Thank you!

Dear Parent,

We did it! I would like to give a special thanks to all Nevada County *Gardenroots* participants for your efforts, motivation, and patience throughout this research project. We appreciate the time you have invested in participating in this project. Altogether, over 33 community members were trained, and 38 soil, 8 dust, 12 water, and 45 plant samples were prepared and analyzed.

This collaborative study was conducted by a team of researchers from the Sierra Streams Institute (a regional nonprofit watershed science organization in Nevada City, CA), the University of Arizona, and the University of CA-San Francisco. This study was funded by the California Breast Cancer Research Program.

By learning about your child's diet and the environmental quality of your community, we were able to identify environmental health research gaps and ways to improve the quality of preschool gardens. This packet shows the test results of the exposure assessment done for multiple preschools including the one your child attends. These results are highlighted and compared to state and federal regulatory standards and/or reference values when available. In this package, we have included the following:

1. Project overview
2. Important terms that you will see throughout the results
3. General information on selected contaminants of concern
4. A guide to reading the results
5. Preschool vegetable, soil, irrigation water, and dust results
6. Child's cumulative exposure results
7. References for further information on environmental quality and guidelines

Sincerely,

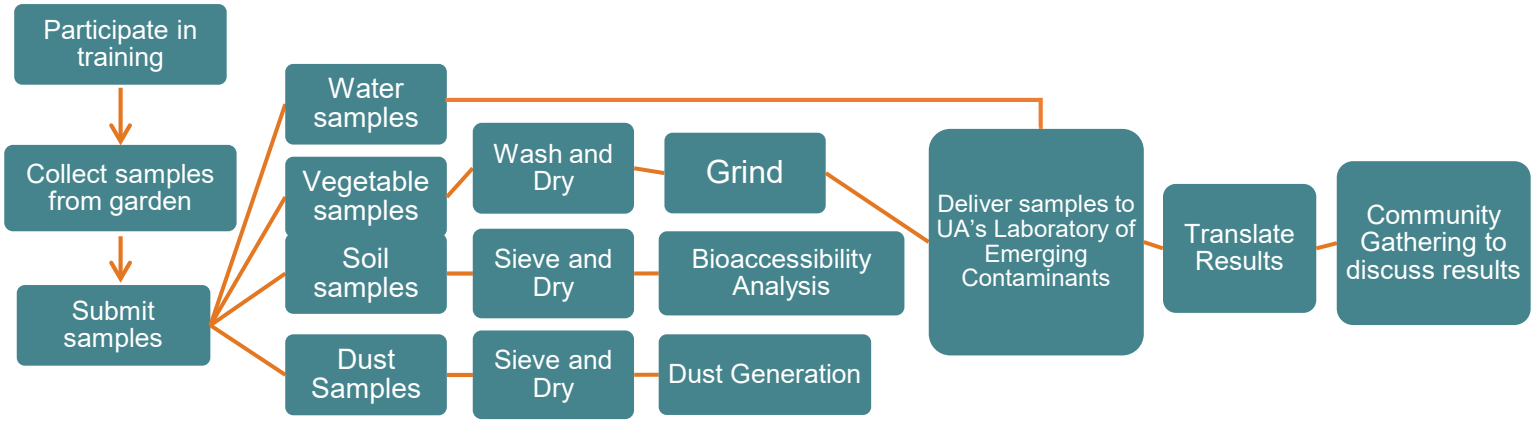
Mónica Ramírez-Andreotta, Assistant Professor
University of Arizona
1177 E Fourth Street, Rm. 429, Tucson, AZ 85721
Phone: 520-621-0091 Fax: 520-621-1647

Joanne Hild
Executive Director, River Scientist
Sierra Streams Institute 13075 Woolman Lane
Nevada City, CA 95959 (530) 477- 7132 Ext. 200
www.sierrastreamsinstitute.org

gardenroots
The Nevada County, CA Garden Project

Project Description

Based on community member's concerns regarding environmental quality, *Gardenroots: The Nevada City, CA Garden Project* was developed. *Gardenroots* is an environmental monitoring and children's exposure assessment project designed to better understand potential child exposure to arsenic, cadmium, and lead. Seeing gardens as hubs for environmental health research and education, *Gardenroots* is trying to understand the state of environmental quality in rural communities. Results from this study are helping to determine whether people are exposed to metal contaminants through gardening and crop ingestion.



Data may be subject to revisions.
The results have been internally reviewed, but have not undergone external peer review and may be subjected to minor changes.

Metals occur naturally in the environment.
While we can measure the level of a metal in certain substances, like water or soil, it is difficult to know the original source of the metal. For example, arsenic may be found in soil in many parts of the state because it also naturally occurs in these regions.

It is important to note that, elements such as arsenic occur naturally in soil and it is impossible to grow plants completely free of these and other trace elements like lead and cadmium.

Please refer to the recommended gardening best practices handouts for ways to reduce levels of harmful chemicals in your garden plot and in your vegetables.

Single exposure measurements are "snapshots in time".
We are measuring metal concentrations at a single point in time. Measuring metal concentrations with a single sampling does not establish what the exposures were in the past or what they may be in the future.

For more information about the study and safe gardening practices, please visit the *Gardenroots* website: http://www.gardenroots.arizona.edu/

Important Terms

Below is a set of terms that you will see throughout your results:

Action Level (AL) – The U.S. Environment Protection Agency (U.S. EPA) regulates lead under the Lead and Copper Rule. This rule describes the water treatment requirements needed to control plumbing corrosion that may contaminate drinking water. If the water concentration of lead is above the action level, this means actions are required to correct the water system to meet this regulation.

Concentration – The amount of a chemical in a given mass of water, soil, or plant tissue. This is written as µg/L (micrograms per liter), µg/m^3 (micrograms per cubic meter), or µg/g (micrograms per gram).

Guideline – A non-enforceable, but recommended maximum concentration of a chemical.

MCL (Maximum Contaminant Level) – The MCL is the maximum amount of a contaminant allowed in drinking water so that it is still safe to drink over many years. This level is set by the US Environmental Protection Agency.

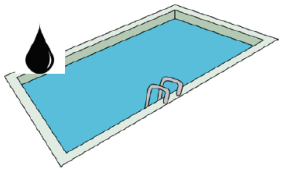
Median – The value at the midpoint (middle value) of the range of values.

National Ambient Air Quality Standard (NAAQS) – These are standards established by the U.S. EPA to protect human health. The standard for lead defines the maximum allowable concentration of lead in a cubic squared meter of outdoor air. This standard is current set to 0.15 µg/m^3.

Percentile – A number where a certain percentage of scores fall below that number. For example, if you know that your score is in the 90th percentile, that means you scored better than 90% of people who took the test.

µg/g (Micrograms per Gram) – A measure of how many micrograms of a substance (such as a metal) are in a gram of a solid (such as soil). This measure is also referred to as parts per million (ppm).

µg/L (Micrograms per Liter) – A measure of how many micrograms (one-thousandth of a milligram) of a substance (such as a metal) are in a liter of liquid (such as water). This measure is also referred to as parts per billion (ppb). For perspective, 1 µg/L or ppb is the equivalent to a drop of ink in a backyard swimming pool.



Micrograms per liter (µg/L)	Parts per billion (ppb)	1/1,000,000,000

Important Terms (con't)

µg/m³ (Micrograms per Cubic Meter) – A measure of how many micrograms of a substance (such as a metal) are in a cubic meter of a air.

Reference Dose (RfD) – Estimate of a daily intake of a chemical that is not likely to result in any significant negative health effects (including sensitive populations like children and elderly). It may be referred to as the acceptable daily intake.

Standards – The standards are enforceable and regulatory values, developed either by federal agencies or by the state of Arizona for water providers/utilities. They are different from advisories (see definition on previous page) and guidelines.

Soil Screening Levels

- **U.S. EPA Regional Screening Level (RSL)** – Risk-based concentrations of contaminant in soils that are calculated using what we know about the exposure to a contaminant and what the U.S. EPA knows about the toxicity of the chemical. U.S. EPA considers these screening levels as initial cleanup goals, when applicable. They are not national cleanup standards, and are based on different target risks.
- **CalEPA California Human Health Screening Levels (CHHSLs)** – Risk-based concentrations of contaminants in soils that are specific to California. Screening levels for lead are not risk-based screening levels, but rather the average Pb concentration in residential soil that would be protective of children and women of child-bearing ages. These values are more conservative than the U.S EPA RSLs.
- **CalEPA California Department of Toxic Substances Control Screening Levels (DTSC-SL)** – Risk-based recommended screening levels that are derived using DTSC-modified exposure and toxicity factors for contaminants in soil. These values are also more conservative than the U.S EPA RSLs.

Arsenic (As)

Contaminant Name: Arsenic (As)
Contaminant Type: Metalloid

What is Arsenic?
Arsenic naturally exists in the Earth's crust and can be found in sediments, soils, and groundwater. Arsenic may also be released into the environment via mining, ore smelting, and industrial use of the element.

What happens to arsenic when it enters the environment?
In the environment, people can be exposed to arsenic in two chemical forms:

- Inorganic: Varying amounts of this poisonous (toxic) form can be found naturally in geologic materials (soils, rocks, aquifer materials) and in ground and surface water, which may also be impacted by mining and industrial wastes and arsenical pesticides).
- Organic (arsenic compounds that contain carbon): Varying amounts of this non-poisonous (low-toxicity) form can be found in sources such as animals, plants, fish and seafood. Fish and shellfish can accumulate arsenic; most of this arsenic is in an organic form called arsenobetaine that is much less harmful.

How can arsenic affect my health?
Severe (acute) arsenic poisoning can cause vomiting, abdominal pain, and diarrhea. This can be followed by numbness and tingling of the extremities, muscle cramping, and death in extreme cases. Ingesting or breathing low levels of inorganic arsenic for a long time (chronic) can cause non-cancer health effects, like a darkening of the skin and the appearance of small "warts" on the palms, soles, and torso. Other non- cancer health effects linked to long- term ingestion of arsenic include developmental effects, diabetes, pulmonary disease, and cardiovascular disease. Ingestion of inorganic arsenic can increase the risk of skin cancer and cancer in the liver, bladder, and lungs. Inhalation of inorganic arsenic can cause increased risk of lung cancer.

Where can I get more information on Arsenic?
Agency for Toxic Substances and Disease Registry. ToxFAQsTM for Arsenic. Last Updated on March 12, 2015. You can access this information at: https://www.atsdr.cdc.gov/toxfaqs/tf.asp?id=19&tid=3

Cadmium (Cd)

Contaminant Name: Cadmium (Cd)
Contaminant Type: Heavy metal

What is cadmium?
Cadmium is found in the Earth's crust. Most cadmium used in the U.S. is extracted as a byproduct during the production of other metals such as zinc, lead, or copper. Cadmium is also recovered from used batteries. Cadmium is used for the following: batteries, pigments, coatings and platings, stabilizers for plastics, photovoltaic (solar power materials) devices, and other uses.

What happens to cadmium when it enters the environment?
Cadmium is emitted to soil, water, and air by metal mining and refining, manufacture and application of phosphate fertilizers, fossil fuel combustion, and waste incineration and disposal. Generally, cadmium binds strongly to organic matter where it can stay in soil and be taken up by plant life, eventually entering the food supply.

How can cadmium affect my health?
Cigarette smoking is a major exposure route to cadmium. Tobacco may have been grown in contaminated soils, or pesticides/fungicides or additives were applied during the growing and manufacturing process.

Exposure to cadmium can occur through breathing contaminated workplace air, drinking contaminated water, or living near industrial facilities that release cadmium into the air. Eating food or drinking water with very high levels severely irritates the stomach, leading to vomiting and diarrhea. Long-term exposure to lower levels of cadmium in air, food, or water leads to a buildup of cadmium in the kidneys and possible kidney disease. Other long-term effects include lung damage and fragile bones. Low levels of cadmium are found in all foods (highest levels are found in shellfish, liver, and kidney meats). In the U.S., for nonsmokers the primary source of cadmium exposure is from the food supply. Breathing high levels of cadmium can severely damage the lungs. Cadmium and cadmium compounds are known to cause cancer in humans.

Where can I get more information on Cadmium?
Agency for Toxic Substances and Disease Registry. ToxFAQsTM for Cadmium. Last Updated on March 12, 2015. You can access this information at: https://www.atsdr.cdc.gov/toxfaqs/tf.asp?id=47&tid=15

Lead (Pb)

Contaminant Name: Lead (Pb)
Contaminant Type: Heavy Metal

What is lead?
Lead is a metal in the Earth's crust that is normally found with other metals such as zinc, silver, and copper. Lead has many uses including manufacturing of paints, batteries, and fishing weights. Lead-based solder, which had been used to connect copper water pipes, was banned in the 1980s, but may still be a source of lead in drinking water in older homes. In the United States, lead was used as a gasoline additive, but was banned beginning in 1973 and eliminated by 1996.

What happens to lead when it enters the environment?
Lead itself does not break down, but lead compounds are changed by sunlight, air, and water. When lead is released to the air, it may travel long distances before settling to the ground. Once lead falls onto soil, it usually sticks to soil particles. Ingestion (soil, food, water) is the main route of exposure in humans.

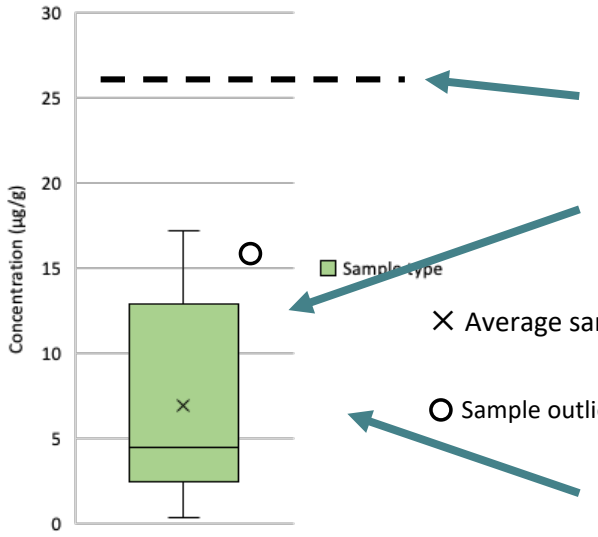
Children are most impacted by lead exposure because they often put their hands and/or toys in their mouths. Pregnant women can also expose their unborn child to lead via ingestion. Adults can be exposed via lifestyle choices (e.g., cigarette smoking) or through their occupation (e.g., plumbing, soldering, manufacturing plants, construction/remodeling companies, smelters, and auto repair shops). There are other sources of potential lead exposure which include: paints, glazed clay pots, wine, food, leaded glass (crystal), stained glass, dyes, and home remedies (e.g., azarcon or greta used to treat digestive illness).

How can lead affect my health?
Lead can affect almost every organ and system in your body, both in adults and children. Exposure to lead can seriously harm a child's health. It can damage the brain and nervous system, slow growth and development, cause learning, behavior, hearing, and speech problems. It causes lower IQ, decreased ability to pay attention, and underperformance in school. Lead exposure also causes small increases in blood pressure, particularly in middle-aged and older people and can cause anemia. In pregnant women, high levels of exposure to lead may cause miscarriage. High-level exposure in men can damage the organs responsible for sperm production.

Where can I get more information on Lead?
Agency for Toxic Substances and Disease Registry. ToxFAQsTM for Lead. Last Updated on August 24, 2016. You can access this information at: https://www.atsdr.cdc.gov/toxfaqs/tf.asp?id=93&tid=22

A Guide to Reading the Results

Guide for reading soil, plant, water, and dust results



Standards, Advisories, and/or Guidelines

Maximum value excluding outliers

× Average sample value

○ Sample outliers

75th percentile

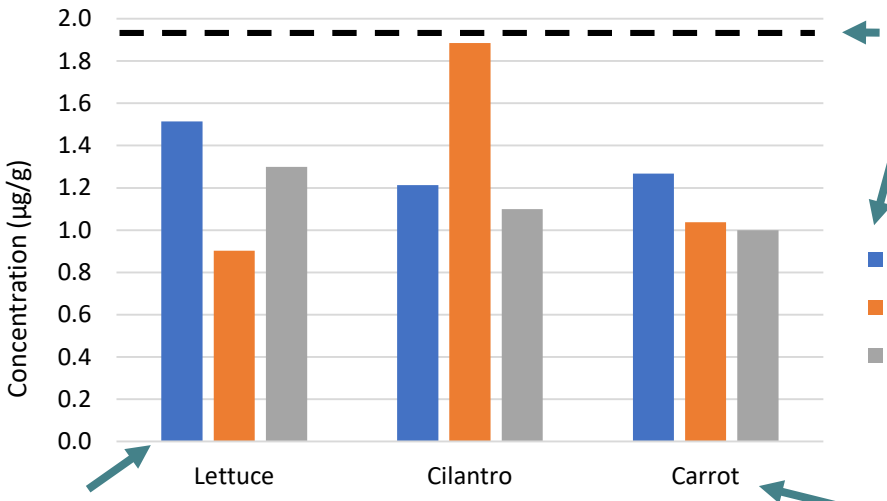
Median sample value

25th percentile

Minimum value

The **Y-Axis** shows the level of contaminant concentration. ***The unit of measurement and scale will change depending on the environmental media.**

Guide for reading BCF and cumulative exposure results



Standards, Advisories, and/or Guidelines

Contaminant

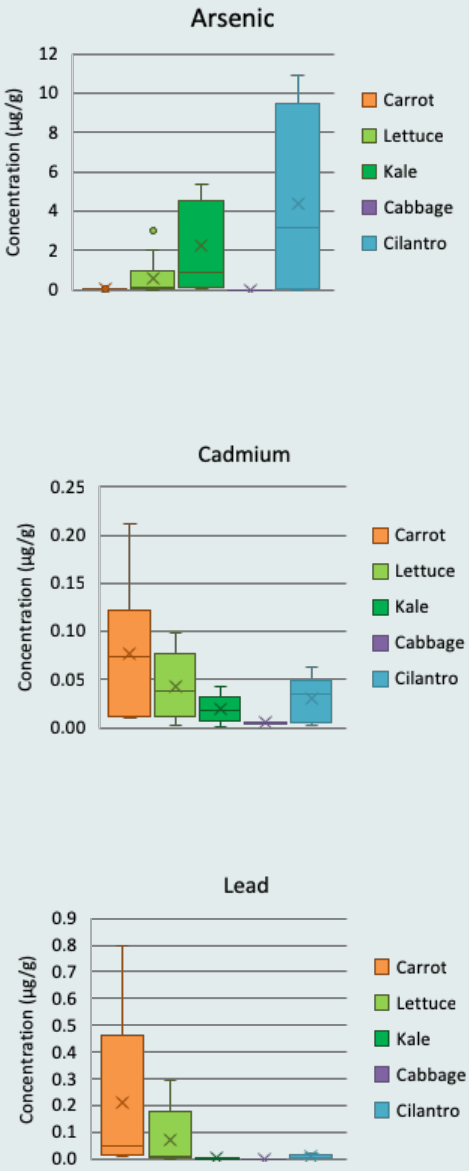
Sample type

Each bar represents only 1 value unless shown as a percentage out of 100% on the Y-Axis

Vegetable Results

Below are the measured arsenic, cadmium, and lead concentrations in vegetables that were collected at each preschool.

Concentration in Garden Vegetables

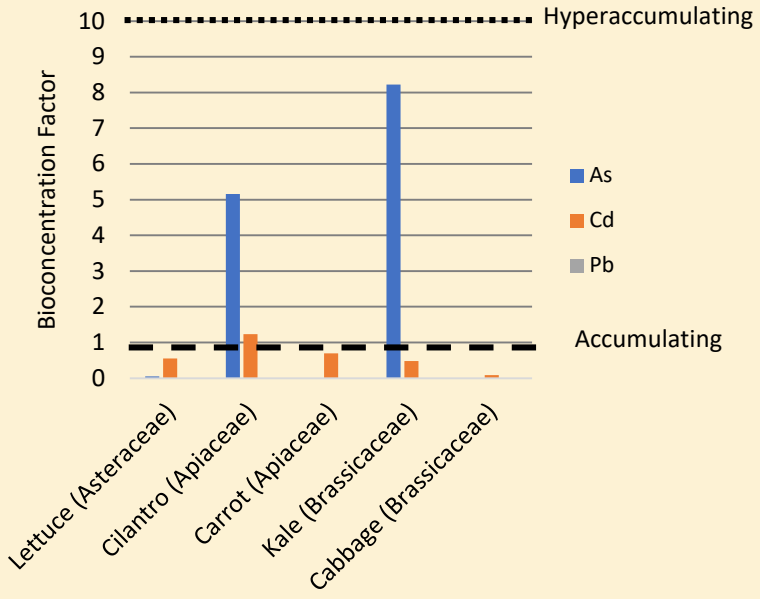


We found that *Apaiaceae* plants (carrot and cilantro) had the greatest median concentrations.

Plant Bioconcentration Factor

The **plant bioconcentration factor (BCF)** is the ratio of the metal concentration in the edible portion in the vegetable (dry weight) and the metal concentration in the soil.

$$BCF = \frac{Contaminant\ concentration\ in\ plant}{Contaminant\ concentration\ in\ garden\ soil}$$



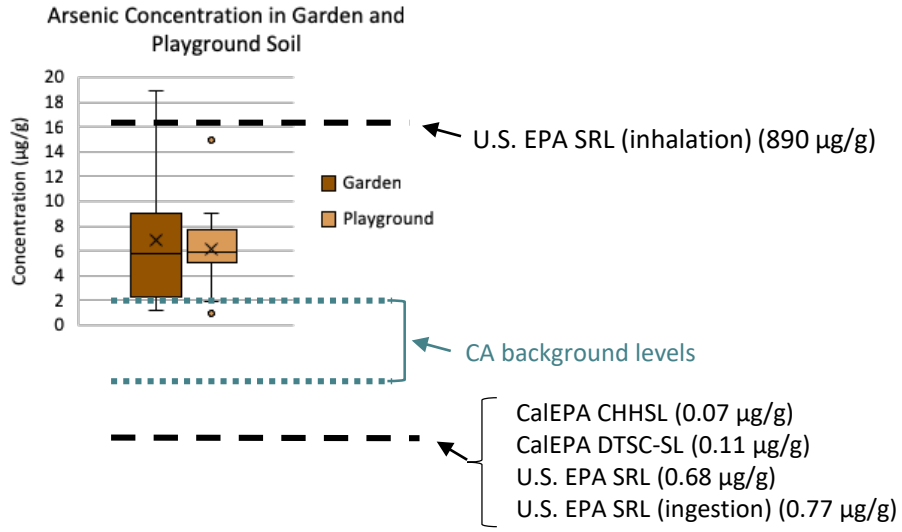
The results suggested that cilantro and kale accumulated more As than other plants, while only cilantro accumulated Cd. Certain members of the Asteraceae and Brassicaceae families have been previously identified as hyperaccumulator plants, meaning they may have a genetic and physiological capacity to accumulate high amounts of metals.

With this evidence, it is recommended that Nevada County, CA home gardeners limit the use of vegetables from the *Apiaceae* and *Brassicaceae* plant families.

Need more information on a term used? Refer back to page 3-4 for important terms.

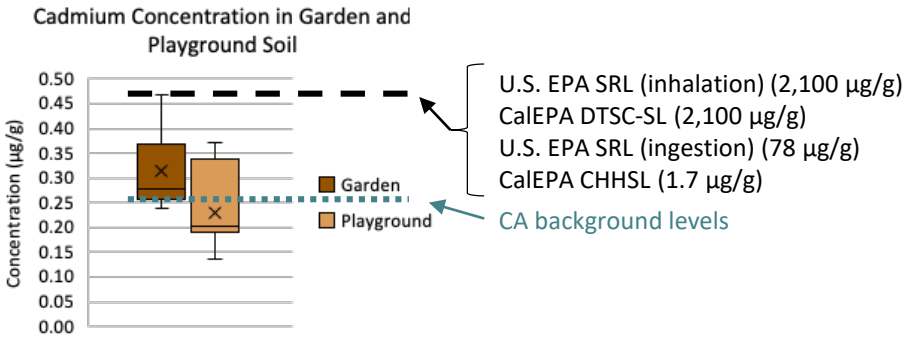
Soil Results

Below are the measured arsenic, cadmium, and lead concentrations in soil samples that were collected at each preschool.



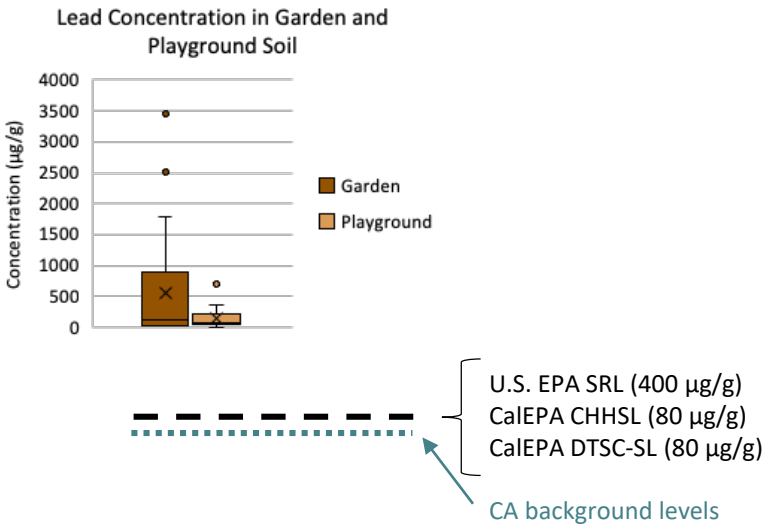
Soil samples exceeded the recommended conservative state and federal soil screening levels for As.

Please note! The measured As concentrations in garden and playground soil were generally similar to CA background As levels. This may suggest, that in general, these levels are not due to human activity or historical land use.



In general, soil samples did not exceeded the recommended conservative state and federal soil screening levels for Cd.

Like As, the measured Cd concentrations in garden and playground soil were similar or below CA background Cd levels. This may suggest, that in general, these levels are not due to human activity or historical land use.



Garden soil samples did exceeded the recommended conservative state and federal soil screening levels for Pb.

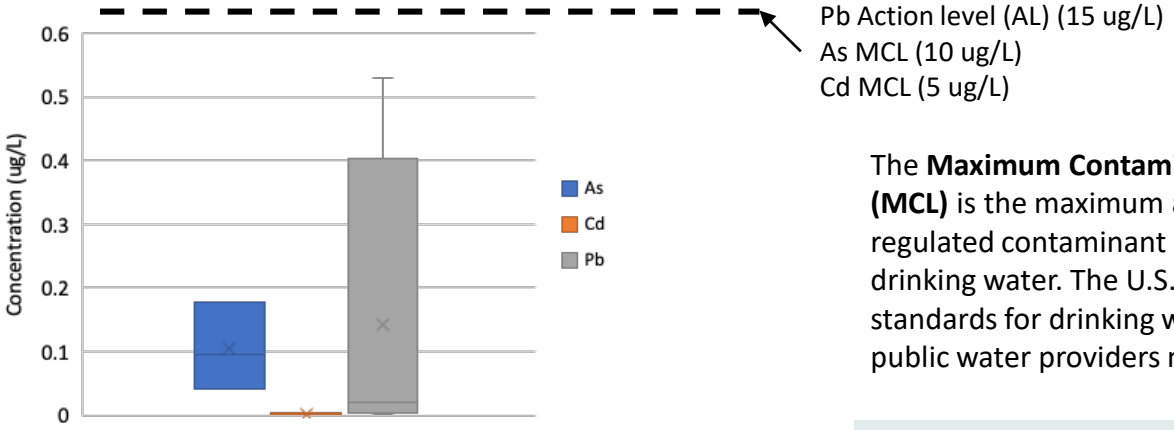
Unlike As and Cd, the measured Pb concentrations in garden and playground soil were overall above CA background Pb levels. This suggests that in general, the elevated Pb concentrations in preschool garden and playground soils are possibly caused by human activity.

Need more information on a term used? Refer back to page 3-4 for important terms.

Water & Dust Results

Below are the measured arsenic, cadmium, and lead concentrations in garden irrigation water and dust results from the samples collected at each preschool.

Contaminant Concentration in Irrigation Water



The **Maximum Contaminant Level (MCL)** is the maximum amount of a regulated contaminant allowable in drinking water. The U.S. EPA sets standards for drinking water that all public water providers must meet.

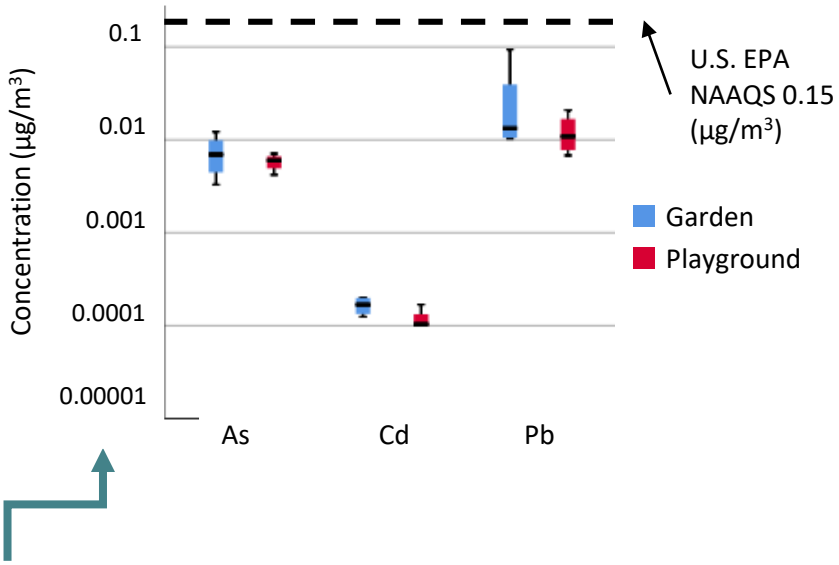
As, Cd, or Pb concentrations did not meet or exceed the MCL.

The contaminant concentrations in dust were calculated using the concentrations measured in dust samples generated from preschool soil, as well as the maximum concentration of particles (10 µm in diameter) in the air measured in 2018 by a local U.S. EPA air monitor.

The median Pb concentration from garden and playground dust in this study were below to the **U.S. EPA's National Ambient Air Quality Standard (NAAQS)** of 0.15 µg/m^3 for Pb.

There is currently no federal or state outdoor air standard for As or Cd concentration available for comparison.

Contaminant Concentration in Dust



Please note! This Y-axis has a **logarithmic scale**.
This means that the Y-axis increases by a power of 10.
Logarithmic scales are useful to show a large range in values.

Need more information on a term used? Refer back to page 3-4 for important terms.

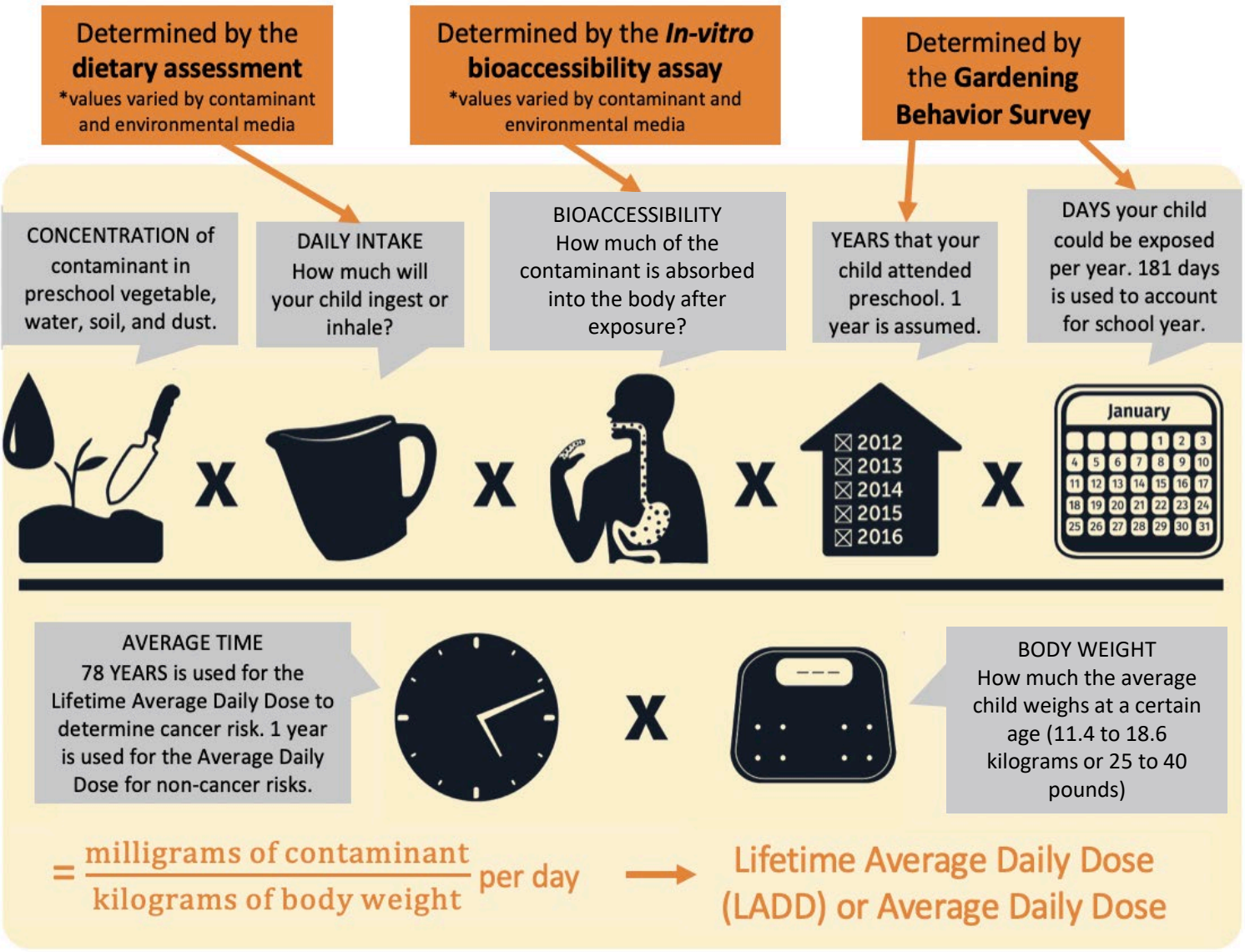
What is an Exposure Assessment?

An exposure assessment aims to answer the following questions: How much of a contaminant is present in the environment? Are we exposed? If so, how and how much are we exposed to?

In this study we estimated a preschool child's daily dose of As, Cd, and Pb from playing and gardening. To do this we used the equation below and the following assumptions:

- Intake rate for the vegetable, water, dust, or soil (incidental) a child would be consuming daily
- Body weight (11.4 to 18.6 kg = 25 to 40 lbs)
- Life span equal to 78 years
- Eating that vegetable, drinking the water, incidentally ingesting soil, and inhaling dust for 181 days out of the year (average school year) for 1 year while attending the preschool
- Bioaccessibility of As, Cd, and Pb once it's in your body

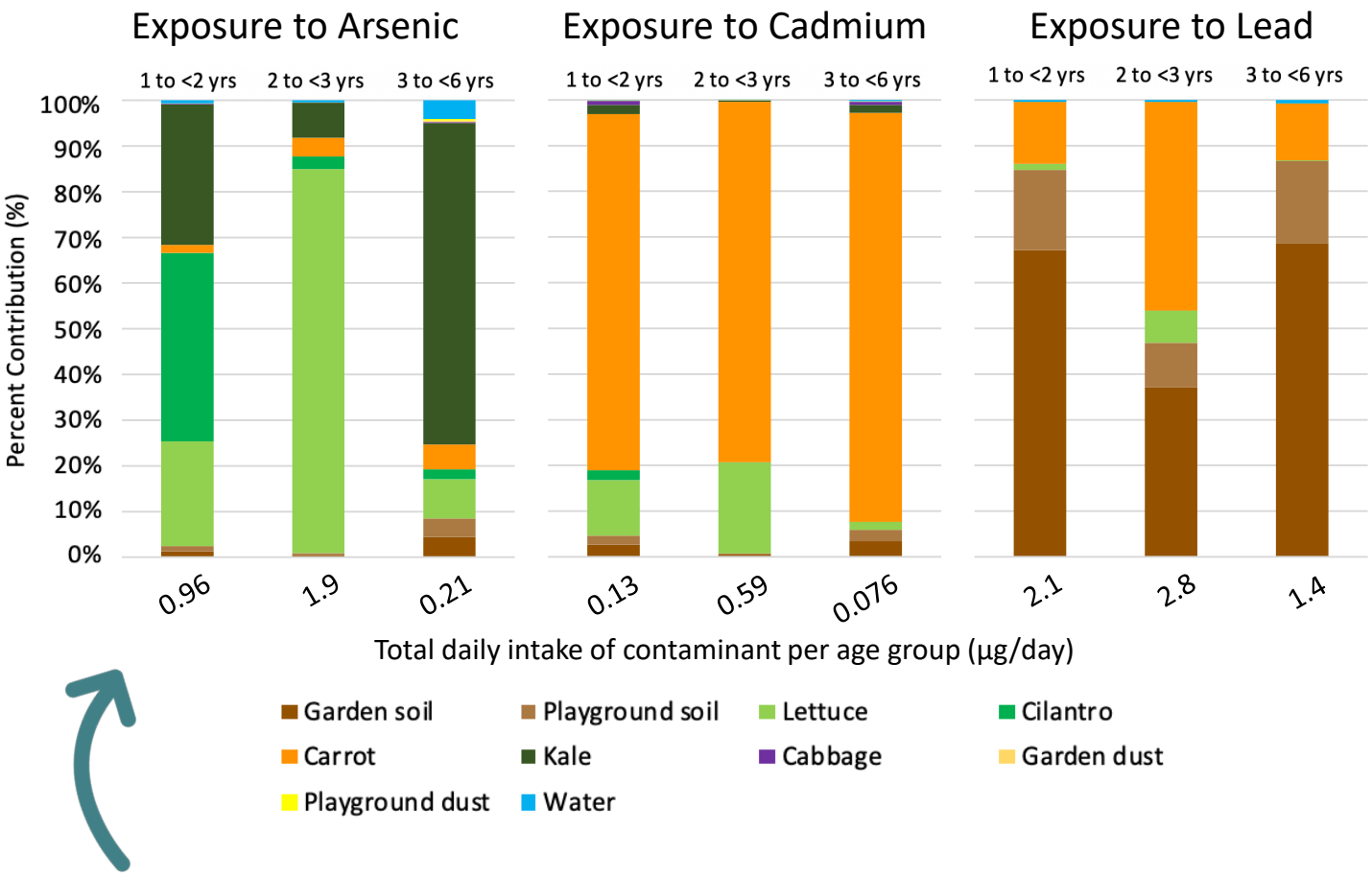
Child-specific estimated values are highlighted in the orange boxes.



Need more information on a term used? Refer back to page 3-4 for important terms.

Estimated Exposure (Daily Intake) to Arsenic, Cadmium, and Lead from Vegetables, Soil, Water, and Dust

A child's cumulative exposure to As, Cd, and Pb was estimated for each age group. We determined how much (percentage) each potential exposure route contributed to a child's daily intake (calculated on page 12).



The estimated daily intake of arsenic from all measured exposure routes (vegetables, soil - garden and playground, water, and dust) **DID NOT** exceed the U.S. EPA's reference dose for arsenic.

Please note! The estimated daily intake of cadmium for 1 to 3 year old children **DID** exceed CalEPA's child-specific reference dose for cadmium.

Need more information on a term used? Refer back to page 3-4 for important terms.

How much can we eat from the preschool garden?

It is your choice to decide what target risk you want to use to make decisions about how many cups per week to consume from the garden.

We calculated how much of each vegetable your child would have to consume weekly to reach a target excess lifetime cancer risk from arsenic exposure. This target excess risk is in addition to our already existing cancer risk from living our normal lives. These intakes were calculated using the median arsenic concentrations in vegetables across all preschools and the same assumptions described on page 12.

Cups per week that your child can eat based on different target risks			USDA recommended amounts for 2-3 year old (cups/week)
Target risk of 1/1,000,000	**Target risk of 1/100,000**	**Target risk of 1/10,000**	
Carrot			**Carrot**
11.5	115	1158	2.5
Lettuce			**Lettuce**
2	21	219	1.5
Kale			**Kale**
0.1	1	10	0.5
Cilantro			**Cilantro**
0.2	2	21	No recommendation available

Please Note!

- There are uncertainties associated with this estimation.
- For example, a child will be eating the vegetable for 181 days a year for his/her entire lifetime (78 years).
- This is unlikely due to limited vegetable growing seasons and changes in garden productivity.
- Therefore, the calculated risks are conservative, and the actual risk values would most likely be smaller.

1/1,000,000 = 1-in-a-million
1/100,000 = 1-in-a-hundred-thousand
1/10,000 = 1-in-ten-thousand

References for More Information

Vegetable

- **U.S. Department of Agriculture (USDA)**
  - http://www.choosemyplate.gov/food-groups/vegetables_amount_table.html
- **U.S. Environmental Protection Agency (U.S. EPA) – Exposure Factors Handbook**
  - http://cfpub.epa.gov/ncea/risk/recordisplay.cfm?deid=236252
- **U.S. Food and Drug Administration**
  - http://www.fda.gov/Food/FoodSafety/FoodContaminantsAdulteration/TotalDietStudy
- **USDA – What's In The Foods You Eat Search Tool**
  - http://www.ars.usda.gov/Services/docs.htm?docid=17032

Soil

- **CalEPA California Human Health Screening Levels (CHHSLs)**
  - https://oehha.ca.gov/risk-assessment/california-human-health-screening-levels-chhsls
- **CalEPA California Department of Toxic Substances Control Screening Levels (DTSC-SL)**
  - https://www.dtsc.ca.gov/assessingrisk/humanrisk2.cfm
- **University of Arizona Superfund Research Program (UA SRP) – Community Information Sheets**
  - https://www.superfund.arizona.edu/info-material/information-sheets
- **U.S. EPA – Soil Screening Guidance**
  - http://www.epa.gov/superfund/health/conmedia/soil/index.htm

Water

- **Agency for Toxic Substances and Disease Registry**
  - http://www.atsdr.cdc.gov/
- **UA SRP – Water Booklets**
  - https://superfund.arizona.edu/info-material/water-booklets-and-videos
- **U.S. EPA - Drinking Water Contaminants – Standards and Regulations**
  - http://water.epa.gov/drink/contaminants/index.cfm

Dust

- **U.S. EPA – Lead National Ambient Air Quality Standard**
  - https://www.epa.gov/criteria-air-pollutants/naaqs-table