

Arsenic in Soil, Groundwater and Air

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Background and Introduction



Bangladesh

- Arsenic contamination from natural aquifers of water supply: Argentina, Bangladesh, Cambodia, Chile, China, Ghana, Hungary, India, Mexico, Nepal, New Zealand, Philippines, Taiwan, United States and Vietnam
- Arsenic leaching problem from mine tailings: Australia, Canada, Japan, Mexico, Thailand, United Kingdom and the United States of America

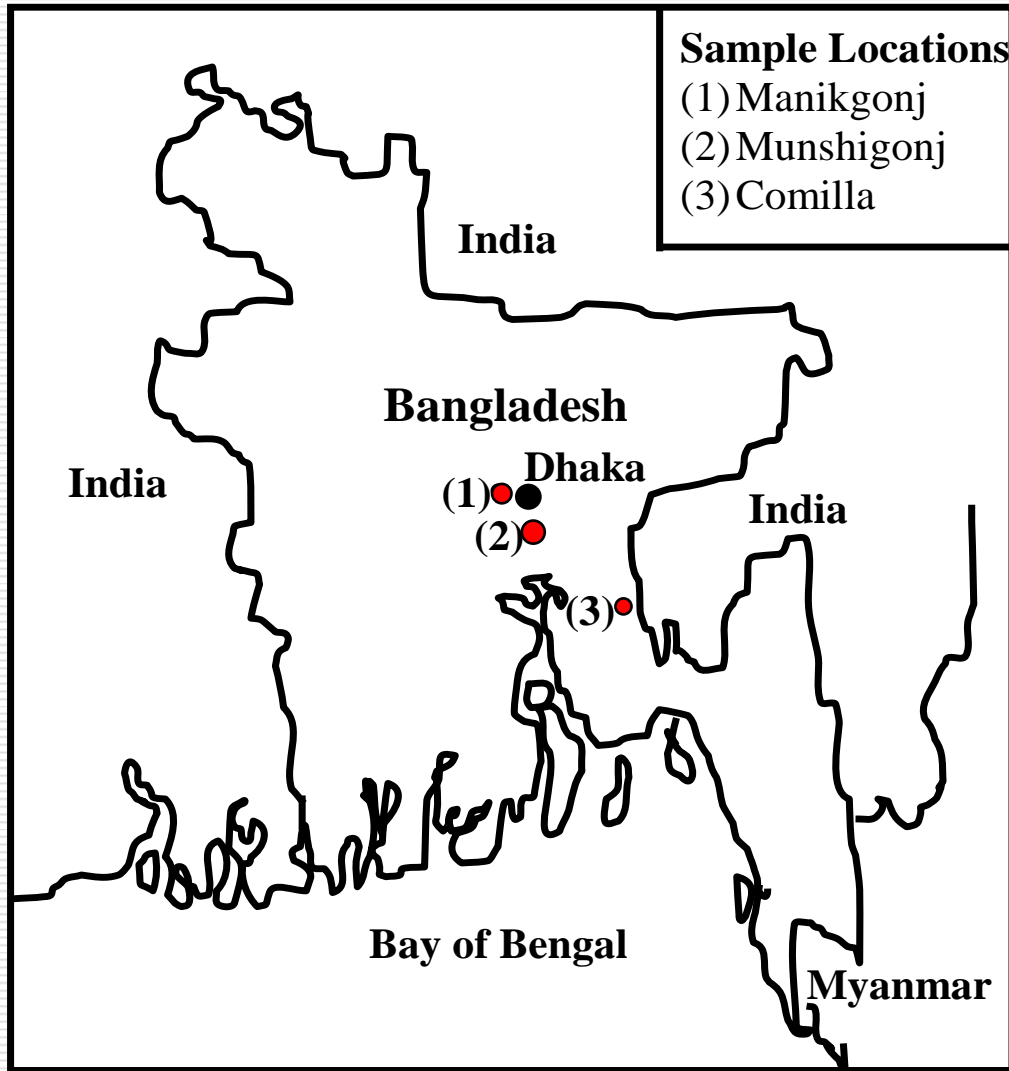
Bangladesh



Latest statistics on arsenic conc in groundwater of Bangladesh

Total area in Bangladesh (km²)	147,570
Total population (million)	128
Total number of administrative districts	64
Total number of districts surveyed	60
Total number of districts where arsenic concentration exceeds 0.01 mg/l	52/60
Total number of districts where arsenic concentration exceeds 0.05 mg/l	41/60
Total area where arsenic concentration exceeds 0.05 mg/l (km²)	<u>89,186 (60%)</u>
Total population where arsenic concentration exceeds 0.05 mg/l (million)	<u>85 (66%)</u>
Median value of arsenic concentration observed in tested samples (mg/l)	0.0108
Maximum arsenic concentration observed in tested samples (mg/l)	1.67

agriculture soil in Bangladesh



Location	Arsenic concentration (mg/kg)
(3)	9.8±0.7
(3)	3.9±0.4
(3)	40.4±2.1
(2)	7.0±0.7
(2)	3.9±0.5
(2)	80.9±4.2
(1)	46.5±2.4
(1)	12.3±1.1
(1)	55.6±3.2
(1)	60.1±3.7

* Depth of soil 0-50 cm

Arsenic contamination in agricultural soil

- ❑ Continued cropping with arsenic contaminated irrigation water increases the extent of contamination in agricultural land
- ❑ A large amount of arsenic as high as 10 kg/ha per year is cycled through irrigated water in Bangladesh (DPHE/BGS 2000)
- ❑ Some recent studies observed considerable arsenic concentration in rice and vegetables grown on arsenic polluted soil

Irrigating As contaminated groundwater by electrical pump



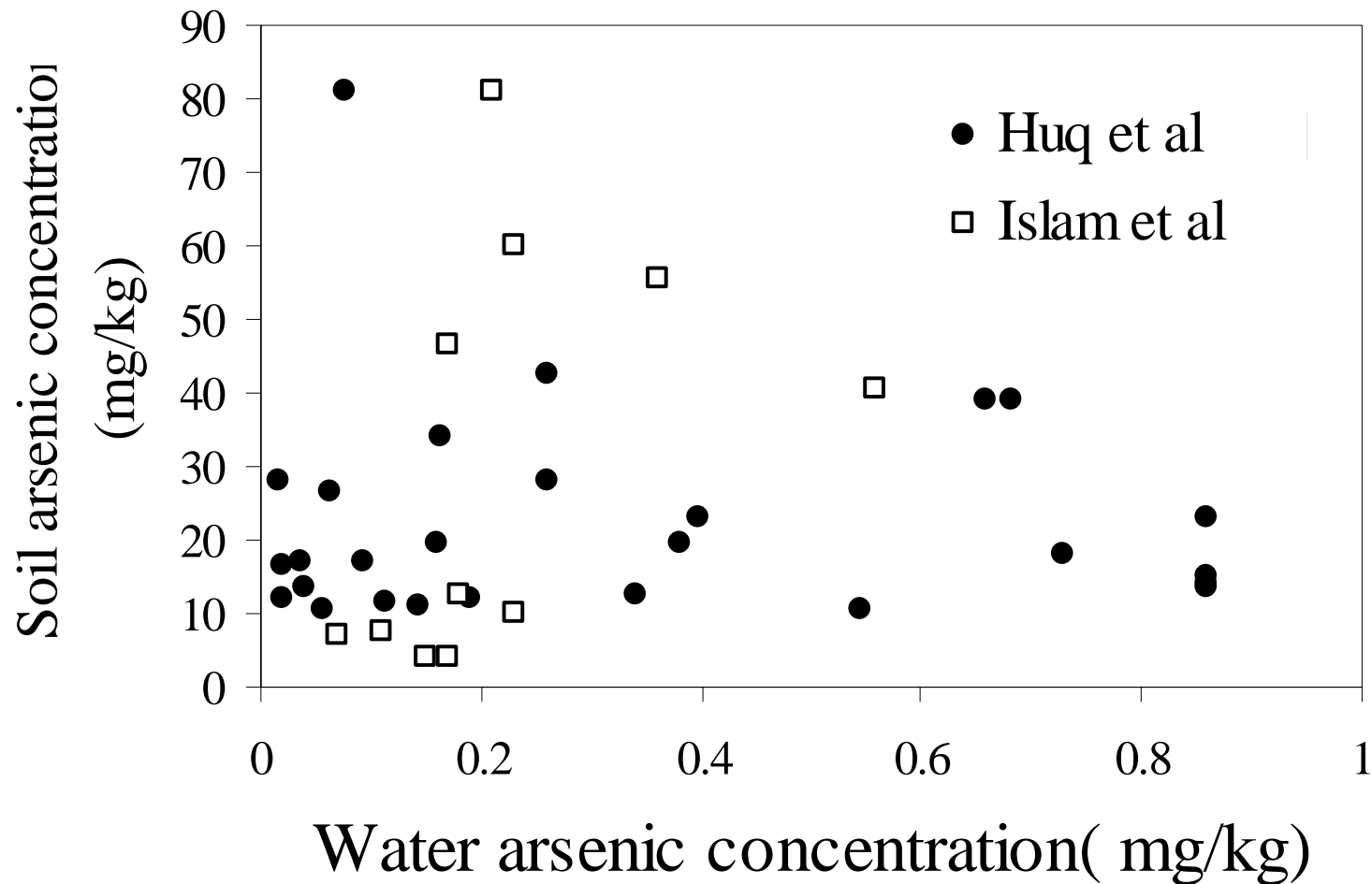
Bangladesh

2003 September Photo taken by Ken Fukushi



Red: Contaminated
Green: Not contaminated
(Bangladesh)

Relationship between arsenic concentrations in soil and groundwater



AIRP



2003 September. Photo taken by K. Fukushi

Arsenic from mine tailing



Thailand

2000 October Photo taken by Ken Fukushi



Polluted area



Polluted surface water

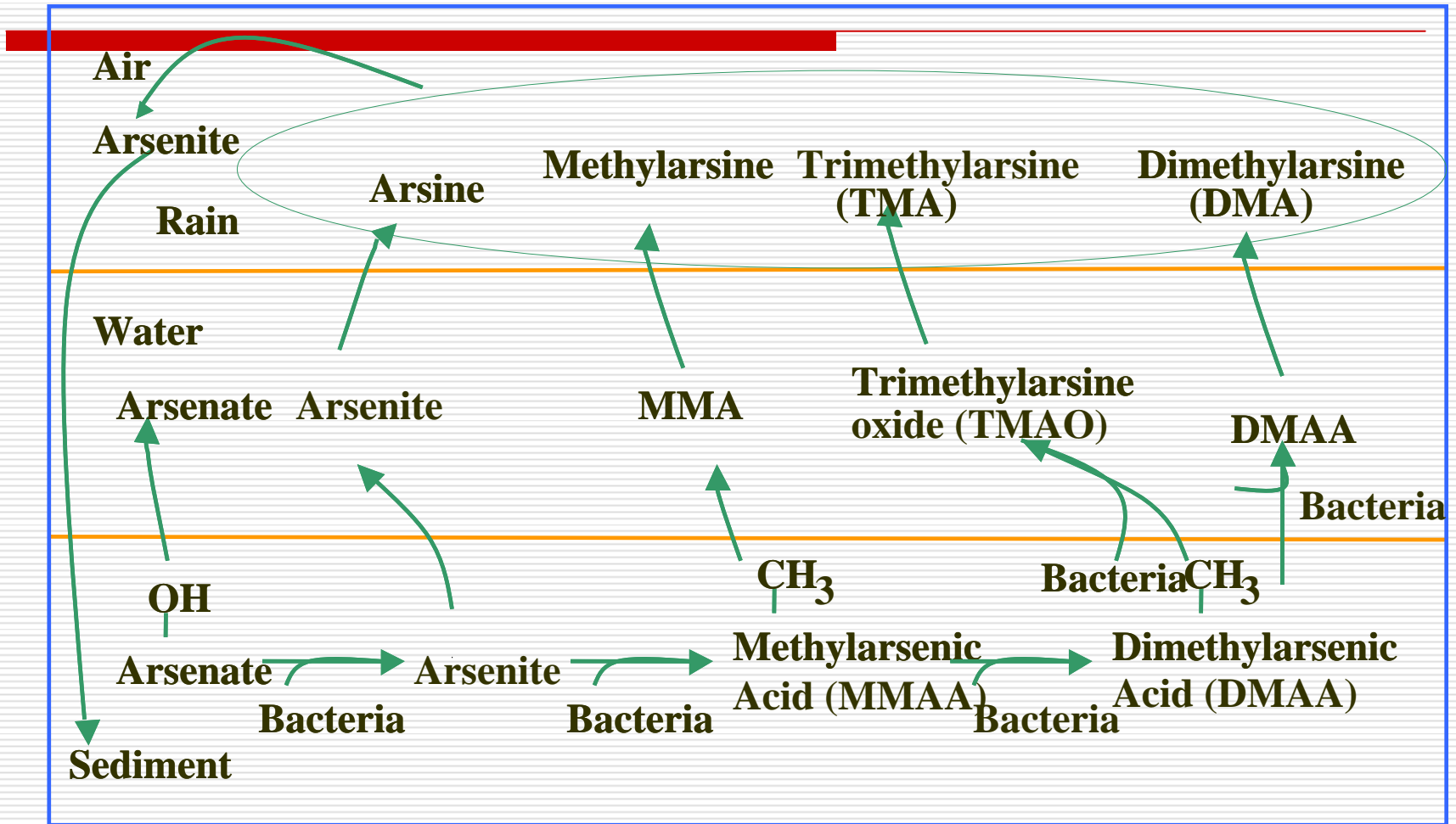


Polluted surface water



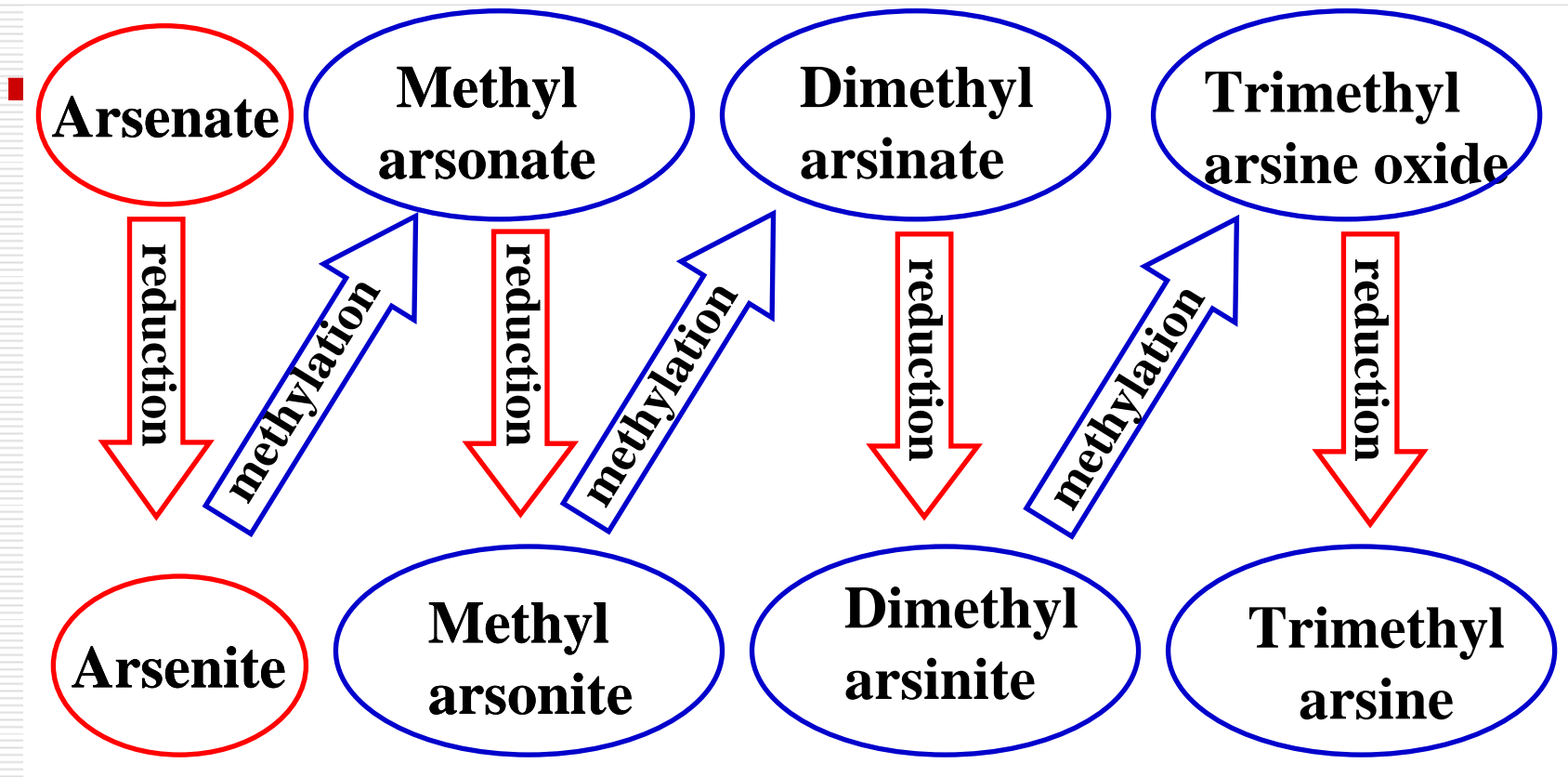
Thailand

Transformation of arsenic in soil environment



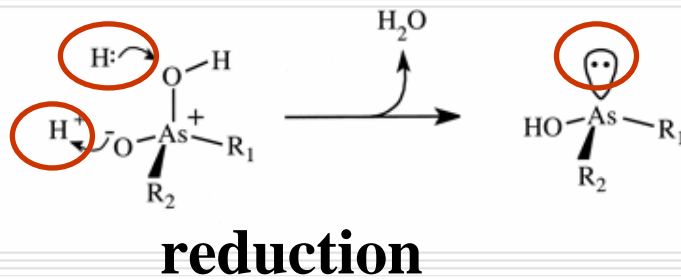
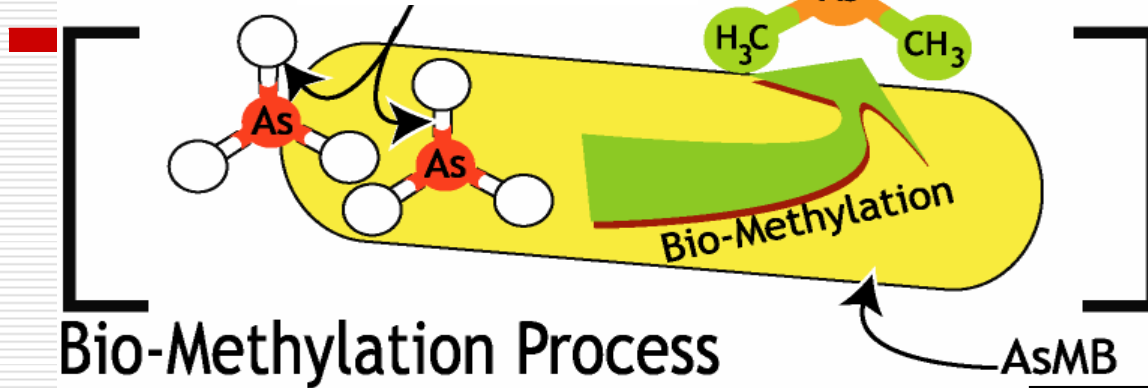
Arsenic in air

Bio-Methylation-mechanism

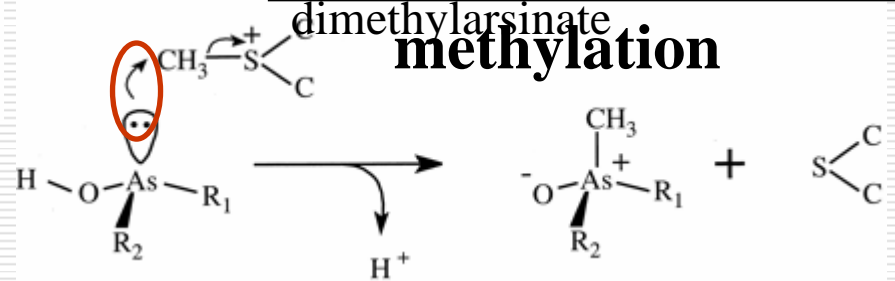


Bio-Methylation

As(V)-As(III)
reduction



$R_1 = R_2 = \text{OH}$, arsenate;
 $R_1 = \text{CH}_3, R_2 = \text{OH}$,
 methylarsonate; $R_1 = R_2 = \text{CH}_3$,



Glutathione (GSH) provides the electrons for reduction and probably methylcobalamin is the methyl donor for anaerobic microorganisms

APPLICATION FOR THE ENVIRONMENTAL CLEANUP TECHNOLOGY

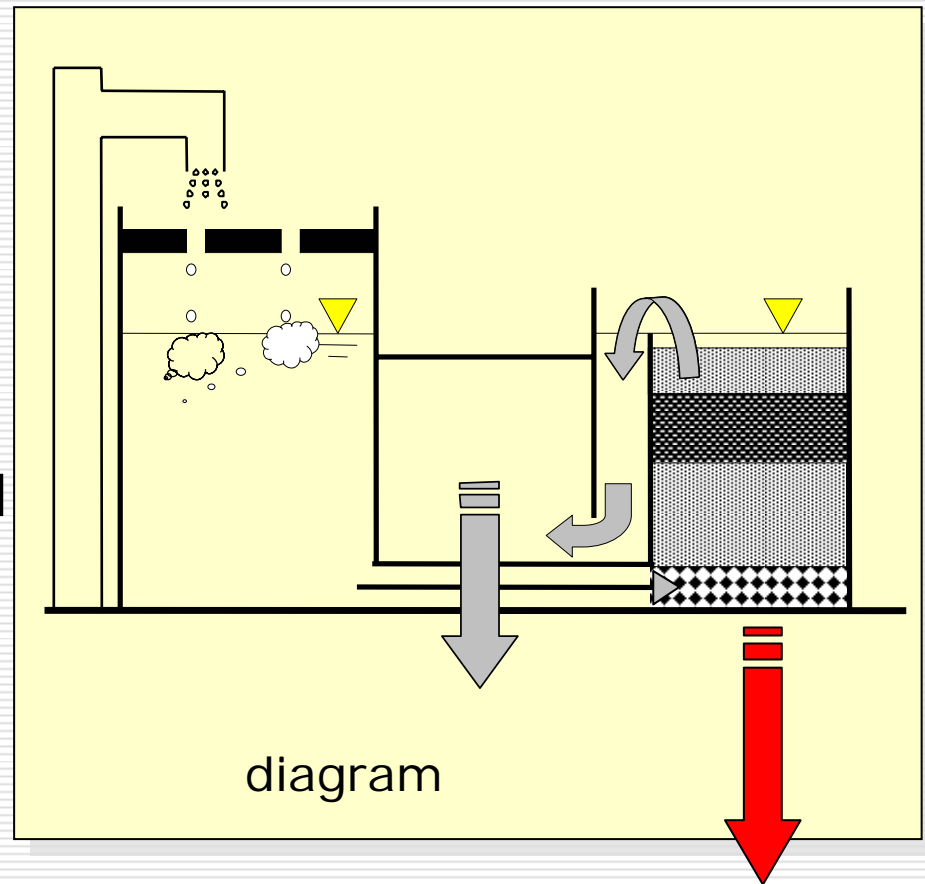
- High efficiency of methylation
 - Up to 100 times comparing over the natural condition by mixed culture
 - Up to 1000 times comparing over the natural condition by pure culture¹⁷¹⁷
- Application examples
 - Soil
 - Sludge from water treatment
 - Other solids containing arsenic

AIRP



Arsenic removal technology

- Arsenic Iron Removal Plant: AIRP
 - Arsenic in groundwater is complexed with ferric hydroxide and removed with sand filter

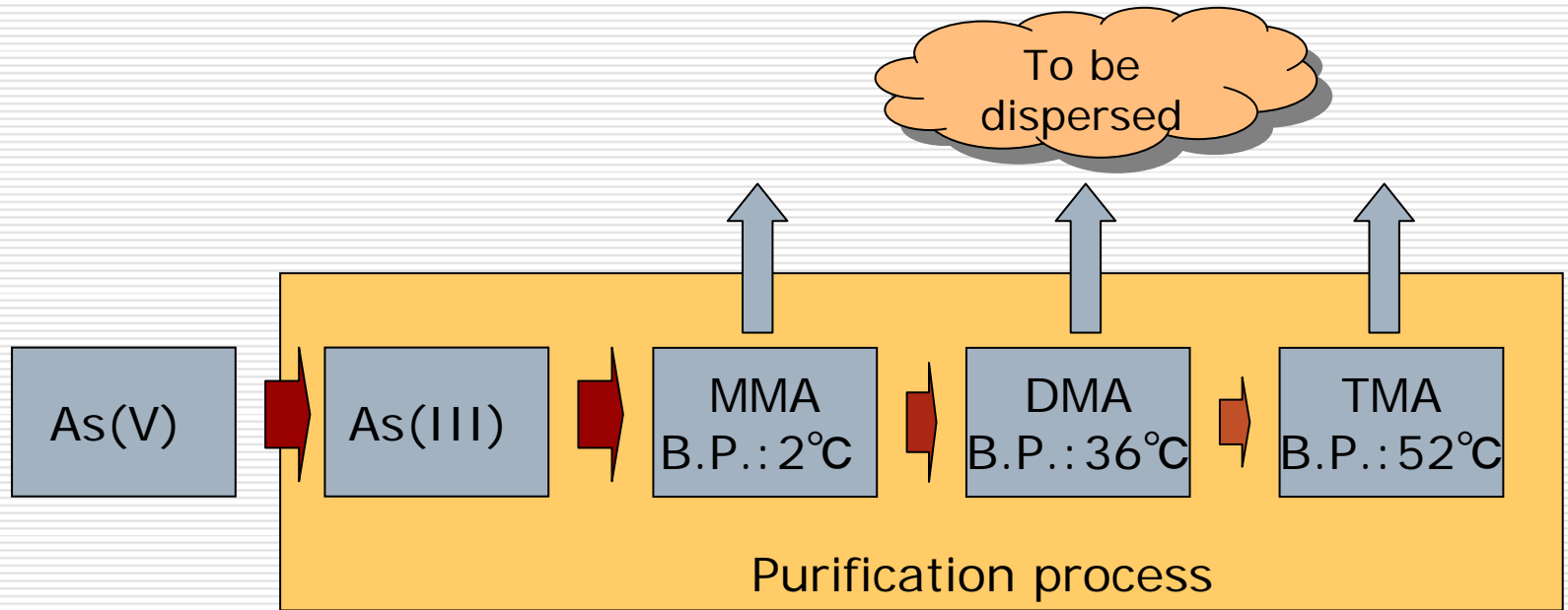


Should be properly disposed



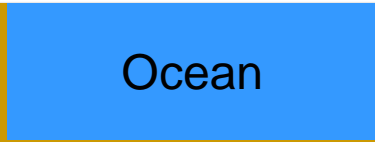
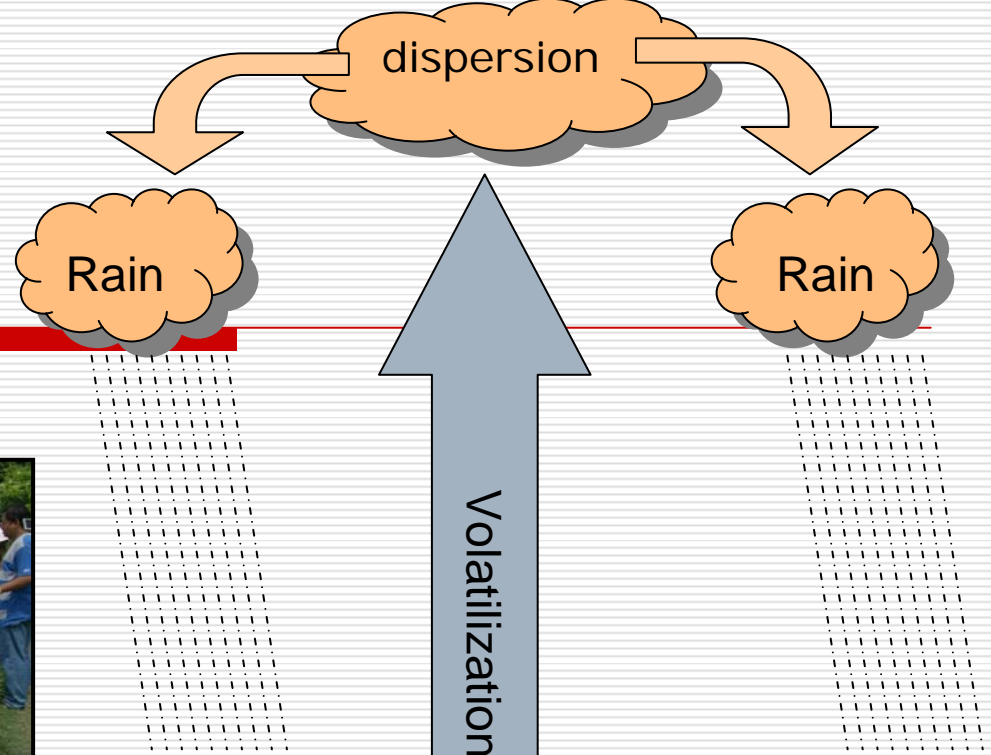
As sludge

ARSENIC VOLATILIZATION



LD ₅₀ (mg/kg)	16	4.5	1000	1800	8000
Relative Toxicity	1	3.6	0.016	0.009	0.002

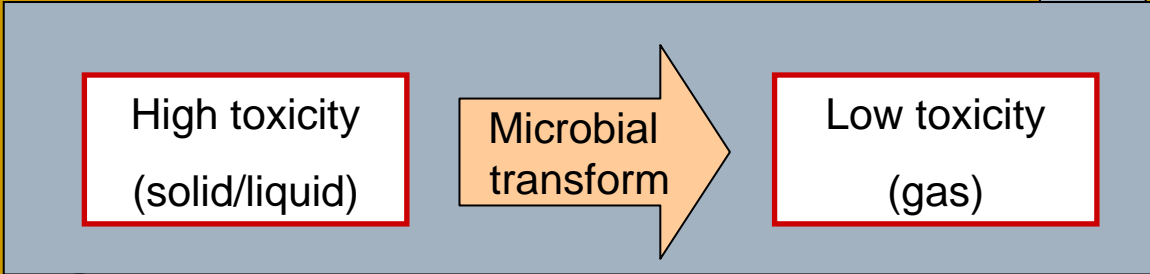
Soil remediation



As

Arsenic polluted soil

As



As

As

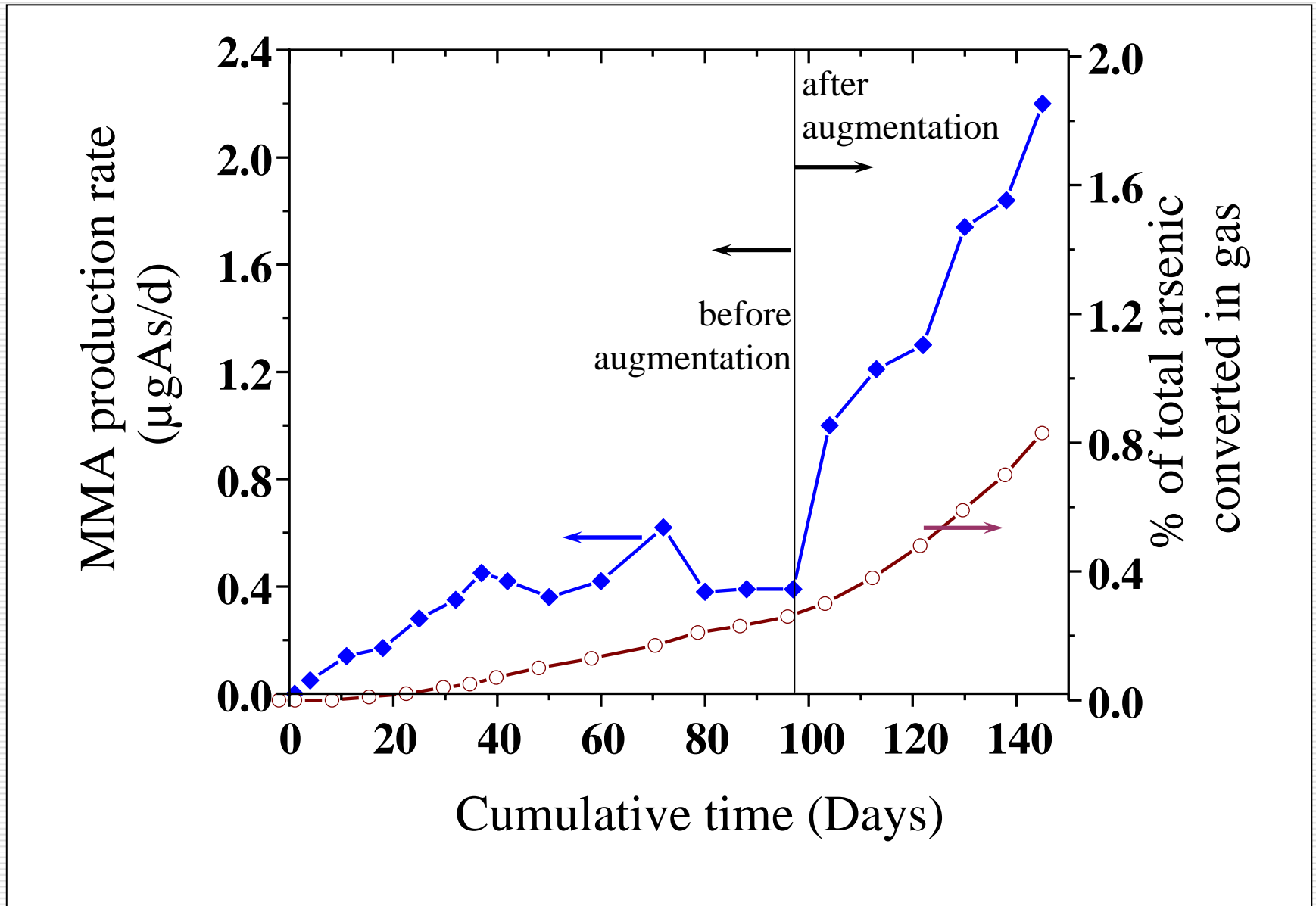
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Arsenic gasification rate in soil column

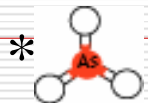
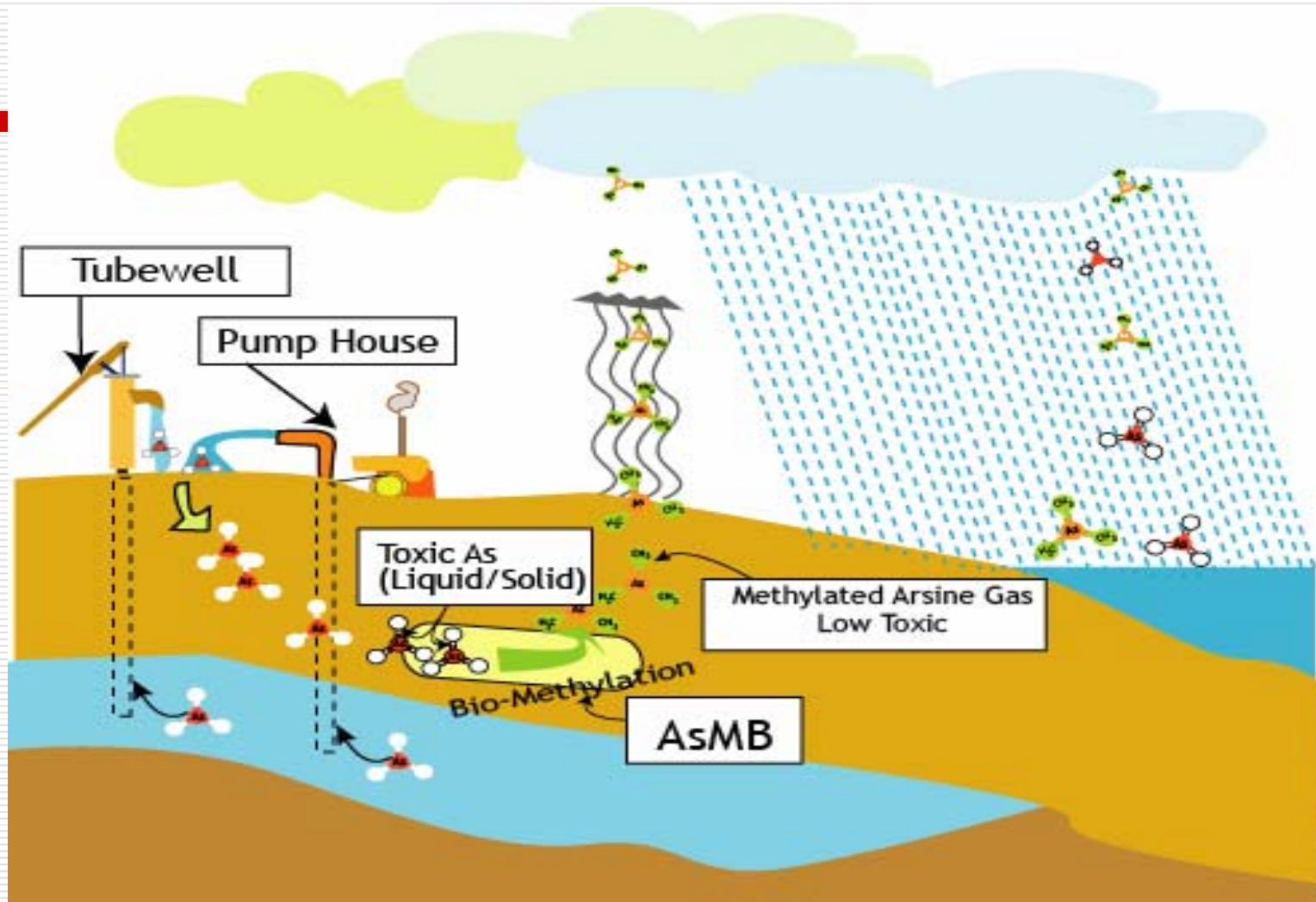


NEED OF DETERMINATION OF BASELINE OF GASEOUS ARSENIC

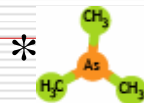
- In order to promote arsenic methylation technology for environmental clean-up, we need to know natural arsenic emission level from earth.
- Natural emission of gaseous arsenic from earth is biologically conducted.
- Fate of gasified As should be investigated



Arsenic cycle on earth (conceptual)



As III/As V



Methylated arsine (TMA)