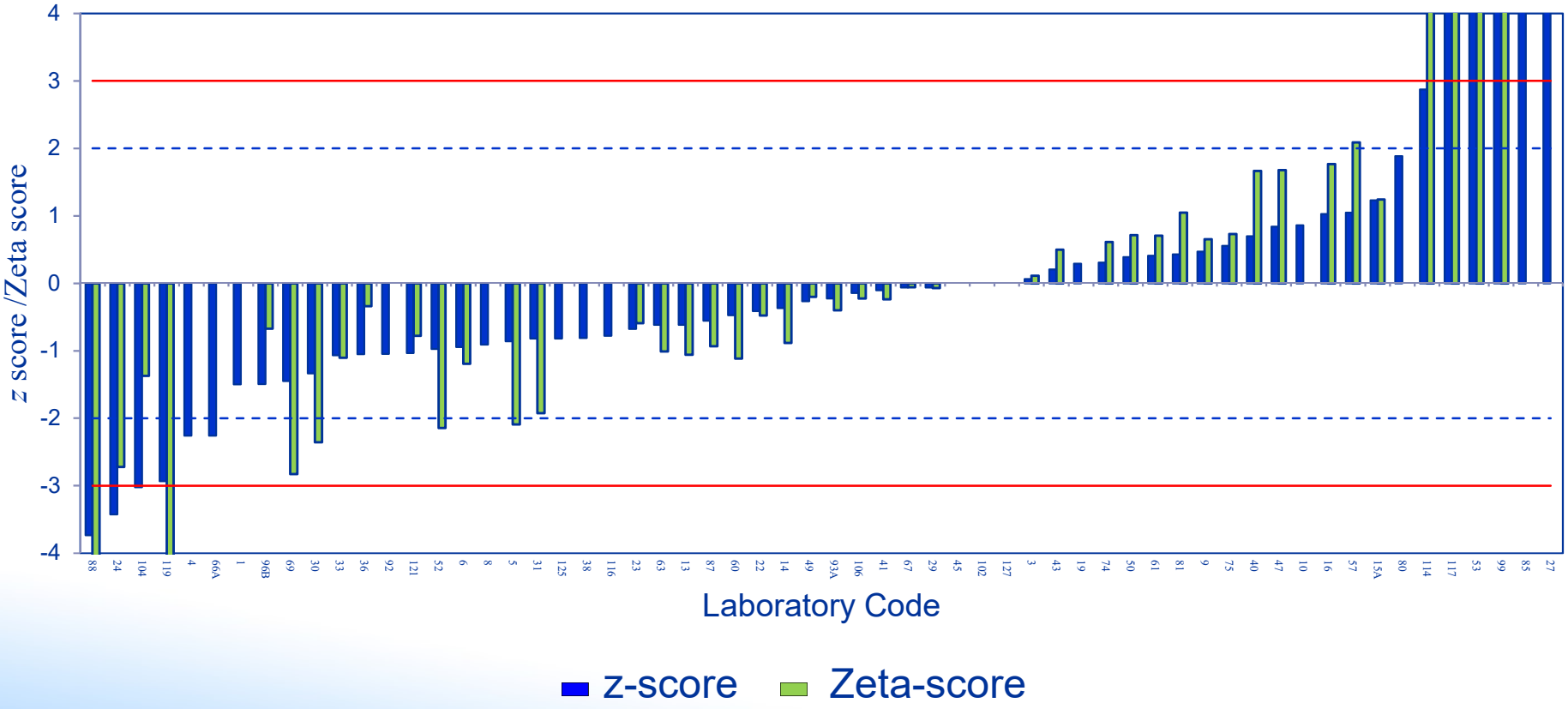
Global ILC Statistics

ILC	Participants	Report HgT	Report MeHg	Performed Speciation*
ILC-SEDIMENT-2018	81 laboratories from 48 countries	49 (60%)	4 (5%)	8%
ILC-BIOTA-2017 (Fish)	49 laboratories from 32 countries	35 (71%)	6 (12%)	17%
ILC-BIOTA-2013 (Clam)	108 laboratories from 52 countries	60 (55%)	17 (15%)	28%
ILC-SEDIMENT-2011	72 laboratories from 38 countries	37 (51%)	NA	NA

* *% of participant reporting Hg that report MeHg as well*

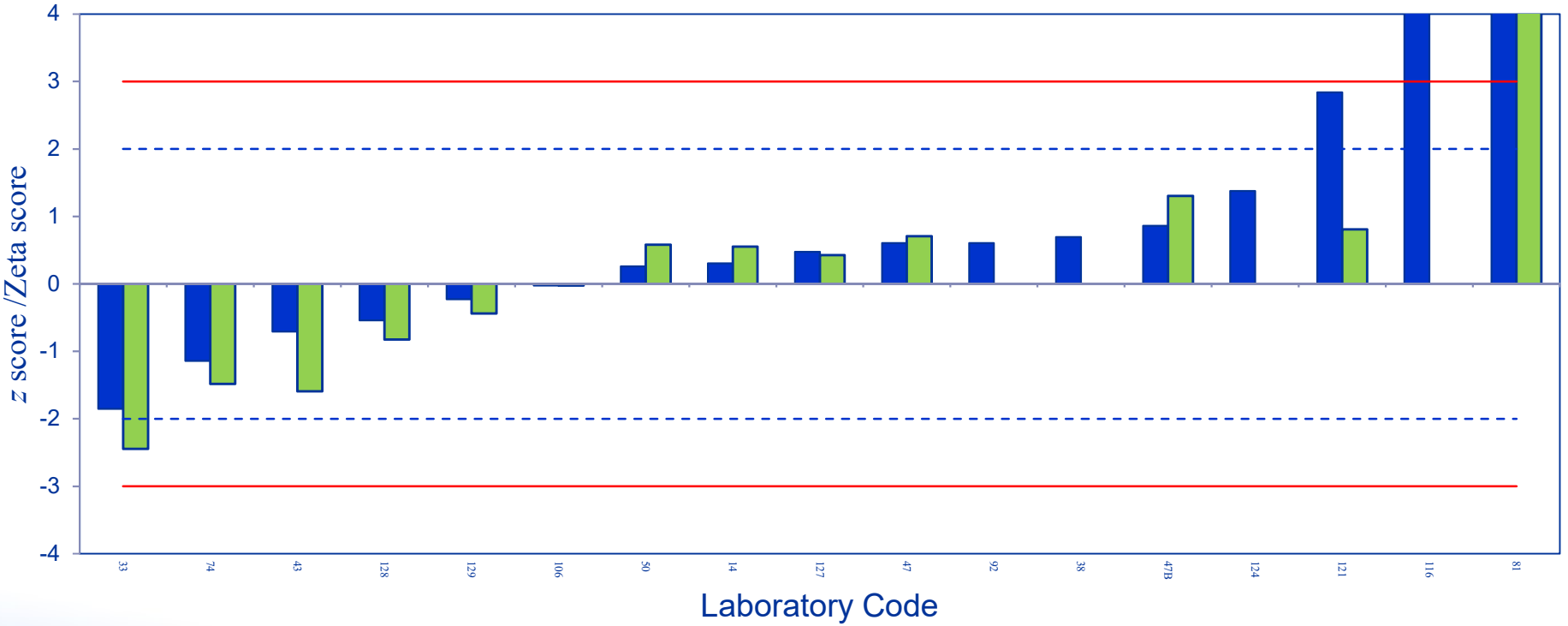
Global ILC IAEA 461(Clam): Total Hg

	Satisfactory	Questionable	Unsatisfactory
z-score	80% (45%)	7%	13%
Zeta-score	74% (43%)	13%	13%

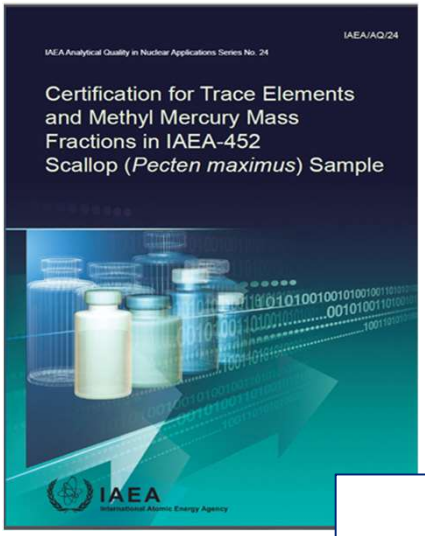


Global ILC IAEA 461(Clam) : MeHg

	Satisfactory	Questionable	Unsatisfactory
z-score	82.4% (12%)	5.9%	11.8%
Zeta-score	84.6% (13%)	7.7%	7.7%



Production of CRM



International Atomic Energy Agency
Department of Nuclear Sciences and Applications
IAEA Environment Laboratories
Vienna International Centre, P.O. Box 100, 1400 Vienna, Austria

REFERENCE SHEET

CERTIFIED REFERENCE MATERIAL
IAEA-452
MASS FRACTIONS OF TRACE ELEMENTS AND METHYL MERCURY IN BIOTA SCALLOP *(Pecten maximus)*

Analyte	Reference value[1] [mg kg^{-1}]	Expanded uncertainty[2] [mg kg^{-1}]
As	17.9	1.1
Cd	30.5	1.6
Cr	5.2	0.7
Cu	11.0	0.8
Fe	1068	47.0
Hg	0.16	0.02
Mn	279	14.0
Pb	2.4	0.3
Zn	167	10.0
MeHg	0.022	0.004

[1] Median of the accepted data sets, each set being obtained by a different laboratory and/or a different method of determination.
[2] Estimated expanded uncertainty with a coverage factor k=2, corresponding to a level of confidence of approximately 95%, as defined in the Evaluation of measurement data - Guide to the expression of uncertainty in measurement JCGM100:2008 [1].

RS_IAEA_452_01/2012-02-20 Page 1 of 6

IAEA:
-Homogeneity Study
-Stability Study

↓

Selected Laboratories with:
- Demonstrated measurement capabilities
- Quality System

↓

Results :
-Different Analytical Techniques

↓

Statistical Treatment:
-Technical validity of data
- Statistical treatment
- Estimation of Uncertainties

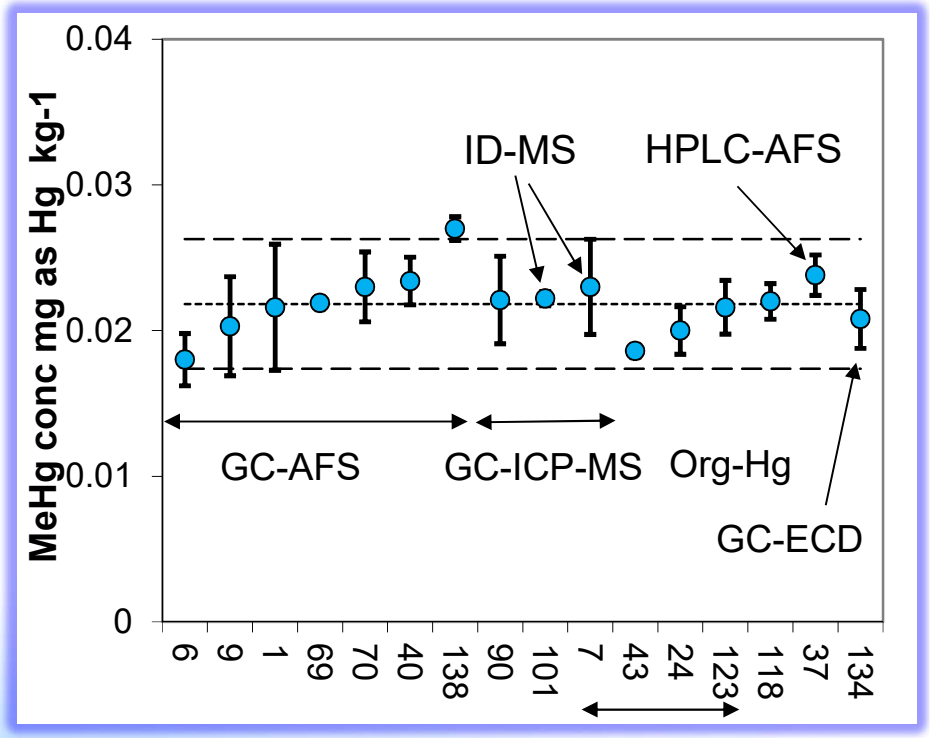
↓

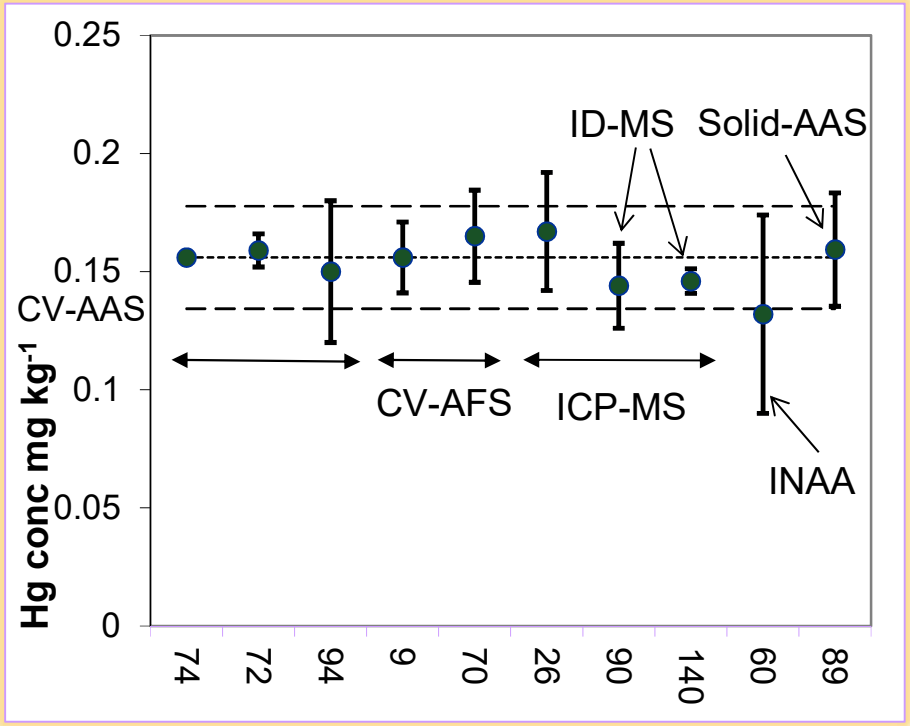
Reference Values ± Combined Uncertainty

Production of CRM

Certification of mercury and methyl mercury in marine biota IAEA 452 Scallop matrix

Lines represents reference value and associated expanded uncertainty (k=2), error bar represents expanded uncertainty as reported by laboratories, participating in the certification





CRMs for Trace Elements including Mercury and MeHg

IAEA – Code	Sample Type	Analyte Groups	Year	Availability
IAEA 475	Marine Sediment	Trace elements & MeHg	2019	On-going
IAEA-476	Fish Homogenate	Trace elements & MeHg	2017	Yes
IAEA-436-A	Tuna fish	Trace elements & MeHg	2016	Yes
IAEA-470	Marine biota-Oyster	Trace elements & MeHg	2015	Yes
IAEA-461	Marine biota-Clams	Trace elements & MeHg	2013	Yes
IAEA-458	Marine Sediment	Trace elements	2013	Yes
IAEA-457	Marine Sediment	Trace elements	2012	Yes
IAEA-456	Marine Sediment	Trace elements & MeHg	2012	Yes
IAEA-452	Marine biota-scallop	Trace elements & MeHg	2010	Yes

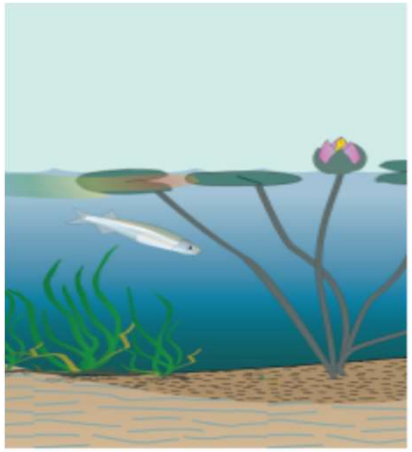
http://nucleus.iaea.org/rpst/

Occurrence in the Environment

Elemental (Hg^0)

Monovalent Hg (I) (Hg_2^{2+})

Divalent Hg (II) (Hg^{2+}, $MeHg^+$, $EtHg^+$ Me_2Hg)



Mason and Benoit (2003) Organomercury compounds in the Environment, Willey, 57

In the case of mercury ……

1. Data produced are oceanographically inconsistent
2. “Different methods measuring different fractions of mercury”
3. “Complexity of sample matrix and the definition of the measurant
4. Errors in the quantification of the analytical blank”

5.Lack o matrix matching CRM

6. Sound and realistic combined uncertainty estimation associated with the declared measurement results is nearly always lacking, which makes the comparison of different sets of results difficult

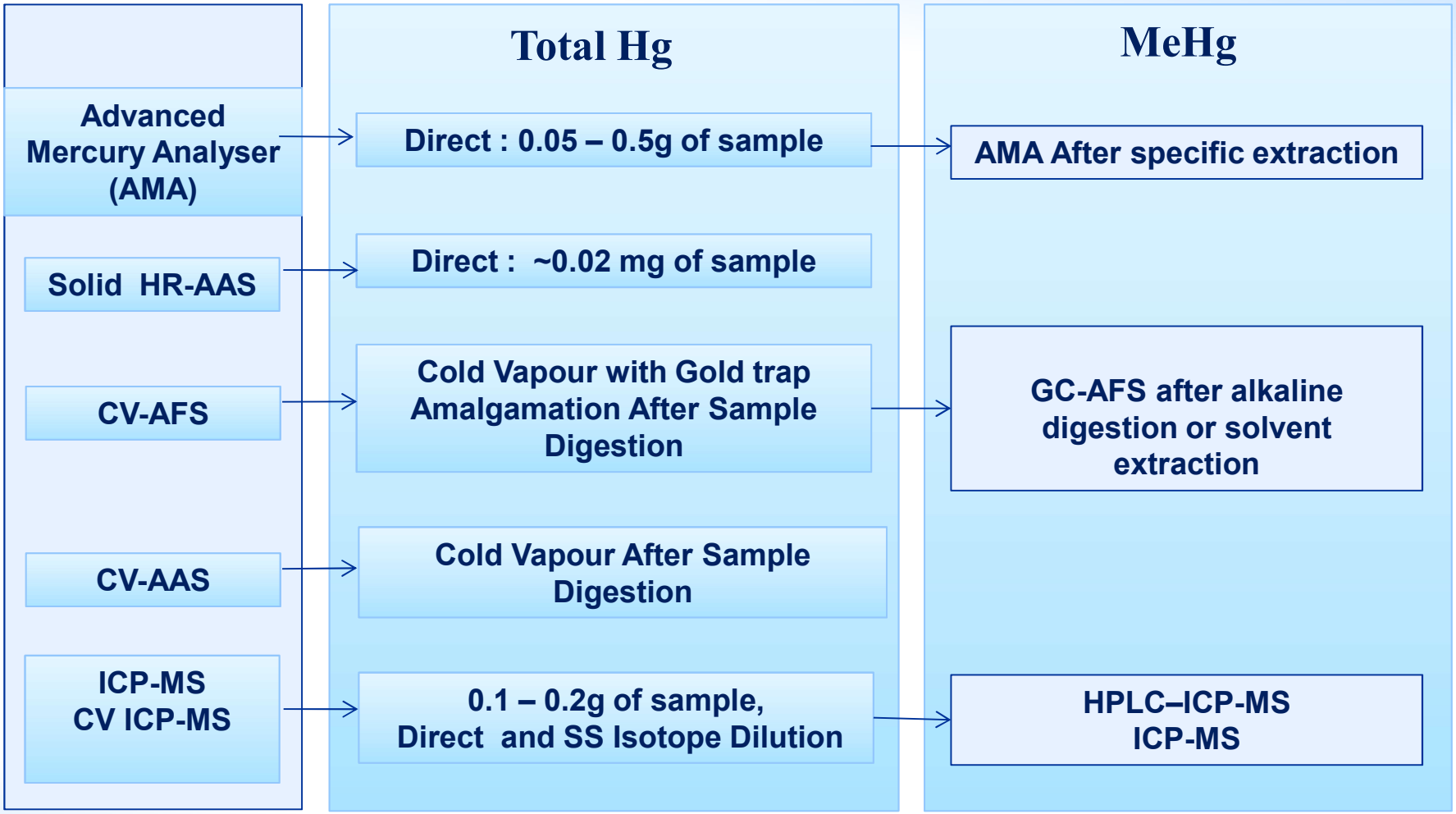
➔ ***ACCURACY OF MEASUREMENT DATA: IT MATTERS!***

Development, validation and distribution of recommended analytical procedures

The use of reference and recommended analytical procedures is important for:

- Comparability of data for environmental assessments
- Improving quality assurance of monitoring data, produced in different MSs laboratories
- The effective use of the generated database and decision making

Reference and Recommended Analytical Procedures for Hg and MeHg



Comparability of monitoring data

Validation *(method fit-for-purpose)*

Quality of measurement result

Traceability
(my result is comparable to common reference)

Uncertainty *(how well do I know the result)*

With curtesy to TrainMiC programme

ISO/IEC 17025

7.2.2 Validation of method

Validation is the confirmation by examination and the provision of objective evidence that the particular requirements for a specific intended use are fulfilled

- 7.2.2.1

Note 2: The techniques used for the determination of the performance of a method should be one of, or a combination of, the following:

- Calibration using reference standards
- Comparison of results achieved with other methods
- Systematic assessment of the factors influencing the results
- Assessment of the uncertainty of the results based on scientific understanding of the theoretical principles of the method and practical experience.

Validation of the analytical procedure

Performance parameters

- ☐ Selectivity
- ☐ Linearity, measuring interval
- ☐ LOD, LOQ
- ☐ Repeatability, Reproducibility
- ☐ Trueness
  - ☐Recovery
- ☐ Ruggedness (robustness)
- ☐ Uncertainty
- ☐ Traceability

Comparison with primary method of measurements

EURACHEM Guide

Estimation of measurement uncertainty

- Error propagation using partial differentiation
- More practical to use numerical approach

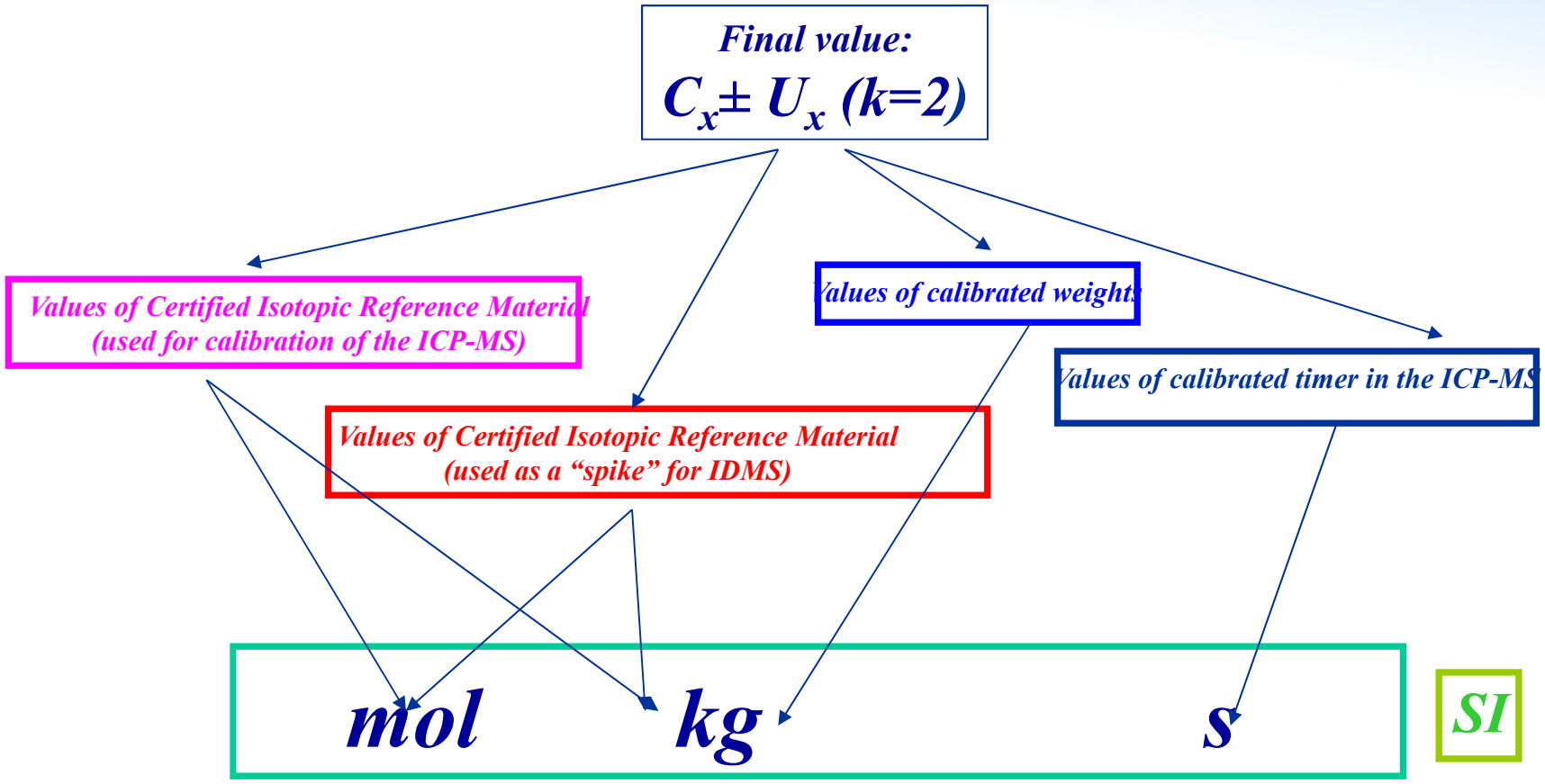
  Kragten's method (Analyst, 1994, 119, 2161)
- Guidelines provided by ISO Guide to the Expression of Uncertainty in Measurement
- Dedicated software used

  GUM Workbench® (Metrodata GmbH, Germany)
- Uncertainties reported with coverage factor k = 2

2%-15%

Specific treatment for the uncertainties on (semi) additive corrections applied to individual isotope signal intensities (instrumental background, isobaric interferences, dead time effects)

Key steps in the attainment of traceability



Mathematical modeling of the entire measurement system demonstrating the traceability to the mole, the kilogram and the second

Reference methods

Reference methods

The analytical procedure to establish reference values for Hg amount contents in marine samples is based on **ID ICP-MS applied as a primary method of measurement.**

$$C_X = C_Y \cdot \frac{m_Y}{m_X} \cdot \frac{R_Y - K_{R_B} \cdot R_B}{K_{R_B} \cdot R_B - K_{(R_1)_X} \cdot R_X} \cdot \frac{\sum\left(K_{(R_i)_X} \cdot (R_i)_X\right)}{\sum (R_i)_Y}$$

Correction for mass-discrimination effects

$K = R_{IRM\text{-}true} / R_{IRM\text{-}Obs}$

Blank corrections

$$C_{X\_bl} = C_X - n_{bl} / m_x$$

Correction for dead-time effects

$$I_{\_dt} = \frac{I_{raw}}{(1 - I_{raw} \cdot \tau)}$$

$$R = \frac{I_A}{I_B}$$

Moisture correction

$$C_{X\_mc} = C_X \cdot \frac{1}{(1 - W_{corr})}$$

Correction for instrumental background

$$I_{\_bkg} = I_{raw} - I_{bkg}$$

Direct IDMS and SS ID ICP-MS for Hg and MeHg in marine biota and sediments

Weighing of the marine sediment sample "IAEA-458"

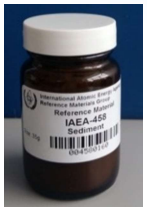
Adding isotopic spikes: ^{202}Hg, $^{198}MeHg$,

Microwave digestion (HNO_3, H_2O_2, HCl, HF)

Isotopic ratio measurements (ICP-QMS, ICP-CC-QMS, ICP-SFMS)

Applying ID ICP-MS equations

Calculation of element mass fractions



Correction for mass-discrimination effects

$$K_b = \left(\frac{R_{IUPAC(ICRM)}}{R_i \cdot \delta_{DT} \cdot \delta_{BG} \cdot \delta_{INT}} + \frac{R_{IUPAC(ICRM)}}{R_{i+1} \cdot \delta_{DT} \cdot \delta_{BG} \cdot \delta_{INT}} \right) \Big/ 2$$

Correction for dead-time effects

$$I_{DT\_corr} = \frac{I_{raw}}{1 - I_{raw} \cdot \tau}$$

$$R_b = I_{a1\_corr} / I_{a2\_corr}$$

Correction for instrumental background

$$I_{INT\_corr} = I_{raw} - I_{INT}$$

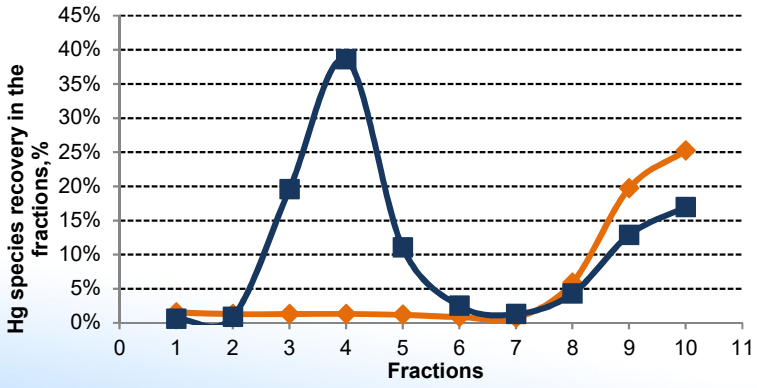
$$c_x = \left(\frac{m_y}{m_x} \right) \cdot c_y \cdot \left(\frac{R_y - K_b \cdot R_b \cdot \delta_{DT} \cdot \delta_{BG} \cdot \delta_{INT}}{K_b \cdot R_b - R_x \cdot \delta_{DT} \cdot \delta_{BG} \cdot \delta_{INT}} \right) \cdot \left(\frac{\sum_{i=1}^{n} R_{xi}}{\sum_{i=1}^{n} R_{yi}} \right)$$

Blank corrections

$$c_{x\_Bl.corr} = c_x - n_{Bl} / m_x$$

Moisture correction

$$c_{x\_Wcorr} = c_x \cdot \frac{1}{1 - W_{corr}}$$



ID-ICP-MS reference measurements

- ✓ Systematic assessment of all actors influencing measurement results
- ✓ Modeling of the analytical t procedure and estimation of combined uncertainty
- ✓ Validation of all steps of measurement procedure
- ✓ Use of reference standards (isotopically enriched spikes)
- ✓ Demonstrated traceability of the obtained results

I. Wysocka and E. Vassileva, Microchemical Journal, 128, 2016, 198-207

Cold vapor matrix-independent ID ICP- MS for reference measurements of mercury in seawater, sediments and biota

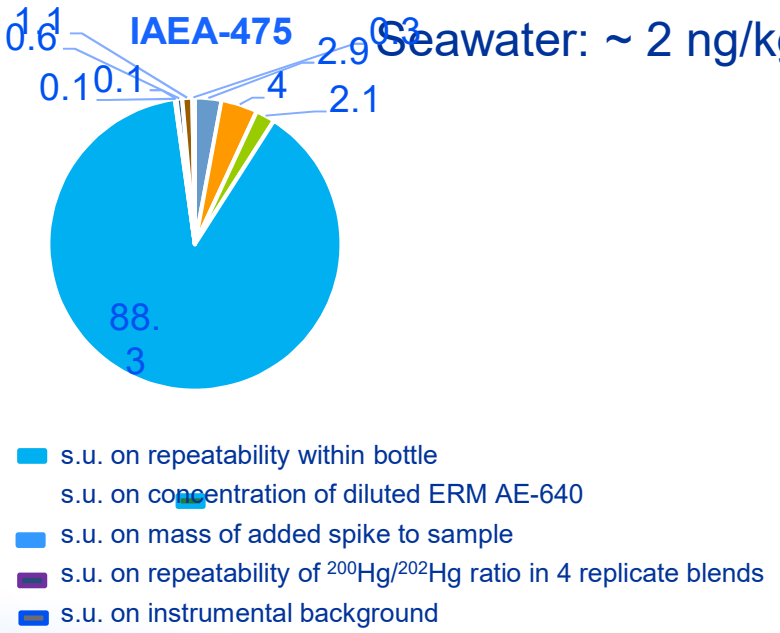
Method development and validation studies for total Hg

$n(^{200}Hg)/n(^{202}Hg)$

IAEA-475: sediment

IAEA-470: oyster

Seawater: ~ 2 ng/kg



Materials	Isotope dilution C ± U, µg/kg (k=2)	U, %	Certified value / PT value	U, %
IAEA-470	20.1 (0.7)	3.5	21.2 (2.1)	9.9
IAEA-475	30.2 (1.3)	4.5	29.9 (1.5)	5.0
BCR-579	1.96 (0.06) $\cdot 10^{-3}$	3.0	1.9 (0.5) $\cdot 10^{-3}$	26
PT Seawater I	4.83 (0.14) $\cdot 10^{-3}$	3.0	4.84 (0.11) $\cdot 10^{-3}$	2.2
PT Seawater II	9.85 (0.23) $\cdot 10^{-3}$	2.4	9.86 (0.90) $\cdot 10^{-3}$	9.1
PT Seawater III	34.2 (0.5) $\cdot 10^{-3}$	1.6	34.1 (1.8) $\cdot 10^{-3}$	5.3

- ➢ Gas phase sample introduction
- ✓ separate Hg from matrix

^{200}Hg: $^{184}W^{16}O^{+}$ and ^{202}Hg: $^{186}W^{16}O^{+}$

- ✓ reduce memory effects
- ✓ increase sensitivity

A. Krata, E. Vassileva, E. Bulska, Talanta , 160, 2016, 562-569

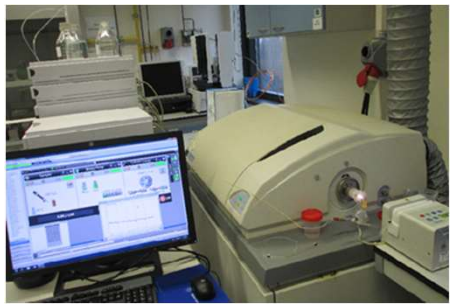
Hyphenated techniques for mercury species using direct and species-specific Isotope Dilution ICP-MS

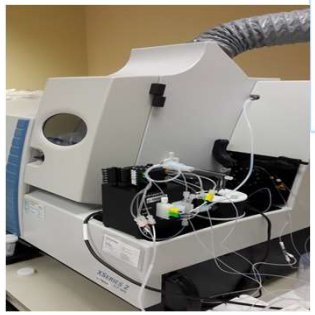
HPLC ICP-MS

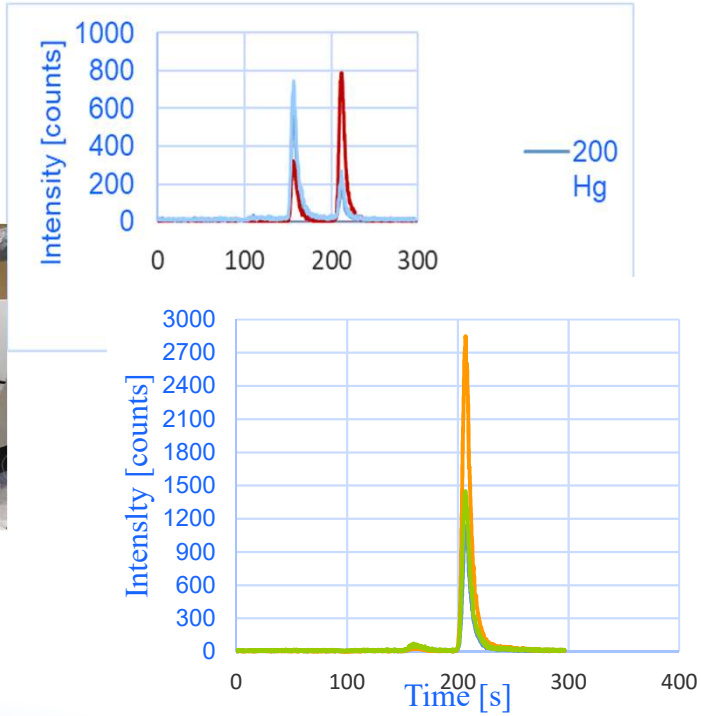
$n(^{200}Hg)/n(^{202}Hg)$ and $n(^{201}Hg)/n(^{202}Hg)$

Method development and validation studies for total Hg and MeHg

IAEA-476: fish homogenate
IAEA-461: Gafrarium tumidum clam
IAEA-470: oyster







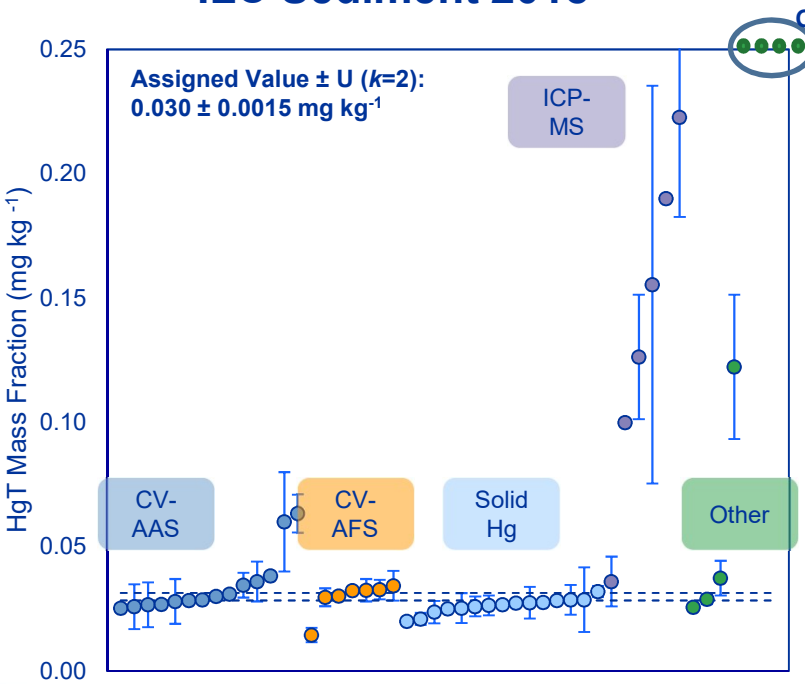
A. Krata, E. Vassileva, E. Bulska, Talanta , 160, 2016, 562-569

Testing methods

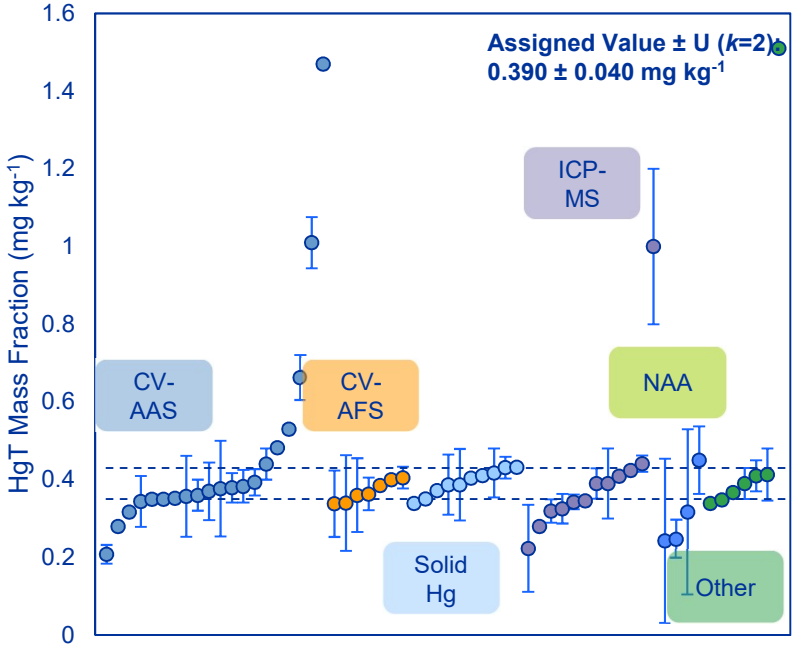
Global Total Hg : Example of Results

Lines represents reference value and associated expanded uncertainty (k=2), error bar represents expanded uncertainty as reported by laboratories, participating in the ILC

ILC Sediment 2018



ILC Clams 2013



Determination of Hg and MeHg in Marine Biota Samples by using Advanced Mercury Analyser

Advanced Mercury Analyser

Sample preparation procedure

MeHg in Marine Biota

0.1-0.8 g of dried sample

↓

5ml of HCl (25% v/v) vortex 30s

↓

10ml of toluene, vortex 3 min, centrifuge 5000rpm 5-20minutes

↓

Collect 4 to 8 ml of solvent phase,
Add 5 to 15 ml of thiosulfate (0.002 mol l^{-1}),
vortex 3 min,
Centrifuge 5000rpm 5-15 minutes

↓

50-400 µl of thiosulfate solution analyzed by AMA

S.Azemard and E.Vassileva, Food Chemistry, 176, 2016, 367-375.

Validation Parameters

Marine biota samples

Parameters	$MeHg^+$
Recovery	92-108%
Repeatability	1.3-3.9%
Reproducibility	1.7-4.5%
Working range	0.002-20 µg kg^{-1}
Linearity	0.9932
LOD	0.5 $ngkg^{-1}$
LOQ	1 $ngkg^{-1}$
Traceability	SI system via CRM
Uncertainty	17.5% (k=2)
Procedural Blank	*<0.68 pg*

S.Azemard and E.Vassileva, Food Chemistry, 176, 2015, 367-375.

Determination of Hg in marine samples by using CV AFS

- Analysis by Dual-Stage Gold Pre-concentration and Direct Atomic Fluorescence
- Direct measurement without pre-concentration
- Applicable to seawater, marine biota and sediment samples

Validation Parameters CV-AFS sediment and biota samples

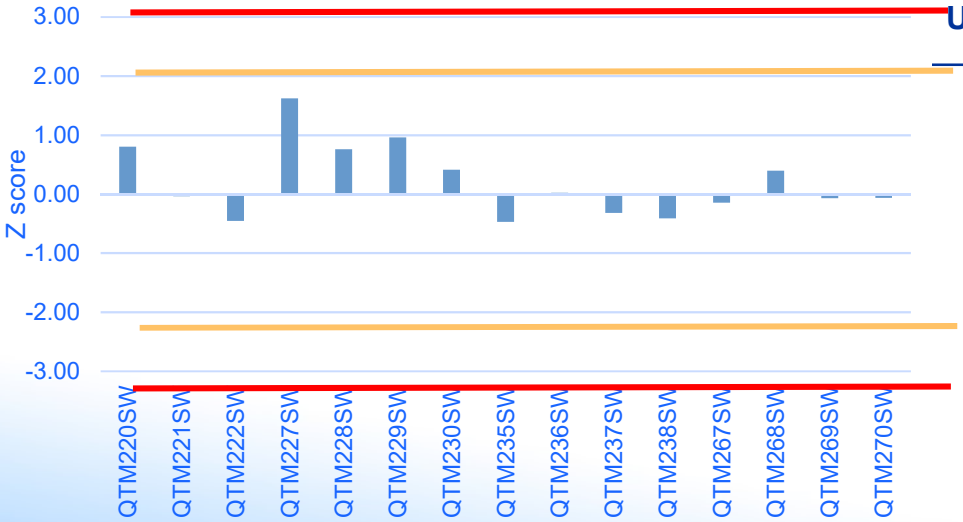
Parameter	CV-AFS
Working range	0.1 to 5 ng kg^{-1}
Detection limit	0.02 -0.05 $ngkg^{-1}$
Quantification limit	0.2-0.5 $ngkg^{-1}$
Repeatability	2-5%
Reproducibility	4-8%
Recovery	96 - 102%
Uncertainty (k=2)	14% (k=2)

THg in Seawater by CV-AFS

Summary of the Method

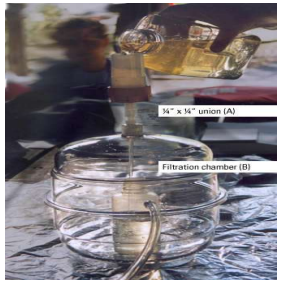
- Filtered or Unfiltered sea Water (25ml)
- Digestion 12h with BrCl
- Pre reduction Hydroxylamine ammonium
- Reduction with $SnCl_2$
- Double Gold trap Amalgamation
- AFS Detection (automated analyzer Brooks Rand or Tekran)

Results of 3 years external PTs on seawater



Validation Parameters :

Parameters	
Linearity	Demonstrated up to 900pg (36 ng kg^{-1})
Working range	0.8 to 900pg (0.03 to 36 ng kg^{-1})
LOD	0.009 ng kg^{-1}
LOQ	0.03 ng kg^{-1}
Repeatability	7.0 -2.4% (for 0.2 to 5 ng kg^{-1})
Intermediate precision	7.3 -2.4% (for 0.2 to 5 ng kg^{-1})
Recovery	94 – 103 %
Uncertainty (U)	30% (*k*=2) with BCR 579 15% (*k*=2) with Spike for recovery

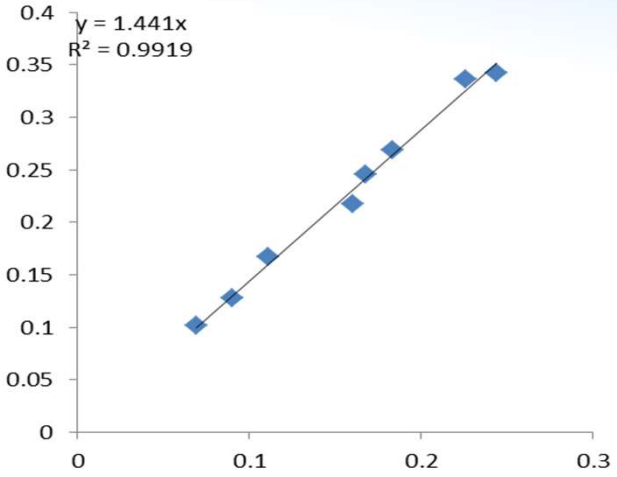


Validation of: $HgT_P = HgT - HgT_D$

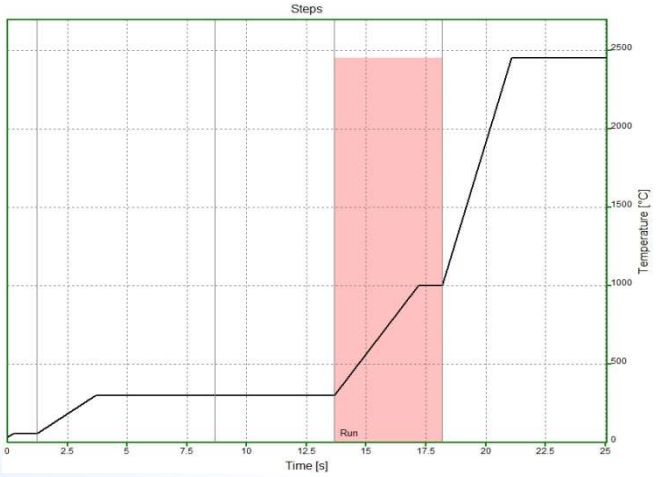
Samples are analyzed Filtered (HgT_D) and unfiltered (HgT)

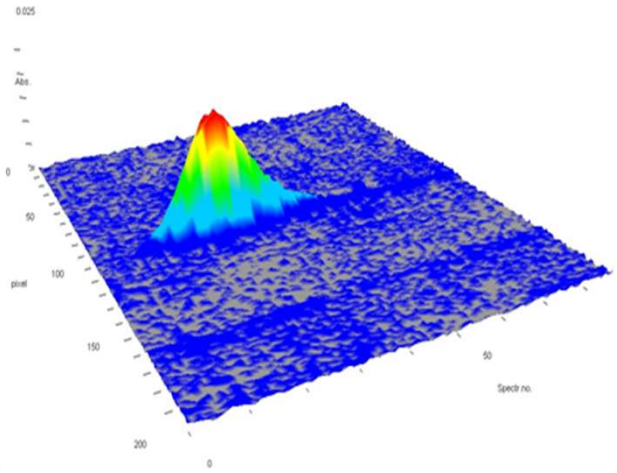
Solid Sampling CS HR AAS for Hg in marine samples: biota and sediments

Step	Name	Temp. [ºC]	Ramp. [ºC/s]	Hold [s]	Time [s]	Ar flow
1	Drying	55	100	1	1.2	Max
2	Pyrolysis	300	100	5	7.5	Max
3	Gas Adaption	300	0	5	5.0	Stop
4	Atomize	1000	200	1	4.5	Stop
5	Clean	2450	500	4	6.9	Max



Sample mass 0.111mg





P. Mandjukov, A. M. Orani, E. Han and E. Vassileva, **Spectrochim. Acta Part B 103-104, 2015, 24-33**.

Validation Parameters

Parameters	Total Hg
Repeatability	RSD=3.2 %
Reproducibility	RSD=11 %
LOD	0.12 ng Hg
LOQ	0.36 ng Hg
Recovery	95-101%
Uncertainty	8.5% (k=2)
Traceability	SI system via CRM

P. Mandjukov, A. M. Orani, E. Han and E. Vassileva, Spectrochimica Acta part B 103-104, 2015, 24-33.

Determination of MeHg in Marine Samples with GC-pyr-AFS

Automatic purge and trap iso-thermal packed GC-Pyr-AFS

Automatic purge and trap Capillary GC-Pyr-AFS

Methods for MeHg determination in seawater, marine biota and sediment samples are based on aqueous ethylation derivatization, purge & trap pre-concentration, GC separation and AFS detection

Assay of Different Extraction Conditions

MAE-HCl (5M)

0.5 g IAEA-452 10 mL of 5 M HCl and 0.25 M NaCl

Teflon vessels were irradiated at 60 °C for 10 min
Centrifugation at 3000 rpm for 20 min

Injection volume 20 µL

94%

MAE-TMAH (25%, w/v)

0.1 g IAEA-452 4 mL of 25% (w/v) TMAH

Teflon vessels were irradiated at 70 °C for 8 min
Centrifugation at 3000 rpm for 20 min

Injection volume 30 µL

20%

MAE-KOH (25%, w/v)

0.15 g IAEA-452 6 mL of 25% (w/v) KOH/MeOH

Teflon vessels were irradiated at 70 °C for 8 min
Centrifugation at 3000 rpm for 20 min

Injection volume 30 µL

49%

Furnace-KOH (25%, w/v)

0.25 g IAEA-452 10 mL of 25% (w/v) KOH/MeOH

Teflon vessels heated in a furnace at 75 °C for 3 h
Dilution to 50 mL

Injection volume 20 µL

97%

Protease digestion

0.2 g IAEA-452 0.02 g of protease XIV
8 mL of 0.1M phosphate buffer pH 7.2/0.05% (w/v) Cys

Teflon vessels heated in a furnace at 37 °C for 4 h while being shaken

Injection volume 20 µL

99%

Validation Parameters

Parameters	MeHg in biota
Recovery	91%
Repeatability	9%
Reproducibility	11%
Working range	1-800 pg
Procedural Blank	*<0.45 pg*
LOD	0.45 pg
LOQ	0.85 pg
Traceability	SI system via CRM
Uncertainty	14% (k=2)

L. Carrasco and E. Vassileva, Analytica Chimica Acta 853, 2015, 167–178.

L. Carrasco and E.Vassileva, Talanta, 122, 2014,106-114.

MeHg in Seawater by GC-AFS

Tekran

Brooks Rand

Summary of the Method

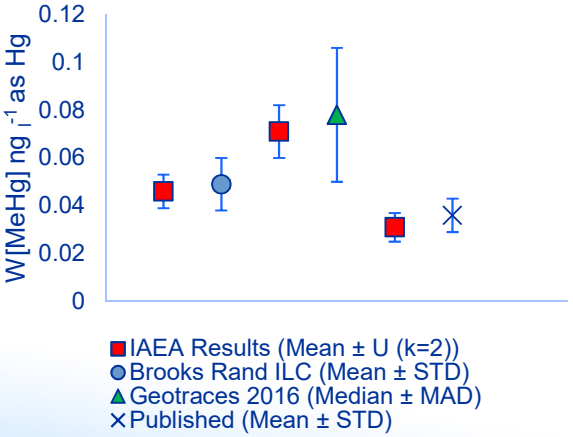
200ml filtered acidified Seawater

Solvent Extraction

Back Extraction Aqueous

Analyse with GC AFS

Validation via External comparisons

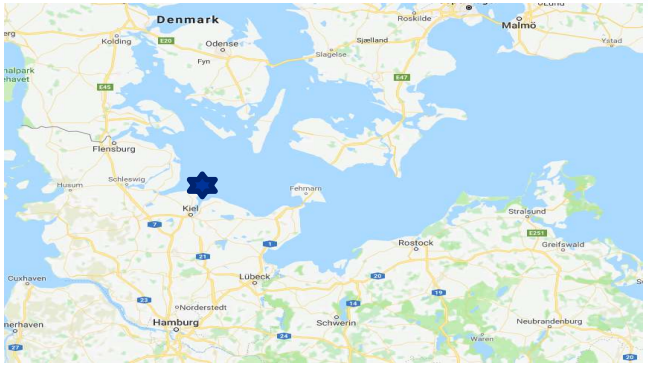


(*Manuscript under preparation*)

Validation Parameters :

Parameters	
Linearity	Demonstrated up to 7pg (0.12ng/l)
Working range	0.2 to 7pg (0.0035 to 0.12ng/l)
LOD	0.001 ng/l
LOQ	0.004 ng/l
Repeatability	3.3% at 0.05ng/l (4.5% at 0.007ng/l)
Intermediate precision	2.9% at 0.05ng/l
Recovery	94 %
Uncertainty (U)	15-25% (*k*=2)

Regional monitoring studies for Hg and MeHg

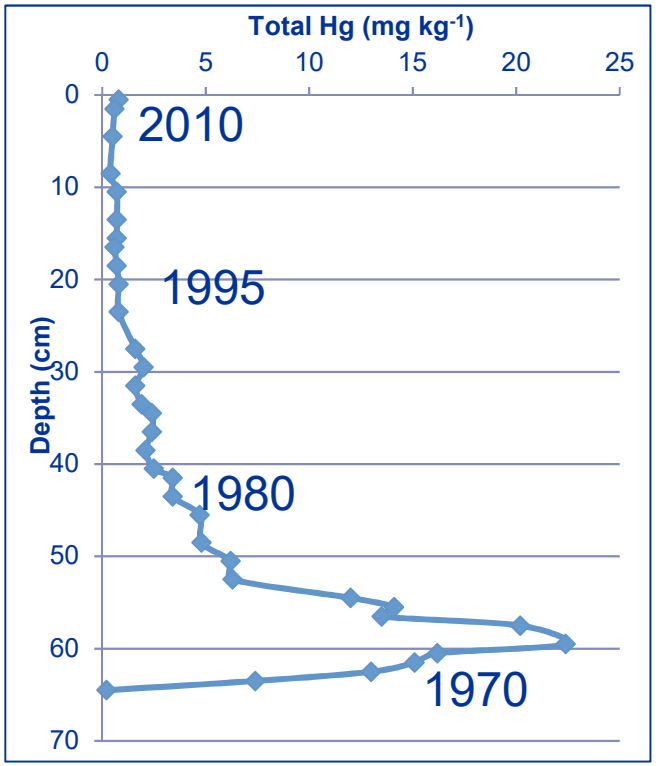


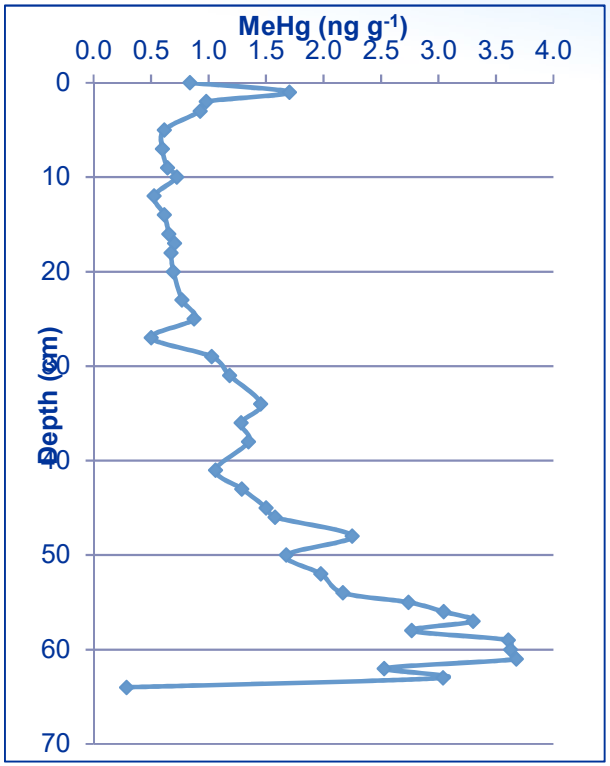
Baltic Sea: Hg and MeHg determination. Pollution history study

Namibia: Baseline monitoring of total Hg along the Namibian coast.

Caribbean region: Cuba, Haiti, Dominican Republic, Colombia. Surface and core samples collected in areas with specific historical Hg contamination

Results: Total and methyl mercury profiles in Colombian sediment





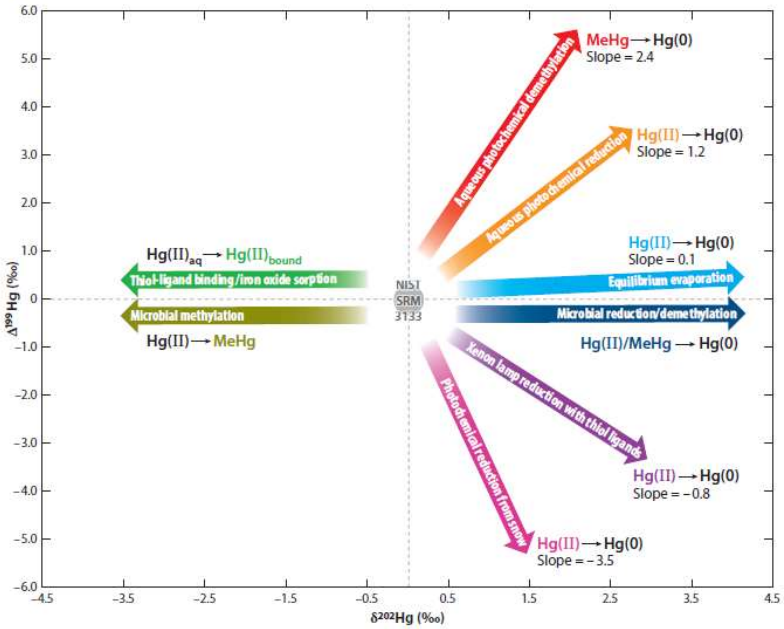
Mercury was used in the production of chlorine **in Alkalis plant in Colombia** and waste waters were discharged directly into the sea.

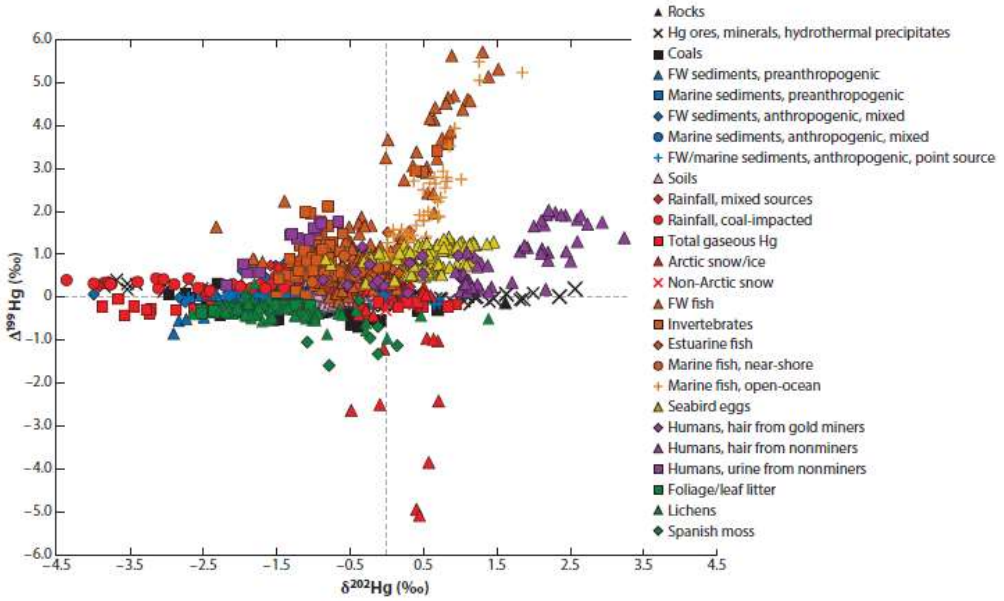
New Developments and Progress in the Environmental Pollution Studies

IAEA
International Atomic Energy Agency
Atoms for Peace and Development

Hg isotopes are used to fingerprint, identify and trace the source of pollution

Mercury Isotope Ratios





Hg isotopes can be used to trace pollution sources, biogeochemical cycling and reactions involving Hg in the environment

Blum et al. Annu. Rev. Earth Planet. Sci. 2014. 42:249–69

Application of Hg isotope ratios for pollution source evaluation

Hg isotopes can undergo two types of fractionation, depending on chemical/physical processes in which they are involved:

- MDF = Mass Dependent Fractionation

$$\delta^{xxx}Hg(‰) = \left\{\left[\left({}^{xxx}Hg/{}^{198}Hg\right)_{sample}/\left({}^{xxx}Hg/{}^{198}Hg\right)_{SRM3133}\right] - 1\right\} \times 100$$

where ^{xxx}Hg = selected Hg isotope

SRM 3133 = Hg standard

As convention, the equation for δ^{202}Hg, involving the ratio ^{202}Hg/^{198}Hg, is used to express the MDF

- MIF = Mass Independent Fractionation

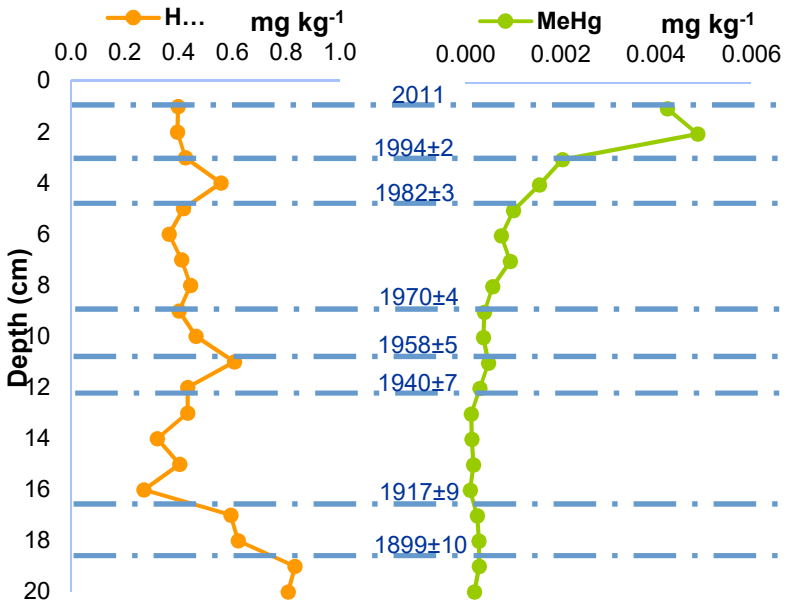
$$\Delta^{xxx}Hg = \delta^{xxx}Hg - (\delta^{202}Hg \times \beta)$$

where ^{xxx}Hg = selected Hg isotope

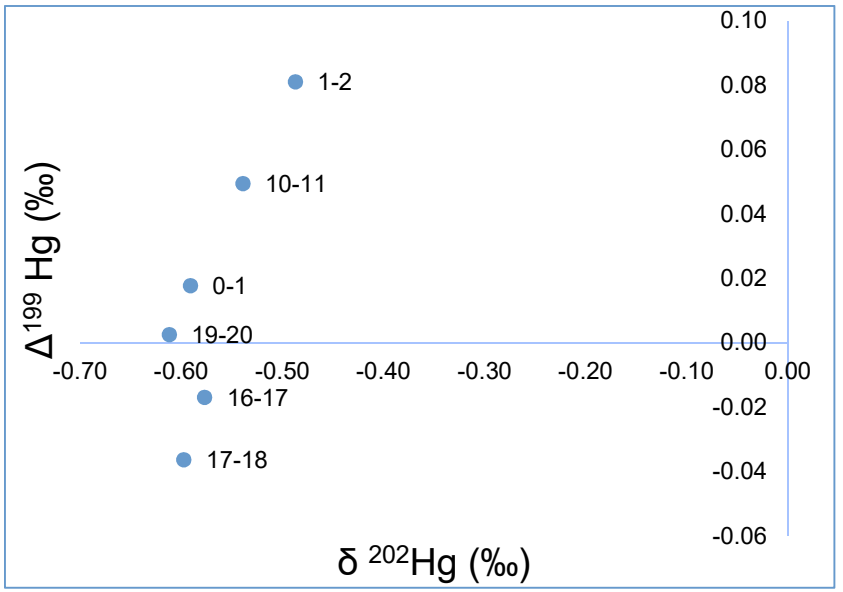
B = 0.252, 0.502 and 0.752 for ^{199}Hg, ^{200}Hg and ^{201}Hg respectively

Hg in Baltic sediment core

Hg and MeHg profiles: pollution history



Hg isotope ratios in sediments



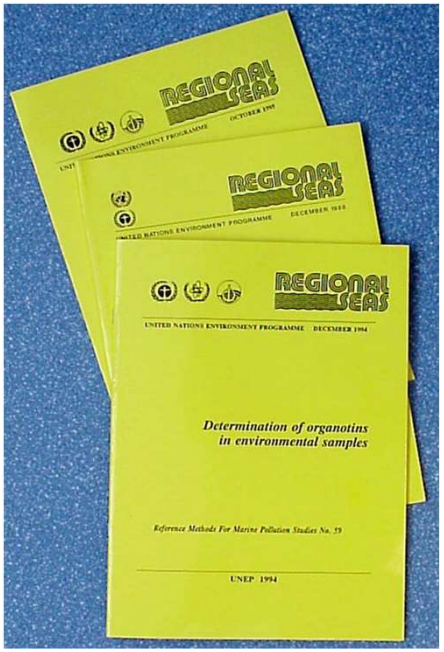
The most probable source of Hg is coal combustion. Highest Hg inputs recorded at the beginning of the 20th century.

Support Capacity Building of Member States to Protect the Marine Environment

Promote excellence in analysis - training of scientists via TC projects and Regional Seas programmes

Dissemination of recommended analytical methods for mercury and methylmercury via peer review papers, scientific presentations and IAEA reports

PUI project on Seafood safety



Conclusions

Sound strategies for marine chemical monitoring are based on measurement systems, capable of producing comparable analytical results with demonstrated quality.

The IAEA's EL supports the improvement of the worldwide performance of monitoring laboratories and the availability of reliable analytical data for global mercury monitoring.

Acknowledgment

- Mr. Lius Carrasco
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Thank You