PREDICTING ARSENIC BIOAVAILABILITY IN CONTAMINATED SOILS BY USING IN VITRO GASTROINTESTINAL BIOACCESSIBILITY FOR SITE-SPECIFIC RISK ASSESSMENT

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Introduction

Exposure risk associated with soils contaminated with As is assessed by human health risk assessment (HHRA). Often the most important pathway for As in soil (i.e., the risk driver), associated with human exposure is soil ingestion. The use of total soil As in HHRA overestimates human exposure because soil properties sequesters As. A more accurate and site-specific HHRA accounts for bioavailability of soil As. Extensive research efforts have been directed toward development and application of in vitro gastrointestinal methods to predict relative bioavailable As (RBA As) across four continents. Several studies have reported in vitro-in vivo correlation (IVIVC) between IVBA As and RBA As measured from juvenile swine dosing bioassays. RBA As vs. IVBA As regression equations are used to predict RBA from IVBA. These methods are gaining regulatory acceptance for HHRA on contaminated sites. However, the ability of bioaccessibility methods to predict RBA As for contaminated sites and sources outside those used in developing the IVIVC regression equation is unknown. The objective of the current study is to evaluate the ability of several international bioaccessibility methods to predict RBA As for 12 contaminated sites. The use of these methods to provide site characterization data for HHRA and aid in risk management decisions will be presented.

Methods

Soils were collected from 12 contaminated sites (i.e., locations). Bioaccessible As (IVBA As) was determined by several in vitro gastro(intestinal) methods including the SBRC (Juhasz et al., 2009), RBALP (Drexler and Brattin, 2007; Brattin et al., 2013), USEPA Method 9200 (Diamond et al., 2016), OSU IVG (Basta et al., 2007), and Modified OSU IVG (Whitacre et al., 2016). Relative bioavailable (RBA) As was determined from dosing trials using juvenile swine. Regression equations from published IVIVC were used to predict RBA As from in vitro arsenic bioaccessibility.

Results

Comparison of RBA As predicted from published IVIVC with actual juvenile swine RBA As are summarized in Table 1. The predicted RBA As followed the trend MOSU IVG ≥ OSU IVG > RBALP, SBRC, USEPA 9200. The most accurate predicted RBA fall within the 90% RBA As confidence interval (C.I.). However, conservative values that exceed the 90% C.I. are desirable because they are protective from a regulatory perspective. Several in vitro methods meet the criteria where predicted RBA As ≥ measured RBA As can be used for site specific HHRA. Site specific factors that affect the agreement between predicted and measured values for all 12 experimental sites will be presented.

Table 1. Comparison of measured and predicted RBA As for select contaminated sites. Bolded values are within or greater than the measured RBA As.

	Predicted Mean RBA As (%) from IVBA					Measured RBA As (%)	
Site	SBRC[a]	RBALP[b]	USEPA 9200[c]	OSU IVG[d]	MOSU IVG[e]	Mean	90% C.I.[f]
1	9.89	**24.8**	4.0	**19.1**	**21.0**	14	13-15
2	2.9	**20.5**	3.9	**12.9**	**22.8**	15.3	11.7-18.8
3	**7.5**	**7.5**	**7.7**	**20.9**	**13.5**	9.0	6-13
4	**28.5**	**36.5**	**24.4**	**28.9**	**35.7**	26.0	24-28
5	14.0	27.4	12.8	29.9	37.0	41.0	38-44

[a]SBRC, RBA As = 0.992 IVBA + 1.66, $r^2 = 0.75$ (Juhasz et al., 2009)
[b]RBALP, RBA As = 0.62 IVBA + 19.7, $r^2 = 0.72$ (Brattin et al., 2013)
[c]USEPA 9200, RBA As = 0.79 IVBA + 3.0, $r^2 = 0.72$ (Diamond et al., 2016)
[d]OSU IVG, RBA As = 0.883 IVBA + 9.6, $r^2 = 0.74$ (combined data Basta et al., 2001, Basta et al., 2007)
[e]MOSU IVG, RBA = 0.79*IVBA + 4.85, $r^2 = 0.92$ (Whitacre et al. 2016)
[f]CI = confidence interval

Conclusions

Many of the IVBA methods underpredicted RBA As. The MOSU IVG method was consistently close to the RBA As values for the sites studied. However, previous research studies have shown good agreement between predicted and measured RBA As for non MOSU IVG methods. Other site data is needed to improved confidence of the non-MOSU IVG methods prior to application. The additional site data (i.e., arsenic speciation) is needed to allow proper selection of methods by risk assessors to accurately predict RBA As and human exposure and gain acceptance by the regulatory community.

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