

# Can microbes be used to control arsenic accumulation in rice?

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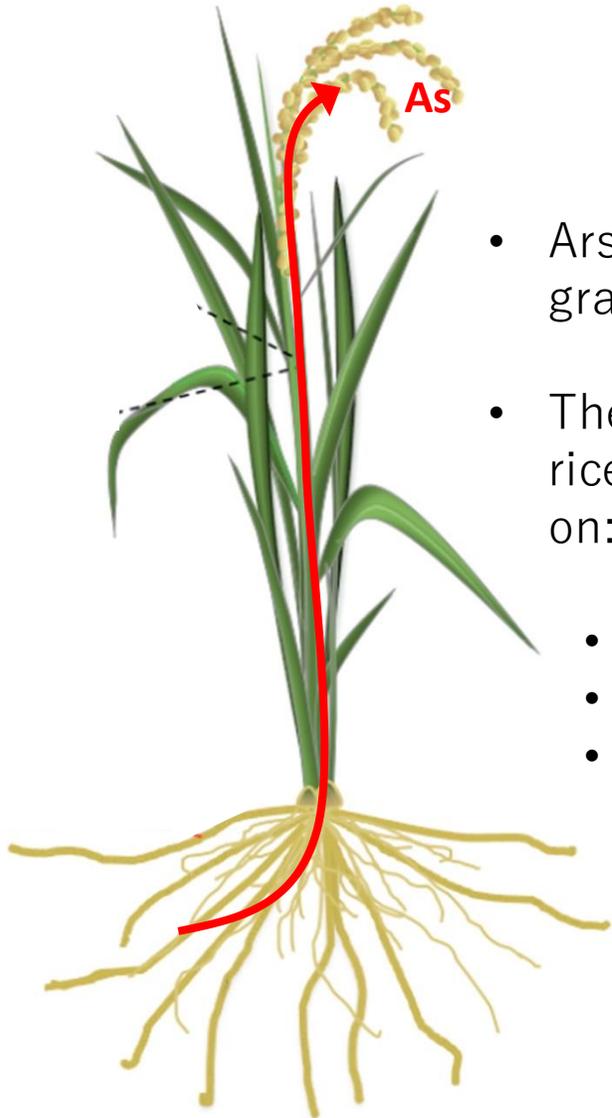
# Arsenic



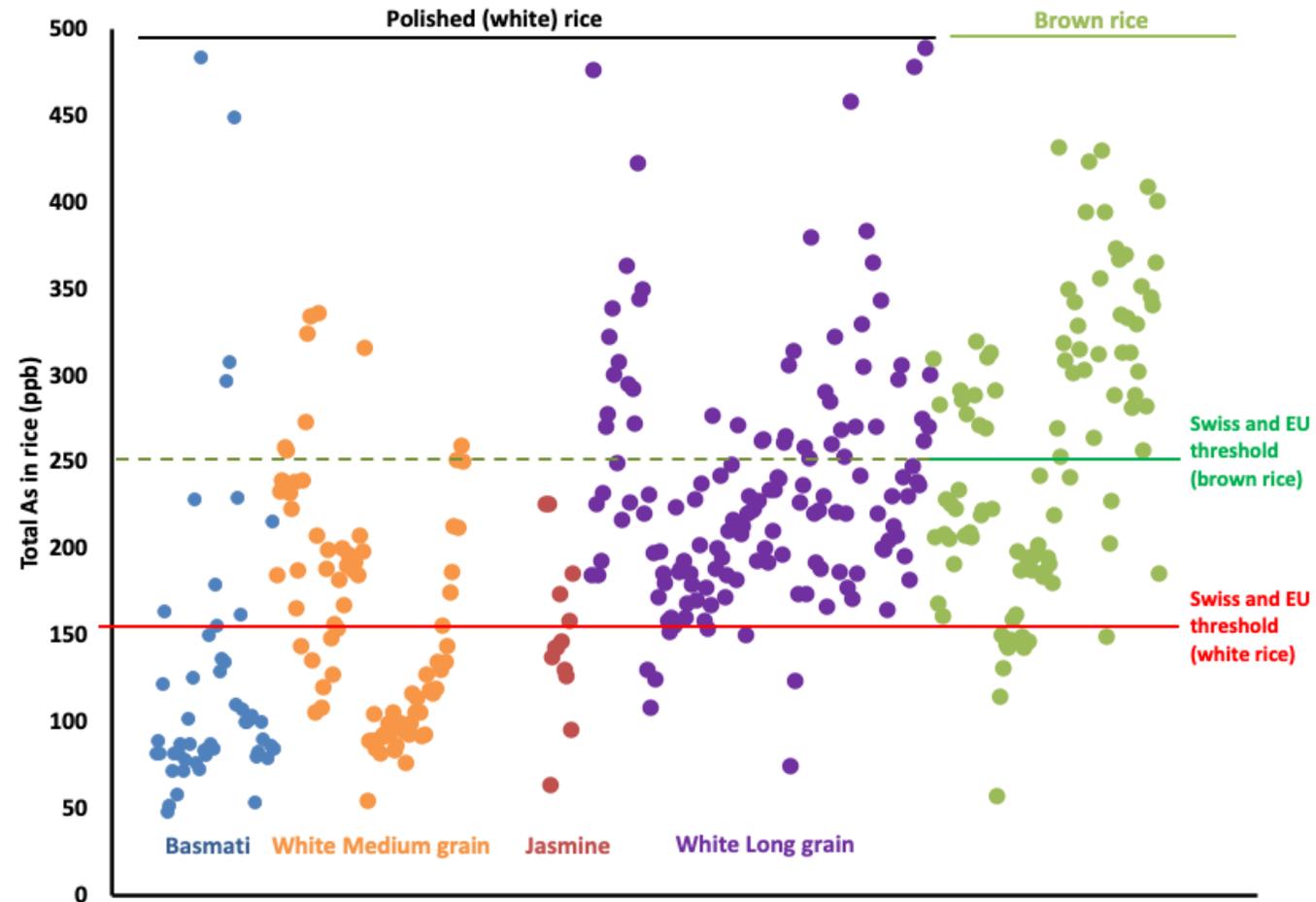
- Natural environmental toxin.
- First symptoms are skin lesions (keratosis, melanosis)
- Carcinogenic: lung, bladder cancers cause heavy mortality
- Impact of children (birth weight, impaired cognitive development)



# Arsenic and rice



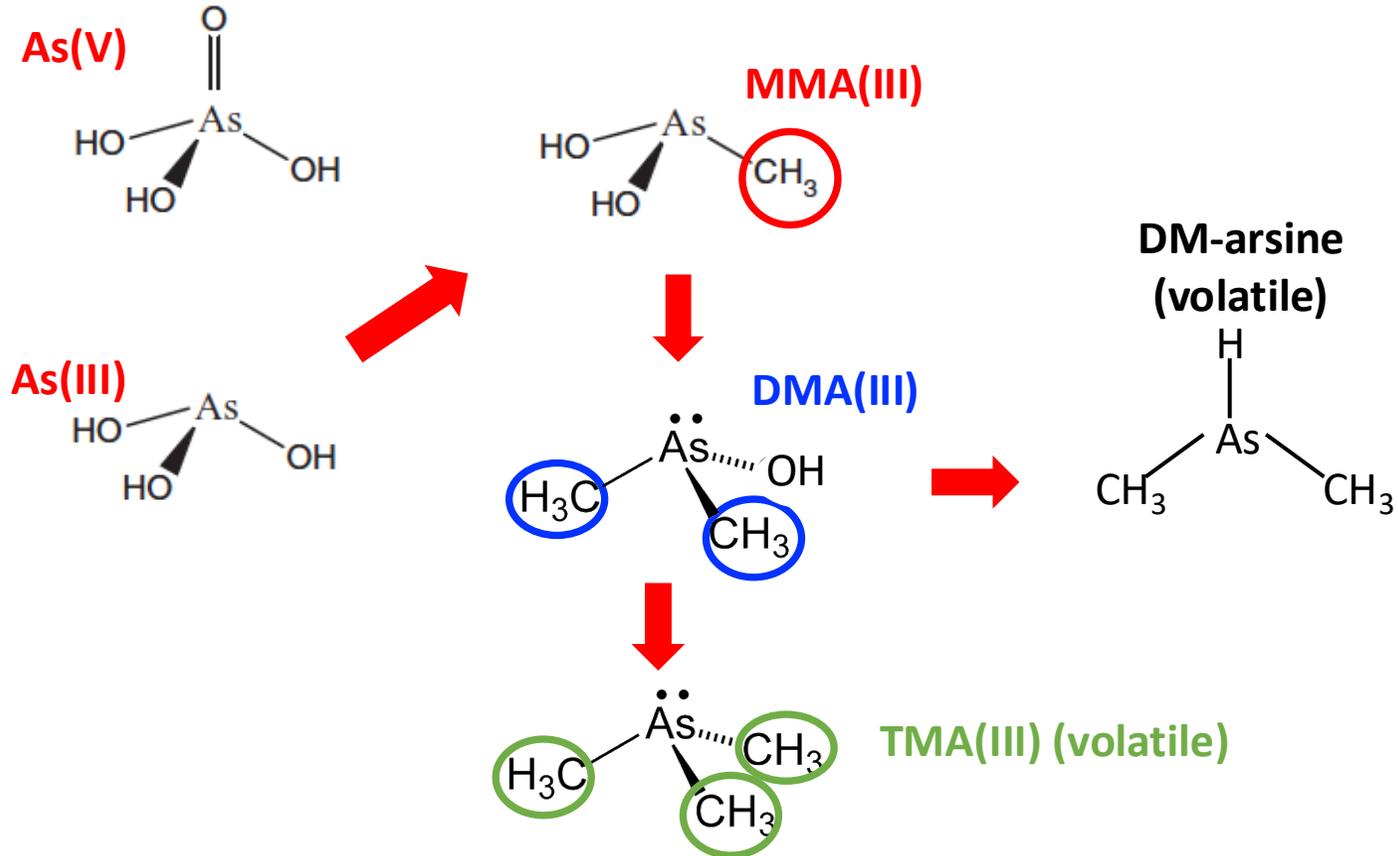
- Arsenic accumulates in rice grains
- The concentration of As in rice varies greatly based on:
  - geographical origin
  - rice variety
  - rice processing



# Microbes chemically transform arsenic

Inorganic arsenic

Methylated arsenic

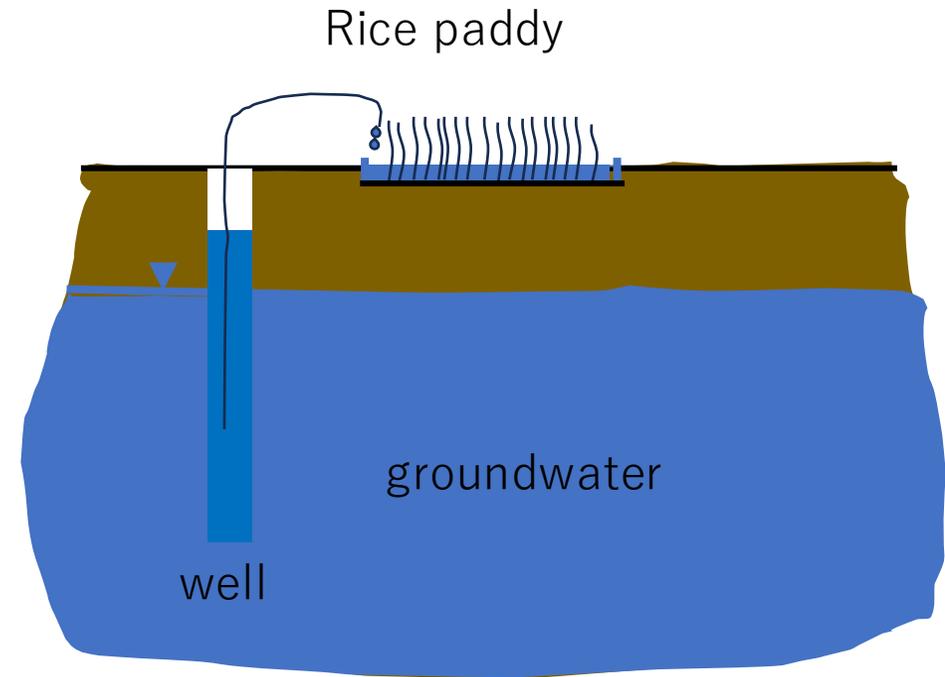


Soil microorganisms drive As methylation and volatilization

# Rice cultivation requires irrigation



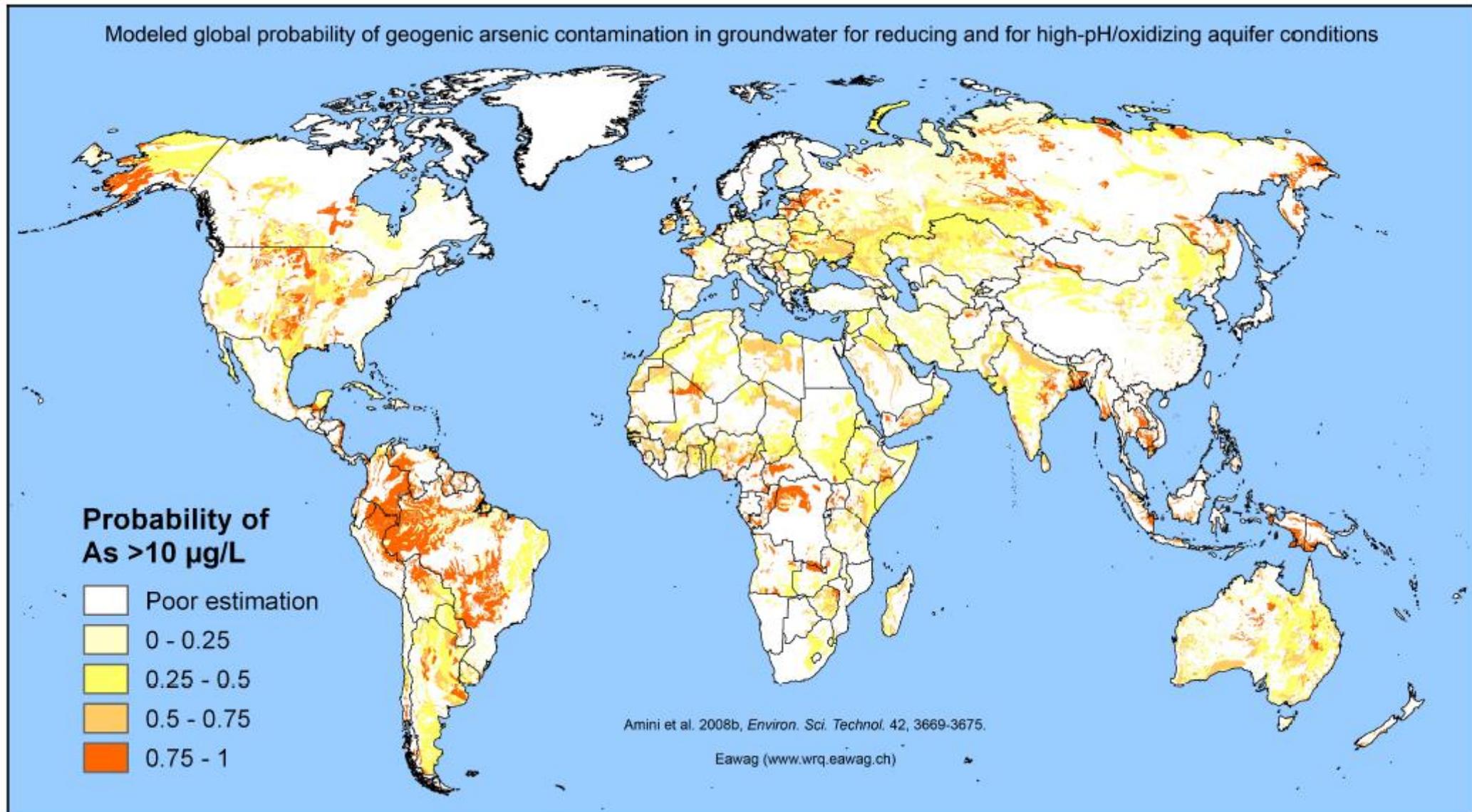
Flooded rice paddy



Groundwater irrigation

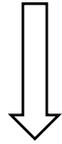
➡ However, groundwater can contain arsenic

# Arsenic in groundwater



# Engineer biological arsenenic volatilization

Stimulate As methylation



Arsenic methylation microorganism (bio-augmentation)

Chemical compound that stimulates existing arsenic-methylating organisms (bio-stimulation)

Land management to stimulate arsenic methylation

Allow partitioning to atmosphere



Trap gas-phase and remove As



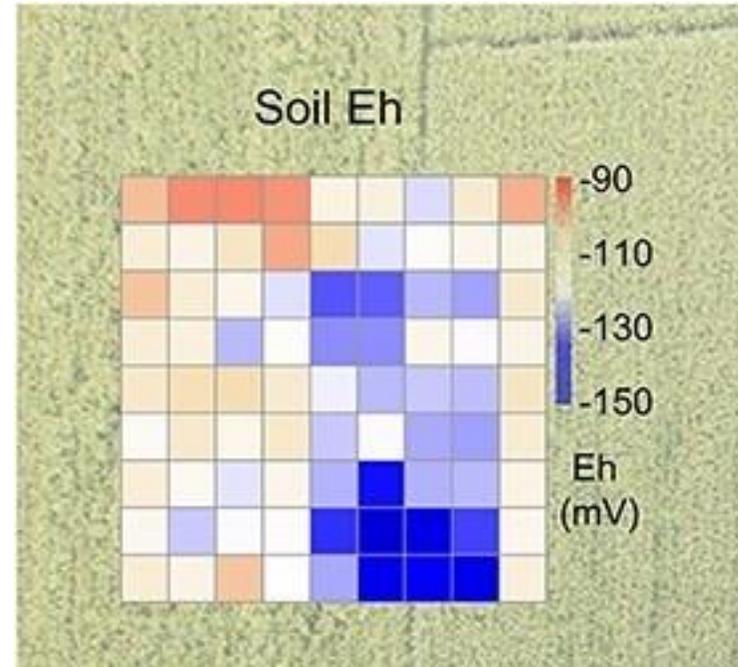
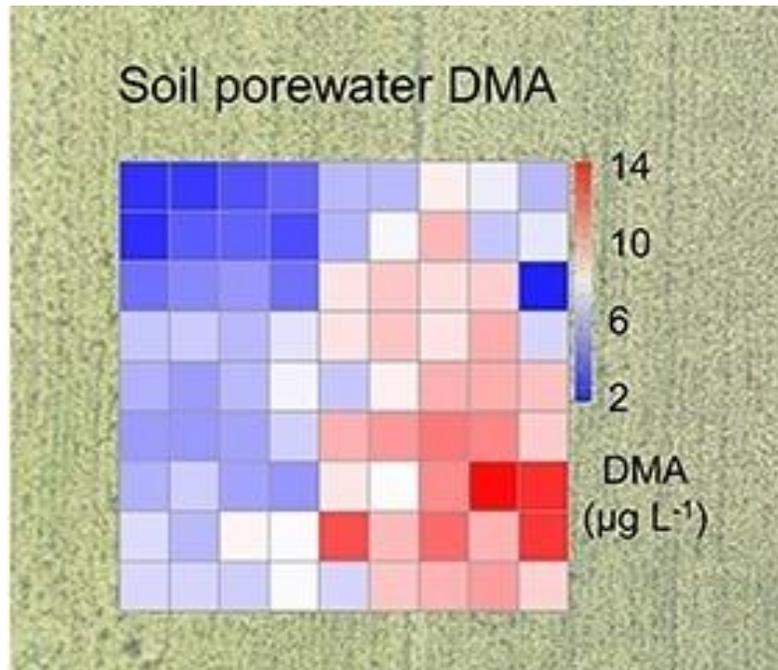
# How to promote arsenic methylation in soil?

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- The absence of oxygen

# Anaerobic conditions promote As methylation

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Gao et al, 2024 ISME J

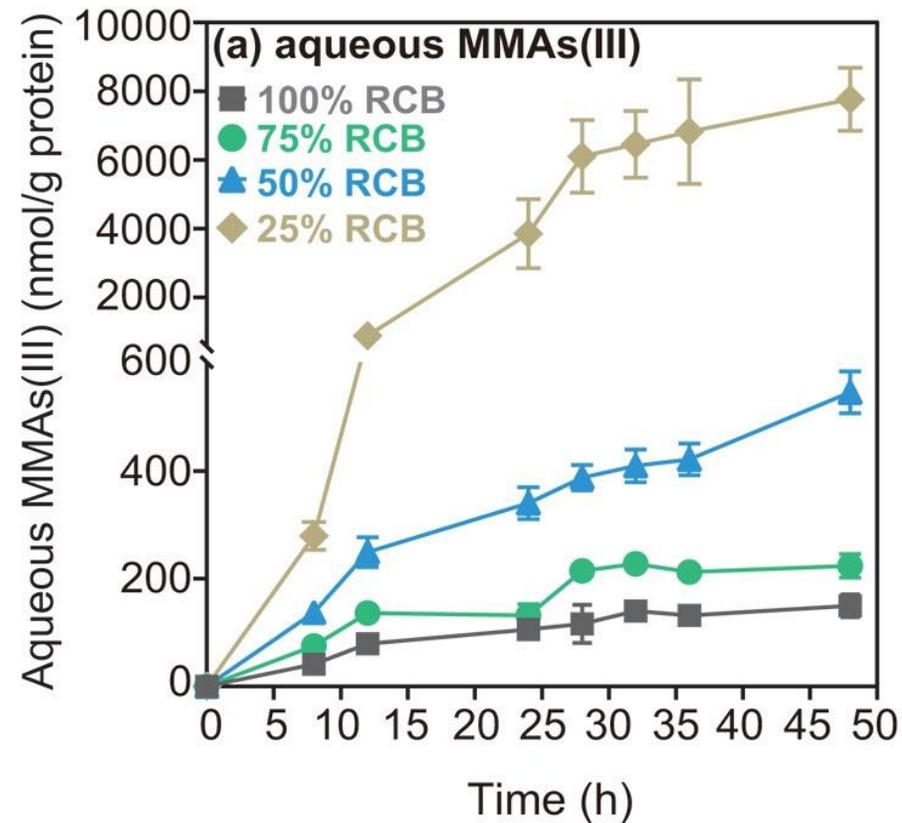
- The absence of oxygen (flooded soil) promotes arsenic methylation. Therefore, keeping the soil flooded even in between cropping cycles could promote volatilization.

# How to promote arsenic methylation in soil?

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- The absence of oxygen (flooded soil) promotes arsenic methylation. Therefore, keeping the soil flooded even in between cropping cycles could promote volatilization.
- Nutrient limitation

# Nutrient limitation promotes As methylation



Increasing  
organic  
carbon

Increasing  
methylated  
As

Qiao et al, 2024 ASM

- Nutrient limitation (low organic carbon) promotes microbial arsenic methylation. Therefore, in between cropping cycles, it is important to remove rice straw and keep the soil flooded and bare.

# How to promote arsenic methylation in soil?

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- The absence of oxygen (flooded soil) promotes arsenic methylation. Therefore, keeping the soil flooded even in between cropping cycles could promote volatilization.
- Nutrient limitation (low organic carbon) promotes microbial arsenic methylation. Therefore, in between cropping cycles, it is important to remove rice straw and keep the soil flooded and bare.
- The amendment of sulfate (for instance as gypsum) promotes arsenic methylation (in the absence of oxygen).
- Goal in the future: identify very efficient arsenic methylating bacteria that are anaerobic (live without oxygen).

# Acknowledgments

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Funding



**THANK YOU FOR YOUR ATTENTION**

# Function of arsenic methylation

Detoxification mechanism.

**Detoxification:**

Toxicity

Trivalent methylarsenicals

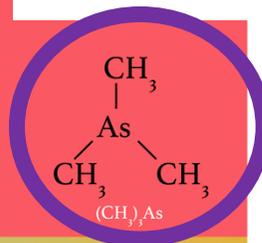
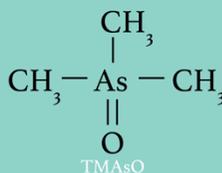
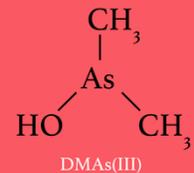
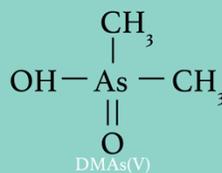
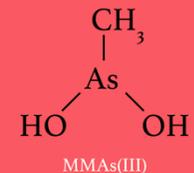
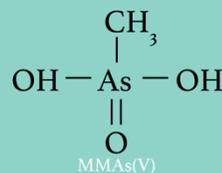
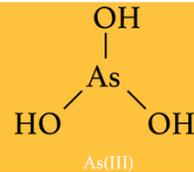
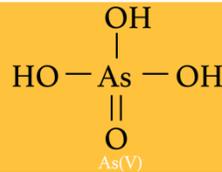
Inorganic As (unmethylated)

Pentavalent methylarsenicals

+5 valence  
(water soluble)

+3 valence  
(water soluble)

+3 valence  
(volatile)



Volatile

Methylation

Oxidation

Reduction

- Lower toxicity of the pentavalent methylarsenicals.
- Volatilization by trimethylarsine.