Center for Health, Work & Environment
colorado school of public health

JULY
2024

San Luis Valley Water Quality Report

Arsenic

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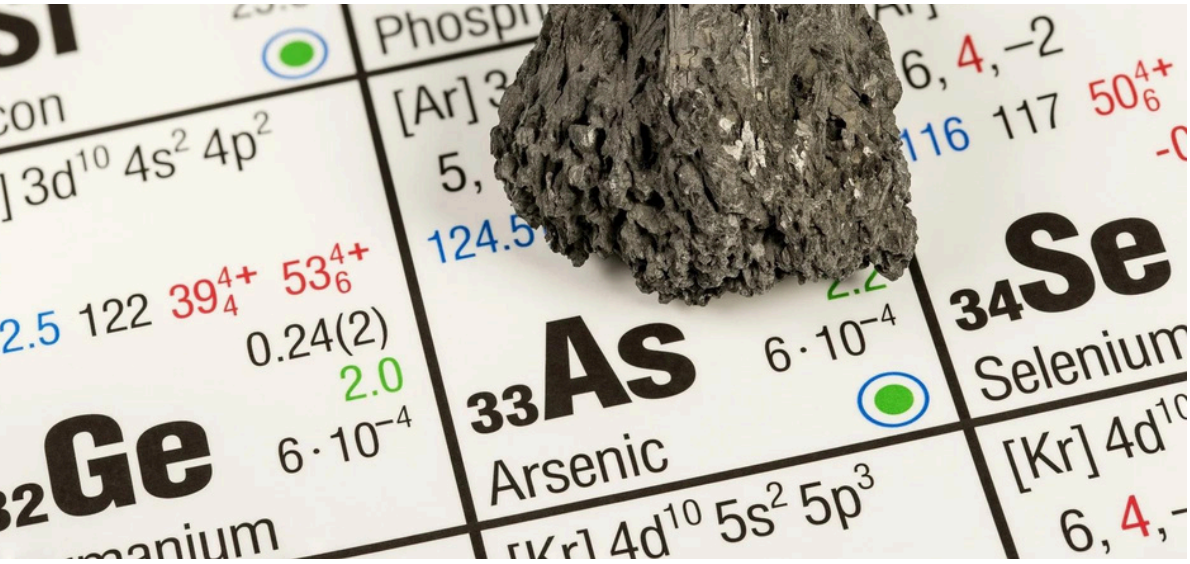
Research reported in this publication was supported by the National Institute of Environmental Health Sciences of the National Institutes of Health (NIH) under Award Number R01ES032612. The content is solely the responsibility of the authors and does not necessarily represent the official views of the NIH.

Table of Contents

CONTENTS

WHAT IS ARSENIC?



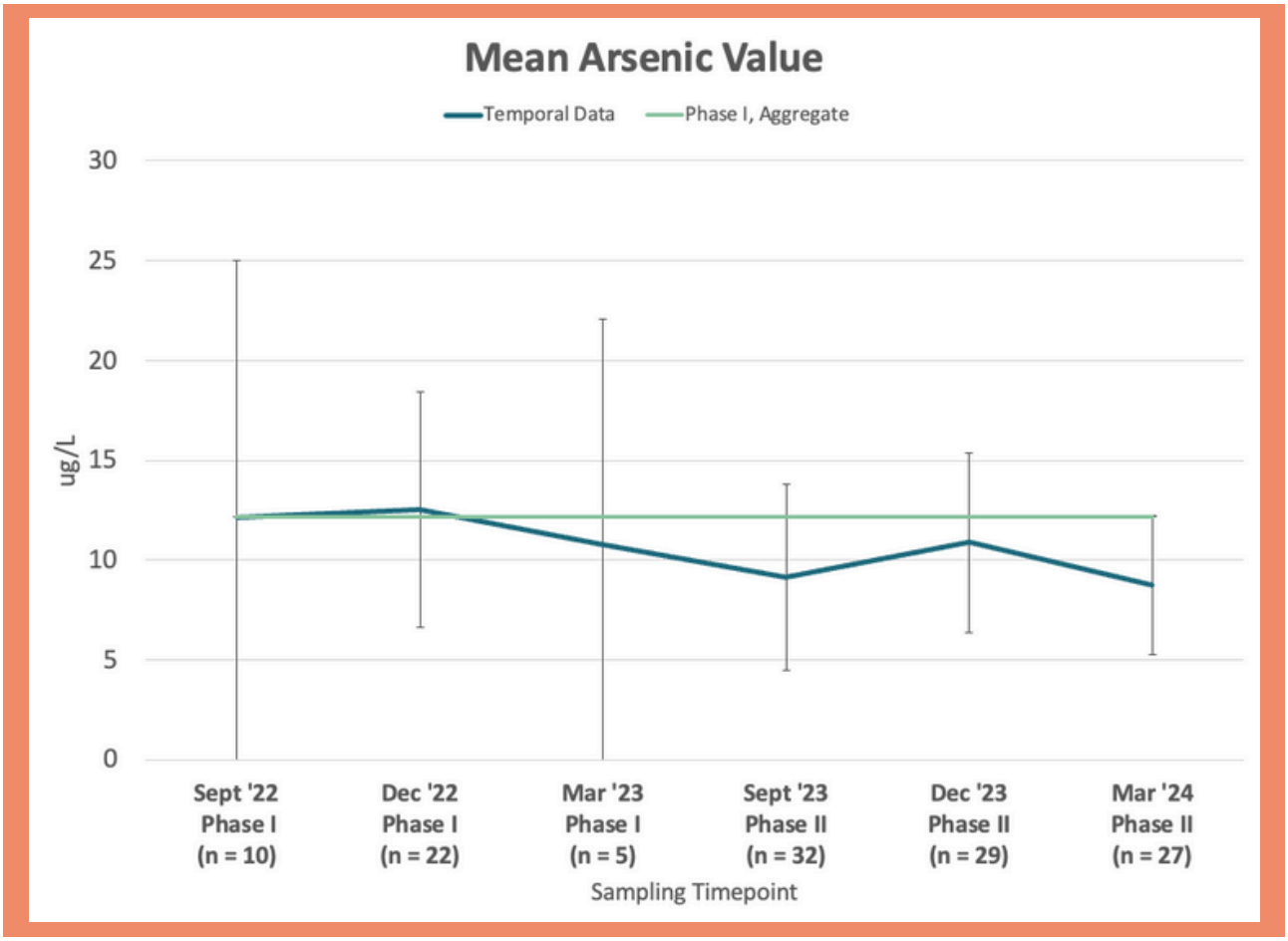
Arsenic is a naturally occurring element in the earth's crust. Often classified as a metalloid, arsenic in the environment is usually found combined with other elements such as oxygen, chlorine, and sulfur (inorganic arsenic); or carbon and hydrogen (organic arsenic). Most arsenic compounds are white or colorless powders that do not evaporate, have no smell, and no special taste. It is almost impossible to tell if arsenic is present in food, water, or air without laboratory analysis.

In the San Luis Valley (SLV), the presence of arsenic is largely due to the region's geologic formation along the continental divide and historic volcanic activity. However, human activities can also introduce arsenic to the environment. Mining can expose arsenic deposits to the elements, allowing it to infiltrate water resources or be displaced by the wind. While arsenic is no longer permitted for use on agriculture produce, it may still be present in the soil where it was heavily used.

Globally, arsenic possesses the greatest threat to human health through drinking water (specifically in the more toxic, inorganic form). A number of countries including Argentina, Bangladesh, Cambodia, Chile, China, India, Mexico, Pakistan, the United States, and Viet Nam have regions known for high levels of arsenic in groundwater. Populations in these regions are at an increased risk of health effects from cumulative exposure.

While the general U.S. population may experience minimal or no exposure from drinking water, this is not the case for drinking water from private wells in the SLV. In Phase I of our community-wide sampling of privately owned groundwater wells, 94.8% of samples contained a measurable level of arsenic. However, it is also important to note the technical limits of the equipment used to measure levels of arsenic in these samples. Our team has established the ICP-MS equipment used to analyze samples to have 5% accuracy (percent error from known reference solutions) and 5% precision (percent variation in triplicate measurements in known reference solution).

Current government regulations only regulate drinking water contaminate for municipal or public water suppliers. There are no established programs for addressing contaminated drinking water for private well owners.



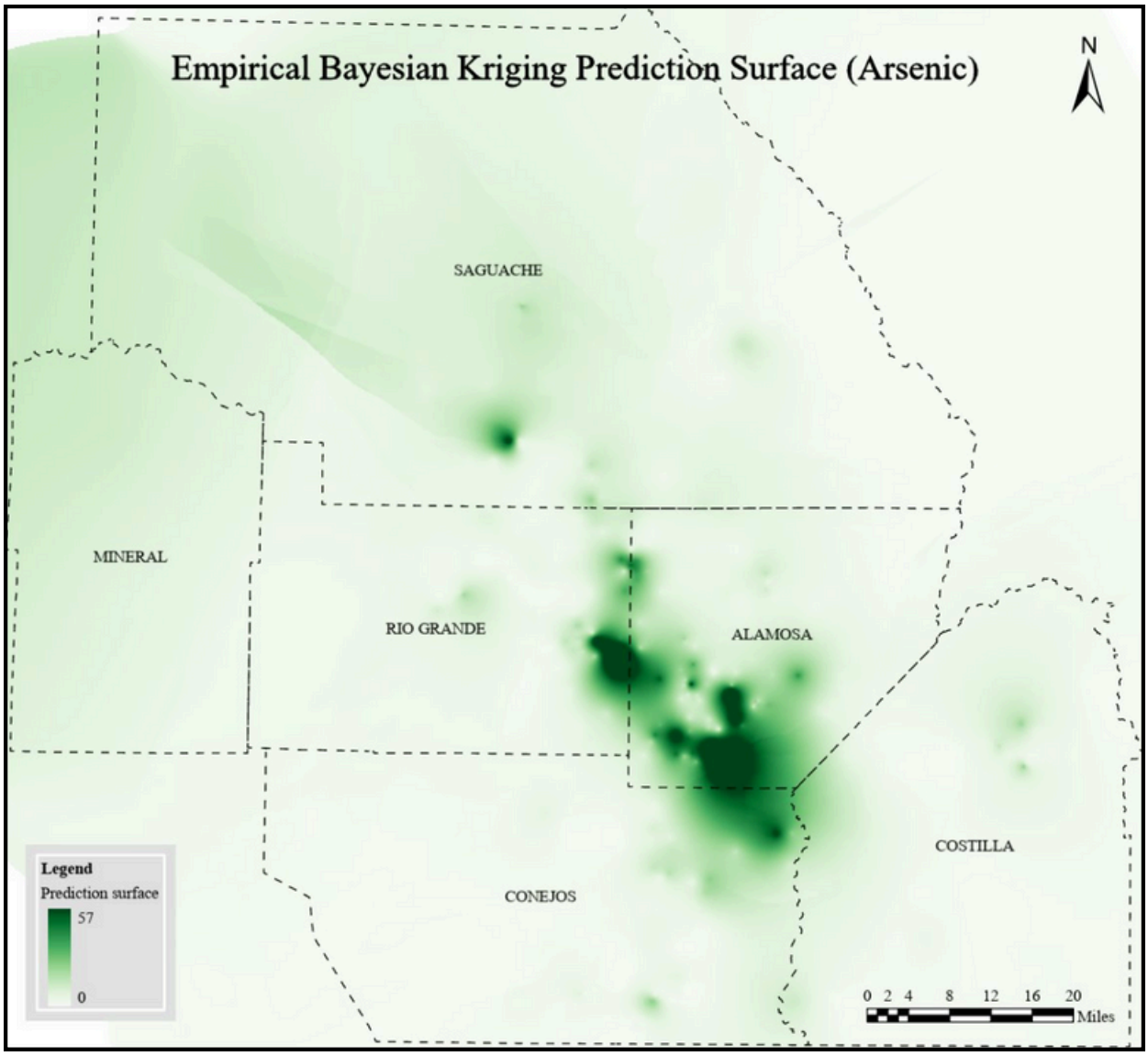
TEMPORAL MODELING

As part of our current project, we're investigating how arsenic levels in groundwater vary across the San Luis Valley region and over time. By analyzing samples from the community and information from well permits publicly maintained by the Division of Water Resources, our partners at Colorado State University and Stanford University are using results to create a predictive arsenic model.

In the graph above, we've displayed preliminary results for the fluctuation of arsenic over time. These results are based on the roughly 45 community members participating in the Phase II repeated sampling. Phase I timepoints were created using Phase I samples from Phase II participants. The green reference line indicates the mean level of arsenic for alPhase II participants across the Phase I timeframe.

Please note, that these results are limited in their generalizability due to the uneven distribution of Phase I samples across these pseudo timepoints and may not accurately represent how water quality changes with time Our understanding of this relationship is likely to change as we collect more data.

On the next page, we included a spatial model predicting the presence of arsenic in groundwater across the SLV.



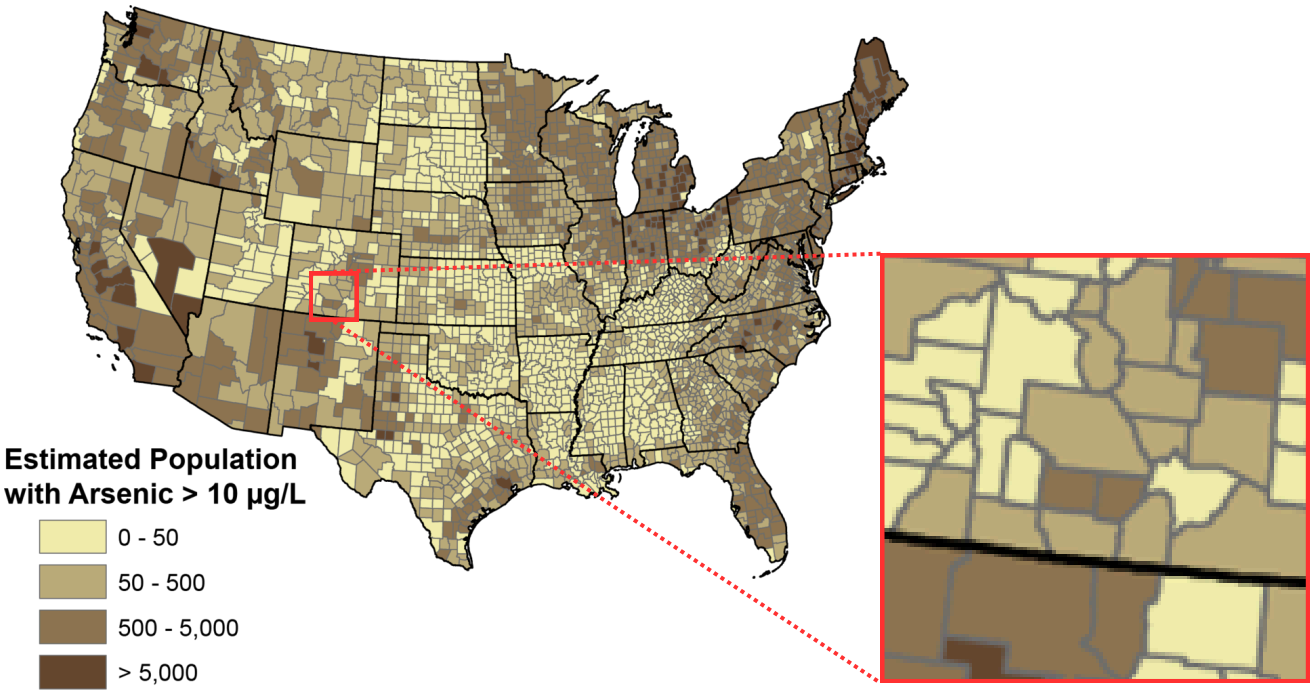
Prepared by Guiye Li and Dr. Geofeng Cao at the Department of Geography at the University of Colorado, Boulder.

University of Colorado Boulder

CONCENTRATION MAP

Using data collected in Phase I of the study, we've created a map to show the distribution of arsenic concentrations across the San Luis Valley. Please note, arsenic concentrations are likely influenced by well depth, surrounding soil/minerals, and other complex geologic factors

This map was created using Empirical Bayesian Kriging (EBK) methods. EBK is a modeling technique that uses prior collected data to predict a range of values at locations without any sampling sites. It allows us to estimate metal concentrations more accurately while accounting for a level of uncertainty.



https://www.usgs.gov/mission-areas/water-resources/science/arsenic-and-drinking-water

GROUNDWATER PRESENCE

The United States Geologic Service plays an active role in monitoring and managing natural resources. It has facilitated multiple assessments on the contaminants of groundwater resources in the United States, including arsenic. The map above utilizes information collected by USGS to estimate portions of the population at-risk for arsenic exposure from groundwater resources. Using these county-level estimations, we would expect the following percentage of county residents to be exposed to water with arsenic levels above 10 ug/L:

3% - 33% ALAMOSA
Population: 15,181

0% - 7% MINERAL
Population: 764

1% - 6% CONEJOS
Population: 8,161

4% - 44% RIO GRANDE
Population: 11,238

1% - 13% COSTILLA
Population: 3,822

1% - 18% SAGUACHE
Population: 6,824

Due to regulations established by the U.S. Environmental Protection Agency, municipal and public water districts are required to monitor arsenic contamination and implement mitigation strategies when contamination reaches the 10 ug/L threshold.

Following sections in this report will cover information on health effects and possible interventions.

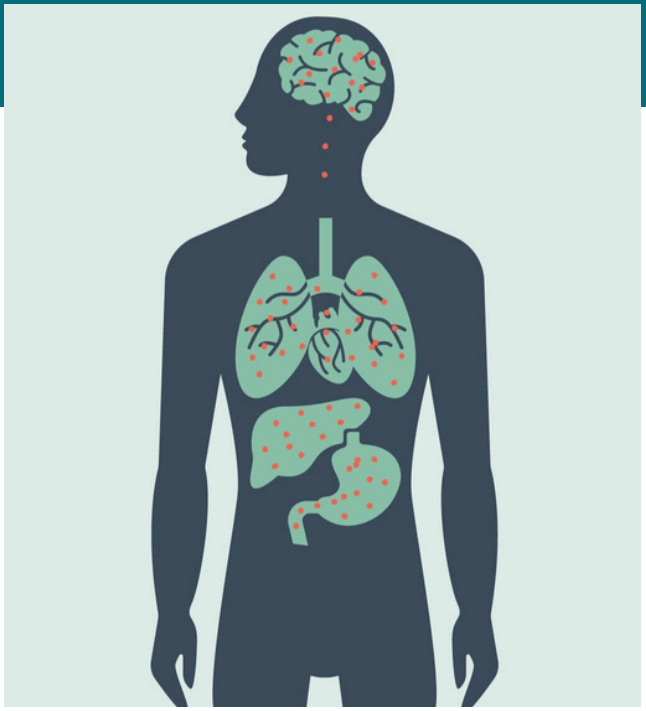
EXPOSURES AND HEALTH EFFECTS

Exposure to arsenic can result in a variety of health effects depending on the the metal's form, mode of exposure, and duration of exposure. In the context of the San Luis Valley (SLV) communities and environmental health, ingestion is the primary mode of arsenic exposure. Inhalation exposure is of concern for certain occupations, but not the typical community setting. Dermal exposure results in low absorption by the body, and rarely results in adverse health effects.

While we discuss the health effects of arsenic within the individual context of these three modes of chronic exposure, their influence on human health is cumulative. Additionally, research on the health effects of arsenic is primarily focused on the more toxic inorganic form. In any circumstances where your level of exposure is of concern, we recommend consulting with your primary care provider.

INGESTION

As previously mentioned, water resources in the SLV have been characterized by the presence of arsenic. This is primarily due to the region's geologic formation and may be exacerbated by regional drought conditions. While we expect ingestion of arsenic to primarily occur from contaminated water, it may also occur in smaller amounts due to bioaccumulation in certain produce. Root crops like potatoes, beets, and carrots can accumulate arsenic in the outer-skin layer. Grains like rice, which are highly water-absorbent, are often seen to have higher levels of arsenic due to the amount of water needed to grow, harvest, and cook the grain. The amount of arsenic absorbed by these crops is dependent on the amount and form of arsenic in the soil and water. Due to its previous use in agrochemicals, lingering amounts of arsenic in orchard soil may



still be absorbed by fruits like apples, pears, and grapes. While this level of absorption is relatively low; concentrates made from these fruits may also result in overall higher arsenic concentration.

After absorption by the body, arsenic can be found in nearly all bodily tissues (including the brain and fetal tissue). Therefore, long-term ingestion to arsenic can been associated with a wide range of human health effects. Epidemiological studies have found exposure to arsenic to be a risk factor for developing skin, bladder, lung, and all-type cancer. Additionally, research has started to show associations between in-utero and early childhood exposures and adverse neuro-cognitive effects. A table on the next page describes exposure doses and associated health effects.

INHALATION

Most research on the health effects of arsenic exposure via inhalation focus on occupational settings where workers are regularly exposed to airborne particulate. In the community setting, we would expect to see minimal or non-existent exposure to airborne arsenic particulate unless introduced from nearby smelting facilities, chemical plants, or weathered geologic arsenic deposits.

Our research team is currently not aware of any

environmental sources of inhalation exposure in the San Luis Valley. Occupational exposure may occur from smelting facilities, chemical plants, or agriculture pesticides. Specifically, organic arsenic compounds used in pesticides include cacodylic acid, disodium methyl-arsenate (DSMA), and monosodium methyl arsenate (MSMA). Concern for occupational exposures may best be addressed by your employer or primary care provider.

For instances where there is a notable amount of community-level exposure, research has found inhalation of arsenic to be associated with impaired neural conductivity, general respiratory irritation, and lung cancer. Inhalation exposure will contribute to your overall cumulative exposure, and may contribute to health effects associated with other modes of exposure, or health effects with multiple contributing factors.

DERMAL

Adverse health effects of arsenic from dermal exposure have not been extensively investigated. Any observable health effects would likely occur due to frequent exposures at high concentrations. The literature primarily cites studies focused on occupations in metal production facilities and agriculture. These exposure are most likely to result in general skin irritation or contact dermatitis.

INGESTION DOSES AND HEALTH EFFECTS

mg/kg/day	Health Effects	Equivalent Dose (mg/day)*
0.002	Anemia and leukopenia	0.18 - Adult Men 0.15 - Adult Women 0.13 - Adolescents 0.07 - Child 0.02 - Infant
0.005	Neurologic symptoms (fatigue, headache, dizziness, insomnia, extremity numbness)	0.45 - Adult Men 0.39 - Adult Women 0.33 - Adolescents 0.18 - Child 0.04 - Infant
0.006	Adverse reproductive outcomes	Unavailable
0.03-0.05	Minor respiratory symptoms	3.6 - Adult Men 3.08 - Adult Women 2.64 - Adolescents 1.4 - Child 0.32 - Infant
0.015-0.065	Decreased blood circulation in hands and feet	
0.03-0.05 (chronic)	Nausea, vomiting, diarrhea, and abdominal pain	
0.006-0.1	Liver damage	4.77 - Adult Men 4.08 - Adult Women 3.5 - Adolescents 1.86 - Child 0.42 - Infant
0.055	Hypertension	4.95 - Adult Men 4.24 - Adult Women 3.63 - Adolescents 1.93 - Child 0.44 - Infant
0.01-0.1	Warts or corns on palms and soles of feet, hyperpigmentation of the face, neck, and back	
0.03-0.1	Damage to sensory and motor nerves	5.85 - Adult Men 5.01 - Adult Women 4.29 - Adolescents 2.28 - Child 0.52 - Infant

*Assuming average weights for adult men (90kg), adult women (77kg), adolescents (66kg), children (35kg), and infants (8kg). Estimated dose represents exposure accounting for volumen of intake, concentration, and body weight - all of which fluctuate daily.

INTERVENTIONS

Identifying a health risk is the first step in promoting public health. If you're being exposed to arsenic and want to take precautions, what's next?

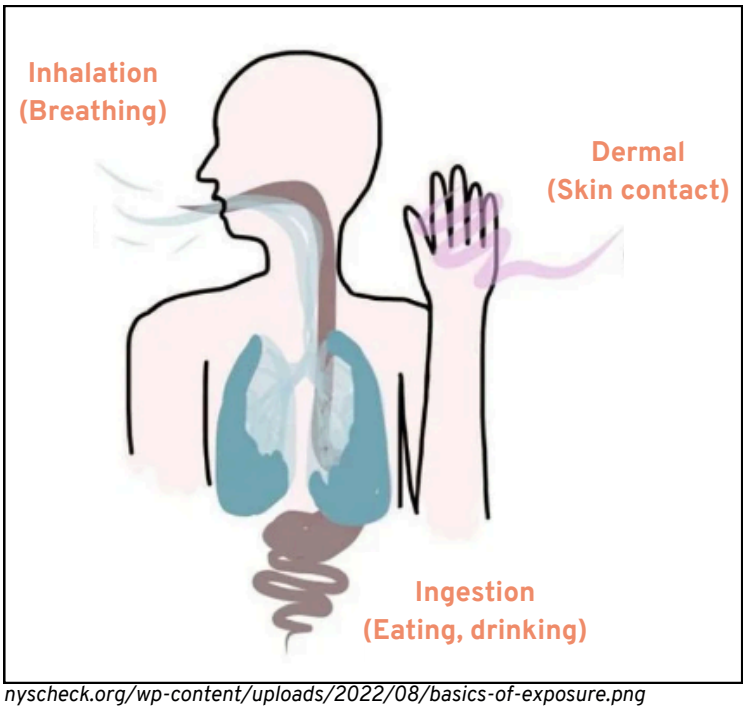
CUMULATIVE EXPOSURES

Understanding where your exposure originates is important. While this report described health effects of arsenic through routes of exposure most likely to cause health effects, they are not mutually exclusive. In fact, human health effects almost always result from your cumulative exposure - or your total exposure.

Toxicologists have investigated arsenic's interaction with the human body and have estimated proportions of arsenic absorption based on the route of exposure:

95% Ingestion
60-90% Inhalation
<1-5% Dermal

Understanding how arsenic enters your body is important for mitigation of health effects.



nyscheck.org/wp-content/uploads/2022/08/basics-of-exposure.png

EXPOSURES AND INTERVENTIONS

In the San Luis Valley, our primary concern for exposure is ingestion. Our research team is not aware of any sources of notable concern for inhalation or dermal exposure.

Ingestion exposure is most likely to occur due to groundwater contamination in the region. Contamination is dependent on a variety of contextual factors and may occur seasonally. Ingestion may also occur through bioaccumulation of arsenic in root crops from soil and water. Bioaccumulation in crops is of less concern than direct water consumption, but still contributes to cumulative exposure. By identifying ingestion as the primary mode of exposure, we can be more efficient in targeting interventions. For residents with elevated levels of arsenic in their well water, we strongly encourage the installation of an in-home water filter or switching to municipal water sources. Point-of-use filters are more cost-effective than whole-home filters, and can significantly reduce cumulative exposure. Reverse osmosis and anion exchange filters are commonly used to reduce arsenic contamination.

It can be difficult to identify which crops may have bioaccumulated heavy metals. Consuming a well-balanced diet can help reduce the risk of consuming foods with bioaccumulated arsenic, and therefore, reduce overall exposure.

INFORMATION SOURCES

Where did we get this information?

Results and modeling in this report were created using the data collected from this research project. Specific questions about this data can be directed to Dr. James (Kathy.James@cuanschutz.edu).

Information on the human health effects of arsenic exposure, presence of arsenic in groundwater, and intervention strategies for mitigating arsenic exposure were aggregated from the following sources. Please note, the information presented was tailored to the contextual factors of the San Luis Valley. This report is not an exhaustive summary of research on arsenic exposure.

ATSDR Agency for Toxic Substances and Disease Registry

CDC Centers for Disease Control and Prevention
CDC 24/7: Saving Lives, Protecting People™

EPA United States Environmental Protection Agency

NIH National Institutes of Health
Turning Discovery Into Health

USGS science for a changing world

World Health Organization