Biological Monitoring of Inorganic Arsenic and Its Metabolites

Jeffrey Jacquez
Faculty Mentor: David Kalman

IUPUI
Indiana University–Purdue University Indianapolis

Introduction

Background

- Naturally occurring arsenic contamination of drinking water is an enormous public health concern in many countries including Chile, India, and Bangladesh
- Biological monitoring, using urine samples, allows a better assessment of exposure than simply measuring drinking water concentrations
- By measuring the quantities of inorganic arsenic and its metabolites in arsenic exposed populations, researchers are searching for useful biomarkers to assess arsenic exposure

Specifics

- The first goal of the study is to check the feasibility of using MMA (III) as a biomarker for arsenic exposure; because of its elusiveness and instability, its use as a biomarker is still under question
- The second goal of the study is to assess whether the oxidation state of inorganic arsenic is related to the pH and redox potential (E_h) of the urine sample

Methods

- Spot urine samples were received from people in Chile and Bangladesh from populations whose only source of drinking water greatly exceeds the World Health Organization guideline of 10 ug/L; a subset of 67 samples from Chile were used in this study
- Total arsenic concentrations were measured using inductively coupled plasma mass spectrometry (ICP-MS)
- The concentrations of As (III), As (V), arsenobetaine, MMA (III), MMA (V), and DMA (V) were measured using high performance liquid chromatography-ICP-MS

- The pH and E_h of the samples were measured using a pH meter; to measure the E_h an Ag/AgCl redox electrode was used and then adjusted to the standard hydrogen electrode potential

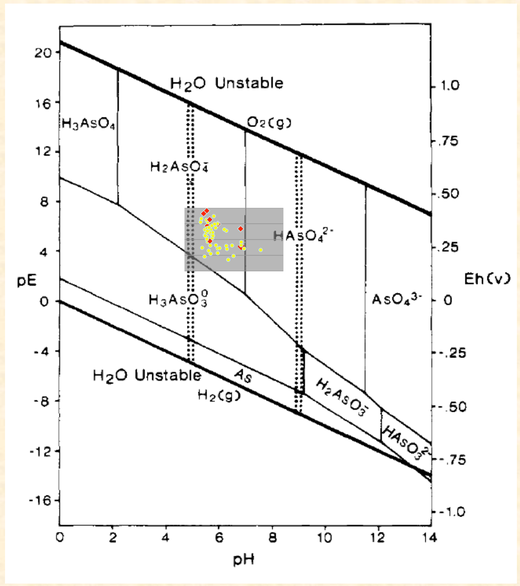
Results: Goal 1

- MMA (III) was found in only two samples at concentrations near the limit of detection for the instrument
- Sample 1: The MMA (III) concentration was 0.38% of the total arsenic concentration
- Sample 2: The MMA (III) concentration was 0.05% of the total arsenic concentration

	Mean Concentration (ug/L)	Percent of samples in which species was found
MMA (III)	0.15	2.9%
As (III)	1.56	83.8%
As (V)	1.09	91.7%
DMA (V)	31.71	98.5%
MMA (V)	2.98	97.0%
Arsenobetaine	26.25	97.0%

Results: Goal 2

- The graph (placed within a typical pH/E_h diagram for arsenic in water) shows that, under the pH/E_h range of our samples, the dominant arsenic species was As (III) , although the diagram suggests that As (V) would be the dominant species



Yellow Dots = Samples with higher As (III) concentration

Red Dots = Samples with higher As (V) concentration

Conclusion

Goal 1

MMA (III) is an intermediate in the metabolism of arsenic, and very reactive with tissues. These may be the reasons for its elusiveness in arsenic speciation analysis. In a 2008 study, Rabieh (1) noted that in numerous studies the percentages of urine samples found to contain MMA (III) ranged from 2-11% with one study claiming up to 40%. MMA (III) was only found in 2.9% of our samples, and the concentrations were near the limit of detection. Idiosyncratic differences in metabolism, and the low percentages of MMA (III) in urine samples, in this and other studies, shows that MMA (III) in urine is not a robust indicator of overall exposure to inorganic arsenic. Its use as an indicator of biological levels of reactive intermediate arsenic metabolites remains questionable.

- Further research is needed to understand its stability, and to make sure oxidation is not the cause of its low concentrations in urine samples, since MMA (V) was found in 97% of our samples with a mean concentration of 2.98 ug/L.

Goal 2

The stability of As (III) is shown in the graph. The As (III) concentration is higher in 83.6% of the samples although the conditions are more favorable for As (V) in all of the samples. The random distribution of the graph also suggests no correlation between ph/E_h and the oxidation state of these inorganic arsenic species in urine samples. This shows pH and E_h are not reliable indicators of the oxidation state of inorganic arsenic in urine samples.

- Further research is needed to test whether the same ratio of As (III) to As (V) exists directly after the urine is excreted and after shipping and storage, which in many studies can be up to four months.

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