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

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## 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 (one scoop, collected separately for each fruit and vegetable sampled).
- **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, MD.

## 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 on site 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):

1. **How were these laboratory methods different from those of commercial mail-in soil testing services?**
   Because of the digestion method and instrument (ICP-OES) 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 (e.g., 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.

2. **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 (e.g., water that comes from a spigot or sink attached to a building) and any other sources a garden may use (e.g., rain barrels, aquaponics systems, etc.).
- 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 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 you would (and often with your help!), 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 (e.g., 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, MD.

## 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 of 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.

While regulatory guidelines do not exist for produce items specifically, **there are daily recommended limits for the amount of each metal you can consume in a day (across all foods) without a risk of getting sick.** We used these daily recommended limits to help you interpret what the amounts of metals in your specific produce samples mean.

To do so, we first considered the amount of each produce item that a person typically eats. The USDA My Plate Guidelines recommend that people eat 1-3 cups of vegetables daily, depending on age and sex. We chose one cup as this is the typical adult serving size for a vegetable.

We then multiplied the level of metal in each sample by the typical amount of mass present in one cup of the item, using standard values from the United States Department of Agriculture's Food Composition Database. This gave us the amount of metal present in one cup of each sample (in micrograms), which we compared to the corresponding daily recommended limit (in micrograms/day) for each metal.

## FREQUENTLY ASKED QUESTIONS

**How and why were these recommended limits chosen as the "limits" to which we compared the produce results?**

The sources and our rationale for setting the daily recommended limits vary by metal:

- Arsenic: There are no established regulatory or safety standards for arsenic in produce in the United States. The US Environmental Protection Agency has established a maximum contaminant limit for arsenic in drinking water of 10 micrograms per liter. For the purposes of interpreting your results, we compared the amount of arsenic you would get from eating one cup of each fruit or vegetable to 1/10th of the amount allowed in drinking water (i.e., 1 µg/day). We believe this approach to be protective. Although we calculated this ourselves, we refer to this as a "daily recommended limit" for simplicity throughout the report.

- Barium: There are no established regulatory or safety standards for barium in produce in the United States. The US Environmental Protection Agency (US EPA) has established a reference dose for barium of 0.2 milligrams per kilogram of body weight per day. For an adult of average weight of 80 kilograms (176 pounds), this would mean a daily recommended limit of 16,000 micrograms per day. There were no urban produce samples that had barium concentrations that exceeded the daily recommended limit for barium intake from consuming one cup.
- Cadmium: There are no established regulatory or safety standards for cadmium in produce in the United States. The Agency for Toxic Substance Substances and Disease Registry (ATSDR) has established a recommended limit of cadmium intake orally through what is called the Minimal Risk Level. This level is set at 0.1 micrograms per kilogram of body weight per day. For an adult of average weight of 80 kilograms (176 pounds), this would mean a daily recommended limit of 8 micrograms per day. We chose this value because it is smaller and thus more protective than the US EPA's reference dose for cadmium in food specifically (which is 0.1 milligrams per kilogram of body weight per day). There were no urban samples that had cadmium concentrations that exceeded the daily recommended adult limit for cadmium intake from consuming one cup.
- Lead: There are no established regulatory or safety standards for lead in produce in the United States. The US Food and Drug Administration (FDA) has established a provisional daily recommended limit for lead from all food. The daily recommended limit for adults is 12.5 micrograms per day and 3 micrograms per day for children under 6 years of age, **but many people in the US regularly exceed this level**. We chose FDA's Interim Reference Level for lead because it was updated in 2018 to be consistent with the Center for Disease Prevention and Control's decision to reduce the blood lead reference level from 10 micrograms per deciliter to 5 micrograms per deciliter and incorporates the best available science.
- Nickel: There are no established regulatory or safety

standards for nickels in produce in the United States
The Food & Nutrition Board of the Institute of Medicine has established an upper limit for nickel from all foods of 1000 micrograms per day for adults, 600 micrograms per day for children 9-13 years old, 300 micrograms per day for children 4-8 years old, and 200 micrograms per day for children 1-3 years old. There were no urban samples that had nickel concentrations that exceeded the daily recommended adult limit for nickel intake from consuming one cup.

**How should the results be interpreted for children?**
For simplicity of reading the charts and tables, we compared the amount of metal present in one cup of each produce sample to the recommended daily limits for adults and (when available) children. We recognize, however, that children eat less than adults. The US Department of Agriculture has established typical serving sizes of vegetables for children ranging from 1/8 cup to ½ cup, depending on the age of the child. When comparing the amount of a metal reported in one cup of your produce sample to the child limit, keep in mind that children may be eating less than one cup at a time or on a given day, and thus our approach represents an protective interpretation.

**How were the levels of the beneficial elements measured in the produce samples interpreted?**
We used the same approach to interpret the levels of beneficial elements in each produce sample reported in Appendix Table 2. We compared the amount of metal present in one cup of each sample to the corresponding Recommended Dietary Allowance (RDA) or Adequate Intake (AI) (in grams, milligrams, or micrograms, depending on the element) from the Institute of Medicine Food and Nutrition Board. These numbers reflect the recommendations for females (f) who are not pregnant or lactating and males (m) between 19-50 years old. The full list of recommended intakes of the beneficial elements by age and sex is available here. The recommended intake of potassium by age and sex is available here.

The analytical method we used measures the total amount of each element present in each sample but does not distinguish the total amount that is present in the produce item and the amount that is directly beneficial to a human eating it. These results should not necessarily be used to draw conclusions about the nutritional content of the items tested.

**Can I test the levels of metals in my 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 your 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. If you have further questions about this, please contact:

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