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In light of the urban wildfires, I heard many people echo my own questions about whether produce was safe to eat, how to know if soil was contaminated, and how to remediate garden spaces. As a garden educator, I felt a huge sense of responsibility to make informed decisions for myself and the children and families I work with; however, I soon realized that finding answers was not a simple process. In this document, I start by providing an overview of what might be contaminating plants and soils. After that, I try and address questions that I myself have as well as questions I have heard others pose. I want to acknowledge Vanessa Raditz and everyone who has contributed to the group, Produce Safety after Urban Wildfire. Their work has helped me and others sift through all the uncertainty that has settled in the fires' wake. They just received a grant to fund analysis of samples of leafy greens collected right after the fires to better understand the effect of urban wildfires on crops.

The UC Cooperative Extension Sonoma County acknowledges that when assessing the safety of foods that have been exposed to house fires, there is no conclusive answer as to whether the items are safe to eat. Crops may have been exposed to Polycyclic Aromatic Hydrocarbons (PAHs), dioxins, and metals (UCCE, 2017)<sup>1</sup>. Here is a quick break-down of PAHs, dioxins, and metals:

## BACKGROUND

- [PAHs](#) are hydrocarbons formed from combustion of natural or man-made items. Primary sources of PAHs are wood burning and biofuel combustion. According to the Agency for Toxic Substances and Disease Registry, "PAHs generally have a low degree of acute toxicity to humans." However, they also add that occupational exposure to PAHs is linked with increased likelihood of lung, skin, and bladder cancer (2008).<sup>2</sup> UC Cooperative Extension cites an unpublished literature review on health impacts of PAHs from traffic-related air pollution on lettuce in an urban area: According to these findings, PAHs ingested from eating this lettuce fall below the EPA's level of concern for lifetime risk of cancer. They also find that eating the nutrients and vitamins from leafy greens may outweigh the risks incurred from ingesting PAHs (UC Cooperative Extension, 2017).
- [Dioxins](#) are a group of toxins considered persistent environmental pollutants (POPs). In light of the recent fires that burned both urban and wild areas, dioxin production results from combustion of household and industrial sites, and to a lesser degree, combustion of plant matter. According to the

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<sup>1</sup> [http://cesonoma.ucanr.edu/Disaster\\_Resources/Crop\\_Resources/](http://cesonoma.ucanr.edu/Disaster_Resources/Crop_Resources/)

<sup>2</sup> <https://www.atsdr.cdc.gov/csem/csem.asp?csem=13&po=11>

EPA, “dioxins do not typically exist in materials before they are incinerated. However, when materials and waste are burned, dioxins are produced and introduced into the environment,” (2017).<sup>3</sup> While dioxins are omnipresent, the level of normal exposure is not considered a health risk. However, dioxins in concentration are highly toxic and can lead to an impaired immune system, can affect the developing nervous system, the endocrine system, and the reproductive system. Infants are most susceptible to negative outcomes from dioxin exposure.

In this particular case, the primary concern is that elevated levels of dioxins would be present at burn sites or that it would be aerially deposited to surrounding areas through ash. According to (Tuyet-Hanh, Vu-Anh, Nhoc-Bich, & Tenkate), plant roots do not normally absorb dioxins (2010).<sup>4</sup> The EPA corroborates that plants do not generally absorb dioxin, and further notes that, “any dioxin that falls on fruits and vegetables can mostly be removed by washing” (Facts About Dioxin, 1999)<sup>5</sup>.

The World Health Organization estimated that more than 90% of human exposure is through the food supply. Since dioxins accumulate mainly in the fatty tissue of animals, the main source of contamination is meat, dairy product, fish, and shellfish. The World Health Organization cautions that eating a balanced diet of fruits, vegetables, and cereal grains will prevent excess contamination from a single source (2016).<sup>6</sup>

- Metal contamination results from burned houses constructed from treated wood, galvanized nails, and other building materials that release heavy metals when burned. They also result from burned household goods such as refrigerators, electronics, cleaning materials, and paints. Heavy metals cannot be chemically degraded; they must be physically removed or transformed into non-toxic compounds.

While some heavy metals are important trace minerals (even if they may be toxic in higher concentrations), others are known to be harmful to humans. In a study of burned-out residential areas in Southern California in 2007, ash was found to contain elevated levels of arsenic, antimony, lead, copper, and chromium (Johnson, 2017).<sup>7</sup>

It is important to note that in Sonoma County, soils commonly have elevated levels of organic arsenic, which is generally considered to be less toxic than inorganic arsenic found in ash from treated wood (Tangahu, Abdullah, Basri, Idris, Anuar, & Mukhlisim, 2011).<sup>8</sup>

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<sup>3</sup> <https://www.epa.gov/dioxin/dioxins-produced-backyard-burning>

<sup>4</sup> <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2898056/>

<sup>5</sup> [https://www.epa.gov/sites/production/files/documents/r8\\_dioxinfacts.pdf](https://www.epa.gov/sites/production/files/documents/r8_dioxinfacts.pdf)

<sup>6</sup> <http://www.who.int/mediacentre/factsheets/fs225/en/>

<sup>7</sup> <https://www.nytimes.com/2017/10/16/us/california-fires-cleanup.html?mwrs=Email>

<sup>8</sup> <https://www.hindawi.com/journals/ijce/2011/939161/>

## **QUESTIONS:**

### **Do I need to pull out all of the plants?**

- Not necessarily. If you haven't already pulled all your plants, first have your soil tested. This will let you know if your soil has elevated levels of heavy metals. If so, then you will likely not want to eat vegetables currently growing in the soil. The next step would be to work towards removing or remediating soil.

If your soil does not test positive for elevated levels of heavy metals, then you might be concerned about PAHs. While there has been little research conducted about the extent to which PAHs are absorbed by leafy greens after an urban fire, there is research showing that plants exposed to PAHs in urban traffic zones do not contain unhealthy levels of PAHs. Additionally, this same research study found that nutrients and vitamins from leafy greens may outweigh the risks incurred from ingesting from low levels of PAHs. If you do choose to eat leafy greens from your garden, you can reduce your risk of exposure to PAHs by also eating a wide variety of leafy greens from multiple sources.

You may also be concerned about the presence of dioxins. Dioxins are found in soil, but are not believed to be absorbed by plants. This means that the primary means of consumption would be through eating dirt containing dioxins or eating fruits or vegetables with ash stuck to them. To avoid consuming dioxins, thoroughly wash ash and soil from fruits and vegetables.

### **Is it safe to eat the plants?**

- Unfortunately, there is no definitive answer to this question. While tests to detect dioxins and PAHs are very expensive, less expensive tests do exist to detect heavy metals. You can have soil tested to eliminate concern about contamination from heavy metals.

Plants may have absorbed PAHs when the smoke was thickly blanketing our county. There is little research questioning the extent to which plants absorb PAHs through smoke after urban wildfires. Additionally, PAHs may have been aurally deposited from falling ash.

Soil may also be contaminated by dioxins, also aurally deposited by ash, resulting from incomplete combustion. Research shows that plants do not uptake dioxins and that most dioxins can be removed from thorough washing.

### **If I choose to wash the produce and eat it, what is the best practice for washing?**

- Washing instructions from the UC Cooperative is to soak vegetables in a vinegar and water solution for 10 minutes. The solution ratio is 2 1/2 tablespoons of vinegar per gallon of water.

### **Is the soil toxic?**

- No, not inherently. Soil testing can help inform whether your soil contains elevated levels of heavy metals. Note that lead accumulates in the top 8 inches of soil. Also note that soils in Sonoma County may have baseline levels of heavy metals that exceed EPA limits. For example, soils in West Sonoma County tend to be high in naturally occurring arsenic. If possible, compare current levels of arsenic with any past soil tests. Soil may also contain dioxins, but evidence shows that plants do not uptake dioxins. Soil may also contain PAHs from dust and ash.

### **Where can I get soil tested for an affordable price?**

- Brelje & Race Laboratories, Inc. recommend a soil test looking for 17 different heavy metals plus low levels of mercury. This is called a Cam 17 test.
- Remember to compare results with background levels of heavy metals when possible.
- I give two companies that will test soils:
  - [Harmony Farm Supply](#), Sebastopol (between \$240-\$280, inquire about their different tests)
  - [Brelje & Race Laboratories, Inc.](#), Santa Rosa (\$280)

### **Where should I take soil if it does contain higher than background levels of heavy metals?**

- You can take bagged soil to the Clover Flats dump in Calistoga. Call Kaye Woodsworth for more information prior to dumping at 707-337-9135.

### **How should I amend my soil?**

- Before developing a plan for amending soil, have your soil tested. If it tests positive for elevated levels of heavy metals, each metal is remediated a little differently. Lead accumulates in the top 8 inches of soil, so if your soil has elevated levels of lead then you should scrape the top 8 inches, place the soil in plastic bags, and take to a dump that will accept soil contaminated from the fires.
- Studies show that cow manure, mulch, and composting can decrease PAHs. Manure and mulch helps supply nutrients for indigenous bacteria to begin transforming PAHs. Compost has also been successful at remediating soil because it increases soil organic matter content and soil fertility (Megharaj & Naidu, 2017).<sup>9</sup> Animal manures are not recommended for school sites, so compost and mulch would be the better options for schools.
- A recent study published in 2017 by researchers from Michigan State University suggests that activated carbon, “rendered it [dioxins] completely unavailable to the food chain.”<sup>10</sup> Additionally, plants have been successfully used to sequester heavy metals and turn them into non-toxic compounds in a process known as phytoremediation (Tangahu et. al, 2011).

### **How should I care for my soil in light of the fires?**

- Research above suggests that incorporating mulch, manure (animal manures not recommended at school sites), and compost into soils can help bacteria transform PAHs. In addition, activated charcoal shows promise to remove dioxins and plants themselves can sequester heavy metals. Research confirming activated charcoal, also known as activated carbon, to remediate soils is very recent. I was unable to find an activated charcoal to soil ratio for soil treatment.

\*\*Please email Annie with any suggestions, information you would like to add, or anecdotes you would like to share at [annie.schoolgardennetwork@gmail.com](mailto:annie.schoolgardennetwork@gmail.com)

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<sup>9</sup> <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5609233/>

<sup>10</sup> <https://www.canr.msu.edu/news/research-breakthrough-could-cleanse-soil-sediment-and-water-pollution>