

Report for 2004GU29B: Speciation studies of arsenic in Guam Waters Phase II.

- Conference Proceedings:
 - John Limtiaco, Tovahl Aube, Maika Vuki, Gary Denton, Rick Woods, Arsenic Speciation Studies in Guam Waters, Abstract, CLASS Annual Conference, March 2005, University of Guam.
 - Maika Vuki, John Limtiaco, Tovahl Aube, Rick Woods, Gary Denton, Book of Abstracts, 8th International Conference on the Biogeochemistry of Trace Elements, April 2005, Adelaide, Australia, pages 244-245.

Report Follows

Project Title: Arsenic Speciation in Guam waters, Phase II

Problem and Research Objectives

Arsenic contamination in ground water is a major concern in several states in the US. Arsenic is known to be carcinogenic and several countries, particularly Bangladesh, has been known to suffer from severe health problems that is related to arsenic contamination in ground water. In the US alone, more than 50% of ground water sources have significant levels of arsenic that requires constant monitoring. As a result, USEPA has recently reduced the maximum allowable level of arsenic to 10 µg/L or parts per billion (ppb). Preliminary investigations by the Guam EPA (2001) on the spring waters that discharged from the northern lens aquifer in Guam reported some unusually high levels of arsenic. This was unusual since the major geological formation on the northern region of Guam is predominantly carbonaceous rocks and these rocks are known to have low levels of arsenic. About 80% of Guam's water source is derived from the limestone aquifer. There are more than 100 ground water wells on the northern part of the island. Some of these wells are connected through conduits that flow out as springs or seeps along Tumon Bay. A follow up study conducted on the same sites along the Tumon Bay region in 2003 showed low levels of arsenic. The major differences in sampling and analytical methods in these two separate studies requires further work to validate the arsenic data generated from this northern region. The aim of this project is to verify the differences from the two studies and investigate possible contamination pathways that may contribute to any high levels of arsenic. The objectives are

- i. To investigate the levels of Arsenic in Tumon Bay, the connecting freshwater wells on Guam and other potential sites during the wet and dry season.**
- ii. To conduct speciation studies of arsenic to ascertain the levels of the different forms of As both organic and inorganic.**
- iii. To conduct an inter-laboratory validation exercise**
- iv. To correlate the levels of arsenic to the likely sources and sinks.**
- v. To relate these levels to the parameters; pH, salinity, dissolved oxygen and temperature.**

Methodology

Water samples were collected from the flowing springs and seeps from 10 sites along Tumon Bay. The samples were acidified with a small amount of concentrated hydrochloric acid (0.25mL/100mL) and stored in ice cooled containers and transported to the main laboratory for further treatment. During sample collection, measurement for dissolved oxygen, conductivity, temperature, and pH were also conducted. In the laboratory, samples were filtered and stored under 4°C temperature until the analysis of arsenic under the hydride generation method.

Arsenic speciation involves the treatment of samples under three reagent regimes. Pretreatment 1 (PT1) which measures arsenic (III) uses only HCl with no heating. Pretreatment 2 (PT2) measures As(III) and As(V) and this method uses a mixture of reductant KI and HCl followed by intermediate heating under a microwave oven. Pretreatment 3 (PT3) measures both organic and inorganic arsenic species. The reagent is a mixture of $K_2S_2O_8$ and NaOH followed with a series of heating (under microwave) and cooling cycle. PT3 is then followed by PT2 to reduce all arsenic to As(III) before analysis. The hydride generation method is coupled with Atomic Absorption Spectroscopy. This method was successfully developed from the first part (Phase I) of this study. The detection limit obtained was 0.30 μ g/mL (ppb).

Principal Findings and Significance

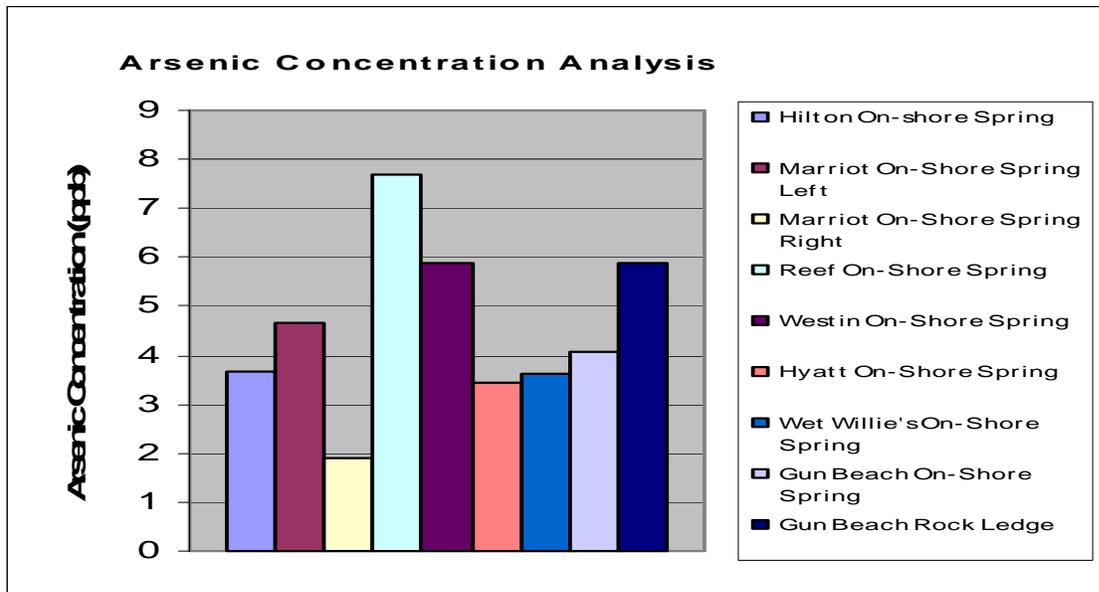
Table 1.0 show a summary of the levels of arsenic from the 10 sampling sites along Tumon Bay. The total inorganic arsenic levels given under pretreatment 2 (PT2) are very low. Arsenic (III) levels (PT1) are all below detection limit. All these values are well below the recommended level stated under the USEPA guideline (10 μ g/L).

Table 1.0

Sample	PT1	PT2
	As conc. (μ g/L)	As conc. (μ g/L)
TB1(Hilton)	<0.3	0.8
TB2 (Marriot)	<0.3	1.2
TB3 (Marriot)	<0.3	0.6
TB4 (Wet Willies)	<0.3	0.8
TB5 (Holiday Inn)	<0.3	0.9
TB6 (Outrigger)	<0.3	1.0
TB7 (Outrigger)	<0.3	0.6
TB8 (Reef)	<0.3	0.9
TB9 (Westin)	<0.3	<0.3
TB10 (Okura)	<0.3	<0.3
MilliQ + 20 μ g/L As(III) + 20 μ g/L As(V)	25.1	37.8
Method detection limit: 0.3μg/L		

Figure 1.0 show levels of total arsenic from the same sites using the ICP-AES method of analysis. These results were conducted in partnership with a collaborating laboratory. The evels of As shown in figure 1.0 are higher that those in Table 1.0. These high values are expected due to the interference of metals such as tin and other metals in the similar spectral region under the method used. The ICP-AES analysis method did not involve any speciation procedure and the levels reported are for the total arsenic concentrations in water. The results show the arsenic levels are still lower than 10µg/L. These two sets of data (Table 1.0 and Figure 1.0) clearly show that arsenic levels are low in the Guam springs. Arsenic levels from neighboring streams and rivers on Guam were also analysed for comparison. Results obtained were consistent with the low values measured from spring waters. Organic arsenic levels obtained from PT3 also show low levels. Therefore the total arsenic concentrations in the spring waters are low and pose no immediate threat to the environment or human health.

Figure 1.0. Arsenic levels measured under ICP-AES technique without hydride generation method from the same study sites. Arsenic concentration is reported in part per billion, µg/L.



Conclusion.

The speciation method used was able to distinguish between the inorganic arsenic (III) and inorganic arsenic (V) species in spring water samples. The levels of arsenic in the spring water are well below the maximum allowable limits set under the USEPA guideline. Therefore there is no immediate threat of arsenic pollution along Tumon Bay and the ground water levels of Guam. The values of arsenic levels from this study are also consistent with those reported by Guam Waterworks Authority (GWA). The low values are also consistent with the natural background levels based on the carbonate rocks on the northern region of Guam. However, regular monitoring will be necessary due to the increasing industrial development along the Tumon Bay area and the northern region in general. Such developments may introduce localized point source contamination that would pose environmental and health risk to the community.