Low-level arsenite boosts rhizospheric exudation of low-molecular-weight organic acids from mangrove seedlings

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Outline

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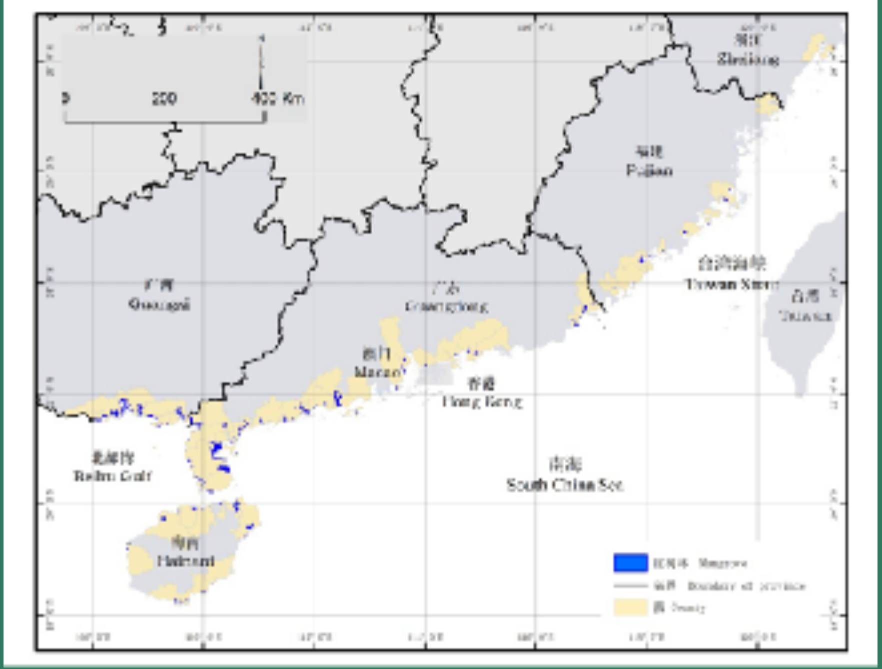
Quanzhou, 2016



Dan xinqiu, 2016

PART ONE

Background

Mangrove wetland

Carbon Storage

Habitat /Spawning

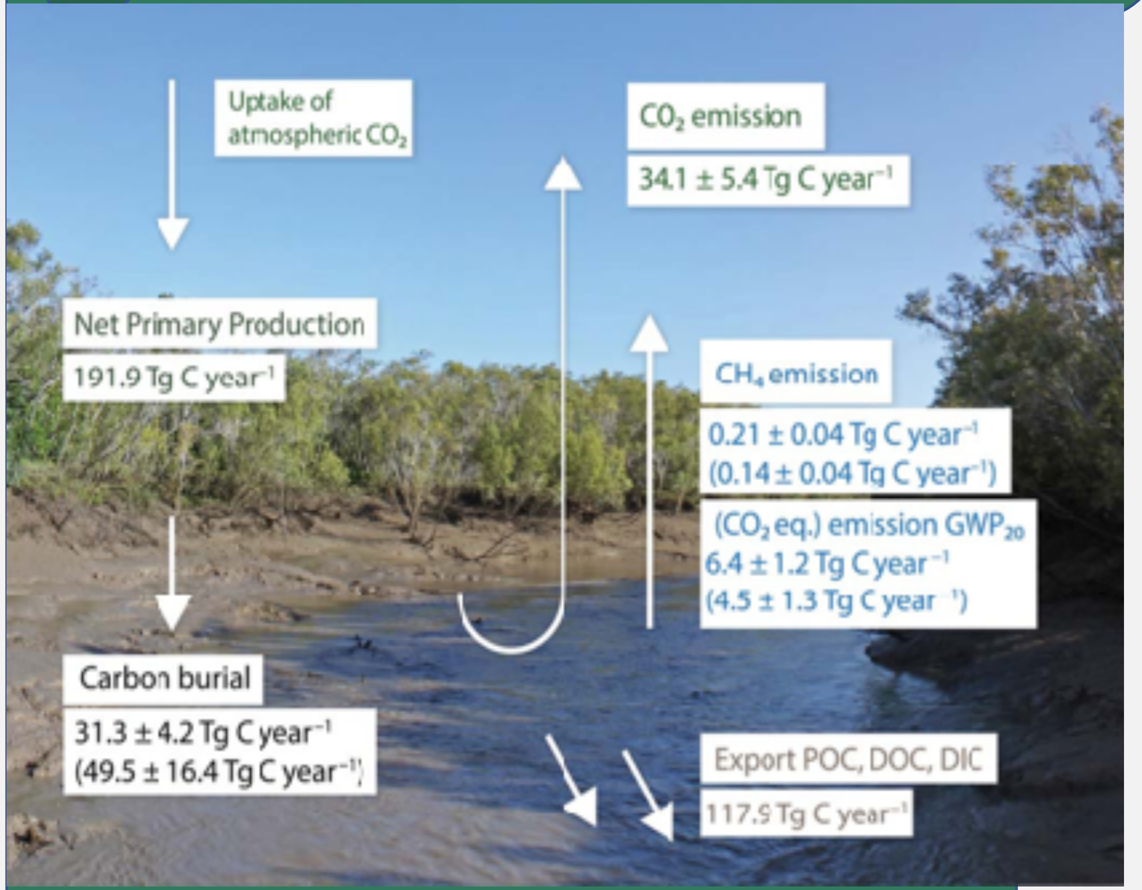
Ecological benefit

Human activities and environmental characteristics

- Industry
- Agriculture
- Aquaculture
- Deforestation

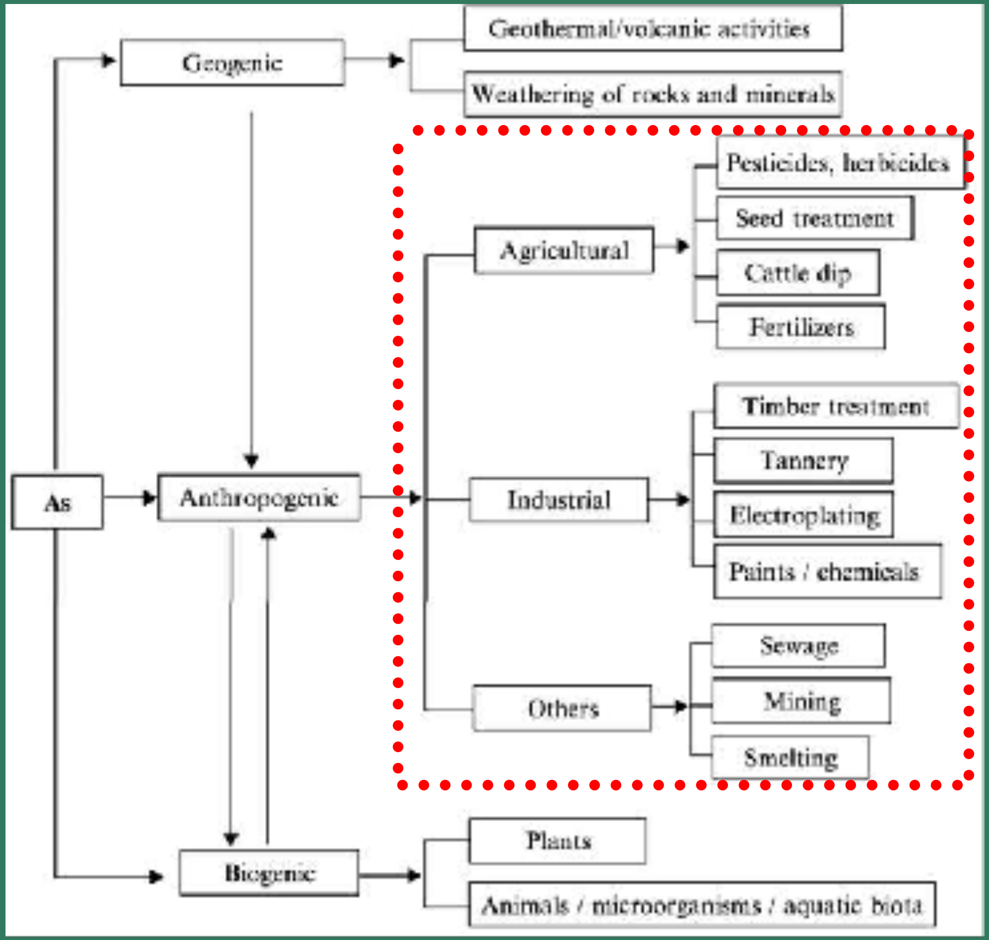
- High organic matter
- High Fe & S
- Reducing environment
- Food chain/web

Heavy metal accumulation



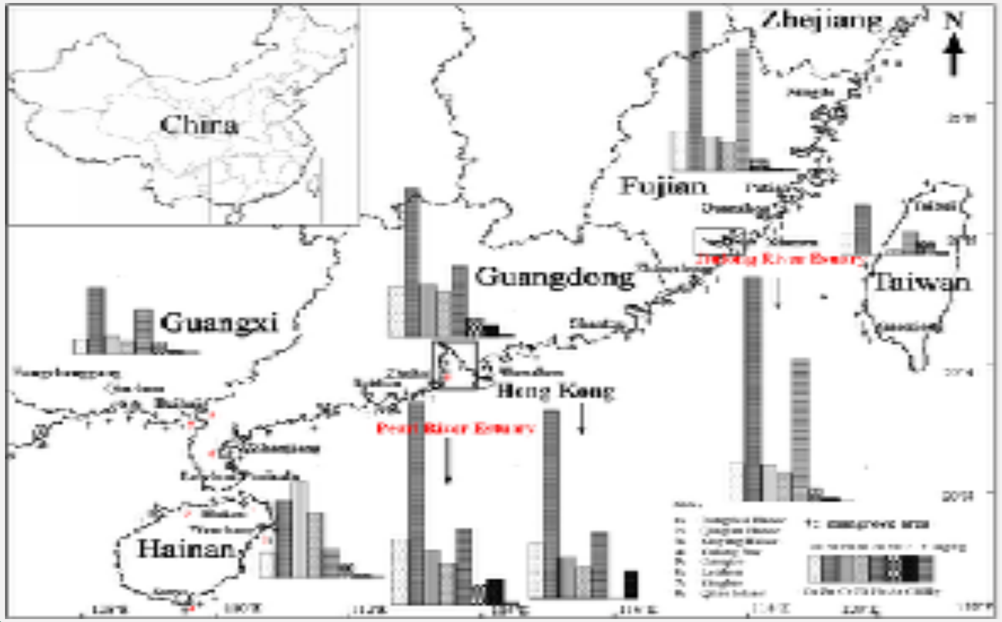
Judith, Science Advance, 2018

Arsenic



Kumar，2015

Arsenic content in mangroves

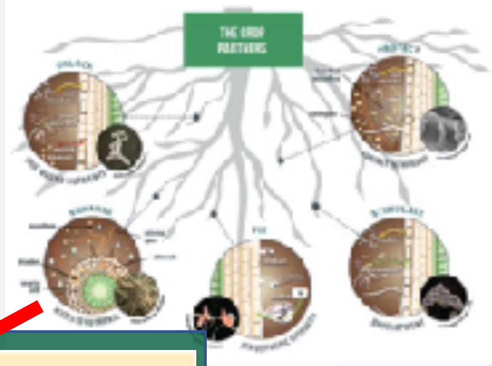


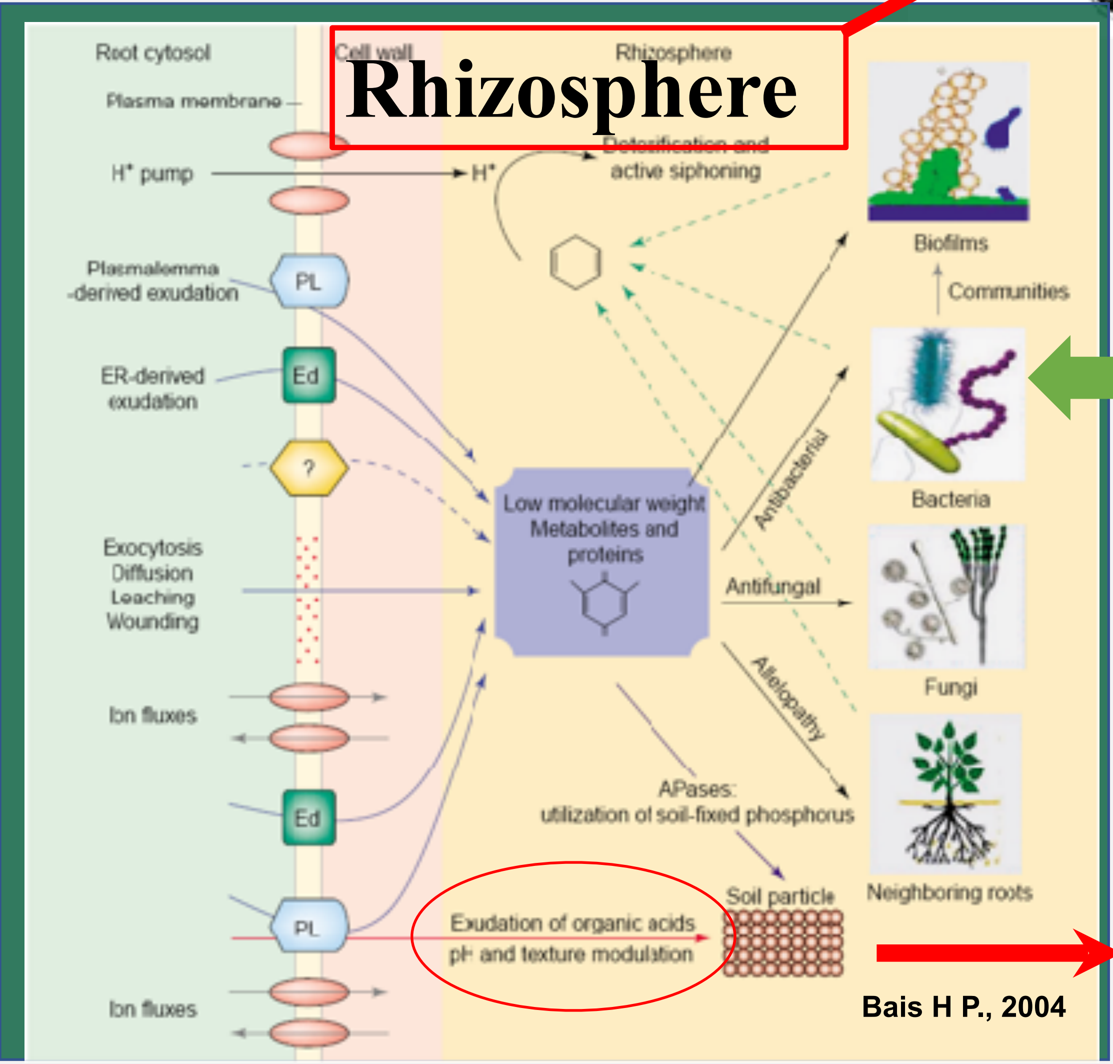
K. Pan, 2012

Arsenic pollution

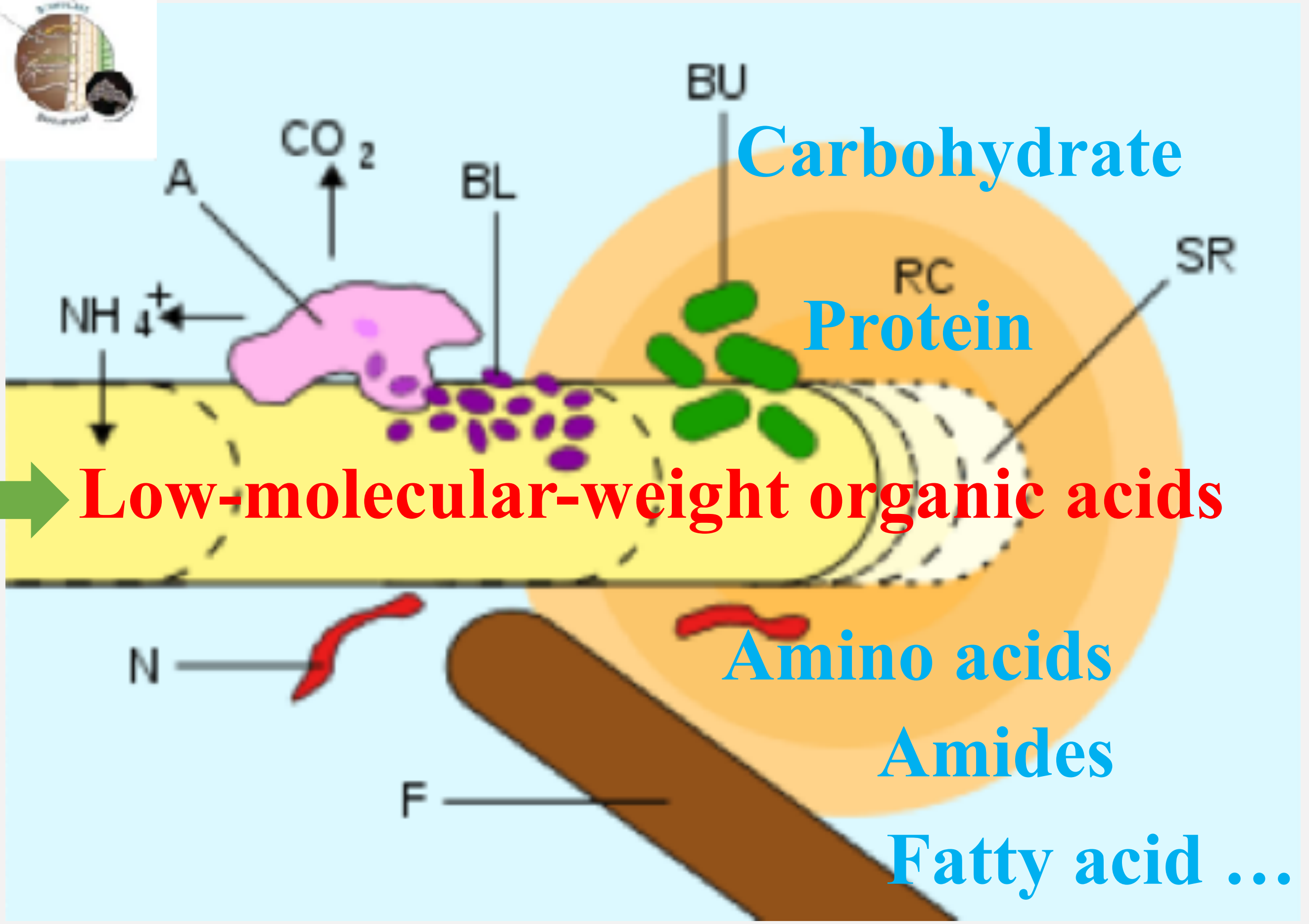
- National nature reserves： < 15 mg/kg
- 30 mg/kg (wetland) and 40 mg/kg (dry farm)

Root exudates





Bais H P., 2004



- ➢LMWOAs change soil pH;
- ➢affect complexation/chelation with metal ions;
- ➢Microbial composition and microbial activity.

How to understand regarding phytoextraction and mangrove tolerance to As toxicity, and the rhizospheric behaviour of metalloid As-contaminated sediments in the mangrove ecosystems.

PART TWO

Material & Method

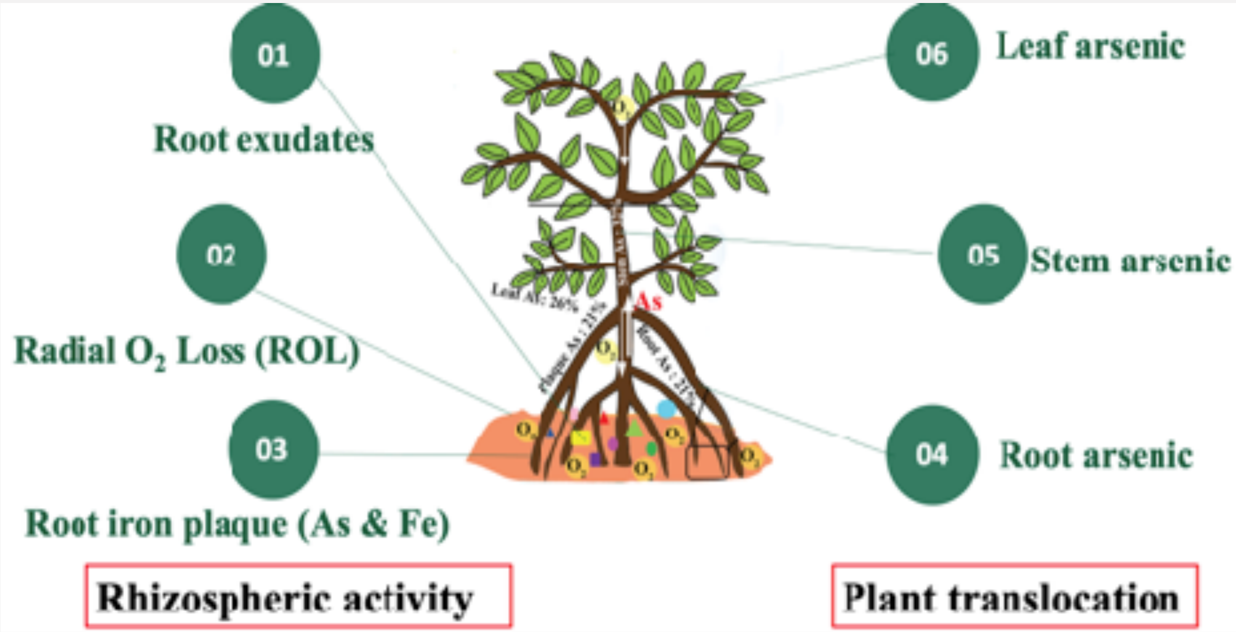
Research design

Pot experiment

Sand cultivation

Arsenite (As^{3+})	0 μM/L	5 μM/L	10 μM/L	20 μM/L	30 μM/L

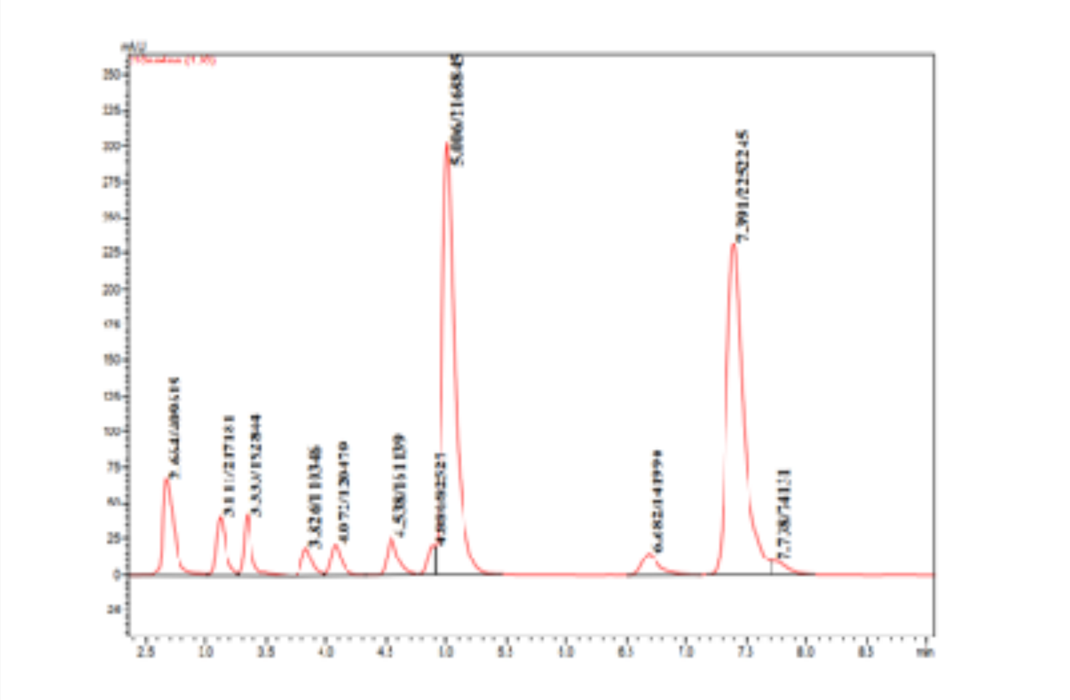
Plant Analysis



- ➢LMWOAs constitution and changes
- ➢Root responses to As toxicity
- ➢As phytoextraction of mangroves

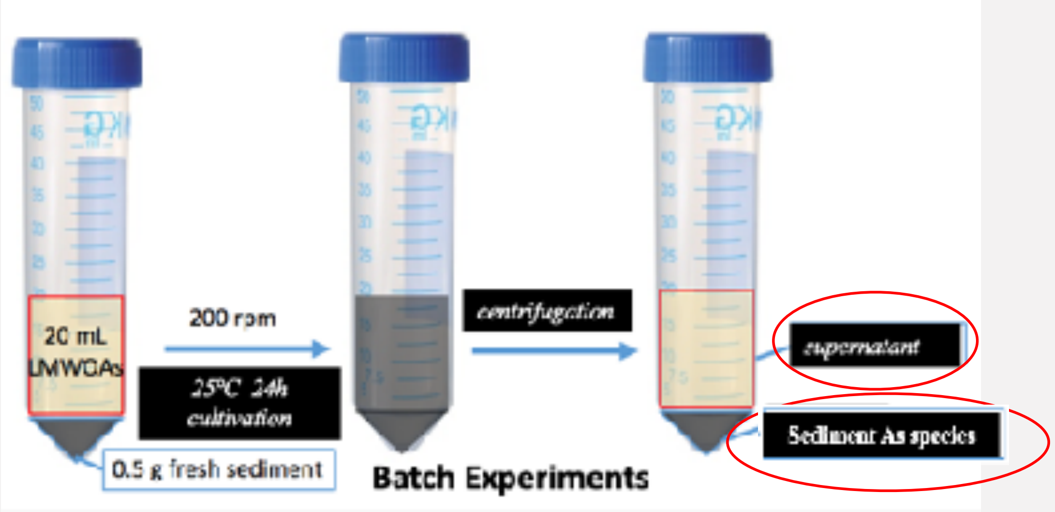
Research design

Pot experiment



Chromatogram of 10 organic acids mixture analyzed by HPLC. oxalic acid (2.664 min); tartaric acid (3.111 min); formic acid (3.333 min); L-malic acid (3.826 min); malonic acid (4.072 min); lactic acid (4.538 min); acetic acid (4.88 min); maleic acid (5.006 min); citric acid(6.682 min); fumaric acid (7.391 min).

Batch experiment



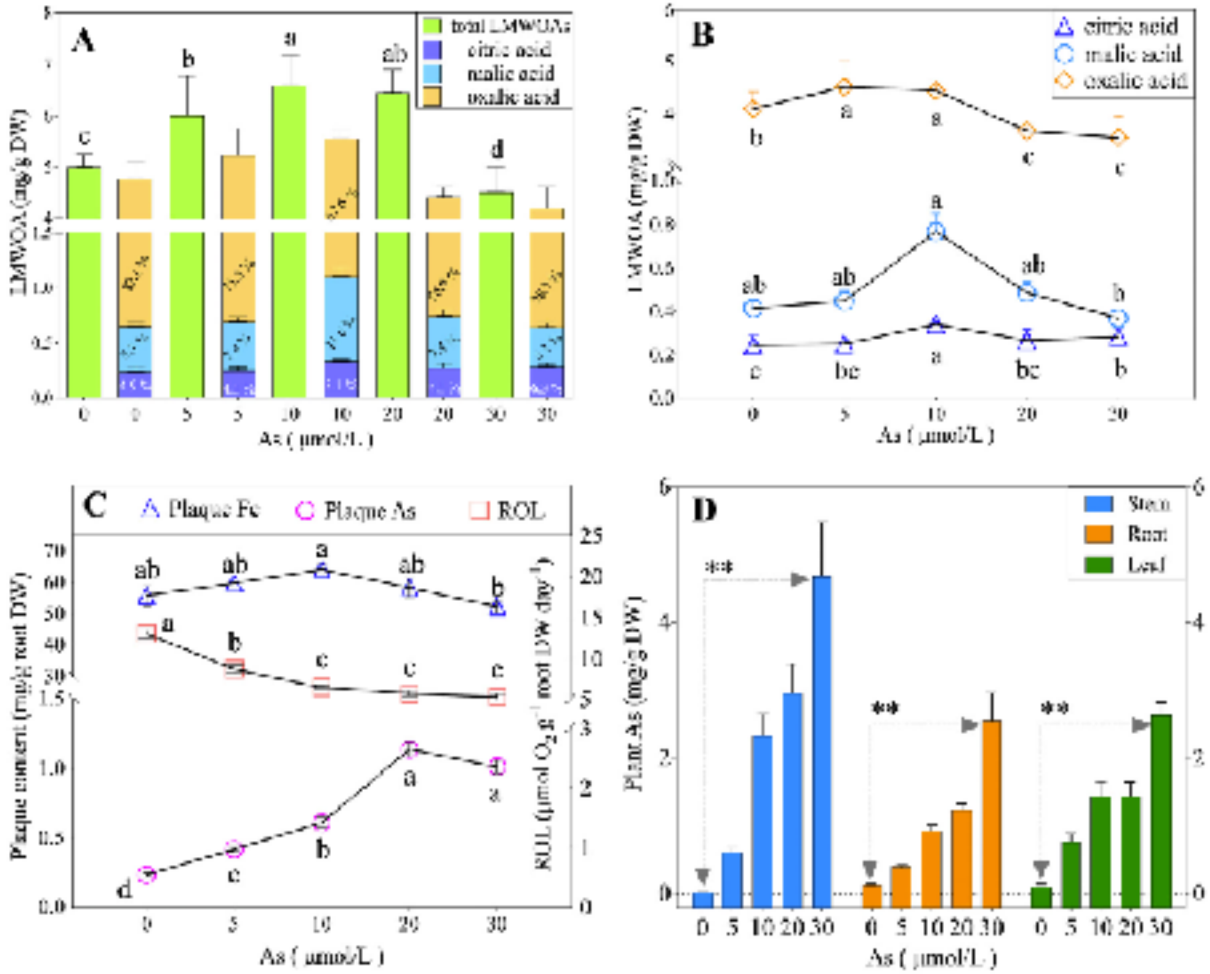
As treatment

As in sediments	As0 (0 mg/kg)	As20 (20 mg/kg)	As40 (40 mg/kg)
LMWOAs	citric acid	malic acid	oxalic acid

PART THREE

Results & Discussion

Pot experiment



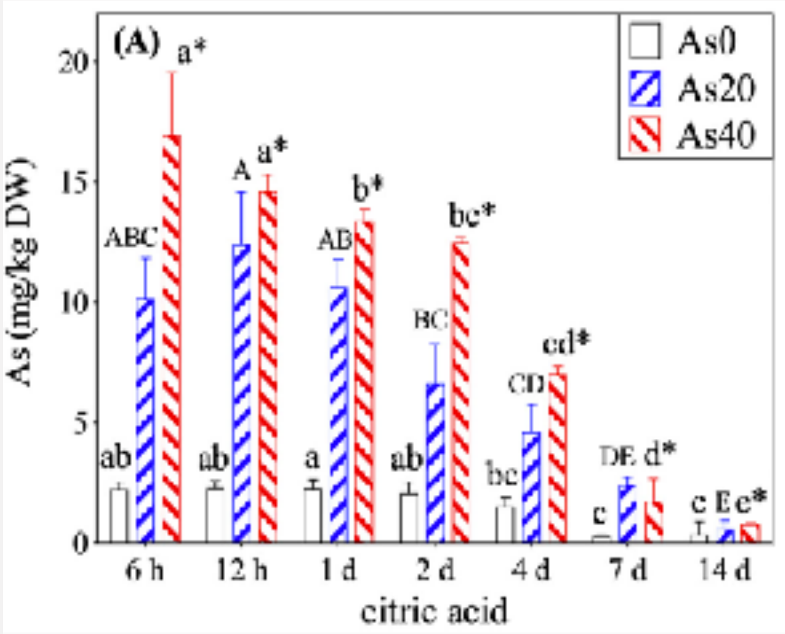
Root Exudation

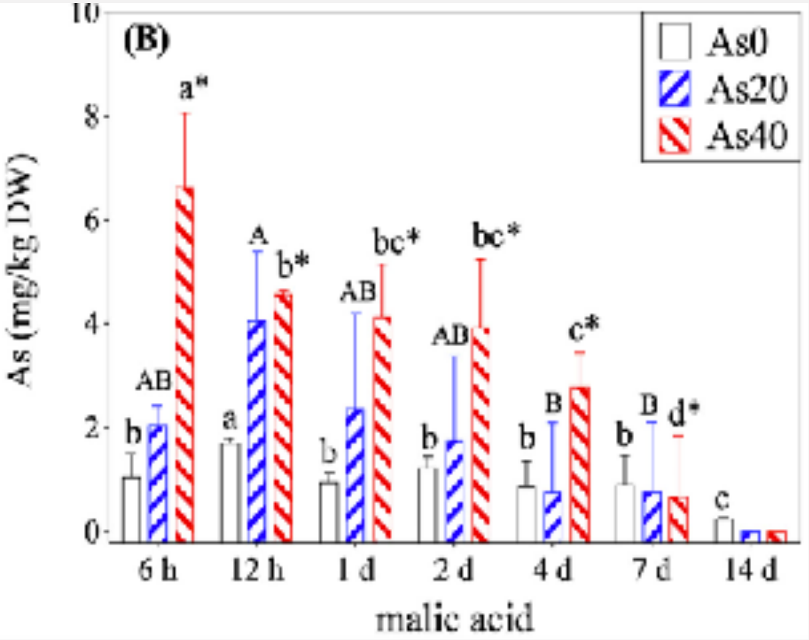
➢Low-level As promoted the secretion of Low-molecular-weight organic acids (LMWOA, 4.5–6.59 mg/kg root in dry weight) and Fe plaque formation in their rhizospheres.

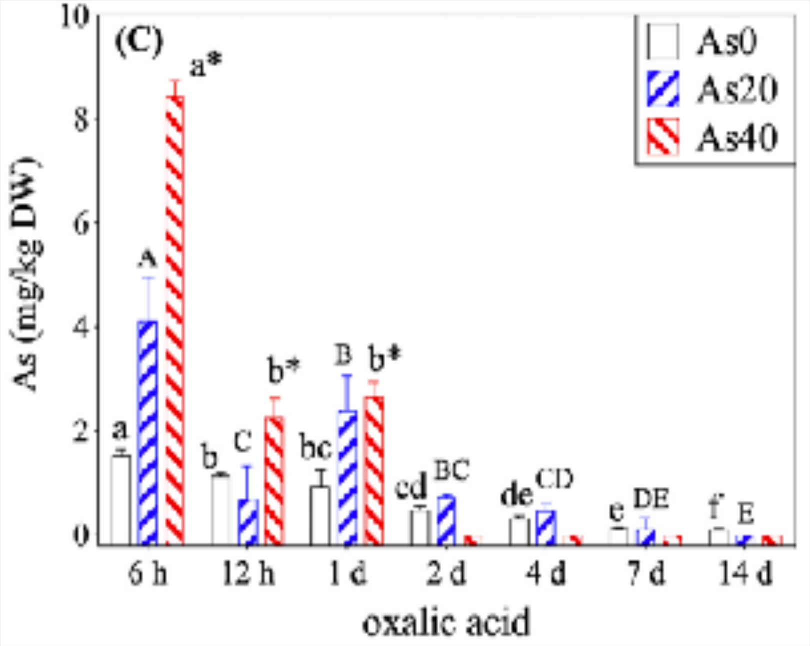
➢ Citric, oxalic, and malic acid were the three main components (84.3%–86.8%) in the 10 LMWOAs (Fig. A).

➢Low-level As (5 and 10 μmol/L) also inhibited the rate of radial oxygen loss (ROL, Fig. C) but increased the accumulation of plant As (stem > leaf > root, Fig. D) and plaque As (0.23–1.13 mg/kg root in dry weight).

Batch experiment







01

LMWOAs

➢ LMWOAs promoted sediment As mobilisation and followed the order of citric acid > malic acid > oxalic acid.

02

As treatment level

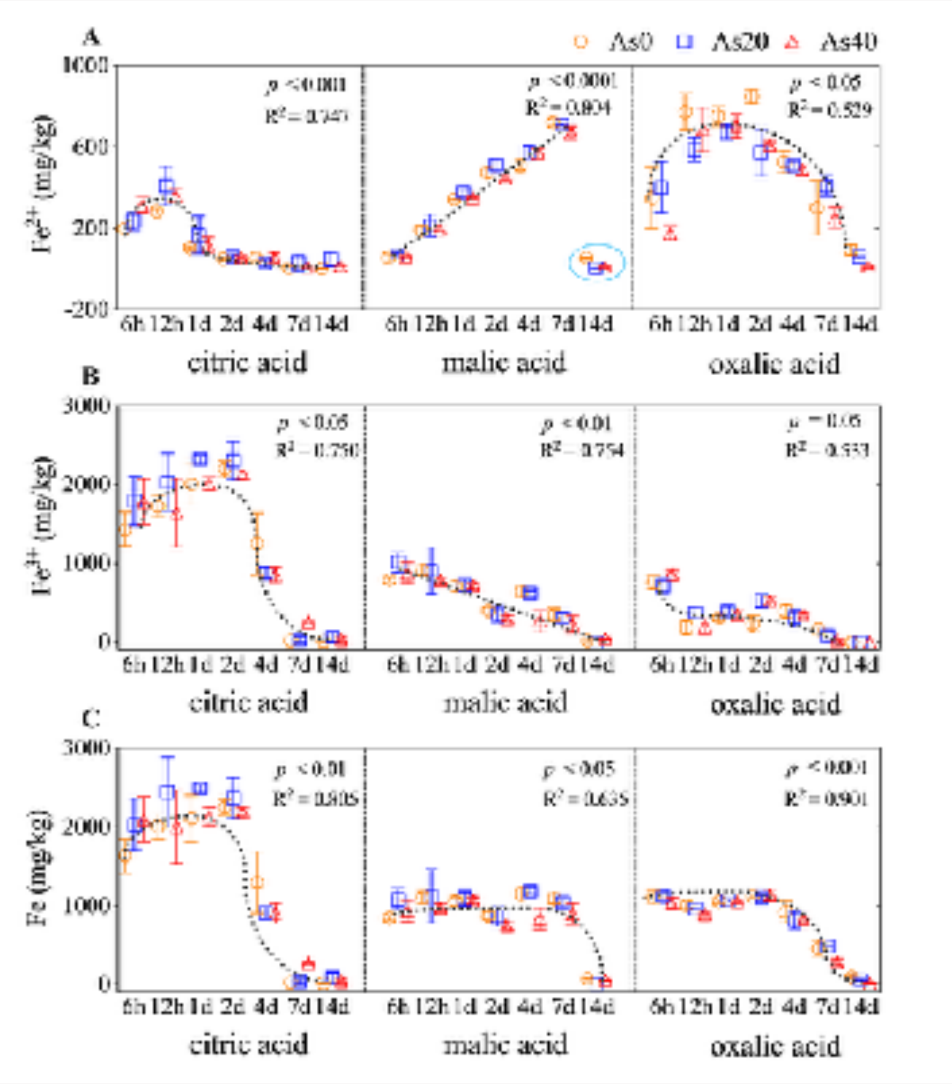
➢ The As concentration significantly increased through As addition ($p < 0.01$) to the LMWOAs extracts and showed the following decreasing trend: As40 > As20 > As0.

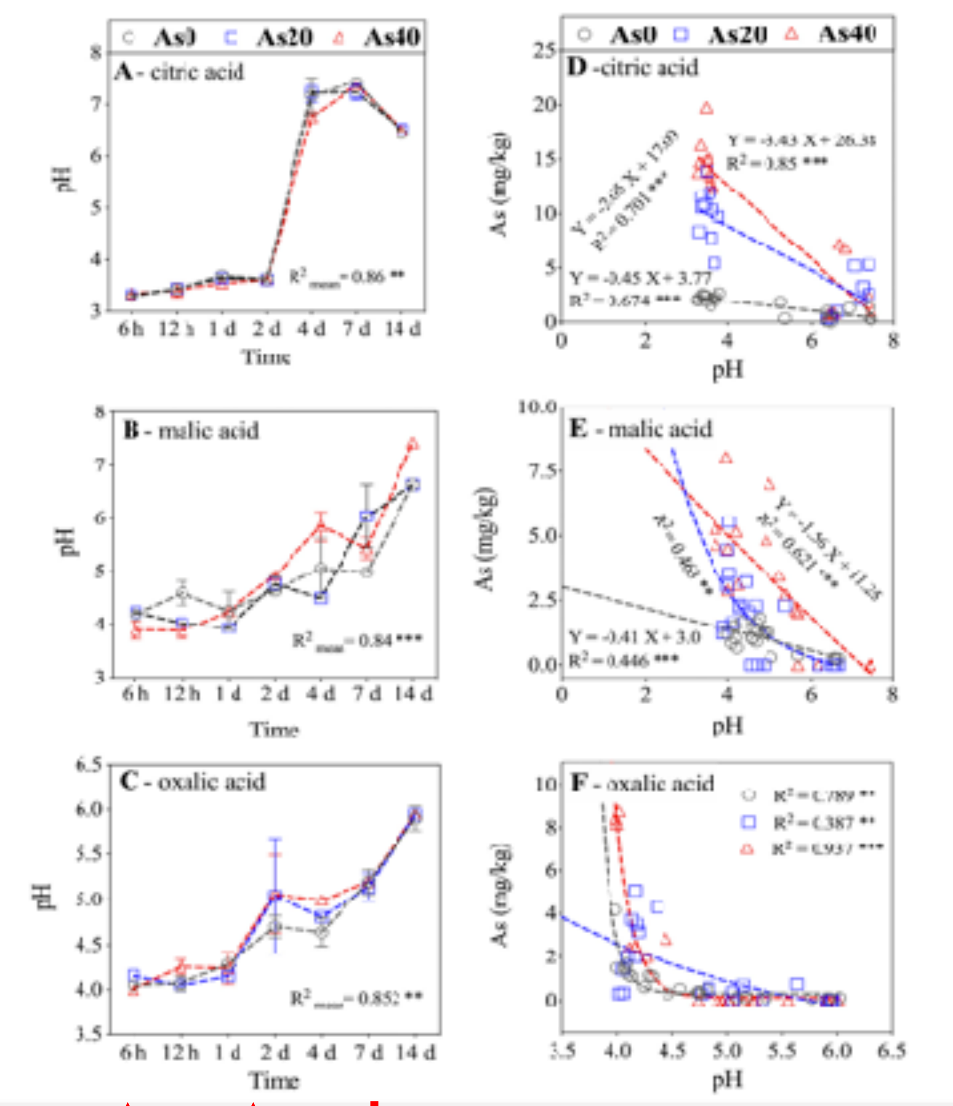
03

Solution As

➢ The total As levels in the citric acid extracts were 2.88 and 4.16 times those in the malic and oxalic acids respectively.

Fe species and pH

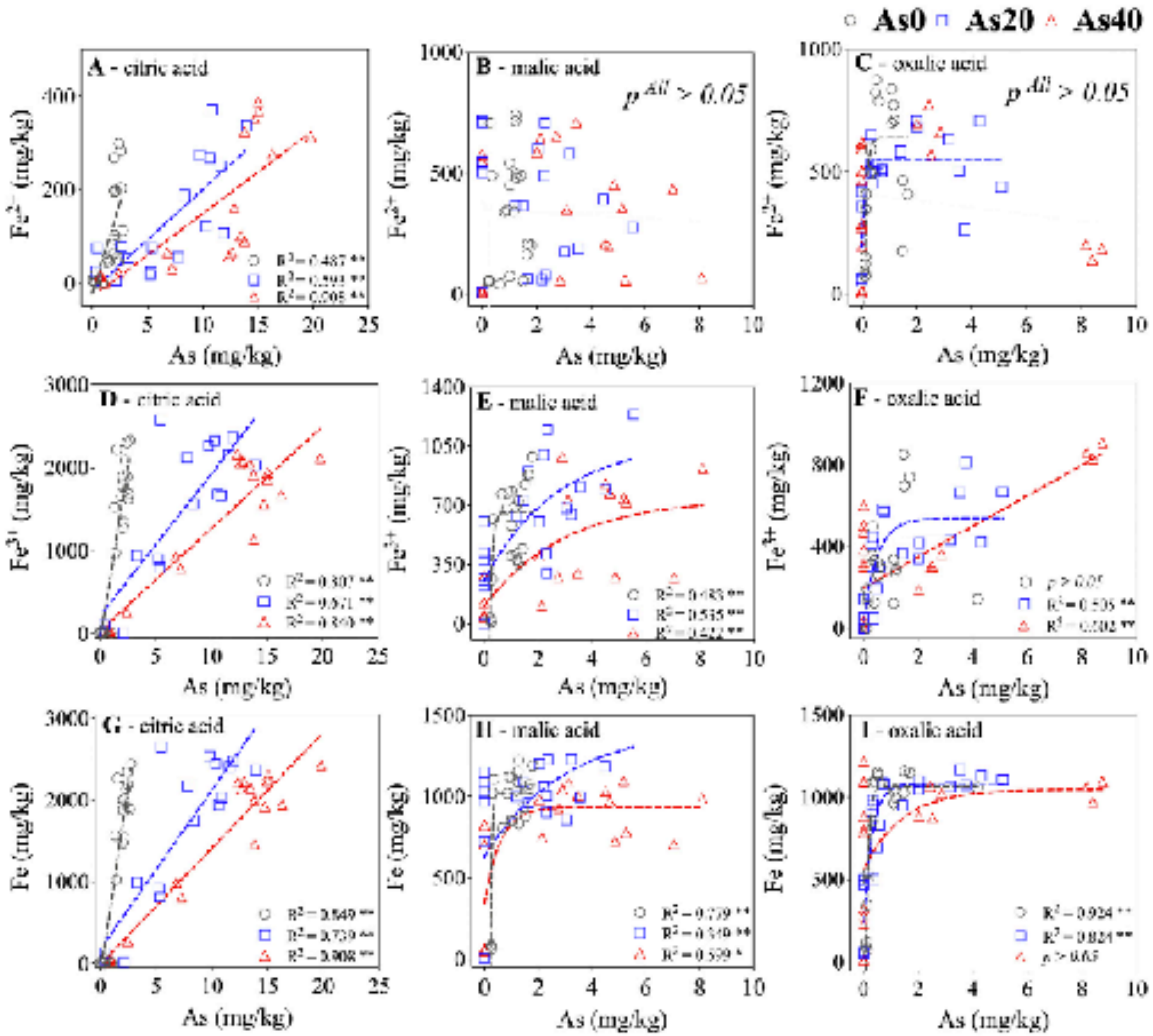




Fe & Fe^{3+}: citric acid > malic acid > oxalic acid
Fe^{2+}: oxalic acid > malic acid / citric acid

time↑ As↑ pH↓
As & pH： negative correlation

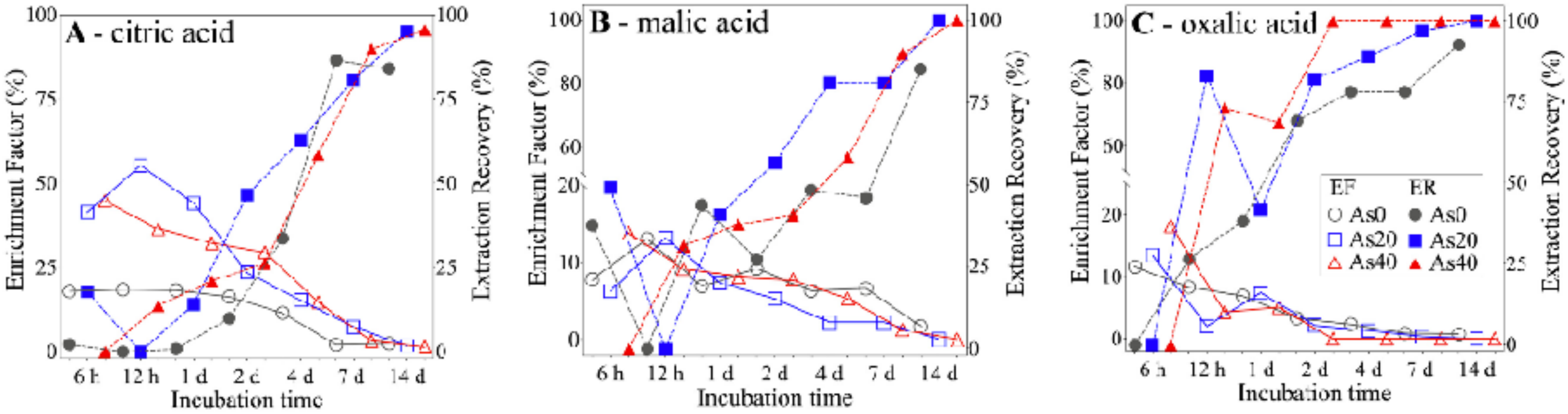
Fe species v.s. As



Iron influences

- ➢ **Hydrolysis precipitation**, with Fe^{3+} readily precipitated by hydrolysis;
- ➢ **Ferric malate complexation**, as the strong affinity of malic acid could determine the reduction potential of Fe^{3+}/Fe^{2+};
- ➢ **Reducibility**, since oxalic acid possesses strong complexing properties and reducibility, reducing dissolved Fe^{3+} to Fe^{2+} and enhancing the formation of highly soluble iron oxalate complexes.

Migration effects



$$EF\ (\%) = \frac{aqueous\ As}{solid\ As} * 100$$

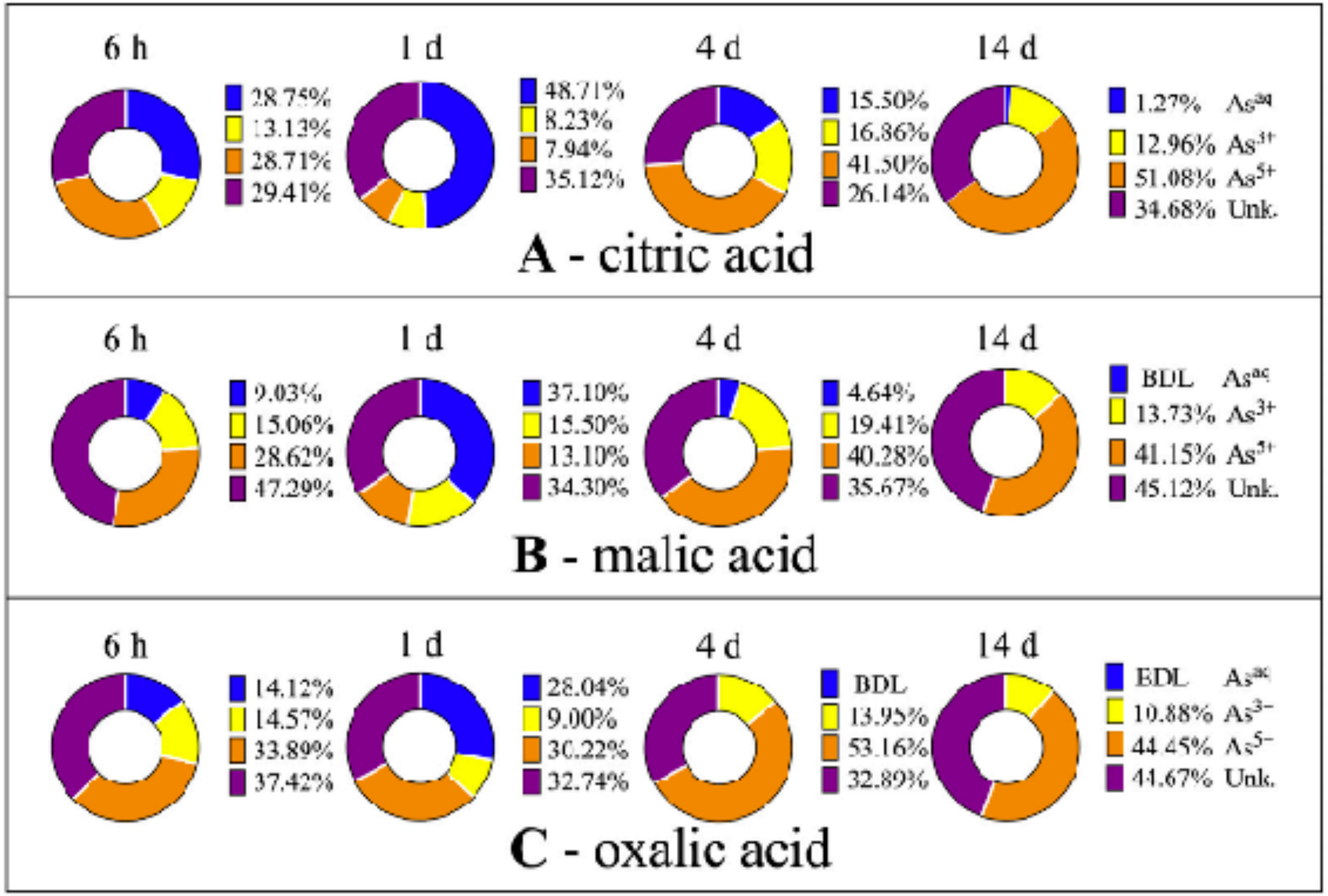
$$ER\ (\%) = \frac{maximum\ As - aqueous\ As}{maximum\ As} * 100$$

Enrichment Factor

Extraction Recovery

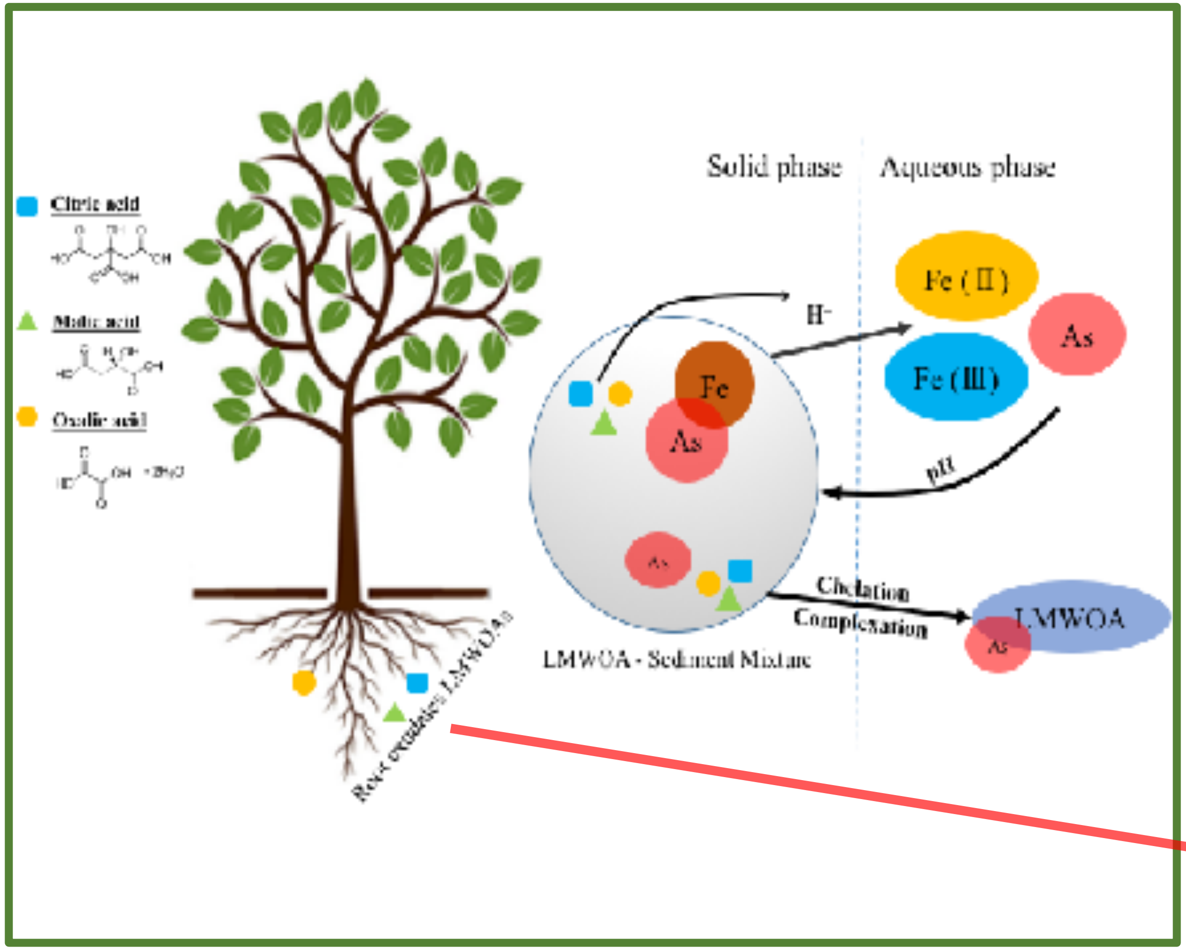
Batch experiment

As species variation

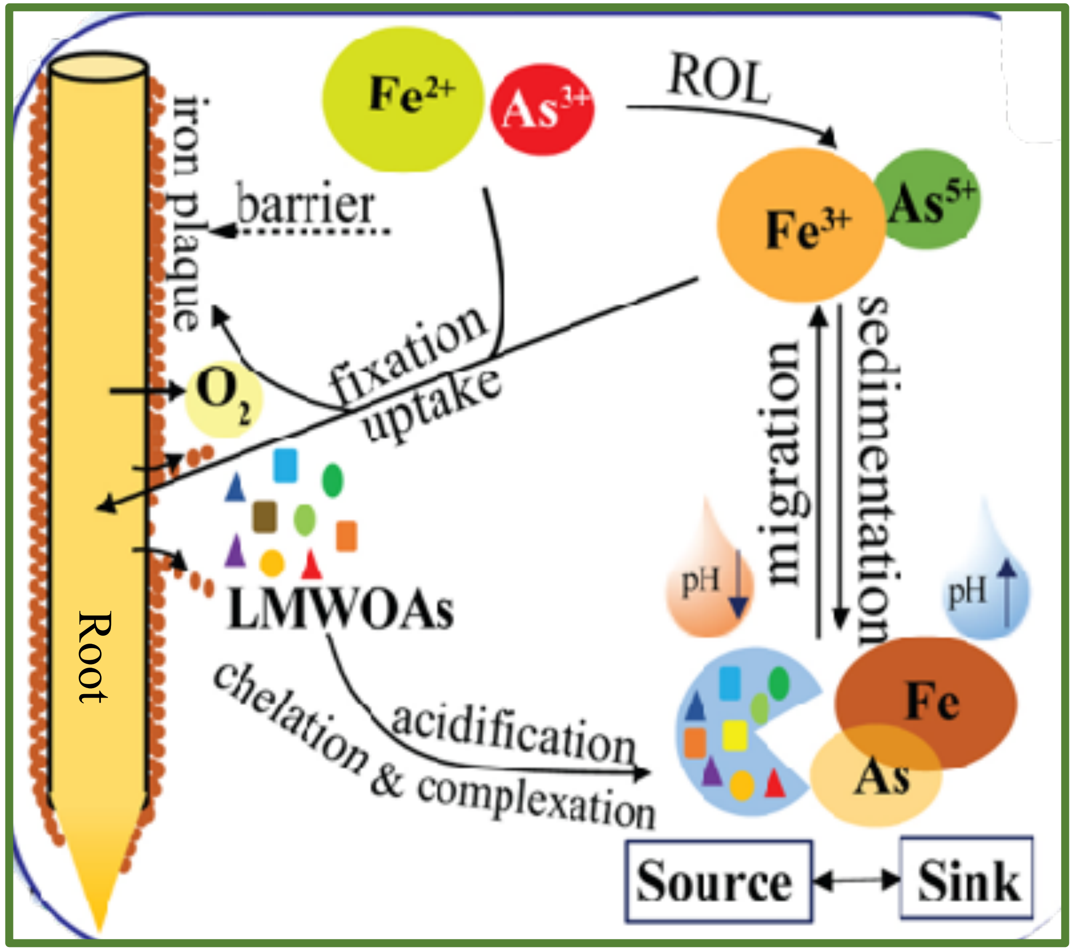


➢Inorganic arsenic（As^{3+} and As^{5+}） were the dominant species.

Rhizospheric processes

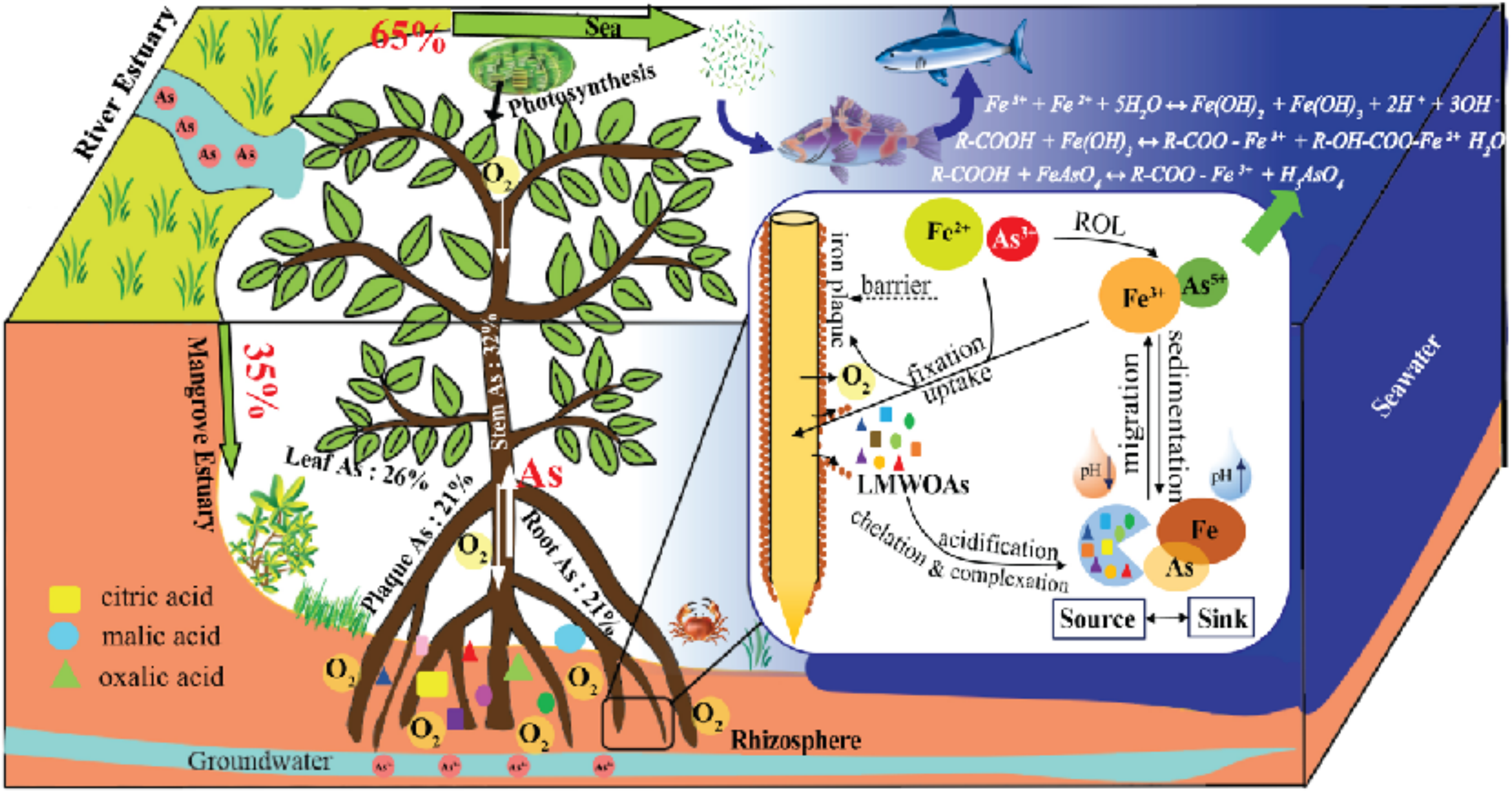


Mei et al., 2020



Mei et al., 2021

Graph abstract



PART FOUR

Conclusion

Summary

Root activity

➢ Low-level trivalent arsenite boosts LMWOAs exudation of mangroves to reduce arsenic toxicity.

LMWOA exudation

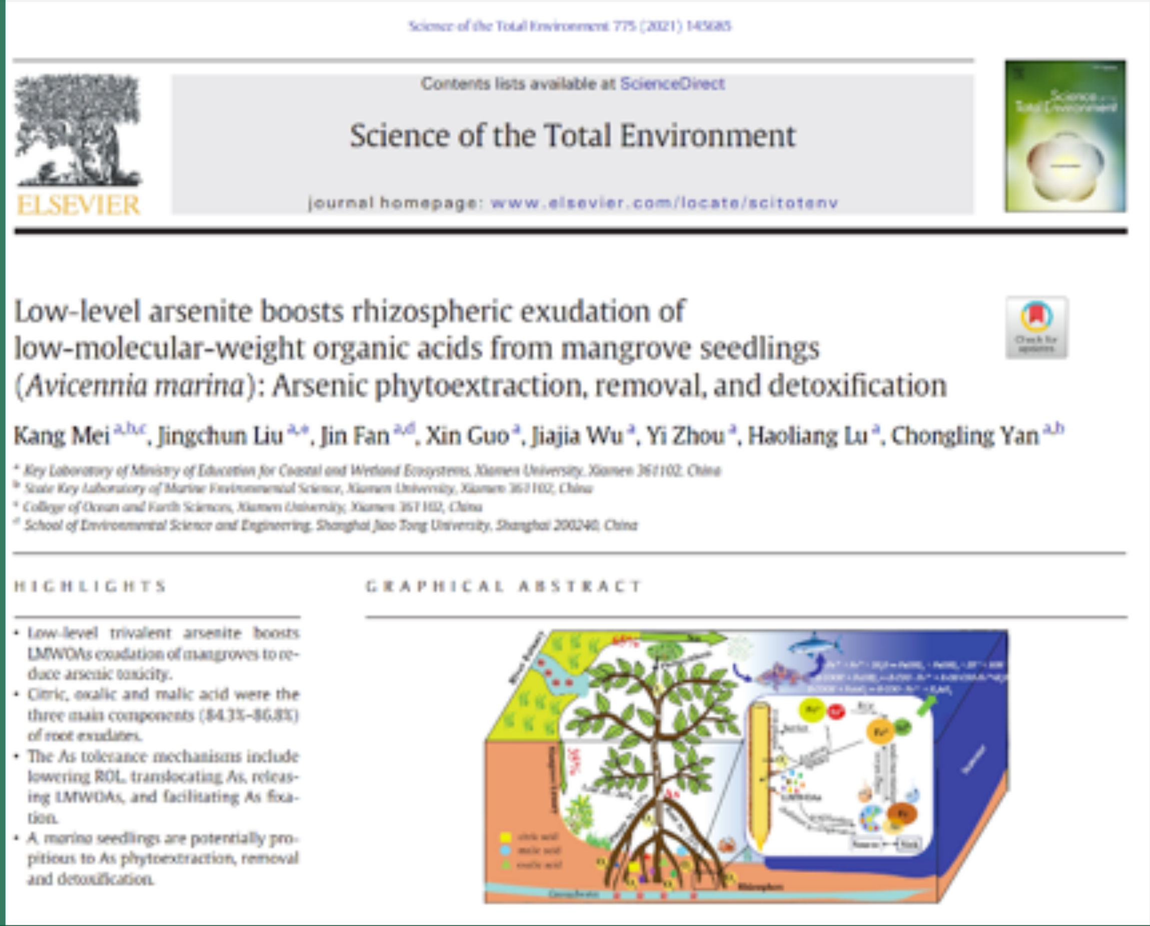
➢ Citric, oxalic and malic acid were the three main components (84.3%–86.8%) of root exudates.

Arsenic tolerance

➢ The As tolerance mechanisms include lowering ROL, translocating As, releasing LMWOAs, and facilitating As fixation.

Potential benefit

➢ *A. marina* seedlings are potentially propitious to As phytoextraction, removal and detoxification.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Low-level arsenite boosts rhizospheric exudation of low-molecular-weight organic acids from mangrove seedlings (*Avicennia marina*): Arsenic phytoextraction, removal, and detoxification

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HIGHLIGHTS

- Low-level trivalent arsenite boosts LMWOAs exudation of mangroves to reduce arsenic toxicity.
- Citric, oxalic and malic acid were the three main components (84.3%–86.8%) of root exudates.
- The As tolerance mechanisms include lowering ROL, translocating As, releasing LMWOAs, and facilitating As fixation.
- *A. marina* seedlings are potentially propitious to As phytoextraction, removal and detoxification.

GRAPHICAL ABSTRACT

谢谢大家

Thank you for your listening!