

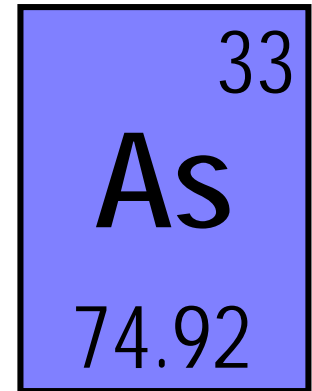
# Arsenic in the Environment

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# Arsenic Occurs Naturally

- All arsenic in the environment is of natural origin (natural background)
- Human activities redistribute this naturally-occurring arsenic (anthropogenic background)

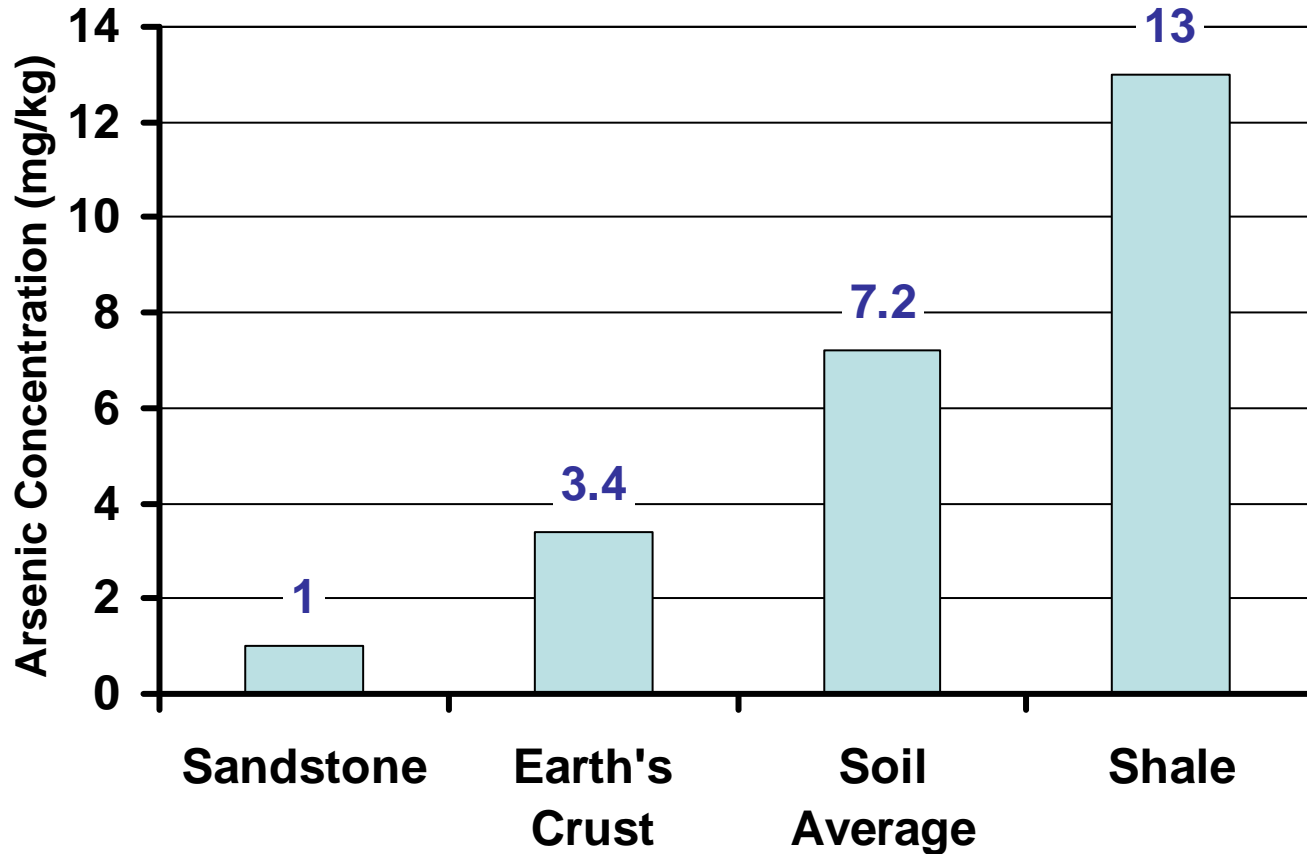


# Arsenic Has Been Used by Man for More Than 5000 Years

- Production of tools, ornaments, pigments, cosmetics
- Backing for mirrors, glass manufacturing
- Medicinal uses
- Distribution through coal-fired furnaces
- Pesticides, including application to fields and crops, for weed control along railroads, cattle dip vats, additive to poultry and swine feed
- Pressure treating for lumber

# Arsenic is Everywhere: Soil

Concentration of Arsenic in Soil

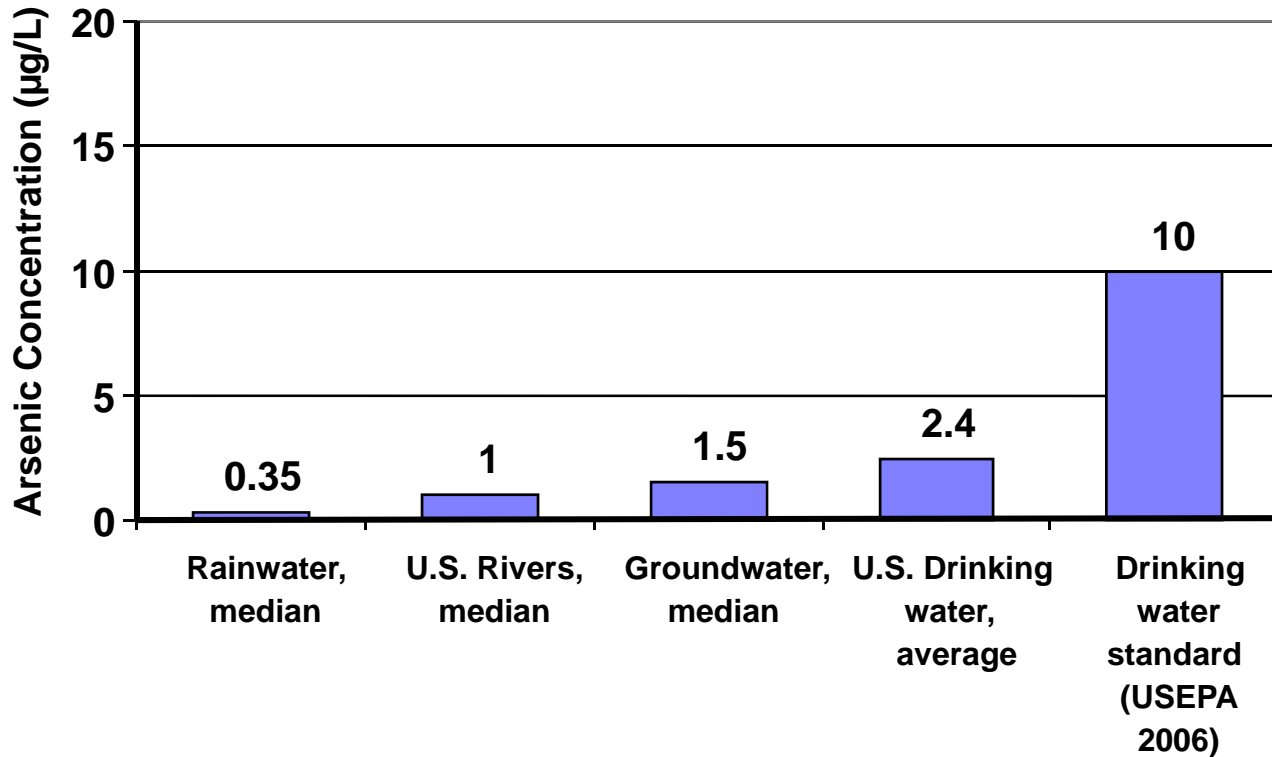


10 ppm is  
1/8 cup of  
sand in a 4  
cubic yard  
dump truck



# Arsenic is Everywhere: Water

Concentrations of Arsenic in Water ( $\mu\text{g/L}$ )



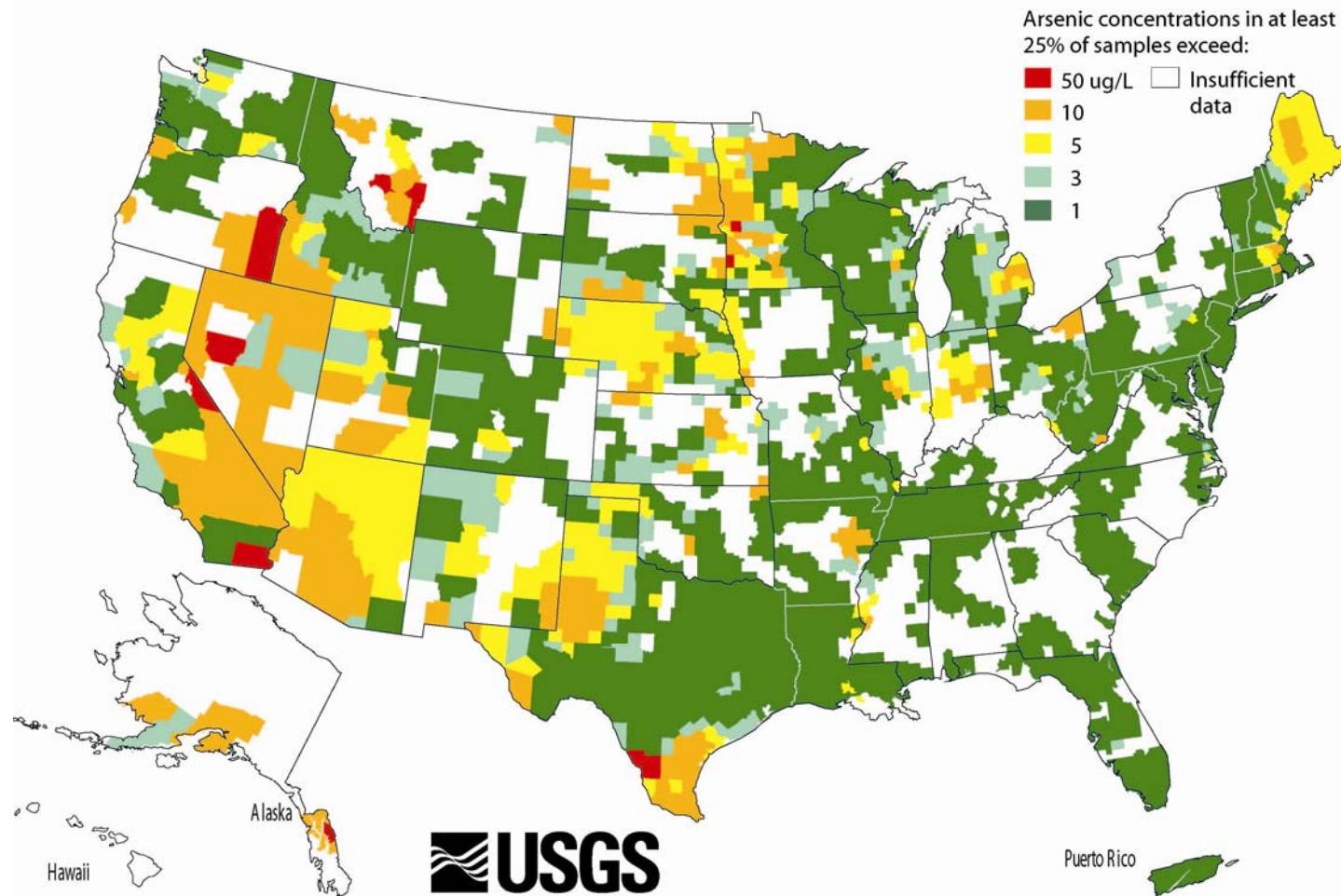
10 ppb is  
1/10 cup  
of ink in an  
Olympic-sized pool

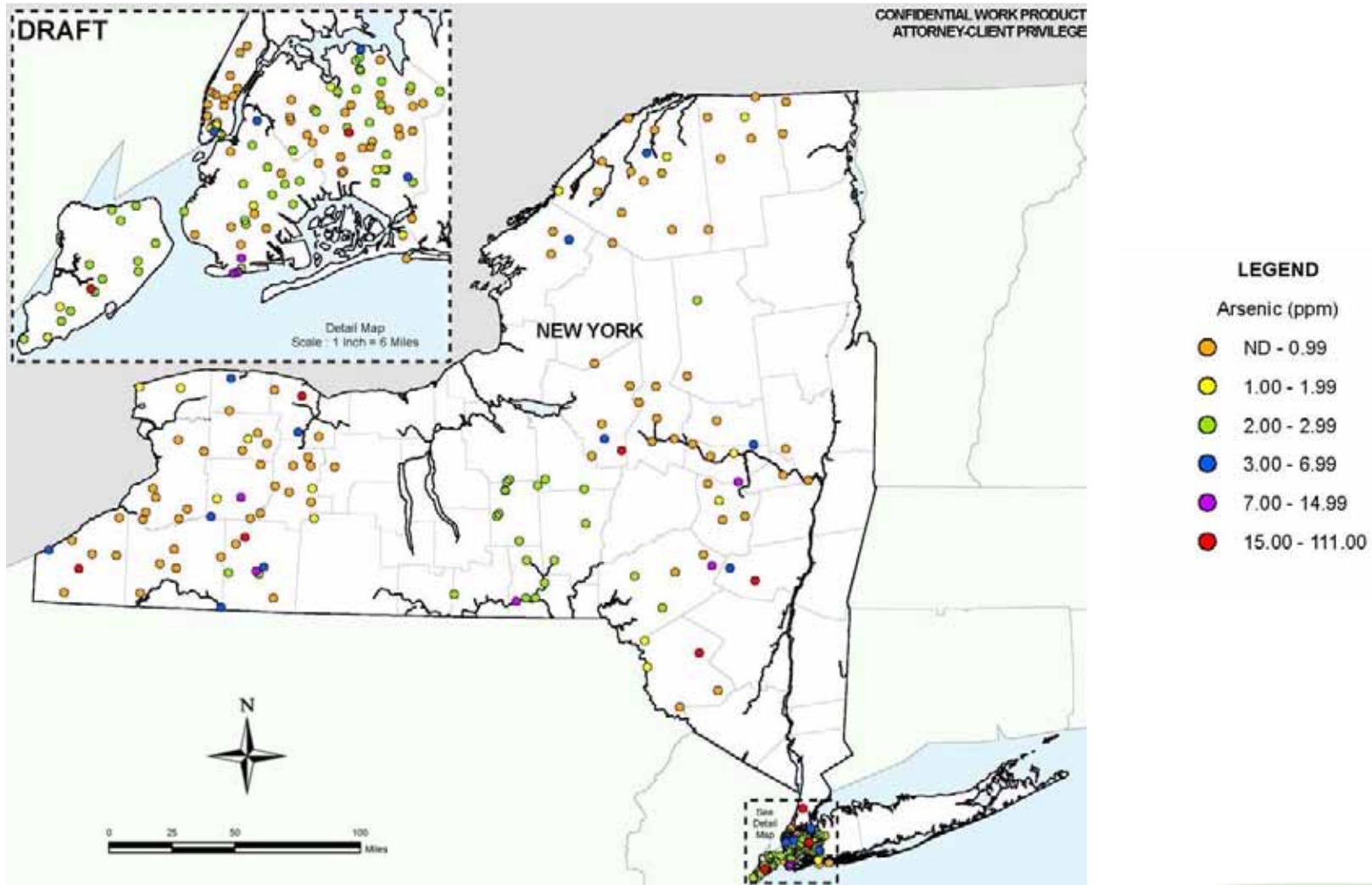


Source: ATSDR Tox Profile on Arsenic.

[http://en.wikipedia.org/wiki/Drop\\_\(unit\)](http://en.wikipedia.org/wiki/Drop_(unit))

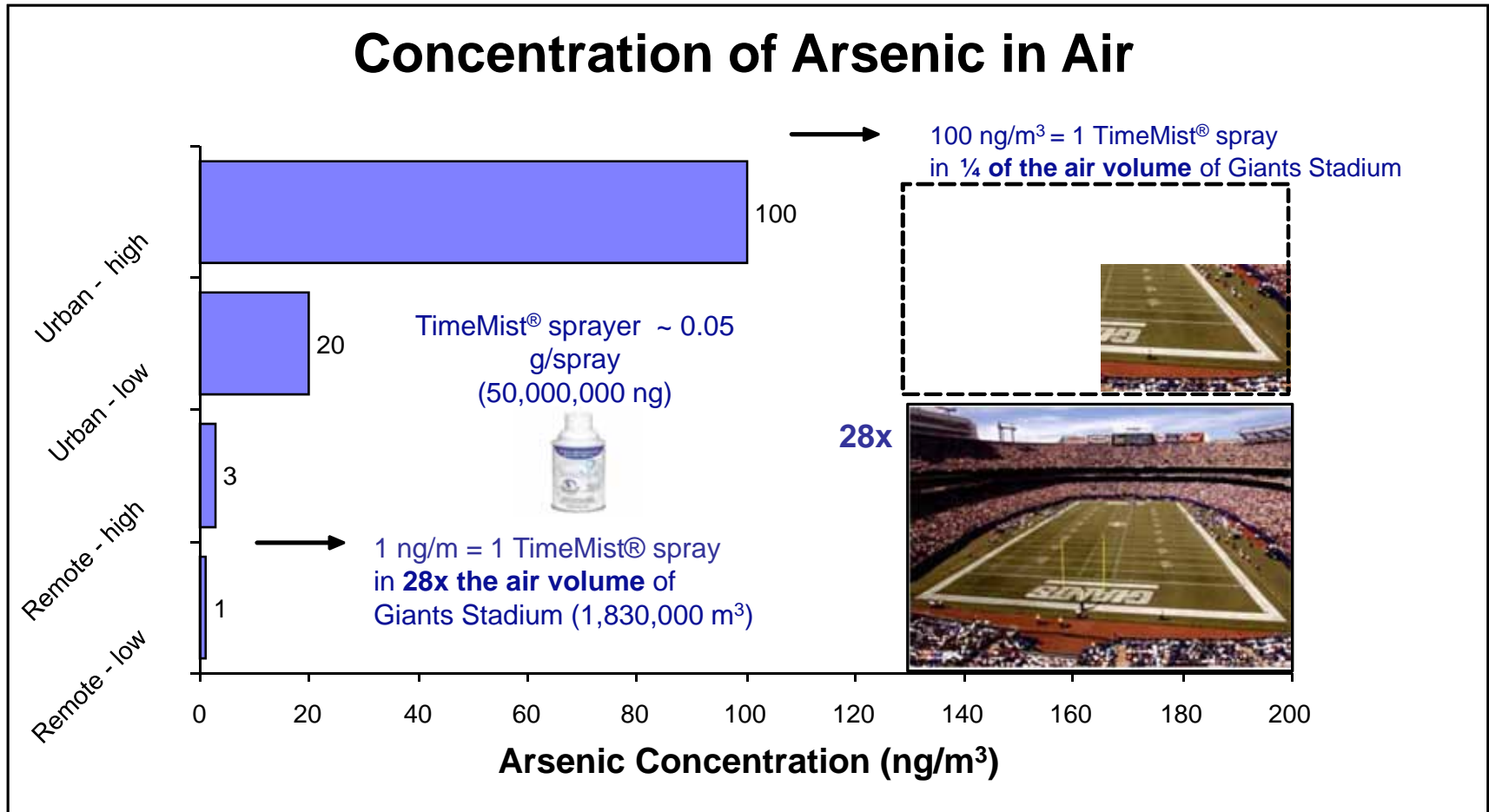
# Arsenic in Water in the U.S.







# Arsenic is Everywhere: Air

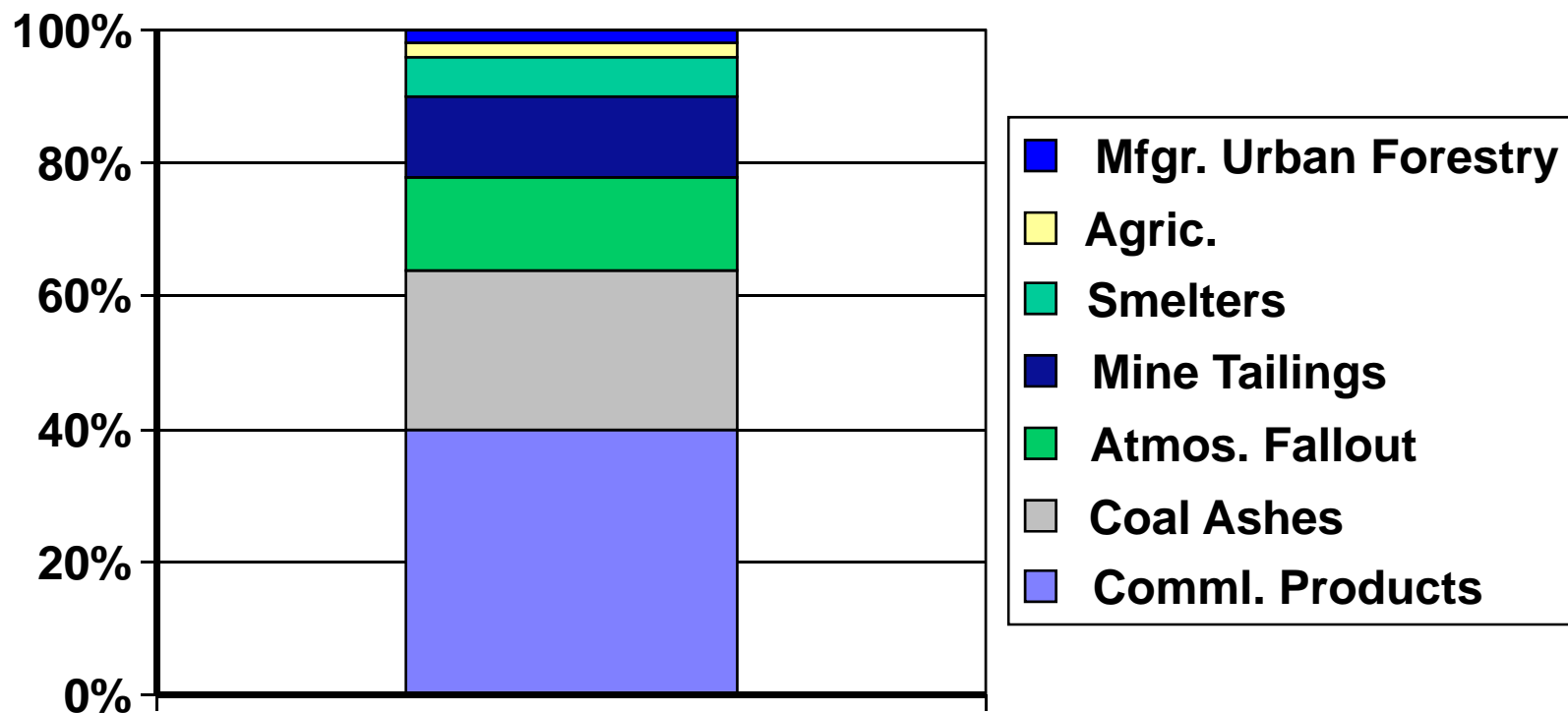




# Natural Levels of Arsenic in the Environment are Variable

- Arsenic concentrations vary by rock type
  - Shales contain more arsenic than granites
- Arsenic concentrations vary by soil type
  - Clay soils contain more arsenic than sandy soils
  - Soils high in organic carbon contain more arsenic
- Mineralized rocks and soils (e.g., areas mined for gold, copper, lead) can contain significantly higher arsenic

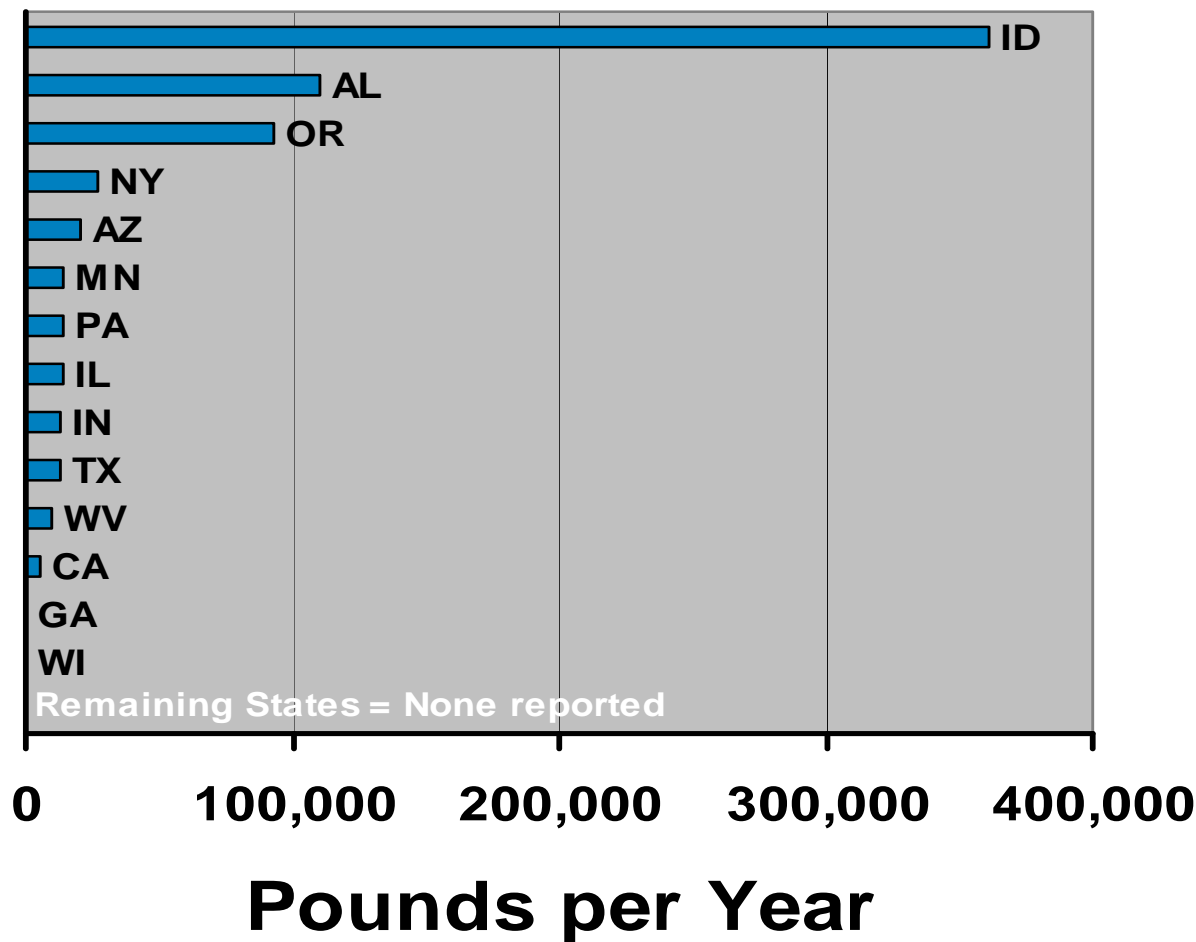
# Worldwide Anthropogenic Additions of Arsenic to Soils in 1988



Source: *Arsenic in the Environment* by Jerome O. Nriagu, 1994.

# Addition of Arsenic to Soil in the U.S.

## Arsenic Released To Soil in 2004



# Example:

## Commercially Available Lawn and Garden Products

Product	Arsenic Concentration (mg/kg)
Scotts Weed & Feed 27-4-4	8.23
Scotts Starter Fertilizer Plus Crabgrass Preventer 18-23-4	7.48
Schultz Moisture Plus Potting Mix 0.08-0.12-0.08	19.6
Vigoro Ultra Turf Turf Fertilizer with Weed Stop	27.5

Source: Washington State Department of Agriculture, 2008. Pesticide Management Database, <http://agr.wa.gov/PestFert/Fertilizers/ProductDatabase>

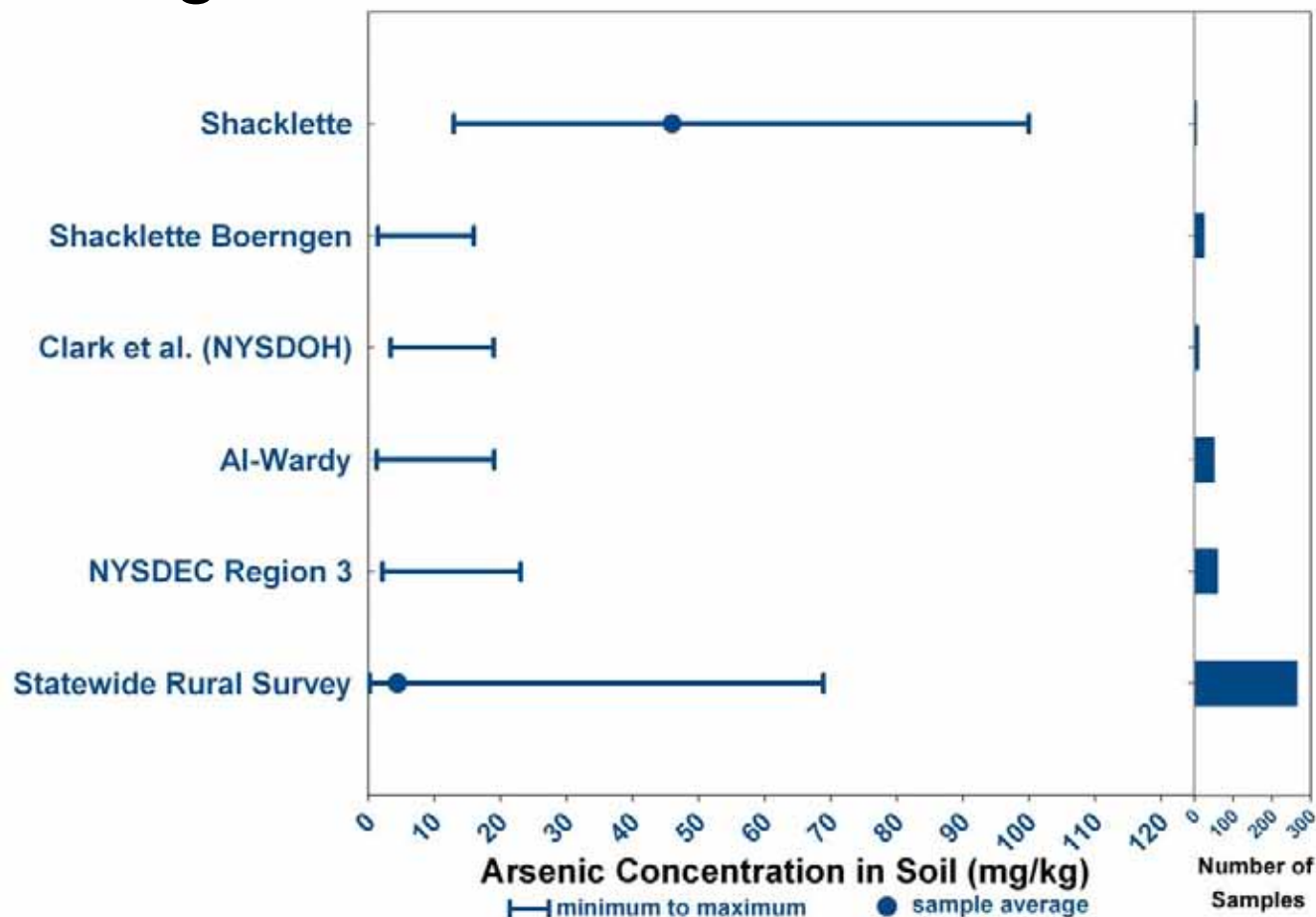
# Is it Natural or Did Man Put it There?

- It can be difficult to distinguish between natural and human influences on observed levels of arsenic as there can be significant overlap in their concentration ranges
- It is generally not possible to distinguish between low levels from human sources and natural background levels

# Arsenic in New York State

- U.S. Geological Survey studies of apple orchards and native soils in New York (Shacklette, Boerngen, 1980s)
- Rural lawns (Clark, 1985)
- Agricultural and forest areas (Al-Wardy, 2002)
- Soils in the lower Hudson Valley (NYSDEC, 2003)
- Statewide Rural Survey of surface soils (NYSDEC, 2005)

# Summary of Results from Soil Arsenic Background Studies in New York State

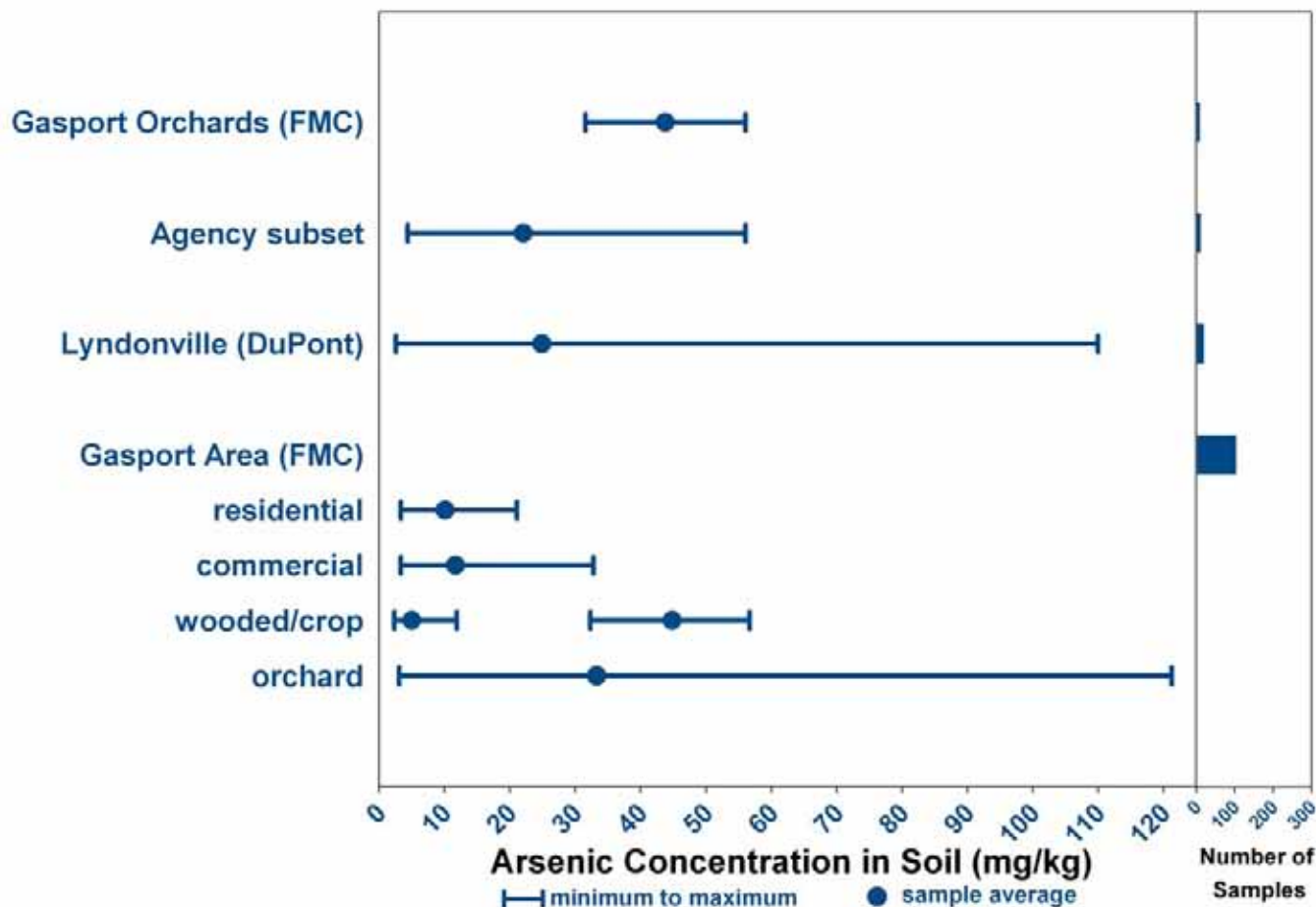




# Arsenic in the Middleport Area

- Gasport apple orchards (FMC, 1989)
- Agencies 1996 background data set
- 1993 – 2002 Lyndonville background data set (DuPont)
- 2001 – 2003 Gasport Area Background Study (FMC + NYSDEC)

# Summary of Results from Soil Arsenic Background Studies in the Middleport Area



# Why is Exposure to Arsenic a Concern?

- Acute toxicity (think Arsenic and Old Lace)
- Long-term exposure leading to risk of vascular, nervous system, reproductive impairment (grouped and assessed as non-cancer effects)
- Cancer risk (skin, bladder)

# How are People Exposed to Arsenic?

- In order of decreasing importance:
  - Food consumption
  - Drinking water consumption
  - Incidental ingestion of (and dermal exposure to) soil and dust
  - Air inhalation

# Exposure Considerations

- “The dose makes the poison”
- Bioavailability
  - Arsenic in water is more bioavailable than arsenic in soil, *i.e.*, more is absorbed by the body
- Inorganic arsenic is more toxic than organic arsenic
  - Soil and water contain inorganic arsenic
  - Food contains both organic and inorganic arsenic



# Arsenic in Food

	Total Arsenic (mg/kg)	Inorganic Arsenic (mg/kg)	Percent Inorganic
Tuna	1.1	0.025	2%
Rice	0.24	0.1	42%
Rice Bran	1.2	0.9	75%
Meat/Poultry	0.020	0.017	85%
Bread (Wheat)	0.024	0.012	50%

Sources: Sun et al., 2008; Yost et al., 2008.

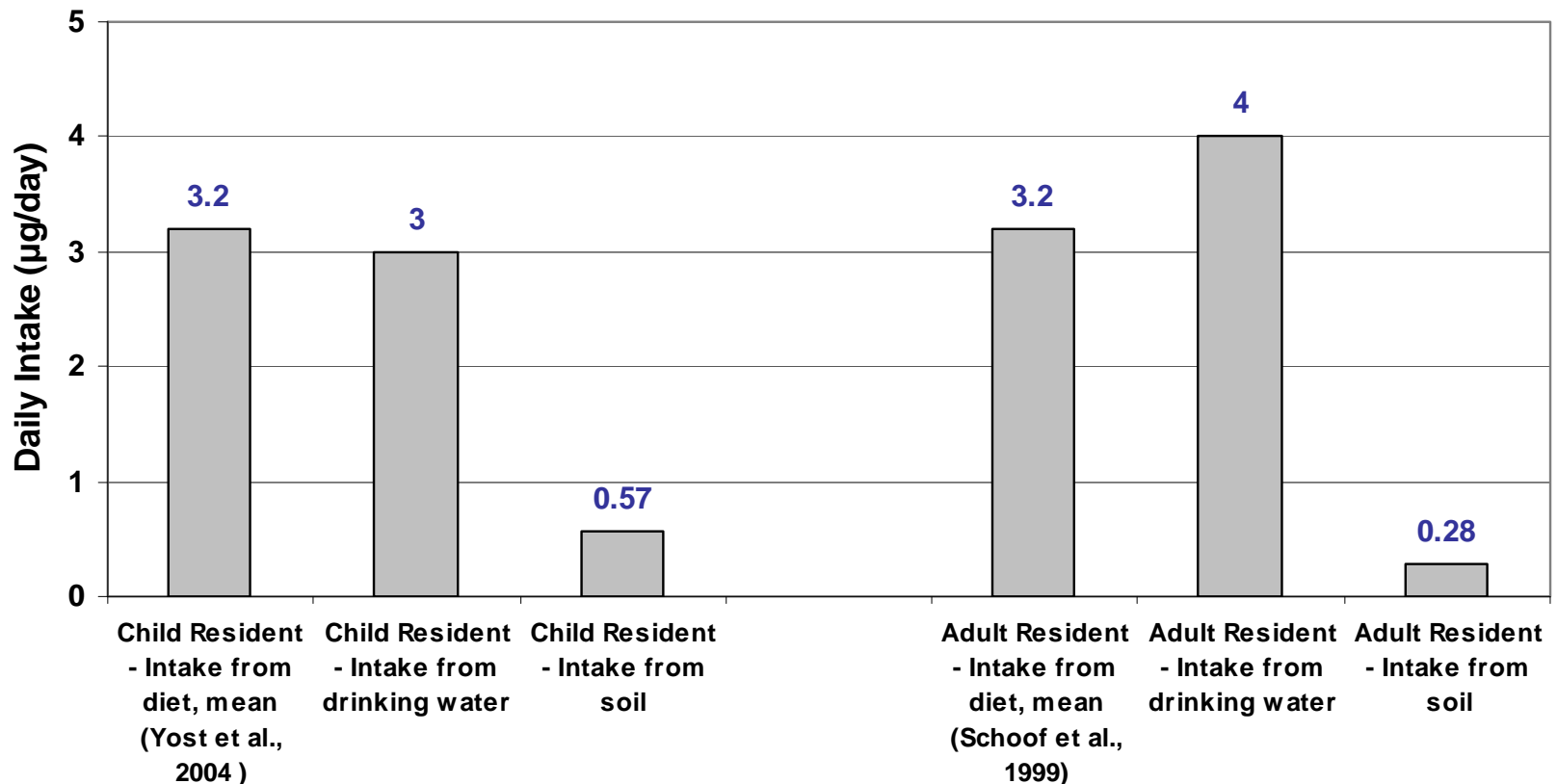
# Arsenic in Food

Rice contains an average of 0.1 mg/kg inorganic arsenic. This concentration is equivalent to one grain of in 408 bags of rice weighing 2 pounds each.





# How Much Inorganic Arsenic Are We Exposed To?



An exposure frequency of 350 days/year (USEPA, 1993) was used for exposure to soil and drinking water. Daily intake of arsenic in drinking water was calculated using a national average background concentration of 2 µg/L (ATSDR, 2000), and drinking water ingestion rates of 1.5 and 2 L/day for the child (ages 1-6 years old) and adult residents, respectively (USEPA, 1997). Daily intake of arsenic in soil was calculated using a soil arsenic concentration of 11.3 mg/kg (USEPA, 1997), soil ingestion rates of 100 mg/day (Stanek *et al.*, 2001; Stanek and Calabrese, 2000) for the child and 50 mg/day for the adult (Stanek *et al.*, 1997; USEPA, 1997), and a relative bioavailability factor for soil arsenic of 50% (Groen *et al.*, 1994; Rodriguez *et al.*, 1999; Roberts *et al.*, 2002).

# How Do We Know We Are Exposed to Arsenic?

- Everyone has arsenic in their urine
- CDC NHANES measured arsenic in urine of 2557 U.S. residents older than 6 years in 2003-2004
  - The average person has about 6  $\mu\text{g/L}$  inorganic arsenic in urine
- Arsenic can also be measured in toe nails and hair

# U.S. EPA did a Risk Assessment for the School Yard in 1998

- Children between ages 5 and 18 years, athletes and non-athletes
- Ingestion and dermal contact with soil, and inhalation of dust, over the school yard as a whole, and in 3 distinct sub-areas
- Evaluated both cancer and non-cancer risks
- Based on the risk results, proposed a soil remediation project in the area of the football field, which was completed by FMC in 1999
- EPA did a subsequent risk calculation based on post-remedy arsenic concentrations, and concluded that the risks of using the school yard did not differ from background risks

# EPA's Risk Assessment was Conservative

- Additional information has been collected in Middleport since 1998 that reduces the uncertainty in risk estimates:
  - Oral bioavailability study
  - Dermal absorption study

# EPA's Soil Screening Level (SSL) for Arsenic

- EPA has established default SSLs for a wide variety of chemicals that can be found in soil
- SSLs are used to define areas that require further investigation, and do not automatically equate to unacceptable risk
- EPA's SSL for arsenic of 0.4 ppm is well known to be below natural background levels everywhere

# Reducing Your Exposure to Arsenic in Soil



- Wash hands before eating
- Wash garden produce before cooking or eating
- Clean dirt from shoes before entering home
- Wear gloves when gardening
- Maintain ground cover (grass) in yard

