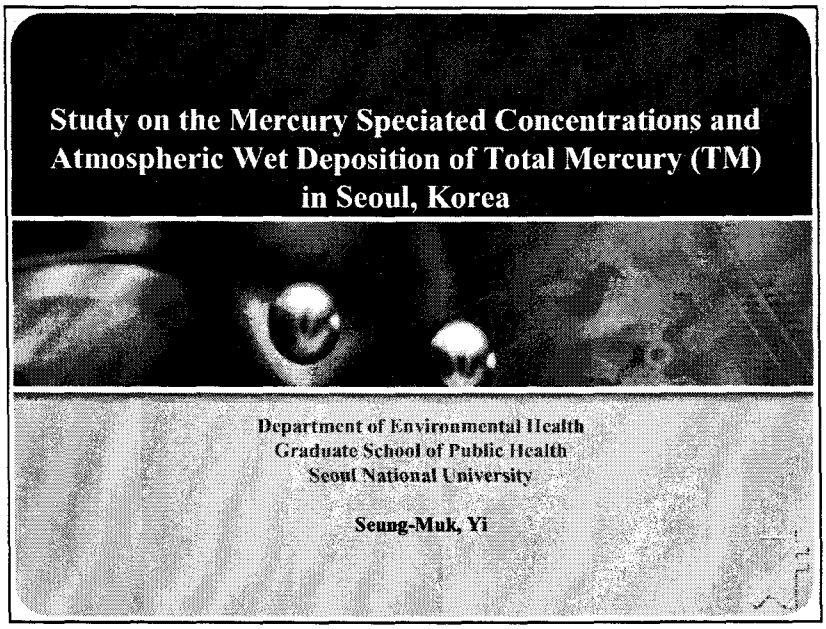
Study on the Mercury Speciated Concentrations and Atmospheric Wet Deposition of Total Mercury (TM) in Seoul, Korea
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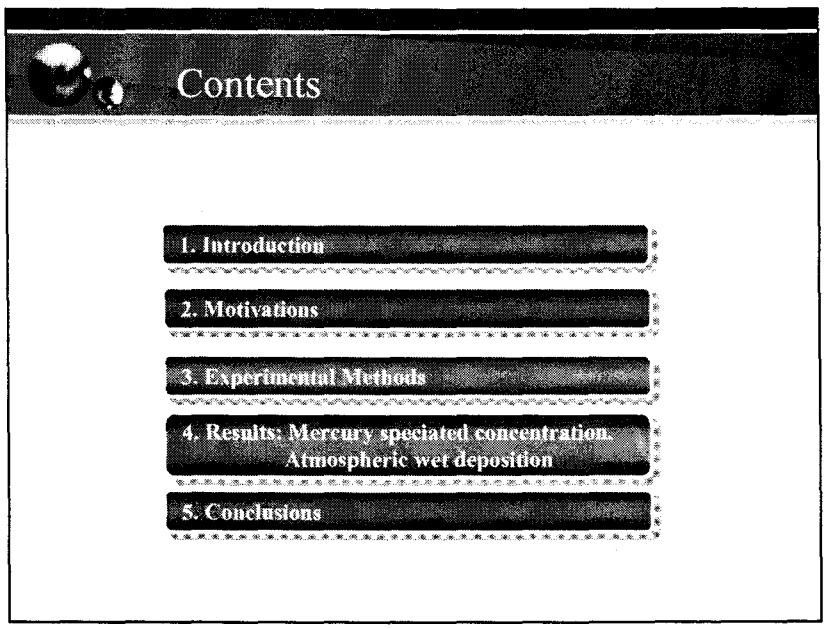
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5. Conclusions

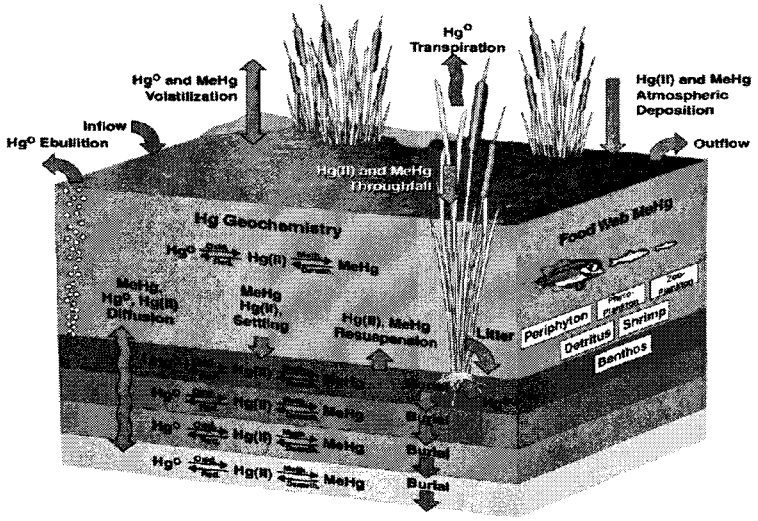
What is mercury??

- Mercury is a cationic metal : Excellent conductor of electricity
- Elemental Mercury (Hg^0) (2.55 tons/yr, U.S. 1999)
  - Predominant species, Long range transport
  - Residence time: 0.5 – 2 yrs.
  - Globally distributed
- Gaseous divalent mercury (Hg^{2+}) (1.50 tons/yr, U.S. 1999)
  - Oxidized mercury: Hg(II) : $HgCl_2$, other species?
  - Highly water soluble -> short atmospheric life time (1 – 2 days)
  - Local and Regional effects
- Particulate Mercury (Hg_p) (0.45 tons/yr, U.S. 1999)
  - Species largely unknown
  - Local and Regional Effects

Where does it come from??

- Natural sources: the mobilization or releases of geologically bound mercury by natural processes
- Anthropogenic sources (EPA, 1999) (2,143 - 2400 tons/yr)
  1. Coal-fired electric utilities (40%)
  2. Industrial boilers (10%)
  3. Hazardous waste incinerators (5%)
  4. Chlorine production (5%)
- Re-emitted mercury (2000 – 2134 tons/yr): previously deposited to the earth's surface by anthropogenic sources
- 2/3 of Hg atmospheric emissions (6,060 – 6,600 tons/yr) – direct or re-emitted anthropogenic sources

Where does it go??



How does mercury affect health??

- Methylmercury accumulates most efficiently in the aquatic food web (four times more efficient than inorganic Hg).
- Dominant exposure for human: Fish consumption
  - : Dietary methylmercury is almost completely absorbed into the blood.
  - : Freshwater fish: Walleye, Bass, Northern Pike
  - : Saltwater fish: Shark, Swordfish, Tilefish, Tuna
- Neurotoxicity – women of childbearing age
- Tremors, inability to walk, convulsions, death

What is EPA doing to reduce mercury emissions??

- **Final regulations for large municipal waste combustors were issued on October 31, 1995 → reduce by 88%**
- **Emission standards for medical waste incinerators were issued on August 15, 1997 → reduce by 95%**
- **Emission standards for hazardous waste combustors were issued on February 1999.**
- **Emission standards for chlor-alkali production were issued on August 27, 2003**
- **EPA wrote proposals that would reduce mercury emissions from coal power plant by 70% by 2018.**

Motivations

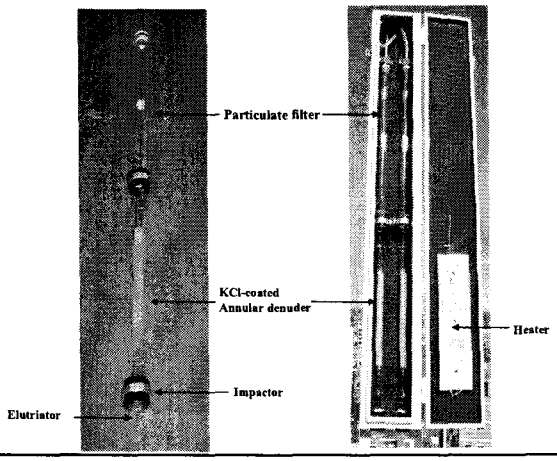
- Atmospheric mercury is origin of anthropogenic mercury.
- Mercury can transport in long range in atmosphere.
- Mercury pollution is not only local problem but also global problem because of the air.
- Measuring accurate mercury concentration in ambient air and finding out important atmospheric mercury sources are the first step to regulate mercury in environment.

Sampling Methods

Mercury species	Sampling site	Sampling period	Sampling methods
TGM	Roof of Graduate School of Public Health at SNU in Seoul Korea (37.514°, 127.001°, 17 m)	February 2005 – February 2006	CVAFS (Tekran Model 2537A)
RGM		June 2005 – February 2006	denuder (URG) coated with KCl
Hg_p (<2.5μm)			denuder (URG) with quartz fiber filter

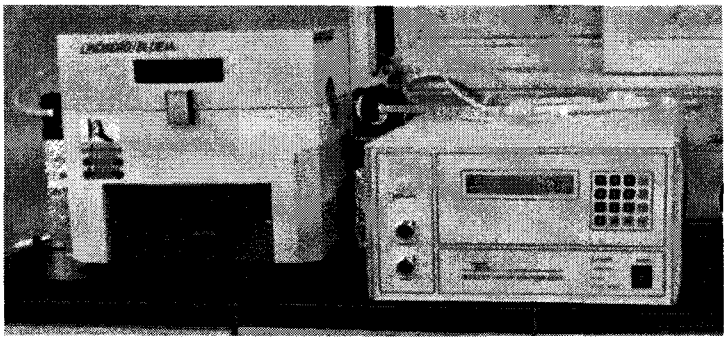
Sampling Methods

RGM, Hg_p denuder (left) and sampling box (right)



Mercury Analysis

Mercury species (TGM, RGM, and Hg_p) analysis



- **RGM and Hg_p: tube furnace (Lindberg 55035C) &CVAFS (Tekran Model 2537A)**

- **TGM : CVAFS (Tekran Model 2537A)**

Quality Assurance and Quality Control (QA/QC)

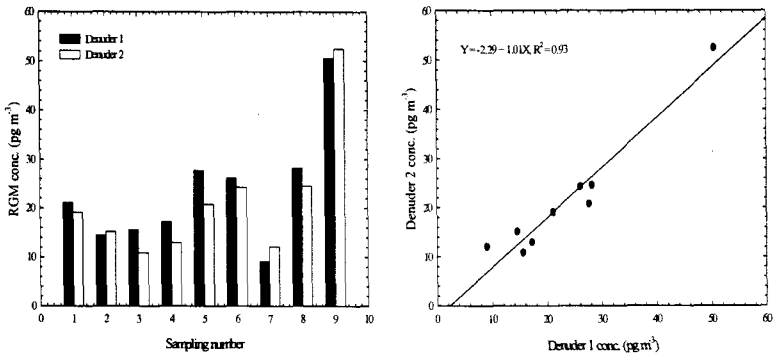
❑ TGM (Tekran 2537A)

- Internal permeation source calibration
  - ✓six steps: clean A, B, zero A, B and span A, B
  - ✓auto calibration interval was set every 24 hrs
- Zero test
  - ✓detection limit: 0.03 ± 0.29 ng m^{-3}
- Source calibration & manual calibration response factor
  - ✓overall precision: 0.038 ± 0.023%
- Span (spike) recovery
  - ✓96 ± 3%
- Recovery
  - ✓ 97 ± 3%

Quality Assurance and Quality Control (QA/QC)

❑ RGM

- **Side by Side:17.75 ± 12.41% (n=9)**

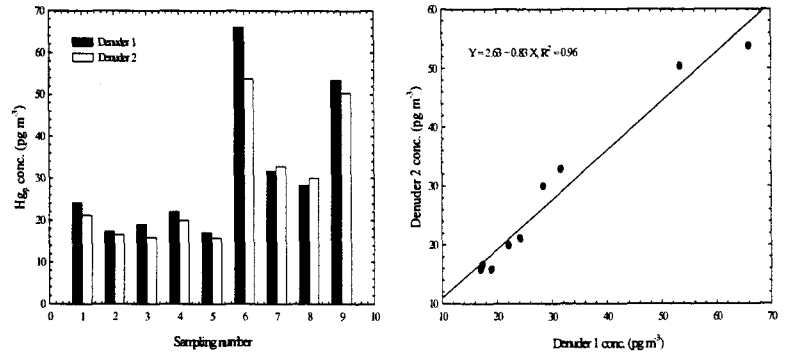


- **Field Blank : 1.4 ± 0.77 pg (n=5)**

Quality Assurance and Quality Control (QA/QC)

❑ Hg_p

- **Side by Side: 9.81 ± 6.08% (n=9)**



- **Field Blank: 1.05 ± 0.88 pg (n=5)**

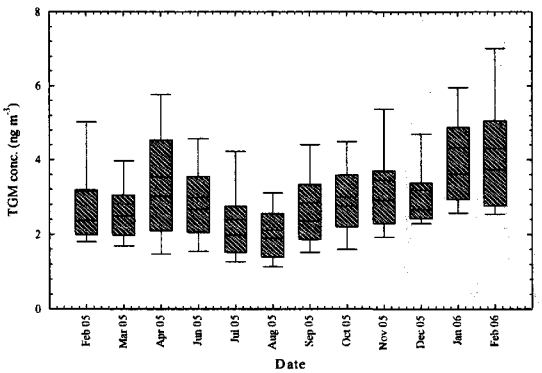
Result

Summary of TGM, RGM, and Hg_p concentrations measured in Seoul

	TGM [a] ($ng\ m^{-3}$)	RGM [b] ($pg\ m^{-3}$)	Hg_p [b] ($pg\ m^{-3}$)
Average	3.21	25.63	23.38
Median	3.14	14.41	19.31
SD	2.15	17.6	19.65
Sample number	25623	76	74

Result

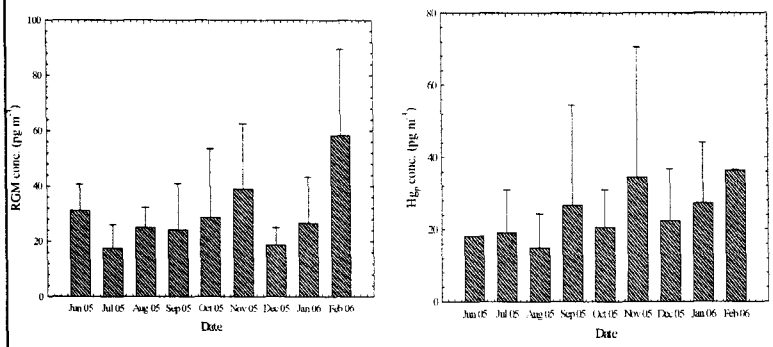
Monthly variations on TGM concentrations



Black lines: median; red lines: mean; upper edge of the box: 75th percentile; lower edge of box: 25th percentile; error bar above and below the box: 90th and 10th percentiles.

Result

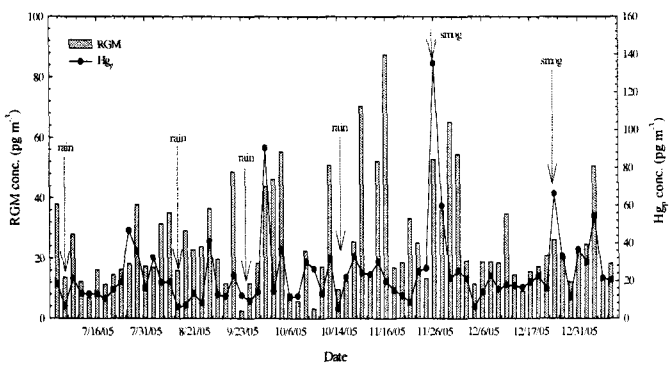
Monthly variations on RGM and Hg_p concentrations



Error bars indicate standard deviations for each month.

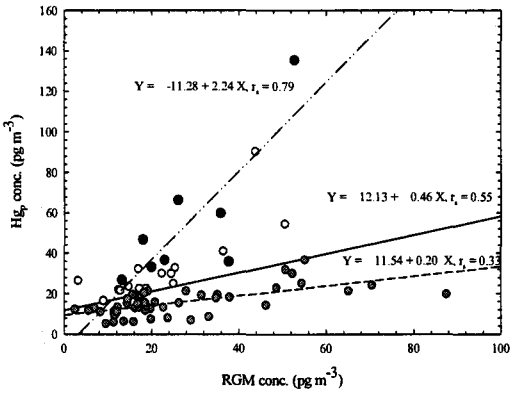
Result

Daily concentrations of RGM and Hg_p



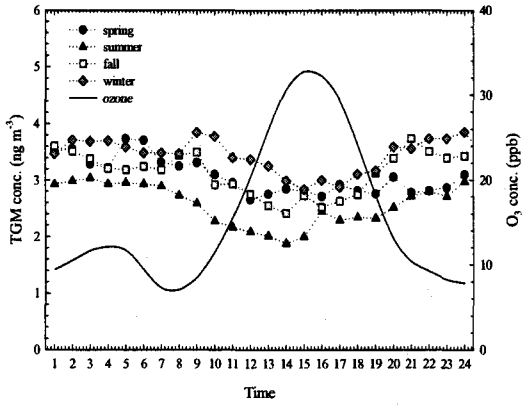
Result

Relationship between RGM and Hg_p concentrations



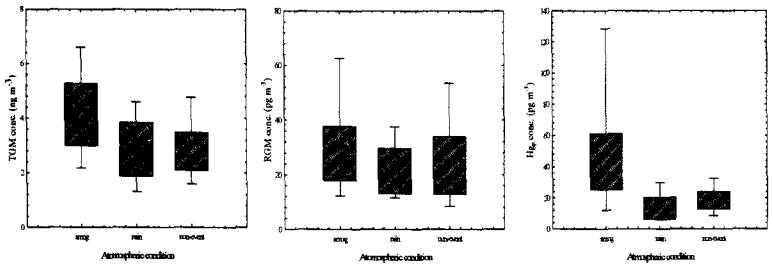
Result

Diurnal variations on TGM concentrations during four seasons



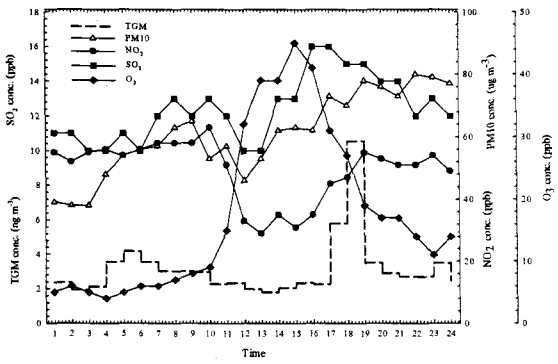
Result

TGM (left), RGM (middle), and Hg_p (right) distributions for different atmospheric conditions



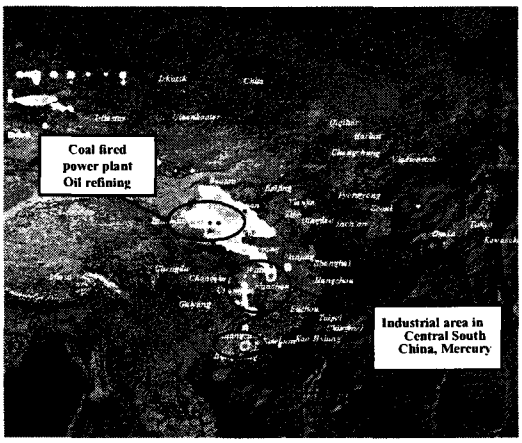
Result

Variations on TGM and other air pollutants during smog event (March 15, 2005)



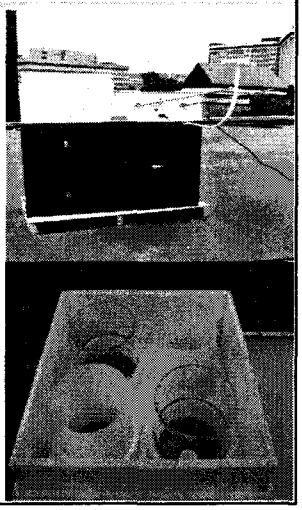
Result

Likely source areas of TGM using back-trajectory based PSCF



Sampling Methods

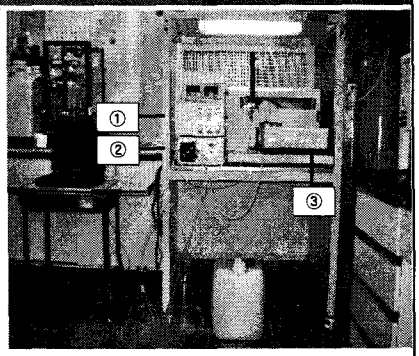
- Sampling Location : Roof of the School of Public Health building of Seoul National University
- Sampling Periods : February 2005 – January 2006
- Sampling Method : modified MIC-B sampler
  - 2 mercury sampling trains + 2 trace element sampling trains



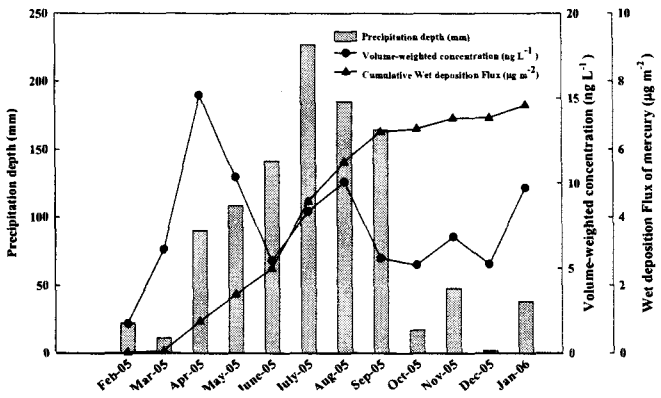
Analytical Method

- Sample Analysis
  - Tekran 2600 (CVAFS system)

① System Control Module
② Pump module
③ Auto sampler

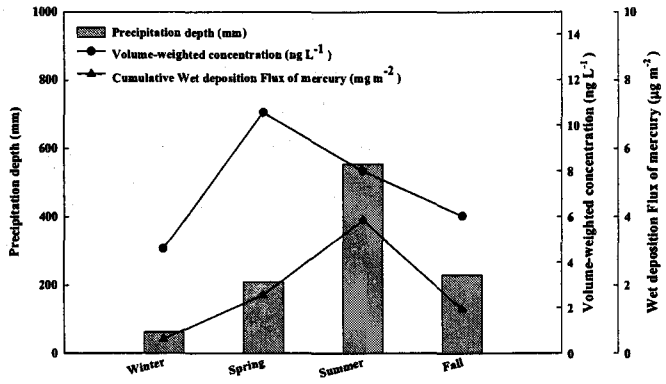


Result



Result

Seasonal Variations of Wet Deposition Flux of TM



Conclusions

❑ Trend in TGM, RGM and Hg_p concentrations distribution

- Monthly and Seasonal variations
  - ✓ TGM (ng/m^3): Winter (3.71 ± 2.54) > Summer (2.59 ± 1.48)
  - ✓ RGM & Hg_p (pg/m^3)

    Winter (23.94 ± 16.08, 24.76 ± 14.49, respectively) >
    Summer (21.45 ± 12.10, 17.54 ± 20.09, respectively)
- Diurnal variation
  - ✓ TGM (ng/m^3): Nighttime (3.31 ± 1.04) > Daytime (2.52 ± 1.31)
  - ✓ RGM & Hg_p (pg/m^3)

    Daytime (27.79±22.22, 29.14±24.53, respectively) > Nighttime (15.46±13.82, 17.23±13.62, respectively)

Conclusions

- **Relationships with meteorological condition & other pollutants**
  - Rain
    - ✓ RGM & Hg_p (pg/m^3)

      Rainy day (21.21± 9.99, 14.67± 8.31, respectively)
      < non rainy day (26.59 ± 18.93, 23.78 ± 19.39 , respectively)
  - CO, PM_{10}
    - ✓ TGM: CO ($r_s = 0.49$, $p < 0.01$), PM_{10} ($r_s = 0.24$, $p < 0.01$)
    - ✓ Hg_p: CO ($r_s = 0.41$, $p < 0.01$), PM_{10} ($r_s = 0.45$, $p < 0.01$)

Conclusions

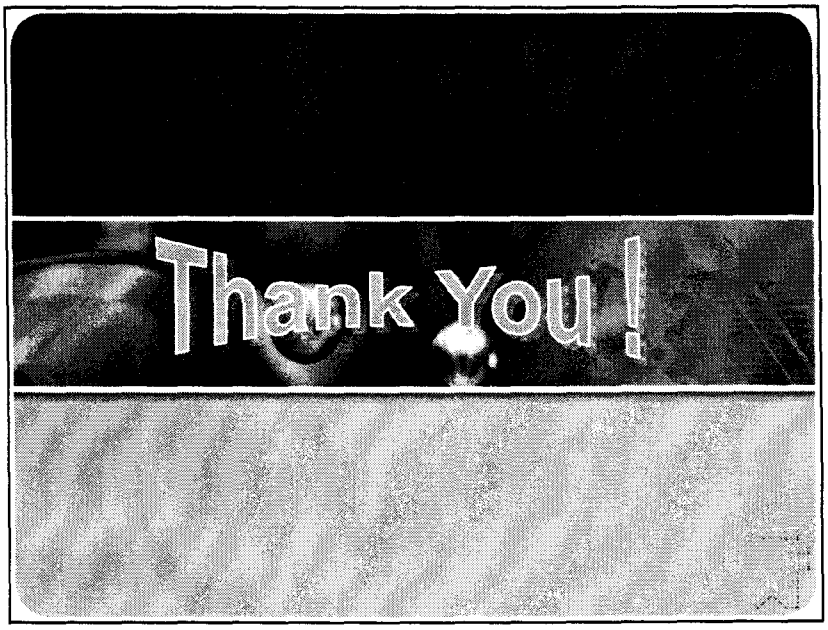
- **Relationships between smog event and mercury concentrations**
  - TGM (ng/m^3)
    - ✓ Smog event (4.32 ± 2.33) > Non smog event (3.09 ± 1.58)
  - Hg_p (pg/m^3)
    - ✓ Smog event (47.28 ± 36.30) > Non smog event (20.83 ± 13.61)
- **Likely source areas of TGM**
  - TGM: Industrial areas in China – Coal fired power plant, Oil refining

Conclusions

- **Average Volume-weighted Concentration of TM: 8.16 ± 6.27 ng/L**
  - **Maximum month: April (15.18 ± 12.83 ng/L)**
- **Cumulative wet deposition flux of TM: 7.30 mg/m^2**
  - **Maximum season: summer (3.90 μg/m^2)**
  - **A significant positive correlation between wet deposition flux and rainfall depth (r^2 = 0.68)**

Acknowledgement

☐ This work was supported by grant No. R01-2004-000-10890-0 from the Basic Research Program of the Korea Science & Engineering Foundation.


Thank You !