COMPARISON OF BIOAVAILABILITY MEASUREMENTS DETERMINED USING JUVENILE SWINE AND ADULT MOUSE MODELS FOR ARSENIC CONTAMINATED SOILS

Brooke Stevens[a], S. Whitacre[a], K. Bradham[b], D. Thomas[b], S. Casteel[c], R. Anderson[d], and N. Basta[a]

[a]*The Ohio State University, School of Environment and Natural Resources, Columbus, Ohio, USA*
[b]*United States Environmental Protection Agency, Research Triangle Park, North Carolina, USA*
[c]*University of Missouri, Department of Veterinary Pathobiology, Columbia, Missouri, USA*
[d]*United States Air Force Center for Engineering and the Environment, Lackland AFB, Texas, USA*
stevens.728@buckeyemail.osu.edu

Keywords: Arsenic; Soil; Bioavailability

Introduction

Ingestion of contaminated soil often is the "risk – driver" for arsenic (As) and other trace element contaminated soils and the key exposure pathway in human and ecological risk assessment. The trace element interactions with the soil and sediment and general soil properties impact chemistry, solubility, and bioavailability. Often the calculated risk for a site can be reduced when the bioavailability of As in the soil is included in site specific risk calculation. Relative bioavailability (RBA) can be determined for specific sites using in vivo bioassays that mimic human gastrointestinal physiology. The juvenile swine model is viewed as the "gold standard" and has been used for years. Research has shown that swine have a similar gastrointestinal physiology to humans and is the reason for their preference over other animals. More recently an adult mouse model was developed as a lower cost alternative to the swine model. However, limited research has been done to determine if the two bioassays are equivalent to one another. The objective of this study was to determine if RBA determined using the adult mouse model is equivalent to the juvenile swine model for 14 As contaminated soils with a range of soil properties, contamination sources, and solid phase As speciation.

Methods

RBA for the 14 As contaminated soils was determined using both the juvenile swine and adult mouse models. As contaminated soils were fed to juvenile swine in a semi fasted state. After dosing urine from each individual was collected and analyzed for excreted arsenic. Following analysis a urinary excretion factor (UEF) was determined by plotting the mass of As excreted by mass of As consumed. RBA was calculated using the UEF from the test material divided by the UEF from a sodium arsenate reference material. 90% confidence intervals were calculated using Fieller's Theorem (Brattin & Casteel, 2013). RBA determined using the adult mouse model involves using groups of mice to determine RBA. As contaminated soil is mixed with the mouse feed and 4 animals within a cage are allowed to consume soil and food *ab labium*. Urine is collected and analyzed for As concentration and a UEF is calculated by dividing the mass of As in the urine by the mass of As consumed. RBA was determined by using a ratio of the UEF for the test material and the UEF for a sodium arsenate reference. 90% confidence intervals for each test material were also calculated using Fieller's Theorem (Bradham et al., 2011). Evaluation of the two bioassays was done using linear regression and confidence interval comparison. Soil properties relevant to As solubility and bioavailability were determined; including total As, reactive Fe and Al, pH, organic carbon content, and clay content.

Proceedings of the 18th International Conference on Heavy Metals in the Environment, 12 to 15 September 2016, Ghent, Belgium
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Results

The arsenic concentrations within the soils ranged from 162 mg/kg to 3,910 mg/kg with an average of 863 mg/kg. Arsenic bioavailability determined using the adult mouse model ranged from 6.4 to 46% with average of 26%. RBA determined using the juvenile swine model ranged from 12 to 60% with a mean of 37%. The median RBA values were 30% for the mouse model and 40% for the swine model. These results show that on average the juvenile swine model reports RBAs that are higher than the adult mouse model. Correlation coefficients for RBA vs total As concentration (mg/kg) for 14 soils are -0.399 and -0.480 for the adult mouse model and juvenile swine models respectively. Correlation coefficients do not suggest that there is a meaningful correlation between total As concentration and RBA As. The juvenile swine RBA tends to be more variable than RBAs determined using the adult mouse bioassay (Figure 1). The 90% confidence intervals for RBA As only overlap for 5 of the 14 soils and the confidence intervals for the juvenile swine RBAs are sider than those determined using the adult mouse bioassay.

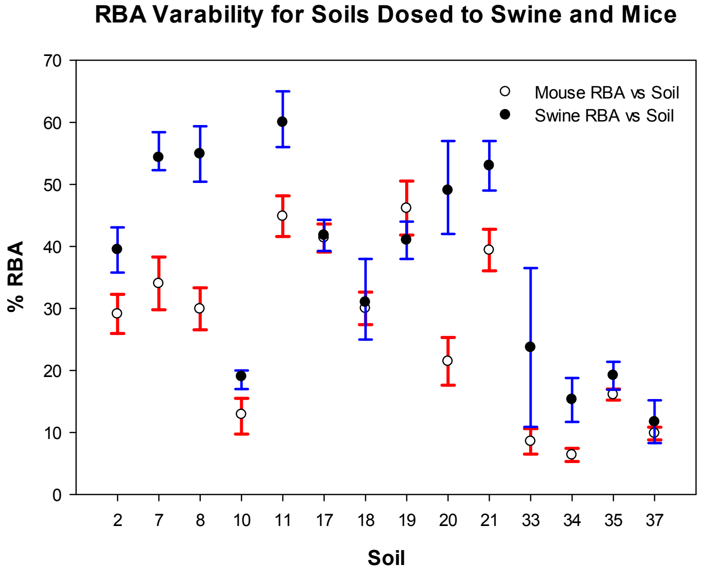

Figure 1. Comparison of 90% confidence intervals for 14 soils determined using both the adult mouse and juvenile swine bioassays.

Conclusion

The soils evaluated in the study using the adult mouse model and juvenile swine model have produced a wide range in RBA values showing how physical and chemical properties of each soil impact RBA As not just the total concentration. The adult mouse bioassay has low variability compared to the juvenile swine model and is more reproducible. However, because little overlap of the 90% confidence intervals between the two methods occurs RBA values generated using each method are not equivalent.

References

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