Arsenic Wastes From Treatment of Arsenic Contaminated Water

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Topics of Presentation

- The source of arsenic
- Estimates of arsenic content in arsenic wastes
- Spent media arsenic content
- Annual arsenic deposition in rice paddies
- Waste Characterization
- Fate of disposed arsenic
- Arsenic profile in the irrigated field
- Volatilization of arsenic
- Arsenic mobility
- Waste disposal options
- GoB arsenic waste management protocol

The Source of Arsenic

- Arsenic is a natural element and is found in soil, plants, animals, rocks, water and air. It is the 20th most abundant element in the earth's crust and 12th most abundant element in biosphere.
- Soil world wide contains 0.1- 40 mg/kg arsenic
- Arsenic contamination of groundwater is acute South & East Asia, South America, etc.
- Important Arsenic Species: Arsenate , arsenite, mono- and dimethyl-arsenic acids.
- Arsenic compounds used as wood preservatives, biocides, in glasses and in pharmaceuticals etc.
- Everybody is exposed to arsenic through air, food and water but the problems arises when the intake exceeds 15µg/week/kg of body weight (FAO/WHO)

The Origin of Arsenic Wastes

Remediation of arsenic contaminated water generates following wastes:

- Spent Media from adsorption technologies
- Reject from Membrane separation technology
- Sludge from flocculation-coagulation-sedimentation processes and back wash water of filtration processes.
- Regeneration of spent media, ion-exchange resins produces caustic and sodium chloride solutions high in arsenic, respectively

Arsenic in Spent Media

Arsenic concentration in spent media, **C**

$$C = [\, V\,(\, Ci - Ce)\,] \,/\, W$$

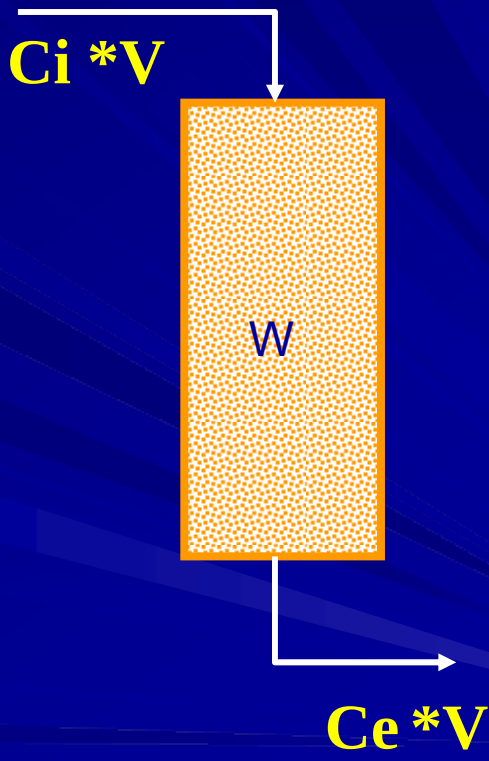
Where **Ci** = As Content of influent water

Ce = As Content of effluent (treated) water

W = Weight of the sorptive media used

V = Volume of water treated

If Ci and Ce are variable, ∑ CiVi and ∑ CeVe are to be used where Vi is the volume of raw water treated with As content Ci and Ve is the volume of treated water with residual As content Ce.



Arsenic in Regeneration of Sorptive Media

Arsenic concentration in Regenerating Fluid , **C:**

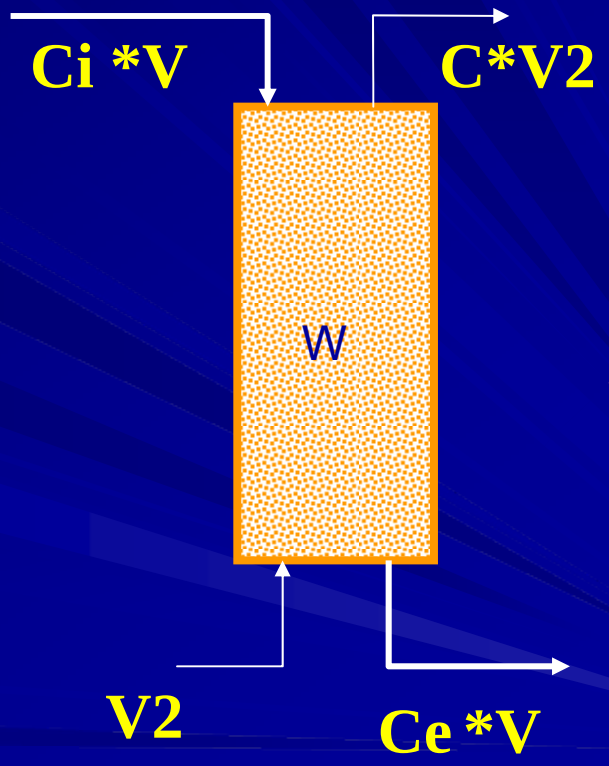
$$C = [\, V\,(\, Ci - Ce)\,] \,/\, V2$$

Where **Ci** = As Content of influent water

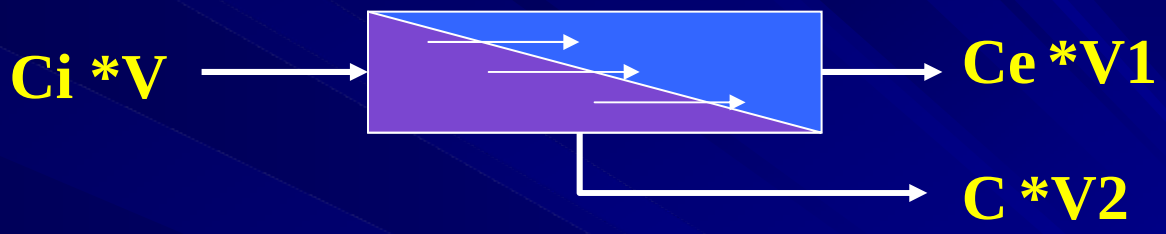
Ce = As Content of effluent (treated) water

V2 = Volume of the regenerating fluid (regenerate)

V = Volume of water treated



Arsenic in Rejected Water in Membrane Filtration



Arsenic concentration in Rejected water, **C**

$$C = [\ Ci\ V - CeV1)\ ] / V2$$

Where **Ci** = As Content of influent water

Ce = As Content of effluent (treated) water

V = Volume of raw water

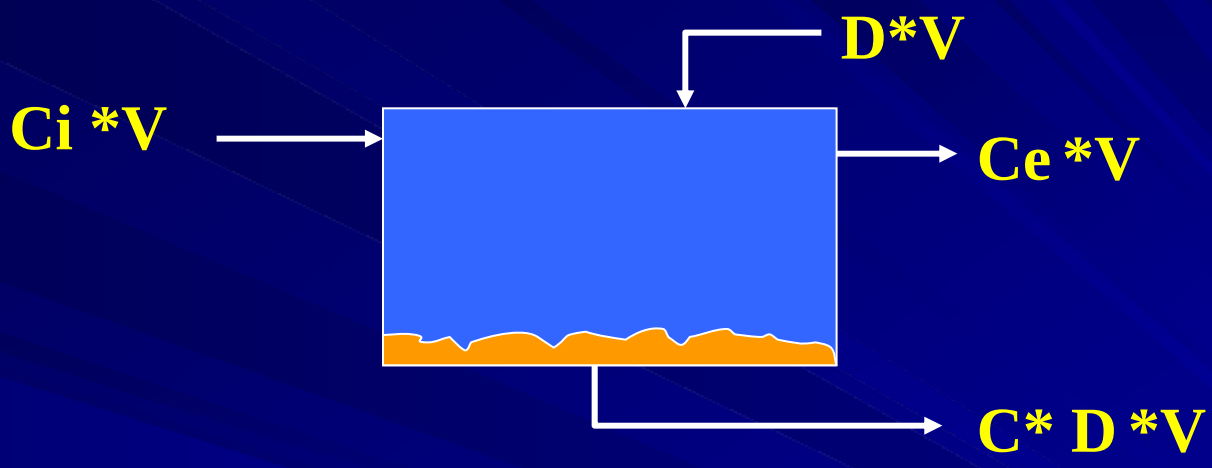
V1 = Volume of water treated

V2 = Volume of As concentrated water rejected

If highly purified water (Ce=0) is produced at 20% rejected water, then

C = 5 Ci , i.e, arsenic is 5 times concentrated in the rejected water

Arsenic in Sludge from Coagulation- Filtration



Arsenic concentration in sludge, **C**

$$C = [\ Ci\ - Ce)\ ] / D$$

Where **Ci** = As Content of influent water

Ce = As Content of effluent (treated) water

V = Volume of raw water

D = dose of coagulant

Spent Media Arsenic Content

Waste	As Level mg/kg	Leached As mg/L
Sludge[1]	6160/7350	0.018/0.003
Iron Hydroxide[1]	2025	0.225
Alumina[1]	72.1	0.426
Iron Oxide[2]	5660	ND
Iron Hydroxide[2]	2240	ND
Alumina[2]	226	0.004

1 - From BETV-SAM;

2 - From the US Arsenic removal plants; Jing, C, Liu, S., & Meng, X. (2007), Environ. Sci. Tech. 39, 1241

Arsenic Deposition in Irrigation of Rice

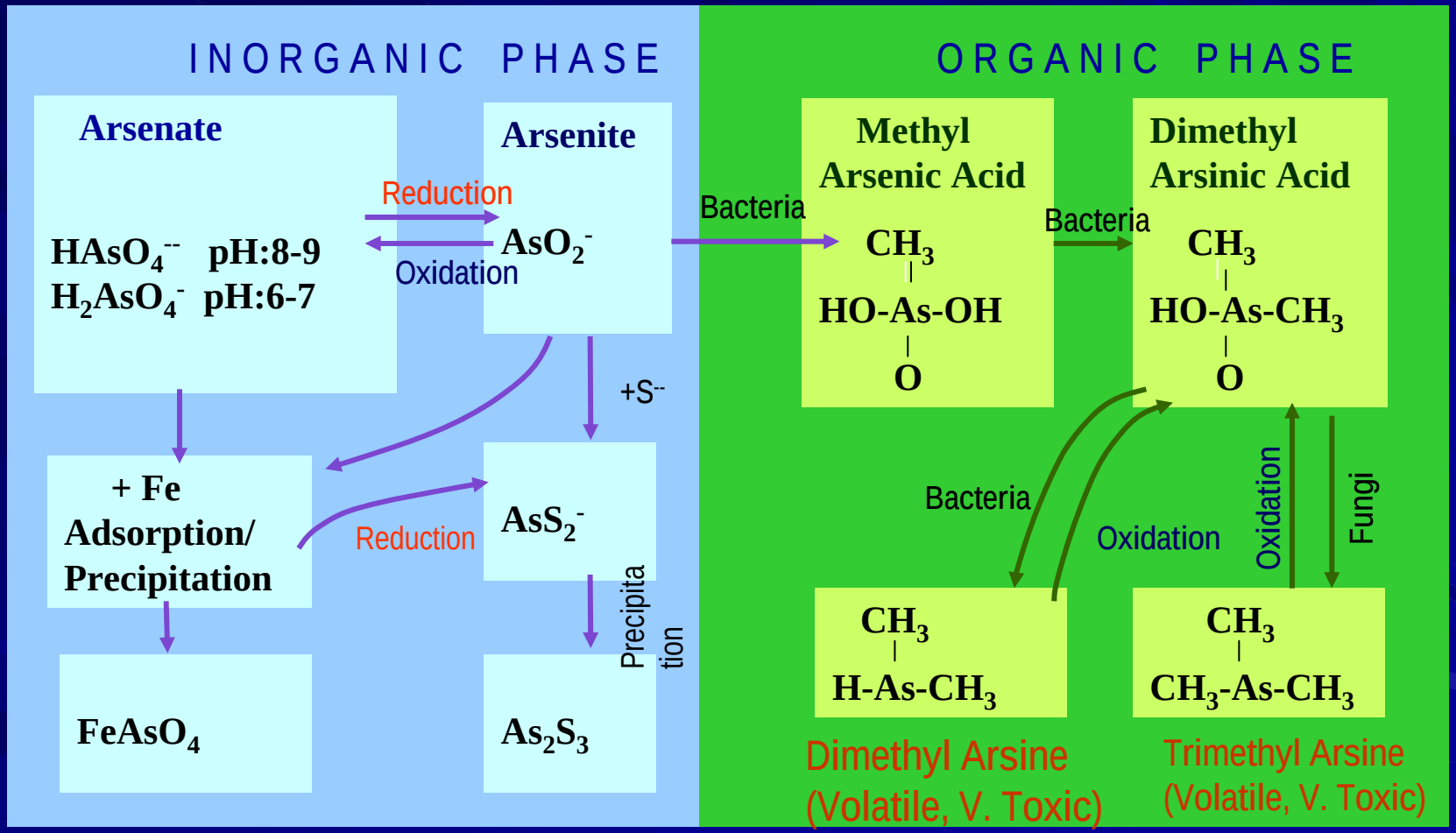
Arsenic Concentration in Well Water, µg/L	Arsenic Applied per ha of irrigated land in one season
50	0.5 kg
100	1.0 kg
250	2.5 kg
500	5.0 kg
1000	10 kg

Arsenic profile in Irrigated Field

Accumulation in top layer with a decreasing trend with depth. Arsenic content of soil reduces significantly in post-irrigation period probably due to:

- Erosion by runoff
- Dissolution of adsorbed As by rain and flood water
- Volatilization
- Leaching into groundwater

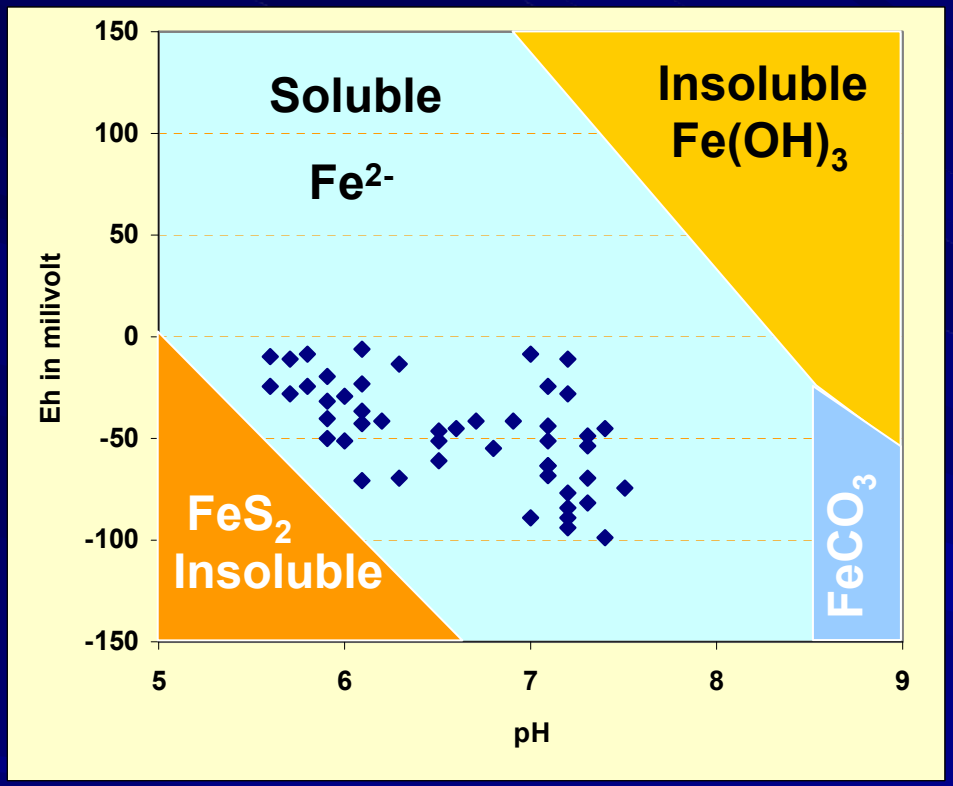
Transformation of Organic-Inorganic Arsenic



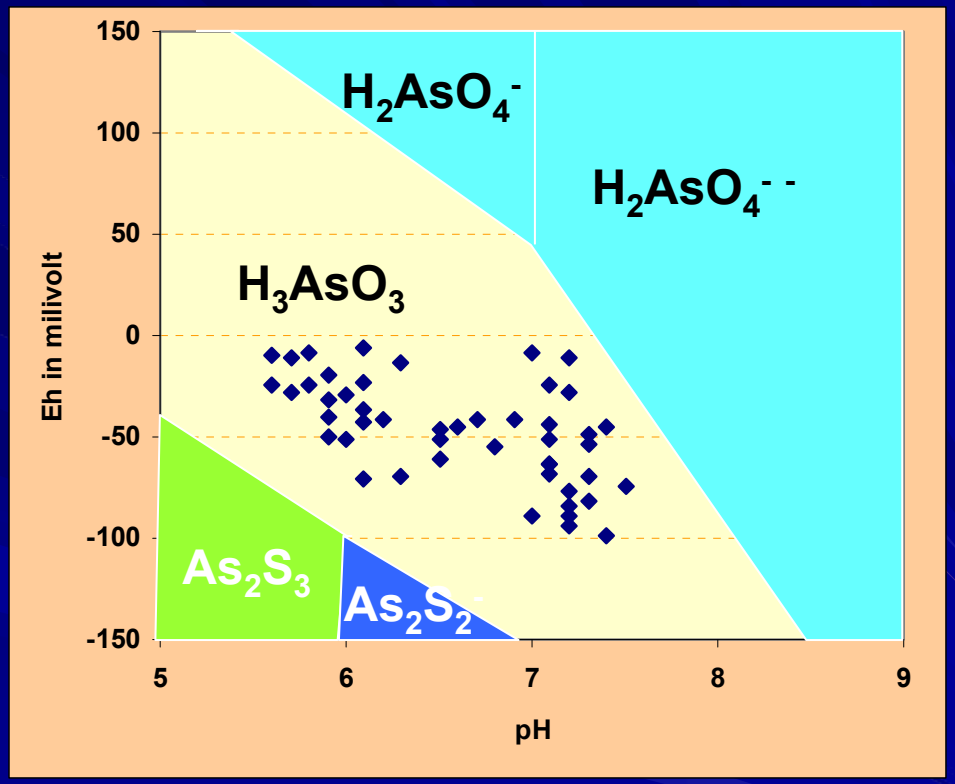
Fate of Disposed Arsenic

- Leach into groundwater;
- Wash-out by rain and flood water;
- Partly taken-up by plants (directly or from the soil);
- Reduce to methyl-arsine/arsine and volatilize

Phase-Stability Diagram of Arsenic and Iron



Phase-stability Diagram for Iron



Phase-stability Diagram for Arsenic

Arsenic Mobility

- Mobility: very low in an aerobic environment but noticeable in an anaerobic environments
- Mobility depends on redox condition; arsenic dissolves from soil to water below 0 redox potential.
- Oxidized iron adsorb arsenic in aerobic condition

Waste Characterization

- There are a variety of method to characterize arsenic waste:
  - Toxicity Characterisation Leaching Procedure (TCLP) - US EPA,
  - Total Available Leaching Procedure (TALP) -Dutch,
  - Waste Extraction Test (WET) – California, US, etc.
- Waste is considered hazardous if ≥ 5 mg/L of As is leached in waste characterization tests
- GoB has chosen TCLP for waste characterization

Waste Disposal Options

1. Disposal in a large water bodies (dilution)
2. Land disposal
3. Mix with fresh cow dung and buried
4. Disposal in pit latrine or septic tank
5. Municipal and/or industrial landfill
6. Landfills designed for hazardous wastes
7. Disposal in locations isolated from human environment
8. Engineering storage

GoB Arsenic Waste Management Protocol

- ART vendors are responsible for managing arsenic wastes
- Technologies that generate liquid waste with ≥ 5 mg/L of Arsenic cannot be certified
- Encapsulate sludge & spent media in a 2.5 cm concrete lined PVC container and burry at a depth of 2 -2.6 m away from populated areas
- Liquid waste/sludge has to be dewatered and handled as above
- Arsenic recovery is allowed
- The GoB protocol should be reviewed periodically

Thank you

for your kind attention