



gardenroots

Encyclopedia of Contaminants and Comparative Values

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COLLEGE OF AGRICULTURE & LIFE SCIENCES
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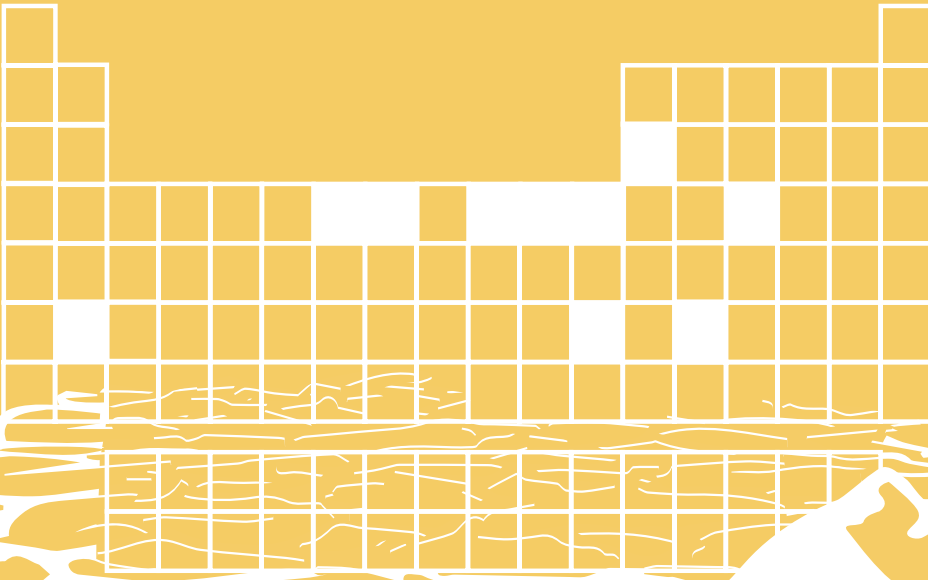


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INORGANIC

You collected samples that were tested for inorganic elements, which refers to metals and minerals. In Gardenroots, we measured metals and heavy metals that are known to cause harm to humans and other living organisms.



INORGANIC

List of Standards, Recommendations Screening Levels and/or Reference Values for Water, Soil, Plant, and Dust



Standards and/or reference values for WATER

How do you use your water? Based on how you use your harvested water, select the appropriate standard, advisory, and/or guideline and compare your data! Use the colors below to guide your interpretation



Surface Water -
Partial Body
Standard



Surface Water -
Full Body
Standard



Drinking Water
Standard



Irrigation Water
Recommended
Maximum
Concentration



Livestock and Poultry
Drinking Water
Recommended Upper Limit

Different standards/advisories/recommendations were selected based on:

- How you and other community members use their water
- Availability of useful standards or advisories.

Please note: Not all pollutants have standards, advisories, and/or guidelines.

Arizona Department of Environmental Quality (ADEQ) Surface Water - Full Body Contact Standard

This ADEQ standard is set for surface waters like lakes, river, or streams that were, are, or could be used for commerce, travel, or recreation. Full body contact means your body will go completely underwater, ingestion of the water is likely, and your eyes, ears, or nose may directly contact with the water.



ADEQ Surface Water - Full Body Contact Standards for Inorganic Elements

Inorganic element	Standard (µg/L)	My water is above this standard, what does this mean?
Aluminum (Al)	No standard given	<ul style="list-style-type: none"> Do not drink your water. Do not swim in your water or do a recreational activity that will cause you to be completely under water.
Arsenic (As)	30	
Barium (Ba)	98,000	
Beryllium (Be)	1,867	
Cadmium (Cd)	700	
Chromium (Cr)	2,800 (as Cr-VI)	
Copper (Cu)	1,300	
Lead (Pb)	15	
Manganese (Mn)	130,667	
Nickel (Ni)	28,000	
Zinc (Zn)	280, 000	

Arizona Department of Environmental Quality (ADEQ) Surface Water - Partial Body Contact Standard

This ADEQ standard is set for surface waters like lakes, river, or streams that were, are, or could be used for commerce, travel, or recreation. Partial contact means that you may come into contact with the water (through an activity like boating or walking through), but you will not go completely underwater and accidentally ingest any of the water or the water will not come in direct contact with your eyes, ears, or nose.



ADEQ Surface Water - Partial Body Contact Standards for Inorganic Elements

Inorganic element	Standard (µg/L)	My water is above this standard, what does this mean?
Aluminum (Al)	No standard given	<ul style="list-style-type: none">Do not drink your water.Do not let your water get into your eyes, ears, or nose.
Arsenic (As)	280	
Barium (Ba)	98,000	
Beryllium (Be)	1,867	
Cadmium (Cd)	700	
Chromium (Cr)	2,800 (as Cr-VI)	
Copper (Cu)	1,300	
Lead (Pb)	15	
Manganese (Mn)	130,667	
Nickel (Ni)	28,000	
Zinc (Zn)	280, 000	

Where can I get more information on the ADEQ Surface Water - Full and Partial Body Contact Standards?

- The Arizona Administrative Code. December 31, 2016. Title 18. Environmental Quality Chapter 11. Department of Environmental Quality - Water Quality Standards.



https://apps.azsos.gov/public_services/Title_18/18-11.pdf

U.S. Environmental Protection Agency (US EPA) Primary Drinking Water Standard

The maximum amount of a contaminant allowed in drinking water so that it is still safe to use over the long-term. This level is set and legally enforced by the US Environmental Protection Agency. They are also referred to as Maximum Contaminant Levels (MCL).

U.S. Environmental Protection Agency (US EPA) Secondary Drinking Water Standard

Non-enforceable guidelines to help manage contaminants that may cause cosmetic effects (such as skin or tooth discoloration) or affect the taste, odor, or color of drinking water.



USEPA Drinking Water Standards for Inorganic Elements

Inorganic element	Standard (µg/L)	My water is above this standard, what does this mean?
Aluminum (Al)	50*	<ul style="list-style-type: none">Do not drink your water.
Arsenic (As)	10	
Barium (Ba)	2,000	
Beryllium (Be)	4	
Cadmium (Cd)	5	
Chromium (Cr)	100 (as Cr-VI)	
Copper (Cu)	1,300^	
Lead (Pb)	15^	
Manganese (Mn)	50*	
Nickel (Ni)	140**	
Zinc (Zn)	5,000*	

^ These are Action Levels. Lead and copper are regulated under the Lead and Copper Rule. The treatment technique for the rule requires water providers/utilities to control the corrosiveness of their water and monitor drinking water at customer taps. If more than 10% of tap water samples exceed the action levels, water provider/utility must take additional steps.

* Secondary standard, not primary.

** Arizona Department of Environmental Quality Standard. There is no USEPA Drinking Water Standard.

Where can I get more information on the US EPA Drinking Water Standards?

- US EPA. National Primary Drinking Water Regulations
Last updated on March 22, 2018.



<https://www.epa.gov/ground-water-and-drinking-water/national-primary-drinking-water-regulations>

- US EPA. Secondary Drinking Water Standards. Last updated on March 8, 2017.



<https://www.epa.gov/dwstandardsregulations-secondary-drinking-water-standards-guidance-nuisance-chemicals>

- US EPA. Lead and Copper Rule. Last updated on March 15, 2017.



<https://www.epa.gov/dwreginfo/lead-and-copper-rule>

The United States Department of Agriculture (USDA) Irrigation Water Recommended Maximum Concentration

The USDA has recommendations for chemicals that may be found in water sources used for irrigation. This standard is based on the amount of a chemical that could hurt crops (toxic to plants), change the way the plant uptakes essential nutrients, and/or reduce yield or quality. This recommendation is also based on maintaining toxic elements at a level below which they concentrate in the soil and become harmful.



USDA Irrigation Water Recommended Maximum Concentrations

Inorganic element	Recommended Maximum Concentration (µg/L)	My water is above this recommendation, what does this mean?
Aluminum (Al)	5,000	<ul style="list-style-type: none">• Your water might hurt your plants.• Over time, the toxic elements in your water may concentrate in the soil and harm your soil and animals.
Arsenic (As)	100	
Barium (Ba)	No recommendation given	
Beryllium (Be)	100	
Cadmium (Cd)	10	
Chromium (Cr)	100	
Copper (Cu)	200	
Lead (Pb)	5,000	
Manganese (Mn)	200	
Nickel (Ni)	200	
Zinc (Zn)	2,000	

The United States Department of Agriculture (USDA) Livestock and Poultry Drinking Water Recommended Upper Limit

The USDA has recommended values for chemicals that may be found in water sources used for livestock and poultry. This recommendation is based on the amount of a chemical that could harm (cause severe health problems) in livestock and poultry.



USDA Livestock and Poultry Drinking Water Recommended Upper Limits

Inorganic element	Recommended Upper Limit (µg/L)	My water is above this recommendation, what does this mean?
Aluminum (Al)	5,000	<ul style="list-style-type: none"> Do not give your water to your livestock or poultry.
Arsenic (As)	10	
Barium (Ba)	10,000	
Beryllium (Be)	No Recommendation given	
Cadmium (Cd)	50	
Chromium (Cr)	1,000	
Copper (Cu)	500	
Lead (Pb)	100 (lead is accumulative and problems may begin at 50 µg/L)	
Manganese (Mn)	50 (may affect taste)	
Nickel (Ni)	No Recommendation given	
Zinc (Zn)	25,000	

Where can I get more information on the USDA Agricultural Irrigation and Livestock and Poultry Drinking Water Recommendations?

- Pick, T. 2011. Assessing Water Quality for Human Consumption, Agriculture, and Aquatic Life Uses Environment Technical Note No. MT-1 (Rev. 2). United States Department of Agriculture Natural Resources Conservation Service.



<https://mwcc.kjpc.tech/media/library/content/Assessing-Water-Quality-for-Human-Consumption-Agriculture-and-Aquatic-Life-Uses.pdf>



Remediation and Screening Levels for SOIL

Use the color below to guide your interpretation.



**Soil Remediation
Level**



**CALEPA Department of Toxic
Substances Control Modified
Regional Screening Level**



**U.S. EPA Regional
Screening Level**

Different levels were selected based on:

- How you and other community members use their soil.
- Availability of useful standards or advisories.

Please note: Not all pollutants have standards, advisories, screening levels,
and/or guidelines.

Arizona Department of Environmental Quality (ADEQ) Soil Remediation Level

This Soil Remediation Level is a residential yard soil screening-level based on a health risk-assessment. If a metal concentration in a residential yard soil is above the level, it suggests further investigation should be taken, but does not necessarily require cleanup.



ADEQ Soil Remediation Levels

Inorganic element	Level (mg/kg)
Aluminum (Al)	77,000
Arsenic (As)	10
Barium (Ba)	15,000
Beryllium (Be)	150
Cadmium (Cd)	39
Chromium (Cr)	No Level given for total Cr
Copper (Cu)	3,100
Lead (Pb)	400
Manganese (Mn)	3300
Nickel (Ni)	1600
Zinc (Zn)	23,000

Table continued on next page.

My soil sample is above this level, what does this mean?

- Future studies may be needed, but does not necessarily require cleanup.
- **Since your values are above the remediation level, it is prudent to:**
 - Wash your vegetables really well! Consider using a scrub brush to remove soil particles**

Look at the shape of your vegetables - some can trap soil particles. For example, soil particles can get trapped in between the flower heads on broccoli, and leafy vegetables have large surface areas where soil can collect.

Important Note: Arsenic and heavy metals occur naturally in soils. Concentrations of metals in soils may be 10 to 100 times greater than concentrations in the vegetables you grow in that soil. Because of this, it is crucial to remove soil particles that stick to your garden crops.
 - Avoid gardening on windy days**
 - Avoid eating and drinking while you garden**

Soil and dust might get on your food or drink and could be accidentally ingested.
 - Keep soils moist while gardening**

This will limit the amount of dust you inhale.
 - Have a designated set of gardening clothes and shoes that you keep outside the home**

Keep your gardening clothes and shoes in a plastic bag outside. It is best to keep your gardening clothes and shoes out of your home.
 - Stay Clean**

Wash up after gardening. Wash your hands and any other body surface that might have soil on it.
 - Leave your shoes outside**

Remove your shoes before entering your home to avoid tracking in soil.
 - Good housekeeping**

Mop floors with a damp mop, and wipe down surfaces in your home regularly. Change your vacuum bag more often, or upgrade your vacuum to one that has a High-Efficiency Particulate Air (HEPA) filter.
 - Gardening Tools**

Wash, and then store all your gardening tools outside.

Where can I get more information about the Arizona Department of Environmental Quality Soil Remediation Level?

The ADEQ web page has great information from the Arizona Administrative Code. For the soil remediation information, check out Arizona Administrative Code, Department of Environmental Quality – Remedial Action. Title 18. Environmental Quality Chapter 7. Department Of Environmental Quality Remedial Action. Last updated on March 31, 2009.



https://apps.azsos.gov/public_services/Title_18/18-07.pdf

U.S. Environmental Protection Agency (U.S. EPA) Regional Screening Levels

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. **The Resident Soil Screening Levels below are from US EPA Regional Screening Levels - Generic Tables, last updated May 2023.**



U.S. EPA Regional Screening Levels - Resident Soil

Inorganic element	USEPA Regional Screening Level Cancer (mg/kg)*
Aluminum (Al)	No Level given
Arsenic (As)	0.68
Barium (Ba)	No Level given
Beryllium (Be)	1600
Cadmium (Cd)	2100
Chromium (Cr)	No Level given
Copper (Cu)	No Level given
Lead (Pb)	No Level given
Manganese (Mn)	No Level given
Nickel (Ni)^	15000
Vanadium (V)	No Level given
Zinc (Zn)	No Level given

*Target Risk = 1 out of a million.

^This value considers the most toxic forms of nickel to reflect a conservative approach and ensure the safety of vulnerable populations.

Additional Table on next page.

U.S. Environmental Protection Agency (U.S. EPA) Regional Screening Levels Continued

US EPA Regional Screening Levels Non-cancer Child Hazard at a Target Hazard Quotient (THQ) of 1.0

- Generally, if you are screening only one contaminant, the THQ=1.0 values can be used.
- This set of US EPA Regional Screening Levels are used when there is only one contaminant present in the soil. Measurements above this screening level indicate that there may be an increased risk to health when there is only one contaminant in the soil.

USEPA Regional Screening Level Non-cancer Child Hazard at a Target Hazard Quotient (THQ) of 0.1

- Generally, if you are screening multiple chemicals, it is preferred to use the THQ=0.1 values. The rationale for using THQ=0.1 for screening is that when multiple contaminants of concern are present at a site or one or more are present in multiple exposure media, the total hazard index could exceed 1.0 if each were screened at the HQ of 1.0.
- This set of US EPA Regional Screening Levels are used when there are multiple contaminants in the soil. Measurements above this screening level indicate that there may be an increased risk to health when there are multiple contaminants in the soil.



U.S. EPA Regional Screening Levels - Resident Soil

Inorganic element	USEPA Regional Screening Level Non-Cancer Child Hazard at THQ of 1.0 (mg/kg)	USEPA Regional Screening Level Non-Cancer Child Hazard at THQ of 0.1 (mg/kg)
Aluminum (Al)	77000	7700
Arsenic (As)	35	3.5
Barium (Ba)	15000	1500
Beryllium (Be)	160	16
Cadmium (Cd)	7.1*	0.71
Chromium (Cr)	No Level given	No Level given
Copper (Cu)	3100	310
Lead (Pb)	400	400
Manganese (Mn)	1800	180
Nickel (Ni)^	820	82
Vanadium (V)	390	39
Zinc (Zn)	23000	2300

*Previously was 71, updated May 2023

^This values considers the most toxic forms of nickel to reflect a conservative approach and ensure the safety of vulnerable populations.

My soil sample is above this level, what does this mean?

- Future studies may be needed, but does not necessarily require cleanup.
- **Since your values are above the remediation level, it is prudent to:**
 - Wash your vegetables really well! Consider using a scrub brush to remove soil particles**

Look at the shape of your vegetables - some can trap soil particles. For example, soil particles can get trapped in between the flower heads on broccoli, and leafy vegetables have large surface areas where soil can collect.

Important Note: Arsenic and heavy metals occur naturally in soils. Concentrations of metals in soils may be 10 to 100 times greater than concentrations in the vegetables you grow in that soil. Because of this, it is crucial to remove soil particles that stick to your garden crops.
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Remove your shoes before entering your home to avoid tracking in soil.
 - Good housekeeping**

Mop floors with a damp mop, and wipe down surfaces in your home regularly. Change your vacuum bag more often, or upgrade your vacuum to one that has a High-Efficiency Particulate Air (HEPA) filter.
 - Gardening Tools**

Wash, and then store all your gardening tools outside.

Where can I get more information about the EPA Regional Screening Level?



<https://www.epa.gov/risk/regional-screening-levels-rsls>

CALEPA Department of Toxic Substances Control Modified Regional Screening Levels

CalEPA California Department of Toxic Substances Control Screening Levels (DTSC-SL) – Risk- based recommended screening levels that are made using DTSC-modified exposure and toxicity factors for contaminants in soil. These values are also more conservative than the U.S EPA RSLs.



CALEPA Department of Toxic Substances Control Modified Regional Screening Level

Inorganic element	CALEPA SL Cancer (mg/kg)	CALEPA SL Non-Cancer (mg/kg)
Aluminum (Al)	No Level given	No Level given
Arsenic (As)	0.11	0.41
Barium (Ba)	No Level given	No Level given
Beryllium (Be)	No Level given	16
Cadmium (Cd)	910	No Level given
Chromium (Cr)	No Level given	No Level given
Copper (Cu)	No Level given	No Level given
Lead (Pb)	No Level given	80
Manganese (Mn)	No Level given	No Level given
Nickel (Ni)	No Level given	820
Zinc (Zn)	No Level given	No Level given

Table continued on next page.

My soil sample is above this level, what does this mean?

- Future studies may be needed, but does not necessarily require cleanup.

- **Since your values are above the remediation level, it is prudent to:**

- Wash your vegetables really well! Consider using a scrub brush to remove soil particles**

Look at the shape of your vegetables - some can trap soil particles. For example, soil particles can get trapped in between the flower heads on broccoli, and leafy vegetables have large surface areas where soil can collect.

Important Note: Arsenic and heavy metals occur naturally in soils. Concentrations of metals in soils may be 10 to 100 times greater than concentrations in the vegetables you grow in that soil. Because of this, it is crucial to remove soil particles that stick to your garden crops.

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Remove your shoes before entering your home to avoid tracking in soil.

- Good housekeeping**

Mop floors with a damp mop, and wipe down surfaces in your home regularly. Change your vacuum bag more often, or upgrade your vacuum to one that has a High-Efficiency Particulate Air (HEPA) filter.

- Gardening Tools**

Wash, and then store all your gardening tools outside.

Where can I get more information about the CALEPA Regional Screening level?



<https://dtsc.ca.gov/wp-content/uploads/sites/31/2019/04/HHRA-Note-3-June-2020-A.pdf>



Reference values for PLANT



Codex Alimentarius Recommended Maximum Level

Different standards/advisories/recommendations were selected based on:

- How you and other community members use their plants.
- Availability of useful standards or advisories.

Please note: Not all pollutants have standards, advisories, and/or guidelines.

Food and Agriculture Organization of the United Nations and World Health Organization Codex Alimentarius Recommended Maximum Level

The Codex Alimentarius Commission (CAC) is a joint Food and Agriculture Organization of the United Nations and World Health Organization Food Standards Program established in 1963. To protect consumer's health, the CAC provides the recommended maximum concentration of a contaminant allowed in food products . Recommended Maximum Levels are based on:

- Health (toxicological) data
- Dietary intake data/human consumption model
- Foods that can significantly contribute to the dietary exposure of the contaminant
- Availability of appropriate lab sampling procedures

Cadmium and lead WHO's Codex Alimentarius Recommended Maximum Levels are provided below. There are no vegetable Recommended Maximum Levels for the other inorganic elements.



Food and Agriculture Organization of the United Nations and World Health Organization Codex Alimentarius Recommended Maximum Level

Plant Type	Cadmium Recommended Maximum Level (mg/kg)*	Lead Recommended Maximum Level (mg/kg)*
Leafy	0.2	0.3
Brassica Vegetables	0.05	0.1
Root and Tuber Vegetables	0.1	0.1
Stalk and stem vegetables	0.1	No Recommendation given
Fruiting vegetables	0.05	0.05
Legumes	0.1	0.1
Bulb Vegetables	0.05	0.1
Fruits	No Recommendation given	0.05
Pulses	0.1	0.1
Herbs	No Recommendation given	No Recommendation given
Berries and other small fruits	No Recommendation given	0.1

*Values are given for fresh vegetable weight.

The Codex Alimentarius cadmium standard does not apply to tomatoes and edible fungi.

Table continued on next page.

My vegetable sample is above this recommendation, what does this mean?

- **Mix it up**
-Eat vegetables from your garden, the grocery store and farmers' market. Eating a mixture of homegrown and store bought can help reduce your potential exposure.
- **Eat a little less from your garden**
-If you eat this plant from your garden routinely, consider eating less of it from your garden and finding a different source.
- **Pare and/or Peel**
-Pare and/or peel root and tuber crops like carrots, radishes, and potatoes. Make sure you throw the parings and peelings away.
- **Consider not compost unused plant parts, peelings or parings for use in the garden**
-This act will reduce the recycling of lead in your compost.

Where can I get more information on the Food and Agriculture Organization of the United Nations and World Health Organization Codex Alimentarius Recommended Maximum Levels?

- Codex Alimentarius Commission - Food and Agricultural Organization of United Nations and World Health Organization Food Standards Programme. General Standard for Contaminants and Toxins in Food and Feed. Last Updated in 2018.



<https://www.usda.gov/codex>

Additional Resources - United States Food and Drug Administration's Total Diet Study

- Four times per year, the U.S. Food and Drug Administration buys about 280 different foods from grocery stores across the U.S. and cooks the foods in the same ways we usually would.
- They test the foods for more than 800 chemical contaminants, including inorganic elements, metals, pesticides, industrial chemicals, and radionuclides. They also test for levels of different nutrients.
- To view the results of these studies, visit: "Analytical Results of the Total Diet Study"



<https://www.fda.gov/food/science-research-food/total-diet-study>



Standards and/or reference values for DUST

Use the color below to guide your interpretation.



Department of Housing and Urban Development's
Porch Floor Lead Clearance Action Level

Different standards/advisories were selected based on:

- Availability of useful standards or advisories.

Please note: Not all pollutants measured in Gardenroots have standards, advisories, and/or guidelines.

Department of Housing and Urban Development's Porch Floor Lead Clearance Action Level

The Office of Lead Hazard Control and Healthy Homes within the Department of Housing and Urban Development has developed lead clearance action levels based on human exposure assessments. These lead Clearance Action Levels are used for clearing or "passing" a home after a lead reduction clean up (intervention)

HUD applies three different standards to indoor floors, indoor windowsills, and outdoor porches to address the different ways that people can be exposed to lead dust from these surfaces. These action levels are designed to protect children from lead exposure and are conservative when applied to adults.



Lead Clearance Action Level

Inorganic element	Sampling Location	Clearance Action Level ($\mu\text{g}/\text{ft}^2$ - micrograms per square feet)	My dust is above this action level, what does this mean?
Lead (Pb)	Indoor Floor	10	<p>To reduce the amount of soil and dust in your home and what you may incidentally ingest:</p> <ul style="list-style-type: none"> • Keep shoes outside, or have a pair of shoes you only wear outside to avoid tracking dust into your home • Use mops and wet wipes to clean instead of sweeping and dry dusting • Use a vacuum with a HEPA filter • Vacuum rugs instead of shaking them. • Wash child's toys • Avoid gardening on windy days. • Keep your soil moist while you are gardening.
	Outdoor porch	40	
	Indoor windowsill	100	

Where can I get more information on the Department of Housing and Urban Development Lead Clearance Action Levels?

- The Office of Lead Hazard Control and Healthy Homes Lead Dust Clearance Policy sheet:



<https://www.hud.gov/sites/documents/LEADDUSTCLEARANCE.PDF>

Where can I get more information on lead

- Lead Poisoning, Arizona Department of Health Services

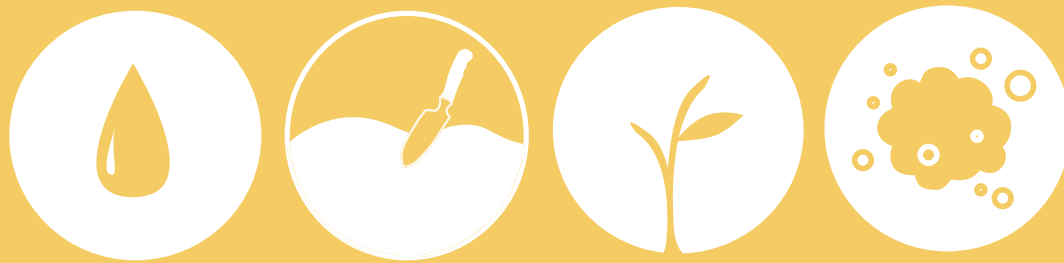


<https://www.azdhs.gov/preparedness/epidemiology-disease-control/lead-poisoning/index.php#brochures-handouts>

- Childhood Lead Poisoning Prevention Program, Center for Disease Control



<https://www.cdc.gov/nceh/lead/default.htm>



INORGANIC

Contaminant List for Water, Soil, Plant and Dust

Aluminum

Contaminant Name: Aluminum (Al)

Contaminant Type: Metalloid

What is Aluminum?

Aluminum is the most abundant element in the earth's crust. It is generally found combined with other elements such as oxygen, silicon, and fluorine. Aluminum is used for beverage cans, pots and pans, airplanes, siding and roofing, and foil. It is also found in antacids, astringents, buffered aspirin, food additives, cosmetics, and antiperspirants.

What happens when Aluminum enters the environment?

Aluminum may be released into the environment through mining and processing of aluminum ores and the production of aluminum metal, alloys, and compounds. In air, aluminum particles settle to the ground or are washed out by rain. However, very small aluminum particles can stay in the air for many days. Most aluminum-containing compounds do not dissolve very well in water unless the water is acidic or very alkaline.

How can Aluminum affect my health?

Exposure to aluminum is usually not harmful, but exposure to high levels can affect your health. Breathing in aluminum, typically in work-related settings, may result in lung problems, such as coughing or abnormal chest X-rays. Aluminum has not been shown to cause cancer in animals.

Where can I get more information on Aluminum?

Agency for Toxic Substances and Disease Registry. ToxFAQs™ for Aluminum.

Last Updated on March 12, 2015.



<https://wwwn.cdc.gov/TSP/ToxFAQs/ToxFAQsDetails.aspx?faqid=190&toxid=34>

Arsenic

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. ToxFAQs™ for Arsenic.

Last Updated on March 12, 2015.



<https://www.atsdr.cdc.gov/toxfaqs/tf.asp?id=19&tid=3>

Barium

Contaminant Name: Barium (Ba)

Contaminant Type: Alkaline Earth Metal

What is Barium?

Barium is a silvery-white metal and combines with other chemicals such as sulfur or carbon and oxygen to form barium compounds. Barium compounds are used by the oil and gas industries to make drilling muds. They are also used to make paint, bricks, ceramics, glass, and rubber. Barium sulfate is sometimes used by doctors to perform medical tests and to take x-rays of the gastrointestinal tract.

What happens to barium when it enters the environment?

Barium gets into the air during the mining, refining, and production of barium compounds, and from the burning of coal and oil. The length of time that barium will last in air, land, water, or sediments depends on the form of barium released. Barium compounds, such as barium sulfate and barium carbonate, which do not dissolve well in water, can last a long time in the environment. Fish and aquatic organisms can accumulate barium.

How can barium affect my health?

People with the greatest known risk of exposure to high levels of barium are those working in industries that make or use barium compounds. Exposure near hazardous waste sites may occur by breathing dust, eating soil or plants, skin contact, or drinking water that is polluted with barium. Some people who eat or drink amounts of barium above background levels found in food and water for a short period may experience vomiting, abdominal cramps, diarrhea, difficulties in breathing, increased or decreased blood pressure, numbness around the face, and muscle weakness. When barium is ingested, it is not likely to cause cancer in humans. There is not enough information to determine if it will cause cancer in humans when inhaled.

Where can I get more information on Barium

Agency for Toxic Substances and Disease Registry. ToxFAQs™ for Barium.
Last Updated on July 27, 2015.



<https://www.atsdr.cdc.gov/toxfaqs/tf.asp?id=326&tid=57>

Beryllium

Contaminant Name: Beryllium (Be)

Contaminant Type: Alkaline Earth Metal

What is Beryllium?

Beryllium is found in minerals, rocks, coal, soil, and volcanic dust. Beryllium compounds are commercially mined, and purified or use in nuclear weapons and reactors, aircraft and space vehicle structures, instruments, x-ray machines, and mirrors. Beryllium ores are used to make specialty ceramics for electrical and high-technology applications. Beryllium alloys are used in automobiles, computers, sports equipment (golf clubs and bicycle frames), and dental bridges.

What happens to Beryllium when it enters the environment?

Beryllium dust enters the air from burning coal and oil. It enters water from erosion of rocks and soil, and from industrial waste. Some beryllium compounds will dissolve in water, but most stick to particles and settle to the bottom. Most beryllium in soil does not dissolve in water and remains bound to soil. Beryllium does not accumulate in the food chain.

How can Beryllium affect my health?

Beryllium can be harmful if you breathe it. People working in industries where beryllium is mined, processed, machined, or converted into metal, alloys, and other chemicals may be exposed to high levels of beryllium. People living near these industries or near uncontrolled hazardous waste sites may also be exposed to higher than normal levels of beryllium in air. Beryllium and beryllium compounds can cause cancer in humans.

Where can I get more information on Beryllium?

Agency for Toxic Substances and Disease Registry. ToxFAQs™ for Beryllium.

Last Updated on June 3, 2015.



<https://www.atsdr.cdc.gov/toxfaqs/tf.asp?id=184&tid=33>

Cadmium

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. ToxFAQs™ for Cadmium.
Last Updated on March 12, 2015.



<https://www.atsdr.cdc.gov/toxfaq/tf.asp?id=47&tid=15>

Chromium

Contaminant Name: Chromium (Cr)

Contaminant Type: Metal

What is chromium?

Chromium is a naturally-occurring element found in rocks, animals, plants, and soil, where it exists in combination with other elements to form various compounds. The three main forms of chromium are: chromium(0), chromium(III), and chromium(VI). Small amounts of chromium(III) are needed for human health. Chromium(VI) is known to be highly toxic, when compared to Cr-III. Chromium is widely used in manufacturing processes to make various metal alloys such as stainless steel.

What happens to chromium when it enters the environment?

Chromium can be found in air, soil, and water after release from industries that use chromium, such as industries involved in electroplating, leather tanning, textile production, and the manufacture of chromium-based products. Chromium can also be released into the environment from the burning of natural gas, oil, or coal. Chromium does not usually remain in the atmosphere, but is deposited into the soil and water.

How can chromium affect my health?

The highest potential human exposure occurs in the metallurgy and tanning industries where workers may be exposed to high air concentrations. Inhalation of chromium compounds can result in irritation of the nasal passages, breathing problems, and other upper respiratory conditions. Chromium(VI) has the potential to affect the male reproductive system and/or the small intestine, and chromium(VI) compounds are known to cause cancer in humans.

Where can I get more information on Chromium?

Agency for Toxic Substances and Disease Registry. ToxFAQs™ for Chromium.

Last Updated on September 28, 2016.



<https://www.atsdr.cdc.gov/toxfaqs/tf.asp?id=61&tid=17>

Copper

Contaminant Name: Copper (Cu)

Contaminant Type: Metal

What is copper?

Copper is a metal that occurs naturally throughout the environment, in rocks, soil, water, and air. Copper is an essential element in plants, animals, and humans, which means it is necessary for us to live. Copper is used to make many different kinds of products like wire, cars, plumbing pipes, and sheet metal. Copper is also combined with other metals to make brass and bronze pipes and faucets. Copper compounds are commonly used in agriculture to treat plant diseases like mildew, for water treatment and, as preservatives for wood, leather, and fabrics.

What happens to copper when it enters the environment?

Copper is released into the environment by mining, farming, and manufacturing operations and through waste water releases into rivers and lakes. Copper is also released from natural sources, like volcanoes, windblown dusts, decaying vegetation, and forest fires. Copper released into the environment usually attaches to particles made of organic matter, clay, soil, or sand.

How can copper affect my health?

Copper is essential for good health, but high levels of copper can be harmful. You may be exposed to copper by ingesting copper-containing fungicides or if you live near or work in a copper mine. Breathing high levels of copper can cause irritation of our nose and throat. Ingesting high levels of copper can cause nausea, vomiting, and diarrhea. Very-high doses of copper can cause damage to your liver and kidneys, and can even cause death.

Where can I get more information on Copper?

Agency for Toxic Substances and Disease Registry. ToxFAQs™ for Copper.

Last Updated on January 21, 2015.



<https://www.atsdr.cdc.gov/phs/phs.asp?id=204&tid=37>

Lead

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. ToxFAQs™ for Lead.

Last Updated on August 24, 2016.



<https://www.atsdr.cdc.gov/toxfaqs/tf.asp?id=93&tid=22>

Manganese

Contaminant Name: Manganese (Mn)

Contaminant Type: Metal

What is Manganese?

Manganese is naturally occurring and found in rocks and soils. Manganese does not occur as a pure metal in nature, instead it is typically bound to elements like oxygen, sulfur, and chlorine. Manganese is used to strengthen metal alloys and can be found in fireworks, fertilizers, cosmetics, etc.

What happens when Manganese enters the environment

Manganese is naturally occurring in air, water, soil, and foods, but may also be released into the environment via manufacturing, and disposal of based products such as gasoline with manganese-additives. Manganese-containing additives can be broken down by sunlight.

How can Manganese affect my health?:

Manganese is an essential nutrient, and eating a small amount of it each day is important to stay healthy. Manganese has the potential to cause lung irritation when inhaled. Manganese may also result in reproductive effects. Workers exposed to high levels of manganese have developed nervous system problems.

Where can I get more information on Manganese?

Agency for Toxic Substances and Disease Registry. ToxFAQs™ for manganese.

Last Updated on January 21, 2015.



<https://www.atsdr.cdc.gov/phs/phs.asp?id=100&tid=23>

Nickel

Contaminant Name: Nickel (Ni)

Contaminant Type: Metal

What is Nickel?

Nickel is a natural element. Nickel can be combined with other metals and is used to make coins, jewelry, and items such as valves and heat exchangers. Most nickel is used to make stainless steel. Many nickel compounds dissolve fairly easy in water and have a green color. Nickel compounds are used for nickel plating, to color ceramics, to make some batteries, and as substances known as catalysts that increase the rate of chemical reactions. While nickel comes in different forms, generally, the abundance of nickel in soil comes in the form of hydroxide and oxide. For the US EPA Regional Screening Levels-Residential Soil, the most toxic forms of nickel were considered (i.e. carbonyl and hydroxide) to reflect a conservative approach and ensure the safety of vulnerable populations (i.e. children and older people).

What happens to nickel when it enters the environment?

Nickel is released into the atmosphere by industries that make or use nickel, nickel alloys, or nickel compounds. Nickel is found in soil and is emitted from volcanoes. Nickel is also found in meteorites and on the ocean floor and It is also released into the atmosphere by oil-burning power plants, coal-burning power plants, and trash incinerators. In the air, it attaches to small particles of dust that settle to the ground or are taken out of the air in rain or snow; this usually takes many days. Nickel released in industrial waste-water ends up in soil or sediment where it strongly attaches to particles containing iron or manganese. Nickel does not appear to accumulate in fish or in other animals used as food.

How can nickel affect my health?

You can be exposed to Nickel through food (major source of exposure), skin contact with soil, bath or shower water, metals containing nickel, smoking tobacco containing nickel, and by handling coins or touching jewelry containing nickel. The most common health effect is an allergic reaction, usually a rash due to skin contact. People working in nickel refineries or nickel-processing plants have experienced chronic bronchitis and reduced lung function by breathing air containing nickel; however, such reactions are the result of breathing amounts of nickel much higher than levels found normally in the environment. Cancers of the lung and nasal sinus have resulted when workers breathed dust containing high levels of nickel compounds. Nickel exists in different forms in the environment.

Where can I get more information on Nickel?

Agency for Toxic Substances and Disease Registry. ToxFAQs™ for nickel.

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<https://doi.org/10.1016/j.envpol.2022.119914>

Vanadium

Contaminant Name: Vanadium (V)

Contaminant Type: Transitional Metal

What is Vanadium?

Vanadium is a natural element found in the Earth's crust. Vanadium is commonly used to prevent rust and stabilize steels. Vanadium compounds are used in ceramics, and magnets, and are used in dietary supplements.

What happens when Vanadium enters the environment?

Vanadium is mostly released through natural processes such as volcanic emissions or ocean vapor. Vanadium is also released through human activity including the industrial use of oil and coal. It is released into the atmosphere and goes into the soil. Vanadium can be separated from air particles and dissolve in water. It builds up in fish but not as much in other organisms. It can be found in plants if the area has high levels of fuel oil consumption.

How can Vanadium affect my health?

Vanadium is a part of our diet (even used in dietary supplements). Despite this, vanadium can still affect your health. People can be exposed to vanadium by:

- Breathing in vanadium (harms the lungs and results in coughing)
- Eating too many dietary supplements that contain vanadium
- Exposure to cigarette smoke

Negative effects occur at 13mg (about 13 times more than the normal dose) or more of vanadium. Taking too much vanadium can result in stomach cramps, nausea, and mild diarrhea. The long-term effects of ingesting or inhaling vanadium are currently unknown.

Where can I get more information on Vanadium?

Agency for Toxic Substance and Disease Registry.

Last Updated on June 15, 2015.



<https://wwwn.cdc.gov/TSP/ToxProfiles/ToxProfiles.aspx?id=276&tid=50>

Zinc

Contaminant Name: Zinc (Zn)

Contaminant Type: Transitional Metal

What is Zinc?

Zinc is found in the Earth's crust. Zn is commonly used as a coating for steel, iron, and other metals to prevent rusting. Zinc compounds are widely used to make paint, rubber, dyes, wood preservatives, and ointments.

What happens to zinc when it enters the environment?

Some zinc is released into the environment by natural processes, but most comes from human activities like mining, steel production, coal burning, and burning of waste. It attaches to soil, sediments, and dust particles in the air. Rain and snow remove zinc dust particles from the air. Most of the zinc in soil stays bound to soil particles and does not dissolve in water. It builds up in fish and other organisms, but it does not build up in plants.

How can zinc affect my health?

Zinc is an essential element in our diet. Too little zinc can cause problems, but too much zinc is also harmful. People can be exposed to zinc by:

- Drinking contaminated water or a beverage that has been stored in metal containers or flows through pipes that have been coated with zinc to resist rust.
- Eating too many dietary supplements that contain zinc.
- Working in any of the following jobs: construction, painting, automobile mechanics, mining, smelting, and welding; manufacture of brass, bronze, or other zinc-containing alloys; manufacture of galvanized metals; and manufacture of machine parts, rubber, paint, linoleum, oilcloths, batteries, some kind of glass, ceramics, and dyes.

Harmful effects generally begin at levels 10-15 times higher than the amount needed for good health. Large doses taken by mouth for a short time can cause stomach cramps, nausea, and vomiting. Taken longer, it can cause anemia and decrease the levels of your good cholesterol. Inhaling large amounts of zinc can cause a short-term disease called metal fume fever. Long-term effects of breathing high levels of zinc are currently unknown.

Where can I get more information on Zinc?

Agency for Toxic Substances and Disease Registry. ToxFAQs™ for Zinc.

Last Updated on January 21, 2015.



<https://www.atsdr.cdc.gov/phs/phs.asp?id=300&tid=54>