

ARSENIC CONTAMINATION OF GROUNDWATER IN THE MEKONG DELTA

RB Merola¹, A Vengosh²

¹rbm11@duke.edu, 201 Old Chemistry Building, Duke University, Durham, NC, 27705

²vengosh@duke.edu, 201 Old Chemistry Building, Duke University, Durham, NC, 27705

Introduction

The Red and Mekong River Delta Regions in Vietnam are one of the most agriculturally productive regions in Southeast Asia (Berg et al. 2001; 2007). In addition to water availability pressures from dam construction and irrigation, groundwater is a prime source of drinking water in the region (Van et al. 2004). Quality of drinking water sources needs to be accounted for in addition to availability and studies have documented high salinity and As (arsenic) in groundwater both of which have the potential to affect not only agricultural production but health as well (Buschmann and Berg 2009; Buschmann et al. 2007; 2008).

Arsenic contamination of drinking water from groundwater sources was investigated in the Mekong Delta. In addition to examining As occurrence and magnitude, toenails from individuals consuming drinking water in the region were collected as a biomarker of As exposure, and a general health and diet questionnaire was administered. The objectives of this study were not only to evaluate As in groundwater but also to assess how it is bioaccumulating in populations exposed to elevated As.

Methodology

IRB approval was obtained from Duke University, Ho Chi Minh Science University, and the Department of Natural Resource and Environment of Dong Thap Province. Sixty-eight groundwater wells were sampled and analysed, in addition to 5 surface water samples from the Mekong River for comparison. All water samples were collected following USGS protocols (USGS 2011).

Toenails (n=62) were collected from participants whose water had also been sampled. Individuals donating samples were also asked to complete a short survey to collect demographic information, water consumption patterns, and basic health issues. All nail samples were collected and analysed according to methods in Merola et al. (2013).

Results

Fifty-three percent (36 of 68 wells) of wells sampled from the Dong Thap region had As levels above the WHO's recommended 10ppb limit. High As was found to correlate with low Eh values.

A literature review was performed to compile an As concentration database (n=7,346) for the entire region. The As concentration values were interpolated and showed a clear pattern with regards to distance from the Mekong River throughout not only Vietnam but also Cambodia. This data was combined with census information to estimate that approximately 12.7 million people in the region live in areas where the average As concentration of groundwater is above the WHO's 10ppb limit.

Nail-As values were found to statistically correlate with water-As values ($r=0.49$, $p<0.001$). Diet and use of filtration systems were also found to have an effect on As accumulation. High meat and low seafood consumption were associated with lower As levels than low meat/high seafood consumption patterns.

Discussion

Several studies have seen a potential threshold at which As begins accumulating in nails (Karagas et al. 2000; Merola et al. 2013). This relationship was also found in this dataset with the threshold found at 1ppb. If this limit is applied to the As database compiled, an additional 4.12 million people are potentially consuming As concentrations that are bioaccumulating.

This study had several important limitations that should be noted. The method used to digest nails for this study only provides total-As concentrations making it impossible to differentiate between organic-As (non-toxic) levels in nails and inorganic-As levels. This setback is particularly of note when analysing As concentrations in nails related to seafood since seafood is a source of organic-As an increase in As-nail concentrations is tangent with increased seafood consumption would not be detrimental to an individual's health.

Conclusions

Arsenic contamination of drinking water wells is a serious health concern that is affecting millions of people living in Southeast Asia. Our analyses showed that the risk of exposure decreases with distance from the Mekong River. Our data also showed that As is bioaccumulating in residents consuming contaminated drinking water at concentrations as low as 1ppb.

References

- BERG, M., STENGEL, C., TRANG, P.T.K., et al. 2007. Magnitude of arsenic pollution in the Mekong and Red River Deltas – Cambodia and Vietnam. *Science of the Total Environment*, **372**, 413-425.
- BERG, M., TRAN, H.C., NGUYEN, T.C., PHAM, H.V., SCHERTENLEIB, R., GIGER, W. 2001. Arsenic contamination of groundwater and drinking water in Vietnam: A human health threat. *Environmental Science & Technology*, **35**, 2621-2626.
- BUSCHMANN, J., BERG, M. 2009. Impact of sulphate reduction on the scale of arsenic contamination in groundwater of the Mekong, Bengal, and Red River deltas. *Applied Geochemistry*, **24**, 1278-1286.
- BUSCHMANN, J., BERG, M., STENGEL, C., SAMPSON, M. 2007. Arsenic and manganese contamination of drinking water resources in Cambodia: Coincidence of risk areas with low relief topography. *Environmental Science & Technology*, **41**, 2146-2152.
- BUSCHMANN, J., BERG, M., STENGEL, C., WINKEL, L., SAMPSON, M., TRAN, P.T.K., VIET, P.H. 2008. Contamination of drinking water resources in the Mekong delta floodplains: Arsenic and other trace metals pose serious health risks to population. *Environment International*, **34**, 756-764.
- KARAGAS, M.R., TOSTESON, T.D., BLUM, J., et al. 2000. Measurement on low levels of arsenic exposure: A comparison of water and toenail concentrations. *American Journal of Epidemiology*, **152**, 84-90.
- MEROLA, R.B., KRAVCHENKO, J., RANGO, T., VENGOSH, A. 2013. Arsenic exposure of rural populations from the Rift Valley of Ethiopia as monitored by keratin in toenails. *Journal of Exposure Analysis and Environmental Epidemiology*, **24**, 121-126.
- US GEOLOGICAL SURVEY (USGS). 2011. National field manual for the collection of water quality data. US Geological Survey, Washington, DC.
- VAN, T.V. 2004. Geological Survey, Utilization and State Management of Groundwater in Vietnam. Coordinating Committee for Geoscience Programs in East and Southeast Asia (CCOP). 41st CCOP Annual Session 15-18 Nov 2004, Tsukuba, Japan.