Supporting Information

Bioaccumulation of Hg in rice leaf facilitates selenium bioaccumulation in rice (Oryza sativa L.) leaf in the Wanshan mercury mine

Chuanyu Chang†,‡, Chongyang Chen†,‡, Runsheng Yin§,*; Yuan Shen†, Kang Mao†, Zhugen Yang§, Xinbin Feng†,‖,*; Hua Zhang†,‖,*

†State Key Laboratory of Environmental Geochemistry, Institute of Geochemistry, Chinese Academy of Sciences, Guiyang 550081, China
‡University of Chinese Academy of Sciences, Beijing 100049, China
§State Key Laboratory of Ore Deposit Geochemistry, Institute of Geochemistry, Chinese Academy of Sciences, Guiyang 550081, China
‖Center for Excellence in Quaternary Science and Global Change, Chinese Academy of Sciences, Xian 710061, China

*School of Water, Energy and Environment, Cranfield University, Cranfield, MK430AL, United Kingdom

Corresponding Authors: Runsheng Yin (yinrunsheng@mail.gyig.ac.cn); Xinbin Feng (fengxinbin@vip.skleg.cn); Hua Zhang (zhanghua@mail.gyig.ac.cn)

The supporting information contains:

9 pages; Text S1, S2; Table S1; Figure S1, S2, S3
**S1. THg, TSe concentrations of the WMM soil in the field study**

THg concentrations of the WMM soil collected in this study ranged from 0.35 to 833.7 μg/g, with a geomean of 21.8 μg/g that is ~550 times higher than the soil background level in China (40 ng/g Hg)\(^1\). THg levels at 13 sites exceeded the limit value (23 μg/g) of inorganic Hg for agriculture soils set by the USEPA\(^2\), indicating an environmental risk. Soil THg at non-artisanal and artisanal mining sites showed high variability, ranging from 0.35 to 833.7 μg/g (geomean: 13.5 μg/g) and from 15.0 to 114.6 μg/g (geomean: 36.8 μg/g), respectively. In general, the higher soil THg concentrations at artisanal mining sites are likely caused by the ongoing artisanal Hg mining activities, as these activities not only release Hg-rich waste materials into the soil but also emit Hg into the ambient air, which is subsequently deposited onto the soil. Some of the non-artisanal mining sites also showed extremely high soil THg levels due to their close location to historically mined calcine tailings (Figure S1).

The TGM concentrations at all sites ranged from 13 to 1287 ng/m\(^3\) (Table 1), comparable to previous results in the WMM (17 to 2100 ng/m\(^3\))\(^3\), and were 1 to 3 orders of magnitude higher than those at background sites (1.5 to 1.7 ng/m\(^3\) for the Northern Hemisphere)\(^4\). The artisanal mining sites showed much higher TGM concentrations (range: 64 to 1290 ng/m\(^3\); geomean: 369 ng/m\(^3\)) than non-artisanal mining sites (range: 13 to 113 ng/m\(^3\); geomean: 38.8 ng/m\(^3\)).

TSe concentrations of soil samples collected in the field study ranged from 0.43 to 21.71 μg/g, with a geomean value of 1.8 μg/g, which is ~36 times than the abundance of Earth's crust (50 ng/g)\(^5\). Soil TSe concentrations at non-artisanal mining sites ranged from 0.43 to 21.7 μg/g (geomean: 2.13 μg/g), which is similar than that observed at artisanal sites mining
(range: 0.63 to 4.20 μg/g; geomean: 1.65 μg/g).

S2. Understand correlations among soil Hg, TGM, and Hg levels in rice tissues

The THg concentrations of leaf and stem at both non-artisanal sites and artisanal sites showed significantly positive linear correlations with TGM (Table S2). It confirmed that leaf and stem receive the majority of Hg from the atmosphere\textsuperscript{6, 7}. It should be noted that at non-artisanal mining sites, THg concentrations of leaf and stem also correlate with the soil THg (Table S2). However, such correlations may be caused by the correlation between THg in soil and TGM at non-artisanal sites, because previous studies have demonstrated that soil is unlikely the major source of Hg in plant ground tissues\textsuperscript{6, 8}. At artisanal sites, there is a lack of significant correlations in THg between soil and the two tissues (leaf and stem, as shown in Table S2), which agree with previous conclusions that the contribution of soil Hg to ground tissues is of less importance\textsuperscript{6-8}. At both artisanal and non-artisanal mining sites, THg concentrations of roots showed positive correlations to soil THg ($r^2 = 0.43$, $p < 0.01$), which is consistent with previous studies demonstrating that root mainly receives Hg from soil\textsuperscript{7-8}. Unlike other tissues, rice grain has been shown to accumulate Hg from both soil and atmosphere\textsuperscript{7}. At artisanal mining sites, THg concentrations of polished rice positively correlate with TGM, which suggests that atmospheric Hg plays a more important role in contributing Hg in rice grain than soil Hg, considering the much higher TGM concentrations.

At non-artisanal mining sites, however, THg concentrations in polished rice do not correlate with either soil THg or TGM, which is strange, may imply largely varied soil and atmosphere roles in contributing Hg in rice grain. The differences in Hg bioavailability and soil physicochemical characteristics between mining vs non-mining sites may be an important
reason causing the difference of Hg bioaccumulation in rice grain at the two studied sites.
Table S1. Pearson's correlation matrix ($r$) among the Hg levels in paddy soils, air, and tissues of rice plants at non-artisanal mining sites and artisanal mining sites.

<table>
<thead>
<tr>
<th></th>
<th>Non-artisanal mining sites</th>
<th>Artisanal mining sites</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Soil</td>
<td>TGM</td>
</tr>
<tr>
<td>Soil</td>
<td>1</td>
<td>0.82**</td>
</tr>
<tr>
<td>TGM</td>
<td>1</td>
<td>0.79**</td>
</tr>
<tr>
<td>Root</td>
<td>1</td>
<td>0.98**</td>
</tr>
<tr>
<td>Stem</td>
<td>1</td>
<td>0.94**</td>
</tr>
<tr>
<td>Leaf</td>
<td>1</td>
<td>0.22</td>
</tr>
<tr>
<td>Polished rice</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Significance level: ** $p < 0.01$; * $p < 0.05$. 

Figure S1 Study area and sampling sites
Figure S2 Distribution of Hg in soil and rice tissues

![Graph showing the distribution of Hg concentrations in different tissues and sites.](image)

- **Non-artisanal mining sites**
- **Artisanal mining sites**

Tissues: soil, root, leaf, stem, polished rice.

Concentration units: μg/g and BAFs of Hg.

Key points:
- Median concentrations.
- Interquartile ranges.
- 95%, 75%, 50%, 25%, 5% percentiles.

S7
Figure S3 Distribution of Se in soil and rice tissues
References
5. Fordyce, F. M. Selenium deficiency and toxicity in the environment. Essentials of Medical Geology: Springer; 2013