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MEMORANDUM

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RE: Revision 0 — Accounting for Uncertainties Related to Arsenic

Introduction

Arsenic in soil and groundwater is a common problem and creates uncertainty with respect to human health risk assessment as well as risk management and decision-making. This memo provides a summary of important sources of uncertainty. A USEPA method used in other regions to address arsenic is included that would be a useful tool at NSA Memphis sites.

Background

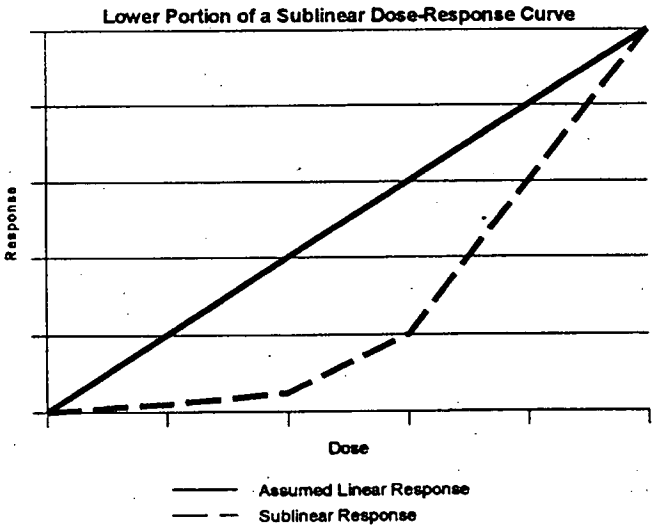
Arsenic is considered a carcinogen by USEPA, who evaluated its cancer potency based on previous literature studies. Limitations in these studies and the methods used by USEPA are generally considered to overestimate arsenic risk. For example, arsenic's MCL is 0.05 mg/L (USEPA, 1996). Yet, the risk posed by drinking water with 0.05 mg/L arsenic per day would exceed the upper bound of USEPA's generally accepted range of 1 in 1,000,000 to 1 in 10,000 excess cancer risk. The method used to calculate the MCL for arsenic is not the same as that used in a risk assessment.

Risk is calculated using a slope factor, which is a value determined by USEPA to represent the cancer potency of a specific chemical. USEPA derived the arsenic slope factor from a Taiwanese

study of human exposures to groundwater containing arsenic (Tseng et al., 1968). The assumptions used by USEPA to derive the slope factor may have underestimated dietary exposure to arsenic (Yost et al., 1994). More recent water intake values were available for the Taiwanese population. These values are higher than the historical Taiwanese data used by USEPA. Using higher water intake values would reduce the expected cancer potency. Likewise, toxic effects of arsenic could have been exacerbated because the study population was reportedly undernourished and many had pre-existing chronic liver disease (Hsueh et al., 1995).

In addition to study limitations, the calculation USEPA used to determine the slope factor may have overestimated the cancer-causing potential of arsenic. A dose-response curve was used to calculate the slope factor, and the particular shape of the curve or slope influences the cancer-causing potential calculated by USEPA. A linear dose-response curve was assumed by USEPA; however, the actual dose-response curve for arsenic may be sub-linear (Loehr et al., 1989). An example of the lower portion of a sublinear dose-response curve is compared to a linear dose-response in Figure 1. Toxic effects predicted based on a linear response may not occur at low doses. In 1989, the USEPA Science Advisory Board concluded that, "...at dose levels below 200-250 micrograms trivalent arsenic per day there is a possible detoxification mechanism that may substantially reduce cancer risk from the levels USEPA has calculated using a linear-quadratic model fit to the Tseng data" (Loehr et al., 1989).

Figure 1



When a substance is ingested, the body uptakes only a portion of the substance; this characteristic, referred to as bioavailability, is often matrix dependent. The Tseng study was based on water ingestion, and many studies indicate arsenic is more bioavailable from water than soil. For example, relative bioavailabilities of arsenic in soil to arsenic in groundwater range from 20 to 78% (Freeman et al., 1993, 1994). Ingesting arsenic in soil may not elicit toxic responses, while the same amount of arsenic ingested from groundwater may be toxic (ATSDR, 1992).

Recommendations

Accounting for matrix dependent bioavailability, USEPA's calculation method, and historical arsenic toxicity data would provide more accurate risk estimates. USEPA determined that risk-based concentrations for arsenic should be multiplied by 10 to account for the uncertainty in arsenic's carcinogenicity (USEPA, 1988). The cancer caused by arsenic is squamous cell carcinoma, which is considered to be a treatable condition. Because the condition can be cured, USEPA has established a higher tolerance for arsenic risk of 1 in 1,000 excess cancer risk. For example, a risk-based concentration of 0.001 mg/L would be changed to 0.01 mg/L. In addition, a mean relative bioavailability of 78% is recommended by USEPA to address arsenic in soil. For example, a risk-based soil arsenic concentration of 1 mg/kg would be modified (e.g., 1/0.78 = 1.282 mg/kg) to approximately 1.28 mg/kg. The 1.28 mg/kg soil concentration would then be multiplied by 10 to account for the uncertainty in arsenic's slope factor, resulting in an adjusted value of 12.8 mg/kg. The relative bioavailability factor would not be applicable to groundwater concentrations, so a risk-based groundwater concentration of 1 mg/L would be modified to 10 mg/L.

Proposal

E/A&H proposes to make the adjustments to future risk calculations in preliminary risk evaluations and human health risk assessments.

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