

UNDERSTANDING BIOAVAILABILITY of ARSENIC and LEAD in Soils at Superfund Sites



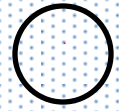
Facilitator Slide Set

This slide set was designed to support an **educational session** to help community members impacted by a Superfund site understand the **concept of bioavailability as it pertains to arsenic and/or lead contaminated soil**. This slide set was developed by the National Institute of Environmental Health Sciences-funded Superfund Research Programs at the University of North Carolina at Chapel Hill (grant: P42ES005948) and the University of Arizona (grant: P42ES04940) as part of a pilot project of the US EPA Partners in Technical Assistance Program.

Visualizing **parts per million (ppm)**

Let's say there are 1 million dots
on this slide.

Can you find the one red dot on
this slide?



1 red dot out of 1 million total
dots = **1 ppm**



1 ppm

How much arsenic (ppm) is present in soil?

Arsenic can occur naturally in soil at levels ranging from 1 to 40 parts of arsenic to a million parts of soil (ppm) with an **average level of 3–4 ppm.**

Source: Agency for Toxic Substances & Disease registry (ATSDR)

Soils can contain levels of arsenic above this amount as a result of arsenic-rich geologic features and/or as a result of human activities (e.g., mining and smelting activities; pesticide application).

How much lead (ppm) is present in soil?

Lead can occur naturally in soil at concentrations less than **50 parts per million (ppm)** but soil lead levels in many urban areas exceeds 200 ppm. The US EPA's Superfund program has a screening level of 400ppm for lead in residential soils and 800ppm for lead in commercial/industrial soils.

Source: Agency for Toxic Substances & Disease registry (ATSDR)

Soils can contain levels of lead above this amount as a result of human activities (e.g., burning fossil fuels, mining, smelting and manufacturing).

Optional

Add Site Specific Information

Facilitator can insert site specific information on extent of arsenic/lead contamination at a site of concern.

THE PROBLEM

Soil at a Superfund site is contaminated with arsenic and/or lead.

Arsenic and lead are elements naturally found in soil at levels that vary depending on the region. Natural processes such as weathering, or human processes such as mining, agriculture or manufacturing, may result in exposure to levels of arsenic or lead that are unsafe for human health.



Iron King Mine Superfund Site, US EPA

HOW CAN THIS AFFECT ME AND MY FAMILY?

Exposure to contaminated soil could cause health problems. Children may be more likely to develop health problems since they have smaller bodies than adults and are still growing, and engage in behaviors that may make them more susceptible to harm from contaminants.

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HOW CAN I BE EXPOSED?

Not all of the arsenic and/or lead present in the soil is in a form that can harm your health. A contaminant must be able to move into the body (exposure) and then be absorbed inside the body to have an effect on health.

Routes of exposure to arsenic or lead in soil include:

- Ingestion (swallowing) of contaminated soil and dust (especially for children, who put objects and hands in their mouths),
- Ingestion of unwashed foods grown in contaminated soil,
- Inhalation (breathing) of soil particles or dust, or
- Absorption of contaminants through the skin



PHOTO COURTESY OF CDC / CADE MARTIN

Ingestion (swallowing) of soil is the most common way arsenic or lead enters the body.

Arsenic and lead present in soil must be **bioavailable** in order to pose a risk to human health.

Bioavailability

is the amount of a contaminant that is **absorbed** into the body following skin contact, ingestion (swallowing), or inhalation.

Source: US EPA



PHOTO COURTESY OF CDC / CADE MARTIN



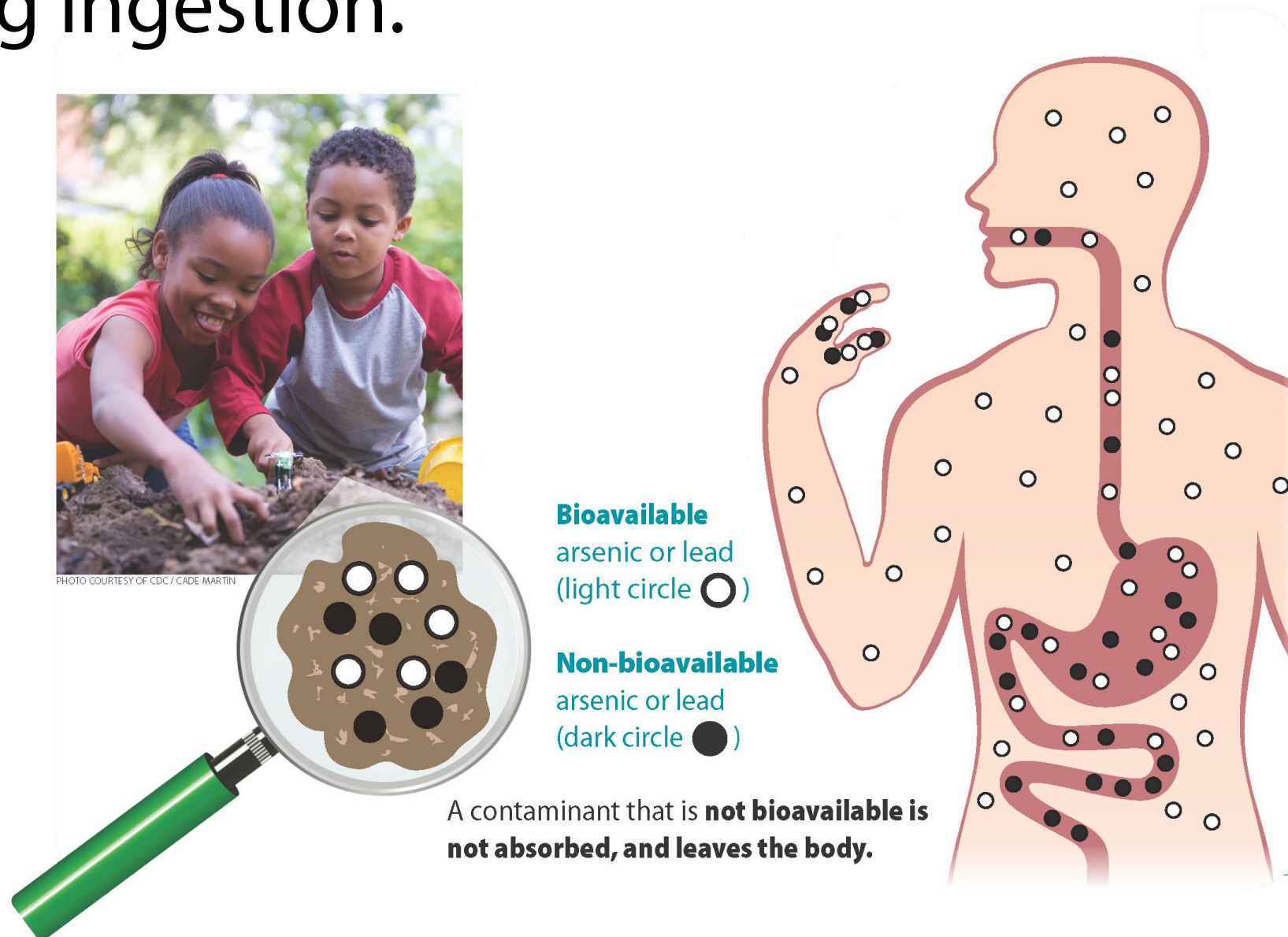
Contaminated Soil Sample

Contaminated soil often contains **different forms** of arsenic or lead that have **different bioavailability**.

Bioavailable
arsenic or lead
(light circle ○)

Non-bioavailable
arsenic or lead
(dark circle ●)

Only bioavailable forms of arsenic and lead will be **absorbed** into the body and **processed or stored** following ingestion.



WHAT CAN I DO?

You can take simple steps to reduce your exposure to arsenic or lead in contaminated soils or dust.



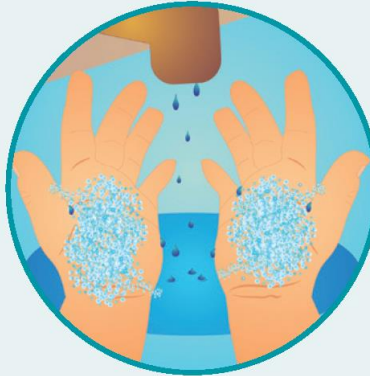
Practice safe gardening and wash foods grown in contaminated soil.



Take shoes off at the door



Clean pets' feet and fur at the door



Wash hands after handling soil



Use damp (not dry) mopping/dusting



Be aware of other sources of exposure (e.g. drinking water) and try to minimize your total exposure

WHERE CAN I GET MORE INFORMATION?

<http://www.epa.gov/superfund/soil-bioavailability-superfund-sites>



HOW IS RISK ADDRESSED AT SITES?




A risk assessment is performed by the US Environmental Protection Agency (EPA) to estimate the risk to human health of exposure to a contaminant at a Superfund site.

EPA considers how much of a contaminant is bioavailable in the soil, and evaluates possible routes of exposure.

[EPA incorporates oral bioavailability information to refine human health risk estimates to achieve cleanup goals at Superfund sites.]

Bioavailable concentration informs clean-up

When determining how to best clean up a Superfund site, it is important to know **the extent to which arsenic and/or lead are bioavailable**. Knowing the bioavailability of a contaminant provides a **more accurate estimate** of the human health risk of exposure and informs clean-up strategies.

Contaminant of Concern				
Total Soil Concentration (Before cleanup)	Bioavailability		Target Soil concentration (after cleanup)	Formula for target concentration
200ppm	100% (default assumption)		40ppm (state specific target)	-
200ppm	50%		80ppm (40ppm bioavailable)	If 50% bioavailable then site can be cleaned to 80 ppm (40 ÷ 50%)
EXAMPLE ONLY 200ppm	25%		160ppm (40ppm bioavailable)	If 25% bioavailable then site can be cleaned to 160 ppm (40 ÷ 25%)

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Bioavailability Demonstration

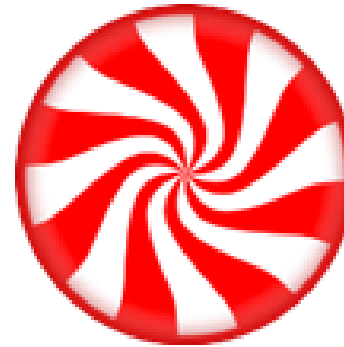
This slide set was designed to support a **hands-on demonstration** to help community members impacted by a Superfund site understand the **concept of bioavailability as it pertains to arsenic and/or lead contaminated soil**. This slide set was developed by the National Institute of Environmental Health Sciences-funded Superfund Research Programs at the University of North Carolina at Chapel Hill (grant: P42ES005948) and the University of Arizona (grant: P42ES04940) as part of a pilot project of the US EPA Partners in Technical Assistance Program.

One Peppermint Candy = 10ppm arsenic

Red area = bioavailable arsenic
White area = NOT bioavailable arsenic



25% bioavailable



50% bioavailable



25% bioavailable

VS

50% bioavailable



Native soil sample
includes any naturally occurring arsenic

Contaminated soil sample human
activities result in excess arsenic

Remediated soil sample
excess arsenic removed to achieve target
clean-up level

How many candies belong in each soil
sample?

20ppm arsenic

200ppm arsenic

40ppm bioavailable
arsenic

Bioavailability Demonstration

Debrief

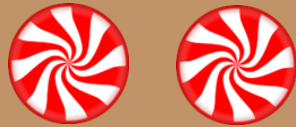
50% Bioavailability Demonstration

One Candy = 10ppm arsenic



Red area = **bioavailable arsenic (50%)**
White area = NOT bioavailable arsenic

Native soil sample
includes any naturally occurring arsenic



20ppm arsenic

Contaminated soil sample human
activities result in excess arsenic



200ppm arsenic

Remediated soil sample
excess arsenic removed to achieve target
clean-up level



40ppm **bioavailable arsenic**

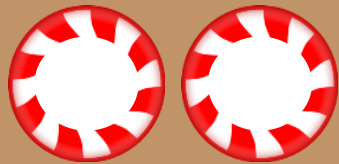
25% Bioavailability Demonstration

One Candy = 10ppm arsenic



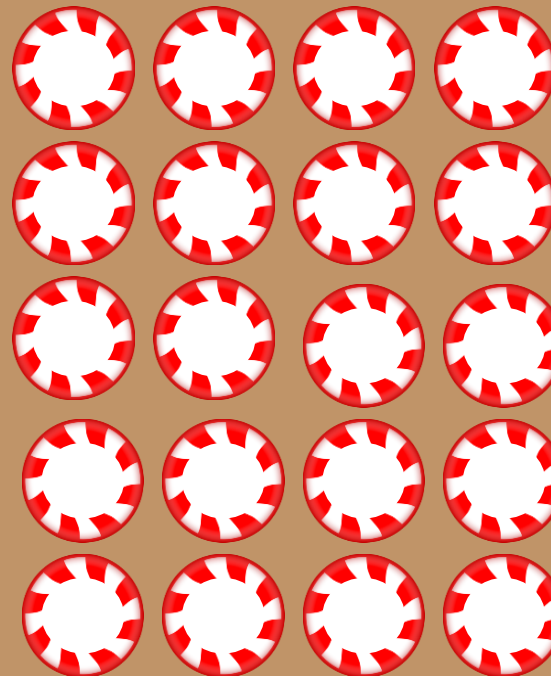
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Native soil sample
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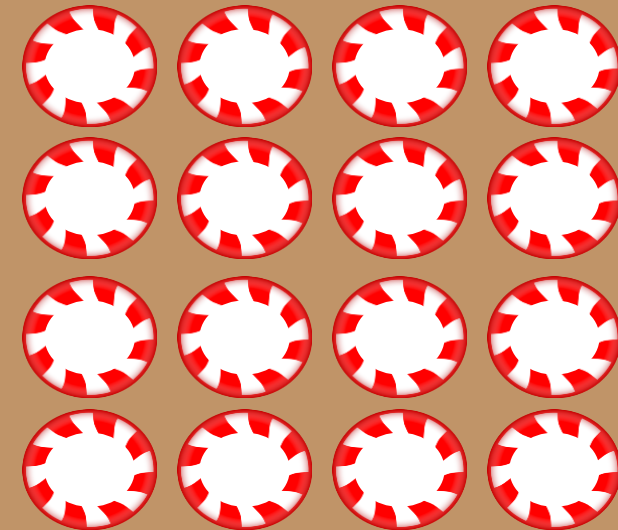
20ppm arsenic

Contaminated soil sample human
activities result in excess arsenic



200ppm arsenic

Remediated soil sample
excess arsenic removed to achieve target
clean-up level



40ppm **bioavailable arsenic**

Comparing Bioavailability

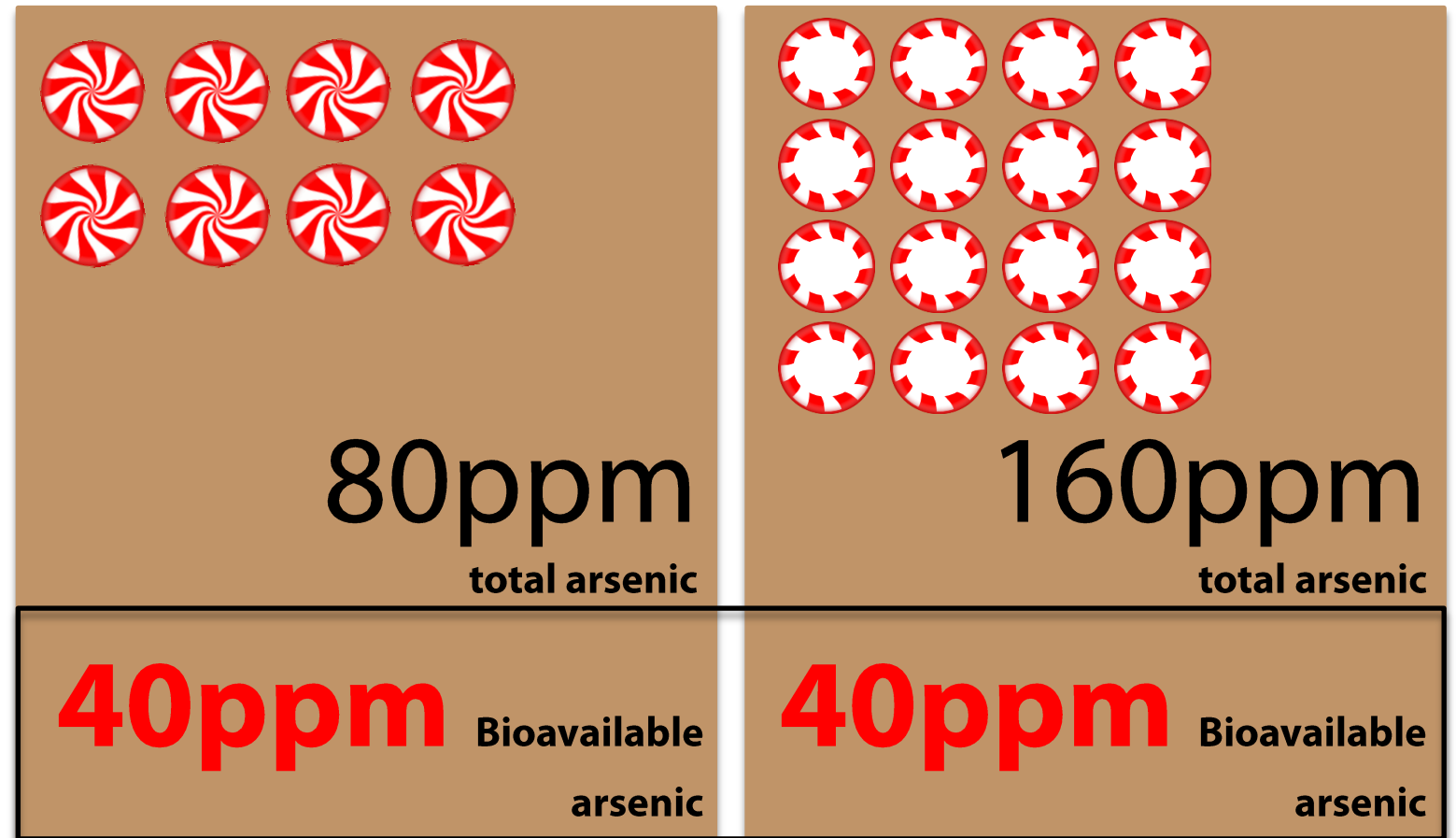
bioavailable arsenic
(50%)



bioavailable arsenic
(25%)



One candy = 20ppm
arsenic






Remediated soil sample
excess arsenic removed to achieve target
clean-up level

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Bioavailable concentration informs clean-up

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Bioavailability Demonstration

Worksheets

Facilitators: Provide one worksheet per group along with minimum number of candies

Starlight peppermint candies (25% bioavailability): at least 38 candies/group

Starlight Pinwheel peppermint candies (50% bioavailability): at least 30 candies/group

25% Bioavailability Demonstration

One candy = 10ppm arsenic



Red area = **bioavailable arsenic (25%)**
White area = NOT bioavailable arsenic

Native soil sample

includes any naturally occurring arsenic

How many pieces of candy should be placed here to represent the total concentration of arsenic in this soil sample?

20ppm arsenic

Contaminated soil sample

human activities result in excess arsenic

How many pieces of candy should be placed here to represent the total concentration of arsenic in this soil sample?

200ppm arsenic

Remediated soil sample

excess arsenic removed to achieve target clean-up level

If only **25%** of the total arsenic is **bioavailable**, how many pieces of candy should be placed here to represent a target clean-up concentration of 40ppm bioavailable arsenic? _____

What is the total concentration of arsenic (bioavailable + non-bioavailable)? _____

40ppm **bioavailable** arsenic

50% Bioavailability Demonstration

One candy = 10ppm arsenic



Red area = **bioavailable arsenic (50%)**
White area = NOT bioavailable arsenic

Native soil sample

includes any naturally occurring arsenic

How many pieces of candy should be placed here to represent the total concentration of arsenic in this soil sample?

20ppm arsenic

Contaminated soil sample

human activities result in excess arsenic

How many pieces of candy should be placed here to represent the total concentration of arsenic in this soil sample?

200ppm arsenic

Remediated soil sample

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