



ICMGP 2024
CAPE TOWN • SOUTH AFRICA • 21 - 26 JULY

Health effects and economic benefit of pollution remediation in typical mercury mining area

Ping Li, Huifang Jiang, Xinbin Feng

**Institute of Geochemistry
Chinese Academy of Sciences**



Outline

- **Background**
- **Methods**
- **Results and discussion**
- **Conclusions**

Background

Toxicity of Hg

- ✓ MeHg, most toxic form of Hg

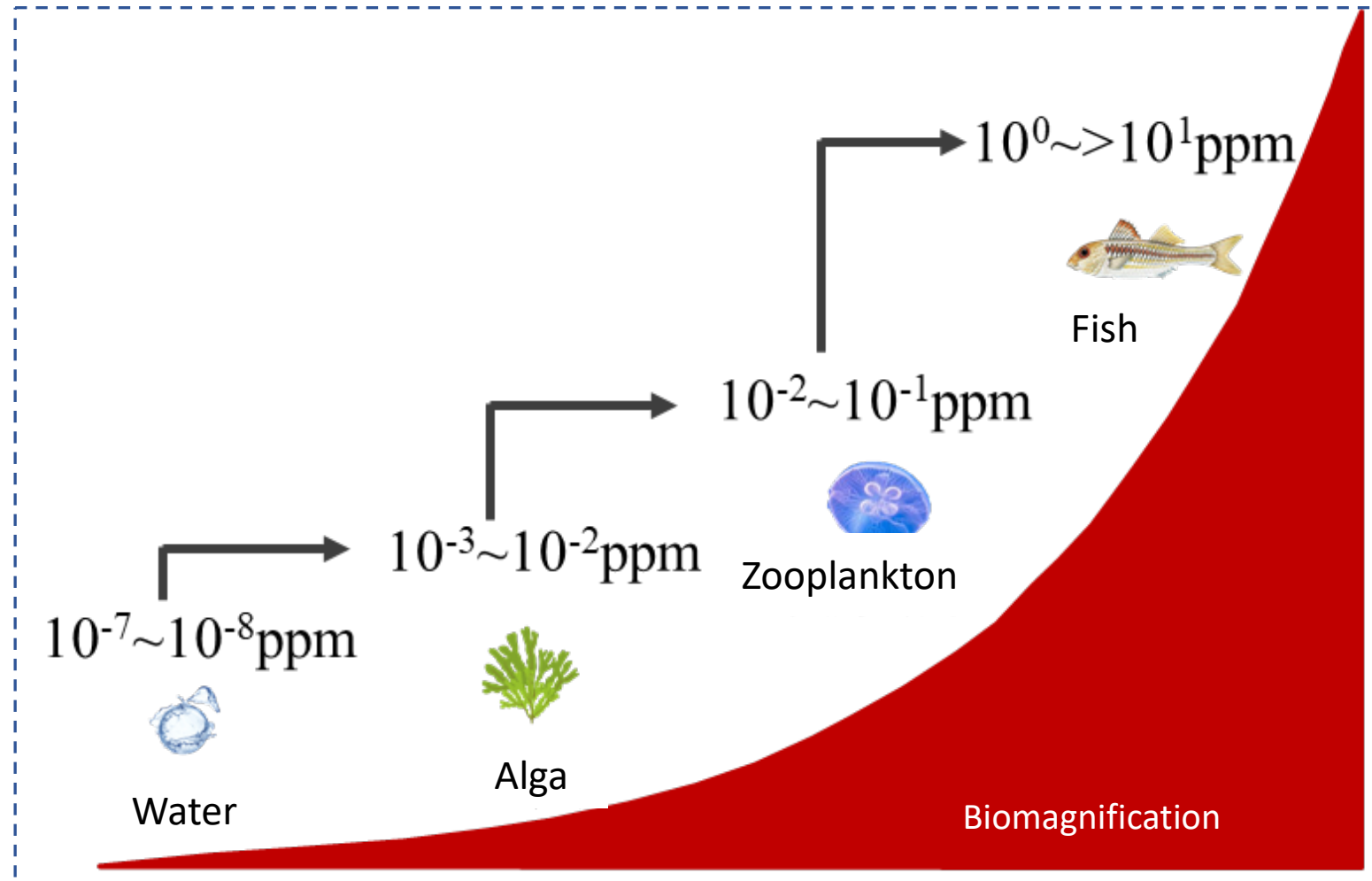
Minamata Disease (acute poisoning)

Patients: 2955; Death: 1784

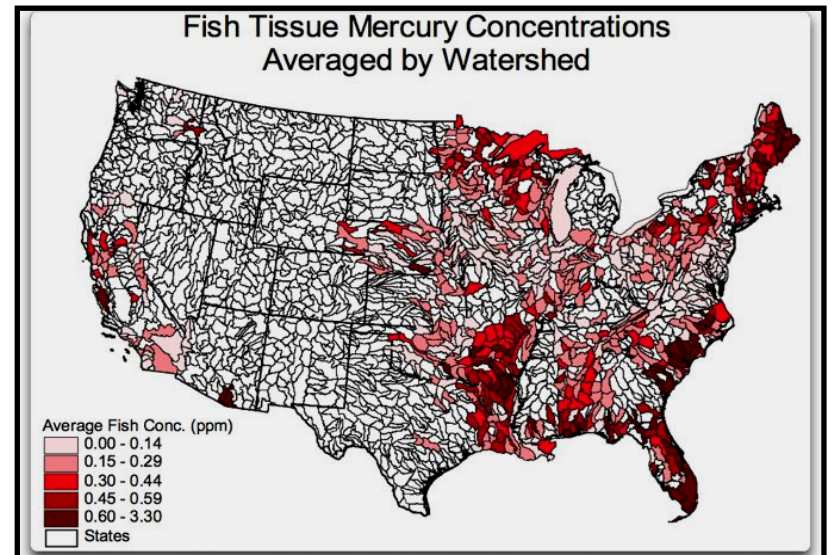
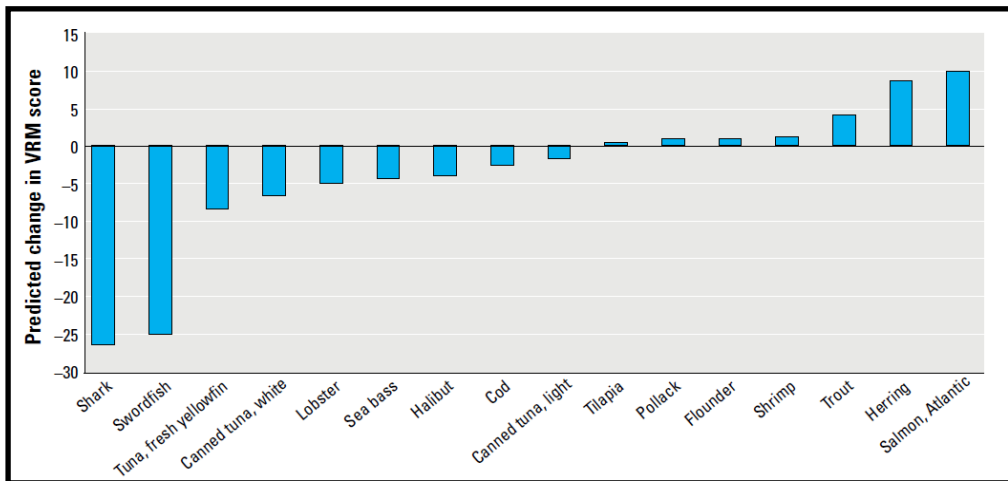
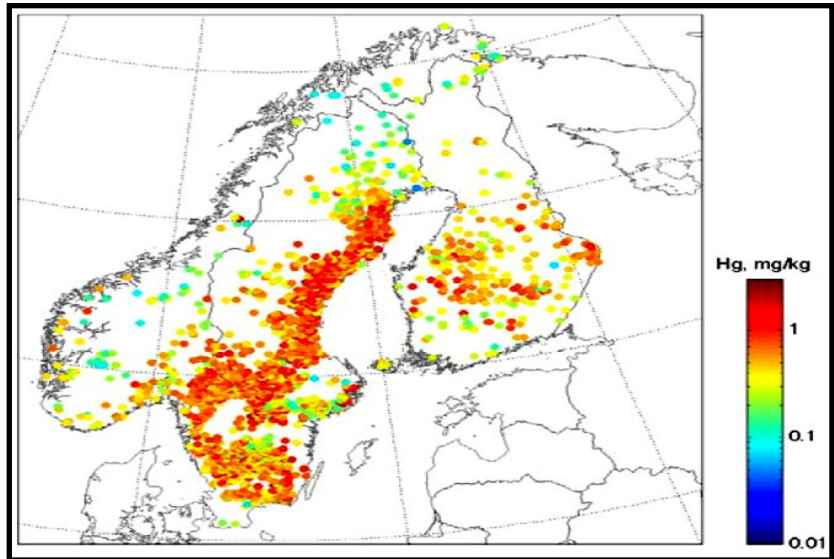
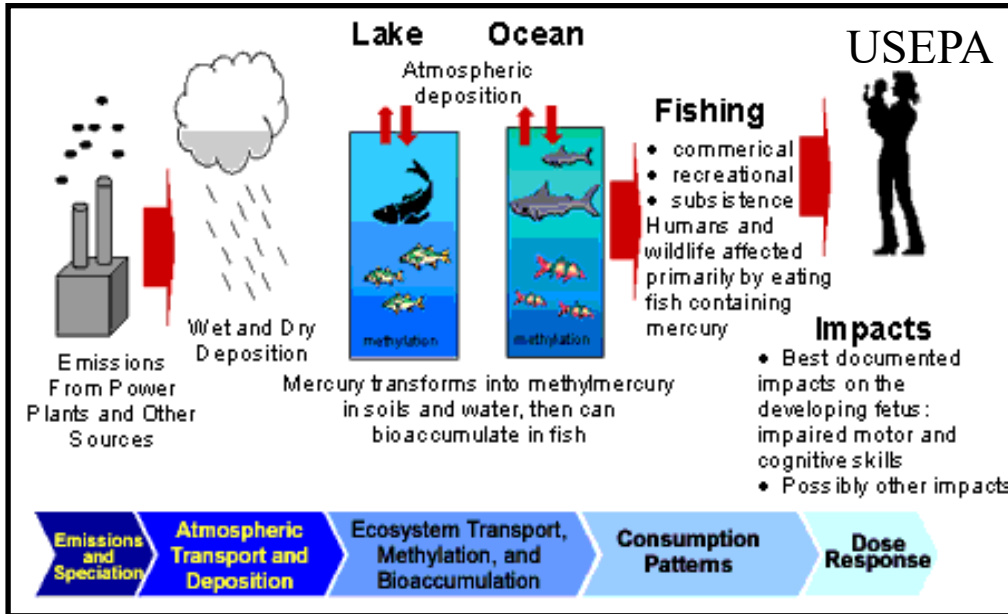
- ✓ Prenatal Long-time Low Level Mercury Exposure and IQ loss



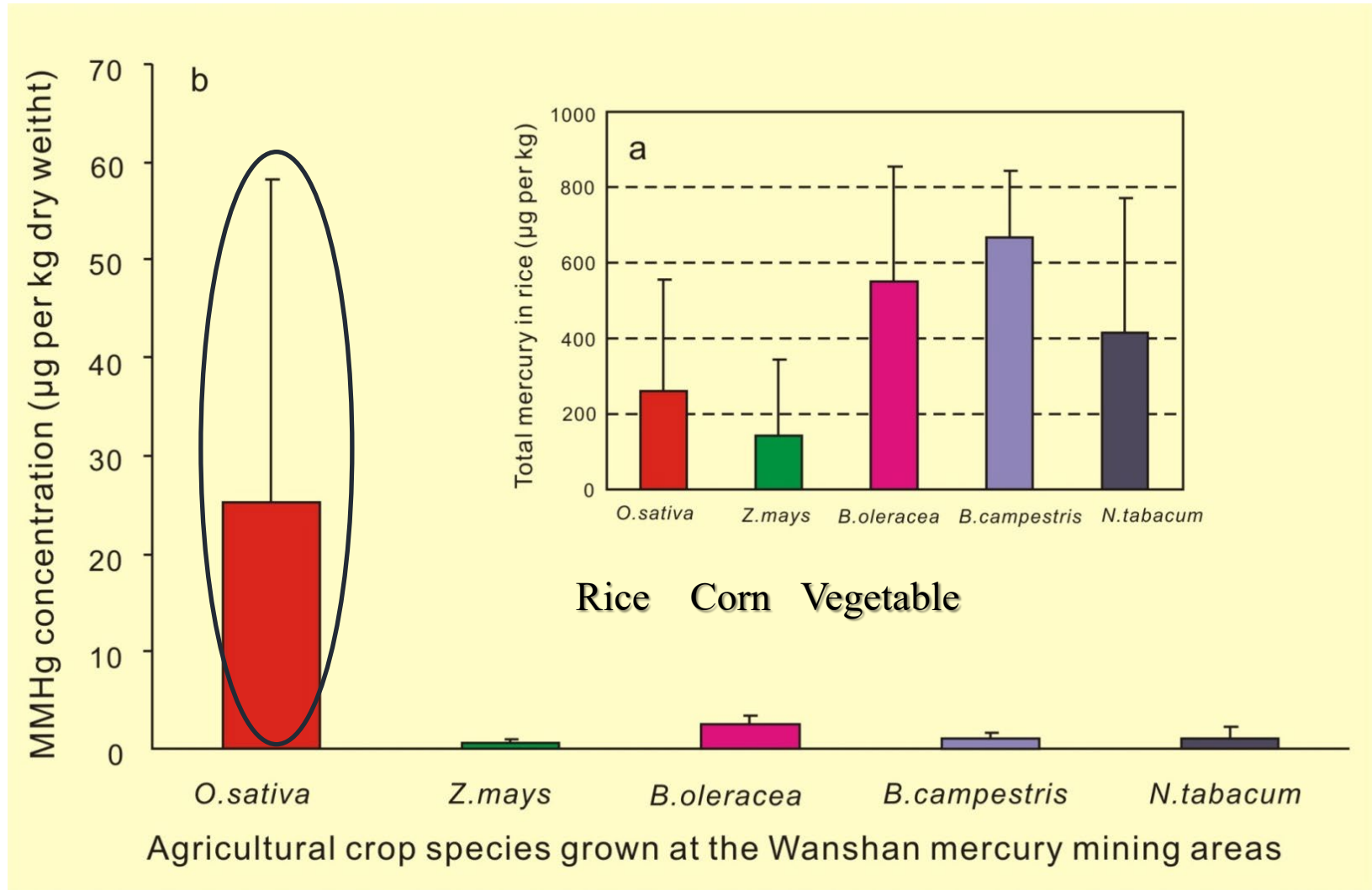
MeHg was easily biomagnified along with food chain



Human MeHg exposure: fish consumption

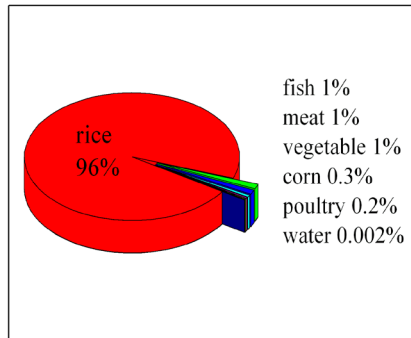
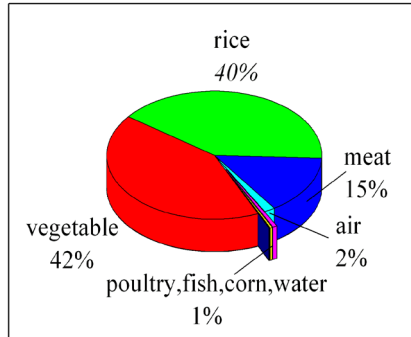


Rice can bio-accumulate MeHg

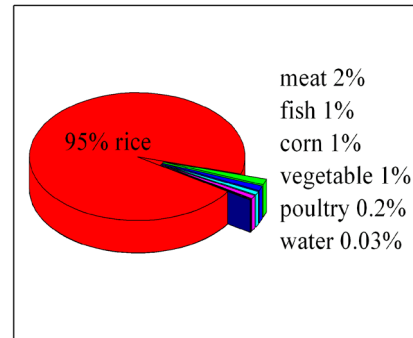
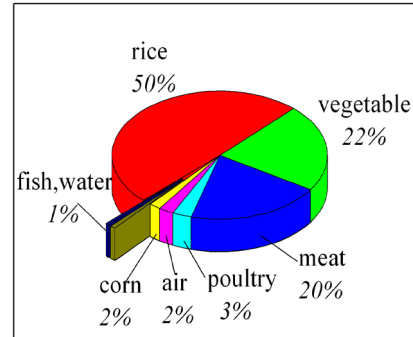


Rice is the Major Pathway for MeHg Exposure in inland China

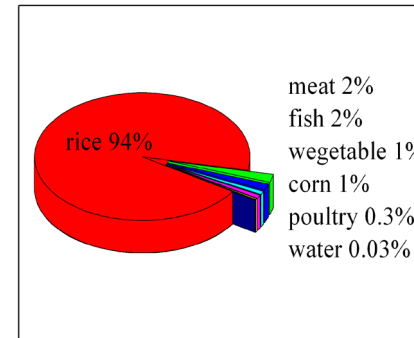
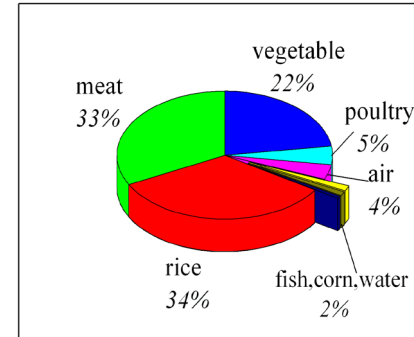
Wanshan Hg mine



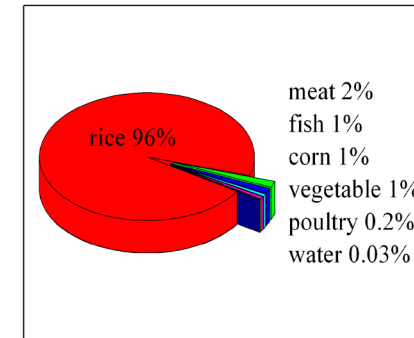
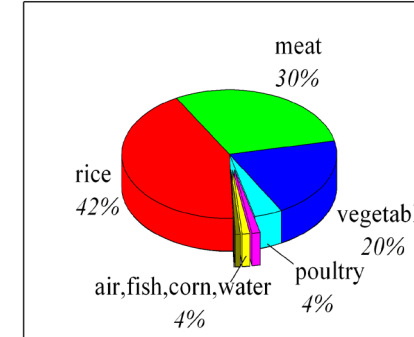
Qingzhen



Weining



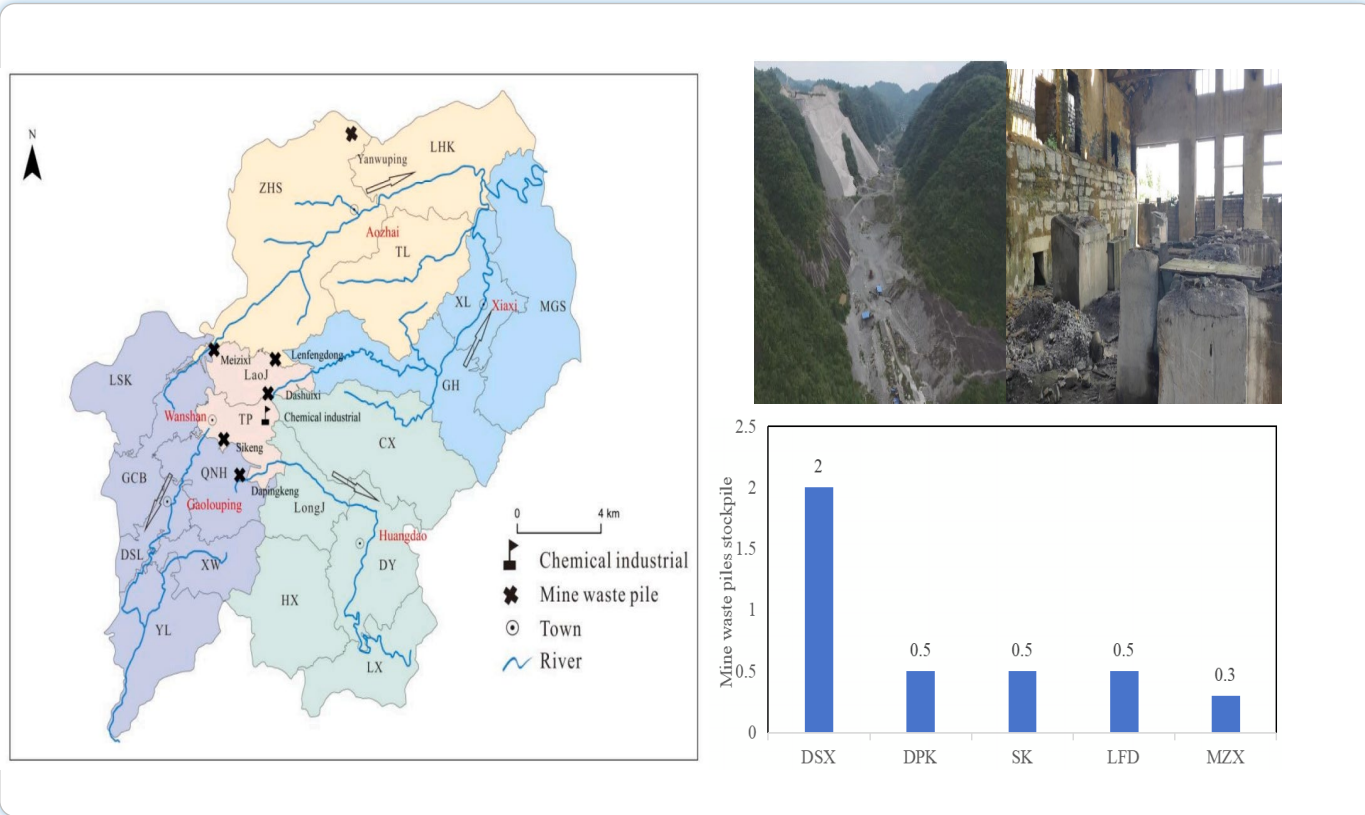
Leigong



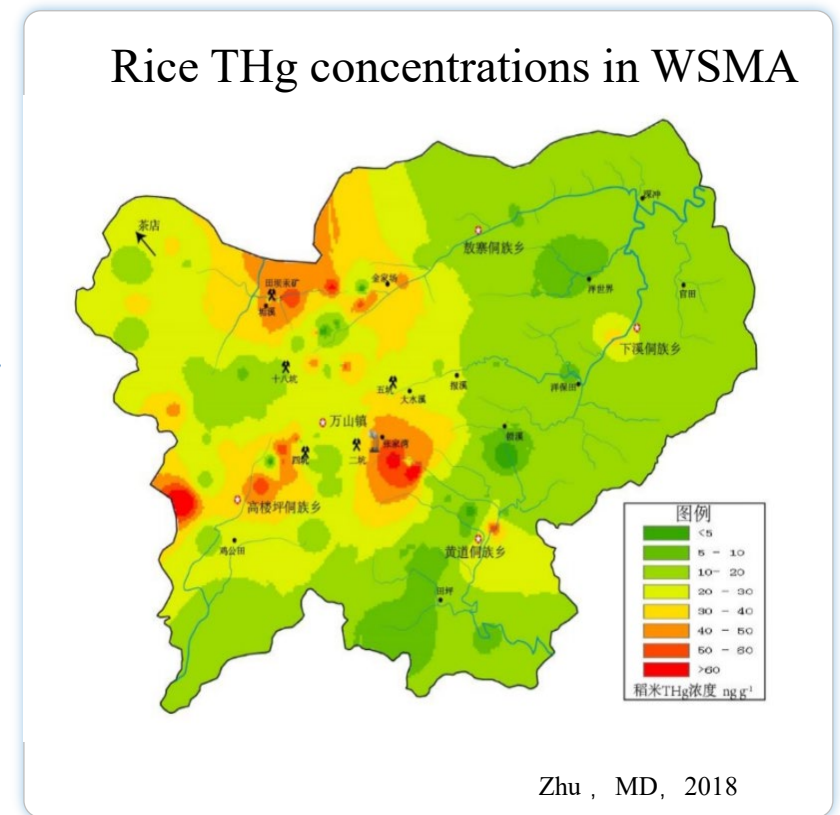
Percentage of estimated THg intake (A) and MeHg intake (B) from different media for the adult populations in Guizhou

Zhang et al., EHP, 2010

Rice Hg contamination in Wanshan Hg mining area (WSMA)

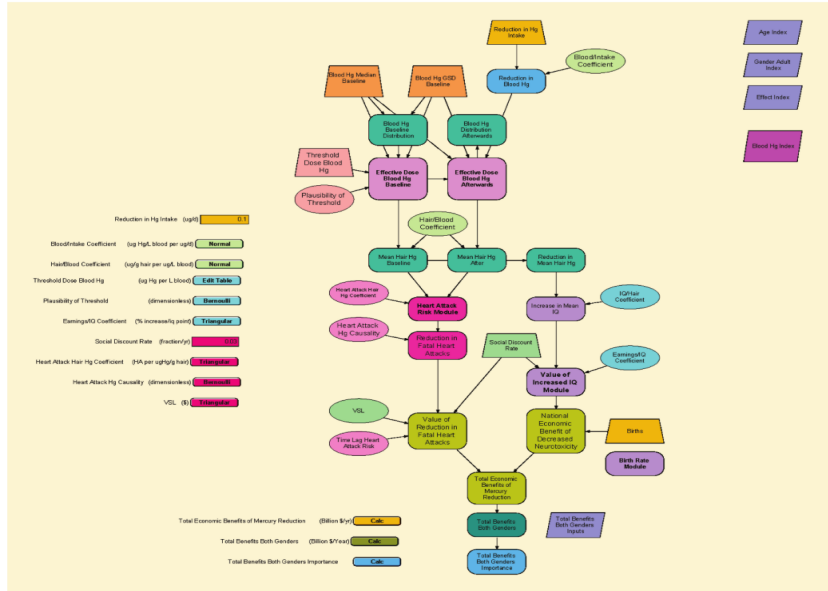


polluted



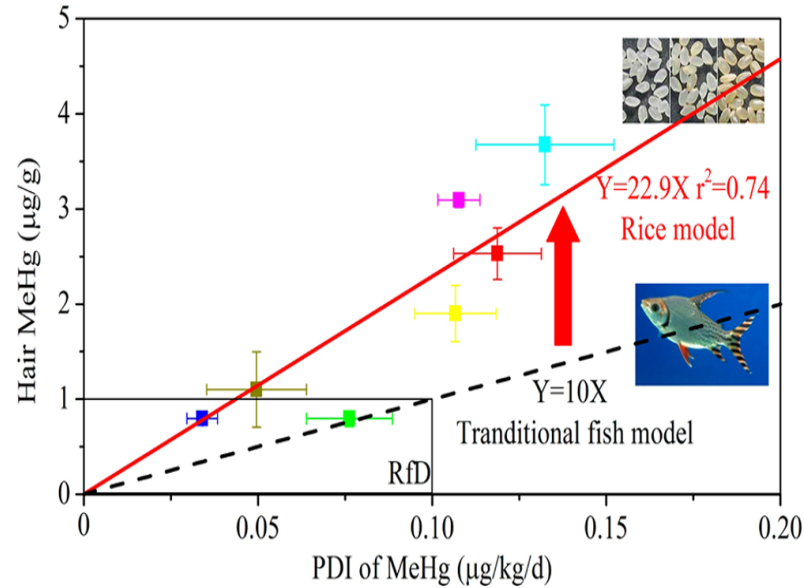
- The WSMA, known as the “mercury capital” of China, produced large amounts of mine wastes
- 40% of rice THg concentrations in WSMA exceeded the Chinese national limit of 20 ng/g

Health risks of human MeHg exposure

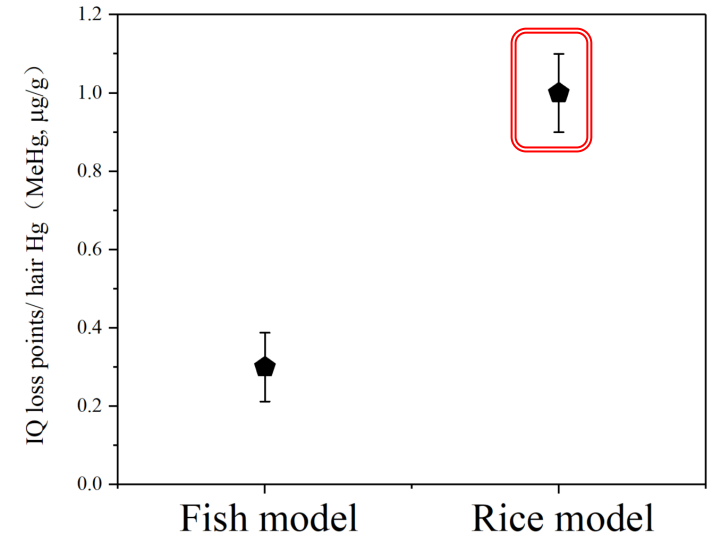


Rice et al., EST, 2010.

- A probabilistic characterization of the health benefits of reducing MeHg intake based on **rice consumption**



Li et al., EST, 2015.



Feng et al., EES, 2020.

- Health risks of human MeHg exposure and IQ loss from MeHg exposure are significantly **higher** from rice consumption than fish consumption

Ecological remediation in Wanshan Hg mine

Pollution source treatment: aims to control Hg released into local environment



Managing mine waste piles



Dredging rivers



Standardizing production in Hg-related enterprises



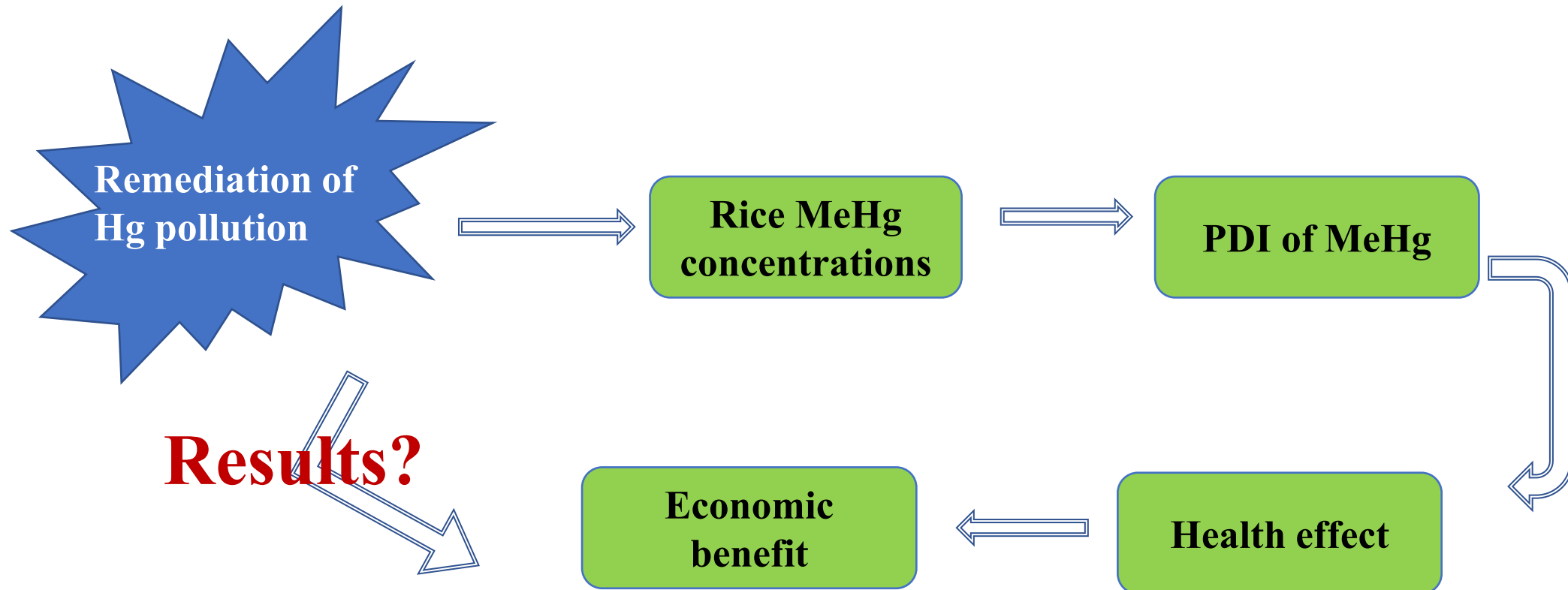
Soil remediation

Planting structure adjustment: reduce the ratio of local rice consumption



Ban crop (such as rice) cultivation to prevent MeHg accumulation
Paddy fields were converted into dry-land or vegetable greenhouse

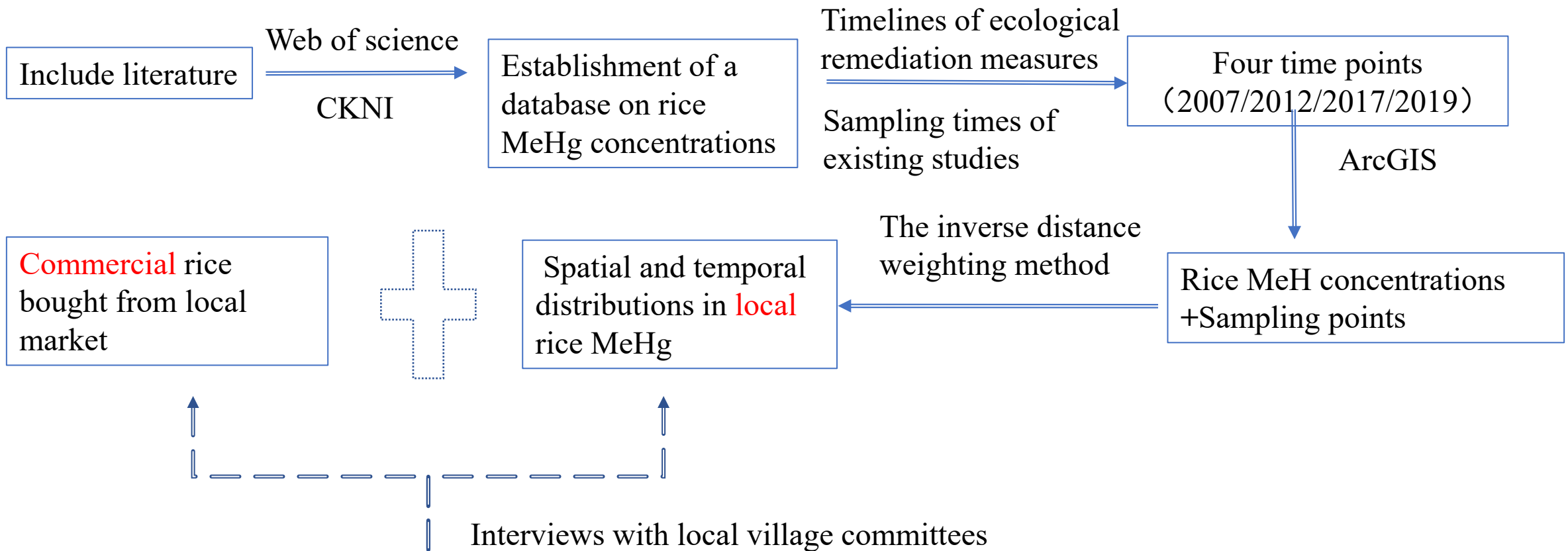
Scientific questions and flow chart of the study



Outline

- **Background**
- **Methods**
- **Results and discussion**
- **Conclusions**

Spatial and temporal distributions in rice MeHg



Ratio of local rice intake = number of cultivating rice households / number of households

PDI(Probable daily intake)/ Health effect/ Economic benefit

PDI assessment

$$PDI_{ek} = (C_{ka} f + C_b (1 - f) \times I_e / BW_e)$$

2007/2012/2017/2019

↓ linearly interpolated

2007-2022

$$\Delta PDI_{i,2007} = PDI_{2007} - PDI_i$$

Health effect

$$\Delta IQ = \gamma \times \rho \times \Delta PDI$$

$$\Delta Cf = Cf \times \omega \times (1 - \exp(-\phi \times \rho \times \Delta PDI))$$

Economic benefit

$$Vn = P_b \times \Delta IQ \times V_{IQ}$$

$$Vc = P \times \Delta Cf \times V_{Cf}$$

Key parameters

Monte Carlo simulation

Uncertainty analysis

C, f ρ, γ, φ

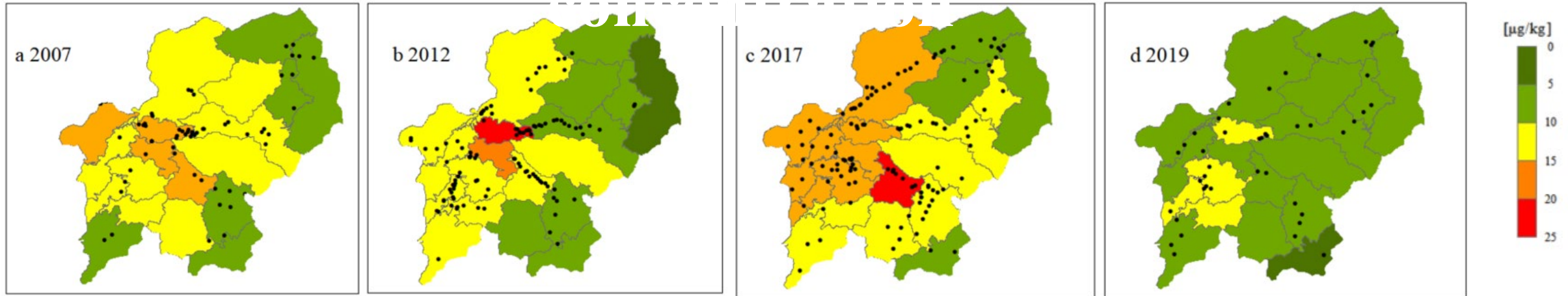
V_{IQ} , V_{Cf}

Ecological remediation

Outline

- Background
- Methods
- **Results and discussion**
- Conclusions

Spatial and temporal variations of rice MeHg



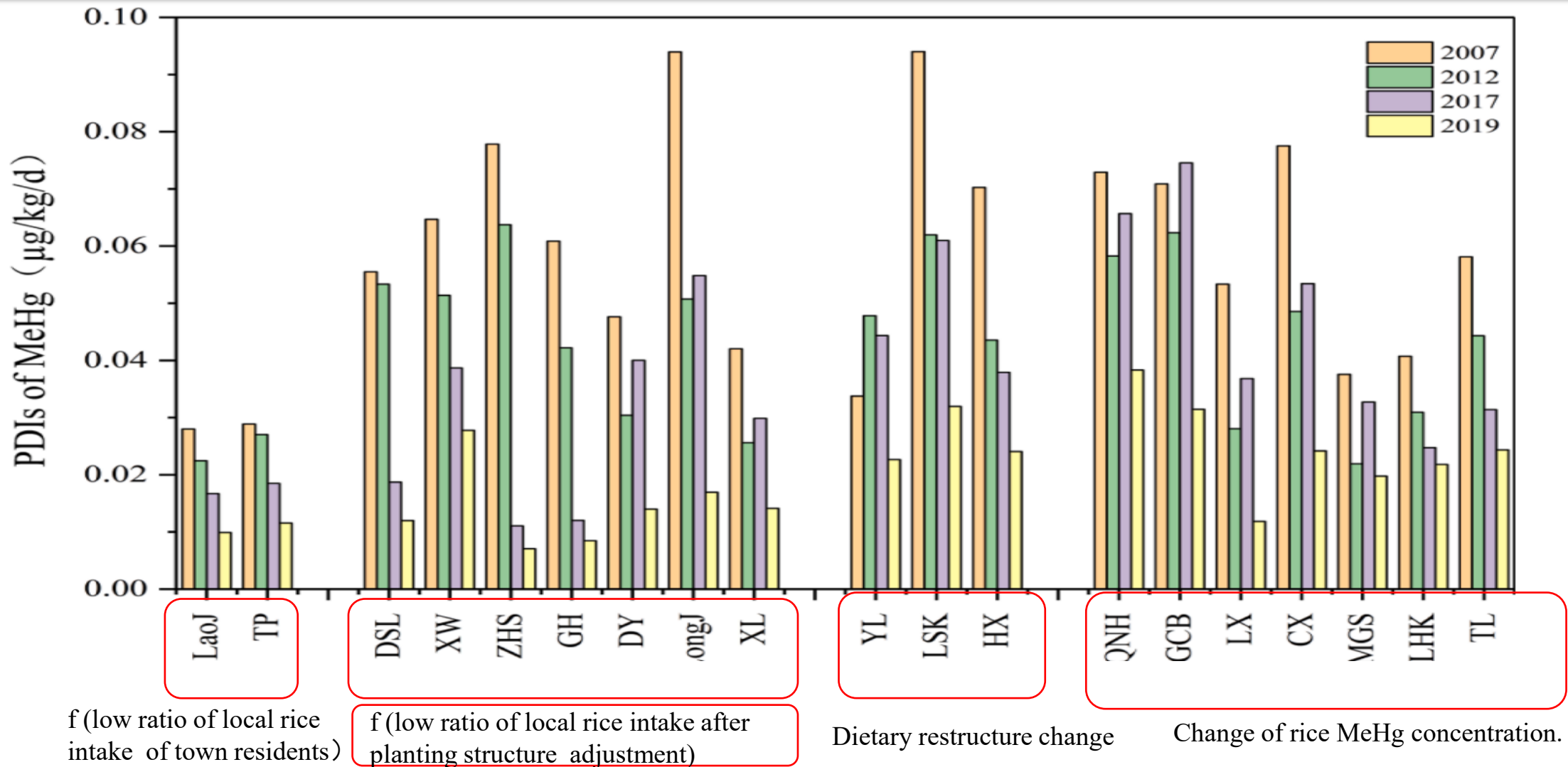
The flooding event in 2016

Remediation and management of mine waste piles during 2007-2011

Since the release of Action Plan for Soil Pollution Prevention and Control in 2016, ecological remediation measures was intensified

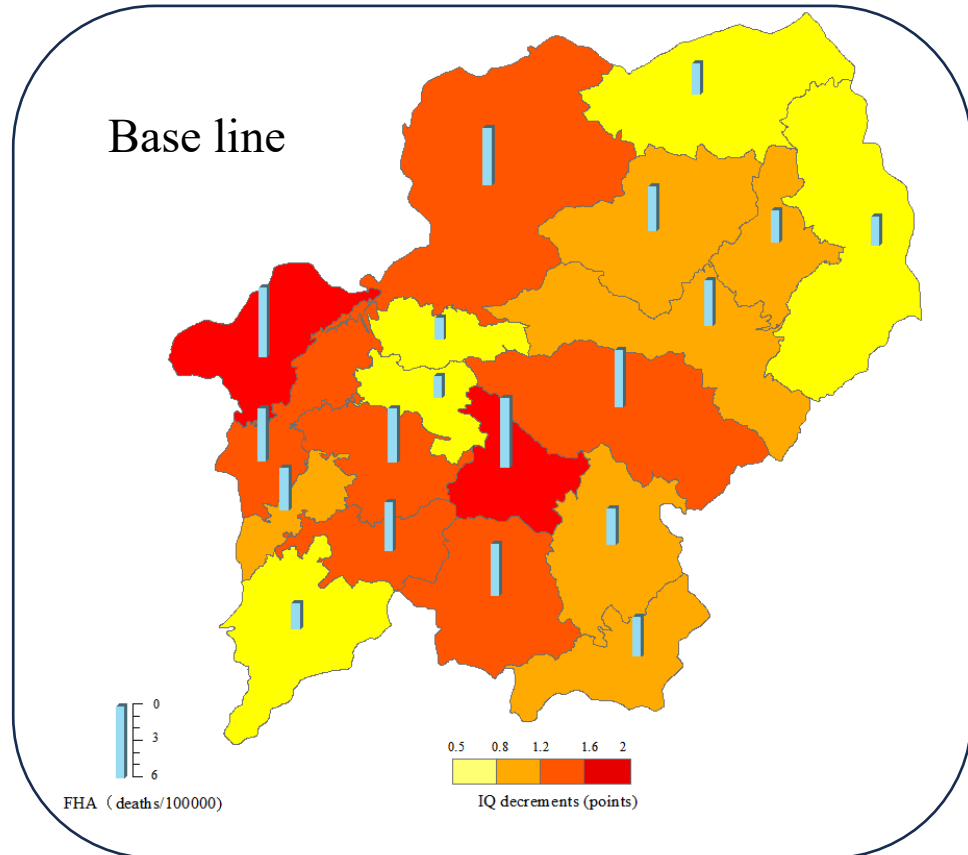
- Temporal variations: Rice MeHg concentrations in most villages showed a decreasing trend and fell into the safe limit ($10.2 \mu\text{g/kg}$) during 2007-2019
- Spatial variations: Rice MeHg concentrations were higher in the center and lower around the perimeter, related to the distance to the waste mine piles

PDI of MeHg-Key influencing factors

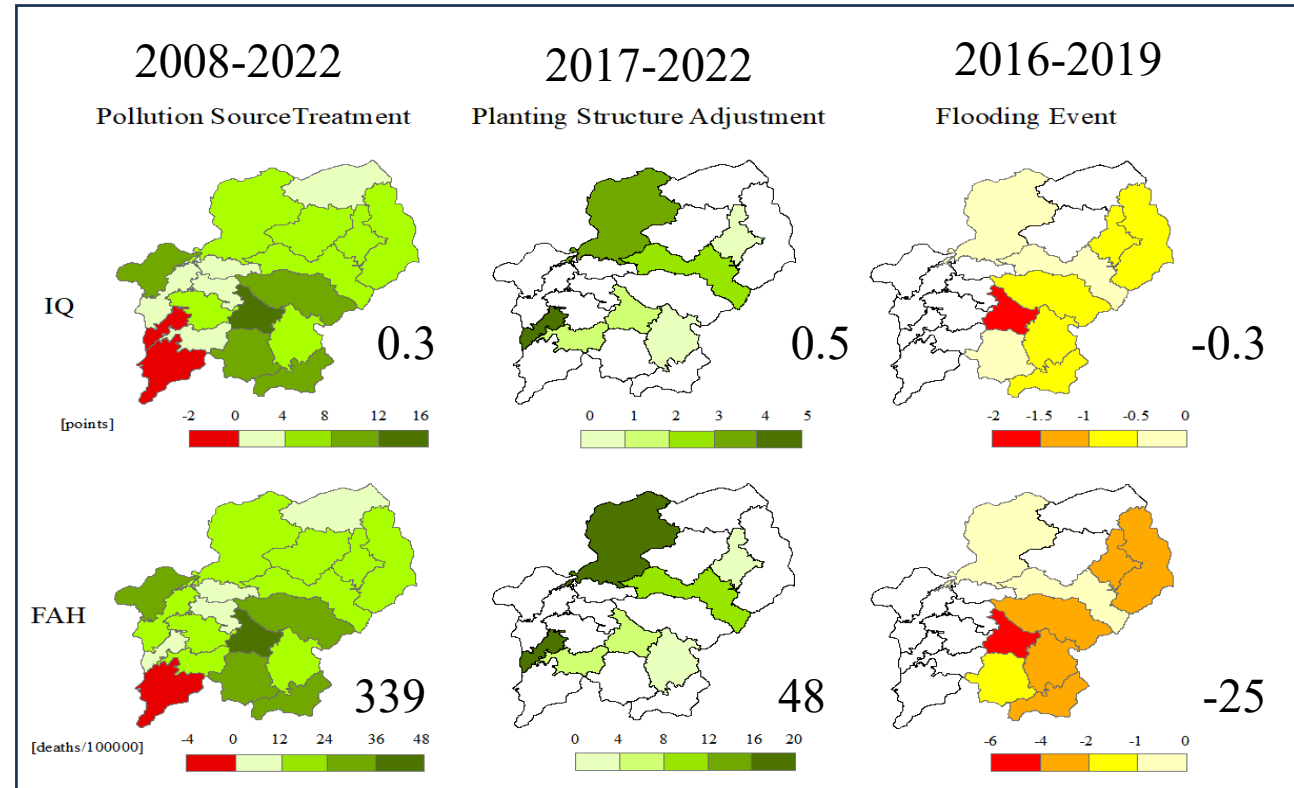


➤ Reducing the ratio of local rice intake through **planting structure adjustment** was an important factor

Health effect (IQ and FHA endpoints)

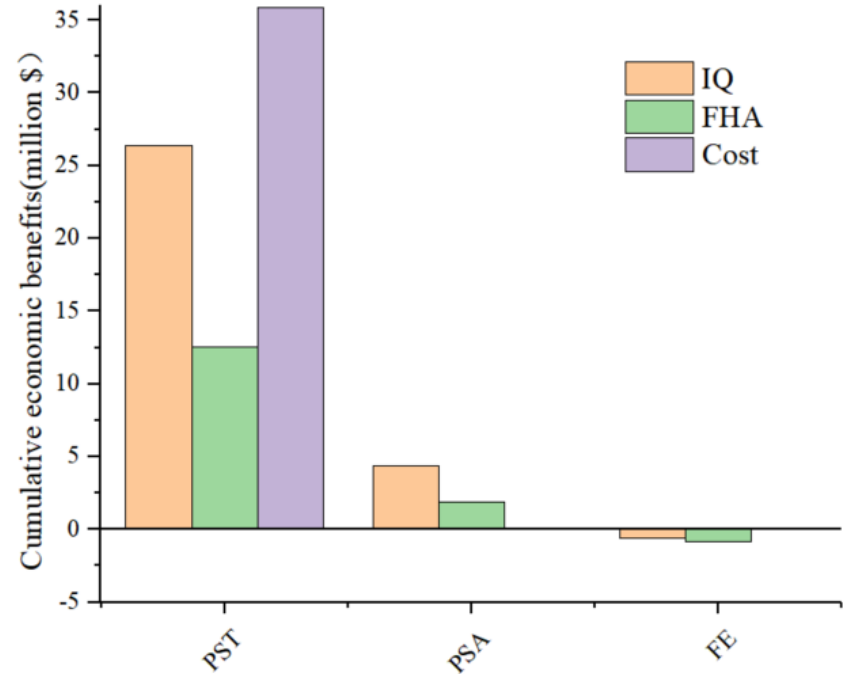


- 1.11 points of per-fetus IQ decrement and 62 deaths per 100,000 from FHA (fatal heart attack)
- Health effects from rice consumption greater than fish consumption

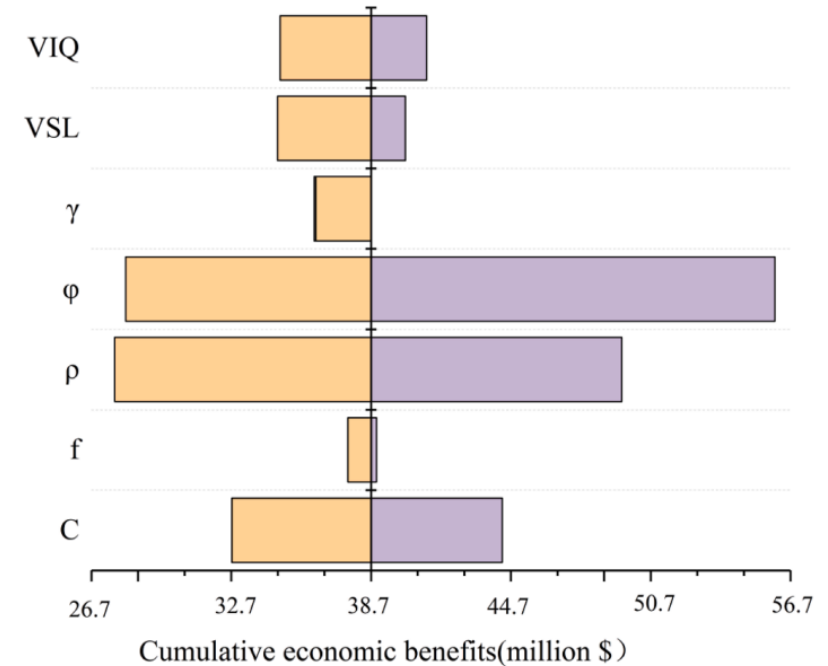


- Pollution source treatment (PST) provided the greatest health effects
- Planting structure adjustment (PSA) generates the greatest economic benefits in the short term
- Flooding event (FE) produced the perturbations

Cost-benefit and uncertainty analysis



- Pollution source treatment maximizes economic benefits in the long term and prevents the perturbations from flooding event
- Planting structure adjustment generates the greatest economic benefits in the short term



- The largest from the risk coefficient of hair MeHg levels to FHA, suggesting the need for more convincing evidence

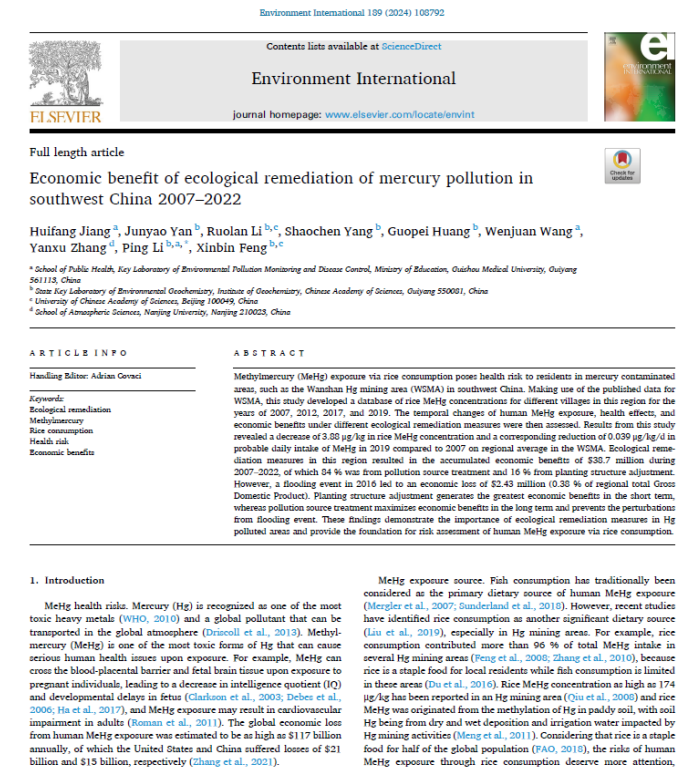
Outline

- Background
- Methods
- Results and discussion
- **Conclusions**

Conclusions

- ◆ Rice MeHg concentrations in WSMA showed a decreasing trend and fell into the safe limit during 2007-2019, but the flooding event produced significant fluctuations.
- ◆ The PDIs of MeHg were all lower than RfD of 0.1 $\mu\text{g}/\text{kg}/\text{d}$, and the health risk was effectively controlled; Reducing the ratio of local rice intake through planting structure adjustment was an important factor in controlling human MeHg exposure.
- ◆ The economic benefits of ecological remediation measures outweighed their economic costs. The combination of planting structure adjustment and pollution source treatment achieves win-win economic/ecological benefits.

Jiang H., Yan J., Li R., Yang S., Huang G., Wang W., Zhang Y., **Li P.,*** Feng X. Economic benefit of ecological remediation of mercury pollution in southwest China 2007–2022. *Environ. Int.* 2024, 189, 108792.



* Corresponding author at: State Key Laboratory of Environmental Geochemistry, Institute of Geochemistry, Chinese Academy of Sciences, Guiyang 550001, China. E-mail address: liping@mail.gyig.ac.cn (P. Li).
<https://doi.org/10.1016/j.envint.2024.108792>
Received 20 March 2024; Received in revised form 26 May 2024; Accepted 30 May 2024
Available online 1 June 2024
0160-4120/© 2024 The Author(s). Published by Elsevier Ltd. This is an open access article under the CC BY-NC license (<http://creativecommons.org/licenses/by-nc/4.0/>).



ICMGP 2024
CAPE TOWN • SOUTH AFRICA • 21 - 26 JULY



Thanks!

Ping Li

+86 13595014967

liping@mail.gyig.ac.cn