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Arsenic speciation study in some spring waters of Guam, Western Pacific Ocean

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Abstract

A survey of the different forms of arsenic species: inorganic arsenic (As), As(III), As(V) and organic As(III) and (V) was carried out on spring waters located along Tumon Bay in Guam. The results show that total arsenic concentrations in the spring water samples ranged from <0.3–1.2 μg/L. Inorganic arsenate, As(V), appears to be the dominant species in the spring water samples tested. The concentrations are much lower than previously reported, probably due to a much more rigorous methodological approach and requires further investigations on the status of As contamination in groundwater on the island.

Keywords: Arsenic speciation; Spring water; FAAS; Hydride generation; Tumon Bay; Guam

1. Introduction

Arsenic (As) contamination of groundwater is known to cause severe health problems in several countries (NRC, 2001). Arsenic is known to cause cancer and the level of toxicity is dependent upon the type of species present in water. Both the inorganic As (arsenite [As(III)] and arsenate [As(V)]) and organic As species (monomethyl- and dimethyl-arsenates (MMA, DMA), are toxic (WHO, 2001). There are numerous studies on the total As concentrations in groundwater (Smedley and Kinniburgh, 2002). An air force base (Andersen AFB), located in northern Guam in the Southwest Pacific was established during World War II, has provided 50 years of military support services, including vehicle maintenance, fuel storage, ammunition stockpiling, and explosive ordinance disposal (Agency for Toxic Substances and Disease Registry, ATSDR, 2002). Base activities have resulted in numerous fuel, pesticide, and chemical spills over part of Guam's aquifer in the Groundwater Protection Zone, which supplies over 70% of the island's population with drinking water. Soil monitoring data revealed very high concentrations of elements such as lead, arsenic, chromium, and cadmium close to the landfills. Public health assessment (ATSDR, 2002), based on the estimated exposure doses for consumption of on-base produce from ingesting arsenic in on-base produce in the Air Base (0.00044 mg/kg/day) is above the ATSDR's chronic oral MRL of 0.0003 mg/kg/day. However, there is limited information on the distribution of As in the groundwater of Guam.

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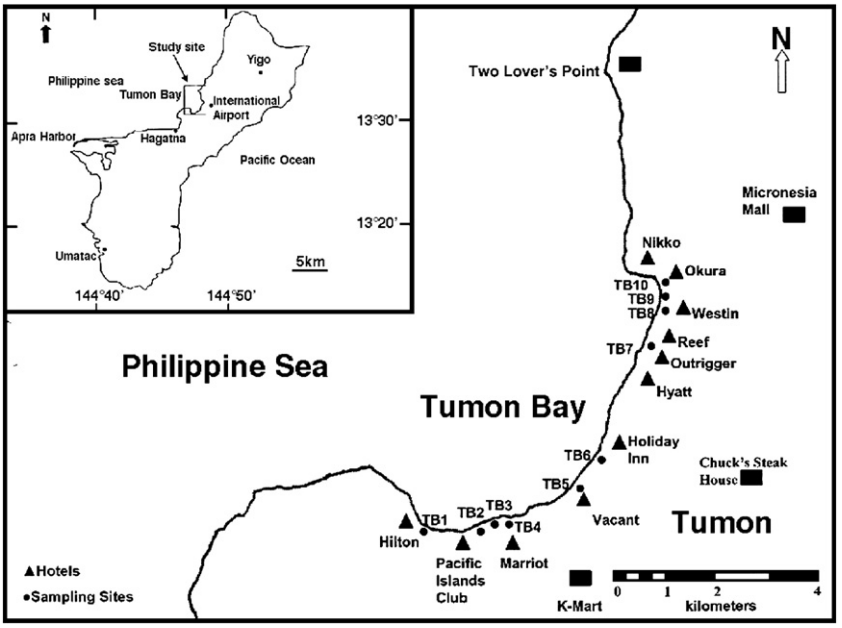

Fig. 1. Map of Guam showing the study area around the Tumon Bay. Insert shows the location of Guam in the North Western Pacific region.

In this study, we report new results for the distribution of As in groundwater springs and seepages at Guam where an earlier investigation conducted by the Guam Environmental Protection Agency (GEPA) on total As, that indicate concerns over As contamination. The work also provides information on As speciation and addresses important issues of analytical methodologies.

2. Study area

Guam, a USA territory, is located at the southern end of the Mariana Islands in the North Western part of the Pacific Ocean. It has a population of 166,000 and more than 80% of Guam's water resources come from groundwater wells that are derived from the carbonate

Table 1
Results of arsenic concentrations from 10 sampling sites along Tumon Bay at Guam

Analytical method	Pre-treatment method							ICP-OES**	GEPA***
	PT1 (±0.2 μg/L) As(III)	PT2 (±0.2 μg/L) As(III)+As(V)	PT1 (±0.2 μg/L) As(III)	PT2 (±0.2 μg/L) As(III)+ As(V)	PT1 (±0.2 μg/L) As(III)	PT2 (±0.2 μg/L) As(III)+ As(V)	PT3 (±0.2 μg/L) As(III)+As(V)+ Organic As	Total As (±0.9 μg/L)	Total As (±1.0 μg/L)
Sampling period/ ID	June 2004		July 2004		August 2004			July 2004	February 2001
TB1	0.5	<0.3	<0.3	0.6	<0.3	1.0	<0.3	3.5	100
TB2	<0.3	<0.3	<0.3	0.9	nd	nd	nd	4.8	22
TB3	0.4	<0.3	<0.3	<0.3	1.0	1.2	0.8	2.6	23
TB4	nd	<0.3	<0.3	0.6	nd	nd	nd	5.9	87
TB5	0.4	<0.3	<0.3	0.7	nd	nd	nd	4.2	6.4
TB6	nd	<0.3	nd	0.7	nd	nd	nd	nd	26
TB7	0.4	<0.3	<0.3	0.5	nd	nd	nd	<1.0	20
TB8	11.0*	<0.3	<0.3	0.7	1.1	0.4	1.0	3.6	16
TB9	<0.3	<0.3	<0.3	<0.3	nd	nd	nd	4.8	31
TB10	<0.3	<0.3	<0.3	0.7	1.2	1.0	1.0	5.4	nd
TB10 spiked*	nd	41.9[a]	41.9[a]	nd	92.3[b]	112.6[b]	19.2[c]	nd	nd

*Sample spiked with As concentrations [a]50 μg/L; [b]100 μg/L; [c]20 μg/L.
**As concentration values measured by ICP-OES.
***As concentration and the values reported by GEPA (2002).