

Asia Pacific Mercury
Monitoring Network

Introduction to the APMMN and State of the Network

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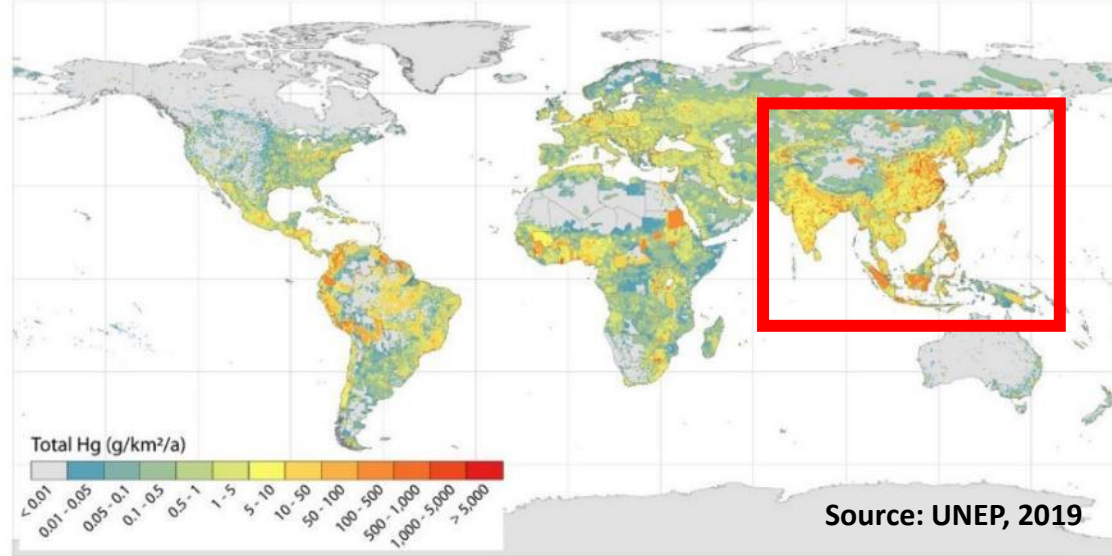
Outline

- Why Regional Atmospheric Hg Monitoring is Needed
- What is APMMN
- What Progress Have Been Made
- Future Plans

Asia Is the Largest Source Region

2015

All sectors

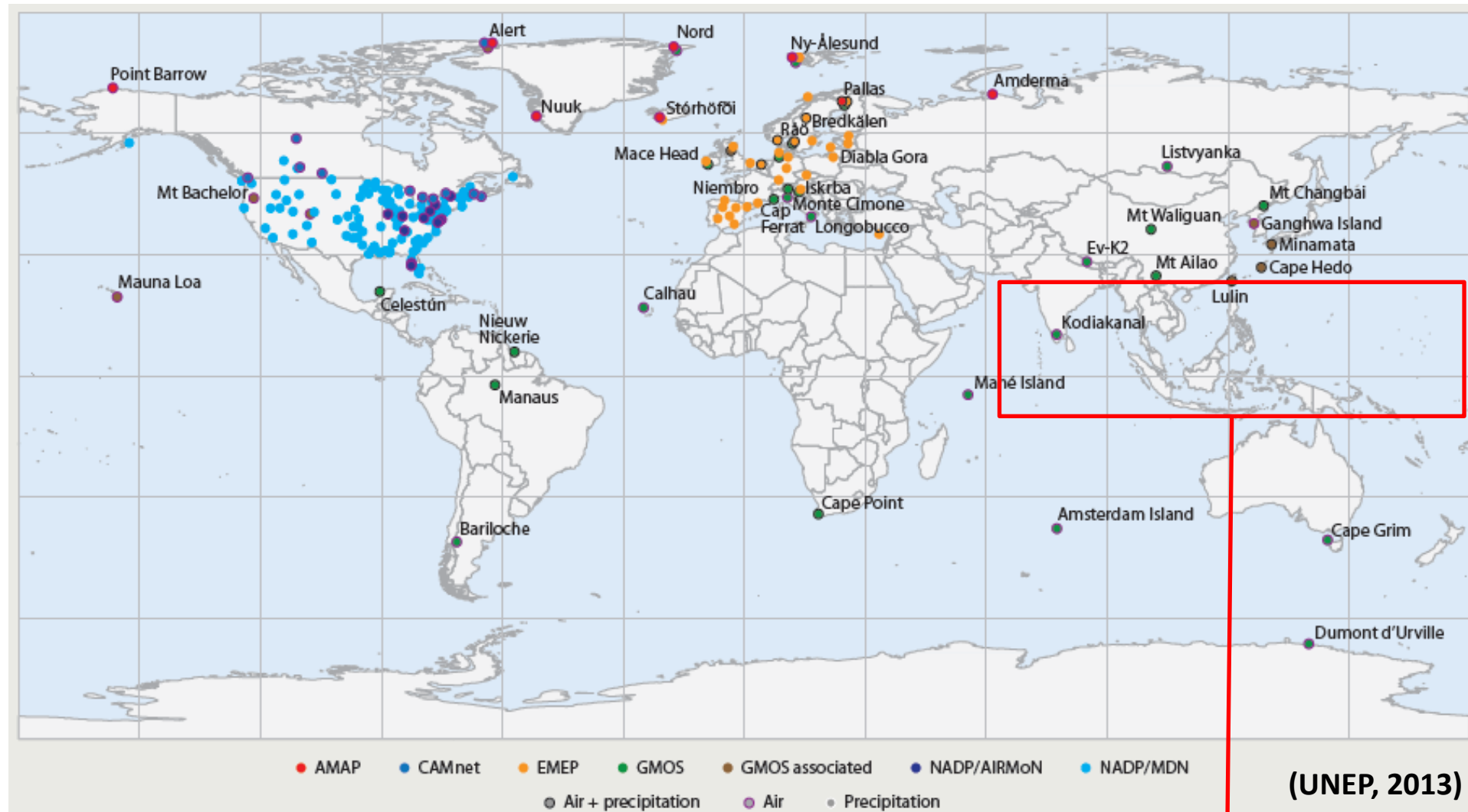


▼ Quantities of mercury emitted to air from anthropogenic sources in 2015, by different sectors in different regions.

	Sector group (emissions, tonnes)				Regional total (range), tonnes	% of global total
	Fuel combustion	Industry sectors	Intentional-use (including product waste)	Artisanal and small-scale gold mining		
Australia, New Zealand & Oceania	3.57	4.07	1.15	0.0	8.79 (6.93-13.7)	0.4
Central America and the Caribbean	5.69	19.1	6.71	14.3	45.8 (37.2-61.4)	2.1
CIS & other European countries	26.4	64.7	20.7	12.7	124 (105-170)	5.6
East and Southeast Asia	229	307	109	214	859 (685-1430)	38.6
EU28	46.5	22.0	8.64	0.0	77.2 (67.2-107)	3.5
Middle Eastern States	11.4	29.0	12.1	0.225	52.8 (40.7-93.8)	2.4
North Africa	1.36	12.6	6.89	0.0	20.9 (13.5-45.8)	0.9
North America	27.0	7.63	5.77	0.0	40.4 (33.8-59.6)	1.8
South America	8.25	47.3	13.5	340	409 (308-522)	18.4
South Asia	125	59.1	37.2	4.50	225 (190-296)	10.1
Sub-Saharan Africa	48.9	41.9	17.1	252	360 (276-445)	16.2
Global inventory	533	614	239	838	2220 (2000-2820)	100.0

Country	Emissions (tonnes)
China	536.8
India	205.9
Indonesia	156.8
Philippines	32.5
Vietnam	18.1
Japan	15.0
Myanmar	13.2
Thailand	11.6
Malaysia	8.3
Mongolia	7.0
Taiwan	7.0
Korea	6.9
Cambodia	4.2
Laos	3.0
Singapore	1.6
Sri Lanka	1.6
Nepal	1.2

But Atmospheric Hg Monitoring Is Limited



Long-term or background atmospheric Hg monitoring activities in SE and S Asia and the Pacific Island countries are very limited.

Asia Pacific Mercury Monitoring Network (APMMN)



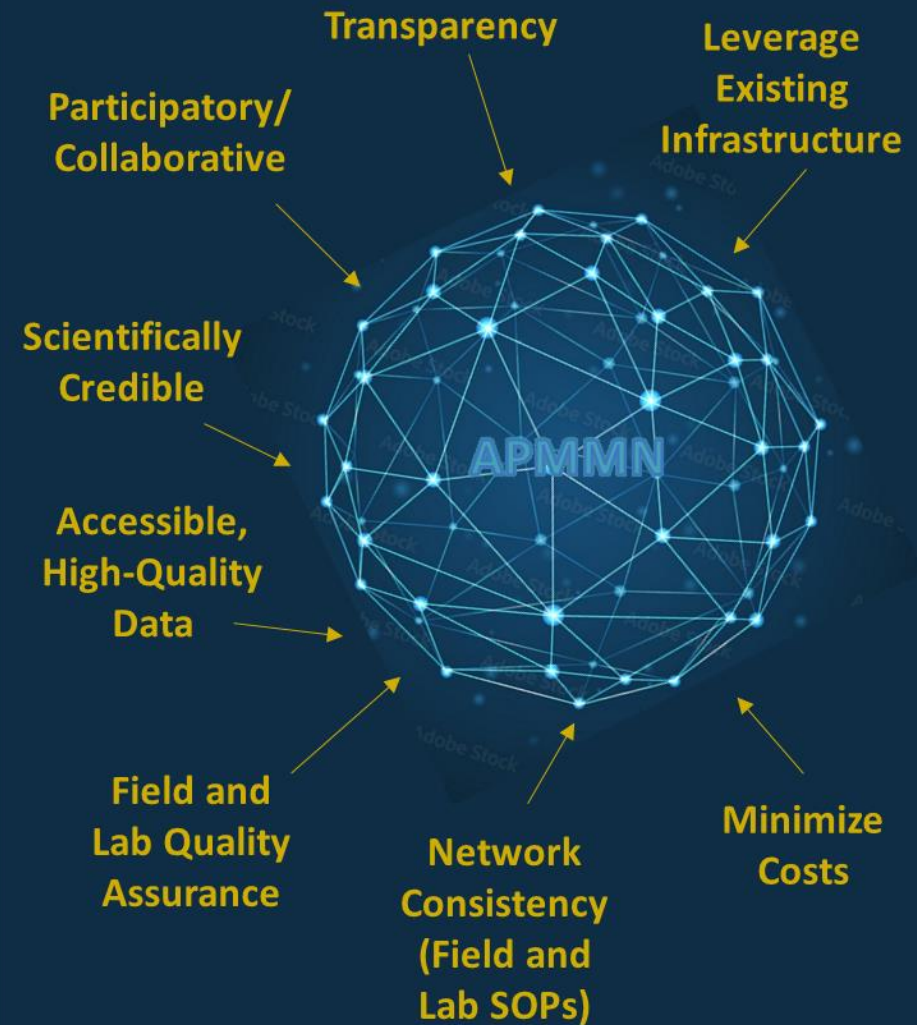
Asia Pacific Mercury
Monitoring Network

- APMMN was established to fill in regional data gap.
- A cooperative effort to systematically monitor [mercury in air and rainwater](#) throughout the Asia-Pacific Region since 2016, but planning began in 2012 with a series of meetings and workshops.
- APMMN involves many different and voluntary groups, including environmental ministries and federal government agencies, academic institutions, and scientific research and monitoring organizations.

APMMN Objectives

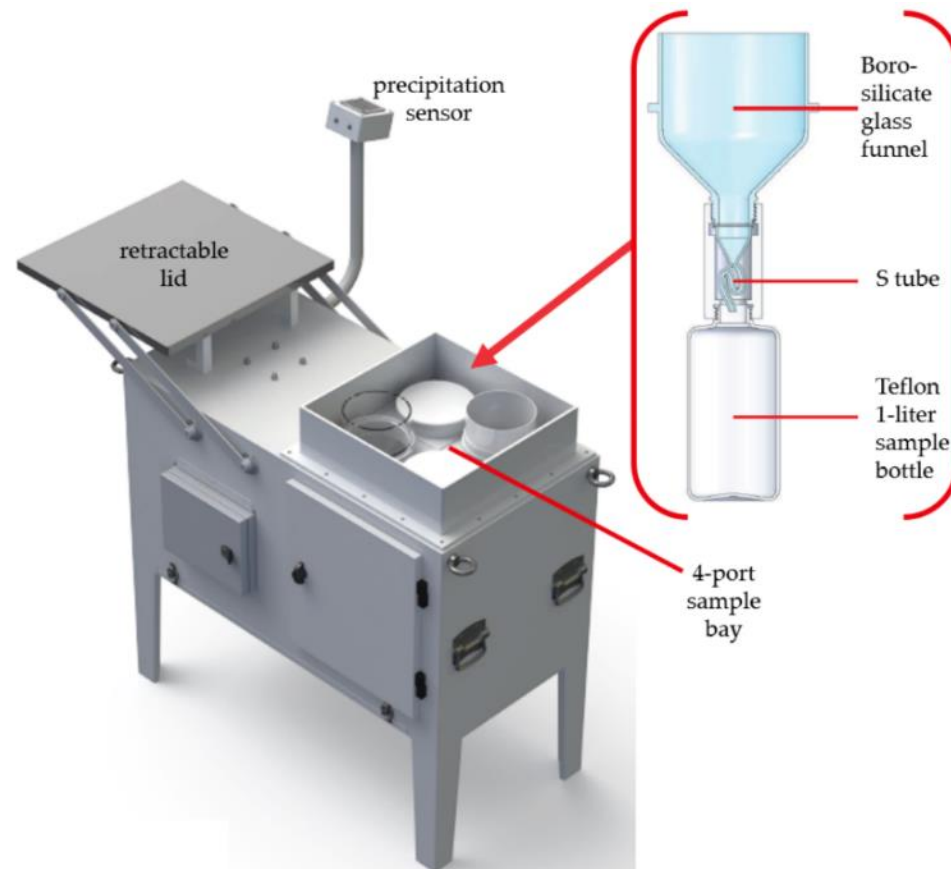
- Determine **status and trends** in concentrations of atmospheric mercury, and wet, dry, and total deposition
- Develop a **robust dataset** for modeling and assessment
- Assist partner countries in **developing monitoring capacity**
- **Share data** and monitoring information

Network Design Principles



Approach

- Started with wet deposition monitoring
- Automated wet deposition sampler provides by Taiwan MOENV
- Site operator and lab staff training
- Samples shipped to National Central University(NCU) in Taiwan for Hg analysis
- Data reported back to partner countries



APMMN Wet Deposition Sampler

Chemical Analysis: Cold vapor atomic fluorescence spectroscopy (CVAFS) at National Central University, Taiwan

Mercury Forms: Total mercury wet deposition and precipitation concentrations

Sampling Frequency: One week; Tuesday – Tuesday schedule

Meteorology: Precipitation depth measured onsite (best) or as close as possible to the sampler (within 5 km)

Site Types: Regionally representative; urban, remote, rural areas with estimated high levels of mercury and deposition; sensitive ecosystems

Center for Environmental Monitoring and Technology

- To support the operation of APMMN, Taiwan MOENV funded the establishment of the **Center for Environmental Monitoring and Technology** on NCU campus in 2016.
 - Rainwater sample Hg analysis
 - Meetings and workshops
 - Capacity building
 - Technology transfer



Lab for Ultra-Trace Level Mercury Analysis

- 3 class 1000 cleanrooms and 2 clean benches
- 3 Tekran 2600 CVAFS mercury analyzers
- Tekran 2537 and NIC EMP GOLD+ atmospheric mercury monitoring systems
- 1 NIC MA-3 solo
- 2 DI water systems
- UHP Ar supply
- pH/conductivity meter
- 2 analytical balances
- 4 chemical hoods
- Chemical furnace
- Labware furnace



Lab for Ultra-Trace Level Mercury Analysis

Class 10000 Buffering Area



Air Shower



**Class1000 Cleanroom
(Acid Wash)**



**Class1000 Cleanroom
(Chemical Preparation)**



Lab for Ultra-Trace Level Mercury Analysis

Analytical Area



Cylinder Area



Clean Bench



NIC EMP GOLD+



Tekran 2600 CVAFS



Elga Purelab DI System



NIC MA-3 Solo



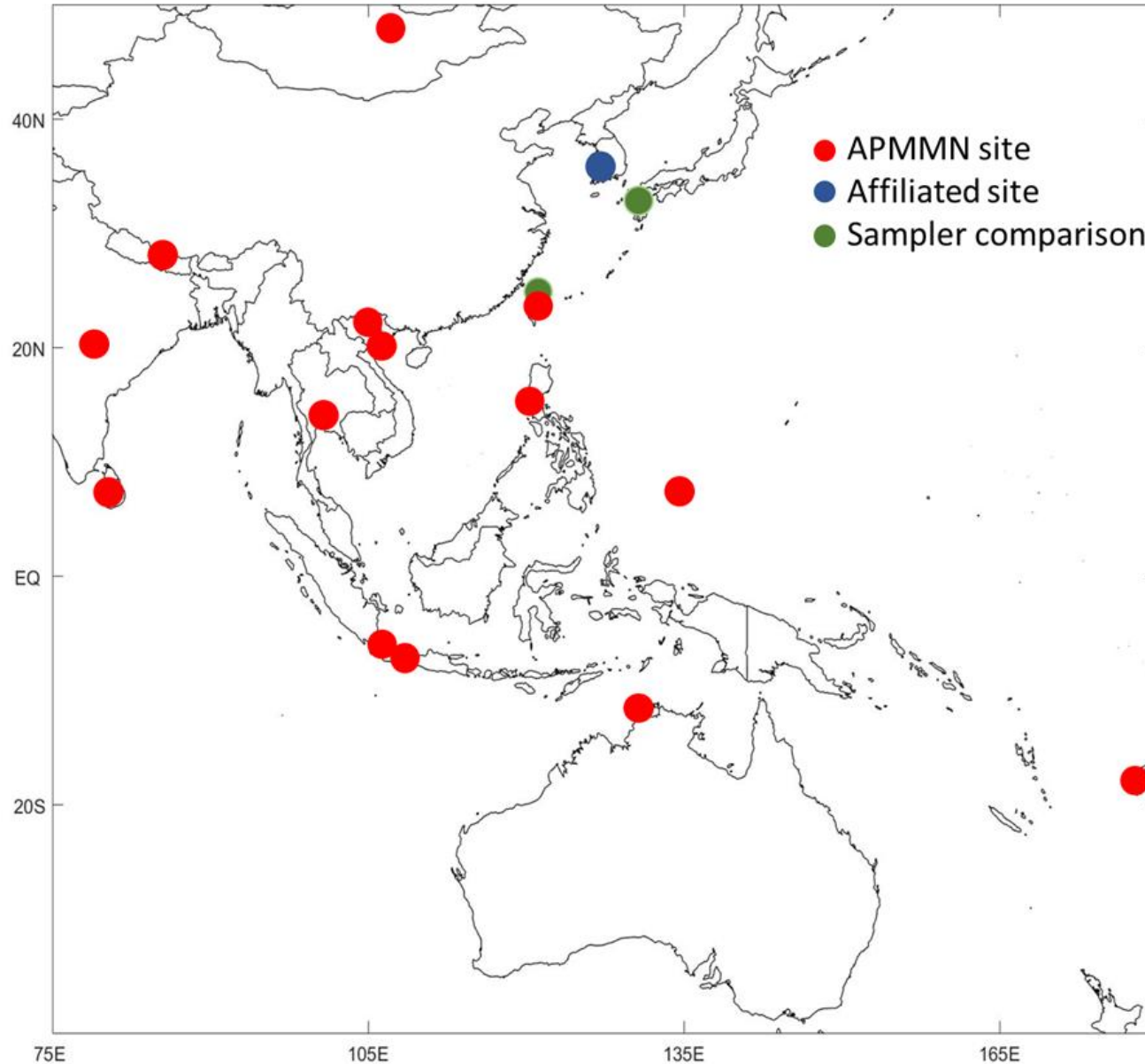
Roles of NCU Hg Lab

- NCU Hg Lab serves as the center for ultra-trace level Hg analysis and training
 - To help analyze rainwater and other environmental samples
 - To train scientists and technicians from APMMN partner countries for capacity building on ultra-trace level Hg sampling and analysis

Wet Deposition Samplers to Partners



APMMN Site Map



- **15 APMMN sites**
 - Australia
 - Fiji
 - India
 - Indonesia
 - Korea
 - Mongolia
 - Nepal
 - Palau
 - Philippines
 - Sri Lanka
 - Taiwan
 - Thailand
 - Vietnam
- **2 sampler inter-comparison sites**
 - NCU, Taiwan
 - NIMD, Japan

Partners Meetings and Workshops in 2012-2019



APMMN Partners Meetings in 2020-2022 (Virtual)



APMMN Partners Meeting in Taipei, Taiwan in 2023



APMMN Partners Meeting in Taipei, Taiwan in 2024



Capacity Building and Training

Training workshop in Taiwan (May 2017)



Training workshop in Taiwan (June 2019)



Capacity Building and Training

Advanced Training at NCU (2018-2019)

**March 2019
(Indonesia)**



**April 2019
(Philippines
and Sri Lanka)**



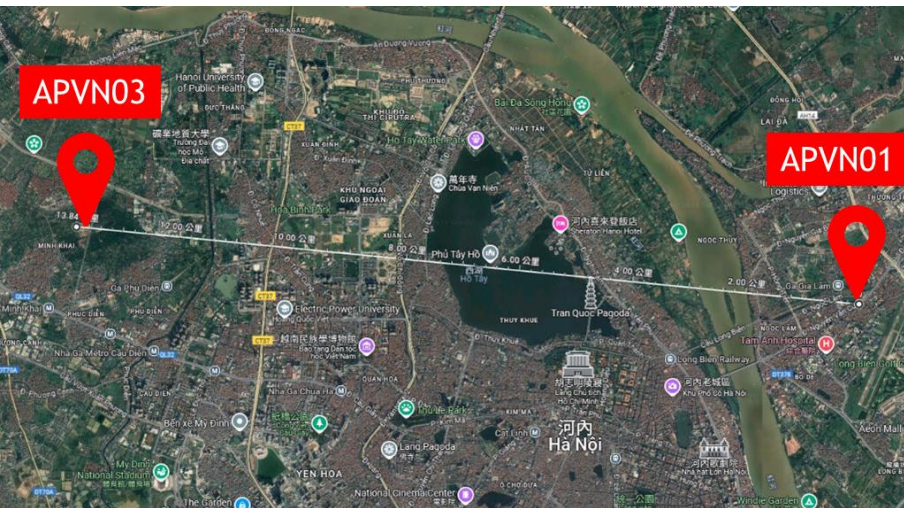
Capacity Building and Training

Training Overseas (2018-2024)

Country	Date
Philippines	June 2018
Indonesia	May 2019
Indonesia	August 2019
Fiji	November 2019
Vietnam	December 2019
Palau	July 2023
Vietnam	December 2024



Visit Northern CEM of Vietnam in December 2024



APMMN Website



apmmn.org

An Article Introducing the APMMN



Communication

A New Monitoring Effort for Asia: The Asia Pacific Mercury Monitoring Network (APMMN)

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Wet Deposition Samples Received and Analyzed

Year	2016-17	2018-19	2020	2021	2022	2023	2024	Sum
Number	279	336	175	266	282	289	266	1893

Year	Total Hg Concentration ¹ (ng L ⁻¹)		
	Mean±S.D	Minimum	Maximum
2016–17	8.6±8.7	0.4	59.3
2018–19	12.2±12.7	0.3	97.8
2020	19.4±21.3	1.5	99.8
2021	17.8±17.5	0.3	97.4
2022	21.4±19.8	1.3	95.2
2023	25.3±23.3	0.7	94.7
2024	19.1±22.7	0.4	99.1

¹Concentrations greater than 100 ng L⁻¹ are not included because of QA/QC concern.

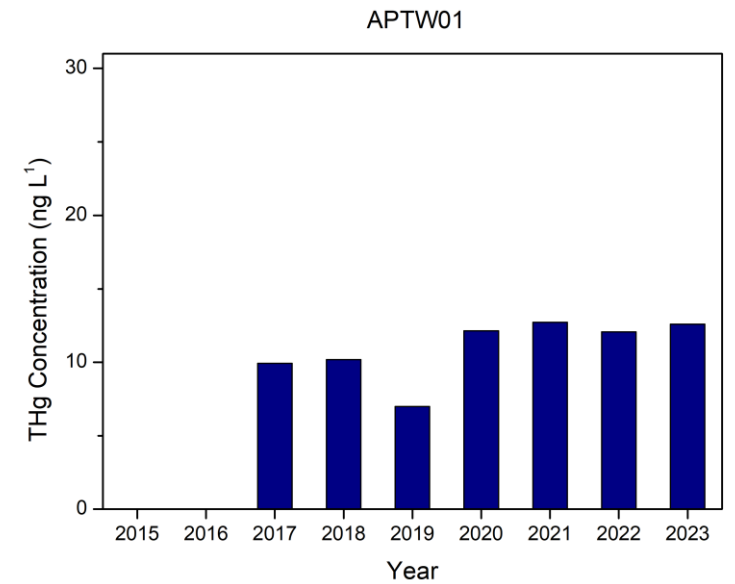
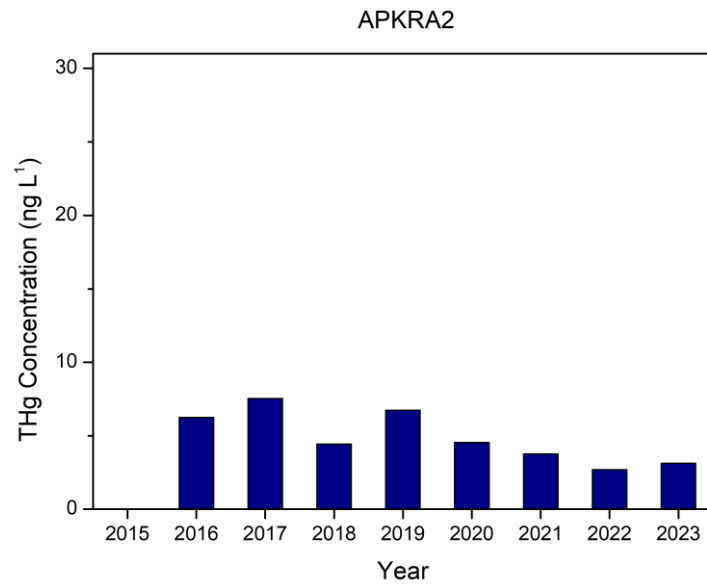
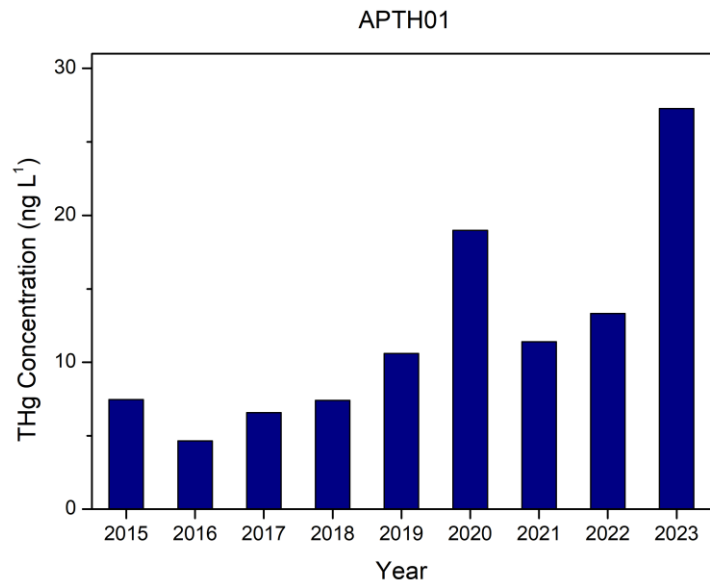
Wet Deposition Samples Received and Analyzed

Site mean Hg concentrations of samples that NCU lab received in 2024-2025

Site	Number of Valid Sample	Min.	Max.	Mean±S.D.
	178	0.4	99.1	19.1±22.7
APAU01	20	1.6	9.4	5.2±2.2
APIN01	25	0.4	68.4	11.8±14.8
APID02	23	7.7	84.2	39.1±24.7
APMN01	7	42.1	93.8	64.7±18.5
APNP01	7	11.5	38.0	18.2±9.2
APPH01	7	9.2	88.6	29.9±27.4
APLK01	6	3.5	9.7	6.6±2.6
APTW01	33	1.3	25.1	8.9±6.3
APTH01	5	12.5	38.5	25.4±10.1
APVN01	4	42.6	99.1	69.8±24.7
APVN02	6	16.6	59.7	35.5±18.9
APVN03	8	13.8	78.0	37.4±21.9
APKRA2	27	0.6	7.9	2.4±1.8

Unit: ng/L

Inter-annual Variation in Rainwater Hg Conc. at APMMN Sites



USGS Standard Reference Sample (SRS) Program

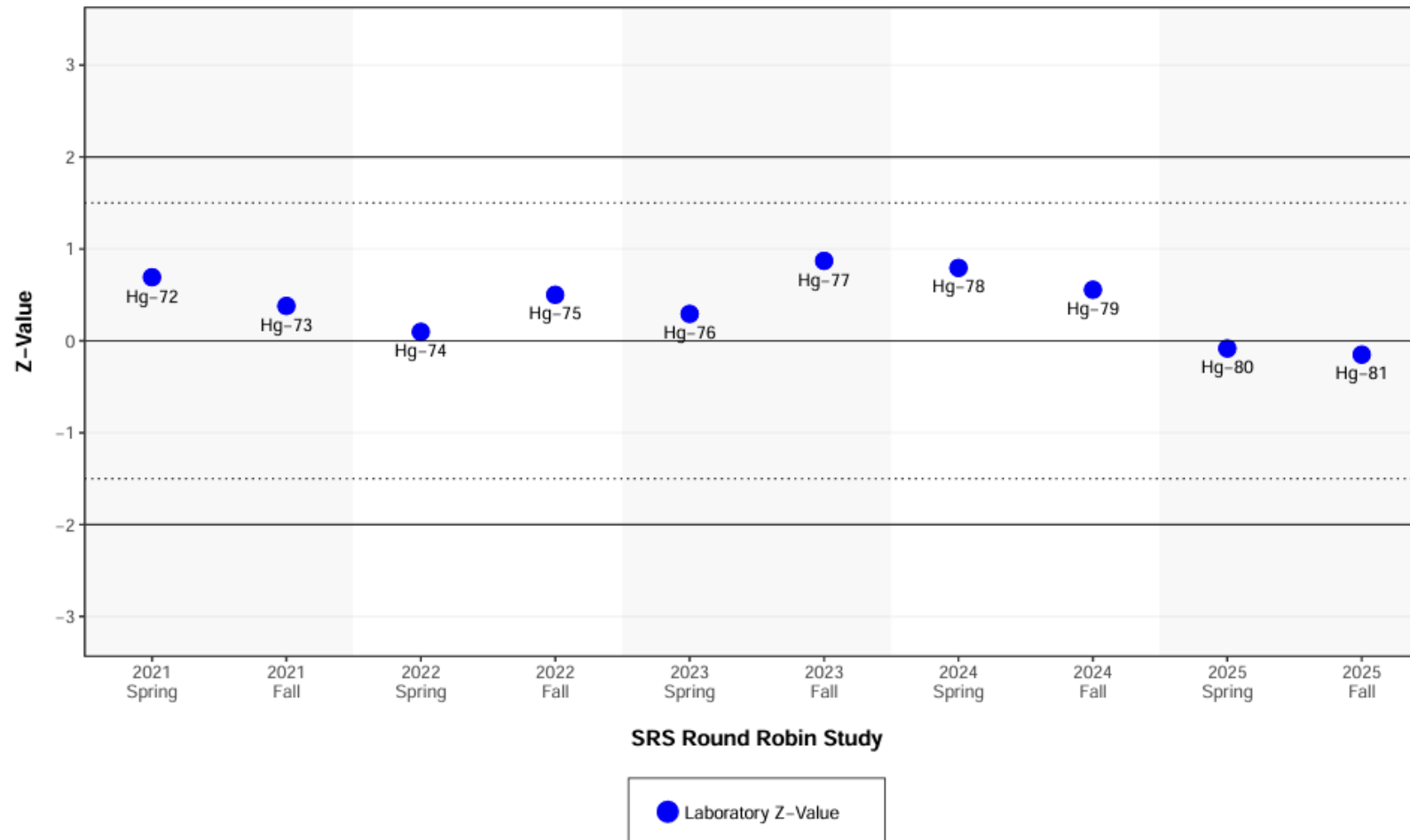


Standard Reference Sample (SRS) Project

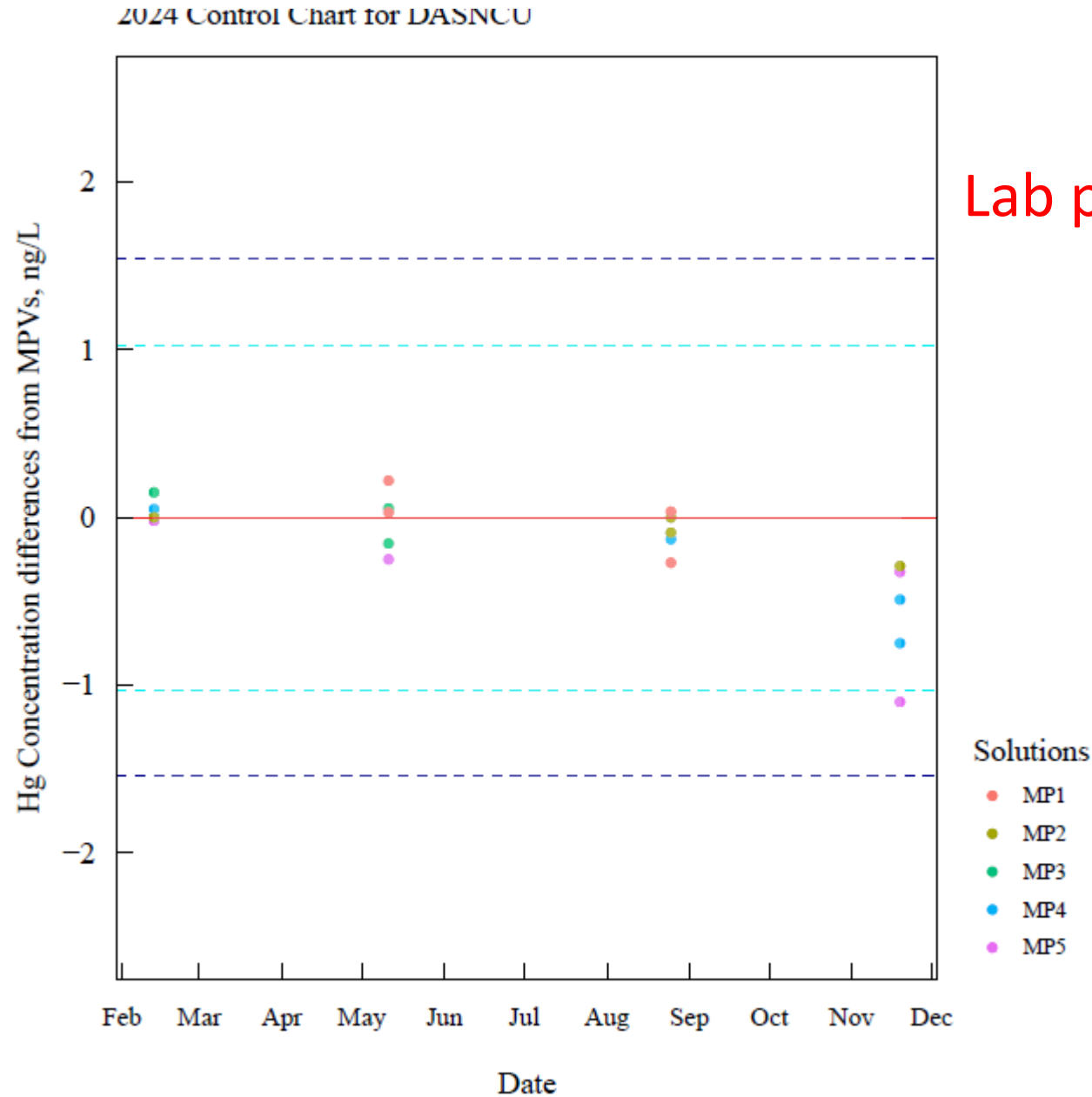


Lab 616 Performance – Z-Value
2021 through 2025 (5 Years)
Sample Type: Mercury – Analyte: Mercury

2021 through 2025



USGS Interlaboratory Comparison Program - MDN



Lab performance in 2024

NIMD-UNEP Mercury Laboratory Proficiency Testing

Programme outlines

PT name: 1st Round of Mercury Laboratory Proficiency Testing – Asia and the Pacific

PT test period: February – March 2022

Test item: One (1) human hair sample

Target parameter: Total mercury

Results

Participant ID: 7

Hair

ID	Results submitted (mg/kg)			
	1	2	3	Average
7	1.450093	1.435046	1.453019	1.446052
Participants' statistics (mg/kg)			z score obtained	
Median			NIQR	
1.458			0.122	
			-0.094	

Programme outlines

PT name: 3rd Round of Mercury Laboratory Proficiency Testing

PT test period: November 2024 – January 2025

Test item: One (1) dried sediment sample

Target parameter: Total mercury and / or methylmercury

Results of total mercury

Participant ID: 2

Sediment

ID	Results submitted (mg/kg)			
	1	2	3	Average
2	4.148	4.098	4.169	4.138
Participants' statistics (mg/kg)			z score obtained	
Median			NIQR	
4.105			0.362	
			0.093	

Programme outlines

PT name: 2nd Round of Mercury Laboratory Proficiency Testing

PT test period: February – June 2023

Test item: One (1) Dried fish sample

Target parameter: Total mercury and / or methylmercury

Results of total mercury

Participant ID: 3

Fish

ID	Results submitted (mg/kg)			
	1	2	3	Average
3	3.860	3.816	3.832	3.836
Participants' statistics (mg/kg)			z score obtained	
Median			NIQR	
4.046			0.279	
			-0.750	

Programme outlines

PT name: 4th Round of Mercury Laboratory Proficiency Testing

PT test period: February – May 2025

Test item: One (1) human urine sample

Target parameter: Total mercury

Results

Participant ID: 1

Urine

ID	Results submitted (μ g/L)				
	Item 1		Item 2		Average
	1	2	1	2	
1	0.455	0.485	0.430	0.450	0.455
Participants' statistics after exclusion of invalid data (μ g/L)				z score obtained	
Median		NIQR			
0.565		0.128			-0.858

Performance of the result is classified by z score as follows:

$|z| \leq 2$: Performance is **satisfactory (satisfactory)**

Inter-comparison of Various Wet Deposition Samplers

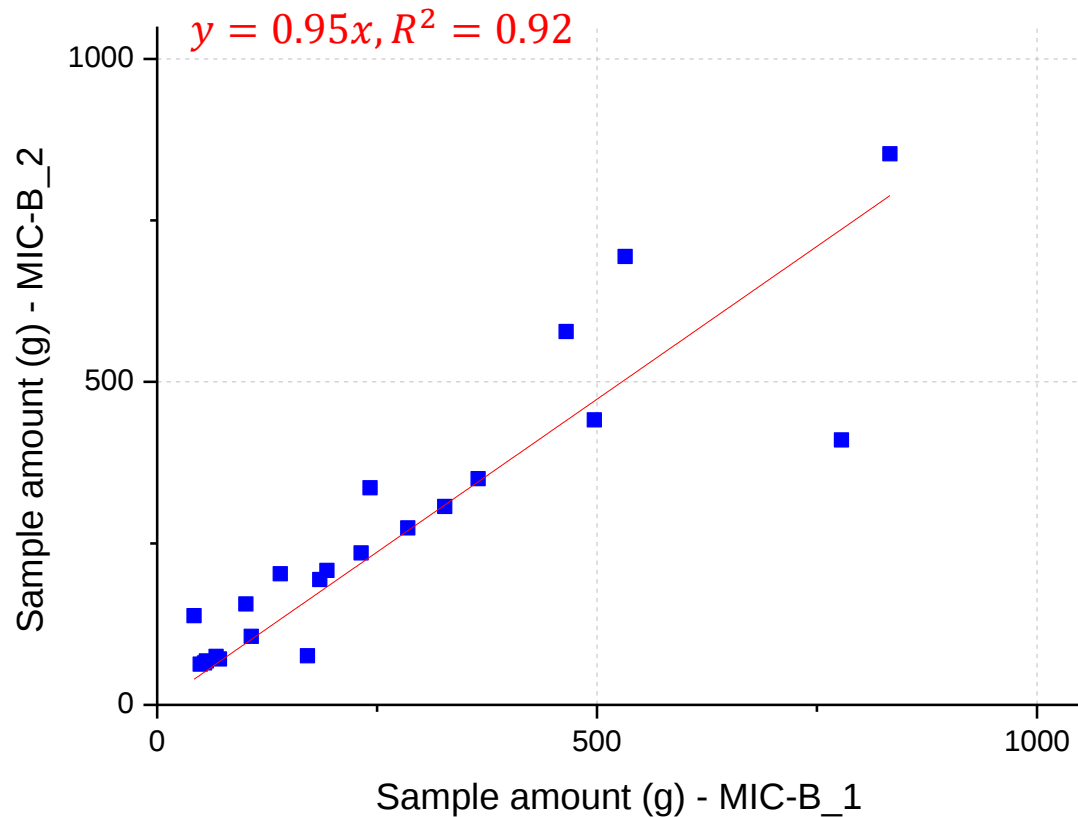
- There is no “standard” wet deposition sampler.
- APMMN uses MIC-B type sampler, whereas NADP/MDN uses N-CON sampler. Japan uses KASC-02 sampler.
- Inter-comparison study conducted on NCU campus to study the influences of the following factors on rainwater Hg measurement:
 - Sampler types
 - Acid pre-charge
 - Bottle size



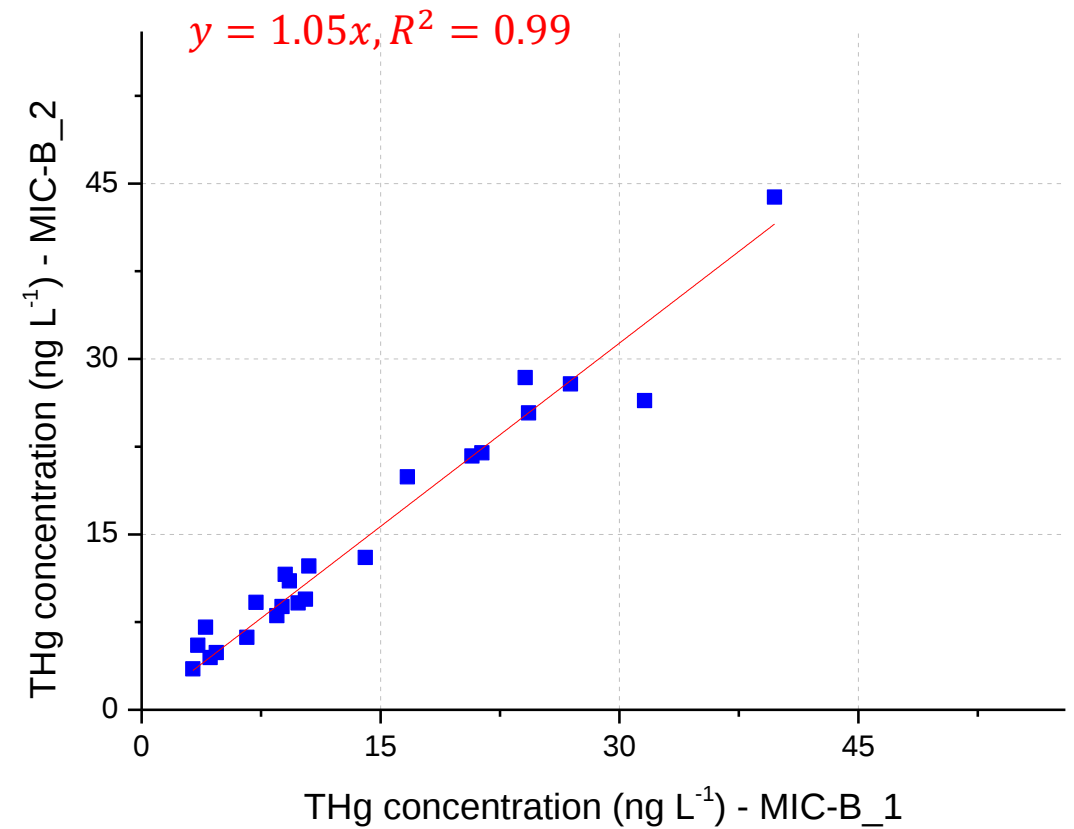
Hg Conc. of Wet Samples (unacidified) by Two MIC-Bs

July 2024 - April 2025

Sample Weight



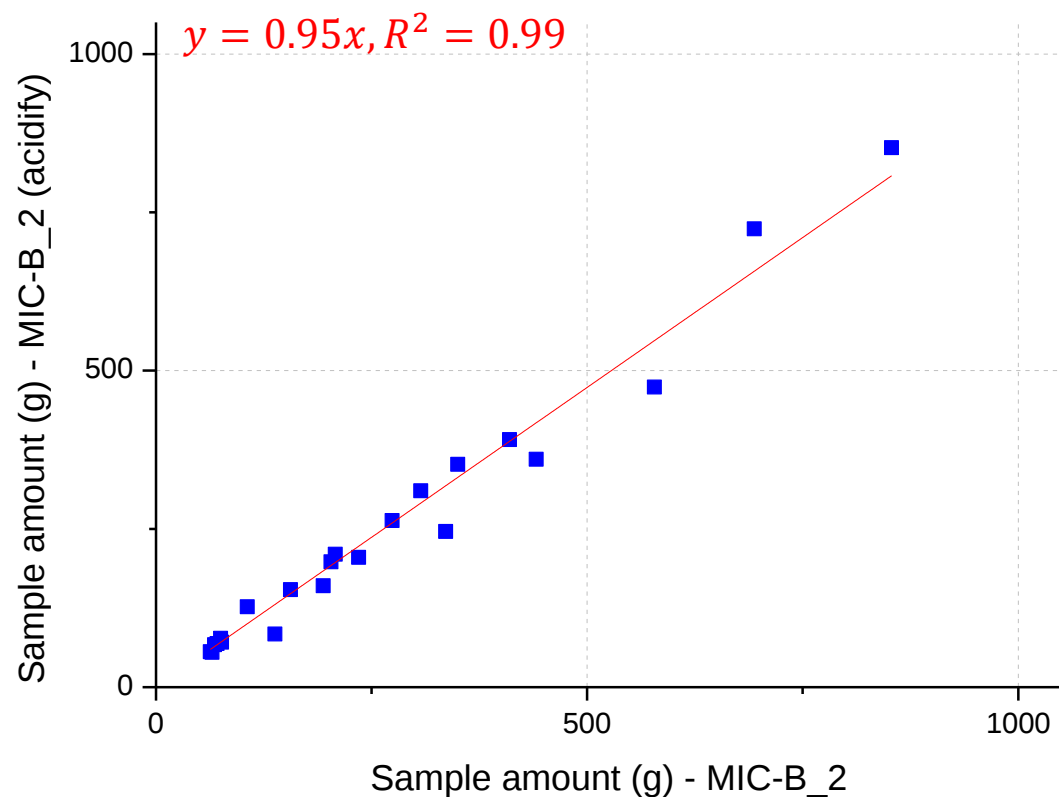
Hg Concentration



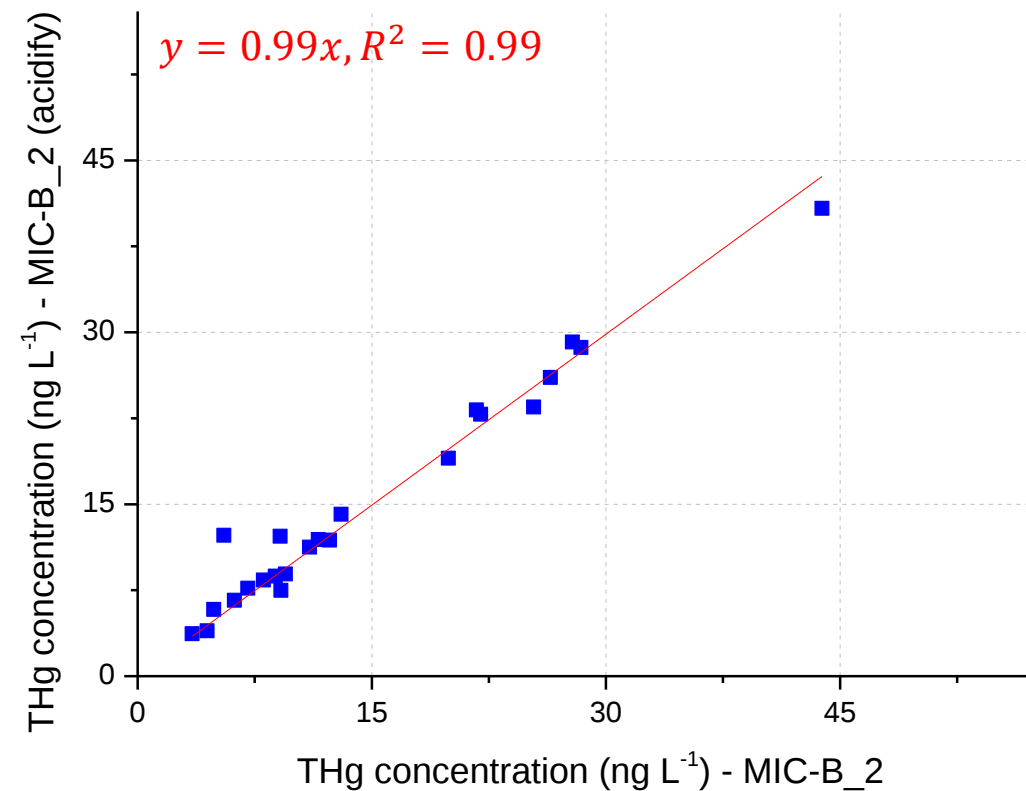
Hg Conc. of Wet Samples by MIC-B (unacidified vs. acidified)

July 2024 - April 2025

Sample Weight



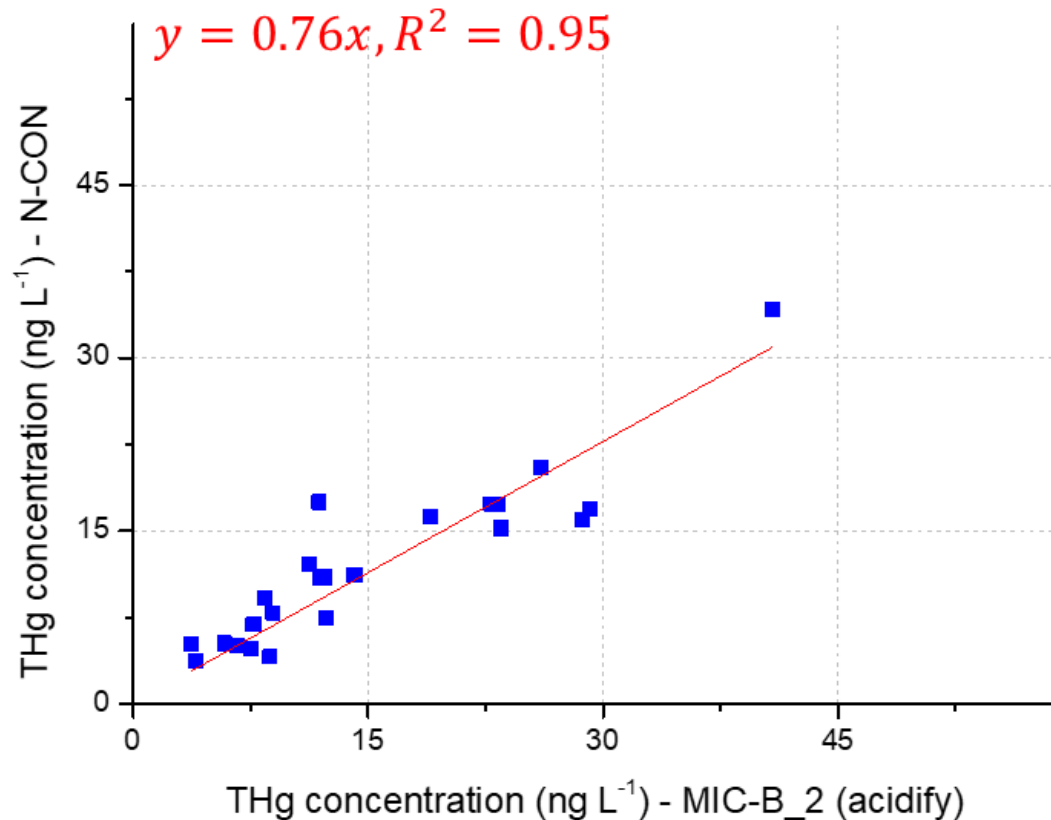
Hg Concentration



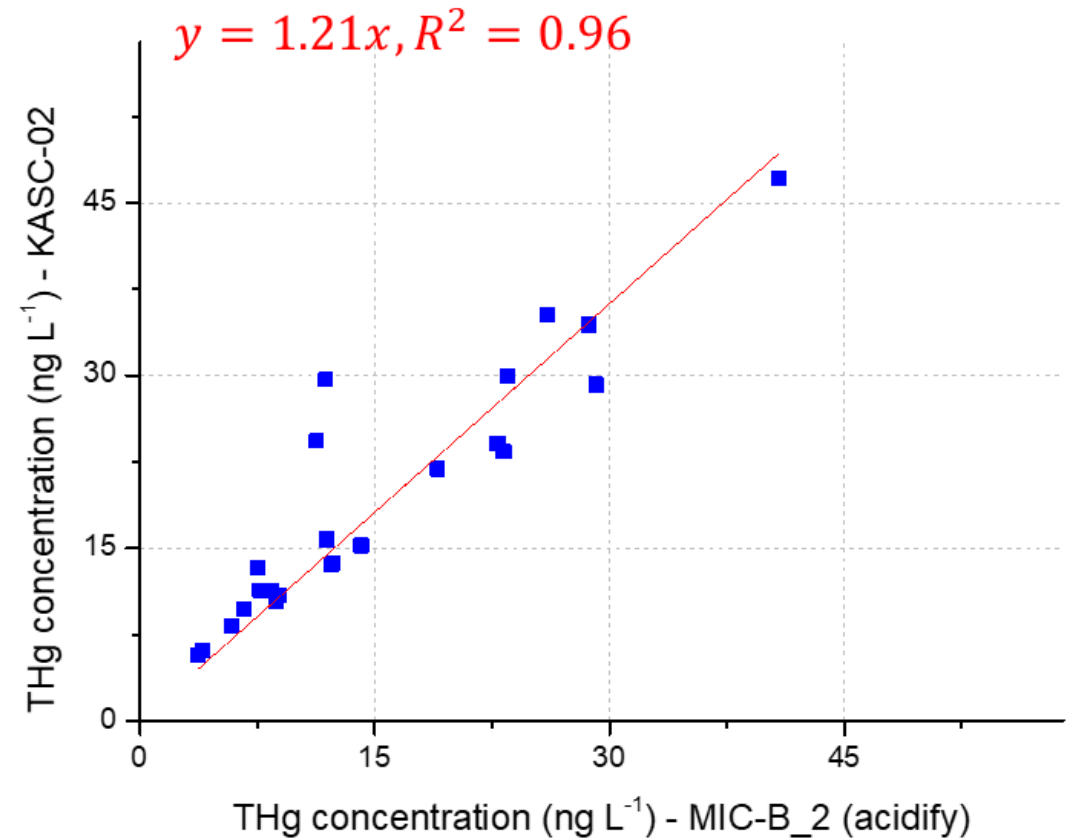
Hg Conc. of Wet Samples by Different Samplers

July 2024 - April 2025

MIC-B_2(acidify) vs. N-CON

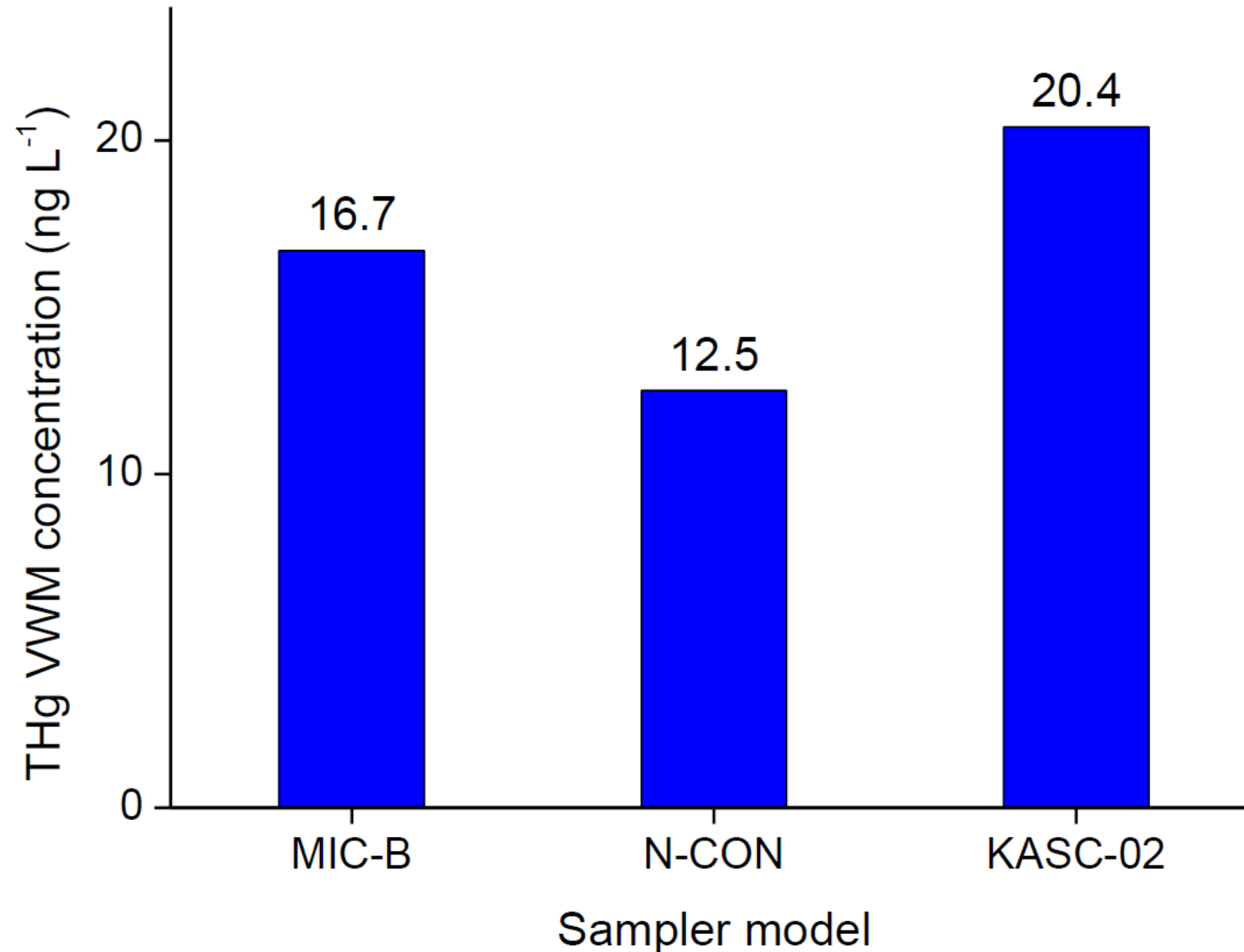


MIC-B_2(acidify) vs. KASC-02



Hg Conc. of Wet Samples by Different Samplers

July 2024 - April 2025

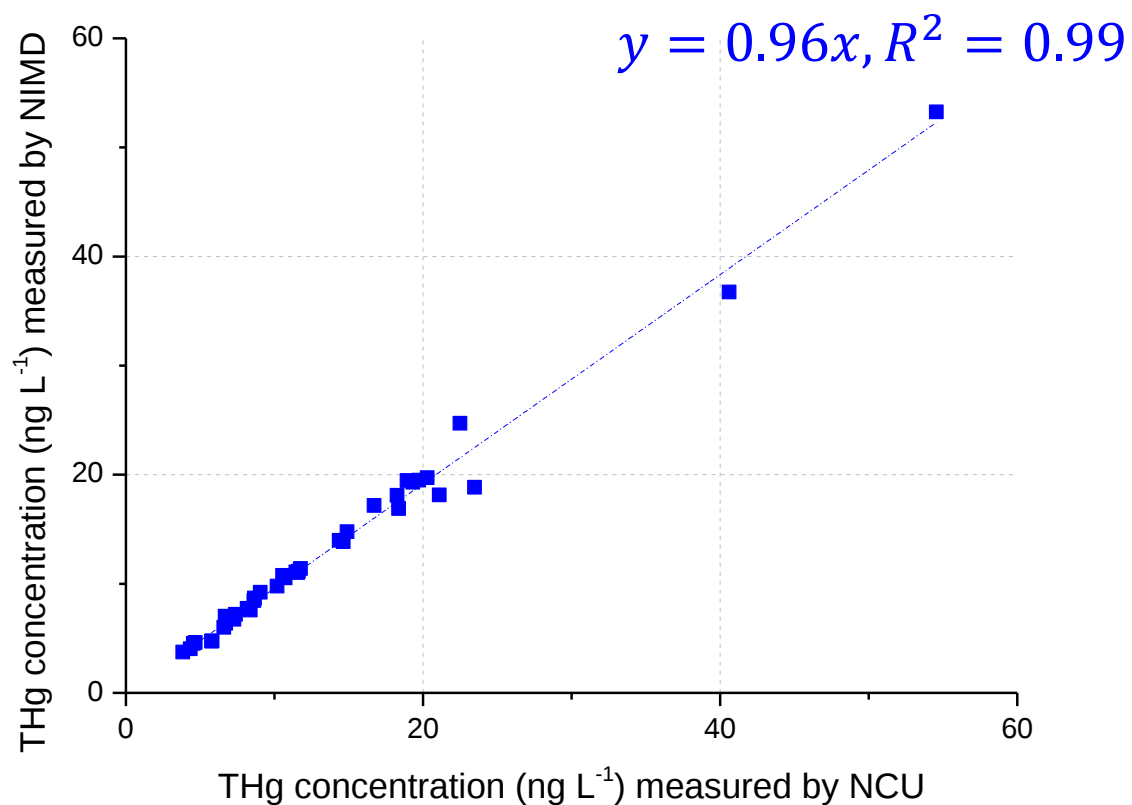


Analytical Laboratory Inter-comparison

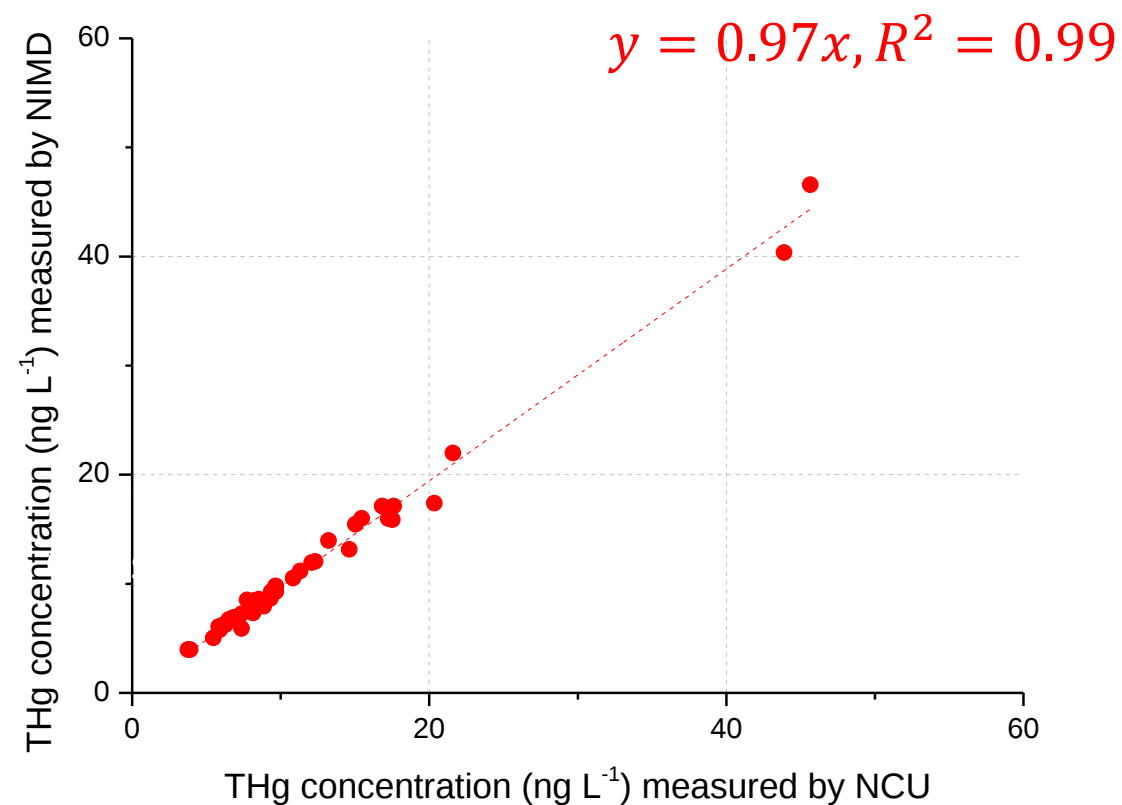
January – December 2022

Sampling Site: NCU

KASC-02



MIC-B

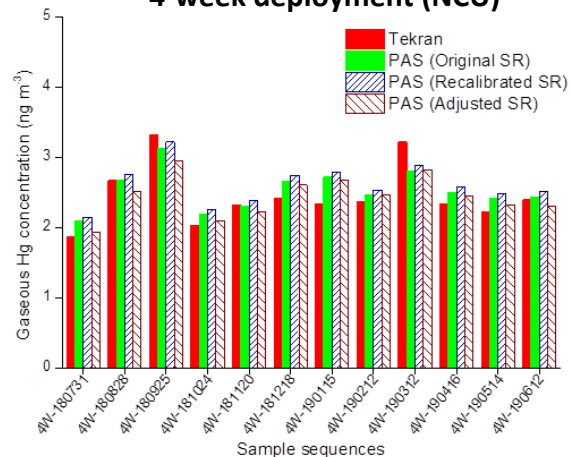


Passive Air Sampler(MerPAS) Test in Taiwan

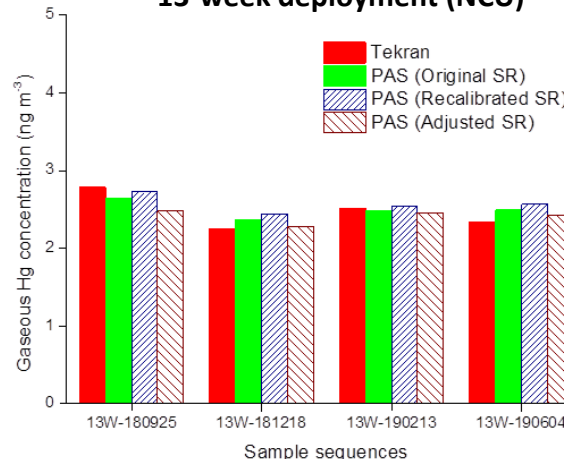
- From July 2018 to June 2019.
- Deployed at site on NCU campus (ground, suburban) and at the Lulin Atmospheric Background Station (mountain, remote).
- Side-by-side with a Tekran system.
- Various temporal resolution.



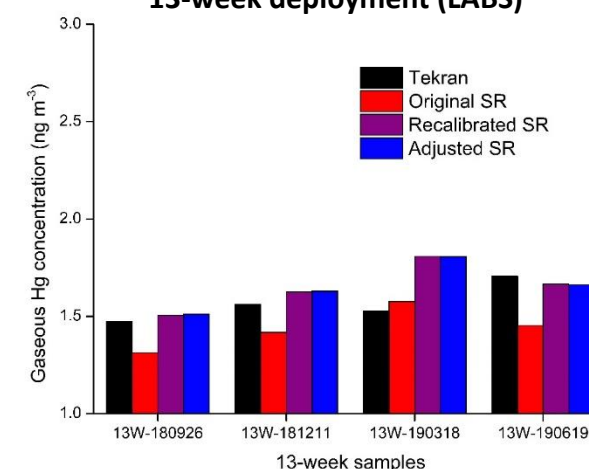
4-week deployment (NCU)



13-week deployment (NCU)



13-week deployment (LABS)



Pilot Study of MerPAS Application in APMMN

	GEM concentration(ng m ⁻³)									
	2023 (Q1)	2023 (Q2)	2023 (Q3)	2023 (Q4)	2024 (Q1)	2024 (Q2)	2024 (Summer)	2024 (Fall)	2024 (Winter)	2025 (Spring)
Indonesia	4.2	8.6	8.8	10.7						
Mongolia	19	1.8	1.7	2.3				2.2		
Nepal					26.2	13.5	9.3	9.7	30.9	13.1
Sri Lanka			1.3	1.9						
LABS, Taiwan				1.5	1.4			1.4	1.5	1.8
NCU, Taiwan				2.2	2.3			2.3	2.5	2.7

Future Plans

- 1. Bring in new partners and expand existing wet network**
 - Deploy new mercury wet deposition collectors
- 2. Continue training and network organizational development**
 - Annual Partners Meeting and training, site visits
- 3. Network atmospheric mercury monitoring stations**
 - Explore networking operating atmospheric mercury monitoring systems into one harmonized network in the Indo-Pacific region
 - Considering a **manual active/passive measurement** of atmospheric Hg in network
 - **Working closely with Japan on gaseous Hg monitoring**
- 4. Data acquisition, management and distribution**
 - QA/QC
 - Developing a database; update website where data will be distributed

**THANK
you!**

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