Regional Cooperation to Track Atmospheric Mercury: The Asia-Pacific Mercury Monitoring Network (APMMN)

2016 Asia Pacific Mercury Monitoring Network Meeting
Bangkok, Thailand

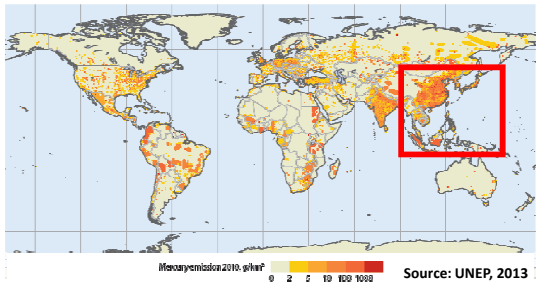
David Schmeltz (on behalf of many!)
U.S. EPA Office of Atmospheric Programs
Washington D.C. USA
July 2016

Outline

- Why do we need an Asia-Pacific Mercury Monitoring Network?
- Approach to network development
- What progress have we made?
- The future

Why do we need an Asia-Pacific Mercury Monitoring Network?

Asia is the largest source of mercury emissions



Source: UNEP, 2013

Region*	Emission (range), tonnes**	%
Australia, New Zealand & Oceania	22.3 (5.4 - 52.7)	1.1
Central America and the Caribbean	47.2 (19.7 - 97.4)	2.4
CIS & other European countries	115 (42.6 - 289)	5.9
East and Southeast Asia	777 (395 - 1690)	39.7
European Union (EU27)	87.5 (44.5 - 226)	4.5
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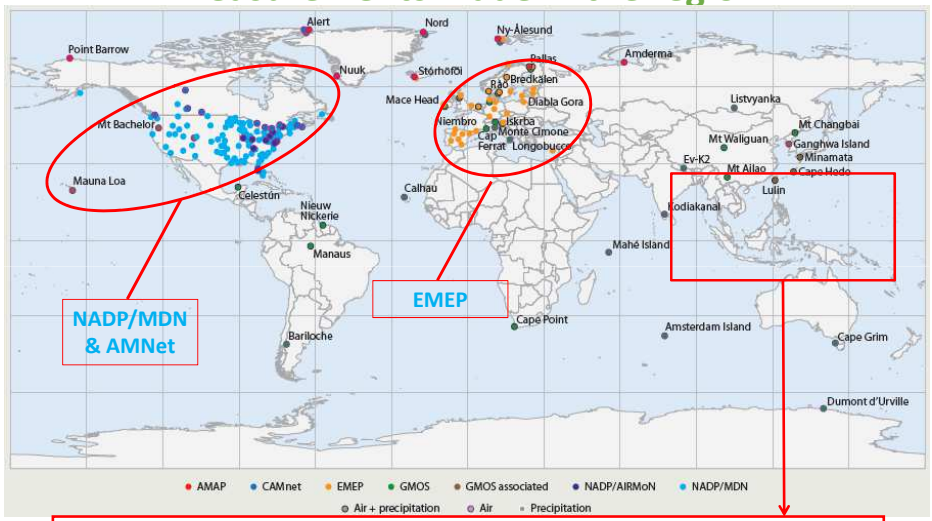
South Asia	154 (78.2 - 358)	7.9
Sub-Saharan Africa	316 (168 - 514)	16.1
Undefined (global total for emissions from contaminated sites)	82.5 (70.0 - 95.0)	4.2
Grand Total	**1960 (1010 – 4070)**	**100**

Country	Emissions (tonnes)
Cambodia	3.9
China	575.2
Indonesia	78.2
Japan	17.2
Korea	7.1
Laos	1.3
Malaysia	6.1
Mongolia	6.9
Philippines	33.1
Singapore	0.9
Taiwan	5.5
Thailand	14.9
Vietnam	11.6

Few long-term atmospheric mercury measurements made in the region



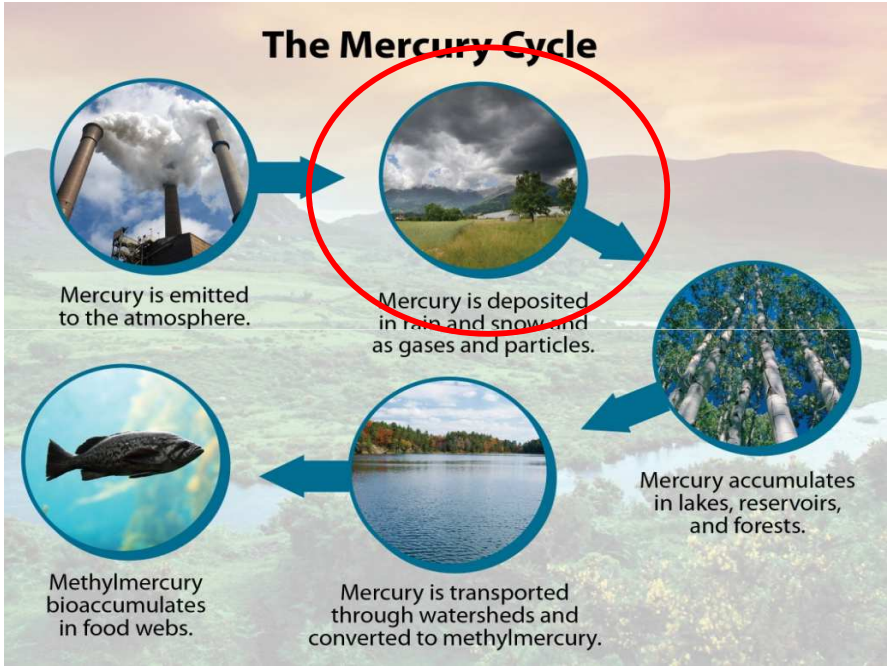
Currently, there is no long-term or background atmospheric Hg monitoring activity in SE Asia; few measurements in East Asia; limited accessible data; no regional network

Minamata Convention will be in force soon

- Controls on all lifecycle stages of mercury
- Currently, 128 signatories; 28 ratifications
- Monitoring provisions and planning activities for effectiveness evaluation

7th session of the Intergovernmental Negotiating Committee on Mercury (INC 7) 10-15 March 2016 | Jordan

What's our approach to network development?

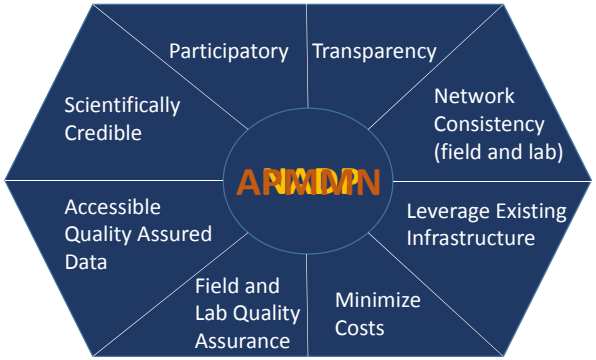


A comprehensive and integrated multi-media monitoring network is needed

- **Our initial focus is mercury in precipitation**
  - Loadings to ecosystems
  - The atmosphere is the first place to identify changes in emissions of mercury
- Lots of monitoring experience; many experts regionally/globally
- We have an opportunity to help
  - Improve monitoring coordination
  - Assist countries with limited experience and capabilities (capacity building)

Network principles

- Based on the National Atmospheric Deposition Program ~40 years of cooperative, long-term monitoring



What progress have we made?

Who is involved?

- **Network regional planning and training workshops 2012-2015**

Ministries and Agencies
- Bangladesh DOE
- Cambodia MOE
- Canada ECC
- Indonesia MOEF
- Japan NIMD, NIES, MOEJ
- Korea NIER
- Laos MONRE
- Malaysia MMD
- Mongolia NAMEM
- Myanmar MOECAF
- Philippines EMB
- Sri Lanka MMDE
- Taiwan EPA
- Thailand MONRE/DEQP, ERTC, PCD
- United States EPA, NOAA
- Vietnam VEA/CEM

Academic, Monitoring, and NGO
- Gwangju Institute of Science and Technology, Korea
- India Institute of Technology
- Kangwon National University, Korea
- National Atmospheric Deposition Program
- National Central University, Taiwan
- Sans Frontiere Progres
- University of Illinois

Milestones 2012-2015

2012 Identified key data gaps in the region and articulated a need for a coordinated network to monitor mercury transport and deposition

2013 Agreed to develop a standardized pilot network to monitor mercury in rainwater and in air; established a network Science Advisory Group (SAG) to guide network activities

2014 Developed and adopted APMMN SOPs to monitor mercury in rainwater

Established three mercury wet deposition pilot sites; central mercury analytical lab at National Central University, Taiwan

2015 Expanded network sites and partners; further developed network infrastructure; hired a network site liaison; website

2016 Expanded lab, launch monitoring and technology center; plans for monitoring atmospheric mercury concentrations; training

Network goal and objectives

- Goal
  - Systematically monitor wet deposition and atmospheric concentrations of mercury in a network of stations throughout the Asia-Pacific region
- Objectives
  - Determine the status and trends in concentrations of ambient mercury species, and wet, dry, and total atmospheric deposition of mercury
  - Develop a robust dataset for regional and global modeling
  - Assist partner countries in developing monitoring and assessment capacity
  - Share data and monitoring information

Where are we?

- A 3-year pilot network for wet Hg deposition monitoring; sites in Indonesia, Thailand, and Vietnam
  - Using APMMN SOPs based on NADP/MDN and adapted to regional conditions
  - Sample collection started 9/2014
- Samples shipped to National Central University of Taiwan for Hg analysis
- Data reported back to operating country
- U.S. led capacity building and site operator training workshops
- Transition to fully-operational wet network anticipated by 2017

Wet network profile

- The Science Advisory Group developed and approved the Mercury Wet Deposition Network Field Standard Operating Procedures V.2.0. *APMMN* (2014)

NCON Model MDN 00-125-2

NADP-style Aerochem 301

Taiwan-style MIC

Sampler: Automated wet only precipitation collection systems (goal one or two)

Sampling Frequency: One week

Sampling Schedule: Sample bottles and glassware are changed every Tuesday

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

Mercury Forms: Total mercury wet deposition and precipitation concentrations

Site Locations: Regionally representative; rural, urban, and suburban areas with estimated high levels of mercury emissions and deposition; and sensitive ecosystems

Asia Pacific Mercury Monitoring Network

Phase 1
Wet Deposition Sites

- Operating
- Sampling Splits
- Affiliated Network (domestic)
- Pending (waiting equipment)
- Initial Interest/Acceptance
- Central Laboratory (NCU)

Asia Pacific Mercury Monitoring Network

Phase 1 & 2
Wet Deposition Sites

- Operating
- Sampling Splits
- Affiliated Network (domestic)
- Pending (waiting equipment)
- Initial Interest/Acceptance
- Central Laboratory (NCU)
- Planned

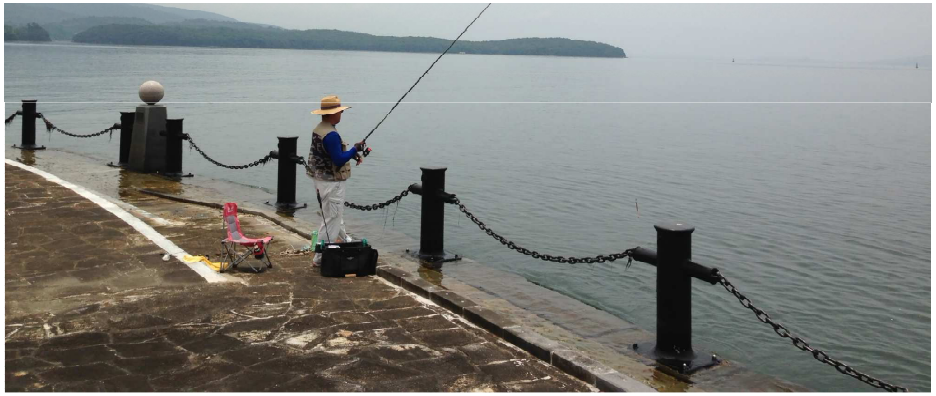
The near future

1. **Bring in new partners and expand existing wet network**
   - Procure and deploy new mercury wet deposition collectors
2. **Continue training and network organizational development**
   - Annual Partners Meeting and training, site visits
   - Launched the APMMN "Program Office" - Joint Center for Environmental Monitoring and Technology, June 2016, NCU, Taiwan
3. **Network atmospheric mercury monitoring stations**
   - Explore networking operating atmospheric mercury monitoring systems into one harmonized network in the Asia Pacific region
   - Tekran Operators Workshop in Japan
4. **Data acquisition, management and distribution**
   - Assist Taiwan in developing a database; update website where data will be distributed
   - Invite monitoring stations and data streams into APMMN (e.g., Korea, Japan)

Summary: The Asia-Pacific Mercury Monitoring Network (APMMN) is…

- A group of countries, agencies, academics and monitoring groups
- Making measurements of mercury
  - Wet deposition
  - Concentrations in gaseous and particle bound forms
- Using the same instruments and standard operating procedures across Asian countries and consistent with NADP
- Sharing data to solve the mercury problem

Thanks!



Atmospheric and wet deposition of mercury in Thailand

Hathairatana Garivait

Environmental Research and Training Center, Department of Environmental Quality Promotion, Ministry of Natural Resources and Environment, Thailand

Asia-Pacific Mercury Monitoring Network Workshop, 26 July 2016.

Recognition & Concern

Mercury is a chemical of global concern owning to

- Its long-range atmospheric transport
- Its persistence in the environment
- Its ability to bio-accumulate in ecosystems
- Its significant negative effects on human health and the environment

Minamata Convention on Mercury

Objective:

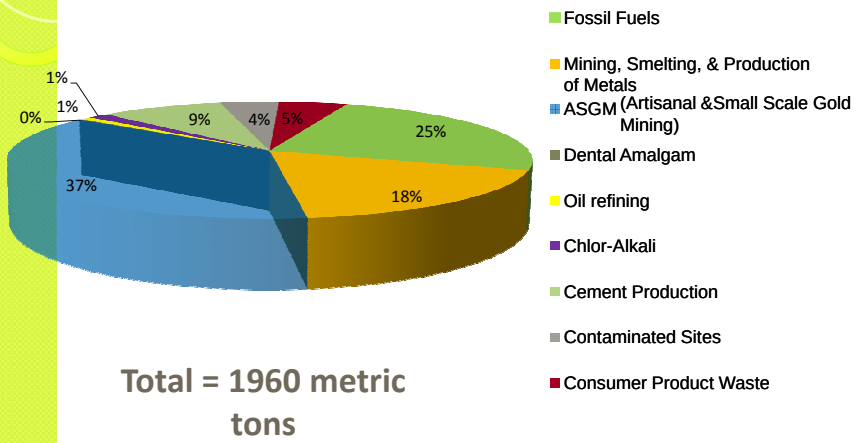
To protect the human health and the environment from anthropogenic emissions and releases of mercury and mercury compounds

APMMN play an important role to the policy context of the Convention

- Article 19: Research, Development and Monitoring
- Article 22: Effectiveness evaluation

Participation in the APMMN workshops

Estimated proportion of global anthropogenic mercury emissions by sector, 2010



Total = 1960 metric tons

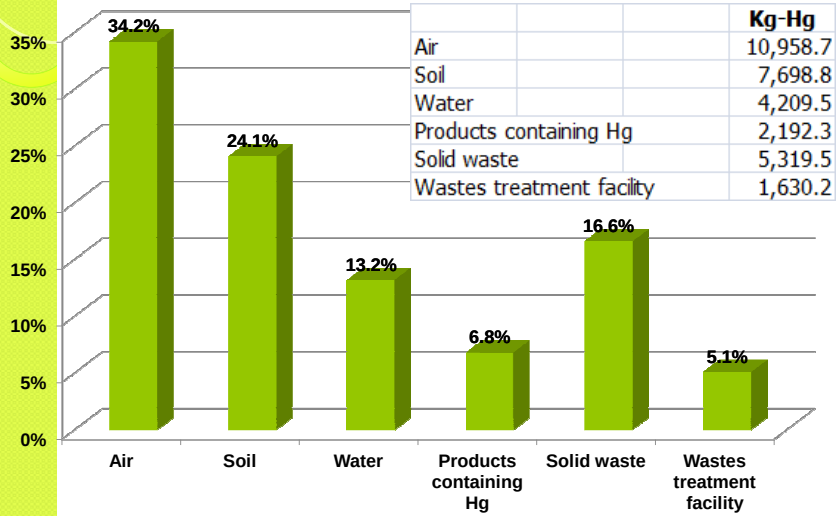
Source: United Nations Environment Programme (UNEP)
The Global Atmospheric Mercury Assessment: Sources, Emissions and Environmental Transport, 2013

Thailand's mercury release inventory 2010

The inventory has been established based on the

"Toolkit for identification and quantification of mercury releases (UNEP, 2010)"

Distribution of mercury in the environment in Thailand 2010



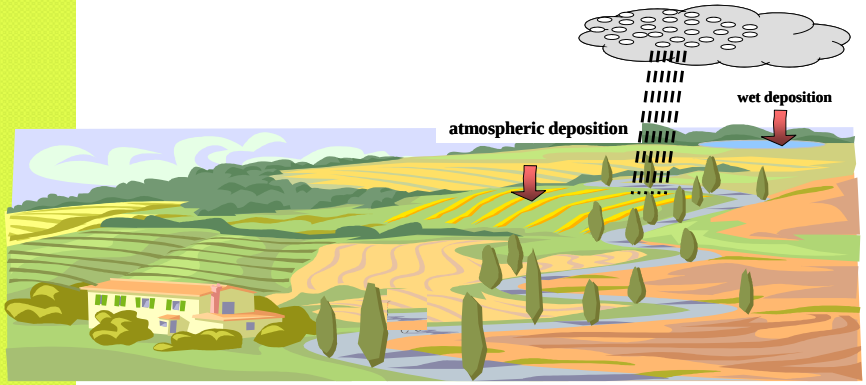
	Kg-Hg
Air	10,958.7
Soil	7,698.8
Water	4,209.5
Products containing Hg	2,192.3
Solid waste	5,319.5
Wastes treatment facility	1,630.2

Progress on atmospheric Hg measurement

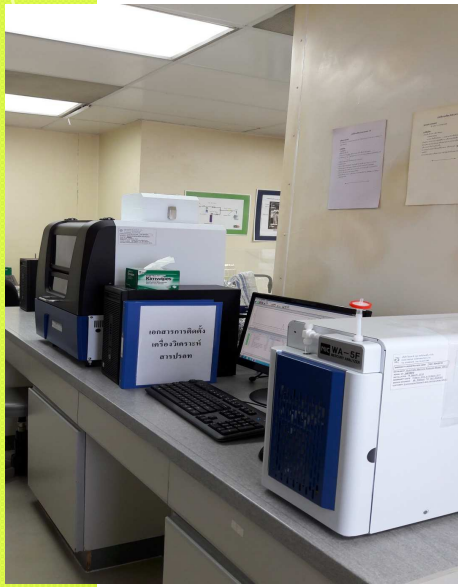
- Department of Environmental Quality Promotion (DEQP)
  ERTC: "Research & Development"
- Pollution Control Department (PCD)
  Air Quality and Noise Management Bureau: "Air Quality Monitoring"

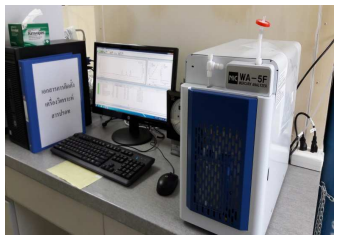
Measurement of Mercury in Air and Precipitation in Thailand (ERTC)

Objective is to develop an appropriate measurement methodology for Hg in air and precipitation for Thailand



New Instruments arrived 20 March 2016





Atmospheric Hg analyzer
(dual gold amalgam CVAFS)

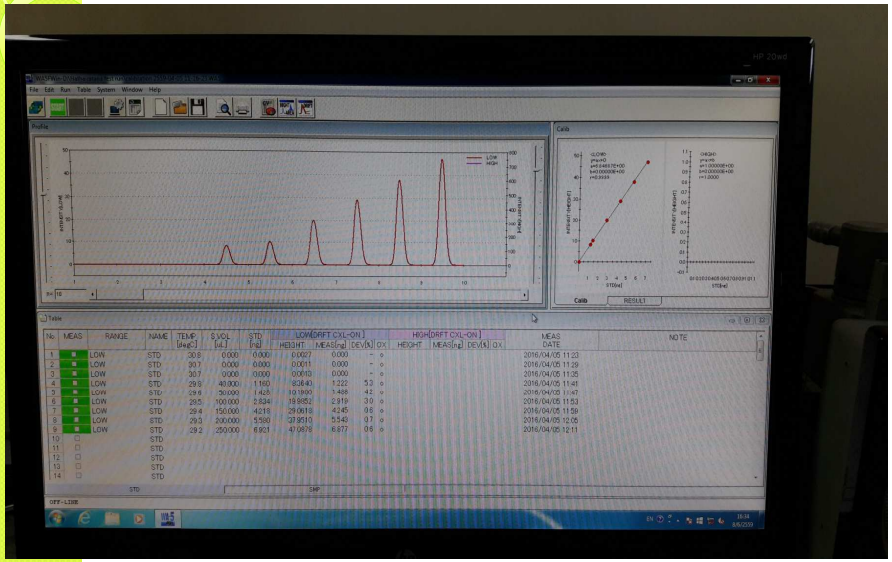
wet Hg deposition analyzer
(gold amalgam CVAFS)

Preliminary survey for atmospheric Hg

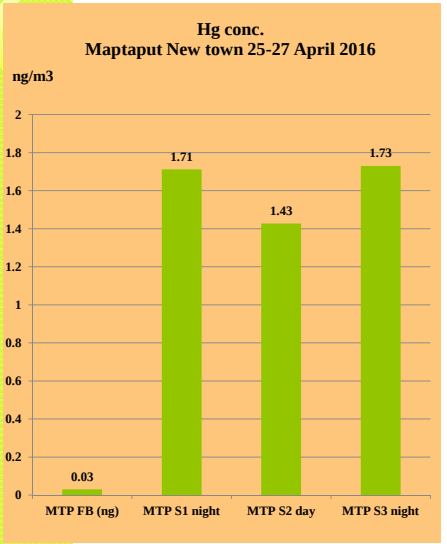
Pathumthani: ERTC
6-9 June 2016

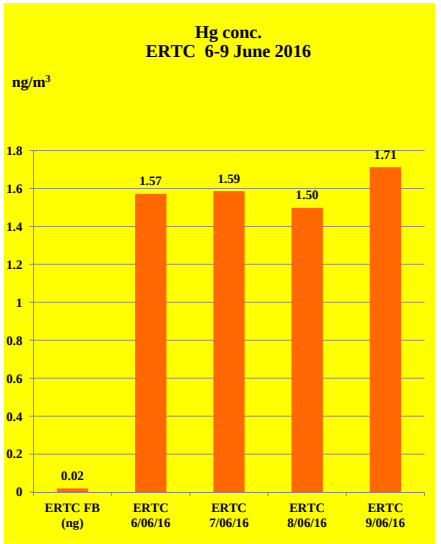
Rayong: Maptaput new town
25-27 April 2016

Data report WA-5F

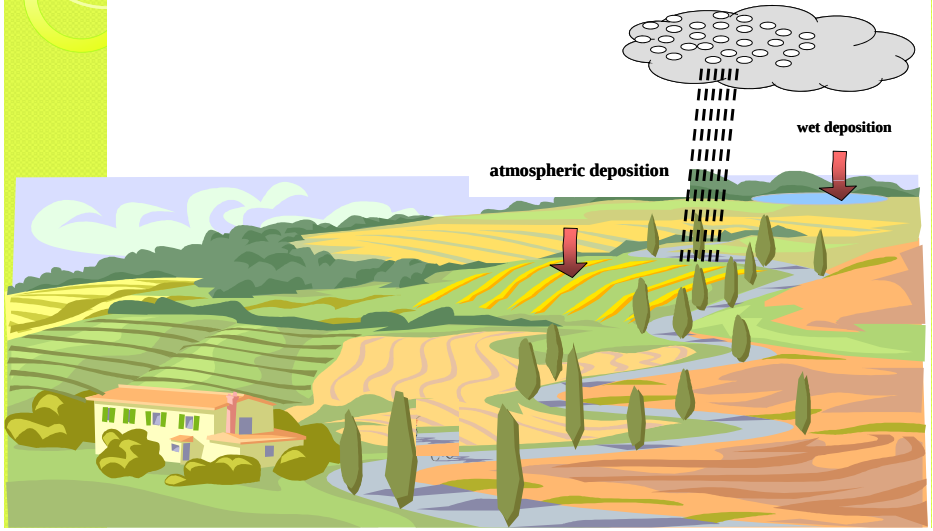


Gaseous mercury: Maptaput & ERTC





Mercury wet deposition monitoring (ERTC)



ERTC station:
Latitude 14^0 02”
Longitude 100^0 42”
Elevation: 6 m msl

Mercury in wet deposition at ERTC

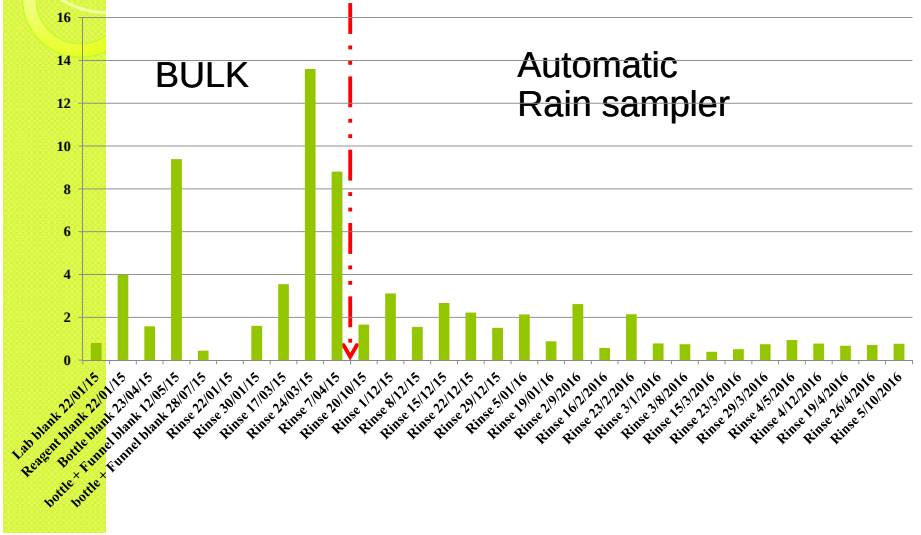
Guidelines for sampling and analysis

- APMMN Field Sampling SOP
- EPA method: Method 1631 revision E

Automatic rain sampler modification

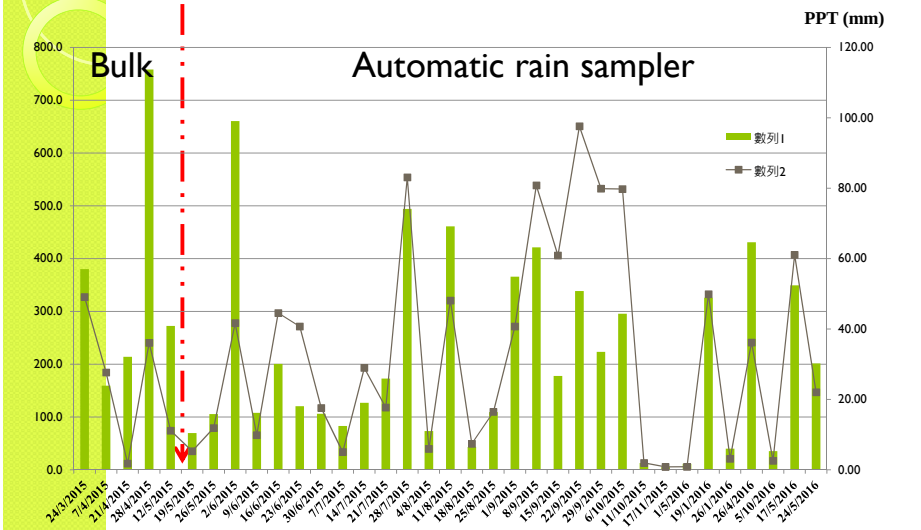
Sampling has started May 12, 2015

Hg conc. (ng/L) for Blanks and Rinsed water

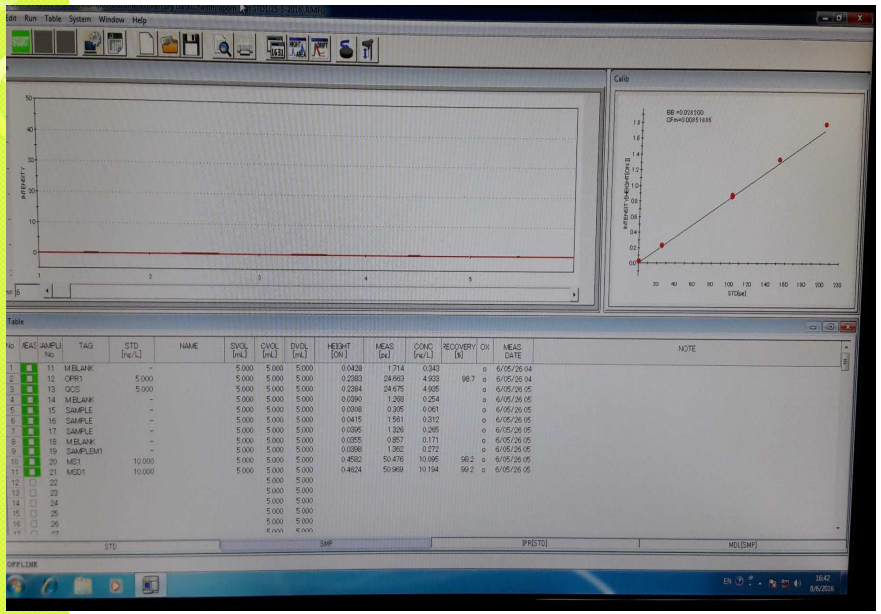


SAMPLE	Sampling Start		Sampling Stop		RGPPT	Sample weight	CAL PPT	CALPPT/ RGPPT	Hg conc.	HgDep (ng/m^2)	Sample	QR
	Date	Time	Date	Time	(mm)	(g)	(mm)		(ng/L)		type	
ERTC Hg-10	5/12/2015	10.20	19/5/2015	9.45	8.6	121.6	11.12	1.29	24.49	272.5	Rain	B
ERTC Hg-11	19/5/2015	10.05	26/5/2015	9.50	5.5	57.8	5.29	0.96	13.15	69.5	Rain	B
ERTC Hg-12	26/5/2015	10.15	6/2/2015	9.25	11.3	129.7	11.87	1.05	8.89	105.5	Rain	B
ERTC Hg-13	6/2/2015	9.35	6/9/2015	9.45	36.6	455.5	41.67	1.14	15.85	660.6	Rain	B
ERTC Hg-14	6/9/2015	10.10	16/6/2015	9.30	8.9	107.6	9.84	1.11	10.95	107.8	Rain	B
ERTC Hg-15	16/6/2015	9.45	23/6/2015	9.40	38.1	486.8	44.54	1.17	4.50	200.6	Rain	B
ERTC Hg-16	23/6/2015	9.55	30/6/2015	9.45	38.2	445.0	40.71	1.07	2.95	120.3	Rain	B
ERTC Hg-17	30/6/2015	10.10	7/7/2015	9.25	15.7	191.8	17.55	1.12	6.05	106.2	Rain	B
ERTC Hg-18	7/7/2015	9.45	14/7/2015	9.50	4.8	55.3	5.06	1.05	16.39	82.9	Rain	B
ERTC Hg-19	14/7/2015	10.05	21/7/2015	9.35	26.2	316.5	28.96	1.11	4.38	126.7	Rain	B
ERTC Hg-20	21/7/2015	9.40	28/7/2015	9.40	15.6	193.6	17.71	1.14	9.75	172.7	Rain	B
ERTC Hg-21	28/7/2015	9.45	8/4/2015	9.50	83.58	908.1	83.08	0.99	5.95	494.2	Rain	B
ERTC Hg-22	8/4/2015	10.05	8/11/2015	9.30	5.6	64.9	5.94	1.06	12.34	73.3	Rain	B
ERTC Hg-23	8/11/2015	9.45	18/8/2015	9.20	43.3	525.7	48.10	1.11	9.59	461.1	Rain	B
ERTC Hg-24	18/8/2015	9.30	25/8/2015	9.45	6.8	80.8	7.39	1.09	5.85	43.2	Rain	B

Mercury wet deposition at ERTC (ng/m^2)



Data report RA-4300 FG



Future plan

- ERTC will be able to analyze gaseous Hg and wet deposition Hg
- We will soon compare the wet deposition data with Prof. Sheu.
- Collaborate closely with PCD and compare the results of atmospheric Hg using different methods in Thailand.

Asia Pacific Mercury Monitoring Network

Discussion

Overview of the APMMN

Current State of the Network: Summary

- We have good fundamental support for APMMN
  - EPA Taiwan
  - Laboratory in place
  - Good laboratory facilities at National Central University
  - Site Liaison in place
  - Training facilities
- We have a very good start
  - Several sites operating

Current State of the Network: Growth

- But we need to grow some
  - We will need more sites to adequately cover Asia
  - New samplers coming!
- Do we want planned growth?
  - Decide which countries/regions to pursue?
  - Invite everyone/anyone to join?

Data being collected

- What do we want to do with this data?

Data being collected…..

- Do we want to be a Scientific Network?
  - Policy Network?
  - Both?
- Release of Data?
  - Any thoughts there?
  - If we release it, scientists will use it…..
  - Individual countries have problems with releasing
  - Any changes there?

Management of the Network

- Do we want/need an Executive Committee?
  - A body to make decisions?
  - Make policy?

Management of the Network

- Do we want a Budget Committee
  - Talk about long term funding
  - Discuss how the money of the network flows?
  - Other?

Management of the Network

- We need to develop the Precipitation Network too…
  - We need reliable precipitation records from each APMMN site
  - Do we need an official gage, or use what is available?
  - How do we maintain the data?
    - In database
    - Get it reported on the field sheets?

Management of the Network

- Shipping Issues
  - What does it cost?
- Basic Bottle purchasing
  - Can we reuse bottles?
  - Mass purchase of bottles?
  - Individual country purchase?

Management of the Network

- Website
  - Hosted at NCU
  - Who is maintaining?
  - What does it need? Anything?

Quality Assurance/Comparability Study

- QC Study at NCU
  - All samplers in the APMMN running simultaneously
  - Need a simple study design
  - Need a Japanese collector running with APMMN and NCON
  - What will we compare
  - Develop and correction factor
  - We will need financial support of the laboratory
  - Japan: is a collector available?

Historical Data

- Some countries have been collecting wet deposition and atmospheric data for a long time
  - Japan, Taiwan, Korea
- Do we want to house this data?
  - For science studies?
  - Historical value?
- Can we do this? is it possible?

Mercury in East and Southeast Asia

Guey-Rong Sheu

Department of Atmospheric Sciences
National Central University
Jhong-Li, Taiwan

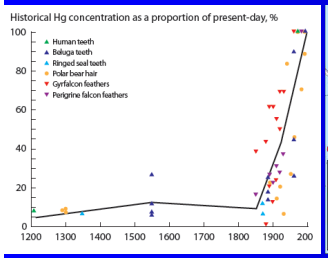
Minamata Disease and Hg Pollution

- Minamata disease, a neurological disease caused by severe Hg poisoning due to consumption of contaminated fish, was first discovered in Minamata, Japan in **1956**.
- Hg-containing industrial wastewater discharge was the major Hg source to the fish in Minamata Bay.

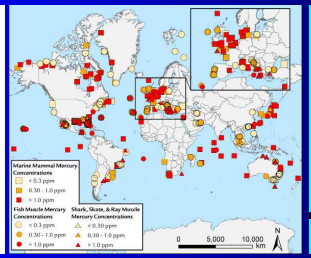
(Time, 2010)

Global Hg Pollution

- Mercury is still a pollutant of global concern.
- Fish consumption is the major exposure route of Hg to many people worldwide.
- Atmospheric deposition is the major source of Hg to many aquatic ecosystems.
- Anthropogenic Hg emission is an important contributor to the Hg in the atmosphere.

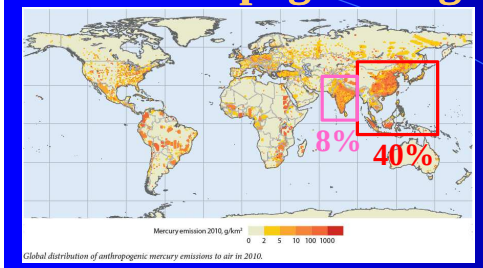


(UNEP, 2013)



(Evers et al., 2012)

Anthropogenic Hg Emissions in 2010



Global distribution of anthropogenic mercury emissions to air in 2010.

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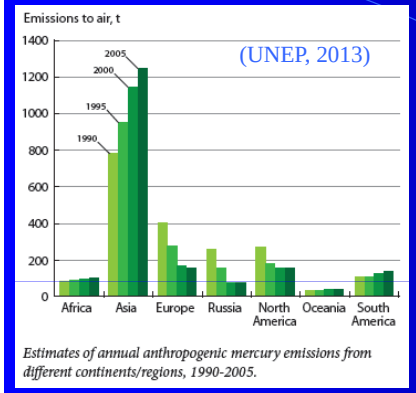
India	144.7
Indonesia	78.2
Japan	17.2
Korea	7.1
Laos	1.3
Malaysia	6.1
Mongolia	6.9
Philippines	33.1
Singapore	0.9
Sri Lanka	0.6
Taiwan	5.5
Thailand	14.9
Vietnam	11.6

(UNEP, 2013)

Trends in Anthropogenic Hg Emissions



Estimates of annual anthropogenic mercury emissions from different continents/regions, 1990-2005.

Anthropogenic Hg emissions from Europe and North America are declining, whereas emissions from Asia are increasing.

Projections of Global Mercury Emissions in 2050 (Streets et al., 2009)

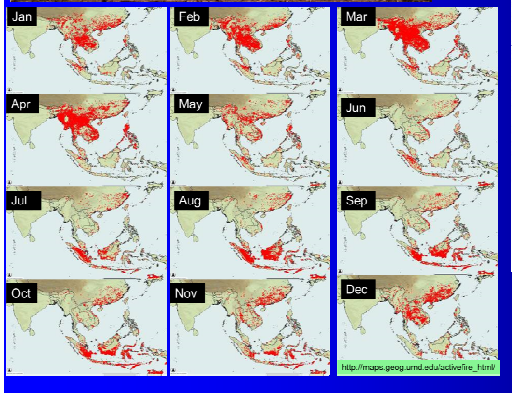
DAVID G. STREETS,*,† QIANG ZHANG,† AND YE WU‡

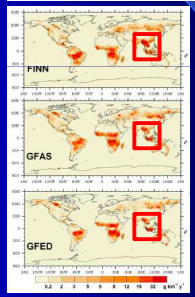
TABLE 4. Mercury Emissions in 2050 by Scenario and World Region (Mg/yr)

scenario	North America	Central and South America	Africa	Europe, Russia, Middle East	Asia and Oceania	world
2050 A1B	225.9	473.6	509.6	676.5	2970.0	4855.6
2050 A2	239.1	415.6	375.5	667.3	2208.5	3905.9
2050 B1	121.9	340.4	357.0	358.1	1208.9	2386.2
2050 B2	131.3	331.2	308.1	398.0	1461.4	2629.9

Projections under various IPCC scenarios of development. It is likely that Hg emission will increase in the future. The main driving force is the expansion of coal-burning electricity generation, especially in Asia.

Biomass Burning Hg Emissions





regions	Hg emissions Mg Hg/year mean	SD[a]
BONA	22	16
TENA	6	3
CEAM	22	25
NHSA	13	10
SHSA	95	39
EURO	2	1
MIDE	0	0
NHAF	83	13
SHAF	58	7
BOAS	99	83
CEAS	7	2
SEAS	57	35
EQAS	192	216
AUST	19	9
global	675	240
boreal[b]	121	85
temperate[c]	9	3
ROW[d]	545	224

SEAS + EQAS = 249 Mg Hg/year
= 37% of global biomass burning emission

(Friedli et al., 2009; de Simone et al., 2015)

Distribution of Atmospheric Hg Concentrations and Deposition Fluxes: Modeling Results

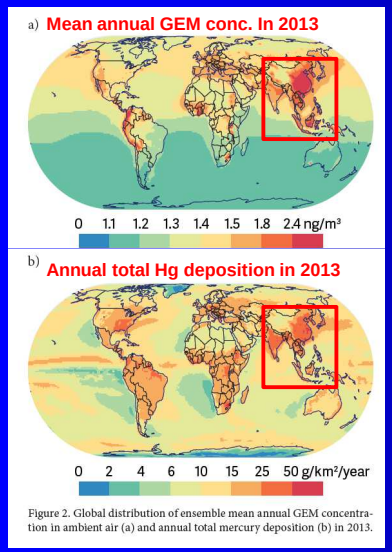
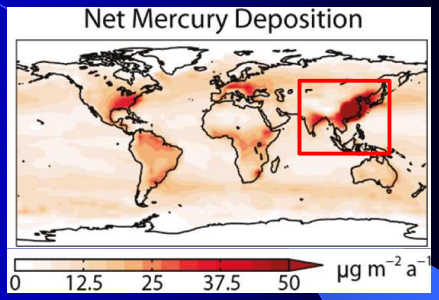
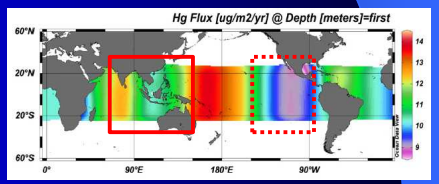


Figure 2. Global distribution of ensemble mean annual GEM concentration in ambient air (a) and annual total mercury deposition (b) in 2013.

AMAP/UNEP, 2015



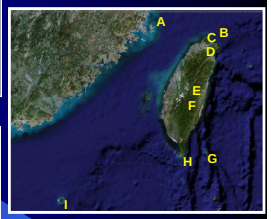
Corbitt et al., 2011

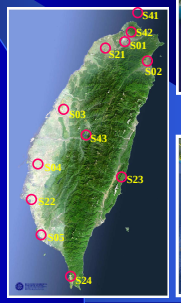


Costa et al., 2012

Atmospheric Hg Research in Taiwan

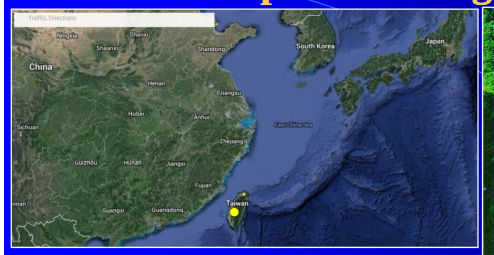
- Long-term continuous speciated atmospheric Hg monitoring at Lulin Atmospheric Background Station (LABS) since 2006
- Establishment and operation of a mercury wet deposition monitoring network since 2008
- Long-term cloudwater Hg monitoring at Mt. Bamboo in spring
- Atmospheric Hg measurements at background and remote sites
- Regional atmospheric Hg Research





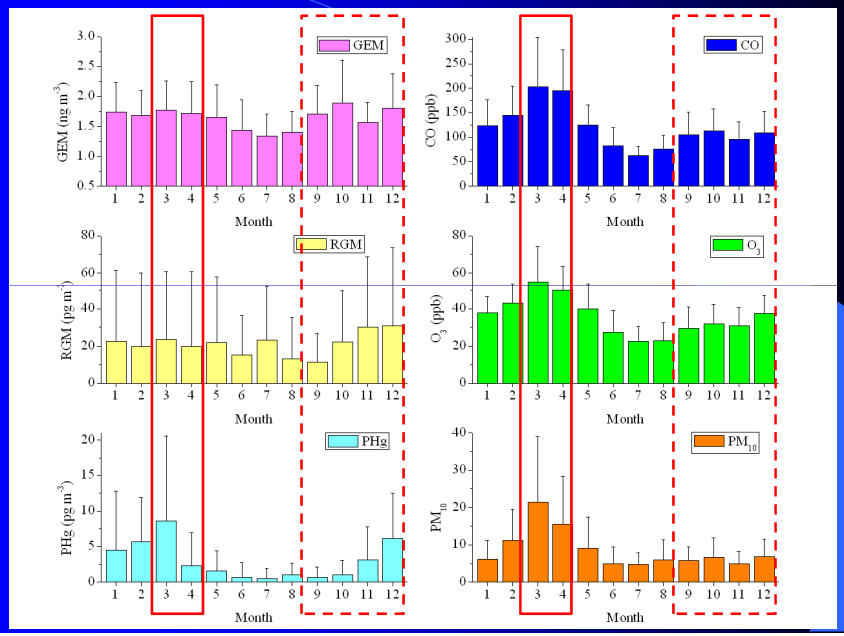
Trans-Boundary Transport of Hg Observed in Taiwan

Lulin Atmospheric Background Station (LABS)

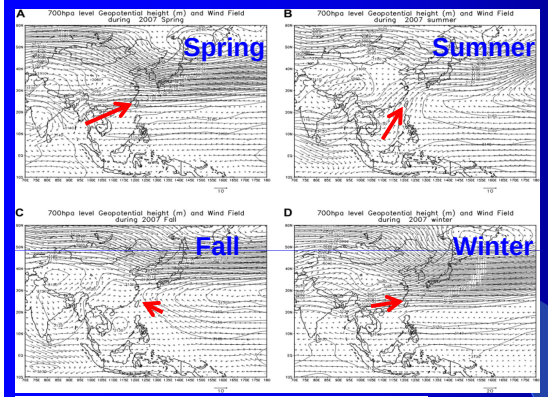


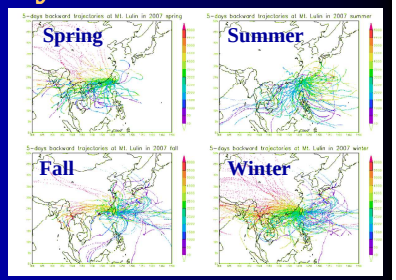
- LABS is located atop Mt. Front Lulin in central Taiwan, with an elevation of 2862 m above sea level.
- Gaseous Elemental Hg(GEM), Reactive Gaseous Hg(RGM) and Particulate Hg(PHg) have been measured using Tekran 2537X/1130/1135 at the LABS since April 13, 2006.

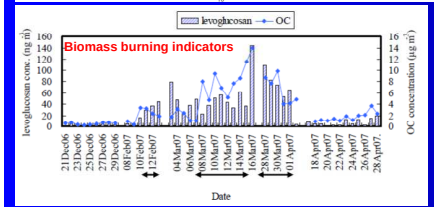
Seasonal Pattern of Hg, CO, O_3 and PM_{10} at LABS

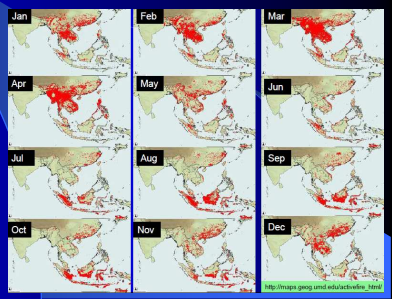


Seasonal Wind Field and Backward Trajectory at 700 hPa and Fire Activity in SE Asia

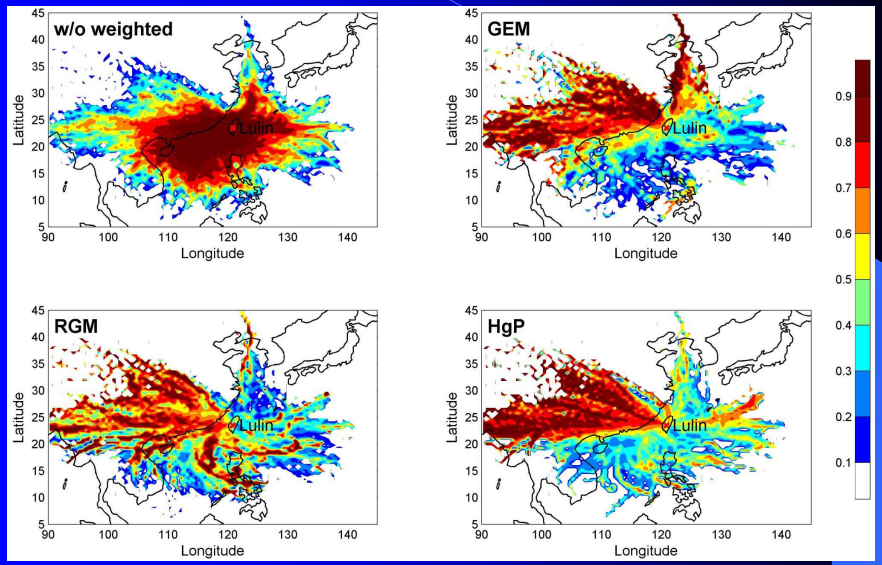




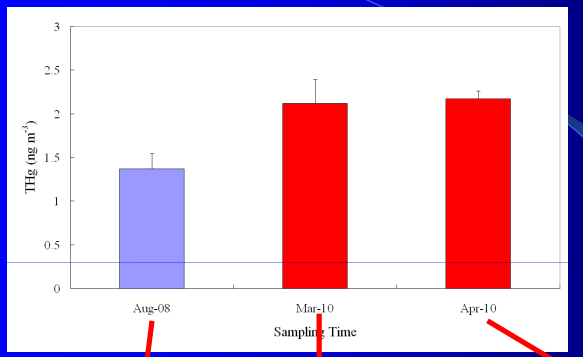


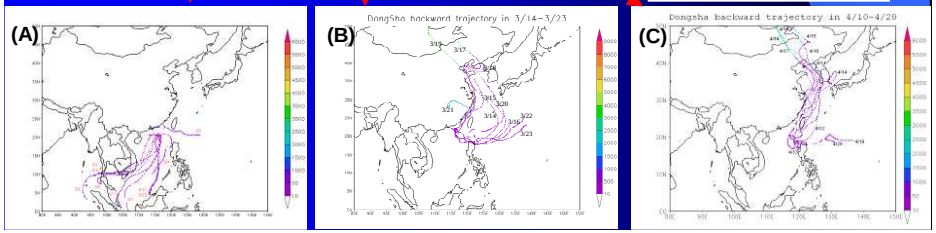


Source-Receptor Relationship: Concentration-Weighted Trajectory



Seasonal Variation at Dongsha Island



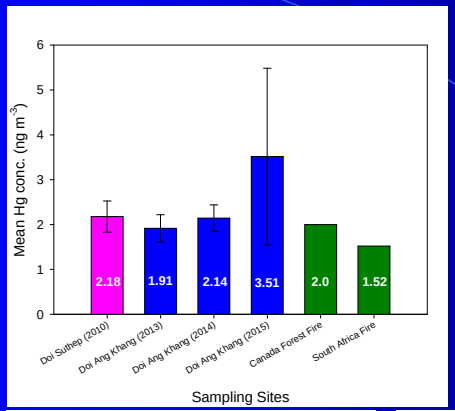


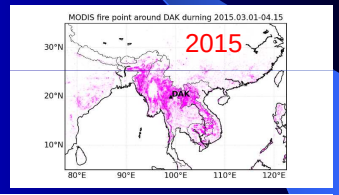
Atmospheric Hg Measurements in Thailand and Vietnam

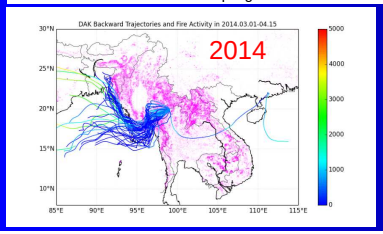
Regional Atmospheric Hg Research

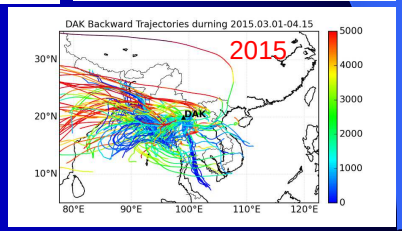
- **2008**: Hg sampling at Mt. Fuji, Japan
- **2009**: Hg sampling at Gosan, Korea
- **2010**: 7-SEAS/Dongsha Experiment
- **2011**: Son La Experiment (I)
- **2012**: Son La Experiment (II)
- **2013**: 2013 7-SEAS/BASELInE Campaign
- **2014**: 2014 7-SEAS/BASELInE Campaign
- **2015**: 2015 7-SEAS/BASELInE Campaign
- **2015**: Hg sampling at Mt. Fuji, Japan

Atmospheric Hg in Thailand in 2010-2015

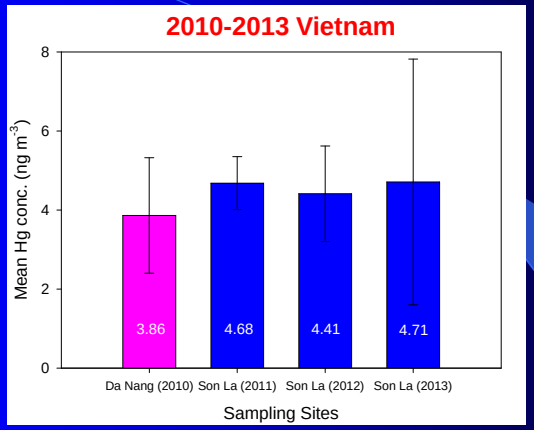








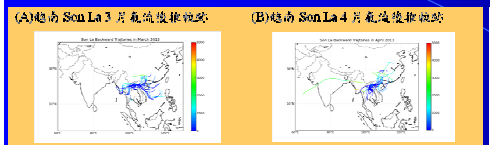
Atmospheric Hg in Vietnam in 2010-2013



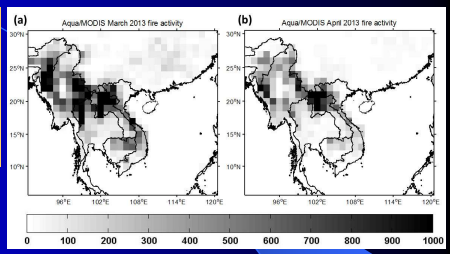
Mean values of atmospheric Hg in Vietnam are about 2.3~2.8 times of the Northern Hemisphere background value (1.7 ng m^{-3}), indicating sources other than the background air are influencing these sites.

Potential Hg Emission Sources in Vietnam

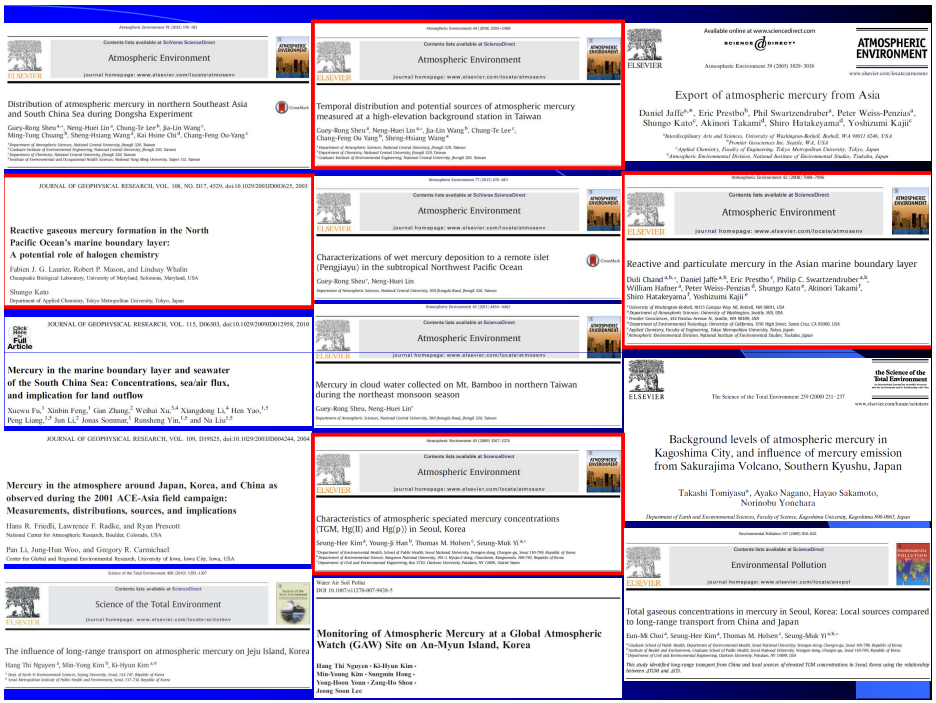
Backward trajectories



Biomass burning activities



Possible Hg emission sources include biomass burning, cement production, and coal fire power plants.



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Distribution of atmospheric mercury in northern Southeast Asia and South China Sea during Dongsha Experiment

Guey-Rong Sheu [a,*], Neng-Huei Lin [a], Chung-Te Lee [b], Jia-Lin Wang [c], Ming-Tung Chuang [b], Sheng-Hsiang Wang [a], Kai Hsine Chi [d], Chang-Feng Ou-Yang [c]

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Article

An Investigation of Atmospheric Mercury from Power Sector in Thailand

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Journal of Ecotechnology Research, 17[1], 11- 15 (2013)
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Original Article

Mercury Contamination in the Atmosphere of Aceh Province, Indonesia

SERIKAWA Yuka*, ROSANA Elvince**, KAWAKAMI Tomonori†*, KUNORI Noriyasu*, NOTO Yuji*, INOUE Takanobu***, NAGAFUCHI Osamu****, MIYAKE Takayuki****and Syamsidik*****

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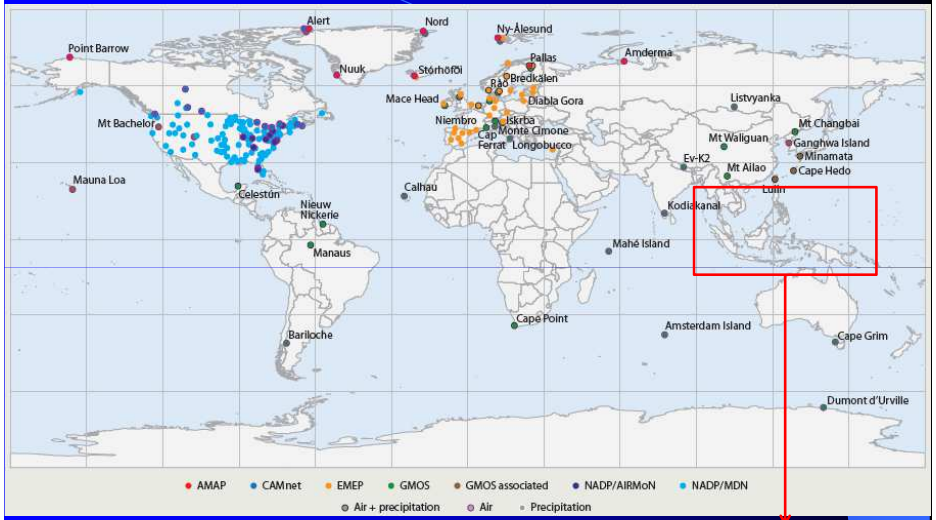
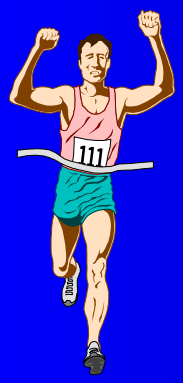
Atmospheric Hg Monitoring Worldwide



Currently, there is no long-term or background atmospheric Hg monitoring activity in SE Asia.

Asia Pacific Mercury Monitoring Network

- Goal
  - Systematically monitor wet deposition and atmospheric concentrations of mercury in a network of stations throughout the Asia-Pacific region



THANK YOU!

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Mercury Situation in Thailand

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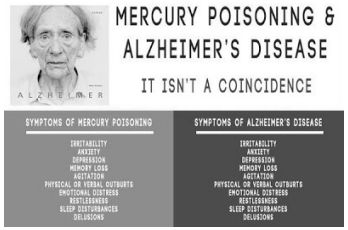
Head of Occupational and Environmental Medicine Center Nopparat Rajathanee Hospital, Department of Medical Services, Ministry of Public Health

President of The Association of Occupational and Environmental Diseases of Thailand

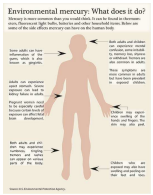
Vice President of ASIAN Association of Occupational Health

Occupation that exposed to mercury

1. **Mercury mine**
2. **Gold mine**
3. **Pesticide manufacturing**
4. **Medical or Scientific Measurement equipment**
5. **Electrical equipment manufacturing and Fluorescent**
6. **Medicine manufacturing**
7. **Chemical manufacturing such as acetic acid, soda ash**
8. **Working with mixing the metal such as amalgam**
9. **Choline manufacturing that use mercury as catalyst**
10. **Wool manufacturing that use mercury as softener**
11. **Paints manufacturing**



WHO mercury poisoning



- Mercury is a naturally occurring element that is found in air,
- water and soil.
- Exposure to mercury – even small amounts – may cause serious health problems, and is a threat to the development of the child *in utero* and early in life.
- Mercury may have toxic effects on the nervous, digestive and immune systems, and on lungs, kidneys, skin and eyes.
- Mercury is considered by WHO as one of the top ten chemicals or groups of chemicals of major public health concern.
- People are mainly exposed to methylmercury, an organic compound, when they eat fish and shellfish that contain the compound.

Occupational and Environmental Toxicology of Mercury and Its Compounds

Hiroshi SATOH: Industrial Health 2000, 38, 153–164

- Classical mercury poisoning is characterized by a triad of signs, namely tremors, erethism and gingivitis.
- Mercurial erethism, which is characterized by behavioral and personality changes such as extreme shyness, excitability, loss of memory, and insomnia are also observed.
- Recently, the effects of mercury exposure at levels around 0.05 mg/m3 or lower have been of concern and may include minor renal tubular damage, increased complaints of tiredness, memory disturbance and other symptoms, subclinical finger tremor, abnormal EEG by computerized analysis and impaired performance in neurobehavioral or neuropsychological tests.
- Abnormal gait, dysarthria, ataxia, deafness and constriction of the visual field are typical of the symptoms of methylmercury poisoning observed in Minamata and Iraqi outbreaks, as well as in occupational methylmercury poisoning cases.

Mercury Intoxication in Thailand

- First report of Mercury toxicity in Thailand was in 1953 by Dr. Sombat Sukontaphan, two patients were toxicated by mercury fumicant as an medicine and one died.
- Surveillance reports in Thailand come in the combination of Mn, Hg, As and Cd and average poisoning per year are 82 cases.

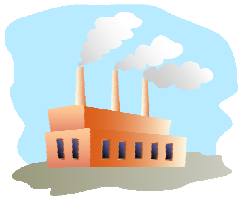


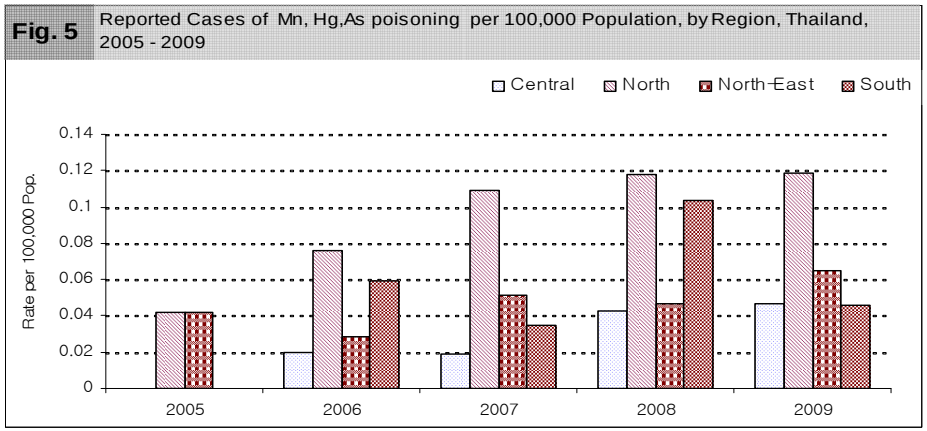
Table 27 : Number of Patients and Deaths Caused by Hazardous Substance Exposure during 2007 – 2011

Unit : persons

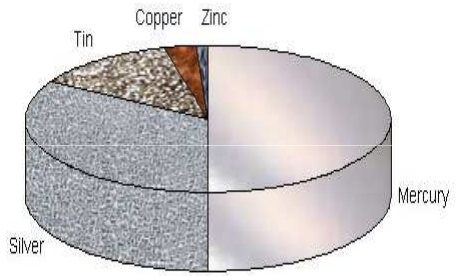
Hazardous Substance	Year	2007	2008	2009	2010	2011
Agricultural hazardous substances	Patients	1,286	1,642	1,649	2,015	2,011
	Death	-	-	-	-	-
Industrial hazardous substances	Patients	300	226	277	291	239
	Death	1	-	-	-	-
total	Patients	1,586	1,868	1,926	2,306	2,250
	Death	1	-	-	-	-
Percentage increase / decrease	Patients	+9.2	+17.7	+3.1	+19.7	-2.4
	Death	-	-	-	-	-

Source : Data from disease surveillance, Bureau of Epidemiology, Department of Disease Control, Ministry of Public Health, 17 February 2012

Statistic of Mn, Hg, and As poisoning in Thailand (Surveillance report)



Dentist exposed to mercury



Determination of Mercury Exposure among Dental Health Workers in Nakhon Si Thammarat Province, Thailand

TABLE 2: Environmental mercury vapor samplings and percentage of mercury airborne levels exceeded (% OELs).

Personal and area samplings	$\mu g/m^3$ TWA					
	n	Mean	Median	Min	Max	Number of mercury airborne levels exceeded (% OELs)
Chairs	24	9.42	5.70	0.20	31.10	2 (8.3)
Amalgam storages	17	19.28	18.00	10.00	29.00	6 (35.3)
Preparation areas	17	8.88	10.50	0.70	20.50	2 (11.8)
Total areas samplings	**58**	**8.58**	**6.40**	**0.20**	**29.00**	**10/58 (17.3)**
Personal air samplings	124	15.60	12.20	2.00	38.00	22/124 (17.7)

Determination of Mercury Exposure among Dental Health Workers in Nakhon Si Thammarat Province, Thailand (Con' t)

TABLE 3: Urinary mercury levels of exposed and unexposed subjects.

Metal	Exposed (n = 124)	Unexposed (n = 124)	P value
Mercury (μg/g creatinine)			
Mean	8.24	2.00	<0.001*
Standard deviation	1.89	0.11	
Range	2.00–22.84	1.00–10.00	

*Significant at P value of <0.05.

Determination of Mercury Exposure among Dental Health Workers in Nakhon Si Thammarat Province, Thailand (Con' t)

TABLE 5: Multiple linear regression of dietary habit, occupational life style, PPEs used, and personal hygiene behaviors on urinary mercury levels in dental health personnel.

Parameters	Regression coefficient	SE	P value
Position (dentists, dental hygienist, and dental assistants)	0.0005	0.0002	0.082
Duration of work (more than 5 yrs versus less than 5 yrs)	0.0024	0.0010	0.011*
Mask using (yes versus no)	−0.0477	0.0118	<0.001*
Glove using (yes versus no)	−0.0259	0.0193	<0.001*
Snack eating/water drinking at work (always versus sometimes)	0.1470	0.0294	0.054
Hand washing before lunch (always versus sometimes)	−0.0483	0.0114	<0.001*
Hand washing after work (always versus sometimes)	−0.0479	0.0159	0.0001*
Dietary habit (fish and seafood consumption; ≤3 times/month versus ≥3 times/month)	0.0026	0.0015	0.013*

*Significant at P value of <0.05.

Mercury levels in urine and head hair of dental personnel

Saengsirinavin C , Pringsulaka P
The Journal of the Dental Association of Thailand [1988, 38(4):170-179]

- Urine and head hair samples were collected from 201 dental personnel and 57 unexposed controls for mercury analysis
- The mercury content was analyzed by using cold vapor atomic absorption spectrophotometry
- **The results showed that mercury levels in the urine and head hair of dental personnel were significantly higher than in the controls (*p* less than 0.01)**
- **The amounts of urine mercury from dental assistants, dentists and dental students were 81.0%, 38.2% and 43.5% higher than the threshold limit value respectively.**
- The mean head hair mercury levels found in dental assistants, dentists, dental students and dental technicians were 10.1 +/- 0.84, 7.5 +/- 1.2, 6.5 +/- 1.54 and 2.8 +/- 0.53 micrograms/g respectively
- The mean head hair mercury concentration of unexposed controls ranged from 0.3-12.2 micrograms/g (means = 2.8 +/- 0.36 micrograms/g).




E-Waste

There are more than 100 sites of E waste separator in Thailand

E waste

- E-waste is defined as computer central processing units, monitors, televisions, cell phones and other digital devices.
- The rapidly increasing number of e-waste has the potential to create serious consequences for human health and environmental quality because hazardous chemicals are used in components of electrical and electronic devices that can release into the soil, water supplies, and evaporate into the air when these electronic wastes are placed into landfills or incinerators

Heavy Metal in e waste business in Kokesa-ard , Kalasin Province (Asia Foundation)

Heavy Metal	Heavy metal founded (mg/Kg)	Standard in housing soil (mg/Kg)
Mercury (Hg)	0.70	23
Lead (Pb)	79,520	400
Cadmium (Cd)	1.46	37
Nickle (Ni)	75.2	1,600
Manganese (Mn)	1,519	1,800

Area	Study	Year	Soil	Copper	Lead	Zinc	Cadmium	Nickle	Manganese	Chromium	Arsenic
Tumbon Koksa-ard Kalasin Province	Penshomet al. (2009)	2008	Waste treatment area	39,161	**79,520**	-	1.46	75	**1,519**	-	-
	Suwanampai (2011)	2010	Waste Buying and separating	-	**26,649**	-	6.16	619	**3,340**	-	**151**
	Environment office area 10	2014	Tamboon Waste treatment area	8,671	**2,636**	11,890	12	118	-	44	**9.6**
			Waste Buying and separating	9,267	**1,388**	580	3.3	27	-	18	**6.0**
Thai Standard				-	**400**	-	37	1,600	**1,800**	300	**3.9**

Study about soil contamination in e waste separating area in Kalasin Province (mg/Kg)

Nielloware workers

Biomonitoring of heavy metals among nielloware workers in Nakhon Sri Thammarat Province.

Decharats S[1], Kongtip P, Phakthongsuk P, Worakhunpiset S, Thetkathuek A, Tharnpoophasiam P.

- A cross-sectional study was conducted by interviewing 45 nielloware workers and 45 matched nonexposed persons living in the municipality of Nakhon Si Thammarat Province, Thailand. Blood and urine samples were collected to determine lead and mercury concentrations by atomic absorption spectrophotometer.
- The blood lead levels (7.30 microg/dl) and urinary mercury levels (3.30 microg/g creatinine) of the nielloware workers were significantly higher than the control group ($p < 0.001$).

Biomonitoring of heavy metals among nielloware workers in Nakhon Sri Thammarat Province.

Decharats S[1], Kongtip P, Phakthongsuk P, Worakhunpiset S, Thetkathuek A, Tharnpoophasiam P.

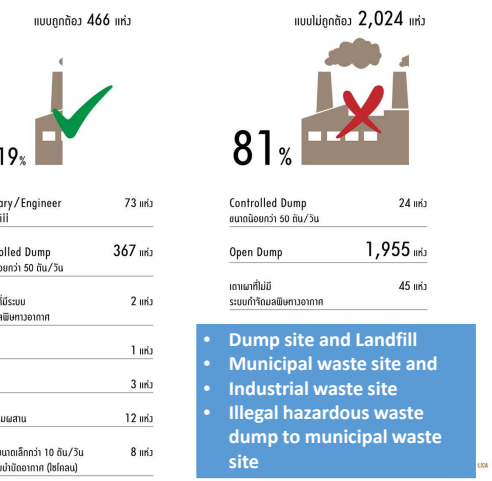
- The nielloware workers developed acute and chronic symptoms, such as headaches, rash, fatigue, tightness in the chest, loss of consciousness, abnormal tiredness and headache at least once a week and those who developed symptoms had significantly higher heavy metal levels than those who did not at $p < 0.05$.

Whitening Cream with Mercury contaminating

- Of the 47 face whitening products sampled from 8 provinces across Thailand, it was found that 1 in 5 of all face whitening creams sampled are contaminated with mercury. The highest level of contamination is 99,070 ppm, while the legal standard for cosmetic products in Thailand is 0ppm of mercury. Moreover, contaminated products contain incomplete labeling according to Thai law. In particular, none of the contaminated products reveal the “notification number” on product labels, meaning that these contaminated products do not exist in the Thai FDA’s database and cannot be traced to the manufacturer should consumers encounter problems from use.

Table 1 Analysis of Mercury Content in Face Whitening Cream

Code	Product Name	Mercury Content (ppm)	Price (baht)	Size	Purchase Location
W41	FC Rice Milk	99,070	40	5 g.	Surat Thani
W37	White Rose	51,600	189	6 g.	Songkhla
W44	Biocollagen	47,960	170	6 g.	Kalasin
W42	Meiyong	41,770	57	5 g.	Songkhla
W39	Best Beauty	34,430	80	5 g.	Samut Prakarn
W40	Pearl Bouncing Face	13,800	20	5 g.	Songkhla
W27	Nature	7,300	300	10 g.	Nonthaburi
W47	Madame	3,435	150	5 g.	Nonthaburi
W32	Babyface	81.14	40	5 g.	Internet
W35	Mahaad Moisturizing Cream	63.53	390	15 g.	Surat Thani
W01	Garnier	<0.05*	179	50 ml	Bangkok
W02	Nivea Day Cream	<0.05*	245	50 ml	Bangkok



INVESTIGATION ON TOXICITY AND HAZARDOUS NATURE OF A MUNICIPAL SOLID WASTE DUMPSITE

by

Romchat Rattanaoudom

A thesis submitted in partial fulfillment of the requirements for the degree of Master of Engineering
Inter-University Program on Environmental Toxicology, Technology and Management

Municipal treatments used in Thailand

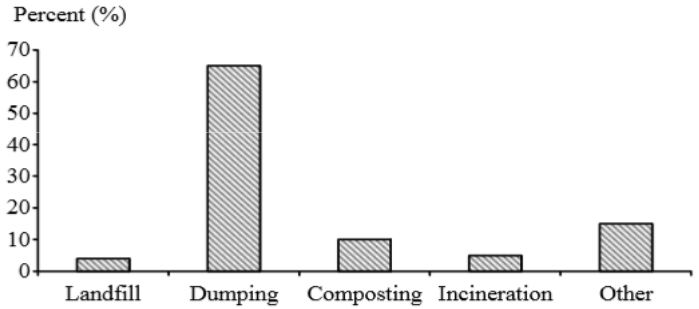


Figure 2.3: Municipal treatments used in Thailand (ARRPET, 2004b)

Table 4.3: The levels of heavy metal contained in TCLP extract comparing with TCLP limit (Toxicity Characteristics Leaching Procedure)

S. No.	S. Code	Hg (ug/L)	Cd (mg/L)	Pb (mg/L)	Cr (mg/L)	Ni (mg/L)	Zn (mg/L)	Cu (mg/L)
1	B 1	7.7	0.6	1.0	1.6	1.9	5.1	1.1
2	B 2	1.8	0.6	0.9	2.6	1.2	5.0	0.6
3	B 3	4.0	0.6	0.8	2.8	1.5	3.2	0.6
4	B 4	4.4	0.2	0.5	3.2	1.3	5.6	0.4
5	A 1	4.7	0.7	BDL	2.0	1.6	4.9	0.3
6	A 2	3.2	0.6	BDL	2.9	1.3	4.1	BDL
7	A 3	3.9	0.7	1.2	3.5	1.5	5.6	1.1
8	A 4	3.7	0.4	1.1	4.0	0.3	6.0	0.4
9	A 5 (4.5m)	-	0.4	BDL	BDL	BDL	1.2	BDL
10	A 6 (4m)	-	0.4	BDL	BDL	BDL	2.7	BDL
11	A 7 (4m)	-	0.4	BDL	BDL	BDL	5.4	BDL
TCLP Regulatory Level[a]		200	1	5	5	20	250	25

[a] source: PSS, 2001

Table 4.7: The concentration of heavy metals contained in soil cover samples of dumpsite

Sample Code	Hg (mg/kg)	Cd (mg/kg)	Pb (mg/kg)	Cr (mg/kg)	Ni (mg/kg)	Zn (mg/kg)	Cu (mg/kg)
Reference point	0.08	BDL	11.9	BDL	5.25	10	18.5
SC 1	6.8	BDL	261.5	130.7	46.1	289.2	404.1
SC 2	1.6	BDL	15.0	94.2	8.4	49.0	32.4
SC 3	2.5	BDL	23.1	70.7	4.4	112.8	37.9
SC 4	2.9	BDL	BDL	32.6	BDL	64.0	7.9
SC 5	1.2	BDL	4.1	147.6	13.7	28.7	6.6
SC 6	2.6	BDL	182.8	73.8	66.9	278.1	423.0
Germany Std[a]	0.1-1	0.4-1.5	40-100	30-100	15-70	60-200	20-60
France[a]	1	2	100	150	50	300	100
Netherlands Std[a]	0.5	0.5	40	30	15	100	40

BDL means Below Detection Limit

[a] source: Compost-Consulting Development, 2004

Mercury Exposure among Garbage Workers in Southern Thailand

Somsiri DECHARAT
Department of Industrial Hygiene and Health Science, Faculty of Health and Sport Science, Thaksin University, Phattalung, Thailand

- : A case-control study was conducted by interviewing 60 workers in 5 hazardous-waste-management factories, and 60 matched non-exposed persons living in the same area of Southern Thailand. Urine samples were collected to determine mercury levels by cold-vapor atomic absorption spectrometer mercury analyzer.

Mercury Exposure among Garbage Workers in Southern Thailand

Somsiri DECHARAT
Department of Industrial Hygiene and Health Science, Faculty of Health and Sport Science, Thaksin University, Phattalung, Thailand

- The hazardous-waste workers' urinary mercury levels (10.07 μg/g creatinine) were significantly higher than the control group (1.33 μg/g creatinine) ($p < 0.001$).
- Work position, duration of work, personal protective equipment (PPE), and personal hygiene, were significantly associated with urinary mercury level ($p < 0.001$).
- The workers developed acute symptoms - of headaches, nausea, chest tightness, fatigue, and loss of consciousness at least once a week - and those who developed symptoms had significantly higher urinary mercury levels than those who did not, at $p < 0.05$.
- A multiple regression model was constructed. Significant predictors of urinary mercury levels included hours worked per day, days worked per week, duration of work (years), work position, use of PPE (mask, trousers, and gloves), and personal hygiene behavior (ate snacks or drank water at work, washed hands before lunch, and washed hands after work).

Mercury Contamination in Economic Aquatic Species in Songkhla Lake

Sutarat Sukapan1 Penjai Sompongchaiyakul1,* and Somkiat Khokiattiwong2

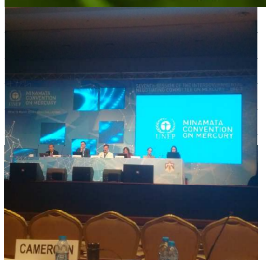
- The concentration of mercury in edible tissue of economic aquatic species in Songkhla Lake is not exceed the maximum residue limit as recommended by WHO and Ministry of Public Health of Thailand. Although the mercury level of fishery resources in Songkhla Lake is currently not yet reaching an upper threshold that creates an acute toxicity, accumulation of mercury via food chain may result in a high risk to the consumers.

Environmental Contamination

- Mercury accumulated in Fish and human higher than safety level in Tah-toom Industrial estate Ampor Srimahaphor,Prachinburi Province.
- Analylsis of Fish in Klong Chalongwang and hair of residence near Coal-fired power plant and Paper mill, founded that Mercury contaminated in fish 3-11 times higher than safety limit and for those who lived within 2 km. and ate fish had mercury in head hair more than safety level

Environment and Climate Change Canada | Environnement et Changement climatique Canada

Canada



Update on the Minamata Convention Monitoring and Effectiveness Evaluation

Dr. Alexandra (Sandy) Steffen
Air Quality Research Division
Science and Technology Branch

Minamata Convention on Mercury

Objectives of the convention

To protect the human health and environment from anthropogenic emissions and release of mercury and mercury compounds

In October 2013, the Minamata Convention on Mercury (led by the United Nations Environment Programme) was opened for signature and has been signed by 128 governments

- ✓28 countries have ratified the convention
- ✓50 countries required to come into force
- ✓Expectation of a spring 2017 ratification
- ✓First Conference of Parties meeting fall 2017

Article 19: Research, Development and Monitoring

1. Parties shall endeavour to cooperate to develop and improve…
   b) Modelling and **geographically representative monitoring of levels of mercury and mercury compounds** in vulnerable populations and in environmental media…
   c) Assessments of the impact of mercury and mercury compounds on human health and the environment…
   d) **Harmonized methodologies for the activities** ….
   e) **Information on the environmental cycle, transport (including long-range transport and deposition), transformation and fate of mercury and mercury compounds in a range of ecosystems**

2. Parties should, where appropriate, **build on existing monitoring networks and research programmes** in undertaking the activities…

Article 22: Effectiveness evaluation

1. The Conference of Parties (COP) **shall evaluate the effectiveness of this convention**, beginning no later than six years after the sate of entry into force of the Convention…

2. To facilitate the evaluation the COP shall, at its first meeting, initiate the establishment of the arrangements for providing itself with **comparable monitoring data** on the presence and movement of mercury and mercury compounds in the environment as well as trends in levels of mercury and mercury compounds observed in biotic media and vulnerable populations.

3. The evaluation **shall be conducted on the basis of available scientific,** environmental, technical, financial and economic **information**…

Intergovernmental Negotiating Committee (INC7)

- To prepare for entry into force of the Minamata Convention of Mercury and for the first meeting of the Conference of Parties to the Convention
- Dead Sea, Jordan March 10-15, 2016
- Contact group met to discuss Article 22 – Effectiveness Evaluation and first steps in preparation of COP1
- Japan and US presented a conference room paper (CRP) (4) "*Thought Starter on mercury monitoring and the effectiveness evaluation"*
- Canada, US and Japan presented a CRP (15) "*DRAFT TERMS OF REFERENCE FOR A TECHNICAL EXPERT GROUP ON THE EFFECTIVENESS EVALUATION"*
- Submission from a contact group was accepted by the INC7

Outcomes from contact group

Submitted to INC7 by the co-chairs on reporting and effectiveness evaluation in relation to effectiveness evaluation:

A plan to assist the Conference of the Parties in initiating the establishment of arrangements for **providing comparable monitoring data to facilitate the effectiveness evaluation**

Mindful that the effectiveness evaluation includes all elements covered in paragraph 3 of article 22, the intergovernmental negotiating committee requests the secretariat, in consultation with national Governments, regional and subregional monitoring programmes and partnerships, the World Health Organization, regional representatives, regional and national institutions, academia, industry, civil society and others as appropriate, to:

Outcomes from contact group (cont…)

a) Compile information on existing monitoring programmes and how they can contribute to an overall monitoring approach, including availability of baseline information

Each country has been asked by the UNEP Secretariat to provide this information for compilation

Outcomes from contact group (cont…)

b) Develop a draft road map to include but not be limited to:

- *(i) Development of an outline of types of data that could be comparable on a regional basis, as well as their availability;*
- *(ii) Creation of a draft framework for a global monitoring approach to integrate comparable results of future monitoring that countries and stakeholders may choose to undertake;*
- *(iii) Development of a draft strategy for incorporating reports and other monitoring information that can be considered for evaluation of the Convention's effectiveness.*

Outcomes from contact group (cont…)

c) **Draft a report with recommendations on the establishment of arrangements for providing comparable monitoring data** on the presence and movement of mercury and mercury compounds in the environment as well as trends in levels of mercury and mercury compounds observed in biotic media and vulnerable populations, as provided for in paragraph 2 of article 22, including references for assessing baselines.

UNEP Secretariat request

Received April 28, 2016

Submissions requested September 15, 2016

Article 22 - Effectiveness evaluation

Governments, regional and subregional monitoring programmes and partnerships, the World Health Organization, regional representatives, regional and national institutions, academia, industry, civil society and others as appropriate are invited to submit to the interim secretariat **information on existing monitoring programmes and how they can contribute to an overall monitoring approach, including availability of baseline information.**

They are further invited to **provide contact details for any individual whom they would designate to participate in consultations** conducted via electronic means for the development of a roadmap as well as a report on effectiveness evaluation.

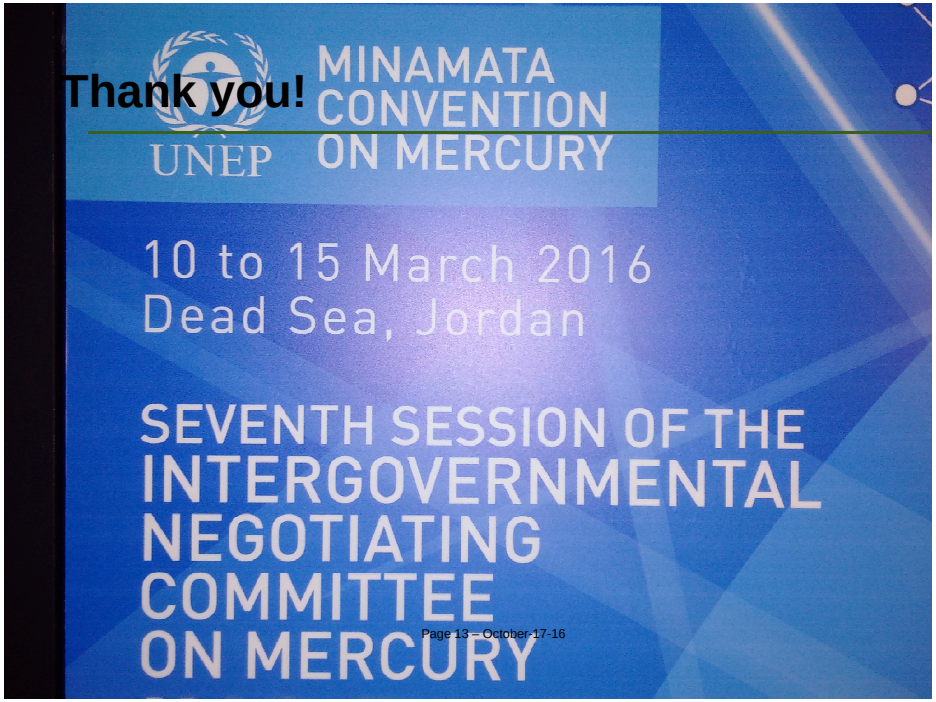
Where can APMMN fit into EE for Minamata?

- ✓ Regional representation
  - ✓ Regional monitoring and data
  - ✓ Technical expert group to define and shape EE plans
- ✓ Effectiveness will likely include measurement of decreases in environmental media based on reductions of anthropogenic emissions – monitoring Hg in air
  - ✓ Use this as a platform to build on
  - ✓ Data comparability
  - ✓ Data availability
  - ✓ Monitoring/research
  - ✓ Capacity building

Moving forward

- UNEP secretariat does not currently have the mandate for a full consultation process at this time, they will develop a very high level roadmap on EE for discussion at COP-1
  - Provide input to UNEP on roadmap
- Need to establish a mandate at COP-1 for a technical expert group
- Work together on data comparability and network integration in preparation for an EE plan
- Global Mercury Assessment underway
  - Have regional input into the document
  - Assess what baselines can be used for what media and time frame

Thank you!


UNEP
MINAMATA CONVENTION ON MERCURY
10 to 15 March 2016
Dead Sea, Jordan
SEVENTH SESSION OF THE
INTERGOVERNMENTAL NEGOTIATING COMMITTEE ON MERCURY

Atmospheric Mercury Monitoring in Thailand

July 26, 2016

Air Quality and Noise Management Bureau
Pollution Control Department (PCD)

Atmospheric Mercury Monitoring in Thailand

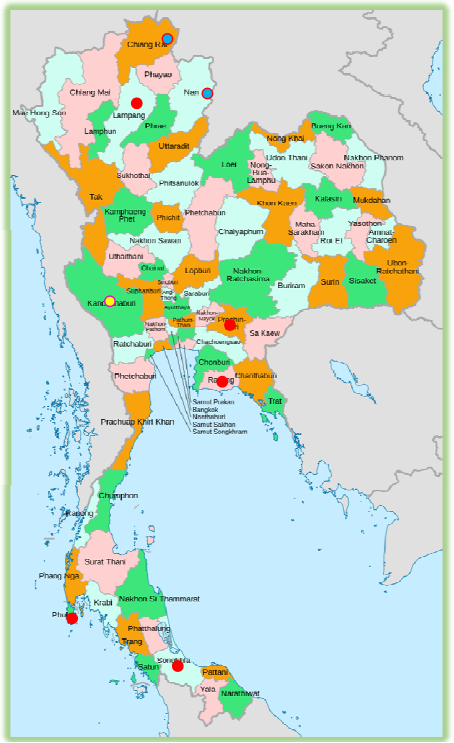
- Initial mercury monitoring plan: Total Gaseous Mercury (TGM) since November 2014
- Instrument: Tekran 2537 (installed in a mobile ambient air monitoring unit)
- Principle: Cold Vapor Atomic Fluorescence (CVAFS)
- Data base: 1-hr average

Objectives

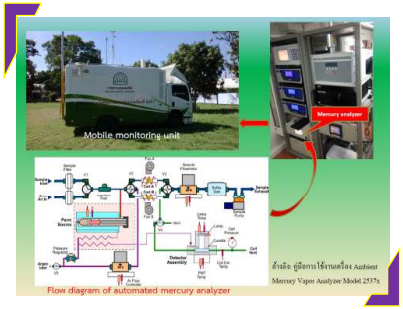
- Establish a baseline of ambient mercury level in Thailand,
- Provide the basis for the long term monitoring (permanent monitoring station),
- Evaluate long term atmospheric mercury trend from which to formulate policy,
- Report atmospheric mercury situation to the public,
- Support further implementation of the Minamata Convention in the future.

Monitoring plan (2014 - 2016)

- Temporary sites: monitoring period ≈2 weeks
- Classify sites:
  - *Industrial site* (*hot-spot site*): 5 sites near industrial sources such as coal-fired power plants, waste incineration facilities, oil refinery, gas separation plant; and pulp and paper industry.
  - *Background site* (*remote site*): 1 site in rural area
    - "Wachi Ra Long Kon Dam" at Kanchanaburi province.
- Special purposes
  - Monitor during haze episode
  - Baseline of transboundary mercury



Atmospheric Mercury Monitoring 2014 - 2016



Remark : ● Hot-spot sites ● Special purpose
○ Remote site

Monitoring period: 1-2 weeks/site

Preliminary Atmospheric Mercury Monitoring Results

Location (*near industrial sources*)	Monitoring period	Total Gaseous Mercury (TGM) 1-hr avg. (ng/m³)		
		Min.	Avg.	Max.
Industrial sites (hot-spot sites)				
1. Prachin Buri province (*sub-bituminous coal-biomass power plant, pulp and paper industry*)	18 Nov. - 1 Dec.2014	1.24	2.12	4.42
2. Rayong province Site1 (*oil refinery*) Site2 (*gas separation plant, power plant*) Site3 (*oil refinery*)	 2 - 25 Dec. 2014 17 Dec. 2015 - 4 Jan. 2016 7 - 28 Jan.2016	 1.12 0.72 0.78	 3.05 1.94 1.53	 9.26 8.02 2.91
3. Lampang province (*coal-fired power plant*)	14 Jan. - 17 Feb. 2015 15 Aug. - 13 Sep. 2015	0.83 0.56	1.55 0.99	8.23 3.01
4. Songkhla province (*waste incineration facility*)	23 Apr. - 1 May 2015 11 - 23 May 2016	0.90 0.36	1.92 1.39	2.97 4.42
5. Phuket province (*waste incineration facility*)	4 - 12 May 2015 26 May - 7 Jun. 2016	0.42 0.73	1.15 1.87	3.70 5.37
Background site (remote site)				
Kanchana Buri province	12 Sep. - 26 Dec. 2015 29 Mar. - 18Apr. 2016	0.36 0.72	0.77 1.29	1.14 2.20

Preliminary Atmospheric Mercury Monitoring Results (con't)

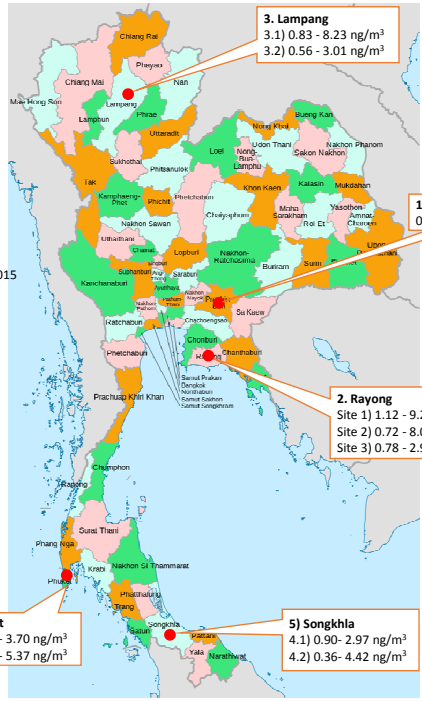
Location	Monitoring period	Total Gaseous Mercury (TGM) 1-hr avg. (ng/m³)		
		Min.	Avg.	Max.
Special purpose				
1. Nan province (baseline for transboundary mercury from nearby country)	19 Feb. - 25 Mar. 2015	0.85	1.66	3.39
2. Chiang Rai province (haze days during dry season) - Mae Sai district - Chiang Khong district	 10 - 17 Mar. 2016 18 - 24 Mar. 2016	 1.15 1.03	 3.23 3.63	 10.96 6.15

Preliminary atmospheric mercury range (min. - max.) in hot-spot sites (2014 - 2016)

3) Lampang province
3.1) 14 Jan. - 17 Feb. 2015, 3.2) 15 Aug. - 13 Sep. 2015

4) Phuket province
4.1) 4 - 12 May 2015, 4.2) 26 May - 7 Jun. 2016

5) Songkhla province
5.1) 23 Apr.- 1 May 2015, 5.2) 11 - 23 May 2016



1) Prachin Buri province
(18 Nov. - 1 Dec. 2014)

2) Rayong province
site 1) 2 - 25 Dec. 2014
site 2) 17 Dec. 2015 - 4 Jan 2016
site 3) 7-28 Jan. 2016

Challenge ahead

- Monitor in hot-spot area near cement clinker production facilities.
- Establish the permanent monitoring stations in urban, industrial, and background areas.
- Determine the mercury level during haze days in dry season

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Environmental Protection Administration
Executive Yuan, R.O.C. (Taiwan)

Taiwan's support to the Asia-Pacific Mercury Monitoring Network

July 26, 2016

Hung-Po Hsu
Department of Environmental Monitoring and Information Management

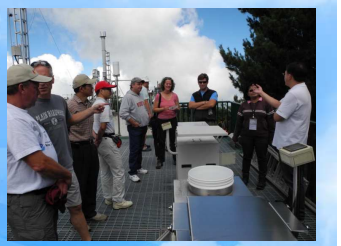
What is the Asia Pacific Mercury Monitoring Network (APMMN)?

- Making measurements of mercury in rainwater and air
- Using the same instruments and standard operating procedures across the region

The purpose of the APMMN is to expand coordinated mercury monitoring capacity in the region

- Determine status and trends of mercury in the ambient air and in wet, dry, and total atmospheric deposition
- Characterize the influence of mercury emissions sources on atmospheric mercury transport and deposition to sensitive areas
- Generate a database for regional and global modeling
- Assist partners in developing their mercury monitoring and assessment capabilities
  - Provide training and demonstration of mercury wet deposition sampling operations

2012 Atmospheric Mercury Monitoring Workshop (Taipei)

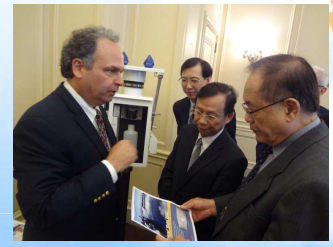


Participants
Canada, Indonesia, Japan, Korea, Taiwan, Thailand, and the U.S

Outcomes
Identified key monitoring gaps in the region

Articulated a need for a coordinated network to monitor mercury transport and deposition

2013 Mercury Monitoring Workshop (Washington D.C.)



Participants

·Canada, Indonesia, Japan, Korea, Taiwan, Thailand, Vietnam, and the U.S

Outcomes

·Agreement on major design elements of an operating mercury wet deposition pilot network for the region

·Established a science advisory group

·Devised a preliminary plan for deploying wet deposition collectors in Southeast Asia

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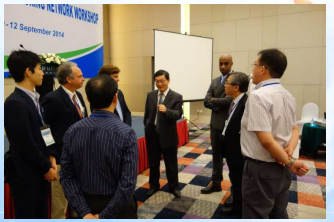
2014 Asia Pacific Mercury Monitoring Network Workshop (Vietnam)



Participants

- Canada, Hong Kong, India, Indonesia, Japan, Korea, Philippines, Taiwan, Thailand, Vietnam, and the U.S

Outcomes

- Completed SOPs for mercury wet deposition
- Proposed pilot sites in Thailand, Vietnam, and Indonesia
- Trained partners on wet deposition operations and atmospheric mercury measurements

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2015 Asia Pacific Mercury Monitoring Network Workshop (Japan)

Participants

- Bangladesh, Cambodia, Laos, Indonesia, Japan, Malaysia, Myanmar, Philippines, Mongolia, Sri Lanka, Taiwan, Thailand, Vietnam, and the U.S

Outcomes

- Mercury monitoring network pilot update
- APMMN website and wet deposition technology transfer center
- Network expansion plans

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2016 Atmospheric Mercury Monitoring Workshop (Taiwan)

Participants

- Bangladesh, Cambodia, India, Korea, Japan, Mongolia, Taiwan, Thailand, Vietnam, and the U.S

Outcomes

- Mercury monitoring network pilot update
- To celebrate the grand opening of the Taiwan EPA and USEPA Center for Environmental Monitoring and Technology
- Demonstration of mercury wet deposition sampling operations.

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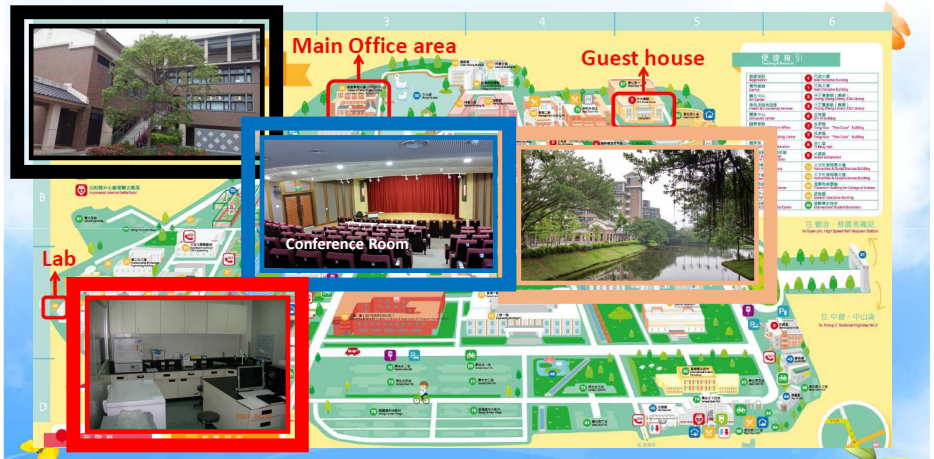
Center for Environmental Monitoring and Technology (NCU Campus)



- Location of Lab, Office and Guest House on NCU Campus

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Center for Environmental Monitoring and Technology (NCU Campus)

- Wet Hg deposition sampling and analysis are currently underway with 3 sites in Vietnam, Thailand and Indonesia.
- Hg Lab serves as the regional center for ultra-trace level Hg analysis, training to help analyze rain water samples and some atmospheric Hg samples.
- Train researchers from other Asian countries for capacity building of ultra-trace level Hg sampling and analysis.

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Instruments at the Lulin station

	Instrument, Manufacturer, Model
Aerosols	**Model**
Particle mass concentration	TEOM Particulate mass monitor, R&P 1400 (PM_{10}, $PM_{2.5}$)
aerosol chemical components	Aerosol sampling, R&P, 3500
	Aerosol sampling, R&P, 2025D
NOAA CPD aerosol system	PSAP,TSI 3010 CPC, TSI 3563 intergrating nephelometer
Radiation	**Model**
7 spectral channels	Sunphotoneter, Cimel, CE-318
6 spectral channels	Shadow band, Yankee, MFR-7
UVA	UVA, Solar Light, MODEL 501
UVB	UV-Biometer, Solar Light,
Total flux	Solar radiation sensor, MetOne, 96-1
	Kipp&Zonen CMP-21 pyranometer
	Kipp&Zonen CGR-4 pyrgeometer
Direct sun radiation	Kipp&Zonen CH-1 pyrheliometer
Gas	**Model**
O_3	Ozone analyzer, Ecotech, ML9810B
CO	CO monitor, TraceAnalytical, TA-3000R
	CO monitor, Horiba, APMA-360
CO_2	CO_2 analyzer, LI-COR, LI-7000
Oxides of Nitrogen	Oxides of Nitrogen analyzer family, ECOTECH, EC9841T (NO_x), EC9842 (NH_3), EC9843 (NO_y)
SO_2	Trace SO2 analyzer, ECOTECH, EC9850T
CFCs	Gas Chromatography, Agilent, HP6890N
Air sampling	NOAA/ESRL/GMD CCGG flask sampler
Mercury	**Model**
Gaseous Elemental Mercury	Cold Vapor Atomic Fluorescence Sepectrometry,Tekran,
Reactive Gaseous Mercury	Mercury Speciation Unit, Tekran, 1130
Particulate Mercury	Particulate Mercury Unit, Tekran, 1135
Precipitation chemistry	**Model**
Rainwater sample	Rain sampler
Met.	**Model**
Visibility	Present Weather Detector, VAISALA, PWD22
Meteorological Monitoring System	MetOne (Temp., Humidity, Press., Rain, Wind)

Many thanks for your attention!

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Update on the APMMN and Progress on Wet Deposition Sample Analysis

Guey-Rong Sheu

Department of Atmospheric Sciences
National Central University
Taiwan

Update on the APMMN: Center for Environmental Monitoring and Technology

Background

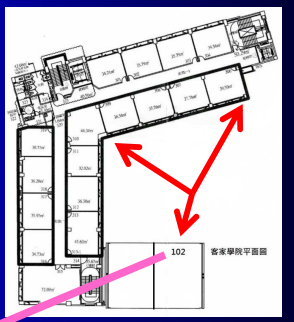
- NCU has been working closely with Taiwan EPA, USEPA and NADP since 2012 to establish the collaborative Asia-Pacific Mercury Monitoring Network (APMMN).

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 of ultra-trace level Hg sampling and analysis
  - However, lab space and analytical equipment are limited
  - 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

Administrative Area: Hakka Studies Building



	Area (m^2)
Room 102	66.14
Room 306	39.50
Room 307	37.76
Room 308	37.76
Room 309	36.56
Total	217.22

Administrative Area: Hakka Studies Building

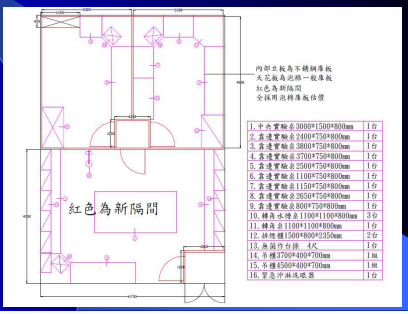
3rd floor offices and meeting rooms

Meeting room

Visitor's office

Staff's office

Lab Space and Equipment Expansion



Lab Space and Equipment Expansion

Area of the new analytical lab = 145.35 m^2

Guest House on NCU Campus

- All double rooms with three room sizes: 17.8 m^2, 22.4 m^2, and 36.4 m^2.

Type	General Price	Discount Price
17.8 m^2	NT 1100/D	NT 550/D
22.4 m^2	NT 1200/D	NT 600/D
36.4 m^2	NT 1800/D	NT 900/D

2016 Atmospheric Mercury Monitoring Workshop at NCU in June

Progress on Wet Deposition Sample Analysis

Commonly Used Units for Trace and Ultra Trace Components

Name of concentration unit	*Part per thousand*	*Part per million*	*Part per billion*	*Part per trillion*	*Part per quadrillion*	*Part per quintillion*	*Part per sextillion*
Volume/volume concentration	vpth (ppth v/v)	vpm (ppm v/v)	vpb (ppb v/v)	vpt (ppt v/v)	vpq (ppq v/v)	vpq_{ui} (ppq_{ui} v/v)	vps (pps v/v)
Mass-mass concentration	ppth	ppm	ppb	ppt	ppq	ppq_{ui}	pps
Percentage (%)	10^{-1}	10^{-4}	10^{-7}	10^{-10}	10^{-13}	10^{-16}	10^{-19}
Amount of analyte in 1 g sample	1 milligram (1 mg)	1 microgram (1 µg)	1 nanogram (1 ng)	1 picogram (1 pg)	1 femtogram (1 fg)	1 attogram (1 ag)	1 zeptogram (1 zg)

Concentration of major ions in rainwater.

Concentration of Hg and MeHg in rainwater and ambient air.

Analytical Methods and Detection Levels

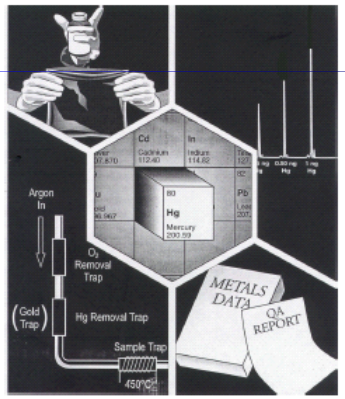
Method Source	Method Number	Media Name	Instrumentation	Detection level
EPA-NERL	245.1	WATER	CVAA	0.2 ug/L
EPA-NERL	245.2	WATER	CVAA	0.2 ug/L
EPA-OSW	7470A	VARIOUS	CVAA	0.2 ug/L
USGS	I-2462	WATER	CVAA	0.1 ug/L
USGS	I-1462	WATER	CVAA	0.5 ug/L
USGS	I-5462	OTHER	CVAA	0.5 ug/L
USGS	I-7462	WATER	CVAA	0.5 ug/L
USGS	I-3462	WATER	CVAA	0.5 ug/L
NOAA_NST	131.01	ANIMAL TISSUE	CVAA	0.012 ug/L
NOAA_NST	131	SOIL/SEDIMENT	CVAA	0.012 ug/L
EPA-EAD	1631	WATER	CVAFS	0.0002 ug/L
EPA-OSW	6010 C	VARIOUS	ICP-AES	17 ug/L
EPA-NERL	200.7	WATER	ICP-AES	7 ug/L
EPA-NERL	200.8	WATER	ICP-MS	0.2 ug/L
ASTM	D6502	WATER	XRF	1 ug/L

CVAFS: Cold Vapor Atomic Fluorescence Spectrometry

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



Rainwater Hg Analysis

- Total Hg is quantified by dual amalgamation CVAFS after BrCl oxidation, $NH_2OH \cdot HCl$ neutralization, and $SnCl_2$ reduction.

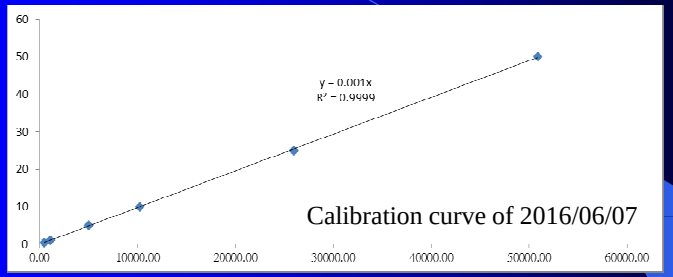
QA/QC: Method Detection Limit

The detection limit and minimum level of quantitation in this Method usually are dependent on the level of interferences rather than instrument limitations. The method detection limit (MDL; 40 CFR 136, Appendix B) for Hg has been determined to be 0.2 ng/L when no interferences are present. The minimum level of quantitation (ML) has been established as 0.5 ng/L. An MDL as low as 0.05 ng/L can be achieved for low Hg samples by using a larger sample volume, a lower BrCl level (0.2%), and extra caution in sample handling.

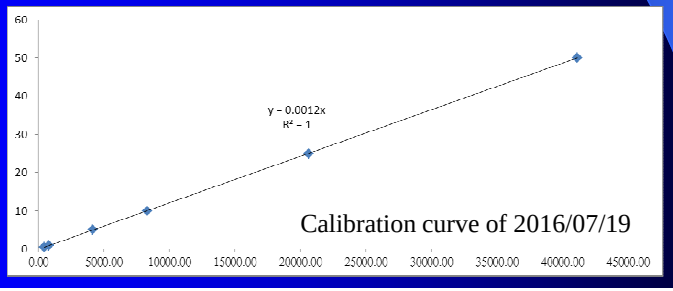
MDL of the NCU lab is 0.16 ng/L

QA/QC: Calibration Curve

R^2 of calibration curve > 0.999



Calibration curve of 2016/06/07



Calibration curve of 2016/07/19

QA/QC: Blanks of Jan.-April 2016

	Freqency	Mean (ng L^{-1})	Min. (ng L^{-1})	Max. (ng L^{-1})	1631 rev. E
System blank	12/12	0.01	0.00	0.08	< 0.5 ng L^{-1}
Bottle blank	12/12	0.09	0.00	0.4	< 0.5 ng L^{-1}

QA/QC: Duplicate Analysis and Matrix Spike

	Results of Jan.-April 2016
Duplicate analysis	0.1% - 1.9%
Matrix spike recovery	99.3 - 104.4%

QA/QC: Percent Recovery of CRM

ORMS-5

Elevated mercury in river water

ORMS-5 is a river water spiked with inorganic mercury. The material is packaged in 50 ml glass ampoules stabilized with 0.5% BrCl.

Table 1: Certified quantity value for ORMS-5

Element	pg/g
Hg	26.2 ± 1.3

	Frequency	Recovery(%)
Before 2015/11	9	88 ± 4
After 2015/11	8	100 ± 4

Rainwater Samples Received and Analyzed

Until 07/19/2016:

Site	Number of Samples
Indonesia	9
Korea-GIST	7
Korea-NIER	9
Thailand	68
Vietnam	20
Total	113

4 samples from Korea and 1 sample from Vietnam received last week will be analyzed soon.

Data Summary of Analyzed Samples

Number of Samples	Mean (ng/L)	Median (ng/L)	Min. (ng/L)	Max. (ng/L)
113	15.3	6.6	0.4	147.1

Summary of Rainwater Hg Conc. Worldwide

Location	Site characteristic	VWM conc. (ng L^{-1})	References
12 sites in Taiwan	Various	7.3-12.1	Lin et al., 2016
Equatorial Pacific Ocean	Open ocean	2.9	Mason et al., 1992
North Pacific Ocean	Open ocean	14.3	Laurier et al., 2003
Bermuda	Island	4.7	Gichuki and Mason, 2014
Long Marine Lab, CA, USA	Coastal (Pacific)	6.0	Steding and Flegal, 2002
Monterey Bay, CA, USA	Coastal (Pacific)	5.8	Conaway et al., 2010
CBL, MD, USA	Coastal (Atlantic)	11.4-15.0	Mason et al., 2000
Nam Co, China	High elevation	4.8	Huang et al., 2012
Mt. Leigong, China	Mountain	4.0	Fu et al., 2010
Chuncheon, Korea	Rural	8.8	Ahn et al., 2011
Pensacola, FL, USA	Urban/suburb	17.3	Landing et al., 2010
4 sites in Xiamen, China	Urban/suburb	11.4-14.0	Xu et al., 2014
Seoul, Korea	Urban	10.1-16.3	Seo et al., 2012
Nanjing, China (9 months)	Urban	52.9	Zhu et al., 2014
Chongqing, China	Urban	30.7	Wang et al., 2012
Moffett Field, CA, USA	Urban	11.6	Steding and Flegal, 2002
EMEP (2013)	Various	2.6-12.5	EMEP, 2015
107 sites in USA (MDN/NADP)	Various	1.6-25.8	NADP 2014 Annual Summary
10 sites in Japan (estimate)	Various	5.2-9.5	Sakata and Marumoto, 2005
10 sites in UK	Various	1.6-5.1	Rowland et al., 2010
2 sites in South Africa	Various	10.6-15.8	Gichuki and Mason, 2013
2 sites in Mexico	Various	7.9-8.2	Hansen and Gay, 2013


THANK YOU!
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