Hg emissions from a coal-fired power plant in North China and its environmental impacts

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Outline

1. Emissions and controls of Hg from the power plant
2. Hg in soils and air
3. Hg in the lake system
4. Conclusions

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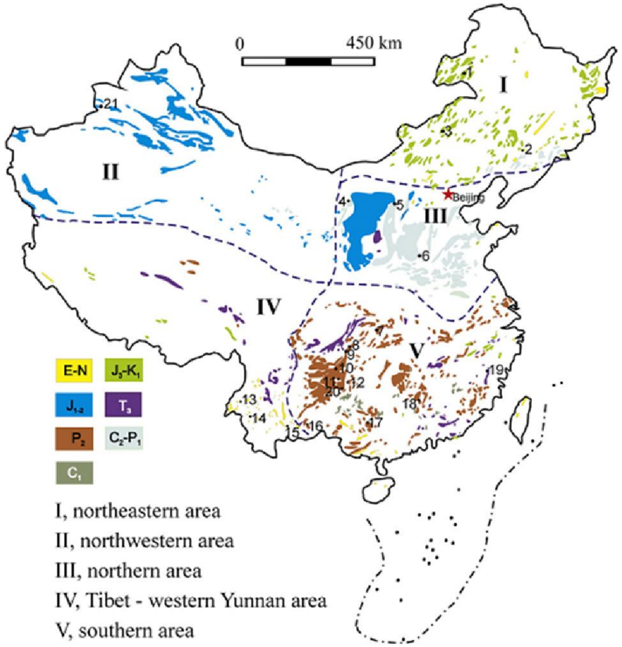
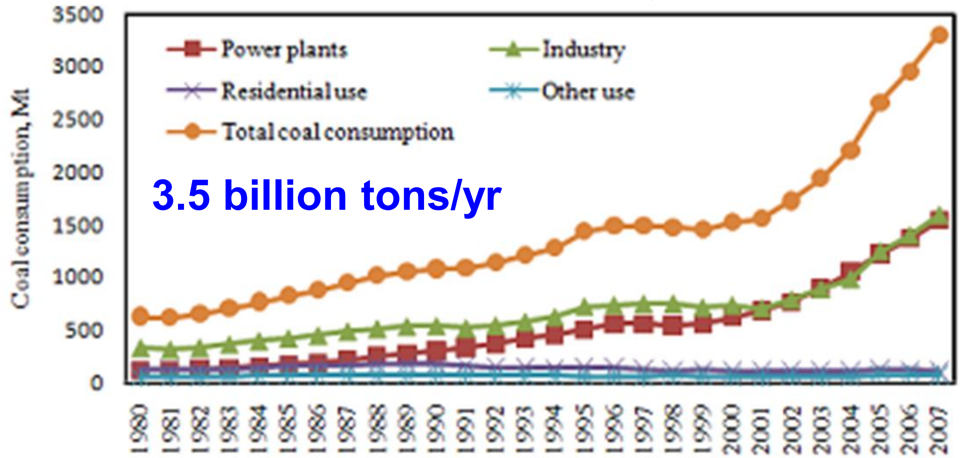
Background



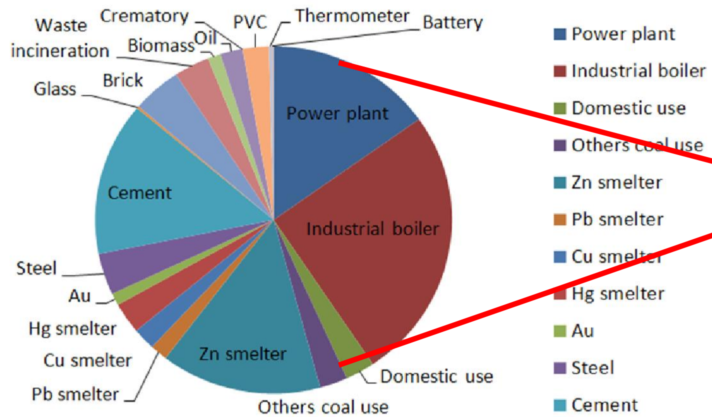
Dai et al., 2012 , Int. J. Coal Geol.

coal consumption in China:

50% of the world; 50% by power plants



3.5 billion tons/yr



Hg national emissions

coal combustion (45%)

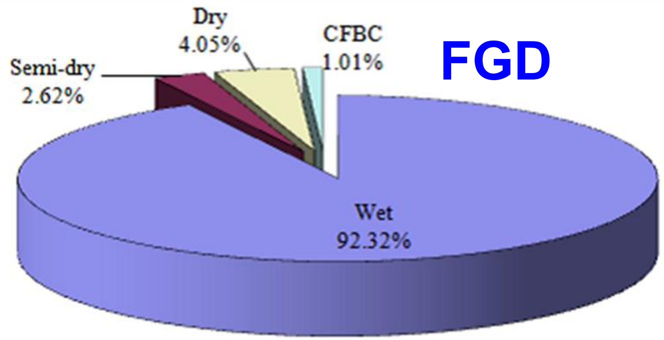
Background

Great changes in the air pollution control device (APCDs) for CFPP in the past 30 year!

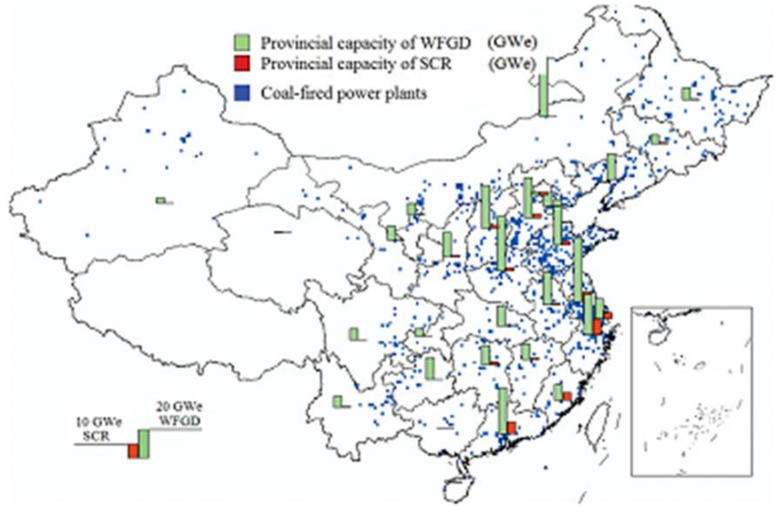
Fly ash: since 1980s, use electrostatic precipitator (ESP) to replace wet dust collector, and cyclone; by 2010, 96% power plant use ESP, and 6% with ESP+FF (fabric filter)

FGD: Flue gas desulfurization begin in 1990s, increased rapidly in the past 10 years (2005-2010), now almost 100% power plants installed FGD, with >90% in wet FGD

De-NOx: flue gas denitrification in 2010 is 14%, and projected to be 83% by 2015 (rapid growth in 2011-2015), of which, 90% is SCR (Selective Catalytic Reduction).



FGD



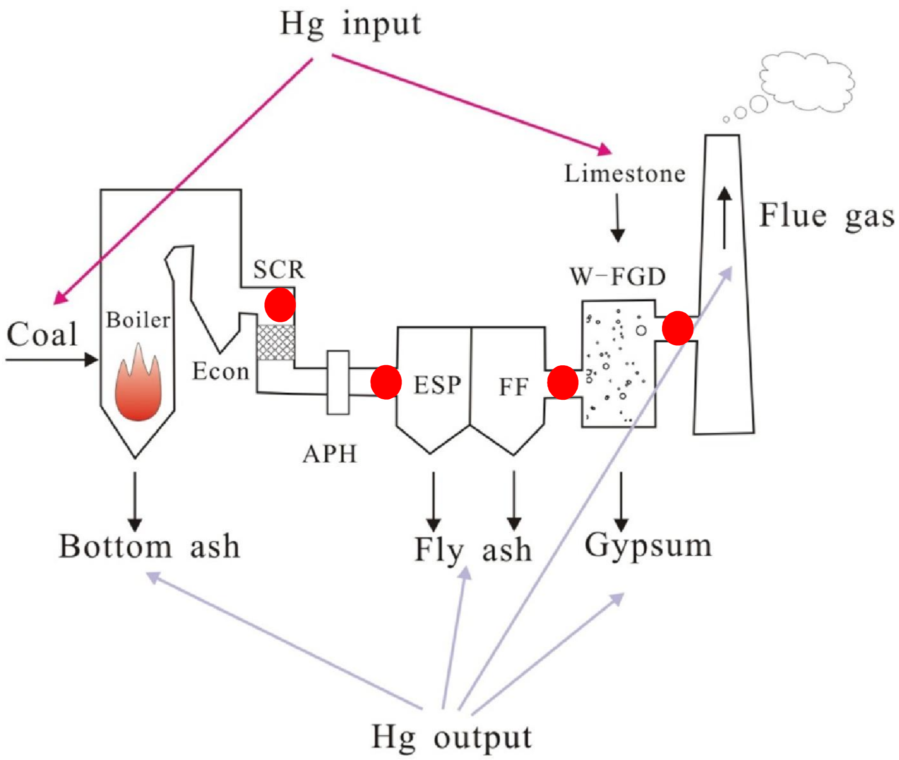
WFGD+SCR installation in 2010

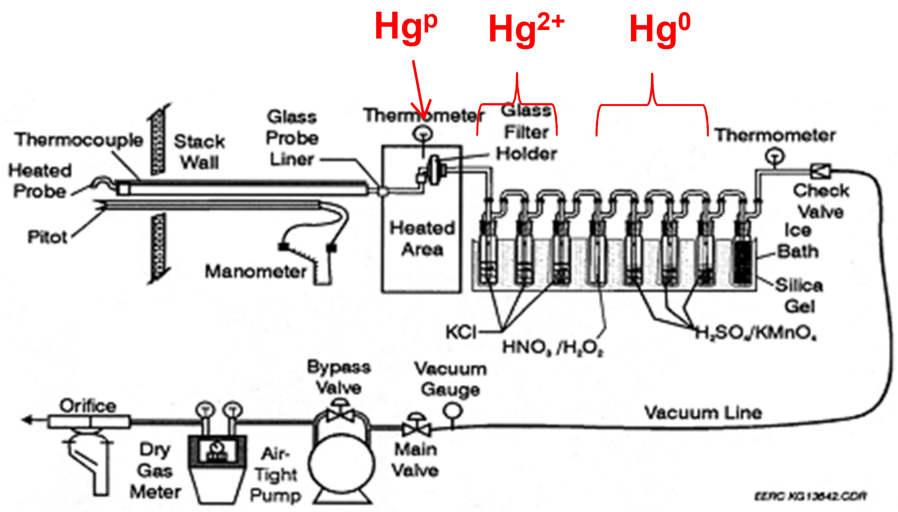
Tian et al., 2010, ACP; 2014 EST

Basic information about the CFPP studied

- **Totally 1550 MW, with 8 units, started into operation in 1970s**
- **Unit #3 studied, with 250 MW**
- **Pulverized coal-fired boiler**
- **Bituminous coal**
- **APCDs: SCR+CS-ESP-FF+WFGD**

Sampling and analysis





Ontario Hydro Method (OHM) for flue gas，
ASTM Method 6784-02

Sampling date: August 13-17, 2013

● **Flue gas sampling sites(each site>3 runs)**

→ **Solid/liquid sampling sites**

Sampling and analysis


SCR inlet


ESPinlet

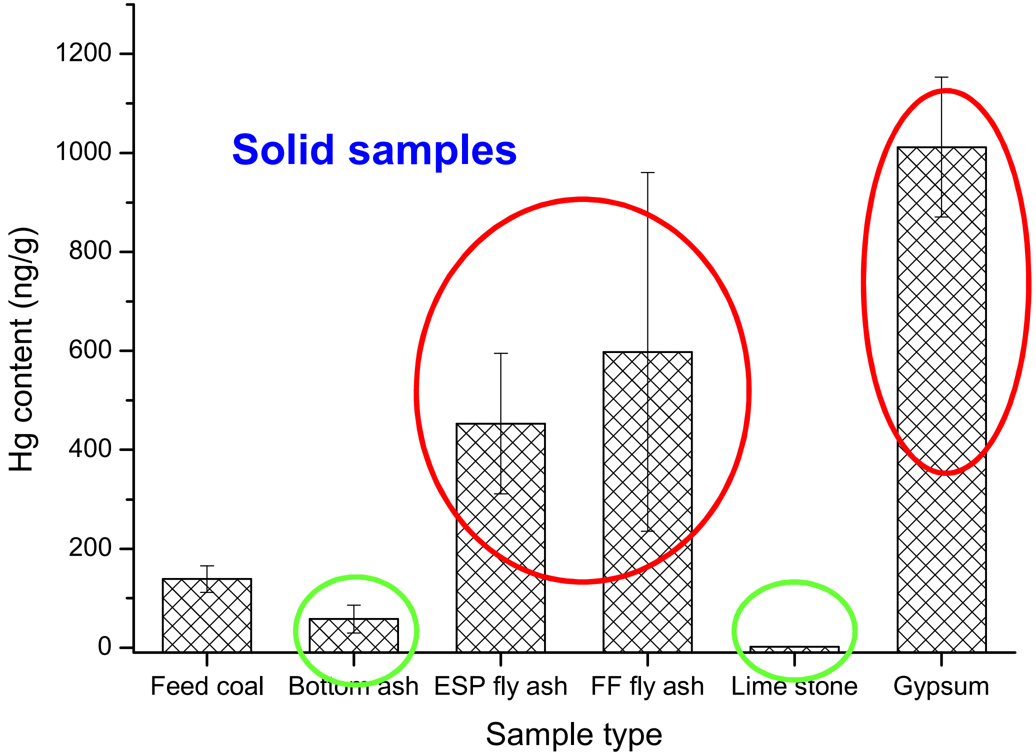

Sampling

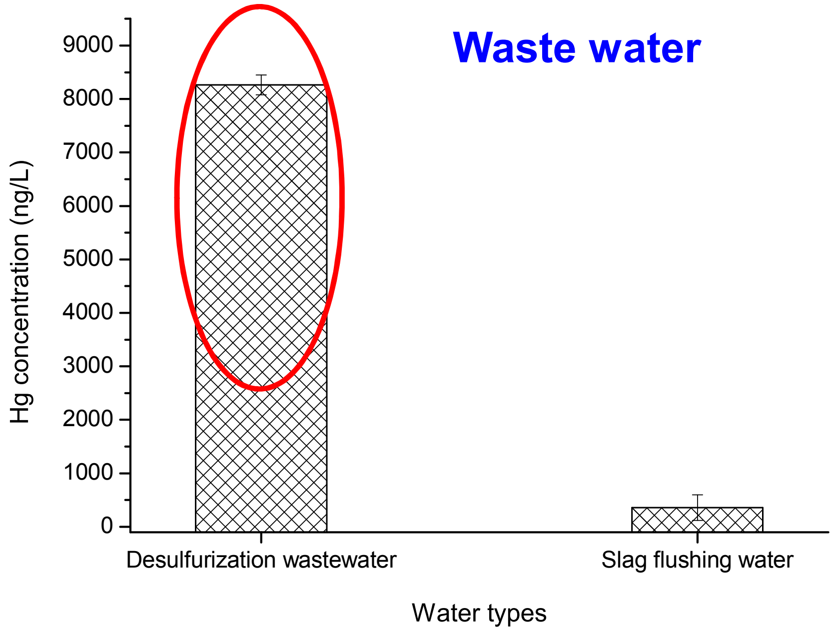

FFoutlet


WFGDoutlet


Lab work

Results: Hg in solid and liquid samples

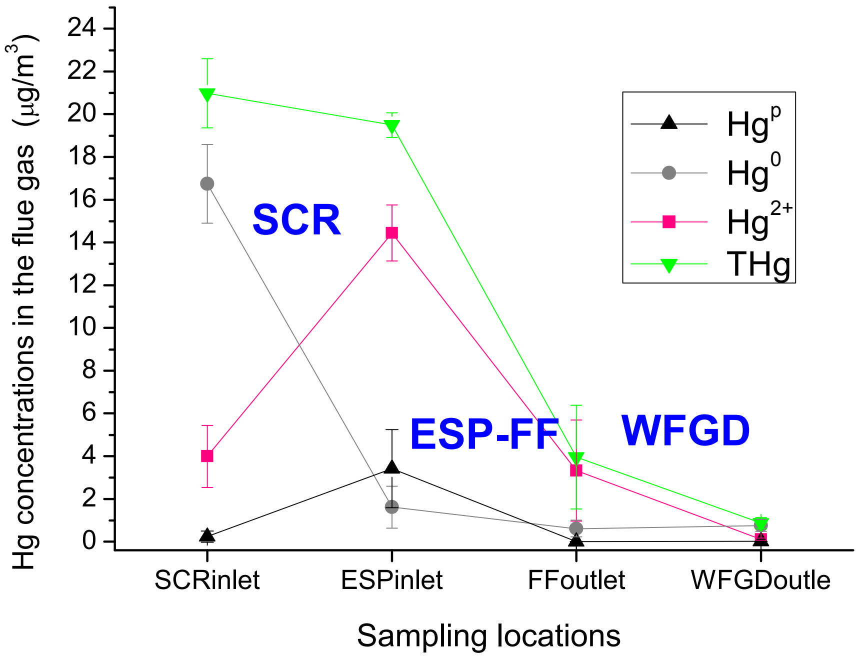




- **Compared with the feed coal (139 ng/g), Hg was much enriched in fly ash, gypsum and desulfurization wastewaters**
- **But Hg depleted in bottom ash and lime stone**

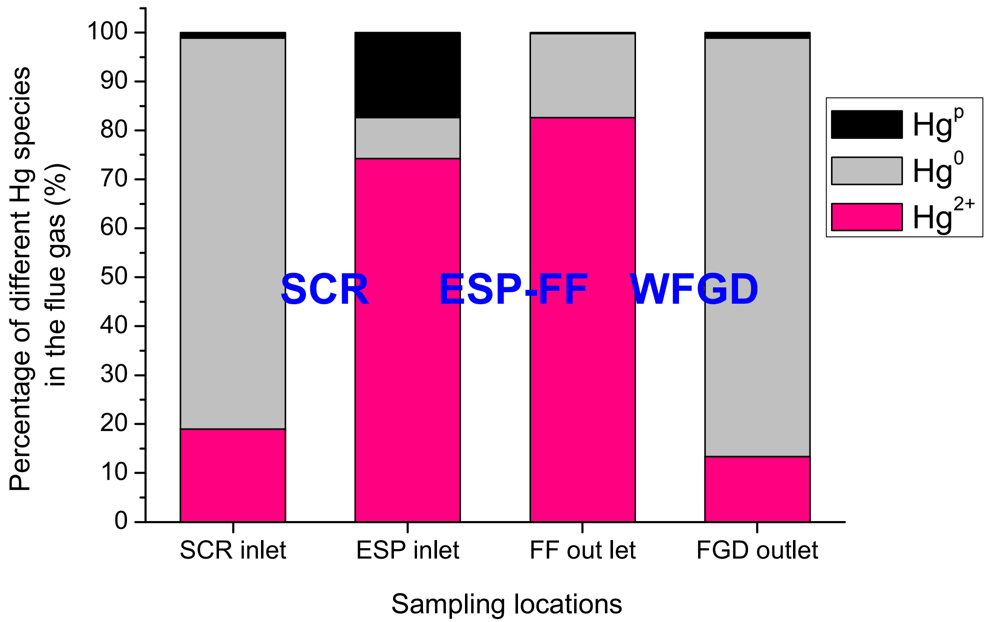
Results: Hg in the flue gas

Hg concentrations in the flue gas



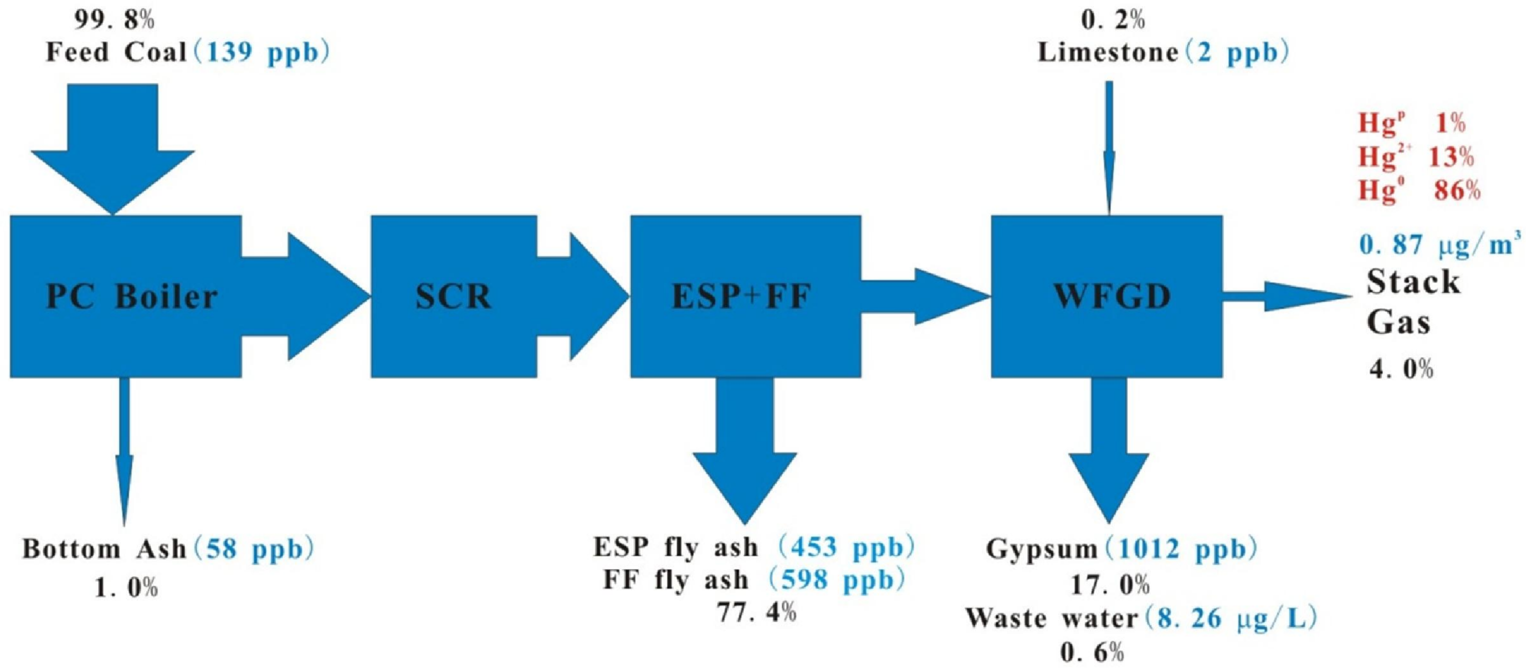
- **Total Hg dropped from 21μg/m³ to 0.87 μg/m³.**
- **Hg removal efficiency is 96%.**
- **Much lower than the emission standard (30 μg/m³ in China and 1.7 μg/m³ in USA)**

Hg species in the flue gas



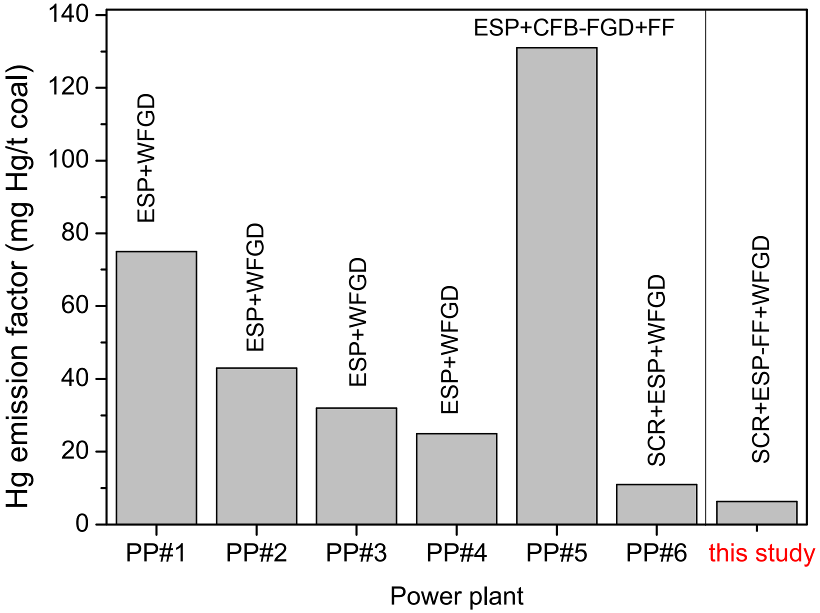
- **SCR oxidization 90% of Hg^0 in to Hg^{2+}**
- **ESP-FF removed 99.8% of Hg^p**
- **WFGD absorbed 97% of Hg^{2+}.**

Results: Mass balance of Hg in Unit #3



- **Most Hg was removed by ESP+FF (77%)**
- **A lesser extent was removed by WFGD (17%)**
- **A small portion (4%) was discharged into atmosphere through the stack, with 86% in Hg^0, 13% in Hg^{2+}, and 1% in Hg^p**

Results: Hg emission factor of Unit #3



Comparison of Hg emission factors with 6 other power plants in China.

Wang SX et al., 2010, ACP

Mercury Removal Efficiencies of Air Pollution Control Devices

	bituminous	
PC+CS-ESP	29%	(42)
PC+CS-ESP+WFGD	63%	(14)
PC+FF	66%	(8)
PC+SCR+CS-ESP+WFGD	67%	(3)
PC+FF+WFGD	90%	(2)
PC+SDA+FF	99%	(1)
PC+SDA+CS-ESP		
PC+CS-ESP+CFB-FGD+FF	68%	(1)
PC+SCR+CS-ESP+SW-FGD	74%	(1)
PC+SCR+SDA+FF	98%	(2)
PC+NID+CS-ESP		
PC+SNCR+CS-ESP	83%	(1)
CFB+CS-ESP	99%	(1)
CFB+FF	100%	(2)
CFB+SNCR+FF	89%	(1)
PC+SCR+CS-ESP-FF+WFGD	96%	This study

Hg removal efficiency by different types of APCDs.

Zhang L. et al., 2012, EST

Hg emission factor of this unit is 6.3 mg Hg/t coal or 3.1 μg Hg/ kW.h, much lower than other power plants that just installed ESP or ESP+WFGD

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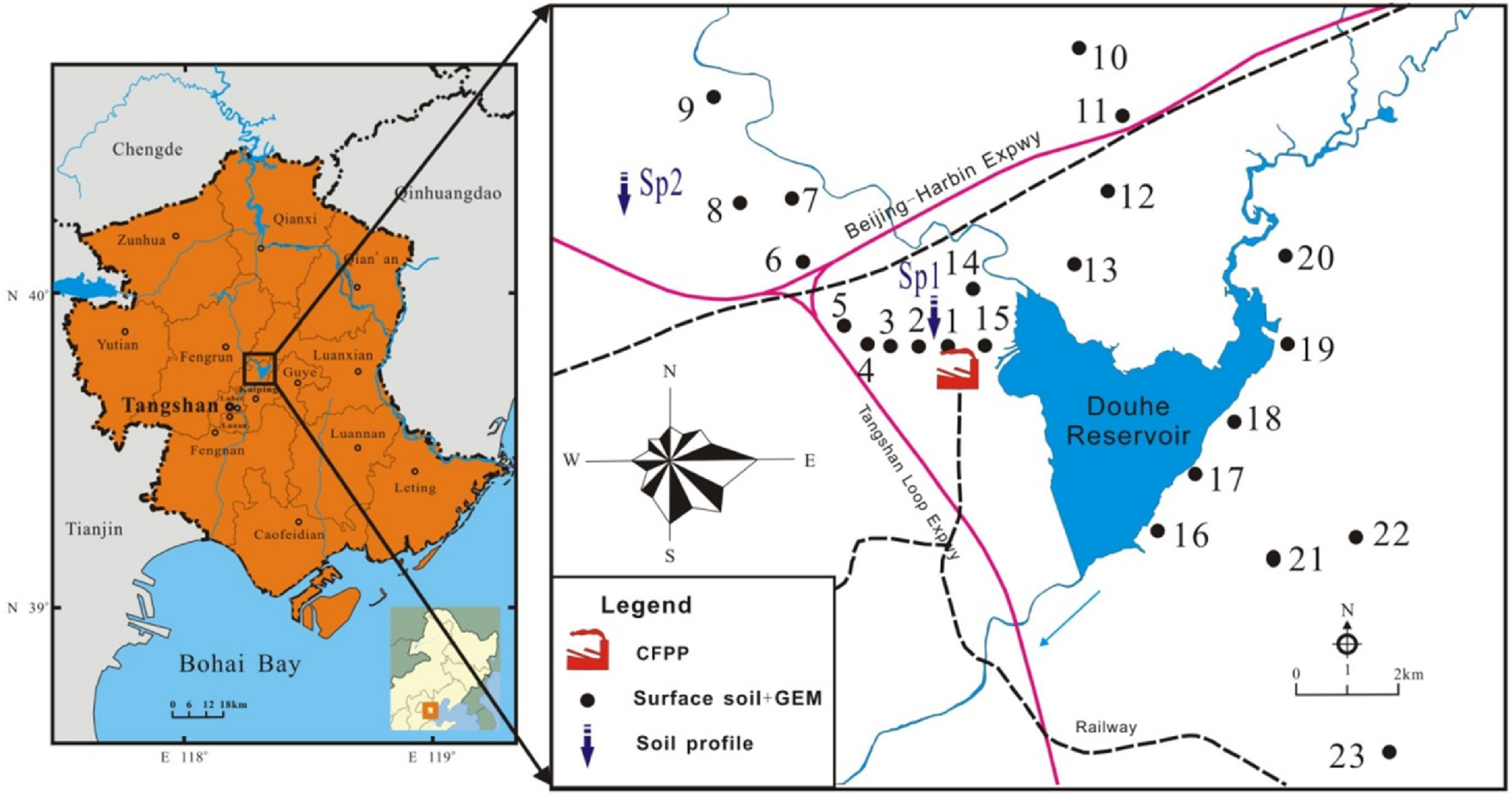
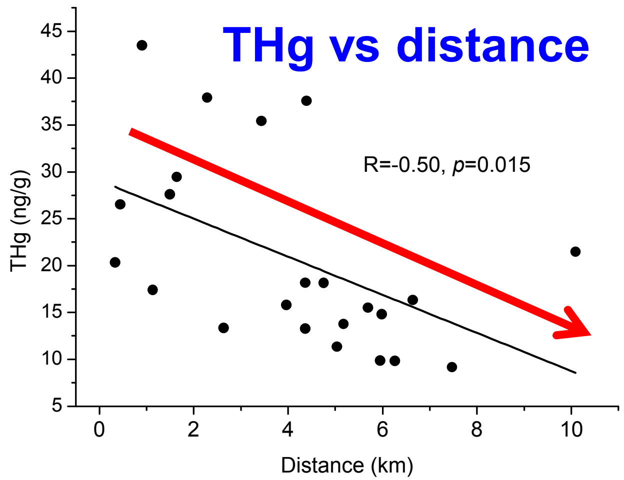
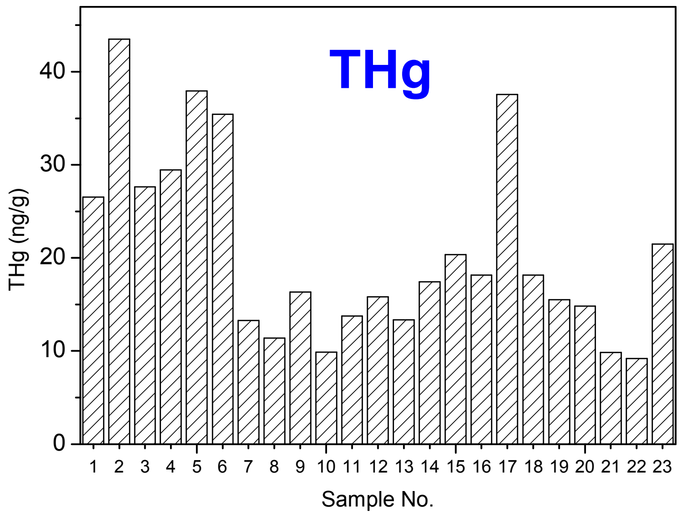
Sampling and analysis



Sampling sites for the surrounding soils and ambient air

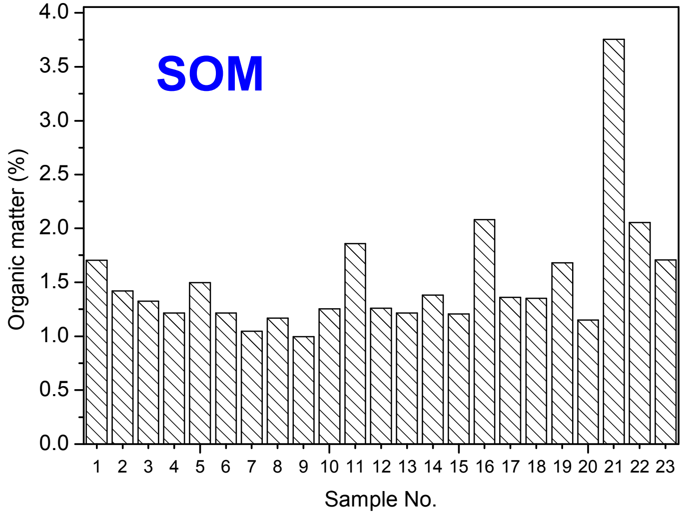
Results: total Hg in the surface soil

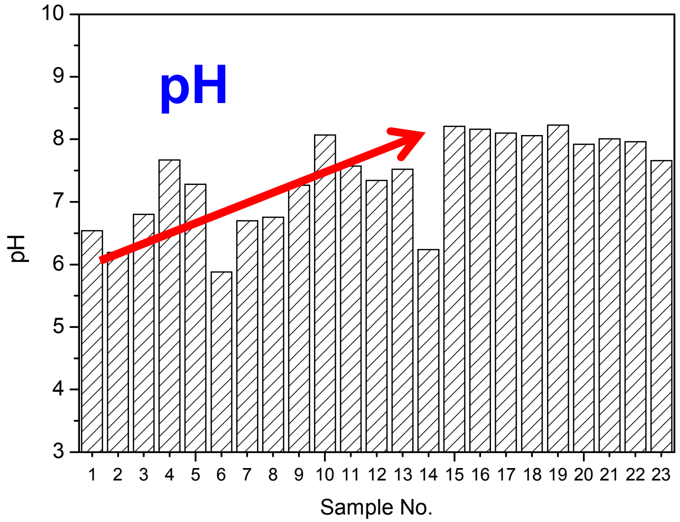




- Agricultural soil: 0-20 cm
- Range: 9.2-43.5 ng/g, mean:20.7 ± 10.0 ng/g
- Less than the national (65 ng/g) and provincial (36 ng/g) background
- Closer sites (<4 km) are significantly higher than the remote ones (26.7 vs 16.1 ng/g)

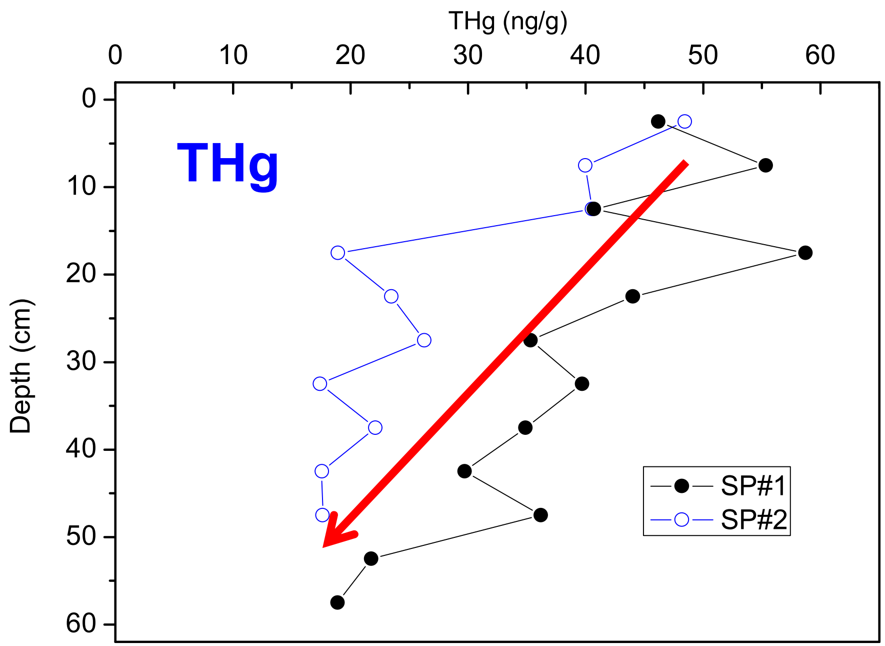
Results: SOM and pH in the surface agricultural soil





- ◆ SOM are low in most sites
- ◆ pH are low (around 6) in closer sites than remote sites (~8)

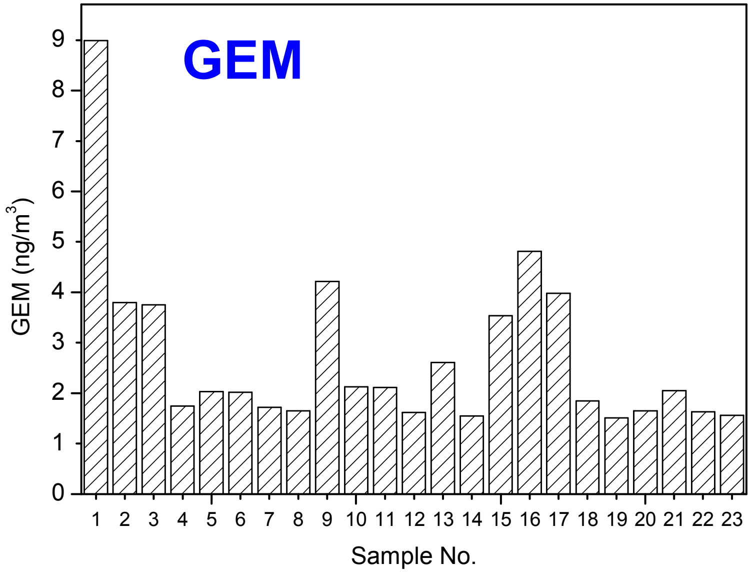
Results: Total in the soil profile



THg in the soil profile

- Hg in surface layer (ca. 50 ng/g) are higher than the bottome part
- Local background is about 10 ng/g
- Soils within 10 km to the CFPP has accumulated 0.59 t Hg, account for 3.47% of the total emitted

Results: GEM in the ambient atmosphere



- GEM: 1.5-9.0 ng/m^3
- Less than the ambient air standard (GB 3095-2012) for Hg (50 ng/m^3)
- No trend with distance to the CFPP

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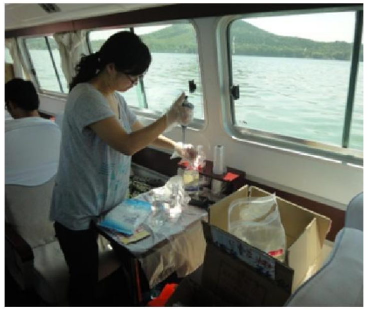
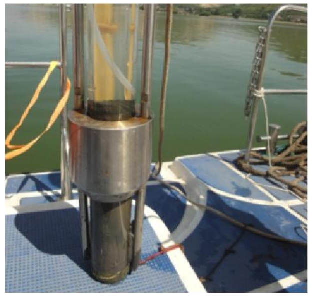
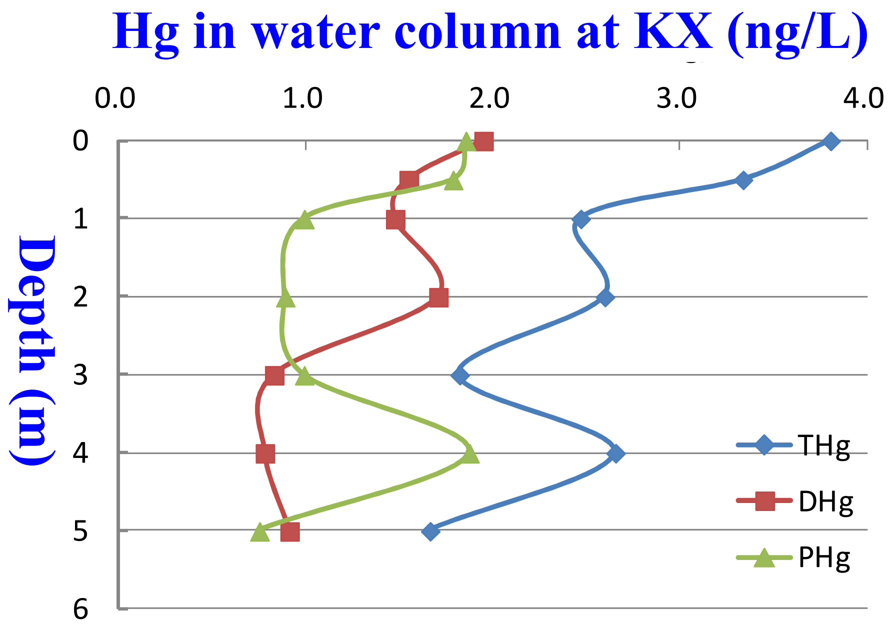




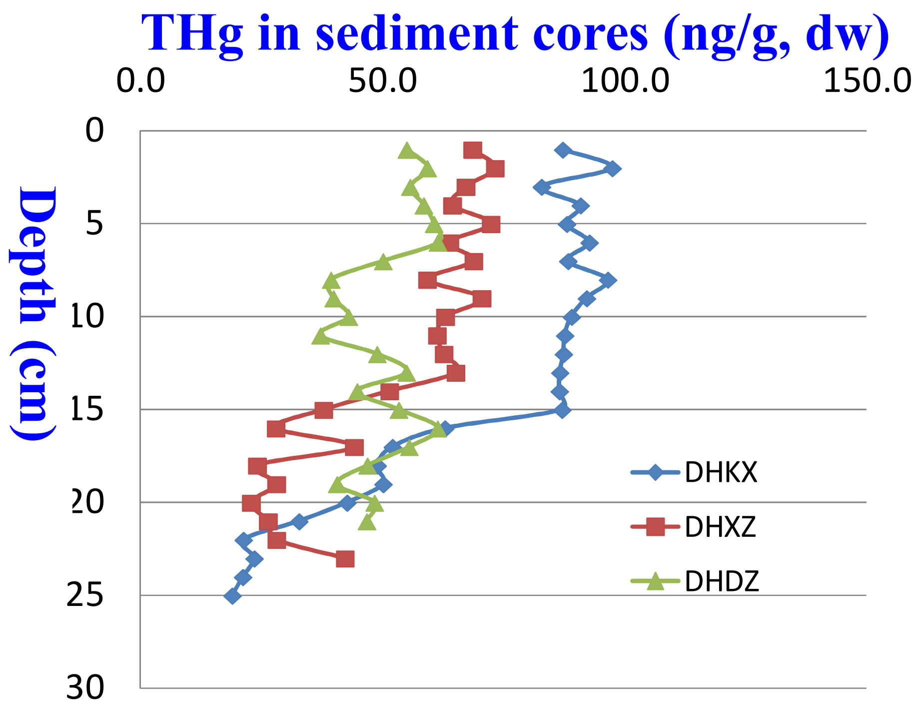
- Waters
- Sediments
- Fishes, shrimp, spiral shell

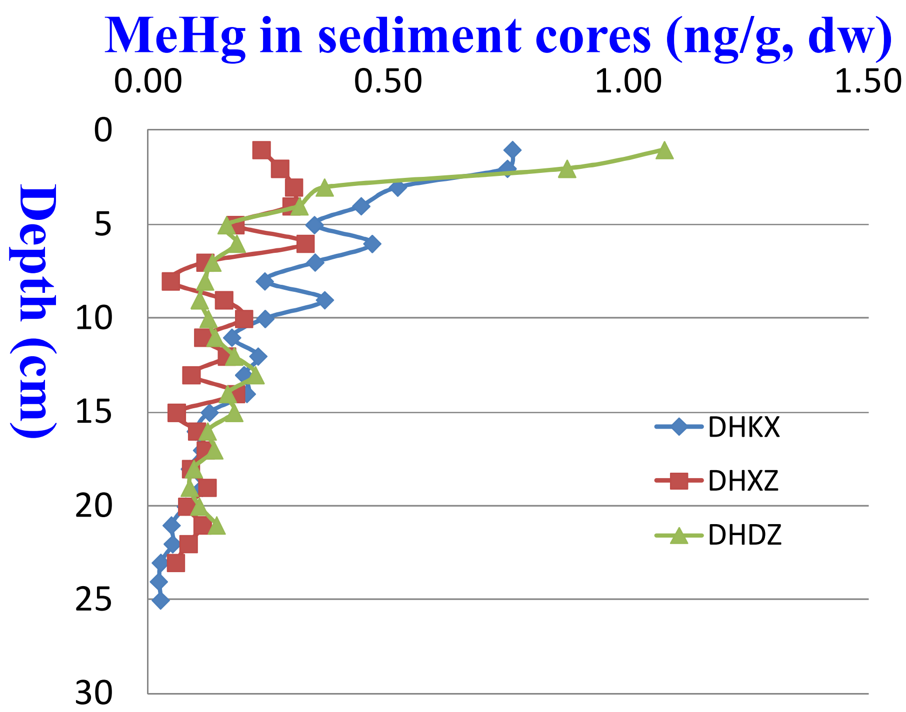
Mercury in lake waters



- THg<4 ng/L, in the natural background range, below the class-I surface water standard in China (50 ng/L)
- DHg ≈PHg

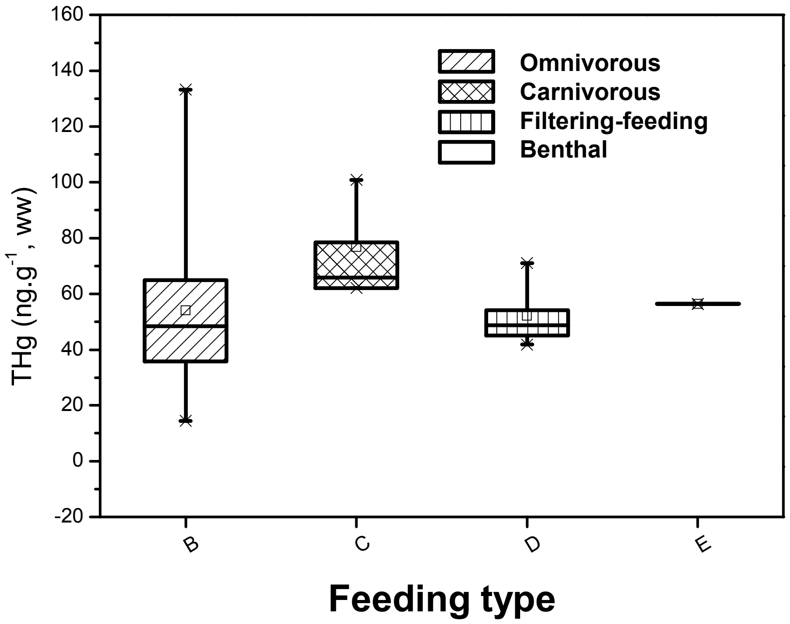
Mercury in sediments

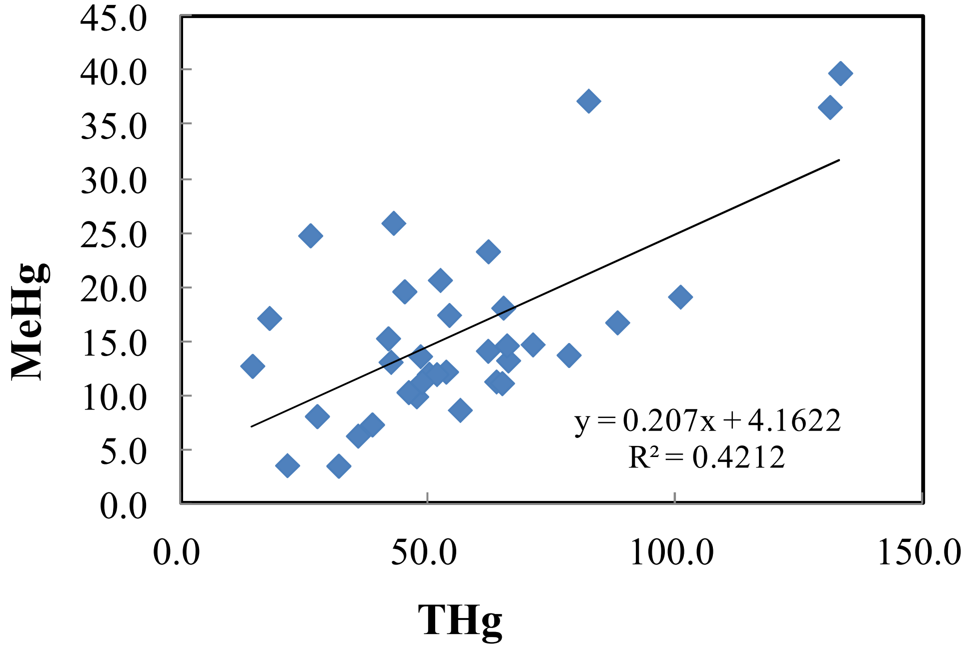




- **Both THg and MeHg are higher in surface layer than the bottom**
- **THg in sediment(up to 100 ng/g) are higher than the surrounding soils, indicating other inputs (such as influent)**

Hg in fishes





- **THg content in fish are low (<140 ng/g), and MeHg% is 28%**
- **THg in fish decreased with feeding types, Carnivorous> Omnivorous>Filtering-feeding**

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Conclusions

- **The installation of conventional pollutant control devices (SCR+CS-ESP-FF+WFGD) has high synergistic mercury removal efficiency (96%), and Hg in the discharged flue gas is lower the emission standard**

- **Hg in the surrounding environmental compartments indicates slightly impacts by the coal-fired power plant**

Acknowledgements

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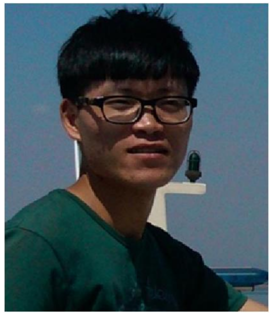

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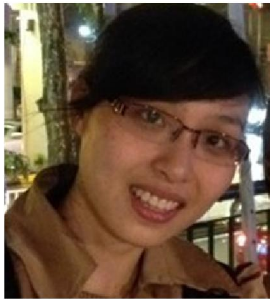

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Thanks for your attention！

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