

***Opening Workshop for Sino-Swedish Mercury Management
Research Framework (SMaReF)***

**Methylmercury accumulation in rice
plant (*Oryza sativa* L.) grown at mercury
contaminated sites in China**

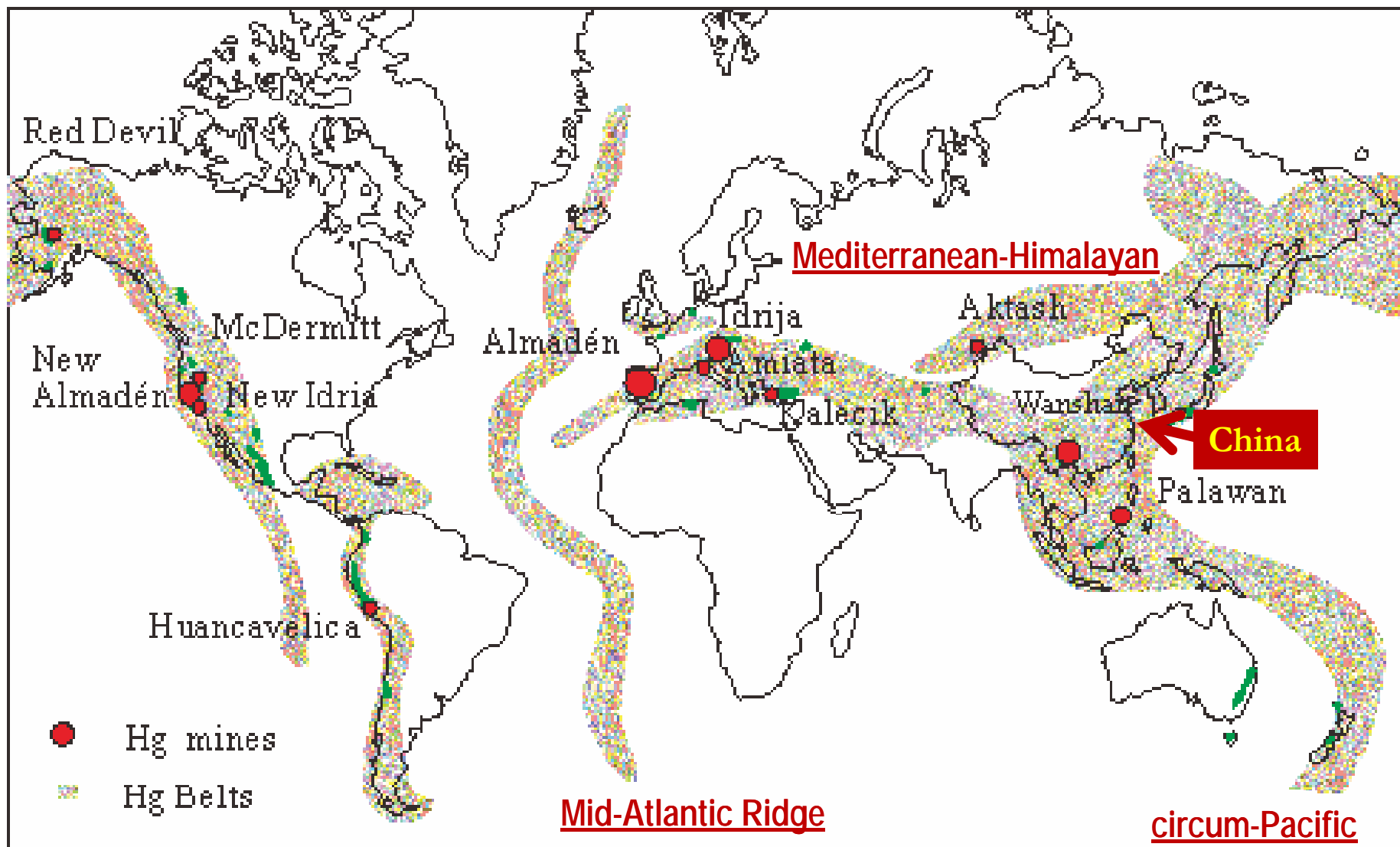
Guangle Qiu

Institute of Geochemistry, Chinese Academy of Sciences

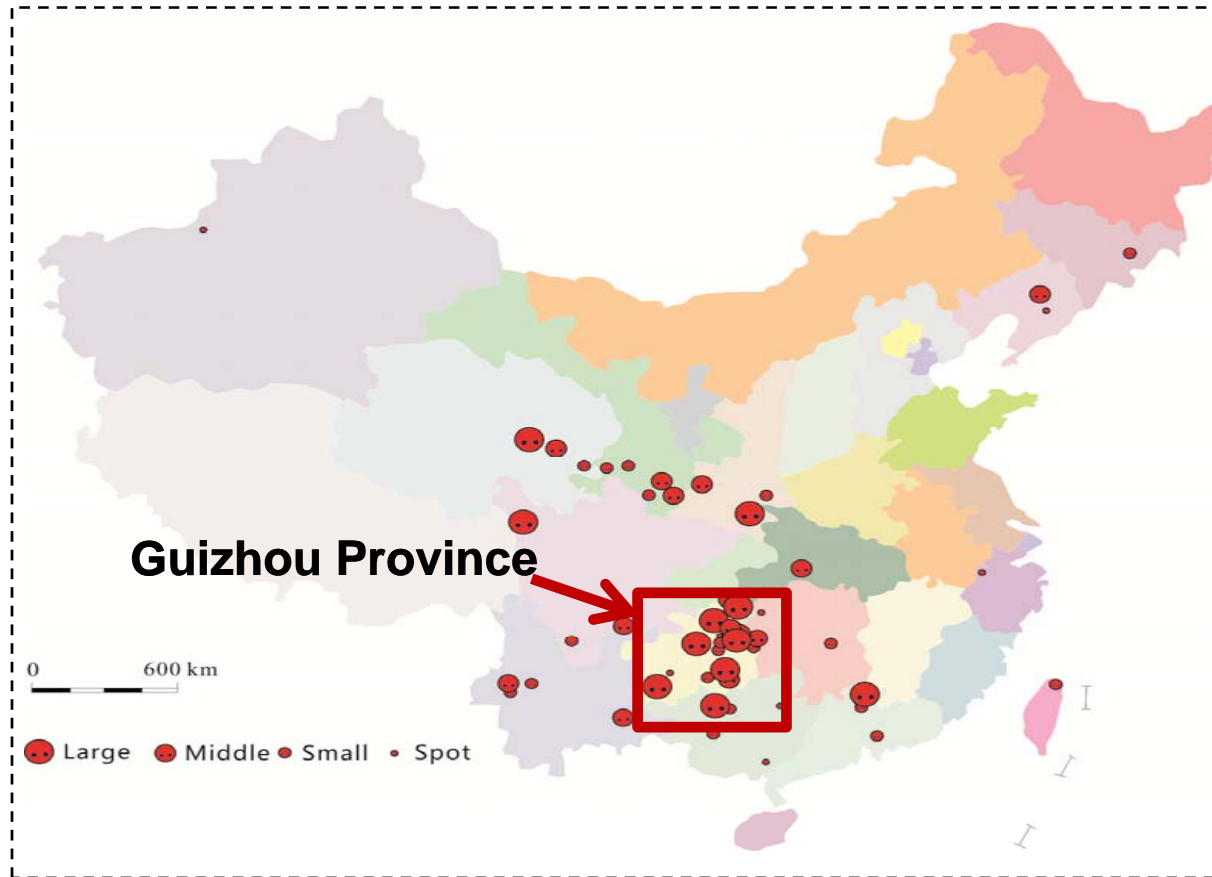
17-27 May, 2014

Uppsala, Sweden

Global mercuriferous belts and Hg mines

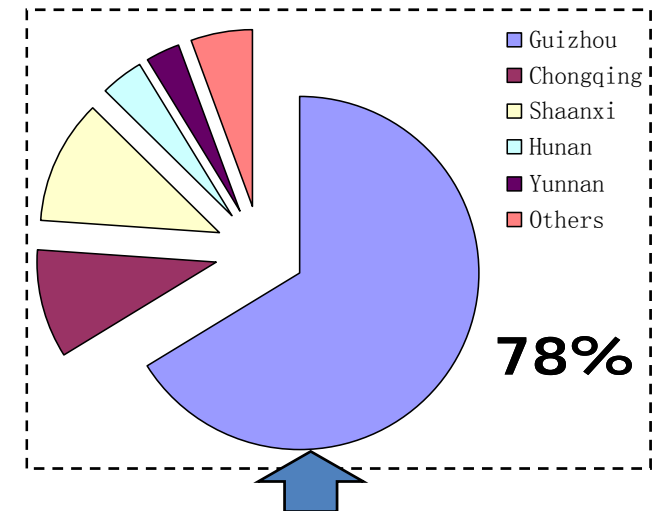


China Hg mines



Mercury mines in China

- Cinnabar resources in Guizhou, Chongqing, and Shaanxi enter into the top three ranks



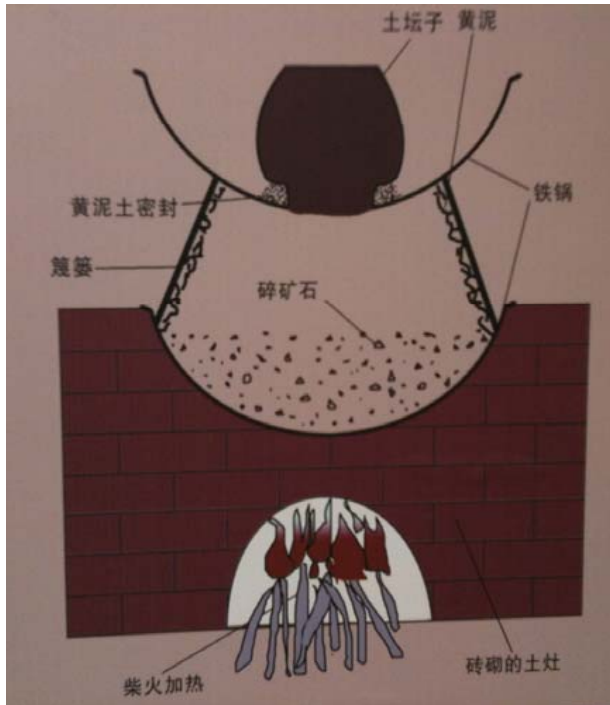
Guizhou Province

Guizhou Hg mines



- ◆ *The Hg mining started at Qin Dynasty (221B.C.)*
- ◆ *All the large scale Hg mining activities ceased in 2004, which experienced 630 years*

Artisanal Hg retorting



Artisanal Hg Retorting

Mining and retorting, environmental contaminations



■ **Water:**
1.9-
12000ng/L

■ **Soil:**
0.18-950ppm

■ **Plants:**
4.9-1120ppb

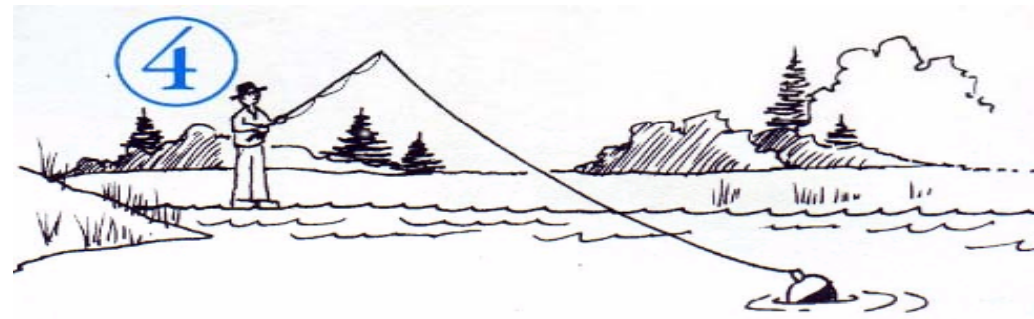


MeHg contaminated fish in aquatic systems

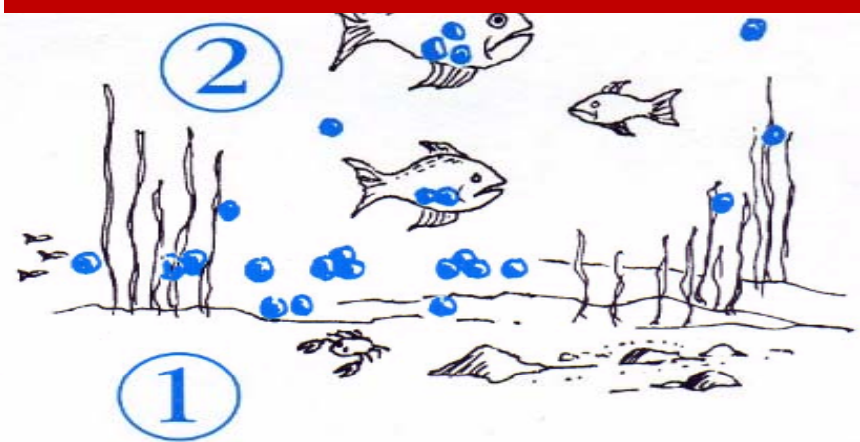


- MeHg exposure from fish consumption

- Elevated MeHg in fish living in remote area lakes



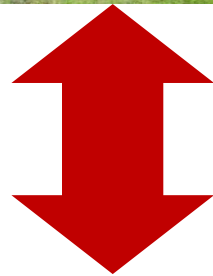
Eating fish is a major pathway of human exposure to MeHg



MeHg contamination in terrestrial environments



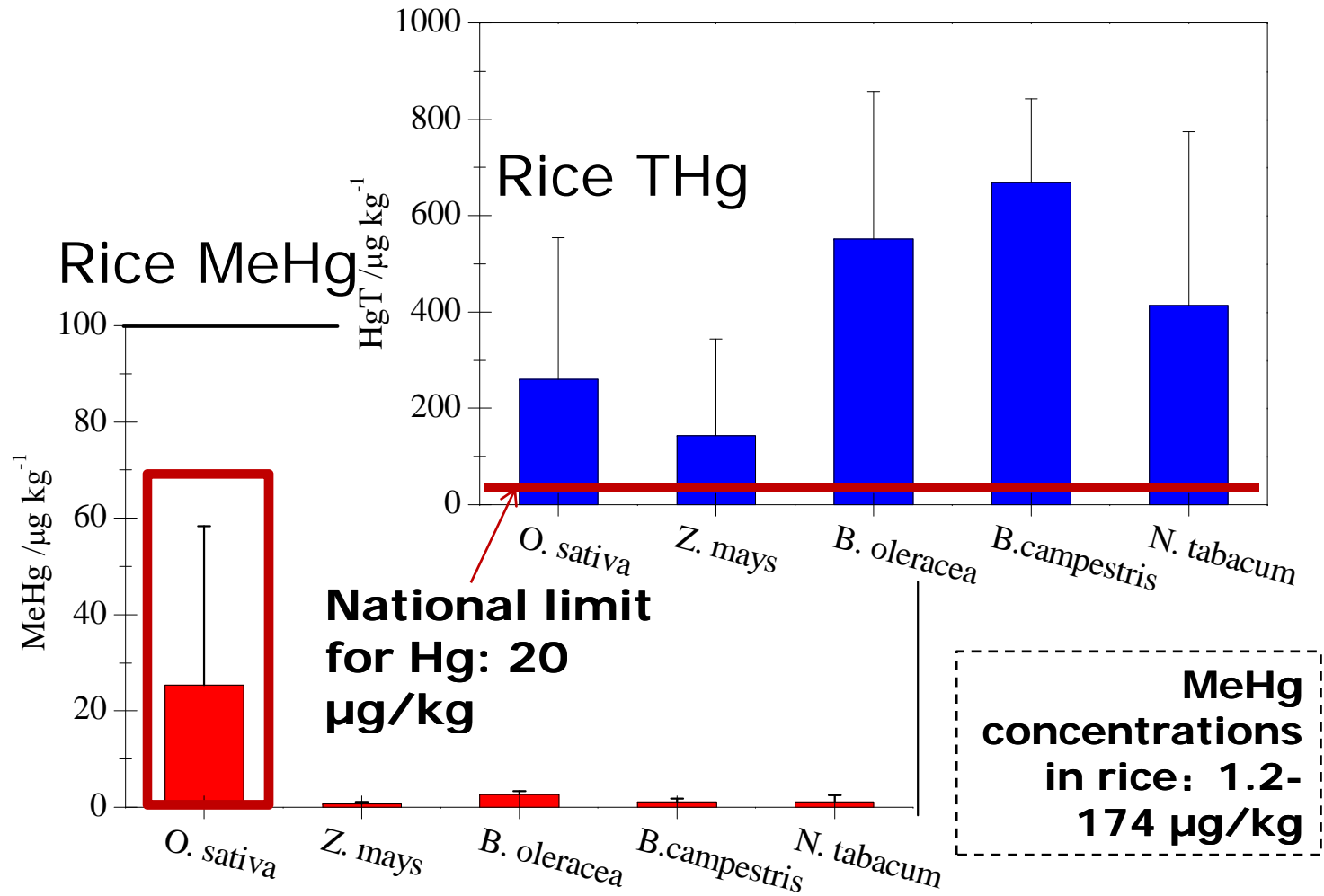
terrestrials



*How is
Methylmercury ???*



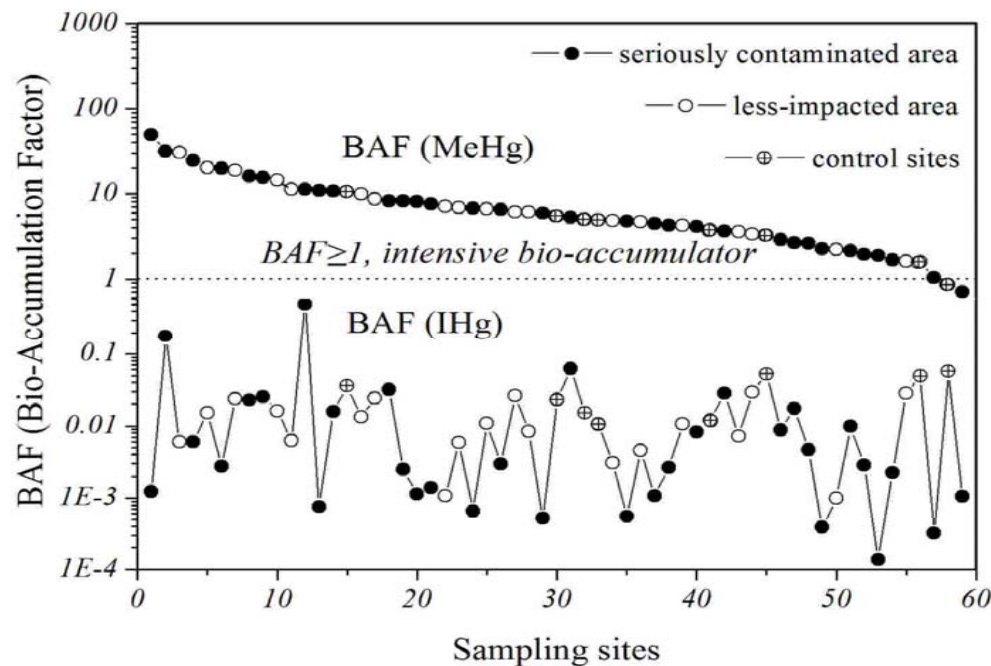
MeHg accumulation in crops



MeHg accumulation in rice

Bioaccumulation of Methylmercury versus Inorganic Mercury in Rice (*Oryza sativa* L.) Grain

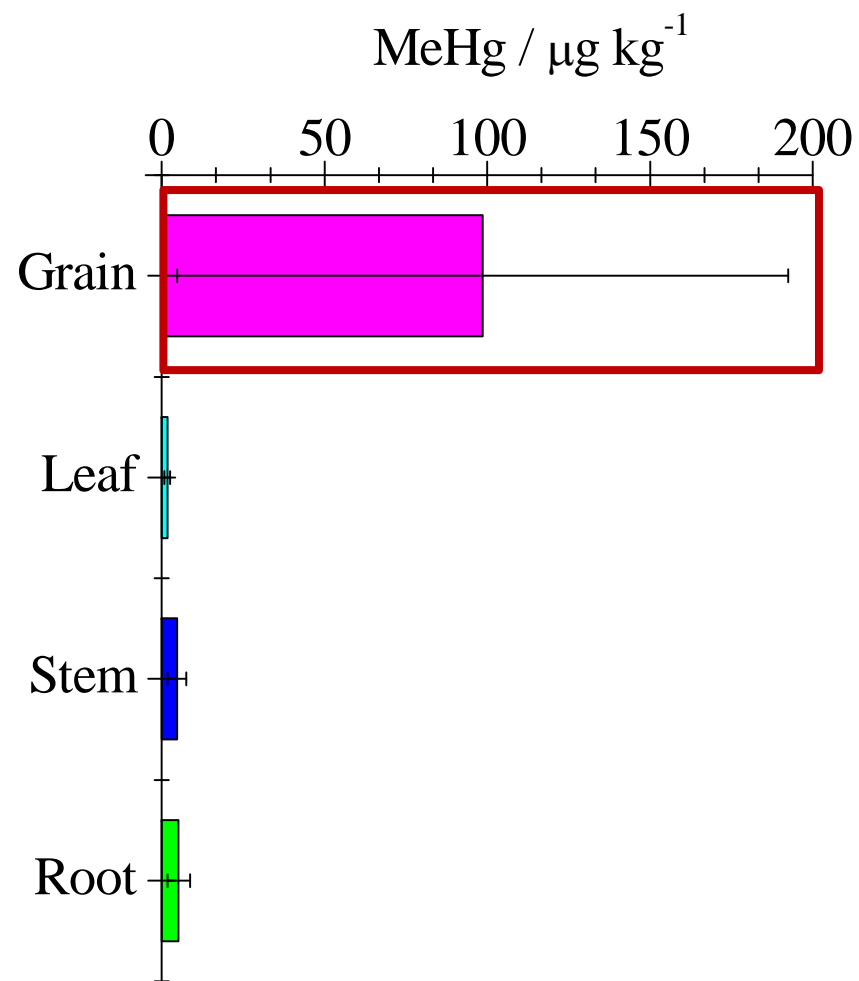
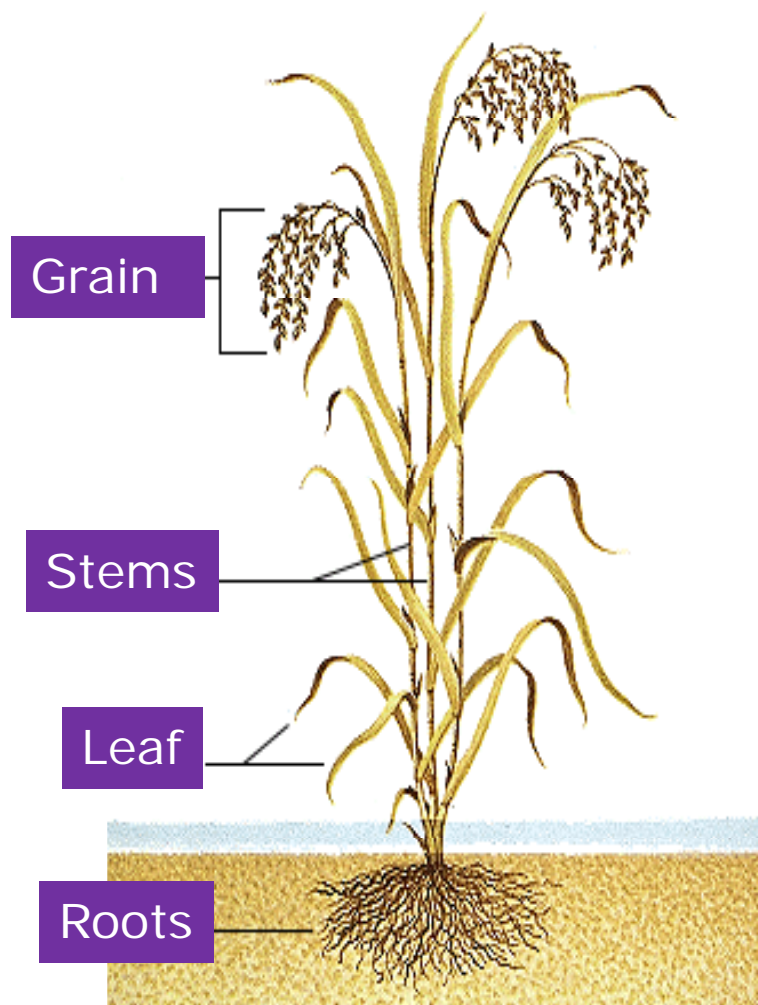
HUA ZHANG,^{†,‡} XINBIN FENG,^{*,†}
THORJØRN LARSEN,^{§,||} LIHAI SHANG,[†]
AND PING LI[†]



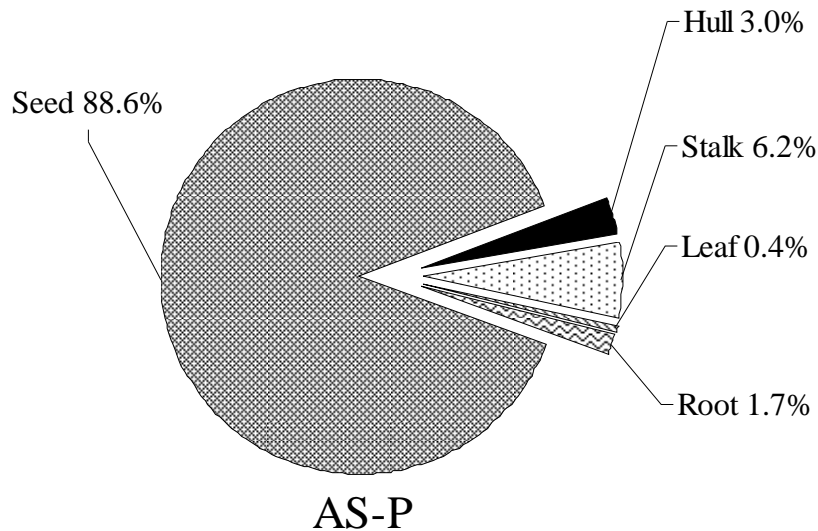
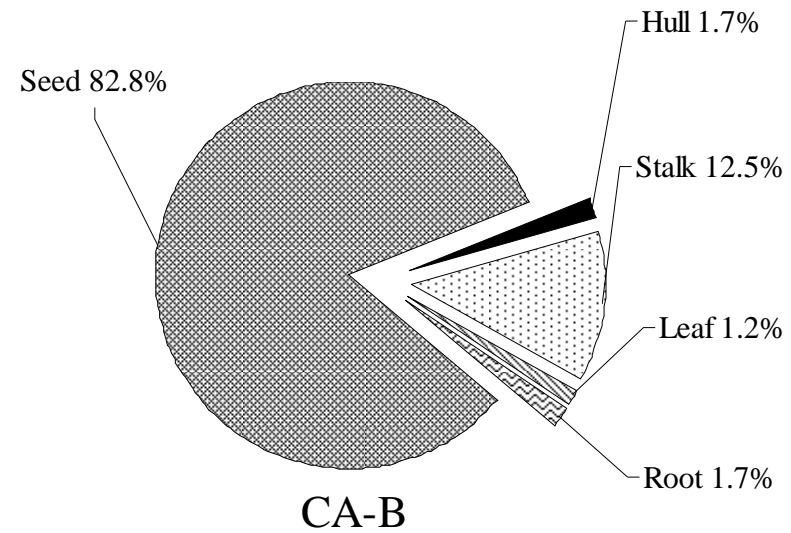
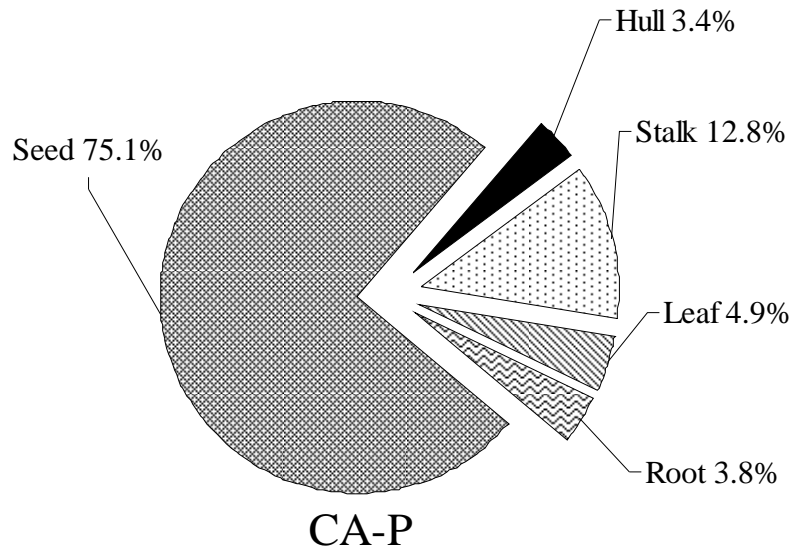
BAF of MeHg is much higher than BAF of IHg in rice

Bio-accumulation factor (BAF) of rice

MeHg accumulation in tissues

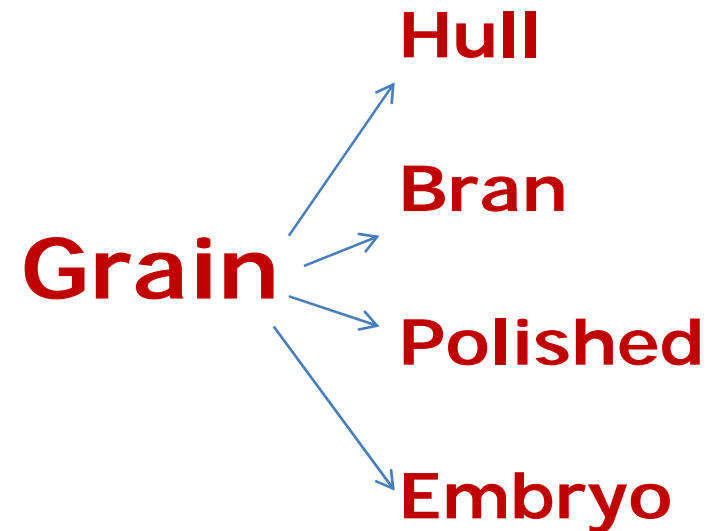
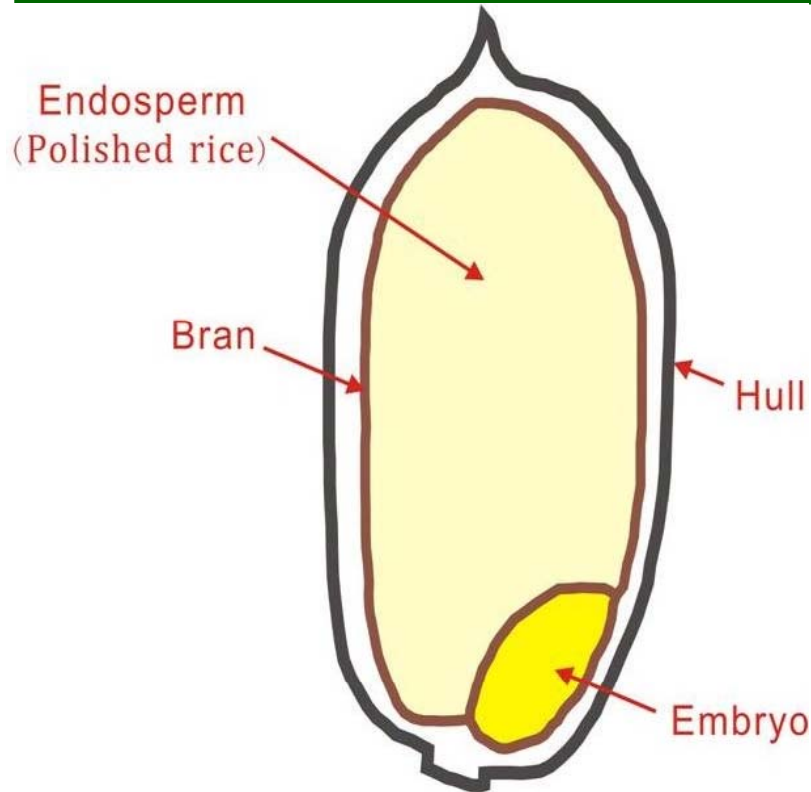


MeHg mass distribution in tissues



About 75%-89% of the total MeHg mass accumulated in edible parts of grain

MeHg and IHg in grain

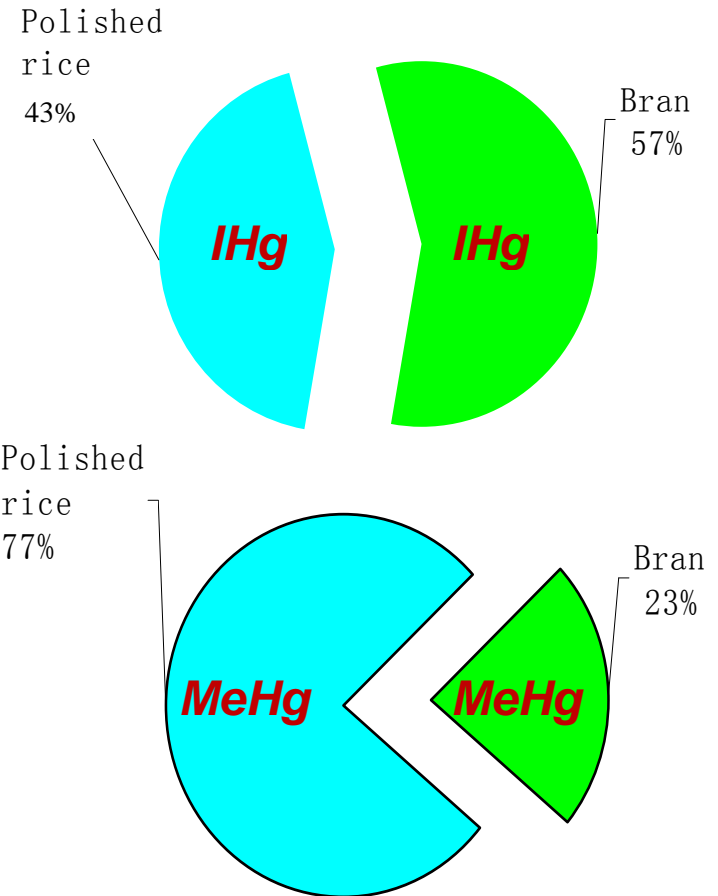
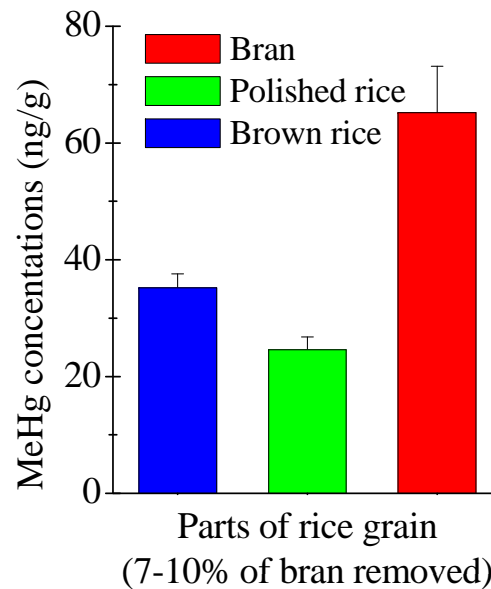
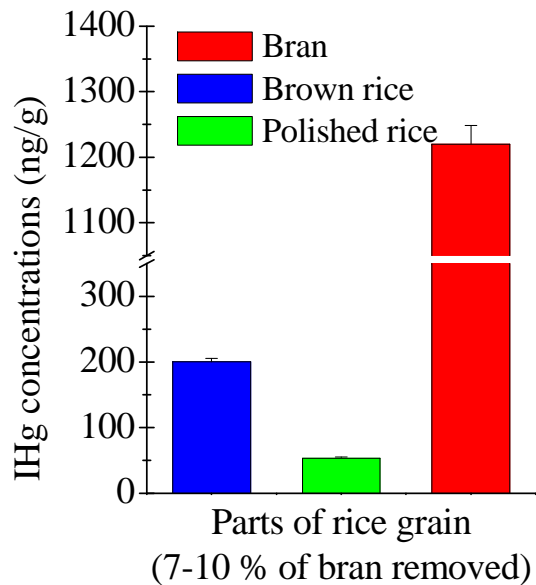


□ *How about the distribution of Hg in different parts of grain?*

□ *How about the Hg levels in rice grain when cooked?*

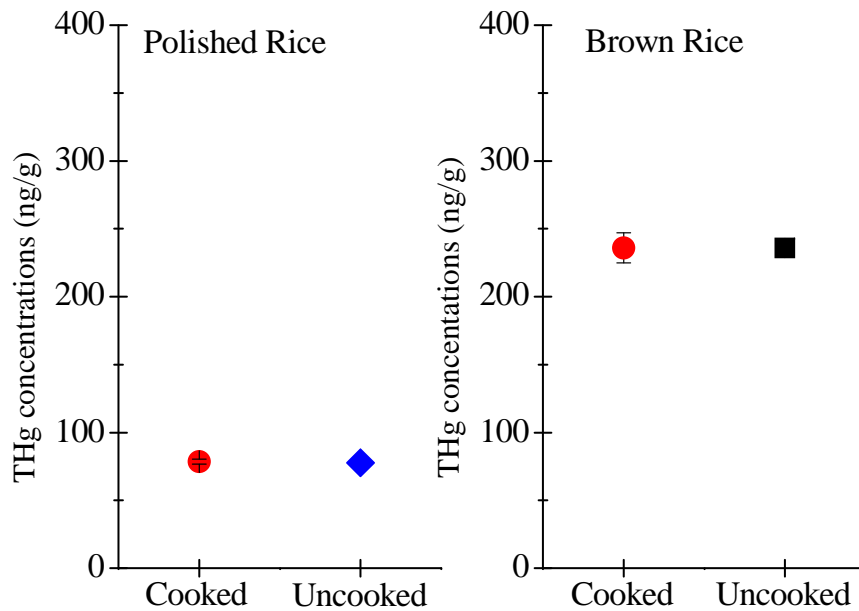
MeHg and IHg in grain

Distributions of IHg and MeHg in different parts of grain

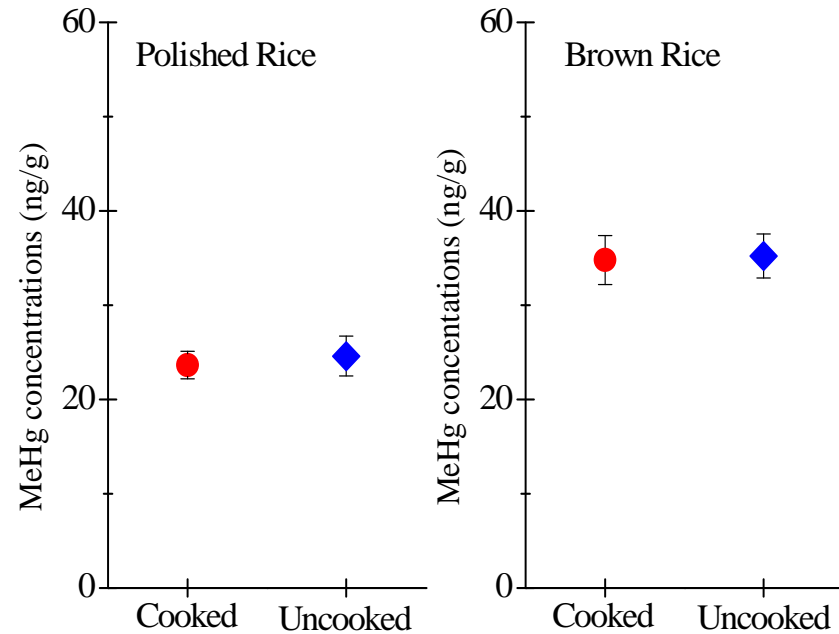


The distribution of IHg and MeHg mass in bran (7%-13%) and polished rice.

MeHg and THg in grain

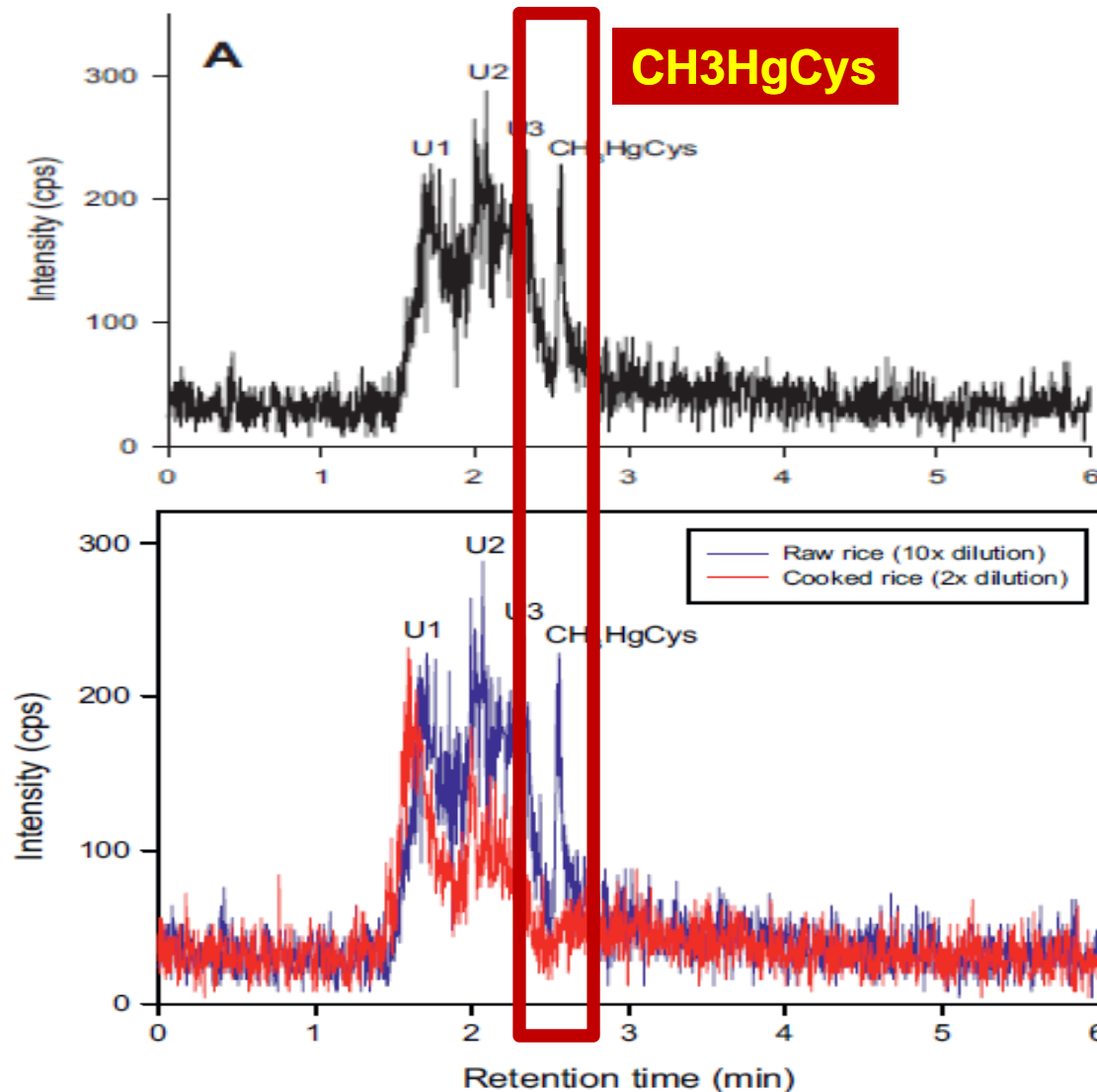


THg in cooked rice and uncooked rice *T*-test: $P > 0.6$, $n = 20$ for polished and brown rice



MeHg in cooked rice and uncooked rice *T*-test: $P > 0.6$, $n = 20$ for polished and brown rice

Speciation of MeHg in grain

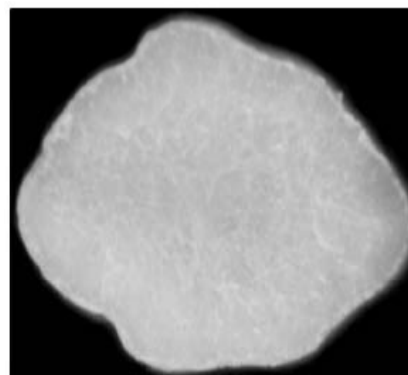
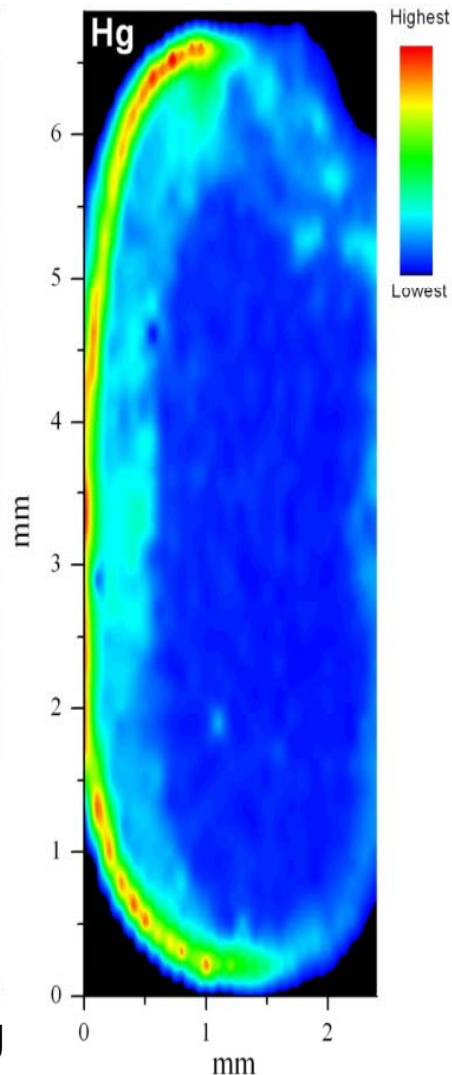


- HPLC-ICPMS revealed that MeHg in grain is present as CH₃HgCys
- Cooking process degraded CH₃HgCys, however, no inorganic Hg and Hg⁰ were formed

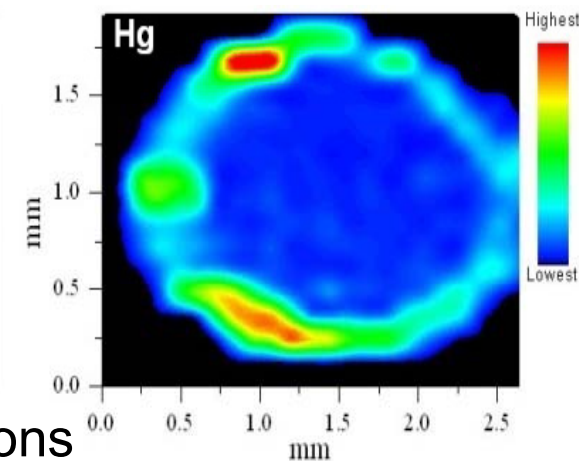
Localization of total Hg in grain



XRF mapping

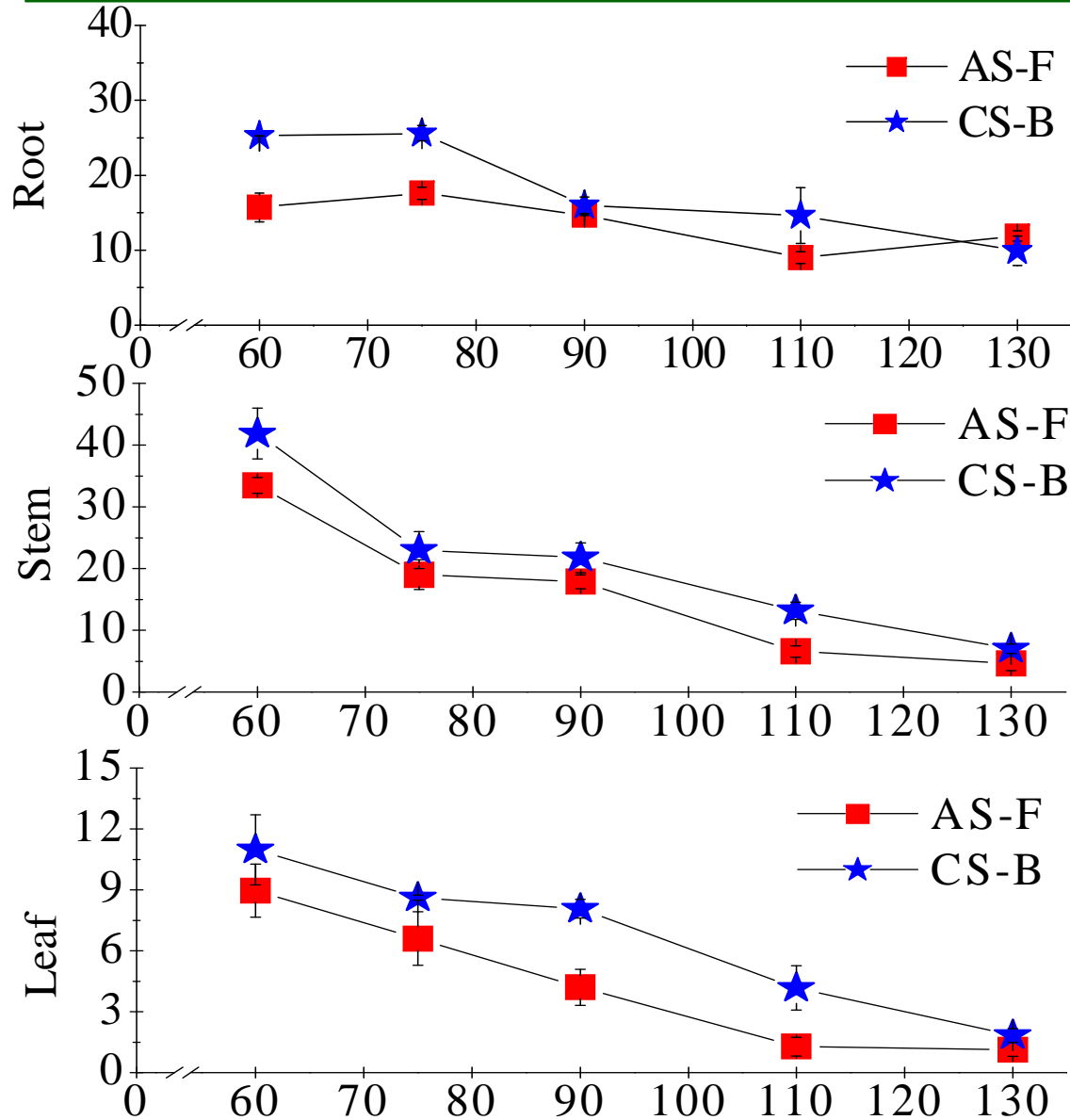


Cutting sections



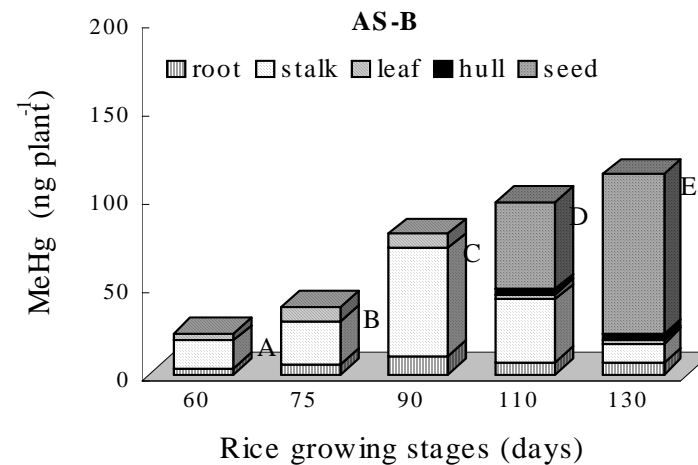
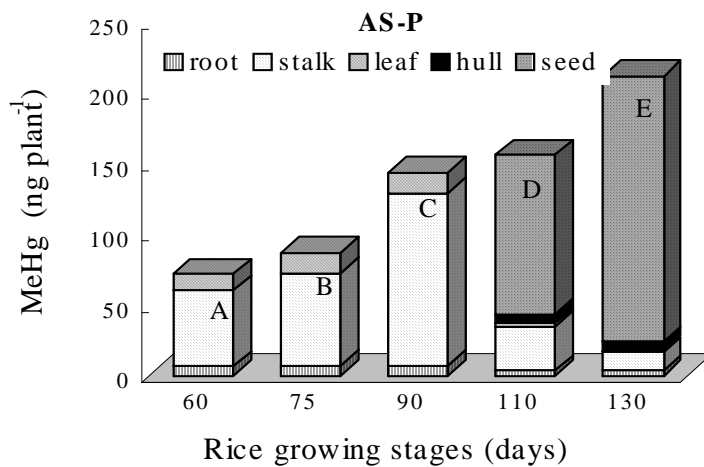
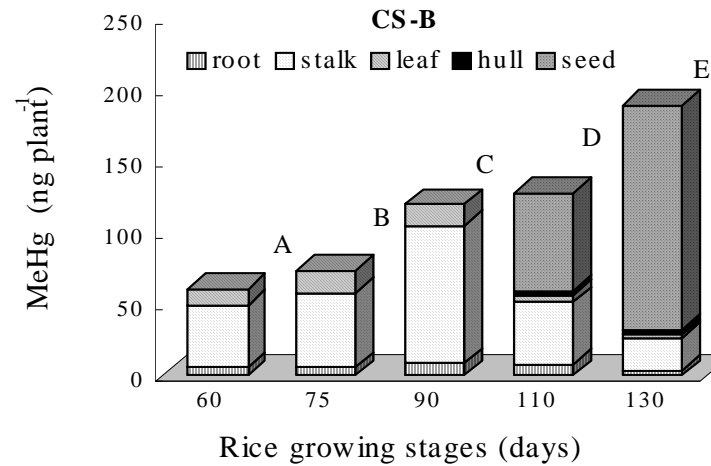
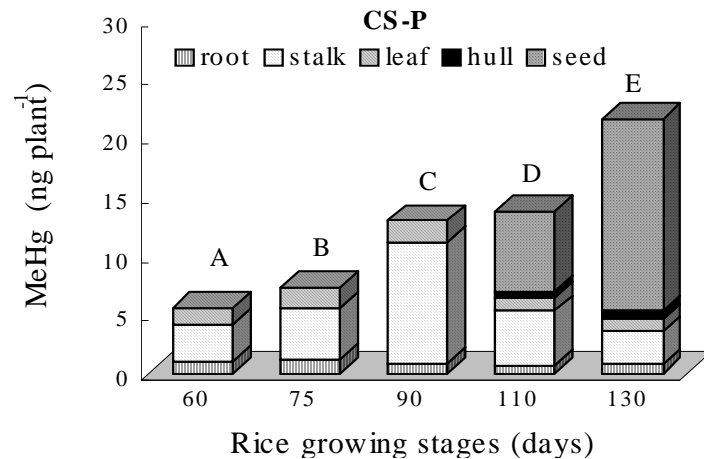
XRF mapping indicated that Hg accumulated in edge part of grain, suggesting unevenly distributed in the whole

MeHg in rice tissues in its growing season



Within rice growing season, MeHg firstly distributed in root, stem, and leaf, while grain forming and filling, MeHg accumulated

MeHg mass in tissues



- A: Tillering
- B: heading
- C: Flowering
- D: Dough
- E: Mature

Most of MeHg accumulate in grain part

During rice growing seasons, paddy soil MeHg is absorbed, then translocated to aboveground parts, finally concentrated in grain during the ripening period.

MeHg source for rice plant

	Root	Stalk	Leaf	Soil
Root	1			
Stem	0.73***	1		
Leaf	0.73***	0.93***	1	
Soil	0.62***	0.41**	0.36**	1

*** Correlation is significant at the 0.001 level (2-tailed).

** Correlation is significant at the 0.01 level (2-tailed).

* Correlation is significant at the 0.05 level (2-tailed).

Pearson's correlation matrix among the MeHg levels leaf, stalk, root, and soil during the entire rice growth stages (n=68).

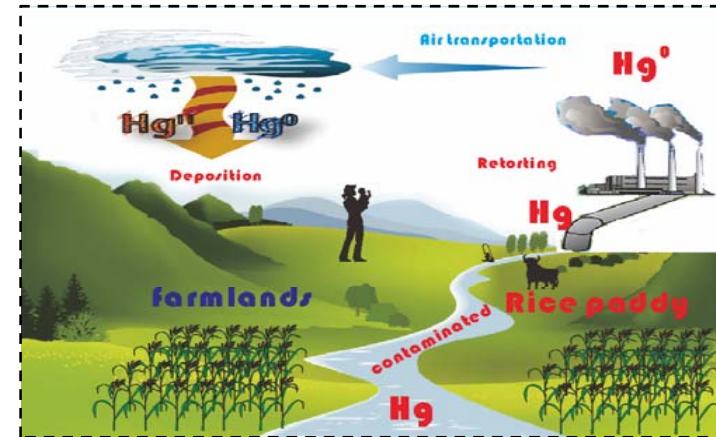
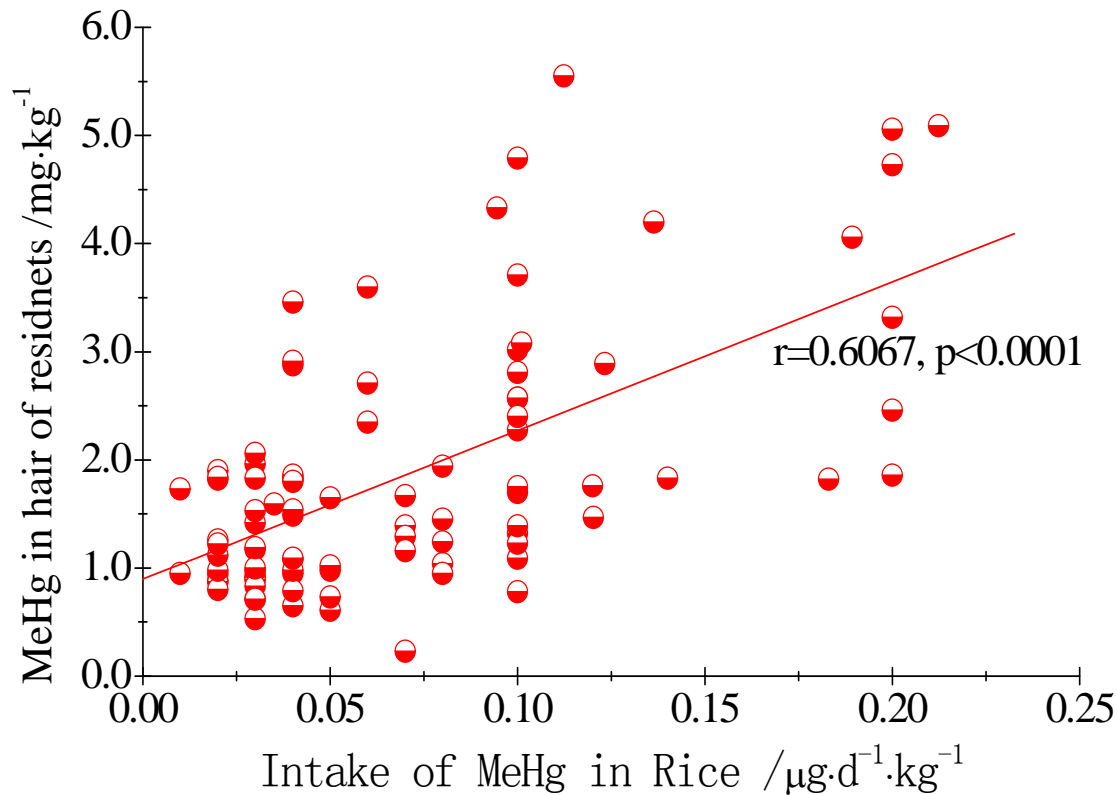
MeHg	F1-PCR	F2-PCR
Stem	0.92	-0.31
Leaf	0.91	-0.36
Root	0.91	0.14
Soil	0.66	0.73
% of variance explained	73%	19%
Cumulative of total variance	92%	

PCA factor loadings and percent variance of the data

Statistic data suggested source of MeHg in rice is soil MeHg

Rice is a staple food

- Rice rather than fish is a staple food in China Hg mining regions



A significantly positive correlation between hair MeHg and rice MeHg intake was observed

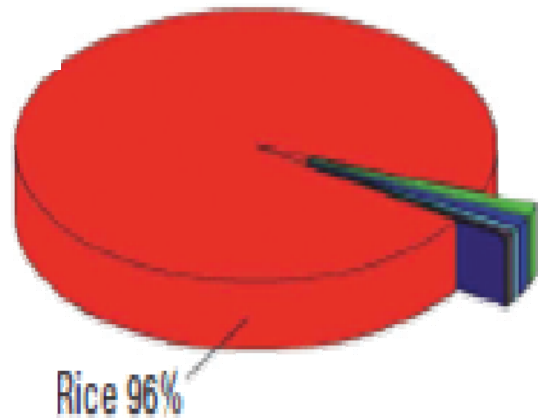
Daily intake of MeHg and IHg

Items	Inorganic Hg		MeHg	
	Daily intake (ID) / $\mu\text{g} \cdot \text{kg}^{-1} \cdot \text{day}^{-1}$	Hazard Index (HI)	Daily intake (ID) / $\mu\text{g} \cdot \text{kg}^{-1} \cdot \text{day}^{-1}$	Hazard Index (HI)
Air	0.037	0.065	–	–
Water	0.0024	0.0042	< 0.0001	–
Rice	0.1	0.18	0.16	0.70
Vegetables	0.13	0.23	0.0037	0.016
Pork	0.0015	0.0026	–	–
Poultry	0.0046	0.0081	–	–
Fish	0.0012	0.0021	0.0049	0.021
Risk	0.28	0.49	0.17	0.73

- JECFA (2010): $0.23 \mu\text{g} \cdot \text{kg}^{-1} \cdot \text{day}^{-1}$
- USEPA (1998): $0.10 \mu\text{g} \cdot \text{kg}^{-1} \cdot \text{day}^{-1}$

Pathway of MeHg exposure

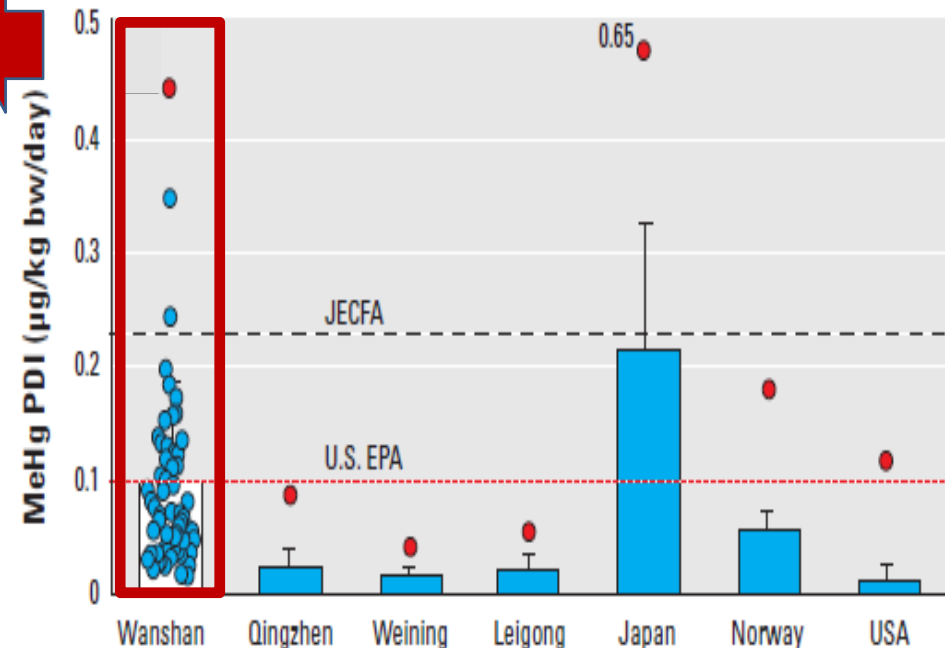
MeHg intake



Fish 1%
Meat 1%
Vegetable 1%
Corn 0.3%
Poultry 0.2%
Water 0.002%

Eating rice is a major pathway of human exposure to MeHg in China Hg mining regions

- MeHg PDI value in mining regions is comparable to other regions worldwide, such as Japan, Norway, where consume fish



Concluding remarks

❖ The paddy soil MeHg is considered as the dominant source for rice

✓ What is Hg-speciation and bio-available Hg in Wanshan soils?

✓ What is the KEY bacteria for Hg methylation?

▪ SRB, IRB, or methanogen?

✓ What is the scenario of the Hg methylated bacteria in Wanshan soil responsible for MeHg formed?

Concluding remarks

❖ Eating rice rather than fish is the major pathway for MeHg exposure to residents

❖ No detailed information about the risk assessment on MeHg human exposure via rice consumption:

✓ **What is the differences of risks between rice and fish consumption?**

- n-3 long chain polyunsaturated fatty acid (n-3 LCPUFA), selenium, essential amino acids
- fibre, starch

✓ **What is the scenario of low-level MeHg exposure to human health risk?**

Thank you very much!