Determination of a Southern California Regional Background Arsenic Concentration in Soil

G. Chernoff, W. Bosan and D. Oudiz

California Department of Toxic Substances Control

Professional affiliations are listed for contact purposes only. Analysis and conclusions contained herein are solely those of the authors, and do not represent official policy of the Department of Toxic Substances Control.

Abstract

Background metals in soil can prove problematic for risk assessment purposes because metals detected at a site may be comprised of naturally occurring metals, regional anthropogenic contributions or a site-specific release. Arsenic is especially problematic since the risk-based soil concentration is 100-times below typical ambient concentrations.

The Department of Toxic Substances Control (DTSC) established a regional background arsenic concentration in soil that can be used as a screening tool for sites throughout southern California. The term "background" collectively refers to both naturally occurring and anthropogenic concentrations in shallow soil. Data were derived from completed Preliminary Environmental Assessment (PEA) reports for proposed school sites. Site data were combined for each county in southern California, including Los Angeles, Orange, Riverside, San Bernardino and San Diego counties. Los Angeles County had the largest number of sites (19 school sites) and arsenic data points (1097 samples) and will serve as the model for the statistical derivation of background arsenic.

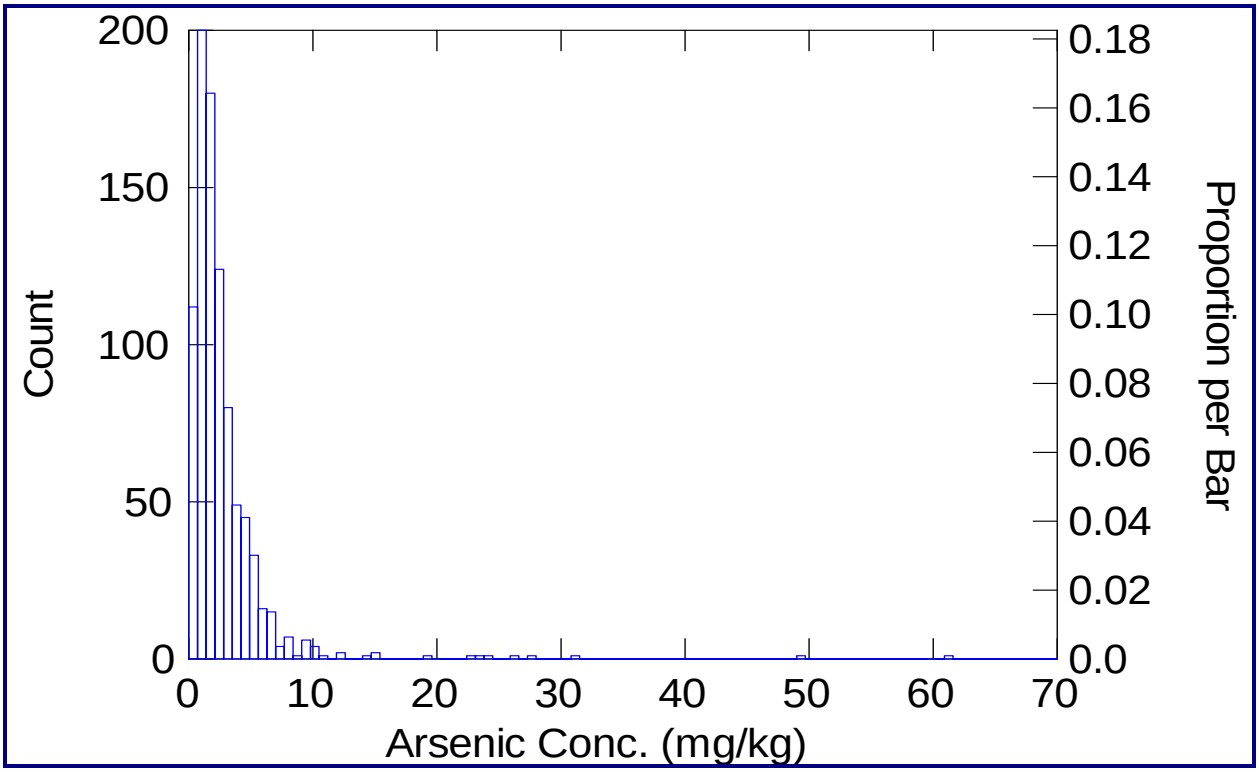
A probability plot of the arsenic data clearly demonstrated a classical, lognormal distribution from which outliers were determined using the box plot. The summary statistics for the arsenic data set, excluding the outliers, were calculated and the upper-bound arsenic concentration estimated using both the 95% confidence limit of the 99th quantile of the arsenic data set and a distribution-free, nonparametric analysis.

Both statistical methods resulted in an upper-bound arsenic concentration of approximately 12 mg/kg for Los Angeles County. Using the same approach, the upper-bound arsenic concentrations were similar for each of the other southern California counties, resulting in an upper-bound estimate of 12 mg/kg for arsenic in southern California. A similar evaluation is being conducted by DTSC for northern California sites in order to derive arsenic screening levels State-wide.

Introduction

The Department of Toxic Substances Control (DTSC) oversees the environmental assessments of proposed and existing school sites. Arsenic has proven problematic at these sites since the risk-based soil concentration of approximately 0.03 mg/kg is nearly always below the concentrations detected on site thereby necessitating the need to establish the arsenic background concentration at each site.

To determine if a regional arsenic background level could be established for the Los Angeles Unified School District (LAUSD), 1097 data points collected from 19 school sites distributed throughout the LAUSD were evaluated using both graphical data plots and statistical calculations.



A histogram of the data demonstrated a classical lognormal distribution with a wide range of arsenic concentrations. A box plot, also known as the fourth spread was used to identify 11 outliers, the two lowest values and the nine largest values, which were eliminated from further analysis. The descriptive statistics for the log-transformed arsenic data set, excluding the outliers previously established are summarized below.

DESCRIPTIVE STATISTIC	VALUE
Sample Size (n)	1086
Mean (μ)	0.1788 (1.51 mg/kg)
Median	0.1761 (1.50 mg/kg)
Standard Deviation	0.3646
Standard Error of the Mean[1]	0.0111
Minimum Concentration	-0.8125 (0.15 mg/kg)
Maximum Concentration	1.2930 (19.63 mg/kg)
Lower Quartile (Q_1)	-0.1249
Upper Quartile (Q_3)	0.4472

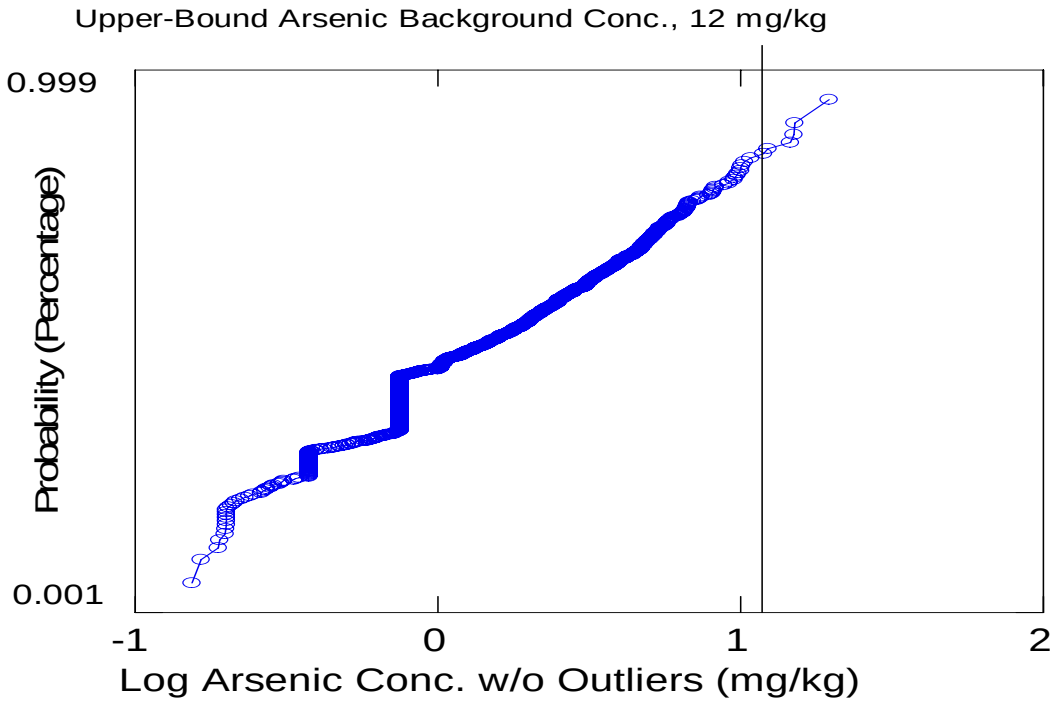
The upper limit of the data set was estimated according to the following equation:

$$UL_{1-\alpha}\left(X_p\right) = \bar{x} + sK_{1-\alpha,p}$$

Calculating the 95% confidence limit of the 99th quantile of the arsenic data set excluding the outliers, the $UL_{0.95}(X_{0.99})$ was found to be 1.054 in log units, or 11.32 mg/kg arsenic. A distribution-free non-parametric analysis to calculate the $UL_{0.95}(X_{0.99})$ as described by Gilbert (1987) used the following equation:

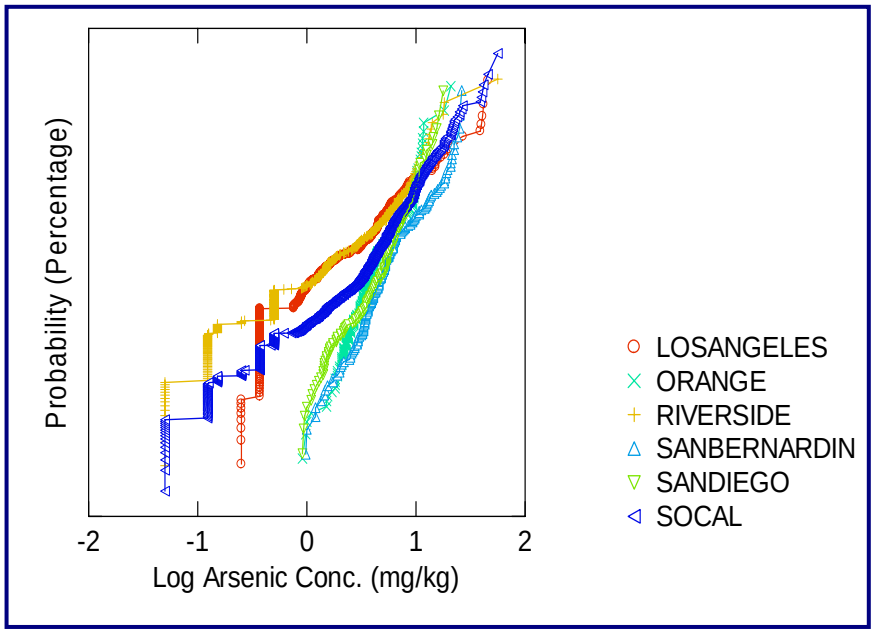
$$Rank\ of\ UL_{0.95}(X_{0.99}) = p(n+1) + Z_{1-\alpha}[np(1-p)]^{1/2}$$

The solution of this equation indicated that the $UL_{0.95}(X_{0.99})$ is 52.4% of the way between the 1081st and 1082nd highest arsenic concentrations which is 12.3 mg/kg. The Probability Plot of the arsenic data set excluding the outliers is shown below:



The plot demonstrates that the log-transformed data is normally distributed with an inflection point at approximately 1.0 which is equivalent to approximately 10 mg/kg. Taken together, the data from the statistical and graphical evaluation of the data from LAUSD has an upper bound between 10 and 12 mg/kg.

The same analysis was conducted on school sites from San Diego County (3 school sites), Orange County (7 school sites), Riverside County (15 school sites), San Bernardino County (6 school sites) and Los Angeles County (21 school sites).



As shown in the Probability Plot of the data from the 5 Southern California Counties, and the combined Southern California data, the individual plots share a common inflection point at approximately 1.1 on the logarithmic scale, or approximately 12 mg/kg.

Conclusion

A Probability Plot and statistical analysis of a large data set from school sites in Los Angeles County gave an upper-bound background arsenic concentration of 12/mg/kg. A Probability Plot for school sites from 5 counties in Southern California also gave an upper-bound background arsenic concentration of 12 mg/kg.

In some of the counties, there was another inflection point at approximately 1.5 mg/kg arsenic. This is interpreted as representing the upper-bound of the naturally occurring arsenic, while the inflection at 12 mg/kg represents the upper-bound of the naturally occurring plus anthropogenic arsenic.

This finding suggests that in Southern California, 12 mg/kg maybe a useful screening number for evaluating arsenic as a chemical of potential concern. A similar evaluation is being conducted by DTSC for school sites in Northern California in order to derive arsenic screening levels State-wide.