June 2021

THE SAFE URBAN HARVESTS STUDY:

AN ASSESSMENT OF URBAN FARMS AND COMMUNITY GARDENS IN BALTIMORE CITY

SAFE URBAN HARVESTS

JOHNS HOPKINS
CENTER *for* A LIVABLE FUTURE

In collaboration with

Baltimore Office of Sustainability
People · Planet · Prosperity

UNIVERSITY OF MARYLAND EXTENSION

FARM ALLIANCE OF BALTIMORE

PARKS & PEOPLE FOUNDATION

Authors:

- Raychel Santo, Johns Hopkins Center for a Livable Future
- Sara Lupolt, Johns Hopkins Center for a Livable Future
- Brent Kim, Johns Hopkins Center for a Livable Future
- Keeve Nachman, Johns Hopkins Center for a Livable Future

Contributors:

We are indebted to our community collaborators, laboratory collaborators, and research assistants for their substantial contributions in designing and carrying out the Safe Urban Harvests study.

Community collaborators:

- Abby Cocke, Baltimore Office of Sustainability
- Neith Grace Little, University of Maryland Extension – Baltimore City
- Valerie Rupp, Parks & People Foundation*
- Mariya Strauss, Farm Alliance of Baltimore

Laboratory collaborators:

- Carrie Green, Environmental Microbial and Food Safety Laboratory, U.S. Department of Agriculture, Agricultural Research Service
- Eton Codling, Adaptive Cropping Systems Laboratory, US Department of Agriculture, Agricultural Research Service
- Ana Rule, Department of Environmental Health & Engineering, Johns Hopkins Bloomberg School of Public Health
- Rui Chen, Department of Environmental Health & Engineering, Johns Hopkins Bloomberg School of Public Health
- Kirk Scheckel, Land Remediation & Technology Division, US Environmental Protection Agency

Johns Hopkins Center for a Livable Future research assistants*:

- Ruth Burrows
- Eleanor Evans
- Bailey Evenson
- Darriel Harris
- Jim Huang
- Jotham Illuminati
- Matthew Kessler
- Audrey Swanenberg
- Colleen Synk
- Rachel Viqueira

**Affiliation at time of project contribution.*

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Administrative assistance by Veronica Greene, Joci Raynor, and Kinyasha Session, Johns Hopkins Center for a Livable Future

Mapping assistance by Jamie Harding, Johns Hopkins Center for a Livable Future

Copy editing by Christine Grillo, Johns Hopkins Center for a Livable Future

Report layout and design by Michael Milli, Johns Hopkins Center for a Livable Future

About the Johns Hopkins Center for Livable Future:

The Johns Hopkins Center for a Livable Future is an interdisciplinary academic center based within the Bloomberg School of Public Health's Department of Environmental Health and Engineering. The Center is a leader in public health research, education, policy and advocacy that is dedicated to building a healthier, more equitable and resilient food system.

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Visit **www.jhsph.edu/clf/suh** for more resources related to the Safe Urban Harvests study, including scientific manuscripts as they are published.

MESSAGES FROM OUR COMMUNITY COLLABORATORS

Farmers and gardeners in Baltimore City have shown enormous resilience during the past year of the COVID-19 pandemic. Yet they face an uncertain future, with unprecedented pressure on them to produce food for their local urban communities and, simultaneously, pressure from real estate development and city land-use policies that may threaten to displace them from their land.

We at the Farm Alliance of Baltimore are grateful to finally have these promising results from the Safe Urban Harvests study to show that the soils, irrigation water, and produce from our urban farms and gardens are indeed by and large safe for the growing of food and fibers. The results of this study should reassure city residents that the choice to farm and garden here in Baltimore is a safe one for them and their families and customers.

The City of Baltimore should look upon these results as further confirmation that farming and gardening are best seen as safe, beneficial uses for vacant land, and should pass zoning and other policies that support the growing of food as a permanent land use. Urban communities, like all communities, deserve the chance to reduce their dependence on global supply chains and to grow their own food. We are proud to be a collaborator in this Safe Urban Harvests study that establishes that this is not only a community-building practice, but also that it is a safe one.

Mariya Strauss, Executive Director, Farm Alliance of Baltimore

As a University of Maryland Extension Educator in Baltimore, I often get questions from farmers and gardeners about how safe it is to grow food in urban soils. The Safe Urban Harvests Study results help answer some of those questions in a way that is nuanced, Baltimore-specific, and consistent with the other research that I have read.

How worried should you be about soil contamination? Worried enough to test your soil and take safety precautions based on the test results, but not so worried that you stop growing food or eating a variety of fresh fruits and vegetables.

Neith Grace Little, Extension Educator—Urban Agriculture,
University of Maryland Extension—Baltimore City

The Safe Urban Harvests Study provides a strong example of how the communities of research, practice, and policymaking can collaborate to produce much stronger results than we could achieve alone. It was important to me to ensure that the study didn't just study urban-grown produce in isolation, but compared it to other types of available produce, so that the findings could best help us compare relative risk. Learning that the vast majority of garden and farm soils in the city comply with guidance on maximum heavy metals levels, and that produce grown in Baltimore City is comparable to produce from other sources, is an enormous leap forward in our ability to confidently recommend the continued support and expansion of urban agriculture in our city.

One concrete benefit to city policymaking from the Safe Urban Harvests Study so far has been in the area of soil safety. In 2014, the Baltimore Office of Sustainability put out a Soil Safety Policy for Food Production document to provide guidance to the general public and requirements for those seeking Use Permits for community gardens and urban farms. We are now in the midst of updating this policy based on the new information gleaned from the study. Changes that we are contemplating include removing the requirements to include cadmium and chromium in metal tests, providing guidance on maximum acceptable levels of arsenic in soil, and refining our guidance on how to respond to lead levels in soil. The study team has also been of great value in helping us streamline the document and link to relevant information. We expect to release the final updated policy this year.

Abby Cocke, Environmental Planner, City of Baltimore Department of Planning

The perennial question, "Is it safe to eat?" is one that resonates through urban gardening communities. Very often, urban gardeners send soil samples to be tested but either don't know what should be included in the test to adequately assess risk or they can't interpret the results. This has led some gardeners to either abandon their community gardening project or move forward, assuming the best. Safe Urban Harvests removed the guesswork for a significant portion of Baltimore agricultural and garden sites.

Given the prevalence of lead paint in demolished properties, ambient industrial contamination and hasty demolition that often involved pushing debris into a foundation and covering the space with poor quality topsoil, urban gardening requires adoption of sound practices to ensure safe harvests. Lead is the most commonly mentioned risk among urban gardeners but only a few sites tested showed elevated lead levels in soil (4% of sites) or water sources (5%), indicating that the presence is relatively low and that most gardens are using sound practices.

The study showed that the produce tested were generally as safe to consume as samples collected at grocery stores and markets. While the findings of the Safe Urban Harvest project provide valuable information to the study of urban agriculture, perhaps its greatest local benefit is the awareness it raises and the complementary information it provides that helps local farmers and community gardeners mitigate safety risks resulting from coming into contact with soil. This risk of individuals too frequently coming in direct contact with soil can be mitigated with responsible practices. This reframes the question from "Is it safe to eat?" to "Are you using safe practices?" With proper precaution, Baltimore farmers and community gardeners will be able to confidently answer, "Yes."

Valerie Rupp, Executive Director, Partnership for the National Trails System (current position); Community Grants Program Director, Parks & People Foundation (position at time of project affiliation)

EXECUTIVE SUMMARY

The Johns Hopkins Center for a Livable Future collaborated with the Baltimore Office of Sustainability, Farm Alliance of Baltimore, Parks and People Foundation, and University of Maryland Extension-Baltimore City to investigate potential metal contamination risks faced by people who grow and eat food from urban farms and gardens in Baltimore City.

During the 2017 growing season, we collected soil, irrigation water, and produce samples from 104 urban farms and gardens in Baltimore City. We also surveyed a representative from each farm or garden to better understand where and how food is being grown, and who is growing it, in the city. Our key findings are listed below.

With rare exceptions, our study shows that urban growers can continue practicing urban agriculture safely in Baltimore City.

URBAN AGRICULTURE IN BALTIMORE

- At the time of the study, the 104 farms and gardens in our study occupied over 24 acres of land. Together, they produced an estimated 93,000 pounds of produce per growing season. They also engaged about two percent of City residents as participants or visitors.
- Farms and gardens in our study varied widely in terms of who participates, how they grow food, and where the produce is consumed.

SOIL RESULTS

- **With rare exceptions, we did not find reason for concern about metals in Baltimore City growing soils. In the small number of cases where levels were high, we identified the source of contamination or provided guidance on how to address the problem.**
- At all 104 farms and gardens, the average concentrations of arsenic, barium, cadmium, and nickel in soils used to grow fruits and vegetables were below (i.e., complied with) public health guidelines.
- It is normal to find lead in the environment, including in urban soils. That said, the average soil lead levels at 96% of study farms and gardens complied with public health guidelines. Where we found higher lead levels, we identified a nearby source of contamination or resampled the soil in greater detail to provide growers with specific guidance on how to farm or garden safely. For all participants, we provided guidance about inexpensive and effective ways to reduce exposure.
- The average levels of total chromium in soils were higher than public health guidelines at 52% of farms and gardens. However, further analysis of the chromium we found led us to conclude that the chromium present was the non-toxic form. Given this, we are not concerned about the chromium found in most soils in Baltimore.

IRRIGATION WATER RESULTS

- **With rare exceptions, we did not find reason for concern about metals in irrigation water. We recommend letting municipal water run for at least ten minutes once at the beginning of the growing season, and then for a few minutes before use each time after that.**
- At 95% of farms and gardens, the levels of six metals harmful to human health in irrigation water were lower than (complied with) public health guidelines.
- At 5% of farms and gardens, lead levels in one or more sources of irrigation water were higher than public health guidelines. For rain barrels that had higher levels of lead, we identified a nearby source of contamination. For other sources of water, we resampled the water and observed a decrease in levels of metals, showing the importance of "flushing" water at the beginning of a growing season.
- We recommend avoiding drinking water from rain barrels or hoses due to the potential presence of harmful bacteria (although we did not test for bacteria in this study).

PRODUCE RESULTS

- **With rare exceptions, we did not find reason to believe urban-grown produce is any more or less safe than produce from grocery stores and farmers markets. We recommend continuing to consume diets rich in fruits and vegetables.**
- The levels of metals in urban-grown fruits and vegetables were similar to the levels of metals in the same items from grocery stores and farmers markets.
- Eating a diet rich in a variety of fruits and vegetables is healthy. The benefits from eating fruits and vegetables likely outweigh any potential risks from the small amounts of harmful metals that may be present in those foods.
- Farmers and gardeners who are concerned about exposure to harmful metals should focus on reducing their contact with soils.

*Note: Whenever possible, it is always a good idea to follow the "General recommendations for reducing contact with metals in urban soils, irrigation water, and produce" provided in this report.

CONTENTS

WHY GROW FOOD IN CITIES?

Baltimore has been at the forefront of the growing movement of people growing food, fiber, plant-based dyes, and other crops, and in some cases, raising livestock and bees, in and near cities. Urban agriculture has been gaining attention for the potential social, health, environmental, and economic benefits it can provide to participants, communities, and cities more broadly (Figure 1).

Figure 1: The Potential benefits of urban agriculture

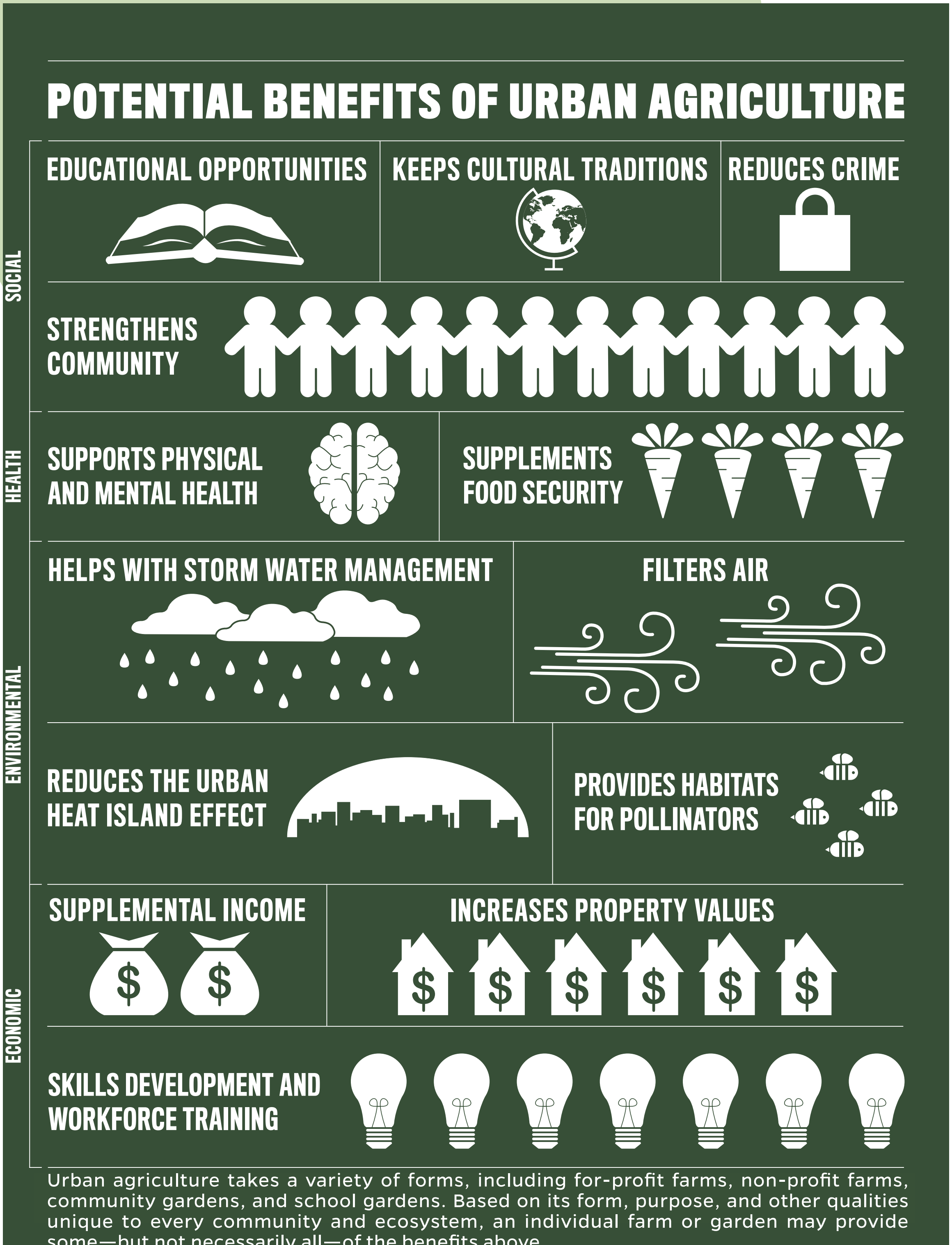


Image credit: Maya Braunstein

THE SAFE URBAN HARVESTS STUDY OVERVIEW

WHAT IS THE SAFE URBAN HARVESTS STUDY?

Along with the many benefits of participating in urban agriculture, we frequently hear questions about the safety of urban soils and urban-grown produce.

The Johns Hopkins Center for a Livable Future collaborated with the Baltimore Office of Sustainability, Farm Alliance of Baltimore, Parks and People Foundation (and its formerly active Community Greening Resource Network), and University of Maryland Extension-Baltimore City to investigate potential metal contaminants in the soil, irrigation water, and produce from Baltimore's farms and community gardens.

This study generated real-world evidence to help answer questions about the safety of urban agriculture and foster a safe and vibrant urban food system.

WHAT QUESTIONS DID THE STUDY SEEK TO ANSWER?

We aimed to answer the following research questions:

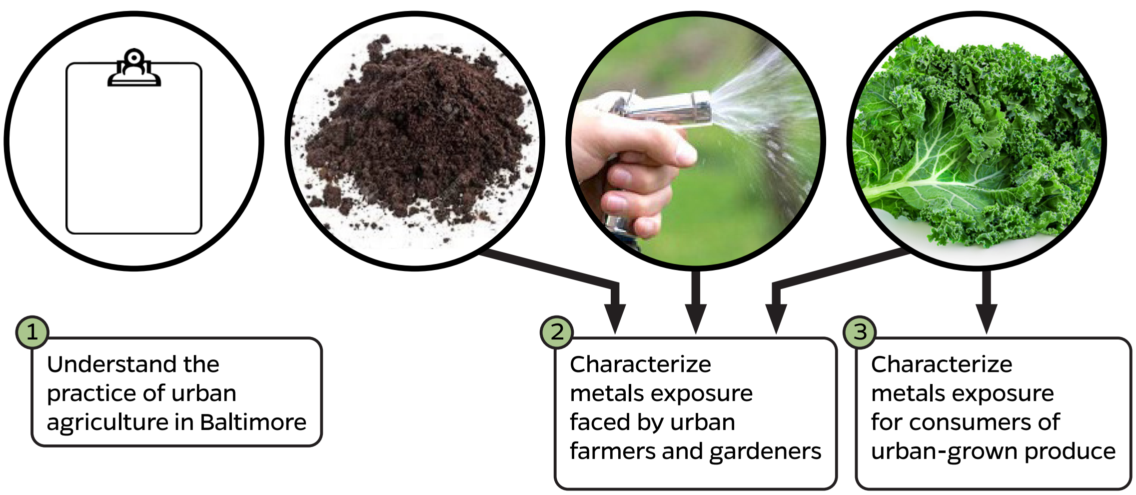
1. Where and how is food being grown in the city, and who is growing it?

2. What are the levels of metals in urban soils, irrigation water and urban-grown produce?

3. How do metals in urban-grown fruits and vegetables compare to those in fruits in vegetables from grocery stores and farmers markets?

These questions allowed us to understand the practice of urban agriculture, and answer questions related to metals exposure for urban growers and consumers of urban-grown produce (Figure 2).

Figure 2: Study aims



WHAT INFORMATION WAS GATHERED FOR THE STUDY?

During the 2017 growing season, we surveyed and collected soil, irrigation water, and produce samples from 104 urban farms and gardens (hereafter: sites) in Baltimore City.

For each site, we asked a representative to complete a survey that revealed information about their site, such as:

- How the land was used before it was a farm or garden
- The use of raised beds, fertilizers, pesticides, and other growing practices
- Who participates in activities at the farm or garden
- What fruits and vegetables are grown, and where they are distributed
- Previous contaminant testing

We then collected and measured the amount of metals in:

616 soil samples

248 urban grown fruit and vegetable samples

114 irrigation water samples

16 compost samples

We also compared the concentrations of metals found in urban-grown fruits and vegetables to concentrations in:

140 conventionally produced fruits and vegetables we purchased from grocery stores

132 fruits and vegetables we purchased from farmers markets in Baltimore City

133 USDA Certified organic fruits and vegetables we purchased from grocery stores

We interpreted the results and shared confidential site-specific reports to each participating site prior to publication of this citywide summary report. We spoke with most site representatives and gave them recommendations regarding how to reduce exposure to contaminants.

We did not collect information about gardeners' and farmers' health status, or the amount of contact they have with metals at farms or gardens. Additionally, we did not collect information about how often or how much urban-grown produce consumers eat. We, therefore, cannot answer questions about direct health impacts.

WHAT ARE METAL CONTAMINANTS AND WHERE DO THEY COME FROM?

Metals are a group of chemical elements that exist naturally in all rural and urban soils. They can be released into the environment by human activities like burning coal for electricity or manufacturing car batteries or building materials that are eventually discarded. In some cases, human activities may cause higher levels of metals in urban soils than rural soils.

Some metals (like arsenic, barium, cadmium, lead, and nickel) can make people sick. Other metals (like calcium, copper, iron, magnesium, manganese, phosphorus, potassium, and zinc) are considered essential for human and plant health and can be beneficial in certain amounts.

Figure 3 shows some of the sources of metals. It also shows some ways that you might come into contact with them while working in the garden or eating urban-grown fruits and vegetables.

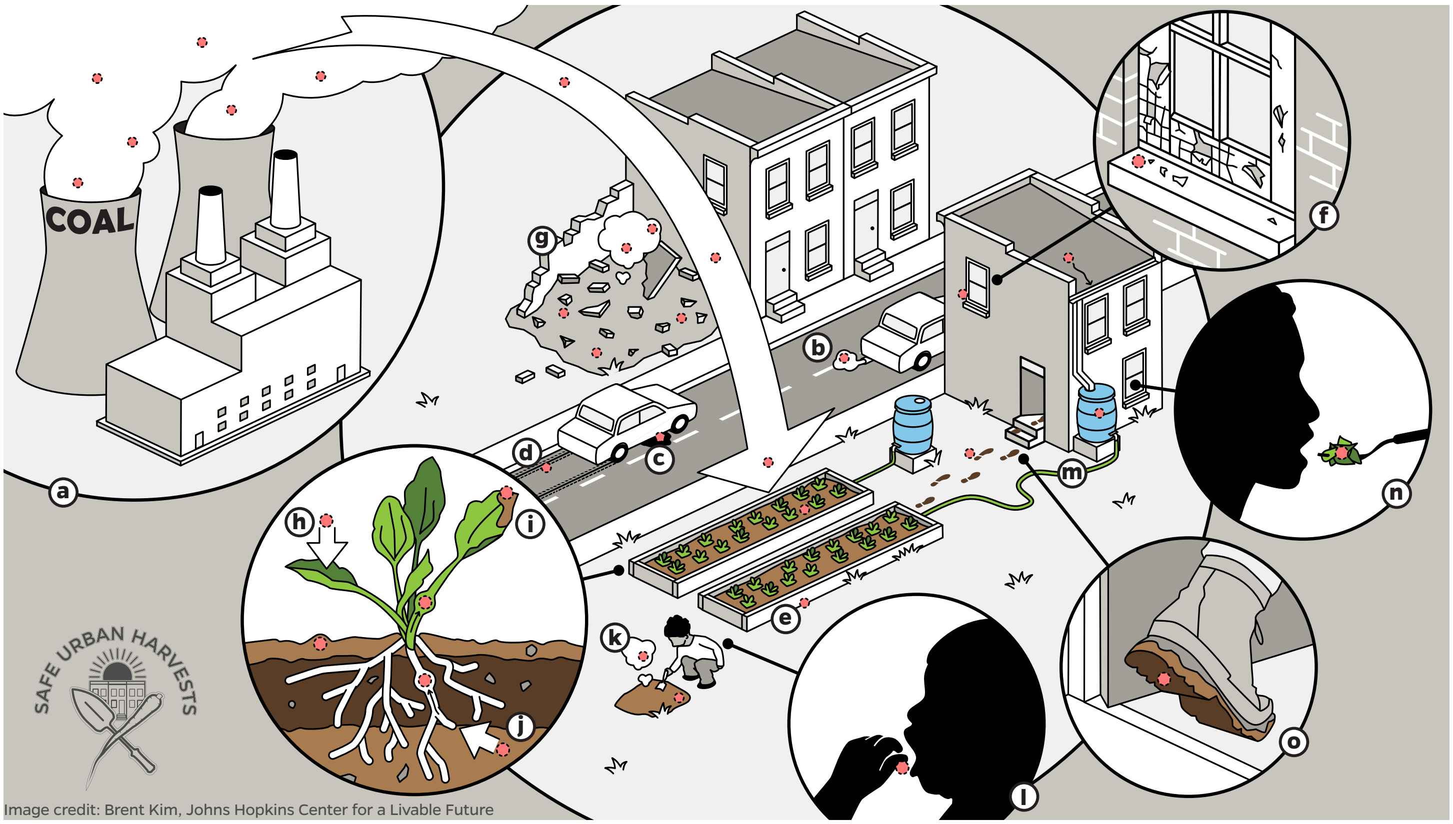
HOW WERE SITES RECRUITED TO PARTICIPATE IN THE STUDY?

We contacted farms and gardens in our collaborator organizations' directories via phone, email, and/or Facebook asking them to participate in the study. We sought out other eligible sites through a combination of word of mouth, online searches, social media posts, and email lists. We also identified a few potential sites while traveling to other sites in the city.

Eligible participants included farms and gardens that were growing edible food within Baltimore City limits in 2016 or 2017 and distributed their produce to more than one family. (Home gardens were not eligible). We did not deliberately recruit school gardens, but we did not exclude those that heard of the study and asked to participate.

A total of 125 eligible sites—urban farms, community gardens, and faith-based or charity gardens—were identified by December 2017. Of those, 92 (74%) agreed to participate. An additional 12 educational gardens (almost all at schools) asked to participate, yielding a total of 104 participating sites. Participating sites were distributed across the city (Figure 4).

Figure 3: Sources of harmful metals and pathways to soil, water, produce, and people



Where do harmful metals come from?

- Industrial sources, such as coal power plants (a)
- Vehicle exhaust (b), automotive fluids (c), and tire wear (d)
- Treated lumber (e), such as for raised beds
- Chipping lead paint (f)
- Demolition of old houses (g)
- Historic uses of leaded gasoline and certain pesticides
- They occur naturally in some soils

How can metals contaminate urban-grown fruits and vegetables?

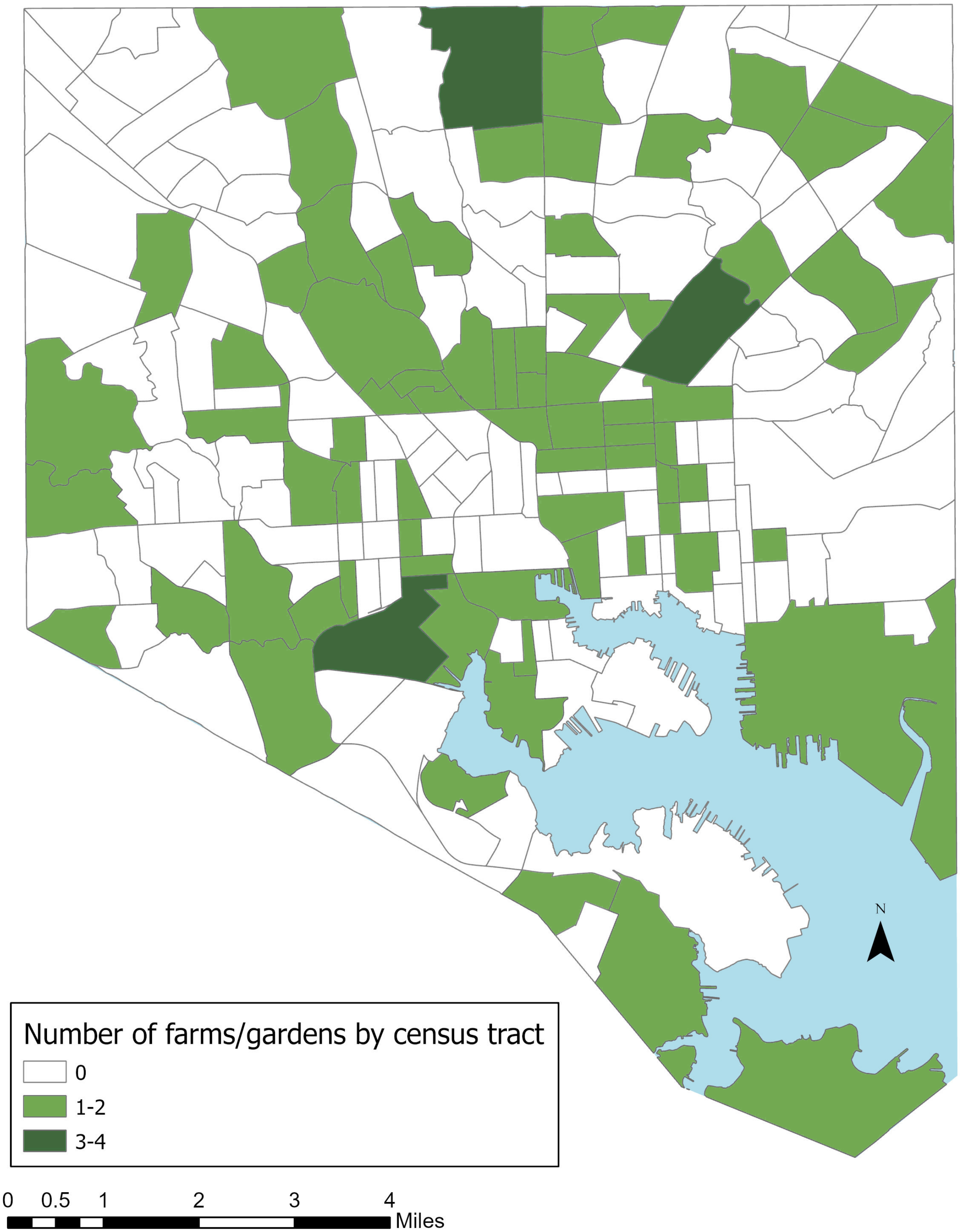
- Airborne dust containing metals can settle on or stick to the outside of fruits and vegetables (h)
- Soil can stick to the outside of fruits and vegetables (i)
- Metals in contaminated soil can be taken up inside fruits and vegetables (j)

How can I come into contact with metals?

- Breathing or swallowing airborne dust (k)
- Unintentionally swallowing contaminated soil while working or playing in it (l)
- Drinking water from a contaminated irrigation source (m)
- Eating contaminated fruits or vegetables (n)
- Tracking soil into your home (o)
- Direct skin contact with contaminated soil

Note: Most soils, water, and produce have some small amounts of harmful metals, and it is impossible for people to eliminate all contact with them. Engaging in urban agriculture may increase contact with these metals, but it does not necessarily mean that participants or consumers will get sick. It is important to recognize that there are many health benefits to growing and eating one's own fruits and vegetables. Balancing these considerations is key when making decisions in each farm or garden. However, to address concerns about contact with these metals, this report includes information about low or no-cost ways participants can reduce their contact with these contaminants on page 32.

Figure 4: Location of participating sites in the Safe Urban Harvests study



SNAPSHOT OF URBAN AGRICULTURE IN BALTIMORE

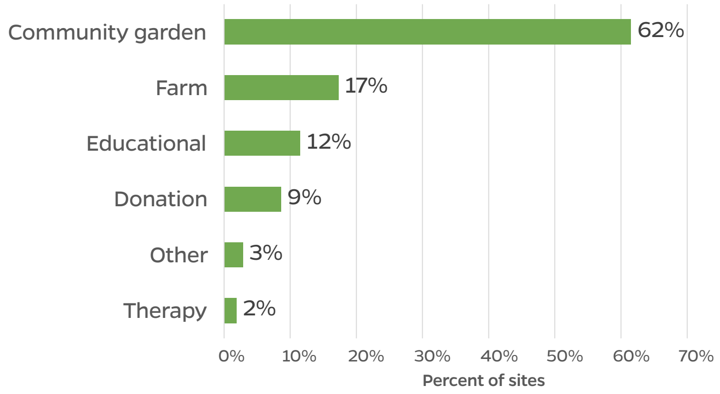
We surveyed farmers and gardeners in the study to better understand where and how food is being grown in the city, and who is growing it. The sites participating in the Safe Urban Harvests study comprised 74% of eligible farms and gardens in the city. The following results represent the characteristics and growing practices of participating farms and gardens and do not necessarily reflect urban agriculture in all of Baltimore.

We did not require respondents to answer all questions in the survey. For all percentages provided in this report, the denominator reflects only the respondents that answered the question. See our corresponding scientific research paper for the number of respondents for each question.

WHAT DOES URBAN AGRICULTURE LOOK LIKE IN BALTIMORE?

Most farms and gardens have broad missions that may include community engagement, educating youth or community members, and selling and/or donating produce. While the lines between these goals are often blurred and overlapping, we found it helpful to categorize sites based on how and where they distributed their produce. This categorization, shown in Figure 5 and described in the textbox, helps paint a picture of the general nature of sites in Baltimore City. **Notably, nearly two-thirds of sites in our study were community gardens**.

Figure 5: Classification of participating sites



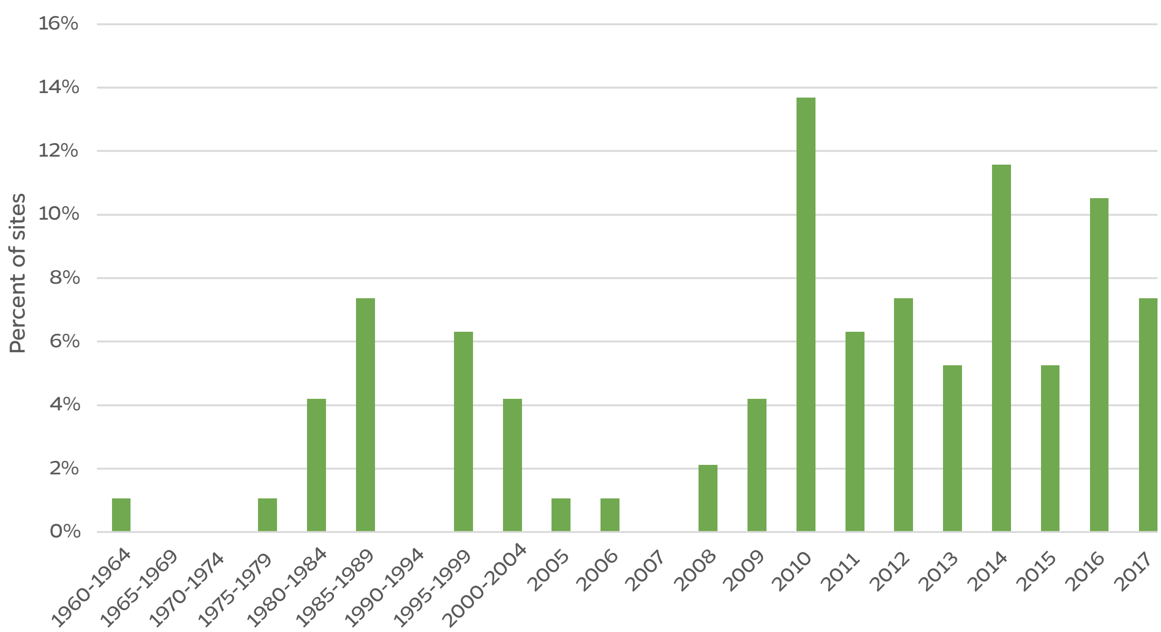
Note: Four sites were counted twice in the figure above. Specifically, three farms had community garden sections and were counted under both categories, and one educational site donated all of its produce and was also counted as a donation garden.

SITE CLASSIFICATION DESCRIPTIONS

We classified sites in our study based on how and where they distributed their produce:

- **Community gardens**: Sites where the produce was primarily consumed by growers, though some may be donated to neighbors or other organizations. They could be managed as communal growing spaces and/or plots for individual gardeners (i.e., allotments).
- **Farms**: Sites where the produce was primarily grown to be sold, although educational or community activities may occur onsite too.
- **Educational** sites: School or youth-focused gardens where the produce was used primarily to teach growing practices. The produce was not usually sold; if it was, its revenue did not contribute to the majority of the site's overall budget.
- **Donation** sites: Sites where the produce was primarily grown to be donated to food banks, soup kitchens or other charities. They were often affiliated with a religious or social services organization.
- **Therapy** sites: Gardens intended to foster health and healing for clients associated with an adjacent center.
- **Other** sites: Farms and gardens that did not meet any of the above criteria.

Figure 6: Year of establishment of participating sites

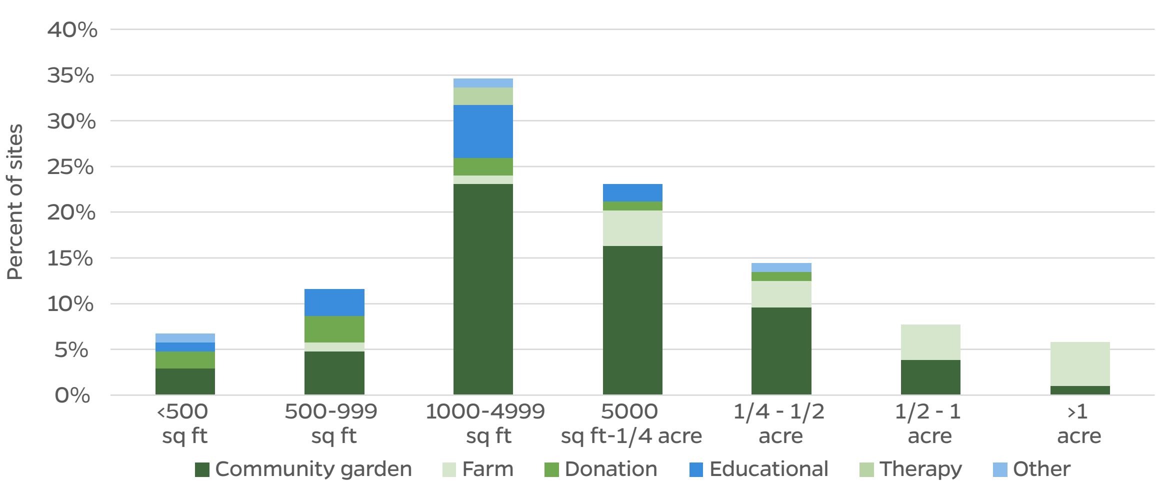


Note: Figure 6 reflects the year established of sites that participated in the Safe Urban Harvests study. There are likely farms and gardens that were established and eventually ceased to exist prior to the start of our study; as we do not have data on these farms and gardens, they are not counted in this figure.

Most sites in the study were established in the past decade (Figure 6). Eighteen percent of sites were newly established in 2016 and 2017.

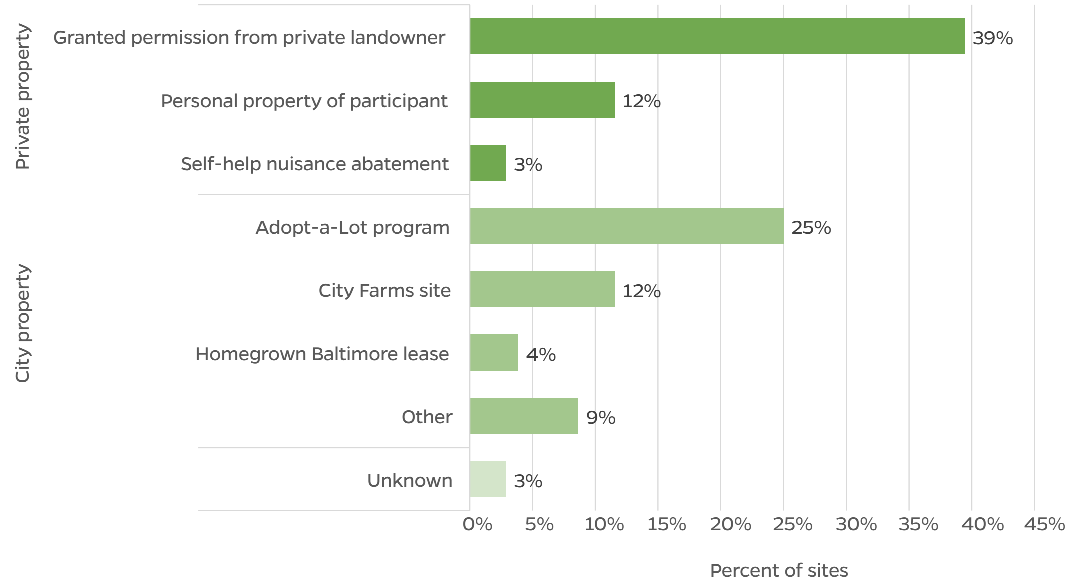
Based on measurements using Google maps, most sites were smaller than half an acre with a few larger outliers (Figure 7). The smallest site was 160 square feet (slightly larger than an average apartment bedroom), and the largest site was nearly two acres (approximately two football fields). Farms, and to a lesser extent community gardens, were most likely to be the largest

Figure 7: Size of participating sites



Note: Four sites were counted twice in the figure above.

Figure 8: Land ownership of participating sites



Note: Sites could select more than one owner of the land(s) occupied.

sites. Therapy, educational, donation, and "other" sites were the smallest, with all but two smaller than ¼ acre.

As shown in Figure 8, 54% percent of sites were located on at least some private property, the majority of which had received permission to grow from a landowner or landowning organization. Forty-nine percent were located on at least some land owned by Baltimore City. Of these, 51% were managed through the city's Adopt-A-Lot program, 24% were city-run allotment gardens (i.e., City Farms), 8% were formally leased through the Homegrown Baltimore program, and 18% occupied other city property, including land managed by local schools and the housing authority. Six sites were located on multiple plots of land with different owners so these results overlap slightly.

Most site representatives were "very confident" (65%) or "somewhat confident" (29%) that all parts of their site would remain a farm or garden in the future. Four percent were "somewhat doubtful" and two percent were "very doubtful" about the future land tenure of at least a part of their site. Of those who were doubtful, reasons cited included the site's lack of eligibility for conservation easements, concerns about the current owner closing the site, and previous experience losing land to private owners.

WHO IS PARTICIPATING IN URBAN AGRICULTURE?

During the most recent growing season, the farms and gardens in our study engaged over 9,500 people—approximately two percent of Baltimore City residents. This included people who regularly participated in growing food on the site, such as staff, interns, garden members and their household members ("regular participants"). This number also included infrequent visitors or volunteers who attended volunteer days or cooking classes.

Approximately 34% of the 5,734 regular participants identified in the study lived within one mile of their affiliated sites.

A median of 15 adults (18+ years) regularly participated at each site. Approximately two-thirds of sites engaged youth (6-17 years), and half engaged children (<6 years); a median of 10 youth and 5 children, respectively, participated at each of these sites.

WHAT ARE COMMON GROWING PRACTICES IN BALTIMORE?

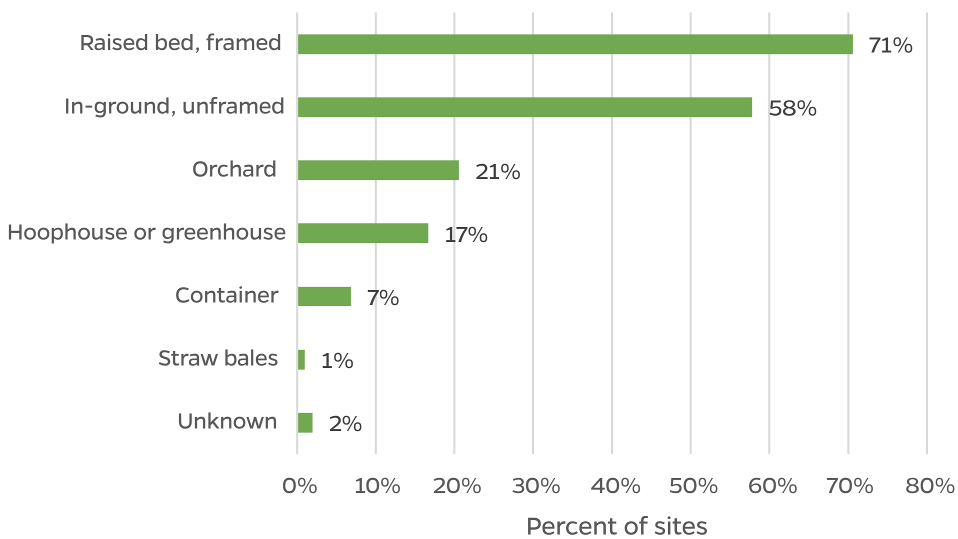
Over half of the sites grew at least some edible plants in above-ground framed raised beds (71% of sites) and directly in-ground without frames (58%) (Figure 9). Twenty-one percent included fruit trees or bushes, 17% had a hoophouse or greenhouse, 7% grew some crops in containers such as pots and tires, and one site grew plants directly in straw bales.

Sites most commonly reported using a hose to irrigate their crops (77%). Nineteen percent used watering cans, 15% used drip irrigation, 9% used buckets or containers brought from offsite, and 2% used sprinklers/misters. Farms were most likely to use drip irrigation (39%), compared to 9% of sites that were not farms.

Forty-one percent of sites were actively composting onsite. The type of composting systems varied from open piles/rows to open bins made with pallets to completely contained systems, although some sites employed more than one method. An additional 8% of sites had a compost pile or bin but had stopped maintaining it; of these, three had stopped composting due to rats.

Neither chemical fertilizers nor pesticides were frequently used. Three percent of sites reported using chemical fertilizers on their whole growing area, and 17% used fertilizers on a portion of the growing area. Two percent applied pesticides on the whole growing area and 20% applied pesticides to a portion.

Figure 9: Modes of production of participating sites



Note: Sites could select more than one mode of production.

WHAT AND HOW MUCH IS GROWN IN BALTIMORE?

We asked site representatives to identify the top five crops grown at their site, based on the area in production for each crop. We used these responses to identify the 13 crops we tested for metals harmful to human health: three fruiting nightshades (tomatoes, peppers, eggplants); three leafy greens (kale, collards, lettuce); two cucurbits (summer squash and cucumbers); four roots and tubers (carrots, beets, sweet potatoes, potatoes); one legume (string beans).

The sites in our study grew an estimated total of 93,306 pounds of produce per growing season. The median annual harvest was 213 pounds (range: 25-20,000 pounds). Farms grew substantially more produce per growing season (median: 1,335 pounds) compared to community gardens (175 pounds), donation gardens (140 pounds), and educational gardens (138 pounds).

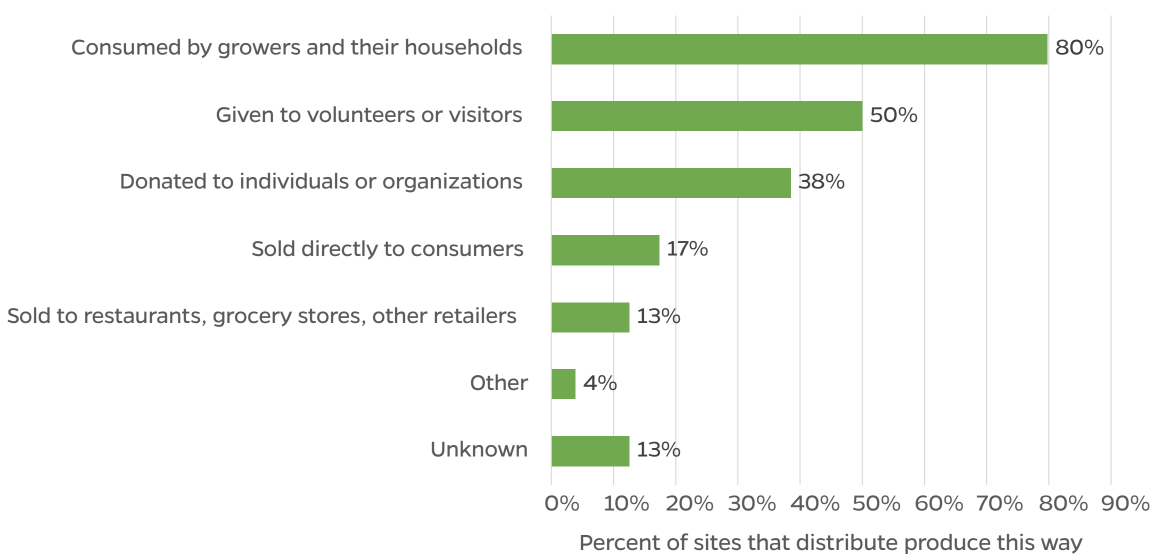
WHERE IS URBAN-GROWN PRODUCE CONSUMED?

At 80% of sites, some produce was consumed by growers and their households (Figure 10). Fifty percent of sites gave at least some produce to volunteers or visitors; 38% donated produce to individuals or organizations; 17% sold produce directly to consumers; and 13% sold produce to restaurants, grocery stores, or other retailers.

Among the sites that donated produce, 38% donated to food banks, food pantries, or produce giveaway programs (including through programs the site operated itself). Thirty-one percent of sites donated produce to community members or neighbors, 23% donated to soup kitchens or prepared meal giveaway programs, and 13% donated to youth/after school programs.

Nine sites that reported selling produce provided estimates of their approximate annual revenue (median: $3,000/year,

Figure 10: Produce distribution channels of participating sites



Note: Sites could select more than one produce distribution channel.

range: $300-80,000), and seven provided estimates of their annual profit (median: $300/year, range: $1,000-6,000). When considering farms only, the annual revenue (median: $5,000) was slightly higher, although the median profit was $0 because one site reported a loss, and two sites reported a profit of $0.

WHAT CHALLENGES DO FARMS AND GARDENS EXPERIENCE?

During onsite conversations with representatives from 89 sites, we asked them to share any challenges with theft, vandalism, or rats that they had experienced.

Forty-four percent of site representatives reported experiencing theft in the past 12 months, with an additional 6% having experienced it previously but not recently. Most of the theft reported involved produce, fruit trees/bushes, or tools/hardware such as tillers, lawnmowers, hoses, or copper piping.

Thirty-six percent reported experiencing vandalism in the past 12 months and 6% reported experiencing it previously but not recently. Littering and illegal dumping were often cited in open-ended responses, as were damage to structures on site such as fences, hoophouses, sheds, or beehives.

Thirty-five percent had observed rats onsite in the past 12 months and 8% had dealt with rats in the past but not recently and/or had resolved their rat problem. One site reported that changing their composting method to a completely contained system successfully addressed their rat problem, but there were only slight differences in the observance of rats on sites with completely contained composting systems (36% reported recent rat sightings) compared to those that used only piles/rows (32%) or open bins (41%).

HOW DO BALTIMORE FARMS AND GARDENS CONTRIBUTE TO FOOD ACCESS?

Baltimore is deeply affected by racial, socioeconomic, and geographical disparities in wealth, food security, healthy food access, and diet-related disease. Nearly a quarter of residents live in Healthy Food Priority Areas (HFPAs), formerly called food deserts, where underlying structural inequities limit access to healthy foods (see textbox). The extent to which urban farms and gardens address food access and food insecurity concerns is an important consideration.

WHAT IS A HEALTHY FOOD PRIORITY AREA?

Baltimore City defines a Healthy Food Priority Area (HFPA) as an area in which:

- the median household income is at or below 185 percent of the federal poverty level,
- over 30% of households have no vehicle
- the distance to a supermarket is greater than 1/4 mile AND
- the area has a relatively low score on an indicator related to the availability of healthy foods within stores
- Source: Misiazsek et al. (2018).

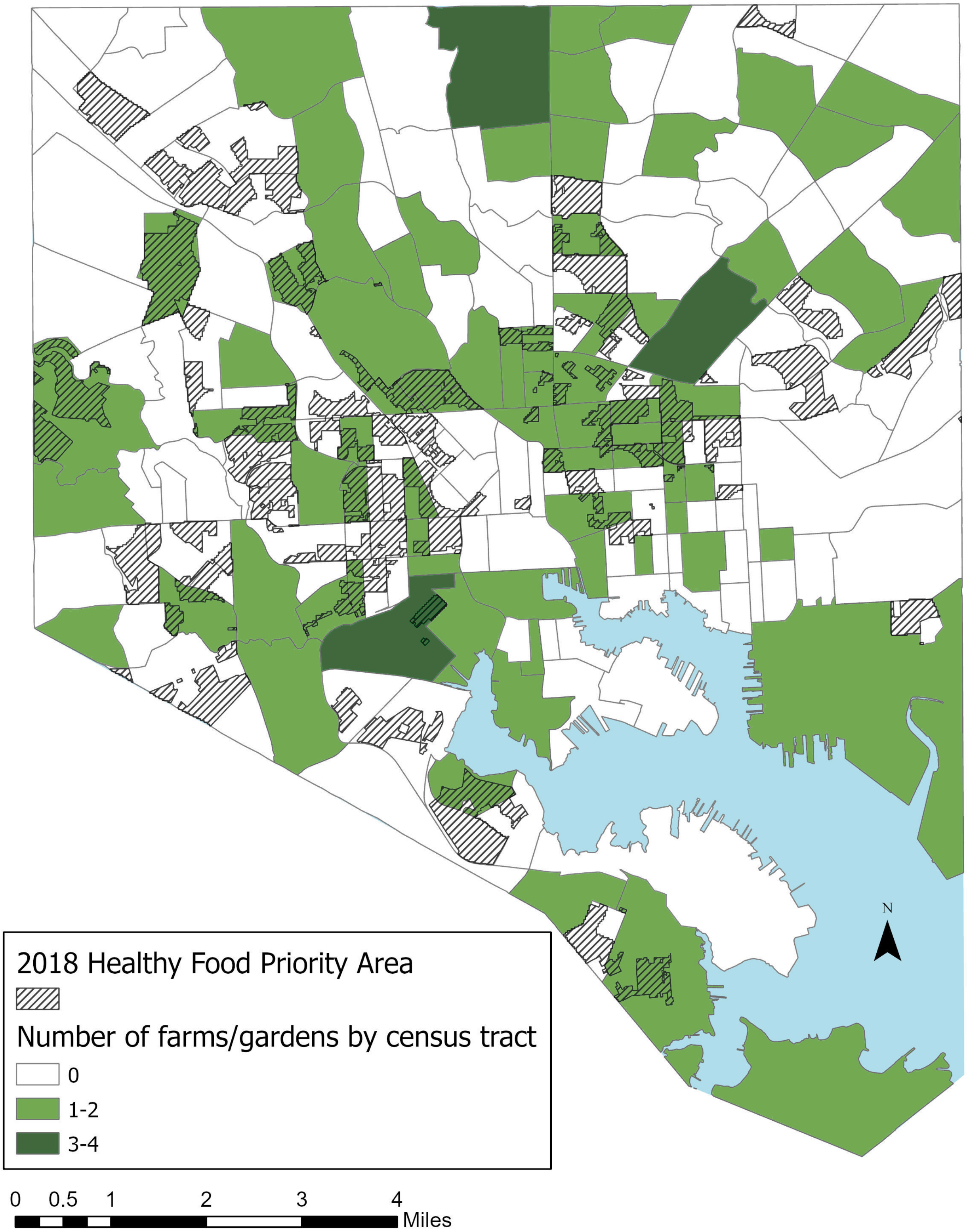
Baltimore's farms and gardens are often located in communities where healthy food access is a priority. Most (62%) sites were located in low-income areas—census tracts with a median household income below $49,199, which was 199% of the 2017 poverty level for a family of four. Fifteen percent of HFPAs in the city included at least one farm or garden in our study (Figure 11). The sites in our study were located within HFPAs at approximately the same proportion (25%) as the proportion of city residents living within HFPAs (23.5%). Additionally, urban agriculture sites within HFPAs had larger proportions of regular participants that lived within a mile of their site compared to sites located outside of HFPAs (median: 90% vs. 82.5%). These findings suggest that while residents living within HFPAs have limited access to grocery stores with healthy foods, they do not necessarily have less access to urban farms and gardens compared to other city residents.

That said, the presence of a farm or garden does not necessarily improve access to healthy food. For example, food may be grown at an urban farm located in an HFPA but be sold to restaurants that serve customers outside the neighborhood. We found proportionately more farms within HFPAs (21% were farms) compared to outside of HFPAs (15%). We also found that sites within HFPAs sold a larger proportion of their produce (average: 15%) and gave a smaller proportion to growers, volunteers, or charity (average: 73%) compared to sites outside of HFPAs (average: 11% sold and 76% given to growers, volunteers or charity).

Many urban farms list improving food access and economic empowerment as among their goals. At the same time, it may be challenging for farmers to ensure food is accessible and affordable to local residents while also staying financially afloat. The extent to which urban agriculture can satisfy these multiple goals for Baltimore producers deserves further research.

Additionally, since beginning this study, there has been increased attention within the Baltimore urban agriculture community towards actively challenging food apartheid (defined as the historical and political context that has created racial and socioeconomic disparities in the food system) through fostering Black food sovereignty. More research into the motivations of Baltimore urban agriculture participants, and how those motivations may influence specific growing practices, produce distribution channels, and other management decisions is merited.

Figure 11: Location of participating sites and relationship with Healthy Food Priority Areas



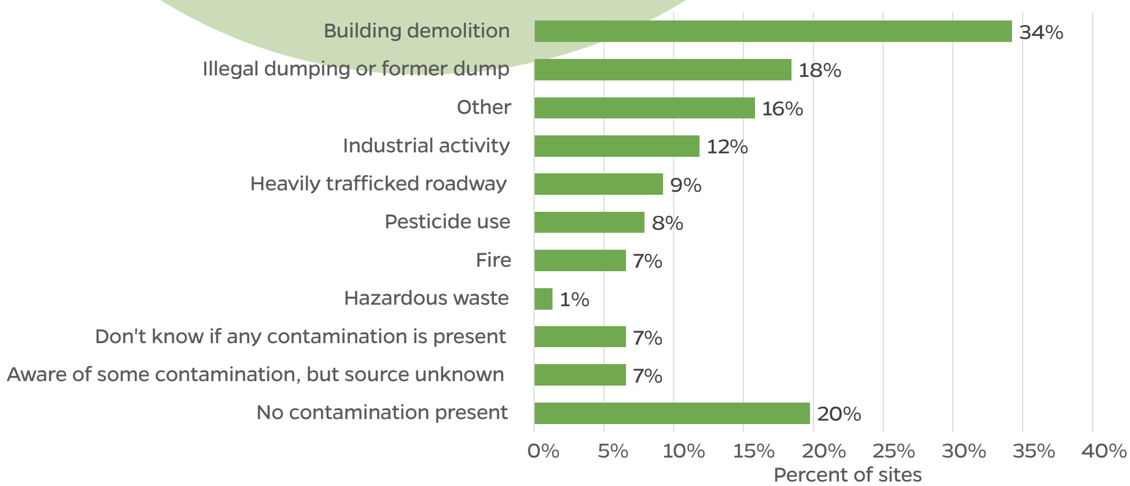
KNOWLEDGE AND PERCEPTIONS OF CONTAMINANTS PRIOR TO THE SAFE URBAN HARVESTS STUDY

WHAT WERE PARTICIPANTS' PERCEPTIONS OF POTENTIAL SOURCES OF CONTAMINATION AROUND THEIR SITE?

We asked participants if they were aware of any current or past potential source(s) of contamination that could affect their site. The most cited potential sources of contamination were building demolition onsite or nearby (34%) and the site being formerly a dump or having experienced illegal dumping before the site was established (18%) (Figure 12). Twenty percent of sites reported no known history of contamination.

Representatives from sites located within Healthy Food Priority Areas (HFPAs) were slightly more likely to report potential sources of contamination compared to sites located outside of HFPAs (69% compared to 53%). This suggests that members from these sites may perceive there to be more contamination in these areas, although our study was not designed to investigate these potential sources.

Figure 12: Potential sources of contamination onsite or nearby



Note: Sites could select more than one potential source of contamination.

HAD SITES PREVIOUSLY TESTED THEIR SOIL, WATER, OR PRODUCE FOR METALS?

SOIL

Fifty-nine percent of sites had previously tested their soil for contaminants, 24% within the previous 12 months. Most (74%) had previously tested their soil through an Agricultural Extension lab. Nine percent had used a commercial lab. Seventeen percent did not know the lab at which it was tested.

In an open-ended question about which contaminants had been tested, 95% reported including lead in a previous contaminant test, 43% had tested for other heavy metals, and one site had tested for "solvents/fuel." In addition to testing for contaminants, several respondents shared that they had tested for nutrients, pH, organic matter, or nitrates, as well.

WATER

Six percent of sites had tested their irrigation water for contaminants prior to the Safe Urban Harvests study. When asked further details, it was revealed that three of these sites were simply reporting that municipal water is tested by the city and two sites did not know where it had been tested or what contaminants had been tested for.

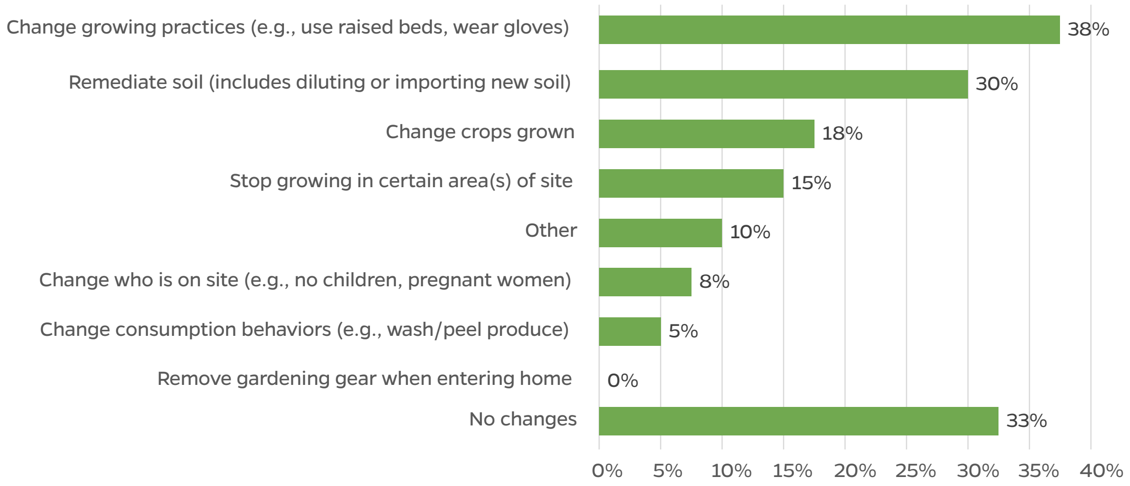
PRODUCE

One site reported having previously tested its produce for contaminants. When asked to specify which contaminants, the respondent only reported soil pH, possibly indicating that they confused an acidity test with a contaminant test.

DID TEST RESULTS PROMPT CHANGES TO GROWING PRACTICES OR PARTICIPANTS' BEHAVIOR?

Among participants who had previously tested their soil, water, or produce, we asked whether the results of previous contaminant tests had prompted site participants to change any growing practices and/or personal behavior(s) from a multiple-choice list of common practices. As shown in Figure 13, site representatives most commonly reported having changed some growing practices (38%), such as by using raised beds or wearing gloves, or remediating soil (30%), including through diluting existing soil or importing new soil. Thirty-three percent of site representatives reported no changes to growing practices or participants' behavior as a result of previous contaminant testing. In some cases, they did not change behavior or practices because satisfactory results suggested that there was no need for change.

Figure 13: Changes in growing practices or behavior in response to test results



Note: Sites could select more than one change in practice or behavior.

WERE THERE ANY BARRIERS THAT MADE IT DIFFICULT TO TEST SOIL, WATER, OR PRODUCE?

When asked about whether they had faced any barrier(s) to testing their soil, water, or produce before the Safe Urban Harvests Study, 63% of site representatives reported no barriers. Of the 37% who reported barriers, the most common barriers reported were the expense of testing (54%), lack of knowledge or experience regarding testing (33%), and lack of time to conduct testing (8%).

SOIL RESULTS

WHAT METALS WERE FOUND IN THE SAFE URBAN HARVESTS STUDY SOIL SAMPLES?

We collected soil samples at 104 farms and gardens in Baltimore and analyzed them for six metals harmful to human health (arsenic, barium, cadmium, chromium, lead, nickel). For information about how soil samples were collected and analyzed, see "Safe Urban Harvests Study Methods: How samples were collected, analyzed and interpreted."

There are no health-based standards specific to soils used in urban agriculture. To help interpret our results, we compared the levels of metals to the New York State Department of Environmental Conservation Soil Cleanup Objectives for Residential Land Use. **The lower the level of metal is below this public health recommendation, the better.**

There is no clear line denoting what is considered "safe." In most cases, there is no immediate health concern to engaging in urban agriculture. However, there may be increased risks with higher levels of exposure over long periods of time. If the level of a metal in soil is higher than the NY Soil Cleanup Objective, it is wise to reduce contact with soil whenever possible.

Figure 14 shows the average levels of four harmful metals in growing areas and non-growing areas (pathway soils, undisturbed soils) at each site in relation to the NY Soil Cleanup Objective.

KEY FINDINGS:

Growing area soils: Because growers are most likely to have direct contact with these soils through planting, digging, and harvesting, the levels of metals in these soils would ideally be less than (comply with) with public health recommendations. **Nearly all farms and gardens had growing area soils that complied with public health recommendations for all metals tested**.

- **Arsenic, barium, cadmium, and nickel**: At 100% of sites, the average levels of these metals measured were all less than (complied with) the NY Soil Cleanup Objective.
- **Lead**: At 96% of sites, the average level of lead was less than the NY Soil Cleanup Objective.
  - At sites where we found higher levels of lead, we identified a source of contamination and/or resampled the soil in greater detail to provide more specific guidance.

Non-growing area soils (includes pathways and undisturbed soils): Because people interact less with soils where they do not grow food, we were less concerned about higher levels of metals in these soils. High levels of metals in non-growing area soils may be of concern at sites where children are playing in them or where people spend extended times kneeling or digging in them.

- **Barium**: At 100% of sites, the average level was less than the NY Soil Cleanup Objective
- **Cadmium**: At 99% of sites, the average level was less than the NY Soil Cleanup Objective.
- **Nickel**: At 98% of sites, the average level was less than the NY Soil Cleanup Objective.
- **Arsenic**: At 96% of sites, the average level was less than the NY Soil Cleanup Objective.
- **Lead**: At 86% of sites, the average level was less than the NY Soil Cleanup Objective.

HOW TO READ THESE PLOTS:

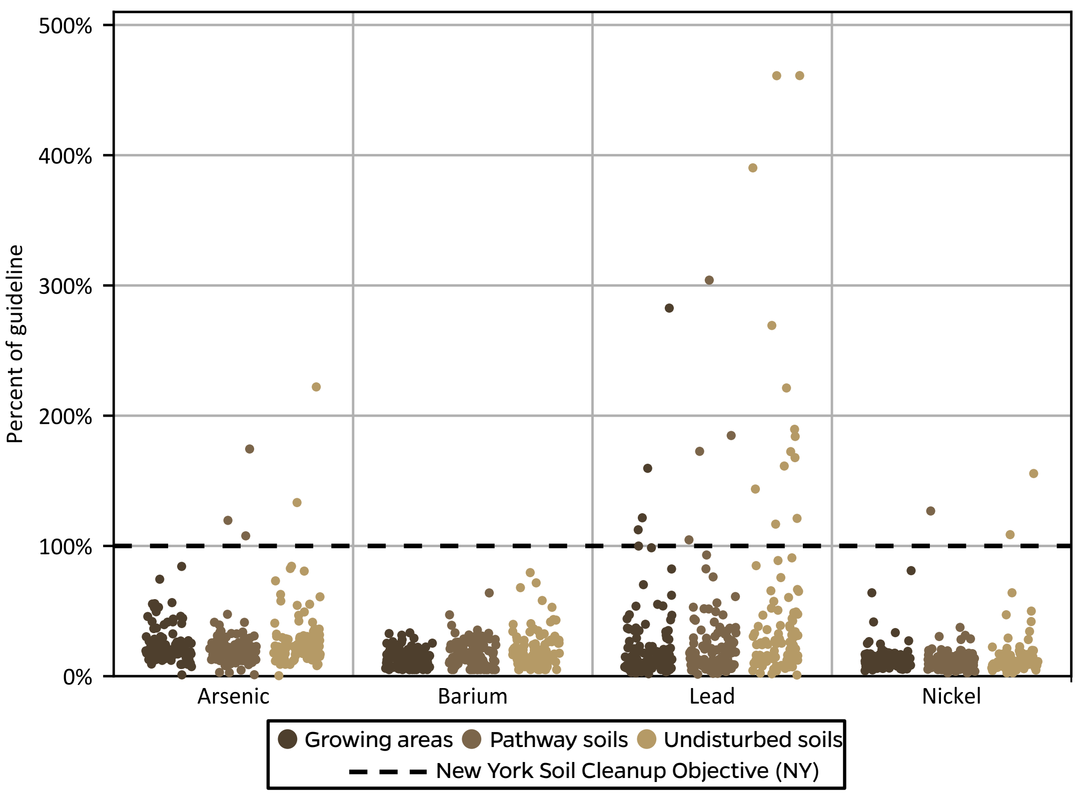
Each dot represents the average level of metal in a growing area, pathway or undisturbed soils at a site.

A value of 50% means the level of that metal in the soil was half of the NY Soil Cleanup Objective for that metal.

A value of 100% means the level of that metal in the soil was the same as the NY Soil Cleanup Objective for that metal.

A value of 200% means the level of that metal in the soil was two times greater than the NY Soil Cleanup Objective for that metal.

Figure 14: Average soil concentrations of four metals harmful to human health relative to NY Soil Cleanup Objective



Note: Cadmium was detected in less than 1% of samples so is not presented above. For the average and ranges of metals measured in soils across all sites, see the Appendix.

SOIL TYPE DESCRIPTIONS

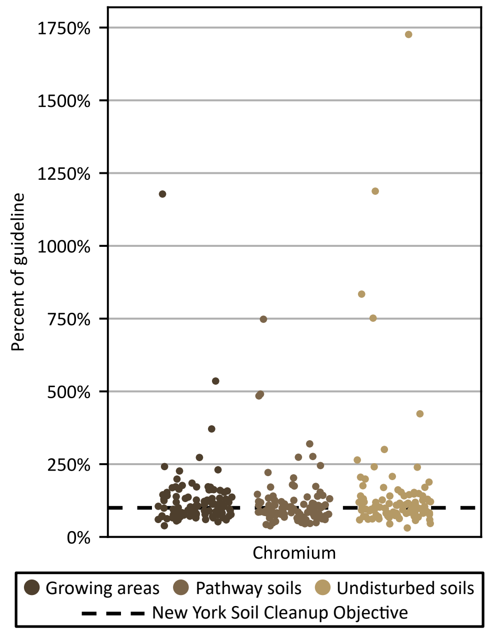
Growing area soils: Soils in which fruits and vegetables were grown. Farmers and gardeners are likely to have the most direct contact with these soils. Growing area soils were collected as a mixture of 6-12 scoops of soil collected from all plots in which the farmer or gardener was growing food. All scoops were collected within 12 horizontal inches of plants, up to six inches deep.

Non-growing area soils: Soil where no fruits and vegetables were growing. Farmers and gardeners are not likely to have much direct contact with these soils while gardening, but they provide additional information about how the levels of contaminants may vary within each site. These samples represent a single scoop of soil, collected from a single, unique location at each site. At most sites, we collected two types of soil samples: a) **pathway soils,** or areas between garden beds, and b) other **undisturbed soils** or uncultivated soils on site.

WHY DOES BALTIMORE HAVE HIGHER LEVELS OF CHROMIUM?

Average chromium levels in **growing area soils** were higher than the NY Soil Cleanup Objective at 52% of sites (Figure 15). Levels in **non-growing area soils** were higher than the NY Soil Cleanup Objective at 65% of sites.

Figure 15: Average soil concentrations of chromium relative to NY Soil Cleanup Objective



Given these results, we conducted additional analyses of soil samples.

Chromium exists in two forms, one of which is more toxic than the other. The less harmful trivalent (III) form is naturally occurring, beneficial in small amounts, and is more likely to be found in soil. In contrast, the more harmful form of chromium, hexavalent (VI), is associated with industrial pollution (such as chromate production) and is more likely to be found in water. Baltimore is located in a hotspot of serpentine soils that are high in naturally occurring chromium, usually found in the less harmful trivalent (III) form. We anticipated that the chromium exceedances we found would likely be in the less harmful form.

Unfortunately, our initial lab testing could not differentiate between the two forms in our samples. We thus sent some of the samples out for further analysis at the US Environmental Protection Agency. As expected, we found that all of the chromium in those samples was the less harmful trivalent (III) form, as opposed to the more toxic hexavalent (VI) form. **Based on our results, we are not concerned about the chromium exceedances found in Baltimore urban farms and gardens.**

DOES IMPORTING SOIL RESULT IN LOWER LEVELS OF HARMFUL METALS?

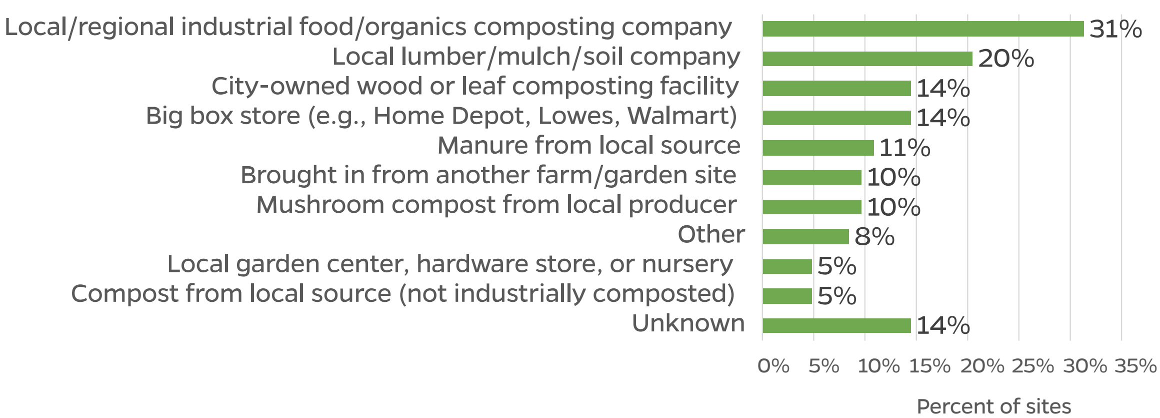
Since urban soils may be contaminated with harmful metals and other chemicals, adding "clean" soil from off-site (i.e., importing soil) is generally considered a best practice when growing edible plants in an urban area. Importing clean soil can dilute levels of contaminants, and make them less available for plants to accumulate. Compost and some fertilizer-containing topsoil may also be added to improve soil fertility.

Of the 100 sites that responded to a question about imported growing media, 95% grew in at least some soil, compost, or mulch brought in from off-site. Thirty-seven percent grew exclusively in imported growing media. The most commonly reported sources of imported growing media were local/regional industrial food waste and organics composting companies and local lumber/mulch companies (Figure 16).

While importing "clean" soil is generally recommended, it is important to make sure that soils and compost being imported into gardens are also free from contaminants. We looked into if and how compost and topsoil for sale must be tested for contaminants in Maryland. We created this guide to help SUH participants and other consumers understand the existing regulations and what they can do to learn more about soils and compost they are interested in importing.

Through our soil tests, we found that the average levels of three metals harmful to human health (arsenic, lead, nickel) were lower at sites that reported growing in exclusively imported soils compared to sites that grew in the existing soils or a combination of existing and imported soils. These results suggest that importing soil may contribute to lower levels of harmful metals. Additional growing practices (e.g., compost and/or fertilizer application) and existing site conditions may also impact levels of these metals in soil, though we were unable to assess the impact of these factors in our study

Figure 16: Sources of imported growing media among sites that imported growing media



Note: Sites could select more than one source of imported growing media.

SOIL SAFETY RECOMMENDATIONS:

Below are some simple—and mostly free—steps you can take to reduce your exposure to contaminants in urban soils.

- **Do not allow children to eat soil or crawl on the ground when at your farm or garden (in growing or non-growing areas)**.
  - Establish designated play areas that reduce soil contact. Choose grassy areas over soil, if possible.
- **Avoid bringing soil into your home**.
  - Remove shoes and dirty clothes before entering the home.
  - Keep tools on site or clean them before transporting home.
  - When transporting plants (including harvested produce), remove as much soil as possible before putting them in bags, baskets, or vehicles.
  - Avoid bringing pets on site.
- **Avoid parts of the site known to be contaminated.**
  - Don't grow edible plants in contaminated areas.
  - Don't put compost piles on top of contaminated areas.
  - Avoid growing near known sources of pollution.
  - Avoid growing near busy roads, demolished buildings, industrial sites, and other known sources of pollution.
  - If possible, grow in a place with less potential for water to drain onto site. For example, avoid growing downhill from a road, building, or downspout.
- **To be conservative (and if finances allow), grow exclusively in raised beds using imported soil**.
  - If possible, don't use treated wood, railroad ties, or vehicle tires to build raised beds. Learn more about the safety of materials used for raised beds here.
  - Try to buy compost, fertilizer or topsoil from vendors who test their materials for contaminants. Learn more here.
  - Use landscaping fabric and/or build raised beds high enough to make sure plant roots do not reach contaminated soil.
- **Reduce the potential for dust.**
  - Use mulch on non-growing area soils (such as walkways) to prevent the "kicking up" of dust. Avoid mulches made from treated wood, if possible.
- **Reduce skin contact with soil.**
  - Wear gloves, closed-toed shoes, long pants, and long sleeves, especially when interacting with contaminated soil.
  - Brush off/dump out soil that accumulates in gloves, shoes, and pockets before going indoors.
  - Dust off any soil from your hands before leaving the site and wash your hands as soon as possible after gardening.

IRRIGATION WATER RESULTS

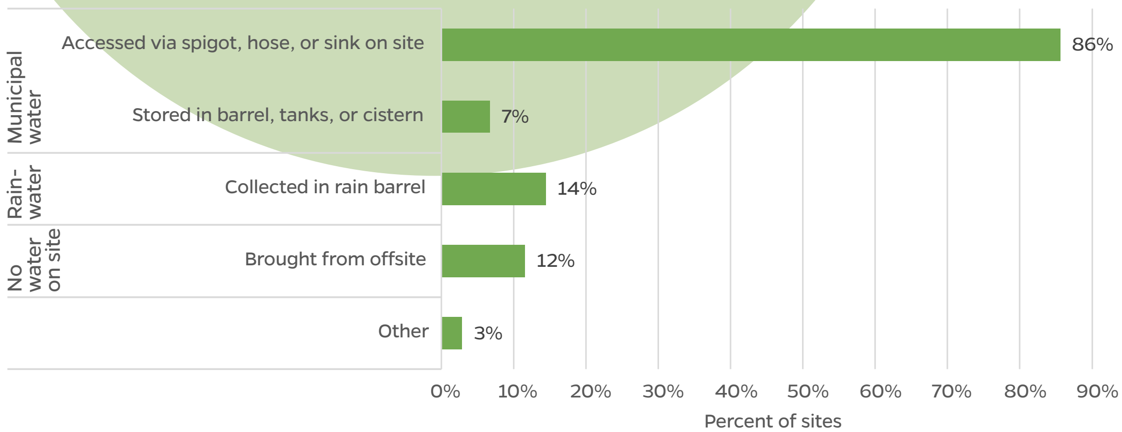
WHAT SOURCES OF IRRIGATION WATER ARE FARMS AND GARDENS IN BALTIMORE USING?

Eighty-nine percent of sites reported using municipal water (i.e., "city water"); 86% accessed it via a spigot, hose, or sink onsite and 7% used municipal water that was stored in barrels, tanks, or cisterns (Figure 17). Fourteen percent of sites used rainwater collected in a rain barrel and 3% used an "other" source of water (including river water or water from an aquaponics system). Twelve percent had no water source onsite and brought municipal water from offsite; 11 of these were community gardens and one was an "other" classification. Twenty percent of sites relied on more than one source of irrigation water so these numbers add up to more than 100%.

NEED ACCESS TO WATER ON SITE?

Community managed open spaces (including gardens and farms) in Baltimore City are entitled to unlimited water use from the Department of Public Works for $120 per year. Sign up at: https://dhcd.baltimorecity.gov/nd/WaterAccessApp.

Figure 17: Irrigation water sources reported by study participants



Note: Sites could select more than one irrigation water source.

WHAT METALS WERE FOUND IN THE SAFE URBAN HARVESTS STUDY IRRIGATION WATER SAMPLES?

We collected irrigation water samples at 92 sites and analyzed them for six metals harmful to human health. For information about how water samples were collected and analyzed, please read "Safe Urban Harvests Study Methods: How samples were collected, analyzed and interpreted."

There are no state or federal guidelines for metals in water used to irrigate food crops. To help interpret the results of our irrigation water tests, we compared the levels of metals in each water sample to the United States Environmental Protection Agency (US EPA)'s drinking water standards. These regulations are set to protect public health assuming the tested water is a primary source of drinking, bathing, and cooking water for an entire lifetime. Since most irrigation water sources are not used for these purposes, this is likely an overly protective standard.

The lower the level of metal is below this public health recommendation, the better. If the amount of a metal is higher than the drinking water standard, it is wise not to drink the water. Since the methods we used we did not measure bacteria, viruses, and parasites in the water on site, it is wise to avoid drinking water from rain barrels and hoses whenever possible, even if it tested lower than the drinking water standard for metals.

Figure 18 shows the average level of metals harmful to human health in each source of irrigation water at each site in the study, compared to the US EPA drinking water standards.

For the average and ranges of metals measured in water across all sites, see the Appendix.

KEY FINDINGS:

- **Arsenic, barium, cadmium, chromium, and nickel:** At 100% of sites, the average levels of these metals tested in irrigation water samples were lower than (complied with) US EPA drinking water standards.
- **Lead**: At 95% of sites, the average levels of lead in all irrigation water samples tested were lower than the US EPA drinking water standard. Among the samples of irrigation water that tested higher than the drinking water standard for lead, three were from rain barrels; two were municipal water; and one was an "other" source of water.
  - At the few sites where we found higher lead levels, we identified a nearby source of contamination (for example, dust deposition into an open rain barrel) or resampled the site and observed a decrease in levels of metals.

HOW TO READ THESE PLOTS:

Each dot represents the average level of metal in an irrigation water source at a site.

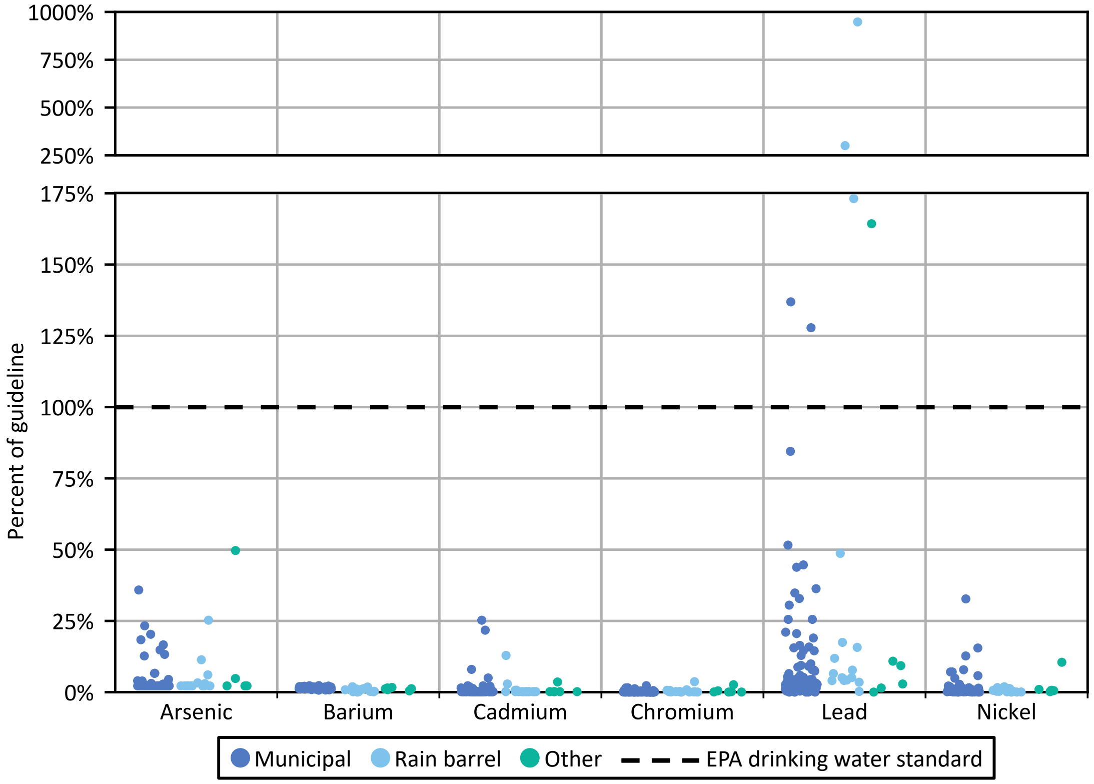
Some sites had more than one source of irrigation water (for example, municipal, rain barrel, other). A site with two sources of irrigation water is represented by two dots for each metal: one dot represents the average of municipal water sampled onsite and one dot represents the average of rain barrel samples collected.

A value of 50% means the level of that metal in the water was half of the drinking water standard for that metal.

A value of 100% means the level of that metal in the water was the same as the drinking water standard for that metal.

A value of 200% means the level of that metal in the water was two times greater than the drinking water standard for that metal.

Figure 18: Average irrigation water concentrations of six metals harmful to human health relative to public health guidelines

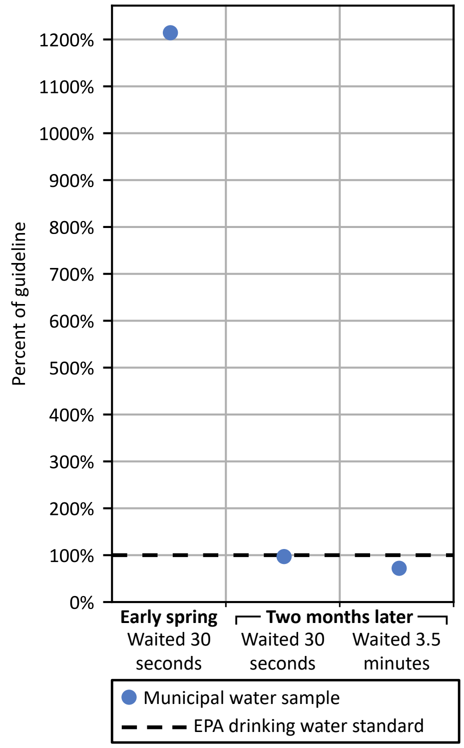


HOW DOES "FLUSHING" PIPES AFFECT THE LEVELS OF METALS IN WATER?

One site in particular had a problem with metal buildup in the pipes that delivered municipal water. The first water sample we took was at the beginning of spring, and we found high levels of lead. This sample was taken after letting water flow for 30 seconds (our standard protocol) before collecting.

Given the high levels we found, we went back to resample the water two months later. At this second trip, we took one sample after letting the water run for 30 seconds and another after the water ran for an additional three minutes. As you can see in Figure 19, the lead levels significantly decreased between the first trip and the second trip, which points to the importance of "flushing" water at the beginning of a growing season for at least ten minutes. The further decrease between the sample collected after 30 seconds of water running and 3.5 minutes of running shows that further flushing between each use can also further reduce lead levels in water

Figure 19: Lead levels in municipal water collected after running the water on different dates and after different time intervals



IRRIGATION WATER SAFETY RECOMMENDATIONS:

Below are some simple—and mostly free—steps you can take to reduce your exposure to contaminants in irrigation water.

- **Do not drink water out of rain barrels, spigots, or hoses**. Bring your own drinking water while working onsite. If a large group typically gardens together, consider bringing a large, insulated beverage cooler (for example, "Igloo") filled with water to the garden.
- **Avoid build-up of harmful metals in the water**. Let municipal water run for ten minutes once at the beginning of season, and then for a few minutes before use each time after that.

PRODUCE RESULTS

WHAT METALS HARMFUL TO HUMAN HEALTH WERE FOUND IN THE SAFE URBAN HARVESTS STUDY PRODUCE SAMPLES?

We collected produce samples at 69 sites and analyzed them for five metals harmful to human health. For information about how produce samples were collected and analyzed, please read "Safe Urban Harvests Study Methods: How samples were collected, analyzed and interpreted."

There are currently no regulatory guidelines for harmful metals in produce in the US, and there is no clear line denoting what is considered "safe." To assess whether levels of metals in urban-grown fruits and vegetables differ from those from other sources, we compared the levels of harmful metals in urban-grown produce samples to the levels measured in samples purchased from grocery stores (both conventionally produced and USDA certified Organic) and from farmers market vendors in Baltimore.

Our study was not designed to compare the relative safety between different fruits and vegetables. For example, in order to compare the relatively safety of lettuce and potatoes, we would need to consider how much of these items people typically consume, which was outside the scope of this study.

Figures 20 and 21 show the levels of arsenic and lead, respectively, in the thirteen different produce items collected in the study, across four production categories (urban; rural, farmers market; grocery store, conventional; grocery store, organic). Note that the number of dots is not consistent for every produce item or production category; we sampled more urban items than grocery store conventional, grocery store organic, and farmers market samples for most produce items.

We also tested produce items for three other harmful metals (barium, cadmium, and nickel), though the levels were relatively low and/or not detected frequently so they are not displayed in the figures below.

KEY FINDINGS:

- For almost all fruits and vegetables tested, there were no patterns of differences in the levels of metals in urban-grown fruits and vegetables compared to those in fruits and vegetables from grocery stores or farmers markets.
  - There was one exception: we found statistical increases in the lead levels of urban-grown leafy greens compared to levels in leafy greens from grocery stores and farmers markets. That said, leafy greens generally had less lead than root vegetables from all sources so we are not concerned about this observation.
- Based on our findings, we are confident that fruits and vegetables from urban farms are similar to those from grocery stores and farmers markets. **Our findings do not suggest reason for concern or for changing dietary patterns with regard to fruits and vegetables**.

Figure 20: Arsenic concentrations in produce items, by production category

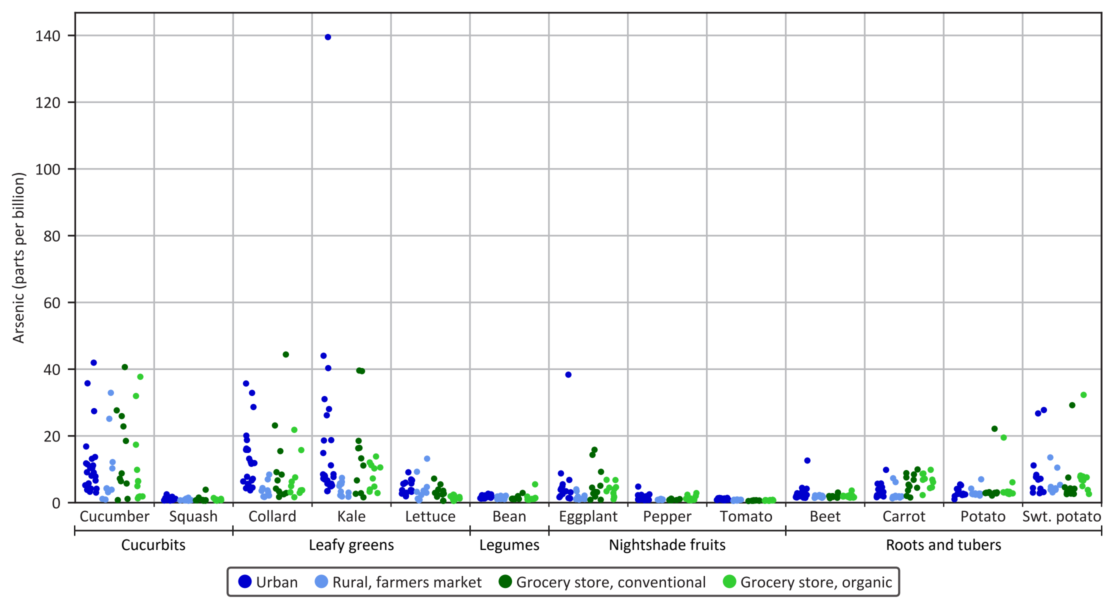
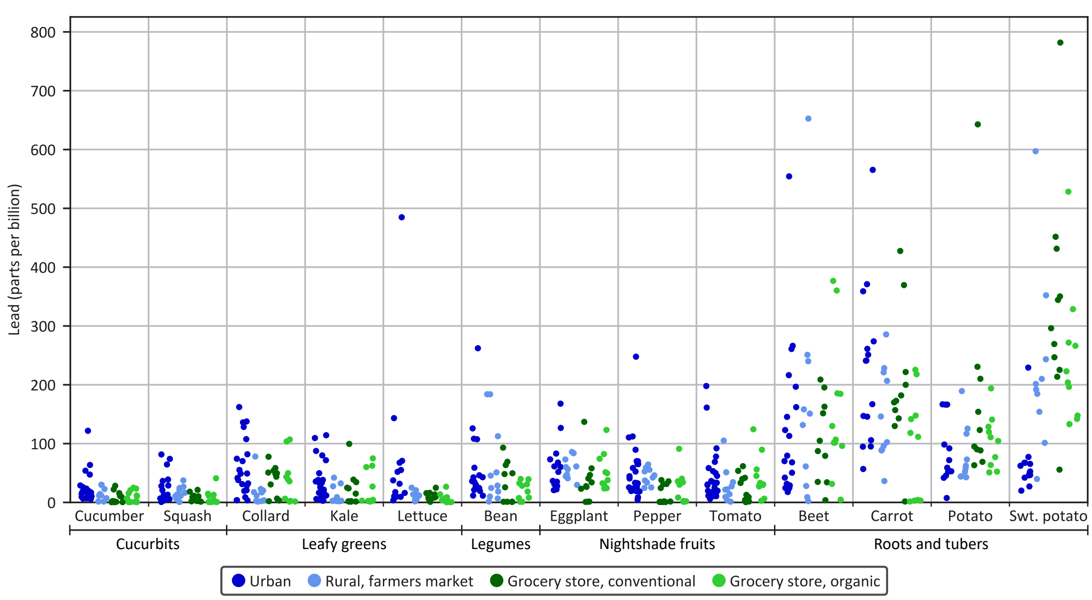


Figure 21: Lead concentrations in produce items, by production category



HOW TO READ THESE PLOTS:

- Each dot represents one sample measured in the study.
- The horizontal axis and color of dots groups the samples by where they were collected (urban farm or garden, farmers market, grocery store conventional, grocery store organic). The horizontal scattering of dots within each category is to help with visibility.
- The vertical axis indicates the concentration of that metal in parts per billion (ppb) fresh weight.

WHY ARE THERE HARMFUL METALS IN VEGETABLES? ARE THOSE LEVELS SAFE?

Metals harmful to human health (including arsenic, cadmium, and lead) exist in a wide variety of foods in the food supply. No diet is—or can be—completely free of metals.

No produce samples measured in the Safe Urban Harvests Study had levels of any metal high enough to pose an immediate health concern. Even when we detected metals in fruits and/or vegetables (from urban or non-urban sources), there is no immediate health concern from consuming them. Fruits and vegetables provide numerous health benefits and should remain an important part of a diverse and nutritious diet. Because these metals do not have any nutritional benefits for humans, the lower the levels of the metals in food, the better.

Your diet is not the only way you may come into contact with metals harmful to human health (especially lead), nor is it generally the greatest source of contact. Exposure to these metals may also occur via drinking water or contact with metals in urban soils, dust, or chipping paint.

Our study did not gather enough information to assess the overall risks from a metal contaminant perspective of consuming fruits and vegetables, in comparison to each other or to other foods. Such research would need to collect more information about gardeners' and farmers' health statuses, how often or how much consumers eat urban-grown produce and other foods, the levels of metals in other foods, and the amount of contact growers have with metals from other sources. It's also important to remember that there are many proven health benefits to growing and eating fruits and vegetables, and that the health risks resulting from cutting fruits and vegetables out of one's diet would likely be greater than those presented by the trace metals that may be present in those foods.

That said, there are ways to reduce contact with metals in the foods you eat—including by washing and peeling produce, and varying the type and source of foods you eat. See the "General recommendations for reducing contact with metals in urban soils, irrigation water, and produce.

DID HIGHER LEVELS OF METALS IN SOIL CORRELATE WITH HIGHER LEVELS IN VEGETABLES?

We did not see statistically significant correlations between the concentrations of metals in soil and produce grown in those soils for most of the metals we tested, including lead. This means that even if the levels of lead in soils were relatively high, that did not necessarily mean that the levels of lead in produce grown in those soils were high; and vice versa.

WHAT ABOUT METALS AND OTHER ELEMENTS BENEFICIAL TO HUMAN OR PLANT HEALTH?

Although our study was focused on harmful metals, we also tested produce samples for nine other elements (including copper, manganese, and zinc) that support plant growth and human health. As with our metals results, we did not observe any consistent or discernable patterns between urban-grown and non-urban-grown items for these elements.

Notably, we did not test the fruits and vegetables for a number of other beneficial elements, such as vitamins and antioxidants, which may differ between urban and non-urban grown items. More research is needed to investigate how urban-grown produce may differ for these other micronutrients.

PRODUCE SAFETY RECOMMENDATIONS:

Below are some simple—and mostly free—steps you can take to reduce your exposure to contaminants in produce.

- **Reduce exposure to contaminants on the surface of fruits and vegetables.** You can do this by:
    - Minimizing consumption of produce onsite at a farm or garden.
    - Washing and peeling produce, especially root vegetables, in a clean sink before consuming.
    - Removing outer leaves of green leafy and cruciferous vegetables (such as broccoli and cauliflower) before eating.
- **Reduce exposure to contaminants in fruits and vegetables**. Vary where you get your produce. For example, source some of your fruits and vegetables from other sources such as farmers markets, grocery stores, or other farms and gardens.
- **Our findings do not suggest reason for concern or for changing dietary patterns with regard to fruits and vegetables**. Eating a diet rich in a variety of fruits and vegetables is healthy. It is likely that the health risks resulting from cutting fruits and vegetables out of one's diet would be greater than any health risks resulting from trace metals that may be present in those foods.
- Farmers and gardeners who are concerned about metals should **focus on reducing soil contact**. The concentrations of metals in soils were 1000x higher (measured in parts per million) than those in produce (measured in parts per billion).

GENERAL RECOMMENDATIONS FOR REDUCING CONTACT WITH METALS IN URBAN SOILS, IRRIGATION WATER, AND PRODUCE

If you are concerned about exposure to metal contaminants in urban agriculture, here are some simple—and mostly free—steps you can take to reduce your exposure.

Change your behavior	What can you do, specifically?
Do not drink water out of rain barrels. While city water is safe, hoses can become contaminated so it's best not to drink from them either.	Bring a full water bottle with you when going to work on site.
	If a large group typically gardens together, consider bringing a large insulated beverage cooler (for example, "Igloo") filled with water to the garden.
	If drinking municipal water from spigot, let it run at least ten minutes once before using at beginning of season, and at least 1-2 minutes before use each time after that.
Reduce skin contact with soil.	Wear gloves, closed-toed shoes, long pants, and long sleeves, especially when interacting with contaminated soil. Brush off/dump out soil that accumulates in gloves, shoes, and pockets before going indoors.
	Dust off any soil from your hands before leaving the site and wash your hands as soon as possible after gardening.
Do not allow children to eat soil or crawl on ground in garden.	Establish designated play areas that reduce soil contact. Choose grassy areas over soil, if possible.
Avoid bringing soil into your home.	Remove shoes and dirty clothes before entering your home.
	Keep tools onsite or clean them before transporting home.
	When transporting plants (including harvested produce), remove as much soil as possible before putting them in bags, baskets, or vehicles.
	Avoid bringing pets onsite.
Reduce exposure to contaminants on the surface of urban-grown fruits and vegetables.	Minimize consumption of produce onsite.
	Wash and peel urban-grown produce, especially root vegetables, in clean sink before consuming.
	Remove outer leaves of green leafy and cruciferous vegetables (such as broccoli and cauliflower) before eating.
Reduce exposure to contaminants in urban-grown fruits and vegetables.	Vary where you get your produce. For example, source some of your fruits and vegetables from other sources such as farmers markets, grocery stores, or other sites.

Make your farm or garden safer	What can you do, specifically?
Avoid build-up of harmful metals in the water.	Let municipal water run for ten minutes once at the beginning of season, and then for a few minutes before use each time after that.
Avoid parts of the site known to be contaminated.	Don't grow edible plants in contaminated areas.
	Don't put compost piles on top of contaminated areas.
Avoid growing near known sources of pollution.	Avoid growing near busy roads, demolished buildings, industrial sites, and other known sources of pollution.
	If possible, grow in a place with less potential for water to drain onto site. For example, avoid growing downhill from a road, building, or downspout.
To be conservative (and if finances allow), grow exclusively in raised beds using imported soil.	If possible, don't use treated wood, railroad ties, or vehicle tires to build raised beds. Learn more about the safety of materials used for raised beds here.
	Try to buy compost, fertilizer or topsoil from vendors who test their materials for contaminants. Learn more here.
	Use landscaping fabric and/or build raised beds high enough to make sure plant roots do not reach contaminated soil.
Reduce the potential for dust.	Use mulch on non-growing area soils (such as walkways) to prevent the "kicking up" of dust. Avoid mulches made from treated wood, if possible.

Some other thoughts:

- Children, infants, and pregnant people are more vulnerable to some of these pollutants. Following these recommendations may be even more important for them.
- The amount of exposure to harmful metals onsite increases as you spend more time there. If you are concerned with exposure, take steps to maximize your time efficiency at the farm or garden.

ADDITIONAL RESOURCES

The following documents are available on the Safe Urban Harvests Study website. They contain additional information about the study and resources for urban agriculture in Baltimore.

Meet our Safe Urban Harvests Study team
Grant and assistance opportunities for Baltimore community gardens and urban farms
Guide to testing soil for heavy metals
FAQ: Safety of soils and compost for sale and how they are regulated in MD

MORE INFORMATION ABOUT METALS

If you would like more information about the metals harmful to human health, please refer to the Agency for Toxic Substances and Disease Registry's Frequently Asked Questions factsheets ("ToxFAQs") for these metals. These factsheets describe the most common sources of exposure and the most severe health effects that may result from frequent contact with high levels of these metals. Please note that not all of the information in these factsheets is relevant to the urban agriculture context. Some information may only apply to high level exposures typical in industrial workplaces.

The factsheets are available at:

Arsenic: https://www.atsdr.cdc.gov/toxfaqs/tfacts2.pdf
Barium: https://www.atsdr.cdc.gov/toxfaqs/tfacts24.pdf
Cadmium: https://www.atsdr.cdc.gov/toxfaqs/tfacts5.pdf
Chromium: https://www.atsdr.cdc.gov/toxfaqs/tfacts7.pdf
Lead: https://www.atsdr.cdc.gov/toxfaqs/tfacts13.pdf
Nickel: https://www.atsdr.cdc.gov/toxfaqs/tfacts15.pdf

SAFE URBAN HARVESTS STUDY TEAM AND COLLABORATORS

SAFE URBAN HARVESTS STUDY TEAM

For questions about the study purpose, methods, and results interpretation:
Johns Hopkins Center for a Livable Future
111 Market Place, Suite 840, Baltimore, MD 21202
Keeve Nachman, Principal Investigator
knachman@jhu.edu
410-502-7576
https://www.jhsph.edu/clf/suh

SAFE URBAN HARVESTS STUDY COLLABORATORS

Baltimore City Office of Sustainability
For questions about zoning for urban agriculture
and growing food on public land
Abby Cocke, Environmental Planner
417 E. Fayette Street,
8th Floor, Baltimore, MD 21201
abby.cocke@baltimorecity.gov
410-396-1670
http://www.baltimoresustainability.org/projects/baltimore-food-policy-initiative/homegrown-baltimore/urban-agriculture-2/

Parks & People Foundation
For information about parks and green spaces in Baltimore
Frank Lance, President and CEO
2100 Liberty Heights Ave,
Baltimore, MD 21217
frank.lance@parksandpeople.org
(410) 448-5663
http://parksandpeople.org/

Farm Alliance of Baltimore
For farms that are producing farm products for sale and donation to the public.
Mariya Strauss, Executive Director
2701 Saint Lo Drive,
Baltimore, MD 21213
mariya@farmalliancebaltimore.org
410-736-8079
www.farmalliancebaltimore.org

University of Maryland Extension — Baltimore City
For questions about growing practices, soil fertility, and soil science
Neith Grace Little, Extension Educator—Urban Agriculture
6615 Reisterstown Road, Suite 201,
Baltimore, MD 21215
nglittle@umd.edu
410-856-1850 ext. 123
http://extension.umd.edu/baltimore-city/urban-agriculture

SAFE URBAN HARVESTS STUDY METHODS: HOW SAMPLES WERE COLLECTED, ANALYZED AND INTERPRETED

SOIL

COLLECTION

- We used stainless steel trowels to collect the top six inches of soil.
- **Growing area soils** are soils where fruits and vegetables were growing. Farmers and gardeners are likely to have the most direct contact with these soils while gardening.
    - Growing area mixtures represent a mixture of 6-12 scoops of soil collected from all over each garden's growing area. All scoops were collected within 12 inches of plants. We thoroughly mixed all scoops in a plastic bucket and then stored four ounces of soil in plastic bags.
    - A single scoop of soil was also collected from the base of sampled fruits and vegetables.
- **Non-growing area soils** are soils where no fruits and vegetables were growing. Farmers and gardeners are not likely to have much direct contact with these soils while gardening. Non-growing areas include walkways and uncultivated sections. These samples represent a single scoop of soil, collected at the location specified on the site map.

PREPARATION AND ANALYSIS

- We air dried the soil to remove excess water and passed it through a two-millimeter sieve.
- We used a digestion process called aqua regia which uses heat and two concentrated acids (nitric and hydrochloric acid) to extract metals from the soil so they can be measured by an instrument that measures metal content called inductively coupled plasma-optima (ICP-OES).
- All soil samples were processed and analyzed at the USDA Agricultural Research Service's Adaptive Systems Cropping Lab in Beltsville, Maryland.

SOIL RESULTS INTERPRETATION

To help interpret the levels of metals in each soil sample, we consulted the New York State Soil Cleanup Objectives (SCO) for Residential Land Use. In setting the SCOs, the New York Department of Environmental Conservation and Department of Health considered exposure to soil contaminants by ingesting soil, breathing in soil particles and vapors, skin contact, and eating home-grown vegetables. These public health recommendations were developed to protect the health of residents who live onsite and grow vegetables in the soil.

In general, the lower the level of metal is below this public health recommendation, the better. For some metals, the calculated health-based SCO was lower (i.e., more protective) than the levels of metals naturally occurring (i.e., "background levels") in rural soils. For these metals, New York State set the rural soil background concentration as the final soil cleanup objective for residential land use.

FREQUENTLY ASKED QUESTIONS (FAQS):

How were these laboratory methods different from those of commercial mail-in soil testing services? Because of the digestion method and instrument (ICPOES) we used, these results have better detection limits than typical soil testing labs. Our method measures the "total" level of each metal present in the soil. Other digestion methods can only measure a portion of the metals present in the soil (for example, Mehlich 3 or DTPA). Additionally, many mail-in soil tests available from commercial laboratories focus on indicators of soil fertility such as soil nutrients, and organic matter content, rather than contaminants. Generally, testing for metals requires a special request and additional cost.

Why were Soil Cleanup Objectives from New York chosen as the "limits" to which we compared the soil results? We considered a variety of potential standards to contextualize the sample results, including the Environmental Protection Agency (EPA)'s Regional Screening Levels, and background levels (i.e., the average of the levels of metals that are naturally occurring in soils around the country). We chose the New York Soil Cleanup Objectives because they were developed specifically to protect the health of people who live on or near the soil and also garden.

IRRIGATION WATER

COLLECTION

- We collected irrigation water from municipal sources (water that comes from a spigot or sink attached to a building) and any other sources a garden may use (including rain barrels and aquaponics systems).
- At each water source, we let the water flow for 30 seconds and then collected 30 milliliters of water in Nalgene bottles.

PREPARATION AND ANALYSIS

- We first added nitric acid to each water sample to prevent any biological compounds that may be present in the water from affecting the instrument's ability to measure the levels of metals.
- We then analyzed each water sample using an instrument called inductively coupled plasma-mass spectrometry (ICP-MS) that measures the level of total metals in the sample.
- All water samples were analyzed at the Johns Hopkins Bloomberg School of Public Health (JHSPH).

RESULTS INTERPRETATION

There are no state or federal guidelines for metals in water used to irrigate food crops. We compared the levels of metals in each water sample to the US Environmental Protection Agency (EPA)'s drinking water standards. These regulations are set to protect public health assuming the tested water is a primary source of drinking, bathing, and cooking water for an entire lifetime. Since most irrigation water sources are not used for these purposes, this is likely an overly protective standard.

FRUITS AND VEGETABLES

COLLECTION AND PREPARATION

- We collected each produce item as growers would by harvesting the fruits and vegetables directly from the stem, loosening the soil around root vegetables and then pulling them up, or using scissors to clip leaves off of green leafy vegetables.
- We stored each sample in a plastic Ziploc bag and used a cooler to transport back to our laboratory at the Johns Hopkins Bloomberg School of Public Health (JHSPH).
- After collection, fruit and vegetable samples were washed (using deionized water) and cut into smaller pieces. We peeled carrots and beets before homogenizing.
- We also removed parts of the plant that are not typically eaten, such as stems, inedible bruises, and unpopular greens (such as beet and carrot greens).
- The samples were homogenized in a food processor and frozen at JHSPH and then transported to USDA for further processing and analysis.

PROCESSING AND ANALYSIS

- Once at the USDA lab, all fruit and vegetable samples were freeze-dried to remove excess water and then ground to produce a fine powder.
- The samples were digested using nitric acid and hydrogen peroxide under high pressure. This digestion process breaks down the plant tissue so that the metals present can be analyzed by an instrument that measures metal content called inductively coupled plasma-optima (ICP-OES). We used a microwave that is specifically designed for plant tissue analysis and uses higher microwave input than can be attained in a home microwave to assist the digestion process.
- All fruit and vegetable samples were processed and are currently being analyzed at the USDA Agricultural Research Service's Adaptive Systems Cropping Lab in Beltsville, Maryland.

RESULTS INTERPRETATION

Our laboratory results reported the level of a metal in each produce sample. There are, however, currently no regulatory guidelines for harmful metals in produce in the US, and there is no clear line denoting what is considered "safe" to consume. Without regulatory guidelines around what level of a metal in parts per billion (ppb) would be considered too high (such as the Soil Cleanup Objective to which we compared to the soil samples), the lab results are difficult to interpret directly.

To assess whether levels of metals in urban-grown fruits and vegetables differ from those from other sources, we compared the levels of harmful metals in urban-grown produce samples to the levels measured in samples purchased from grocery stores (both conventionally produced and USDA certified Organic) and from farmers market vendors in Baltimore.

In the reports in which we shared individual site results, we compared the amount of metal present in one cup of each sample compared to the corresponding daily recommended limit (across all foods) for each metal. We have opted not to include this comparison in this summary report of citywide results.

FREQUENTLY ASKED QUESTION (FAQ):

Can an urban grower test the levels of metals in their produce using a commercial laboratory? We have received questions from participants about where, when, and how to test their produce. Unlike soil (which we recommend re-testing as often as you test for fertility, about every three years), we do not recommend frequent produce testing for metals. Firstly, there was no evidence of an immediate risk to consuming any of the produce samples tested. Our findings suggest that there is no compelling reason to change dietary or purchasing patterns with regard to fruits and vegetables. We do not believe there would be significant differences in the concentration of metals in produce samples over time.

Second, the laboratory testing services to measure metals in produce samples are expensive. Additionally, they may not use methods that have low enough detection limits to provide meaningful data to inform concerns about human consumption.

APPENDIX

SOIL RESULTS

Table A1. Average values of harmful metals measured in soils across study sites in parts per million (ppm). Interquartile ranges* shown in parenthesis.

Sample type	Arsenic	Barium	Cadmium	Chromium+	Lead	Nickel
NY Soil Cleanup Objective	16	350	2.5	36	400	140
Growing area mixture	4 (3–4)	53 (32–68)	<2	46 (28–49)	105 (35–117)	20 (13–22)
Pathway soils	4 (2–4)	63 (36–86)	<2	42 (27–44)	114 (36–122)	18 (11–21)
Undisturbed soils	5 (3–5)	75 (44–91)	<2	56 (29–51)	216 (51–196)	22 (12–22)

*The ranges identified above are reported as interquartile ranges (IQR). This shows the values from the 25th to 75th percentile, or the middle 50% of the values, to avoid giving too much weight to outliers on either the high or low extreme. In this table, IQRs are not shown when both the 25th and 75th percentiles were less than 2.

+Note: Chromium exists in two forms, one that is more harmful than the other. This analysis could not distinguish between the two forms, though our further analysis indicated that all the chromium we found was the non-harmful kind.

Table A2. Average values of other elements measured in soils across study sites in parts per million (ppm). Interquartile ranges* shown in parenthesis.

Sample type	Calcium	Copper	Iron	Manganese	Potassium	Zinc
Growing area mixture	15781 (9903–19961)	53 (37–57)	18376 (13301–21068)	464 (322–505)	1831 (1100–2378	140 (88–154)
Pathway soils	16668 (4654–20232)	44 (27–53)	17459 (12126–21533)	364 (247–433)	1465 (671–2106)	128 (73–156)
Undisturbed soils	14287 (3799–17053)	50 (25–63)	19181 (13629–21163)	374 (227–452)	1380 (768–1901)	188 (88–191)

*The ranges identified above are reported as interquartile ranges (IQR). This shows the values from the 25th to 75th percentile, or the middle 50% of the values, to avoid giving too much weight to outliers on either the high or low extreme.

IRRIGATION WATER RESULTS

Table A3. Average values of harmful metals measured in irrigation water across study sites in parts per billion (ppb). Interquartile ranges* shown in parenthesis.

Sample type	Arsenic	Barium	Cadmium	Chromium	Lead	Nickel
EPA Drinking Water Standard	10	2000	5	100	15	100
Municipal water	<1	32 (28–36)	<1	<1	2 (<1–2)	2
Rain barrel water	<1	16 (5–24)	<1	<1	15 (<1–4)	<1 (<1–1)
Other water	1	23 (19–29)	<1	<1	5 (<1–2)	2

*The ranges identified above are reported as interquartile ranges (IQR). This shows the values from the 25th to 75th percentile, or the middle 50% of the values, to avoid giving too much weight to outliers on either the high or low extreme. In this table, IQRs are not shown when both the 25th and 75th percentiles were less than 1.

Table A4. Average values of other metals measured in irrigation water across study sites in parts per billion (ppb). Interquartile ranges* shown in parenthesis.

Sample type	Calcium	Copper	Iron	Manganese	Potassium	Selenium	Zinc
Municipal water	936 (871–1023)	126 (16–154)	243 (33–174)	11 (2–10)	2825 (2529–2824)	<1	169 (16–118)
Rain barrel water	479 (120–791)	37 (13–59)	556 (37–237)	27 (5–31)	2995 (392–3804)	<1	179 (48–136)
Other water	841 (725–970)	20 (8–19)	1098 (77–1197)	7 (3–8)	8819 (2652–3676)	<1	288 (43–339)

*The ranges identified above are reported as interquartile ranges (IQR). This shows the values from the 25th to 75th percentile, or the middle 50% of the values, to avoid giving too much weight to outliers on either the high or low extreme. In this table, IQRs are not shown when both the 25th and 75th percentiles were less than 1.

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