State of the Network : mercury central analytical lab and site liaison reports

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Background

NCU has been working closely with EPA Taiwan (EPAT), USEPA and NADP since 2012 to establish the collaborative Asia-Pacific Mercury Monitoring Network (APMMN).

2012 in Taipei (1st)

2013 in DC (2nd)

2014 in Hanoi (3rd)

2015 in Minamata (4th)

2016 in Bangkok (5th)

2017 in Taoyuan (6th)

2018 in Manila (7th)

2019 in Jakarta (8th)

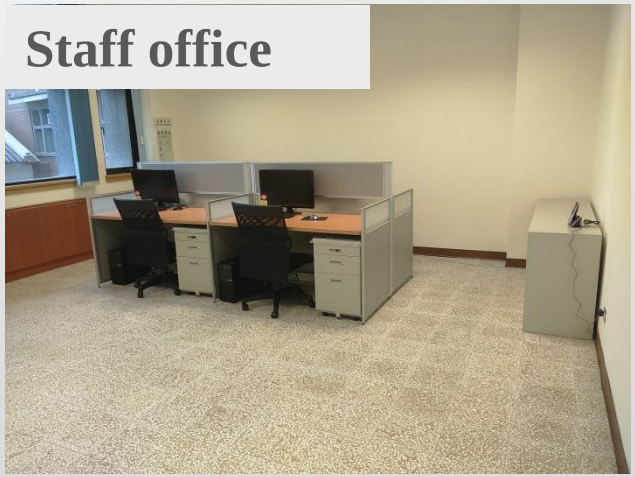
Background

- NCU Hg Lab serves as the center for ultra-trace level Hg analysis and training
  - To help analyze rainwater samples, and to train researchers from other Asian countries for capacity building on ultra-trace level Hg sampling and analysis
- EPAT funded the establishment of the Center for Environmental Monitoring and Technology on NCU campus in 2016
  - Administrative offices and lab expansion to support the operation of Asia-Pacific Mercury Monitoring Network

Center for Environmental Monitoring and Technology

Center Opening Ceremony in June 2016

Administrative Area



Trace-Level Mercury Analytical Lab

Established in 2007. Expanded in 2016. Remodeled in 2019.

- 3 class 1000 cleanrooms and 2 clean benches
- 3 Tekran 2600 CVAFS mercury analyzers
- Tekran and Gardis atmospheric mercury monitoring systems
- 1 NIC MA-3 solo
- 2 DI water systems
- pH/conductivity meter
- 2 analytical balances
- 4 chemical hoods
- UHP Ar supply
- Chemical furnace
- Labware furnace

New Lab Space and Equipment

Class 10000 Buffering Area

Air Shower

Class1000 Cleanroom
(Acid Wash)

Class1000 Cleanroom
(Chemical Preparation)

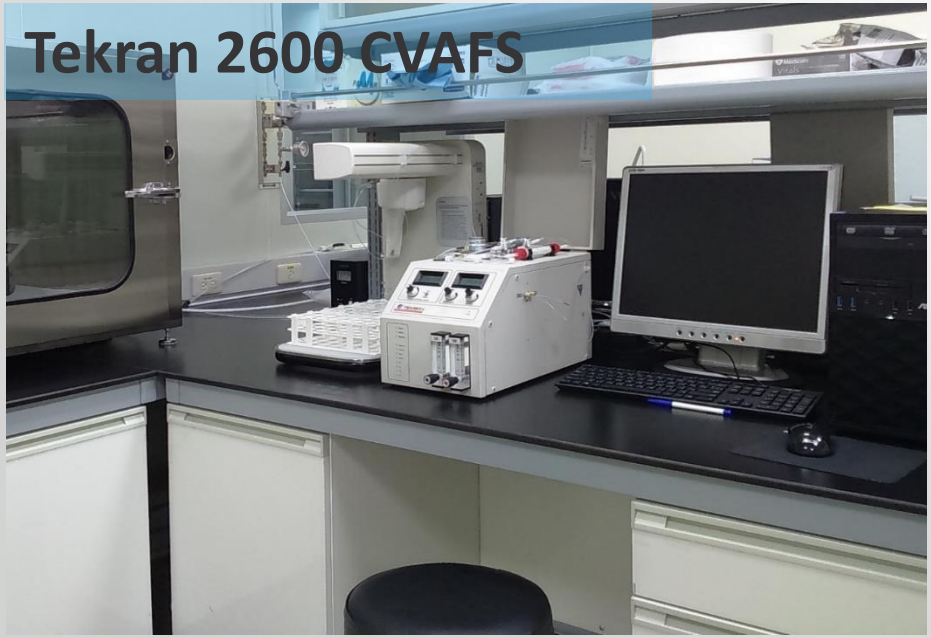
New Lab Space and Equipment

Analytical Area

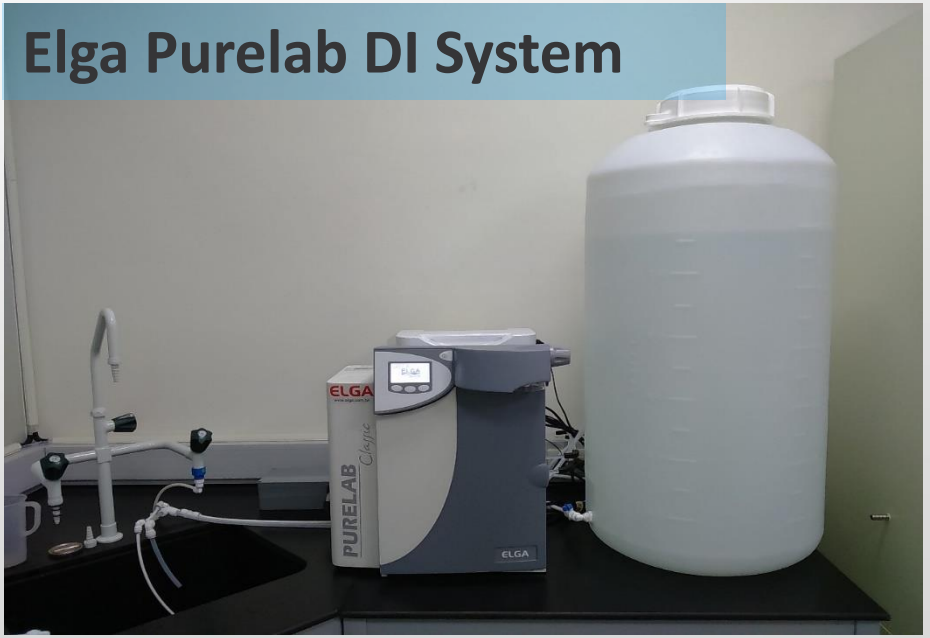
Cylinder Area

Clean Bench

Tekran 2600 CVAFS



Elga Purelab DI System



Remodel of Old Lab Space

Epoxy floor

Air exchange system

Elga Purelab DI System

Class1000 Cleanroom (Cleaning Zone)

Atmospheric and Rainwater Mercury Monitoring Training

Training Activities

Site visit and training, Thailand (February 2017)

Site visit and training, Vietnam (October 2017)

Training Activities

Site survey and training, Philippines (June 2018)

Training Activities

Site visit and training, Indonesia (May 2019)

Training Activities

Visit of Vietnam CEM (April 2017)

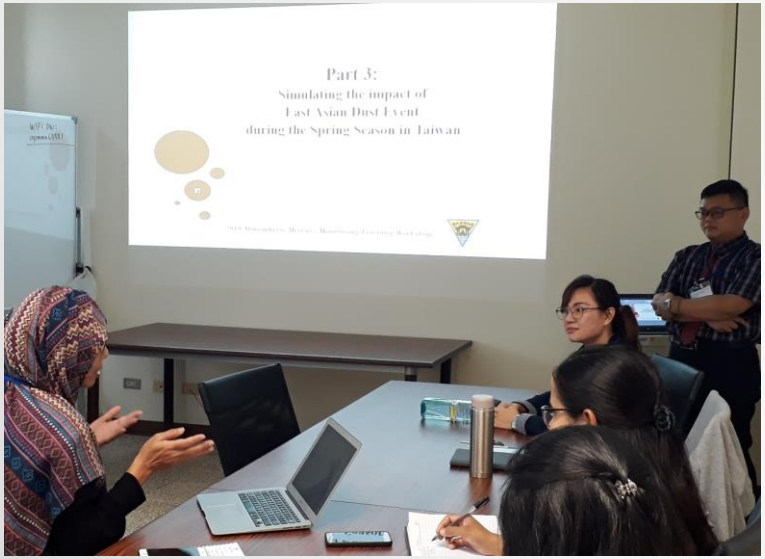
Training Workshop (May 2017)

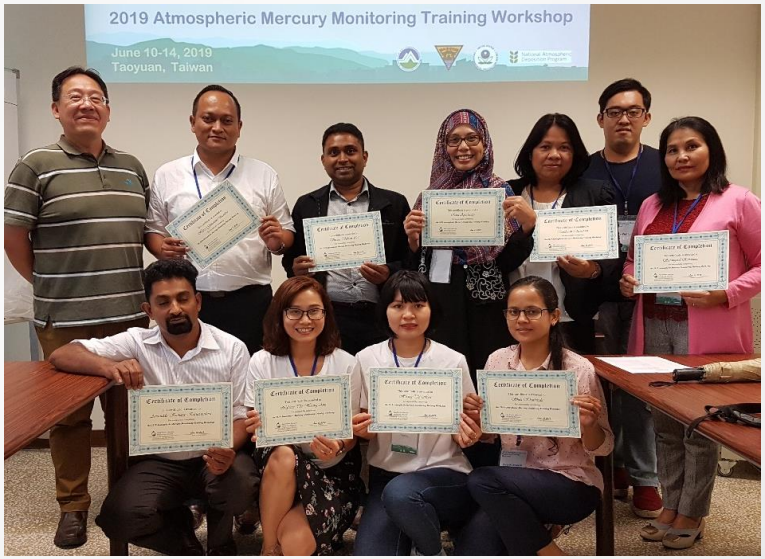
Training Activities

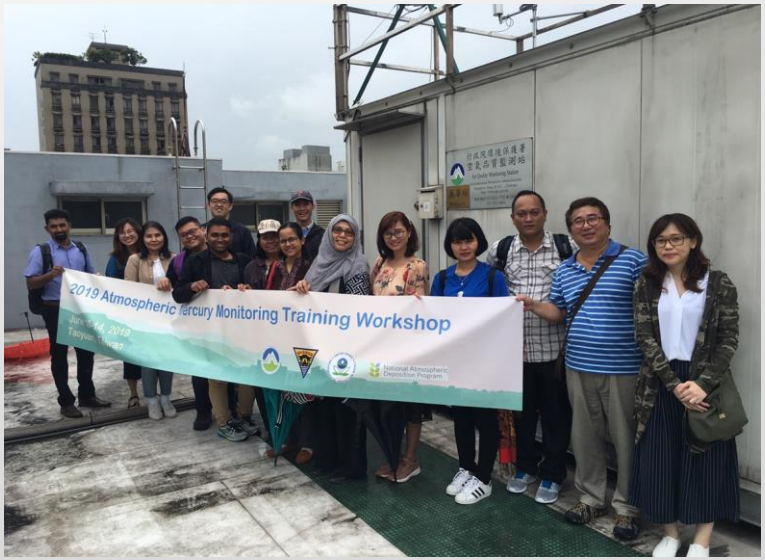
Training Workshop (June 2019)

Training Activities

Training Workshop (June 2019)







Training Activities

Advanced Training (4 sessions)

October 2018
(Thailand)

March 2019
(Vietnam)

Training Activities

Advanced Training (4 sessions)

March 2019 (Indonesia)

April 2019 (Philippines and Sri Lanka)

Wet Sampler Inter-comparison

Inter-comparison of Wet Deposition Samplers

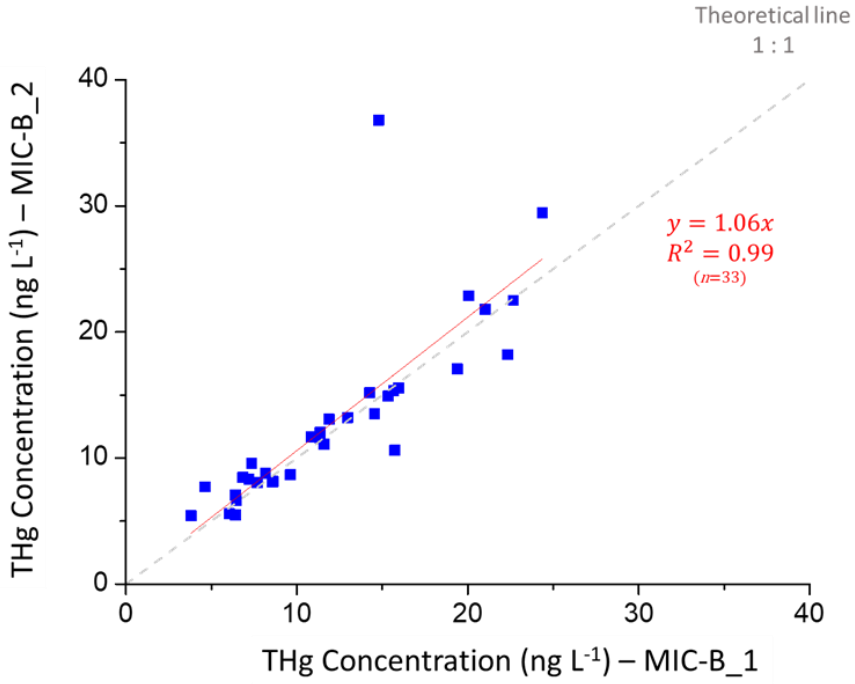
- There is no “standard” wet deposition sampler.
- APMMN uses MIC-B type sampler, whereas NADP/MDN uses N-CON sampler
  - MIC-B vs N-CON : since January 2017
  - MIC-B vs MIC-B : since April 2018

Inter-comparison of Wet Deposition Sampler

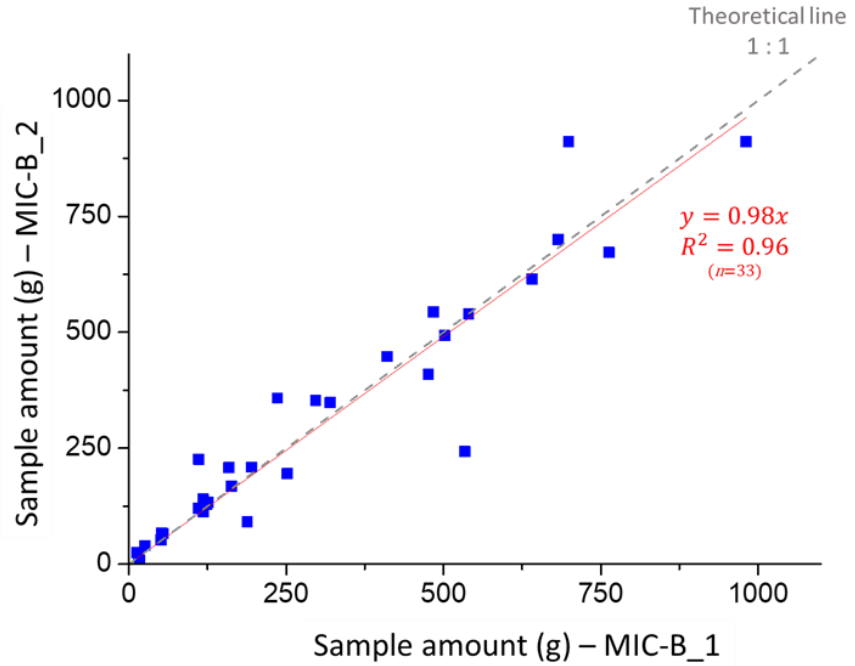
MIC-B vs MIC-B:

33-pair of samples until April 2019

THg concentration



Sample amount

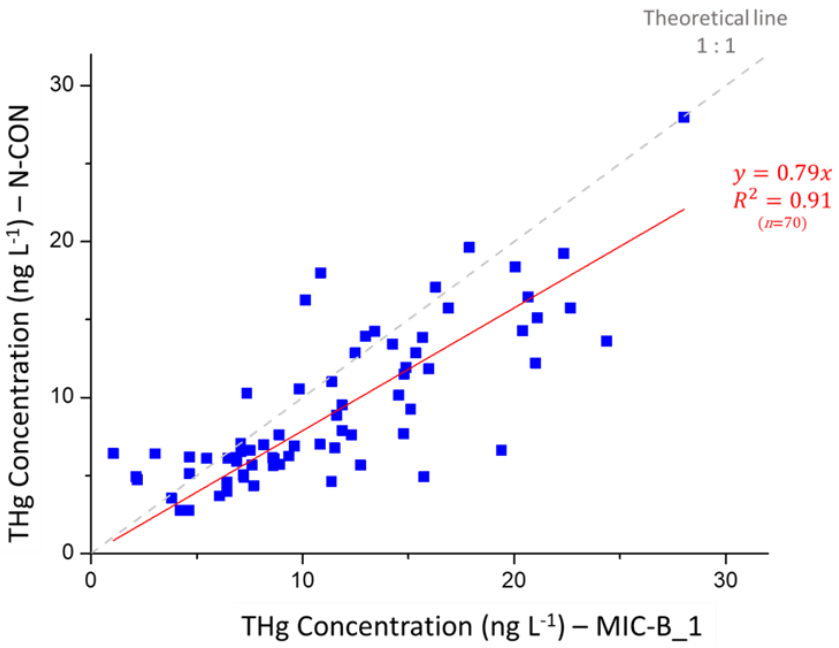


Inter-comparison of Wet Deposition Sampler

MIC-B vs N-CON:

70-pair of samples until April 2019

THg concentration

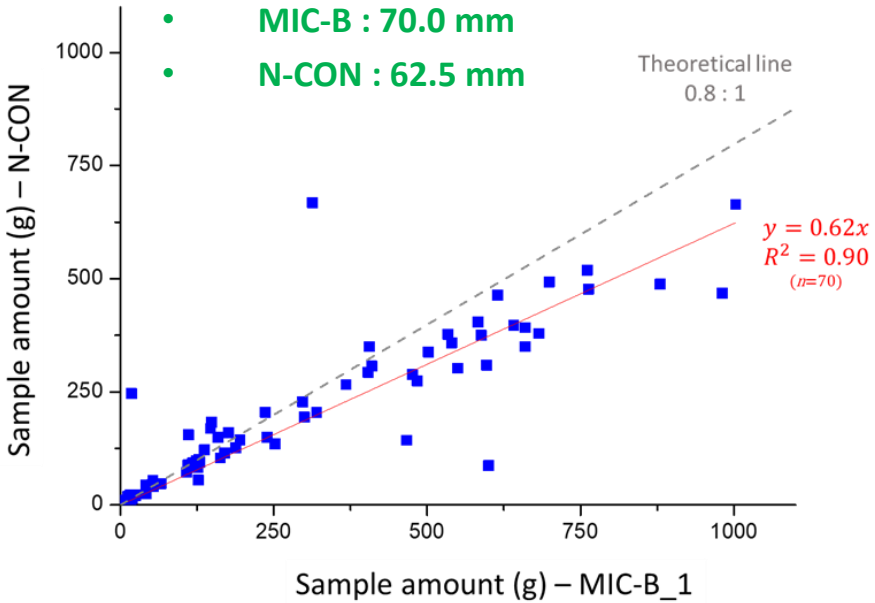


- Lid opening/closing time difference (sensor/motor difference)
- Raindrop bounce/splash

Sample amount

Collection funnel diameter:

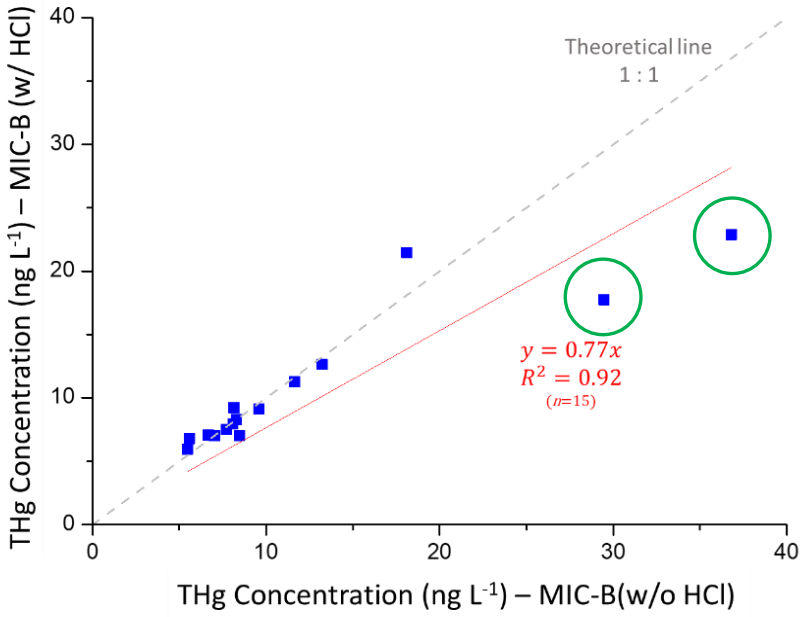
- **MIC-B : 70.0 mm**
- **N-CON : 62.5 mm**



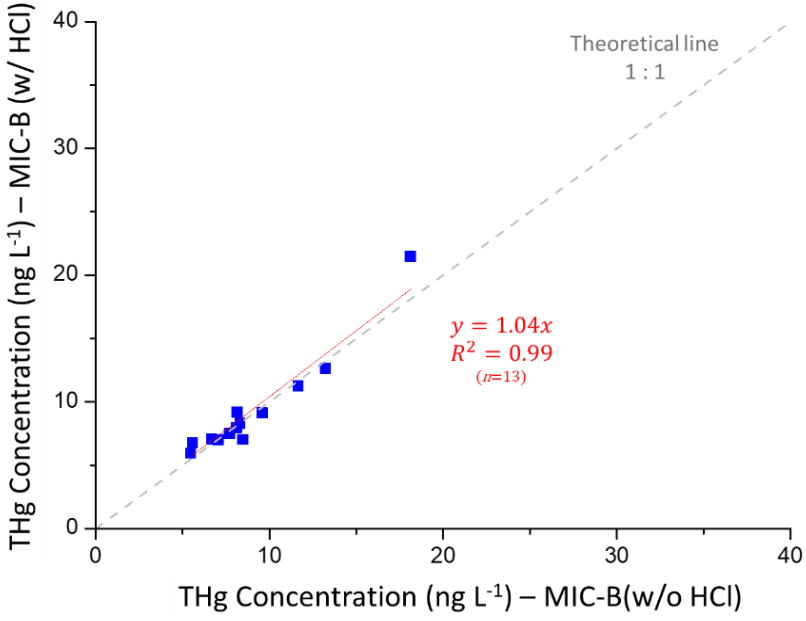
- Evaporation of water and/or Hg
- Wind speed and direction
- Other factors

Inter-comparison of Wet Deposition Sampler

Acid preservation : MIC-B vs MIC-B



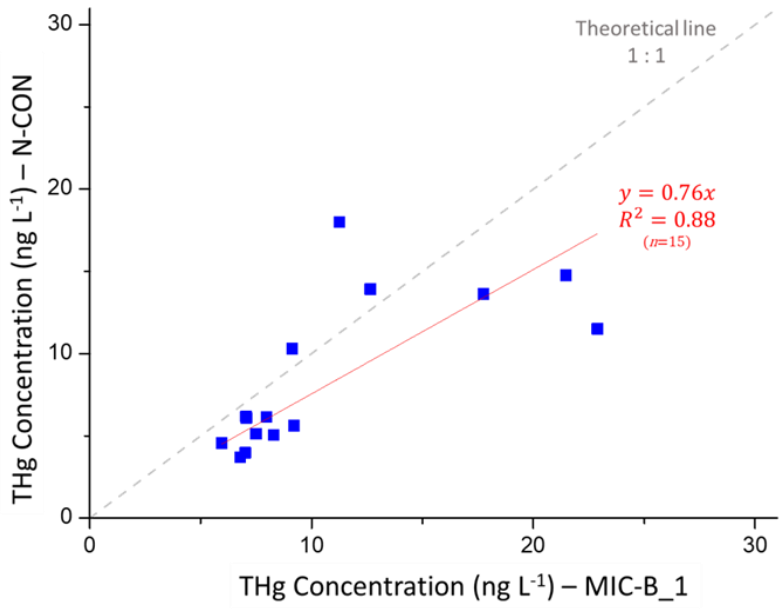
Outliers eliminated



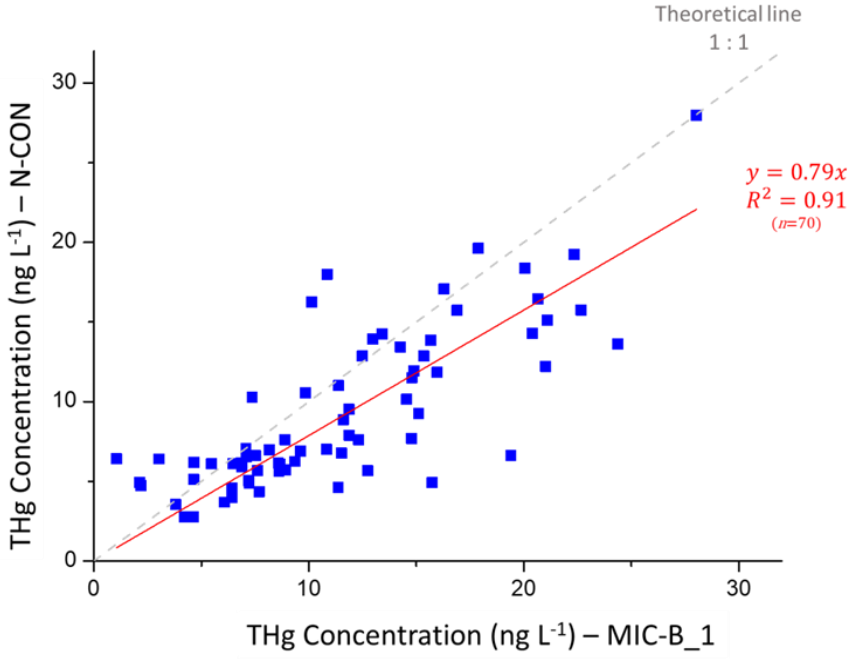
Inter-comparison of Wet Deposition Sampler

Acid preservation : MIC-B vs N-CON

Acidify



Non-acidify



Passive Atmospheric Sampler Tests in Taiwan

Passive Atmospheric Hg Sampler

Advantages:

- Lower cost
- No need for electricity and gases
- Easy to use and deploy
- Improved spatial resolution

Environmental Science & Technology Letters
Letter
pubs.acs.org/journal/estlcu

A High-Precision Passive Air Sampler for Gaseous Mercury

David S. McLagan,[†] Carl P. J. Mitchell,[†] Haiyong Huang,[†] Ying Duan Lei,[†] Amanda S. Cole,[‡] Alexandra Steffen,[‡] Hayley Hung,[‡] and Frank Wania*[,†]

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Supporting Information

Atmos. Chem. Phys., 18, 5905–5919, 2018
https://doi.org/10.5194/acp-18-5905-2018

Atmospheric Chemistry and Physics
EGU

Global evaluation and calibration of a passive air sampler for gaseous mercury

David S. McLagan[1], Carl P. J. Mitchell[1], Alexandra Steffen[2], Hayley Hung[2], Cecilia Shin[2], Geoff W. Stupple[2], Mark L. Olson[3], Winston T. Luke[4], Paul Kelley[4], Dean Howard[5], Grant C. Edwards[5], Peter F. Nelson[5], Hang Xiao[6], Guey-Rong Sheu[7], Annekatrin Dreyer[8], Haiyong Huang[1], Batual Abdul Hussain[1], Ying D. Lei[1], Ilana Tavshunsky[1], and Frank Wania[1]

Environmental Research Letters

LETTER

Identifying and evaluating urban mercury emission sources through passive sampler-based mapping of atmospheric concentrations

David S McLagan[1], Batual Abdul Hussain[1], Haiyong Huang[1], Ying D Lei[1], Frank Wania[1] and Carl P J Mitchell[1,2]

Atmos. Meas. Tech., 10, 3651–3660, 2017
https://doi.org/10.5194/amt-10-3651-2017

Atmospheric Measurement Techniques
EGU

The effects of meteorological parameters and diffusive barrier reuse on the sampling rate of a passive air sampler for gaseous mercury

David S. McLagan, Carl P. J. Mitchell, Haiyong Huang, Batual Abdul Hussain, Ying Duan Lei, and Frank Wania
Department of Physical and Environmental Sciences, University of Toronto Scarborough, 1065 Military Trail, M1C 1A4, Toronto, Ontario, Canada
Correspondence to: Frank Wania (frank.wania@utoronto.ca)

Received: 15 March 2017 – Discussion started: 2 May 2017
Revised: 4 September 2017 – Accepted: 5 September 2017 – Published: 5 October 2017

Passive Air Sampler Test in Taiwan

- From July 2018 to June 2019
- Deployed at site on NCU campus (ground, suburban) and at the Lulin Atmospheric Background Station (mountain, remote)
- Side-by-side with a Tekran system
- Various temporal resolution

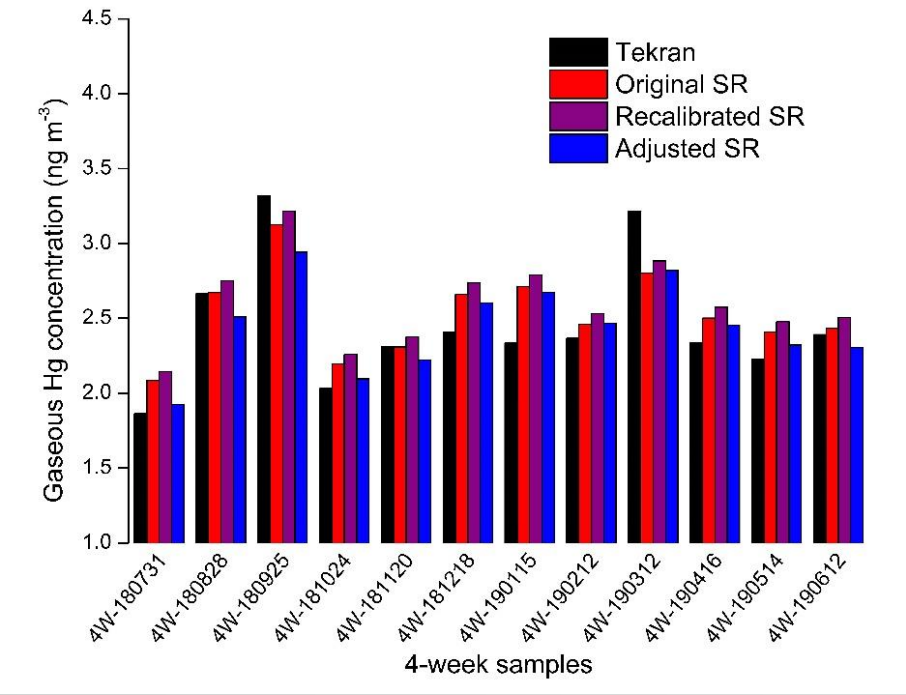
NCU Site

LABS Site

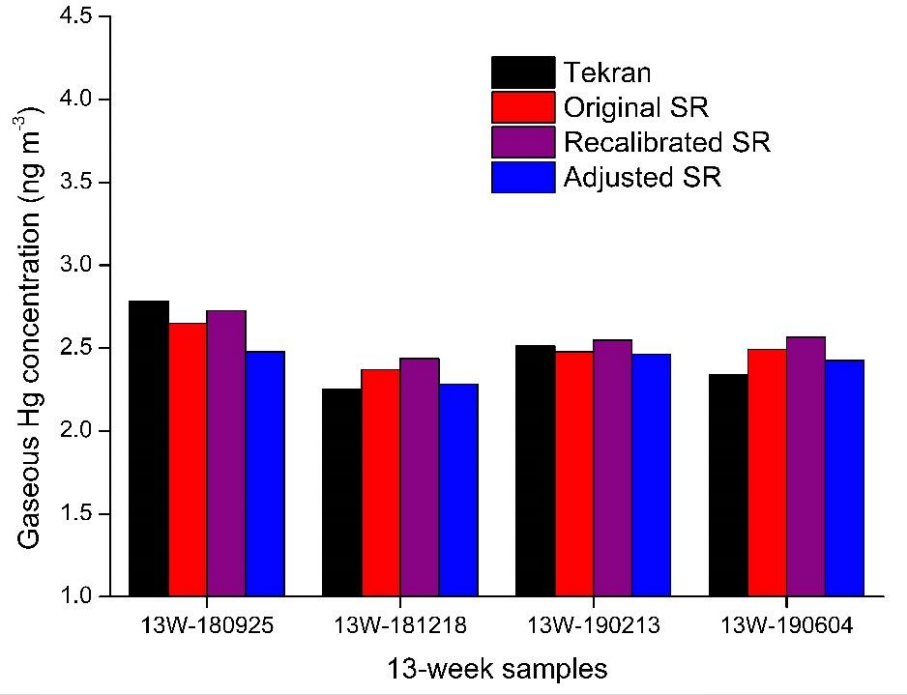
PAS Test Results – NCU

Deployment time	Active Conc. (ng m^{-3})	Passive Conc. (ng m^{-3})		
		Original SR	Recalibrated SR	Adjusted SR
4 weeks	**2.46** ± 0.43	**2.53** ± 0.28	**2.60** ± 0.29	**2.44** ± 0.29
13 weeks	**2.47** ± 0.23	**2.50** ± 0.12	**2.57** ± 0.12	**2.41** ± 0.09

4-week deployment



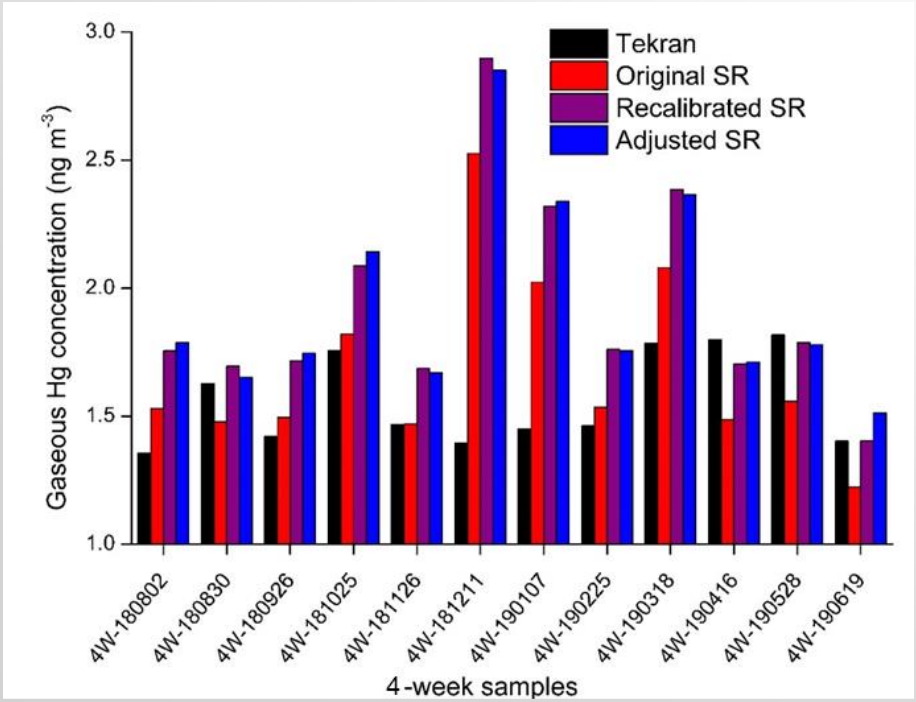
13-week deployment



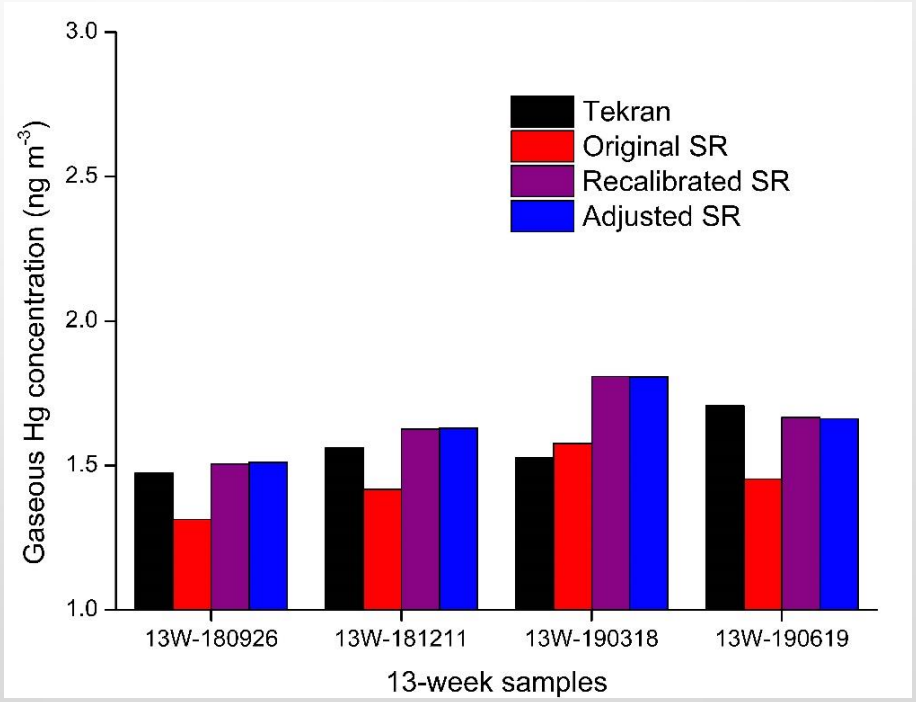
PAS Test Results – LABS

Deployment time	Active Conc. (ng m^{-3})	Passive Conc. (ng m^{-3})		
		Original SR	Recalibrated SR	Adjusted SR
4 weeks	**1.56** ± 0.18	**1.69** ± 0.36	**1.93** ± 0.41	**1.94** ± 0.40
13 weeks	**1.57** ± 0.10	**1.44** ± 0.11	**1.65** ± 0.12	**1.65** ± 0.12

4-week deployment



13-week deployment



APMMN Site Information

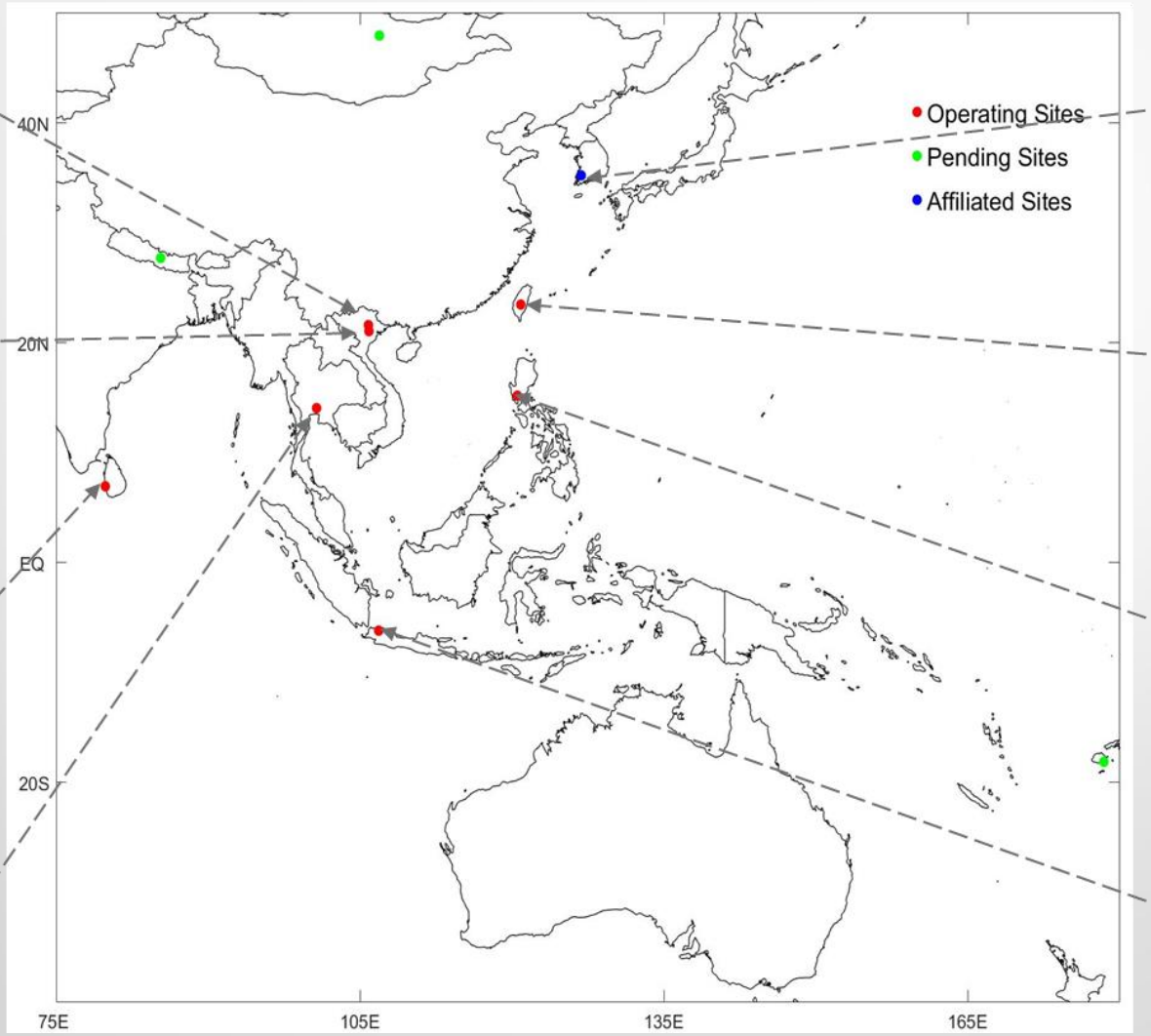
APMMN Site Information

APVN02

APVN01

APLK01

APTH01



APKRA2

APTW01

APPH01

APID01

APMMN Site Information

Country	Site ID	Sampler model
Indonesia	APID01	ACM
Korea	APKRA2	N-CON
Philippines	APPH01	MIC-B
Sri Lanka	APLK01	MIC-B
Taiwan	APTW01	MIC-B
Thailand	APTH01	MIC-B
Vietnam	APVN01	N-CON
Vietnam	APVN02	MIC-B

Current Status

- **8** active sites, including **1** affiliated site.
- **3** sites began operation in 2018 and 2019.
  - APPH01 (2018/09)
  - APVN02 (2019/04)
  - APLK01 (2019/04)
- **3** new sites in progress.
  - Fiji
  - Mongolia
  - Nepal
- APID01 requested to replace the ACM wet sampler with a MIC-B sampler. (in progress)
- **5** sets of sampler are available.

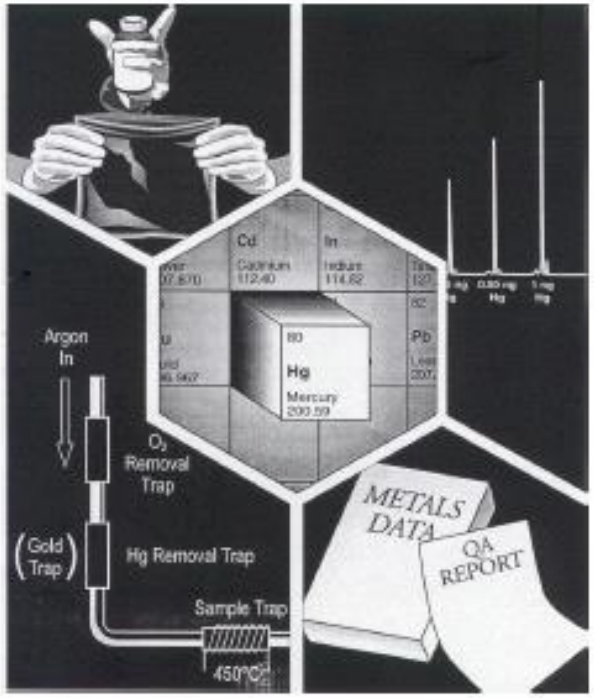
Progress on Wet Deposition Sample Analysis: QA/QC and Data Summary

Rainwater Hg Analysis

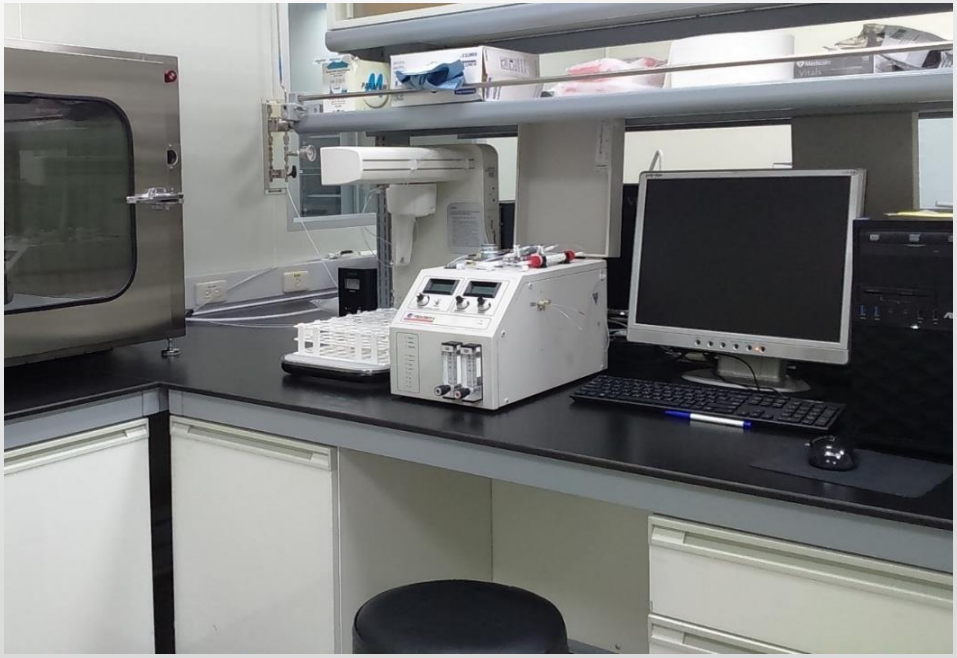
EPA
United States
Environmental Protection
Agency

Method 1631, Revision E:
Mercury in Water by Oxidation, Purge and Trap, and Cold Vapor Atomic Fluorescence Spectrometry

August 2002



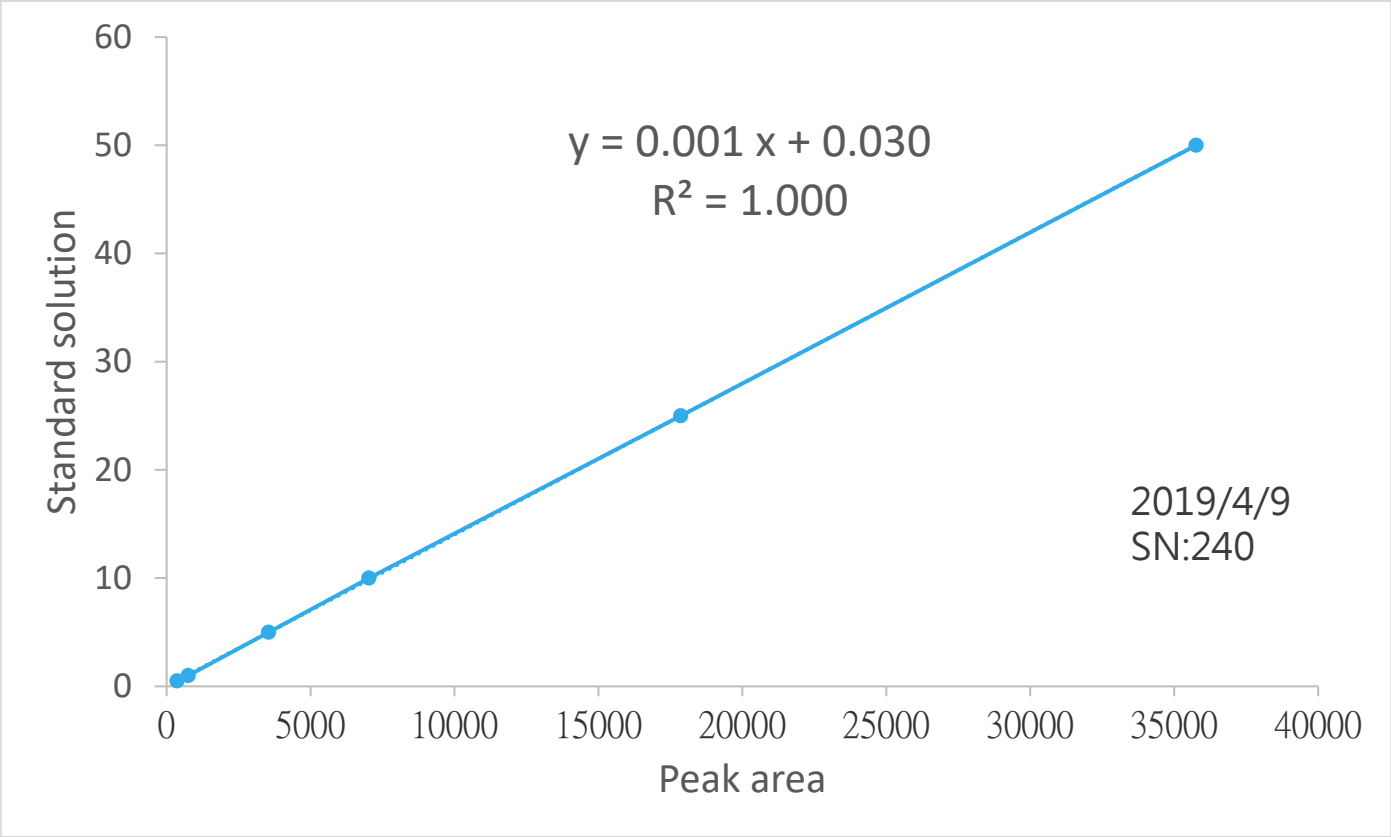
Total Hg is quantified by dual amalgamation Cold Vapor Atomic Fluorescence Spectrometry (CVAFS) after BrCl oxidation, $NH_2OH{\cdot}HCl$ neutralization, and $SnCl_2$ reduction.



Method Detection Limit

MDL of the NCU lab is 0.12 ng/L

Calibration Curve



Blanks

System blank

	Frequency	Mean (ng L^{-1})	Min. (ng L^{-1})	Max. (ng L^{-1})	1631 rev. E
2016 – 2017	127	0.18	0.05	0.53	< 0.5 ng L^{-1}
2018 – Apr 2019	67	0.06	0.03	0.15	

Bottle blank

	Freqency	Mean (ng L^{-1})	Min. (ng L^{-1})	Max. (ng L^{-1})	1631 rev. E
2016 – 2017	83	0.12	0.00	0.48	< 0.5 ng L^{-1}
2018 – Apr 2019	96	0.24	<MDL	1.95	

Duplicate Analysis and Matrix Spike

Duplicate analysis

	Frequency	Mean (%)	Min. (%)	Max. (%)	1631 rev. E
2016 – 2017	128	1.0	0.0	4.9	RPD < ±20 %
2018 – Apr 2019	88	2.4	0.1	11.2	

Matrix spike/duplicate

	Freqency	Mean (%)	Min. (%)	Max. (%)	1631 rev. E
2016 – 2017	130	101.5	96.5	119.6	Recovery 71 – 125 %
2018 – Apr 2019	66	98.8	78.4	110.0	

Recovery of QCS and CRM

Quality control sample (QCS)

	Freqency	Mean (%)	Min. (%)	Max. (%)	1631 rev. E
2016 – 2017	83	100.5	95.6	106.3	Recovery 80 – 120 %
2018 – Apr 2019	86	101.2	91.7	113.7	

Certified reference material (CRM)

	Freqency	Mean (%)	Min. (%)	Max. (%)	1631 rev. E
2018 – Apr 2019	20	95.3	88.5	103.3	--

Samples Received and Analyzed

Rain water sample

From 2016 to April 2019

Site ID	Number of samples				Subtotal
	2016	2017	2018	2019	
APID01	19	20	22	13	74
APPH01	-	-	10	8	18
APLK01	-	-	-	1	1
APTW01	-	44	43	11	98
APTH01	44	43	43	5	136
APVN01	12	13	9	4	38
APVN02	-	-	-	2	2
APKRA2	29	30	29	8	94
Summary	104	150	156	52	462

Samples Received and Analyzed

QC sample (Reagent blank, bottle blank, …)

From 2016 to April 2019

Site ID	Number of samples				Subtotal
	2016	2017	2018	2019	
APID01	-	-	-	2	2
APPH01	-	-	-	2	2
APLK01	-	-	-	-	0
APTW01	-	45	64	32	141
APTH01	14	8	12	12	46
APVN01	4	1	-	1	6
APVN02	-	-	-	1	1
APKRA2	-	-	-	-	0
Summary	18	54	76	50	198

Samples Received and Analyzed

Other samples (e.g. surface water)

From 2016 to April 2019

Site ID	Number of samples				Subtotal
	2016	2017	2018	2019	
APID01	-	-	-	-	0
APPH01	-	-	-	-	0
APLK01	-	-	-	-	0
APTW01	-	-	-	-	0
APTH01	11	9	18	8	46
APVN01	-	-	-	-	0
APVN02	-	-	-	-	0
APKRA2	-	-	-	-	0
Summary	11	9	18	8	46

APMMN Data Summary

From 2018 to April 2019

Site ID	Number of Sample	Rainwater Hg Conc. (**Mean**±S.D; ng L^{-1})
APID01	35	**13.1**±11.7
APPH01	17	**26.5**±27.8
APLK01	1	**7.9**
APTW01	55	**10.5**±7.3
APTH01	46	**9.7**±6.6
APVN01	12	**34.0**±6.6
APVN02	2	**41.3**±16.2
APKRA2	38	**7.7**±7.2
OVERALL	206	**12.4**±12.6

Summary of Rainwater Hg Conc. Worldwide

Location	THg conc. (ng L^{-1})	References
APMMN	7.7-41.3	January 2018 – April 2019
12 sites in Taiwan	6.6-14.3	Lin et al., 2018
10 sites in Japan (estimate)	5.2-9.5	Sakata and Marumoto, 2005
EMEP (2016)	3.5-24.0	EMEP, 2018
NADP/MDN (2017)	2.1-21.4	NADP 2017 Annual Summary
Chuncheon, Korea	8.8	Ahn et al., 2011
Seoul, Korea	10.1-16.3	Seo et al., 2012
Nam Co, China	4.8	Huang et al., 2012
Mt. Leigong, China	4.0	Fu et al., 2010
Chongqing, China	30.7	Wang et al., 2012
4 sites in Xiamen, China	11.4-14.0	Xu et al., 2014
Nanjing, China (9 months)	52.9	Zhu et al., 2014
Monterey Bay, CA, USA	5.8	Conaway et al., 2010
CBL, MD, USA	11.4-15.0	Mason et al., 2000
Moffett Field, CA, USA	11.6	Steding and Flegal, 2002
Bermuda	4.7	Gichuki and Mason, 2014
10 sites in UK	1.6-5.1	Rowland et al., 2010
2 sites in South Africa	10.6-15.8	Gichuki and Mason, 2013
2 sites in Mexico	7.9-8.2	Hansen and Gay, 2013

THANK YOU!