

Soil Screening Levels in Seattle

Capstone

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By

Olivia L. Wright

The University of Washington Bothell

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Capstone Advisor:

Shauna Carlisle, Ph.D.

Second Reader:

Melanie Malone, Ph.D.

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CHAPTER 1

Purpose of the Study

The purpose of this study is to compare the reliability and validity of screening levels that are used to regulate contaminant levels in soils in the Seattle metropolitan area.

This study specifically focuses on contaminants that have known endocrine disrupting and carcinogenic effects in soils in community urban farms/gardens in the Seattle metropolitan area. Endocrine disrupting means disrupting the endocrine system responsible for hormones regulating many vital bodily functions, such as moving and breathing (Hormone Health Network) while carcinogenic refers to cancer causing. The American Cancer Society has a list of *Known and Probable Human Carcinogens* on their website including arsenic, lead, glyphosate and toluene, benzene and cadmium, which are hydrocarbons that are found in gasoline, motor oils and diesel fuel (Myers et al.) (The American Cancer Society, 2019) (Illinois Department of Public Health) (Chilcott, 2006). As they are known widely to have carcinogenic and endocrine disrupting effects, I sampled soils as part of this research at community urban gardens/farms for contaminants from that list which include lead, arsenic, gasoline, diesel and motor oil. I also informally collected interview data from community urban garden/farm users and managers (See Appendix A for literature review questions).

Here in Seattle, there are about 90 public community gardens that total roughly 34 acres of land that is being used to grow food (About the P-Patch Program 2019). Washingtonians using P-Patches and other urban community farms/gardens to grow food need a reliable and economical way to test their soils and ensure their safety. The background of Seattle's community urban farms/gardens has not included testing for contaminants. That said, the concentrations of contaminants are often high, which is known to be a problem in community gardens/farms broadly (Mcclintock 2012). Soil that is not free of endocrine disrupting and carcinogenic contaminants is not clean soil, meaning that it could not produce adequate food,

which everyone has a right to. In their fact sheet “The Right to Adequate Food” the United Nations (UN) states that “Food must be *available, accessible and adequate*”: Available; through natural resources, the production of food via cultivating land and/or for sale at grocers; accessible; meaning that clean food is available locally and that it is affordable and adequate by meeting dietary needs and “Food should be safe for human consumption and free from adverse substances, such as contaminants from industrial or agricultural processes, including residues from pesticides, hormones or veterinary drugs.” (*The Right to Adequate Food* 2010). This fact sheet is relevant to take note of because all but two countries in the world are a part of the United Nations. This means that there is a strong consensus that adequate food is a human right.

Given the importance and necessity of available, accessible and adequate food in community urban farms/gardens in the state of Washington and the need for reliable and valid soil testing methods, this study will examine four soil screening levels for reliability and validity. The first method of screening comes from the Environmental Protection Agency’s Regional Screening Levels (EPA RSLs), which are generic screening values that are put in place by the federal government (“Regional Screening Levels Frequent Questions”, 2019). Soil that comes back from an accredited lab with contaminant levels that are less than the EPA RSLs are not considered an area heavily contaminated with hazardous waste, therefore warrants no further action, meaning no cleanup is required (*Soil Screening Guidance: Fact Sheet* 1996). The EPA’s RSL for ingested arsenic is 0.77 mg/kg. The EPA’s RSL for dermal exposure to arsenic is 5.5 mg/kg. The EPA RSL has no screening level for either ingestion or dermal exposure to lead. The second method of screening levels are The State of Washington Department of Ecology (WA DOE) cleanup levels for arsenic and lead that say that no action is necessary when these heavy metal levels come back from an accredited laboratory as equal to or less than the

cleanup level (Department of Ecology, 2016). The WA DOE arsenic cleanup level is 20 mg/kg. The WA DOE lead cleanup level is 250 mg/kg. The WA DOE cleanup level for diesel range organics (DRO) from 1991 was 200 mg/kg. The WA DOE cleanup level for diesel range organics (DRO) from 2001 was 2000 mg/kg. The WA DOE cleanup level for heavy oils, which includes motor oil, from 1991 was 200 mg/kg. The WA DOE cleanup level for heavy oils, which includes motor oil, from 2001 was 2000 mg/kg. The third method to be tested are the Washington State DOE Toxics Cleanup Program from 1994. They released natural background levels of heavy metals in Washington State. These levels were established to create a benchmark for the state. Relative to the rest of the country, Washington “naturally” has higher concentrations of arsenic and lead (Toxics Cleanup Program Department of Ecology, 1994). The background level for arsenic in Puget Sound in King County, WA is 7 mg/kg. The background level for lead in Puget Sound in King County, WA is 24 mg/kg. Finally, the fourth method of screening levels are the EPA’s established Ecological Soil Screening Levels (Eco-SSLs). These levels are risk-based “ in order to conserve resources by limiting the need for EPA and other risk assessors to perform repetitious toxicity data literature searches and data evaluations for the same contaminants at every site.” (Office of Solid Waste and Emergency Response, 2003). The Eco-SSL for arsenic is 4.5 mg/kg. The Eco-SSL for lead is 14 mg/kg.

I picked these screening levels to test against intentionally in that two of the four screening levels are different. Two of them are federal policies and two of them are policies specific to the State of Washington. Therefore, this study will test the reliability and validity of each of the four screening levels that are used to regulate contaminant levels. Secondly, this study will test the hypothesis that none of the four screening levels that are used to regulate contaminants in soils are effective in assessing toxicity and protecting people that rely on food from community urban gardens/farms in the Seattle metropolitan area.

The dependent variables in this study are varying levels of contamination, which are operationalized using ratio levels of measurement.

CHAPTER 2

Review of Literature

The purpose of this study is to compare the reliability and validity of screening levels that are used to regulate contaminant levels in soils in the Seattle metropolitan area. This is especially important in the Seattle area, as community urban farms/gardens are important to life in the Pacific Northwest. There are many food justice supporters in the Pacific Northwest, and we can see that through the amount of formal and informal urban agriculture in Seattle, as well as the amount of local projects such as farmers markets and cooperatives within the city (Horst, McClintock, & Hoey, 2017). In fact, "As of December 2016, there are 90 P-Patch community gardens, 3,055 plots, and 6,800 gardeners" ("Seattle Department of Neighborhoods P-Patch Community Gardening Program", 2016). P-Patches are designated public spaces in Seattle for community gardens to serve as gathering and knowledge sharing spaces where neighbors can grow their own produce. Seattle's P-Patch program is vital to many community members in the metropolitan region. That said, I am not only sampling P-Patch gardens, as there are many community gardens within the city as well. This study is also particularly relevant to Washington, because Washington contains higher background levels of certain contaminants, such as arsenic and lead.

Arsenic is found in especially high concentrations in community urban gardens in the Seattle metropolitan region. Tacoma, WA was the epicenter of the arsenic industry for roughly 75 years, from 1890-1986, as the Tacoma smelter plume was located in a neighboring city called Ruston ("Dirt Alert! - Tacoma Smelter Plume"). The Washington State Department of Health website states, "The arsenic from farming and smelting tends to bind strongly to soil and is expected to remain near the surface of the land for hundreds of years as a long-term source of exposure" (Public Health - Seattle & King County, 2017). Therefore, very high concentrations of arsenic still exist in the Seattle metropolitan region. On their website, they also mention that

fruits and vegetables that are grown in contaminated soil should be washed before they are ingested. King County says that the Department of Ecology is in charge of the Tacoma smelter via clean-up yet they also state that areas of contaminated soil are too large to dig up (Public Health - Seattle & King County, *What are the most affected areas?*). King County's Department of Ecology acknowledges that the King County communities that are most affected are Vashon-Maury Island, Parts of Federal Way and Kent, Des Moines, SeaTac, Normandy Park, Burien, Tukwila, North Highline area and West Seattle (Public Health - Seattle & King County, *What are the most affected areas?*). Looking on a map, these cities make up a significant chunk of the Seattle metropolitan region (See Appendix G).

Arsenic is one of many chemicals that can be found in community gardens. For centuries, the world has been using chemicals. They are used in everything from household cleaning products to gardens to war weapons. In the mid-19th century, a new category of chemicals was created, called petrochemicals (*American Fuel & Petrochemical Manufacturers: Petrochemical Facts*) which are chemicals that are made from petroleum and natural gas. This industry took off during World War II (WWII) as the demand for raw materials and fuel went up. Eventually, raw materials and natural resources grew scarce, so they turned to synthetic polymers, which the U.S. government supported (Boswell, 2014). Petrochemicals are in synthetic polymers, as well as synthetic rubber, which was one of the most significant discoveries in U.S. history because most people use products that contain petrochemicals in their day-to-day lives. The rubber companies, research laboratories, young chemical companies, and the U.S. government joined forces to quickly come up with an alternative to address the shortage of natural rubber during WWII (American Chemical Society, 1998). By the end of the war, the U.S. had produced two million tons of synthetic rubber and consumed fifty percent of the country's total petrochemical output in the process of doing so (Boswell, 2014).

There was also a food shortage during WWII which led to government rationing food and promoting of "victory gardens," which roughly twenty million people decided to start (Reinhardt, *Farming in the 1940s: Victory Gardens*). In the spirit of patriotism, communities gathered resources and formed cooperatives and began to plant fruits and vegetables on rooftops, backyards and empty lots. Though large-scale farming had been around for many years, and immigrant and working-class families had been growing food in their kitchens, but community urban gardens really became recognized around WWII (Horst, McClintock, & Hoey, 2017). In 1944, U.S. Department of Agriculture published a piece called "A Victory Gardener's Handbook on Insects and Diseases". In this handbook, they recommend pesticides such as corrosive sublimate (bichloride of mercury) to kill cabbage maggots, despite their warning which read "Do not use a metal container, as these materials corrode metal". Interestingly in this handbook, they suggest using other inorganic and toxic pesticides such as cryolite, Paris green, lead arsenate, rotenone, pyrethrum, red copper oxide, anthracnose, etc.

The production of petrochemicals led to the production of many pesticides, which were often the by-products of the processes used to produce petrochemicals (*Ballotpedia: Petrochemicals*). For example, dichloro-diphenyl-trichloroethane (DDT) was the first modern insecticide of the 1940's that had many uses. Its first use was to fight insect-borne human diseases, such as malaria and typhus, during WWII (National Pesticide Information Center, 1999). Soon, DDT, was being used in livestock and crop production, as well as in gardens. DDT's widespread use is the sole reason that many insects developed resistance to it. Given the substantial amount of evidence that it was causing substantial adverse environmental effects, the EPA banned DDT in 1972 (United States Environmental Protection Agency, 2017). That said, there are many pesticides that did not get banned such as Roundup, which is a pesticide that though unrelated to WWII is relevant for this discussion. Chemicals and heavy

metals are often found in pesticides that are readily used in farms/gardens. Roundup is a prime example of a pesticide that is commonly found in community urban gardens. Pesticides are generally cheaper than natural pest deterrents, their use usually results in increased food production, more profitable, less time consuming, less intensive to apply and many people are misled by pesticide advertisements into using these products. For instance, Roundup has been advertised as less toxic than table salt (GMWatch, 2017). Roundup is a very commonly used pesticide. The three classes of pesticides used most frequently on food are herbicides, fungicides and insecticides (National Resource Council, 1993). Pesticides can easily spread and can travel further than intended via runoff, atmospheric drift and through food. Pesticides are subjected to toxicity tests to assess risk, but typically these tests are paid for by the manufacturers of the pesticide (Boone et al., 2014). The pesticides mentioned above contain endocrine disrupting and carcinogenic effects. In other words, they disrupt hormones and cause cancer. Products that contain chemicals of this toxicity that are typically seen in community gardens are diesel, gasoline and the active ingredient in Roundup, glyphosate. Similar to Roundup, Diesel Range Organics (DRO) is a mixture of many chemicals. DRO's chemicals mostly come from crude oil. These chemicals are made up of carbon and hydrogen, and are classified as hydrocarbons. People are often exposed to diesel from anything that is made up of petroleum products. An everyday exposure would be somebody breathing air at a fuel station (Agency for Toxic Substances & Disease Registry).

Post WWII, the public began growing anxious about the degradation of our earth (Leaning, 2000). People were beginning to see the effects of nuclear testing, pollution, pesticide poisoning and exposure to radiation via thermonuclear weapons on our environment and its living inhabitants. In response to the public's growing fear, then President Richard Nixon signed the National Environmental Policy Act (NEPA) into law in 1970. That same year, he created the

Environmental Protection Agency (EPA), which who he gave the responsibility to “regulate” chemicals. Finally, in December of 1970, Nixon signed the Clean Air Act (Revesz & Lienke, 2016). Nixon was pressured to put these things into place for none other than political reasons such as fear of losing the presidency and yet numerous studies have shown that chemical regulation by the EPA is problematic (Revesz & Lienke, 2016). The Washington Post explains that virtually any toxic product that a company wants to monetize is allowed unless the EPA can establish “reasonable risk” within the first month and a half, which proves to be a difficult and lengthy decision to make (Kollipara, 2015).

For example, Monsanto- the company that commercialized the herbicide Roundup- in 1974 (Benbrook, 2016). It is still a very commonly used synthetic herbicide (Malkan, 2019). Each time Monsanto has asked the EPA to raise the tolerance of glyphosate, which is the active ingredient in Roundup, they have done just that (Gillam, 2018). Despite what we know to be true about these harmful chemicals, the government still allows big companies, such as Monsanto to monetize them and say that they are safe. According to the Environmental Working Group, “The Environmental Protection Agency said today the active ingredient in Bayer-Monsanto’s carcinogenic weed killer Roundup is safe, ignoring a growing body of independent research showing a strong connection between glyphosate and cancer in humans. “The National Pesticide Information Center reports that glyphosate is an ingredient in more than 750 products that are sold in the U.S. Monsanto is currently amidst a two-billion-dollar lawsuit against a couple who claims that long term exposure to their weed killer, Roundup, caused them to get identical cancer diagnoses of non-Hodgkin lymphoma only four years apart from one another (Nedelman, 2019).

Given the prevalence of chemicals in many household products and what we know to be true about their endocrine disrupting and carcinogenic effects, this research study used an

Exploratory Approach framework to investigate the reliability and validity of screening levels that are used to regulate contaminant levels in soils in the Seattle metropolitan area.

Horst and colleagues suggest that there are many social benefits to urban agriculture, but that urban agriculture does not necessarily meet goals of food justice (Horst, McClintock, & Hoey, 2017). Food justice is a movement surrounding the idea that healthy accessible food is a human right (*Nourish: Food Justice*). Further that urban agriculture may enforce social inequities and contribute to the displacement of lower-income community members and that land access for urban agriculture is an issue for disadvantaged communities (Horst, McClintock, & Hoey, 2017). Due to the complexities of these issues, it was necessary to use an Exploratory approach so that I could look at the soil samples contaminant levels and talk to community members that manage and use these community farms/gardens to help tell the story. However, one of the most compelling reasons for studies that examine the reliability and validity of soil testing methods is based on the Universal Declaration of Human Rights which states that “(1) Everyone has the right to a standard of living adequate for the health and well-being of himself and of his family, including food, clothing, housing and medical care and necessary social services, and the right to security in the event of unemployment, sickness, disability, widowhood, old age or other lack of livelihood in circumstances beyond his control.” (*Universal Declaration of Human Rights, 1948*). The author of this study seems to believe that it is not only the state's responsibility to understand the reliability and validity of soil testing, but that it is a basic human right for adequate soil testing to be conducted to produce accurate information that informs the food production and consumption of farmers and gardeners in Washington state. This goes hand-in-hand with the food justice movement. In 2012, The Institute for Agriculture and Trade Policy defined food justice as being “the right of communities everywhere to produce,

process, dis tribute, access, and eat good food regardless of race, class, gender, ethnicity, citizenship, ability, religion, or community.” (Horst, McClintock, & Hoey, 2017).

CHAPTER 3

Methodology

The purpose of this study is to compare the reliability and validity of screening levels that are used to regulate contaminant levels in soils in the Seattle metropolitan area. More specifically, this research identifies the concentrations of contaminants that have known endocrine disrupting and carcinogenic effects in soils of community urban gardens in the Seattle metropolitan region. Between the pilot study and the main study, nine community urban gardens were sampled and tested for contaminants that include glyphosate, lead, arsenic, diesel range organics (DROs) and gasoline range organics (GROs).

An initial pilot study was conducted to establish whether or not we would find carcinogenic and endocrine disrupting contaminants in urban community farms/gardens in the Seattle metropolitan area. Four community garden/farm sites were sampled in the pilot study, including 21 Acres in Woodinville, Renew Church in Lynnwood, UWB Campus Garden in Bothell and Georgetown Urban Farm in Seattle, Washington. Note that the post-pilot study conducted under the guidance of Dr. Malone included another four community farm/garden sites, plus two original pilot study sites. That said, the post-pilot study included samples from UWB Campus Garden in Bothell, Renew Church in Lynnwood, Danny Woo Community Garden in Seattle, Jackson P-Patch in Seattle, Beacon Food Forest in Seattle, Marra Farm in Seattle and Yes Farm in Seattle, Washington.

The main difference between the community urban gardens/farms is the geographical locations. Importantly, the community gardens that were given priority had high racial/ethnic diversity, low economic status, prior industrial histories, and were community urban garden/farm sites that receive(d) government or non-profit funding for environmental justice initiatives. The farm/garden sites were also spread out among Seattle, WA using cardinal direction.

At the pilot study sites, the procedures used to collect samples were as follows. I took one composite and ten discrete samples and sent them to two credible laboratories to be analyzed. (See below for a description of the data collection procedures). A discrete soil sample is a collection of soil from one area. A composite sample is a collection of small amounts of soil taken from many different areas in a garden to provide a sample that is representative of the whole garden. Composite samples are generally used when running more expensive tests, like glyphosate for example. The composite sample was analyzed for Diesel Range Organics (DRO), Gasoline Range Organics (GRO), glyphosate/AMPA and motor oil. The discrete samples were analyzed for total lead and arsenic levels.

All of the samples from the post-pilot study sites were discrete samples. These samples were analyzed for total arsenic, total lead, DRO, motor oil and some were tested for glyphosate as well. Main study samples were not tested for GRO because all of the samples from the pilot study came back as “non detect” for GRO and are not included in the tables below. At least ten soil samples were taken from each community garden/farm site, and at some sites, one to two compost samples were also taken from shared compost piles. See Appendix H for samples at each urban community farm/garden. At these sites, the source and type of the compost was recorded. Also, soil physical characteristics were analyzed from each sample during collection in the field, as well as in a UWB campus laboratory, UW2-231. At each sampling location, the following characteristics were recorded: GPS coordinates, soil texture (See Appendix B), amount of roots and size of roots, pH level(See Appendix C), color (See Appendix D), conductivity (See Appendix E) and organic matter content (See Appendix F). I also recorded the type of surface cover (if any) at each sampling location and if the sampling location was within the ground or in a raised garden bed. Additional categories were added after pilot sampling, like surface features and amount and whether it was on the ground or in a raised bed, but I removed

other categories, such as soil texture and size and number of roots. This was done to provide some context for the results that we got. It mattered if there were a lot of wood chips on the surface of a hole where we sampled because there is a possibility that the wood chip may have been contaminated.

Before sampling, organic debris on the surface were removed, such as wood chips, fresh grass clippings and fresh compost. I dug holes at each sample location, using a small hand shovel. The sampling holes were roughly 10 to 12 centimeters in diameter and 15 to 20 centimeters in depth. Approximately 300 grams of soil was extracted from each sampling location. To get samples from across each garden/farm evenly, each community garden/farm site was divided equally into 10 squares, and then a discrete sample was taken from each square. This was the case, unless there was a portion of the garden/farm that was not being used for growing food and eaten out of. All samples were labeled with the sample name, date and time of collection.

During sample collection, all samples were kept in a cooler, not to be exposed to direct sunlight. Once the samples were collected, they were taken directly to the laboratory at UWB and placed in a freezer. Samples were then shipped to the designated laboratories in coolers that were filled with ice, as well as a Chain of Custody (COC) sheet that goes in a plastic bag and inside the cooler, on top of the samples. The COC sheet detailed what samples the cooler contained and what contaminants they needed to be analyzed for. The cooler was then taped shut before shipment.

Sample names used the first letter of the community farm/garden name, followed by an "S", which represents the word "soil". If the sample was a compost sample, the second letters were "CO". The letter "W" stood for a sample that was taken of wood chips. The two letters were followed by a dash, and a sample number. The sample number was determined by how

many total samples were taken from that site already. The first sample from every farm/garden site started with 1. Some examples of sample names include the following: YCO-2, AS-2, and BS-5. Sample names were associated with notes taken in the field, as well as GPS coordinates.

During soil sampling, nitrile gloves were worn to prevent cross-contamination. Before and after every sample collection, I decontaminated the small shovel that was used to dig with alconox.

IRB approval was sought and granted for this project. The community urban farms/gardens owners all gave informed consent and voluntarily participated in this study. Informal interviews were conducted, but I will not be discussing them in this paper because I am focusing on whether or not the screening levels and policies surrounding contaminants are protective of human health. Consent was given by garden managers to sample their soils. There was no harm to participants in this study. To protect the data, it was kept on a secure drive on a password protected computer.

Contaminant data was analyzed against screening levels which come from the EPA's Ecological Soil Screening Levels (Eco-SSL's) (U.S. Environmental Protection Agency, 2003)(Office of Solid Waste and Emergency Response, 2003), WA DOE's cleanup levels (Department of Ecology, 2016), the EPA RSLs (*Soil Screening Guidance: Fact Sheet* 1996) and the Washington State DOE Toxics Cleanup Program's natural background levels (Toxics Cleanup Program Department of Ecology, 1994).

To analyze the purpose of the study was to compare the reliability and validity of screening levels that are used to regulate contaminant levels in soils in the Seattle metropolitan area", this study used a descriptive analysis which included frequencies, percentages, means and medians. These allowed me to compare my results from each farm/garden to one another.

CHAPTER 4

Results

Below are the results of the test that compared the reliability and validity of screening levels that are used to regulate contaminant levels in soils in the Seattle metropolitan area.

See appendices for tables 1-10, table 10 contains the legends for tables 1-9. The figures in the results section reveal the average level of each contaminant in all nine of the sampled farms/gardens. The tables display the soil sample results that were analyzed by accredited laboratories. The laboratory results are being compared to the four screening levels, as mentioned in the methodology section of this paper. All boxes that are highlighted red indicate that the concentration level is equal to or higher than at least one of the soil screening levels that they were tested against. The darker the color of red, the more soil screening levels that sample is equal to or greater than.

Results revealed that Jackson P-Patch has the highest average level of arsenic contamination out of any of the community urban farms/gardens that were sampled with 11.83 mg/kg, as shown in Figure 1. YES Farm has the highest average level of lead contamination with 45.93 mg/kg, as shown in Figure 2. Further, figures 3 and 4 results reveal that Georgetown has the highest average contamination rates of DRO and motor oil with 1500 mg/kg, but only one sample was taken from this community urban garden/farm.

Comparing these results against standard soil screening levels that are said to be protective of public health, these urban farms/gardens that our community members rely on are heavily contaminated, meaning that their soils came back as over the soil screening levels that the government has in place to protect us. Overwhelmingly, each community urban garden/farm was heavily contaminated and had multiple samples above the public policy's soil screening levels that are meant to be protective. The implications of these findings are that the community urban gardens/farms are full of contaminants that have endocrine disrupting and carcinogenic

effects. This means that our community members are ingesting these foods, and therefore ingesting these toxic contaminants.

Figure 1. *Average Arsenic Level per Community Urban Farm/Garden*

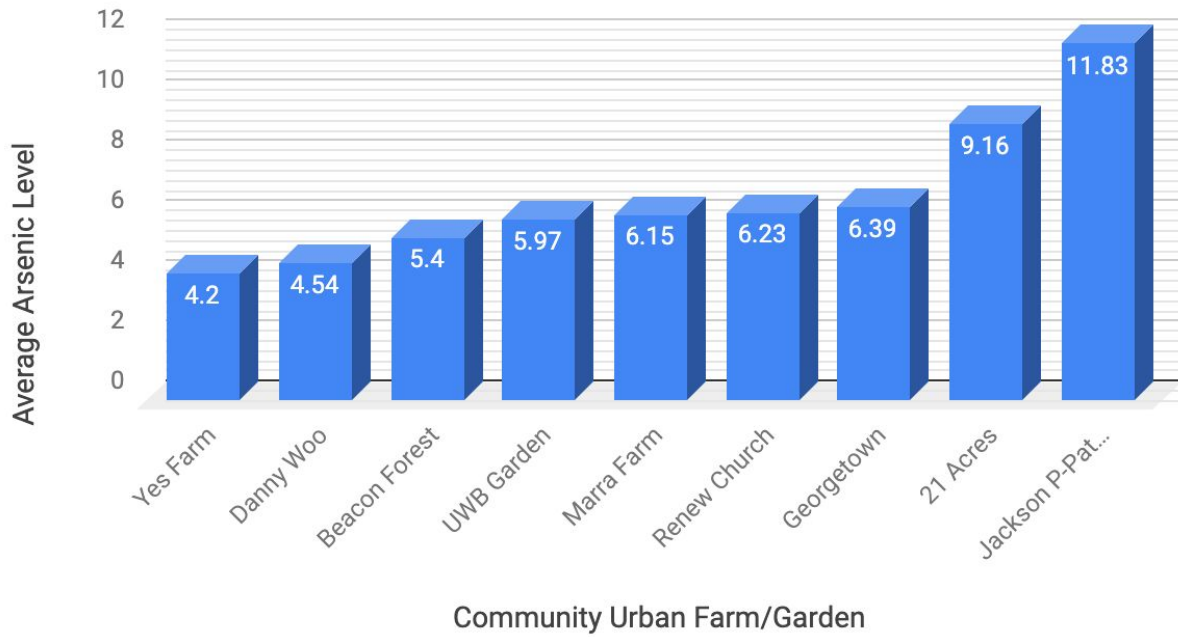


Figure 2. *Average Lead Level per Community Urban Farm/Garden*

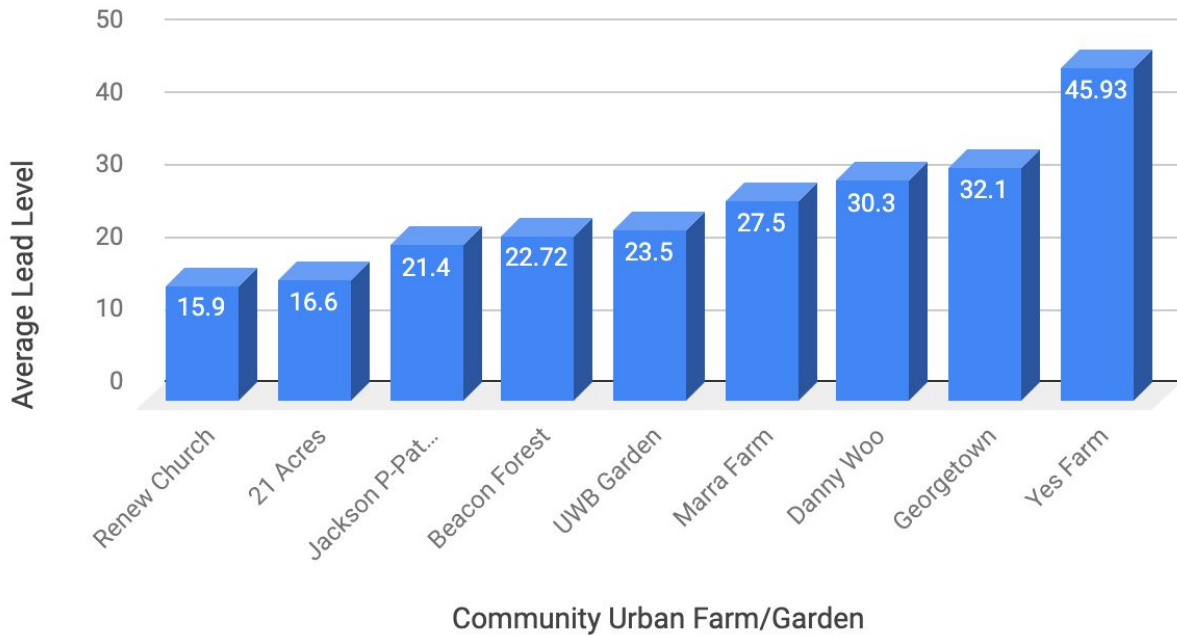
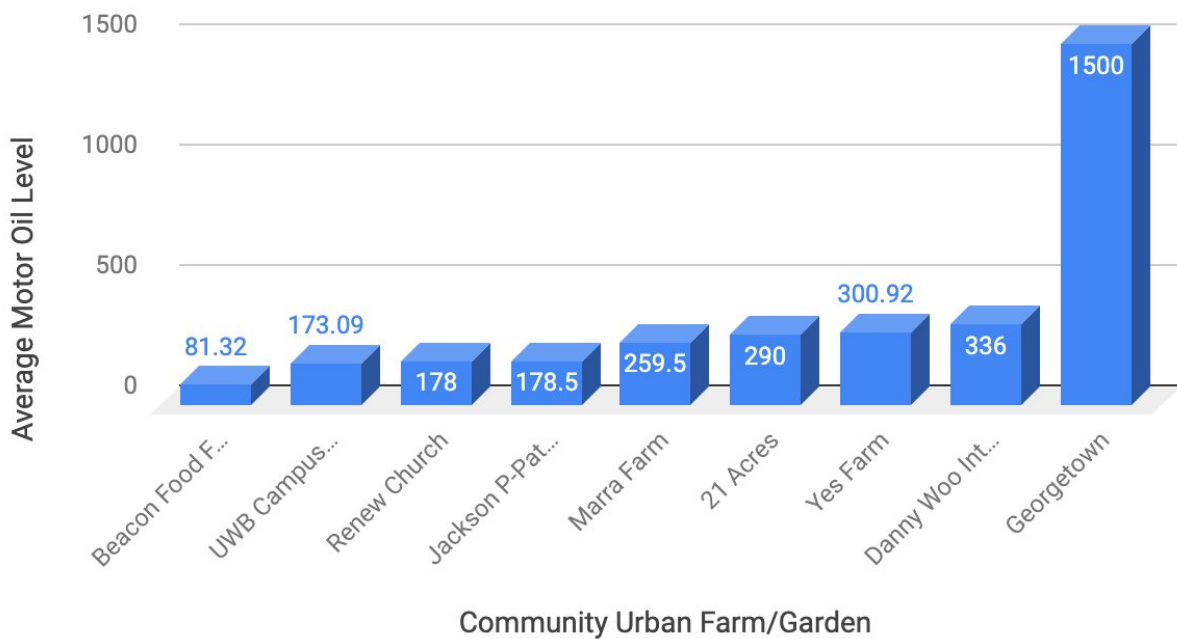
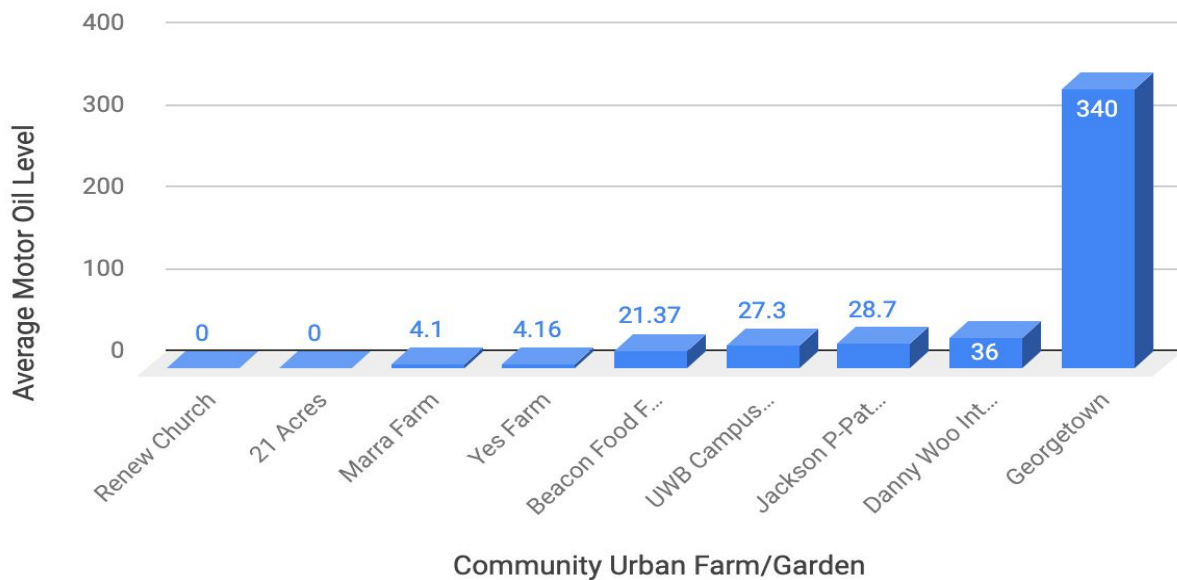


Figure 3. Average Motor Oil Level per Community Urban Farm/Garden



Note: Georgetown appears to be the highest level of motor oil contamination, but only one composite sample was taken.

Figure 4. Average DRO Level per Community Urban Farm/Garden



The following results will be presented by stating the percentage of contamination that exceeded one or more soil screening levels that I tested against from each community urban farm/garden in the study. For each result, the significance will also be noted at $p=.05$.

The results reveal that fifty six percent of contaminant samples from YES Farm came back as above or equal to at least one soil screening level (See Table 1) at a $p=.05$. From Marra Farm, sixty two percent of contaminant samples came back as above or equal to at least one soil screening level (See Table 2) at a $p=.05$. Further, thirty five percent of contaminant samples from Beacon Food Forest came back as above or equal to at least one soil screening level (See Table 3) at a $p=.05$. Fifty eight percent of contaminant samples from Jackson P-Patch came back as above or equal to at least one soil screening level (See Table 4) at a $p=.05$. All, meaning one hundred percent, of contaminant samples from Georgetown came back as above or equal to at least one soil screening level (See Table 5) at a $p=.05$. This has heavy significance. Fifty seven percent of contaminant samples from Renew Church came back as above or equal to at least one soil screening level (See Table 6) at a $p=.05$. The results

reveal that eighty six percent of contaminant samples from 21 Acres came back as above or equal to at least one soil screening level (See Table 7) at a $p=.05$). The results from the UWB Campus Garden reveal that forty eight percent of contaminant samples came back as above or equal to at least one soil screening level (See Table 8) at a $p=.05$). Lastly, the results from Danny Woo reveal that seventy two percent of contaminant samples came back as above or equal to at least one soil screening level (See Table 9) at a $p=.05$).

These results indicate that these community urban gardens/farms are heavily contaminated, meaning that their concentration of contaminants came back higher than many of the screening levels that they were being tested against. They indicate that the soil screening levels in place to protect our community members are not protecting anybody, because a majority of the samples came back as equal to or above at least one of the soil screening levels. The WA DOE soil screening level is in place as a cleanup level, meaning that the State should be cleaning up any site that shows contamination at or above their set level. That said, the WA DOE screening level is not necessarily in place to protect health. This is different than a level like the EPA's SSL's, which do not indicate safety, but they are in place to regulate against an outcome, like a percentage of cancer diagnoses out of a certain amount of people they are okay with.

CHAPTER 5

Discussion and Conclusion

The purpose of this study was to compare the reliability and validity of screening levels that are used to regulate contaminant levels in soils in the Seattle metropolitan area. It is disturbing how poor the validity and reliability of soil screening level contamination measures are considering the amount of community members that rely on urban gardens/farms. It is problematic that the government has public policies in place that say it acceptable to have any amounts of diesel and motor oil in garden/farm spaces where food is grown. According to their website, the EPA aims to ensure that we have clean land, contaminated sites are cleaned and aims to reduce environmental risks by using the best available scientific information (United States Environmental Protection Agency). That said, a piece of literature on food and chemical toxicology notes the credible studies in which the active ingredient in Roundup, glyphosate, is proven unsafe from a lower dose exposure than the dose that they currently consider “safe” (Mesnage et al 2015).

In addition to the quantitative findings, this discussion incorporates comments, concerns and feedback from farm managers and garden users. One farm manager shared that they believe they had felt fuel being dumped on them on more than one occasion, which felt like a mist that left a burning feeling on their skin. This comment is credible considering this community urban farm/garden was located near an airport and laboratory tests revealed high levels of DRO and motor oil.

The number of red boxes that appear in tables 1-9 give a strong sense that the soils in the Seattle metropolitan area are concentrated with endocrine disrupting and carcinogenic contaminants. The implications of this study show us that the soils that are most vulnerable community members are growing their food in, and then feeding their family and friends from these heavily contaminated soil patches. In the case of the Yes Farm, they are farming on

heavily contaminated land, which is located directly next to Interstate 5 because the land was acquired by YES farm through a Request for Proposals (RFP) for the property usage. One might suggest that this is a strong example of public policy failing to use reliable and valid soil contamination testing to inform applications before they begin the RFP process.

One might also suggest that the King Conservation District Soil Testing Program is problematic because they are only providing basic nutrient testing. A basic nutrient tests soils levels of potassium(K), soil pH, magnesium(Mg) and phosphorus(P) (King Conservation District, "KCD Soil Testing Program"). King County entices community members to do this free testing by saying that it can help them manage their soil nutrient levels and that it could result in increased crop production. Based on the results, they may recommend that you amend with specific amendments, such as lime to make your soil more acidic. In other words, they are telling farmers/gardeners *if* they can grow in their farms/gardens, but not if they *should* be growing food in their farms/gardens. They are not testing for cancer causing or endocrine disrupting contaminants. Even if they do try and amend to address the issues that the KCD Soil Testing Program exposes, many of these community gardens/farms are getting wood chips, soil, compost, lumber and other materials via donation, so it would be difficult to control the quality of the gardening products and ensure that those materials are not contaminated, unless you had them tested before using them. Garden managers and users that were informally interviewed during this process were grateful to get gardening/farming resources donated to them, such as wood chips from the City of Seattle, but the issue is that the trees that the wood chips were made from could have been treated with pesticides that contain endocrine disrupting and carcinogenic contaminants. The trees also may have been downtown where thousands of cars drive within a few feet of them everyday, meaning that they could be contaminated with diesel and/or motor oil that are full of endocrine disrupting and carcinogenic contaminants.

While getting every garden/farm input tested is a possibility, it would be very expensive as just one glyphosate test will cost ~\$250 to be analyzed by an accredited lab, such as the ones used in this study.

In conclusion, the purpose of this study was to compare the reliability and validity of screening levels that are used to regulate contaminant levels in soils in the Seattle metropolitan area. This study has done that and might believe that the soil screening levels are not actually keeping our communities safe. As stated earlier, ignoring the weaknesses in the soil testing measures is problematic as I believe this is a human rights violation when state agencies such as the DOH really are not using effective measures to test soil contamination and yet instruct Americans to simply wash food grown in contaminated soil. How are people supposed to trust these state and federal organizations to provide proper advice and accurately explain the potential harm of what possible endocrine disrupting and carcinogenic contaminants could be in their soils when they cannot even rely on the set soil screening levels that are not protective of and adequate for human health?

More specifically, the results of this research suggest that soils tested for carcinogenic and endocrine disrupting contaminants in community urban gardens in the Seattle area come back as above four screening levels that I tested them against. Would this mean that soils in the Seattle area are contaminated, and that this is a violation of the Universal Declaration of Human Rights, as well as the United Nations fact regulations?

Soil testing is expensive, thus creating a barrier and limiting the amount of people that are able to afford to do it. Yet from the comments by our community members, the barrier is knowledge, that is knowing what they should be testing for or how to properly analyze and interpret the results. Given the ambiguous language that the screening level policies use makes it difficult for gardeners/farmers to interpret the laboratory results.

One might suggest that some screening levels are simply stricter than others, but that none are necessarily “better” than another. Ideally, no endocrine disrupting and carcinogenic contaminants would be in our community urban/gardens farms. The American Cancer Society recognizes the contaminants that we tested for, including arsenic, lead, glyphosate and toluene, benzene and cadmium (hydrocarbons that make up motor oil), as probable human carcinogens (Washington State Department of Health, "Arsenic"). This fact should be enough for us to not want and/or allow proven cancer causing contaminants in our community urban garms/gardens. If we are allowing them in our soils, we are allowing them in our crops and ultimately allowing them in our bodies.

Finally, the lack of adequate protective policies regarding endocrine disrupting and carcinogenic contaminants in soils in community urban farms/gardens have real impacts on the community. People who rely on community gardens are ingesting and being exposed to contaminants in these soils that are proven to disrupt the normal endocrine system functions and are proven to cause cancer because the soil screening level standards that are in place are not adequate for informing the community of soil toxins. The Washington State Department of Health has publicly admitted that arsenic is present in our soils that that it can cause health problems in both short-term exposure to large amounts and long-term exposure to small amounts (Washington State Department of Health, "Arsenic"). They even talk about children being more likely to swallow contaminated soil, but they never talk about growing food in contaminated soil nor that their current testing measures may be under reporting soil toxin levels (Washington State Department of Health, "Arsenic").

There were several limitations that need to be considered when interpreting these findings. This research was limited by time, budget constraints, and in some cases, farm/garden plots that could not be sampled because they physically could not be accessed and/or because

farmers/gardeners did not want their plots sampled. This study was also limited by sample size. Ideally, many more community urban gardens in the Seattle metropolitan area would have been tested for contaminants. There was also limited information (in some cases) that were known about past land uses of the sites in which we sampled. Some interviewees suspected previous drug-use on the community urban garden/farm land due to evidence of drug paraphernalia. In another case, the garden manager acquired the use of the land through an RFP put out by the City of Seattle, so it is difficult to say what was happening on the land previously. Despite these limitations, the results from this research provide significant insights into the reliability and validity of soil screening in Washington State and the significant harm this may be causing when state and federal screening methods underestimate soil toxins and contamination.

APPENDICES

Appendix A. List of Interview Questions to be asked during Casual Interviews with Users and Managers of the Farms/Gardens.

Questions (specifically) for Users of the Farm/Garden

- Physical Practices
 - What types of plants do you grow?
 - What type of gardening practices do you use?
 - Did anyone teach you to garden?
 - Is gardening knowledge shared between members of the community? If so, how?
 - What inputs go into your garden?
 - What types of organic fertilizers or pesticides do you use, if any?
 - Why did you choose those inputs?
 - Is your garden organic?
 - What is your definition of organic?
 - Do you use compost?
 - Where does the compost come from? Is it organic?
 - If you make your own compost, what goes into the compost?

- Environmental Justice Related Questions
 - Where did you learn about urban gardens and what was your motivation for becoming involved?
 - Do you see the garden as an environmental justice or social justice project?
 - What are the intended outcomes of the urban garden? Why?
 - How is the garden funded?

- Did you use any p-patch funds for the garden?
- Who maintains the garden?
- Do you know anything about the past site history of where you garden?
- Do you have any concerns about where you garden (e.g. about soils, safety, or other items)?
- Do you feel your concerns are addressed in any way?

- Equity
 - What do you do with the food harvested here?
 - How does one obtain a plot?
 - Is this farm fulfilling a need in the community? What need does it fulfill?
 - How does community input factor into the planning of this garden?

- Diversity and Demographic Data
 - What's the typical age of people using the garden?
 - Does it seem like the garden is used equally by all genders?
 - Do you feel the garden has a diverse range of people using it? Could you explain who uses it?
 - Do any people of international origin or immigrants use the garden?

Questions (specifically) for Managers of the Farms/Gardens

- General Questions
 - What year was the garden started?

- Who started the garden?
- Who is the owner?
- Environmental Justice Related Questions
 - Where did you learn about urban gardens and what was your motivation for becoming involved?
 - Do you see the garden as an environmental justice or social justice project?
 - What are the intended outcomes of the urban garden? Why?
 - How is the garden funded?
 - Do you receive any monetary funds for the garden from any non-profits or municipalities?
 - Did you use any p-patch funds for the garden?
 - Who maintains the garden?
 - Do you know anything about the past site history of where you garden?
 - Do you have any concerns about where you garden (e.g. about soils, safety, or other items)?
 - Do you know if others have any concerns about the garden? If so, explain what those concerns are
 - If there are social or environmental concerns, how do you try to address those concerns?
- Physical Practices
 - What do you allow to be used in the garden?
 - Is the garden organic?
 - What's your definition of organic?

- Where does the compost come from? Is it organic?
- If you make your own compost, what goes into the compost?

- Equity
 - What do you do with the food harvested here?
 - What relationship does this farm have with people in need? What need does it fulfill?
 - How does community input factor into the planning of this garden?
 - How does one obtain a plot?
 - Is there an educational component to the garden? If so, who is in charge of the educational component
 - How do you address the needs of those who farm here and what are their needs?

- Diversity and Demographics
 - Do you know anything about the demographics of people who use the garden?
 - For this garden, is it a priority to include a diverse group of people?
 - What's the typical age of people using the garden?
 - Does it seem like the garden is used equally by all genders?
 - Do you feel the garden has a diverse range of people using it? Could you explain who uses it?
 - Do any people of international origin or immigrants use the garden?
 - Are you taking any active steps to diversify the garden?

Appendix B. Source for Proposed Soil Data Collection Methodology: Soil Texture Test
Soil Texture Test. (n.d.). Retrieved 2019, from
https://hnr.k-state.edu/doc/soil-test-kit/Soil_Texture_Test.pdf

Appendix C. Tool used for Determining Soil pH Level
Cole-Parmer Oakton pHTestr 10 Waterproof Pocket Tester 35634-10. (n.d.). Retrieved June 11,
2019, from
<https://www.coleparmer.com/i/oakton-phtestr-10-waterproof-pocket-tester-35634-10/3563410>

Appendix D. Source used for Soil Color Determination:
Munsell Soil Color Book

Appendix E. Tool used for Determining Soil Conductivity
Cole-Parmer Cole-Parmer Conductivity Meter and Conductivity/TDS Meter. (n.d.). Retrieved
June 11, 2019, from
<https://www.coleparmer.com/p/cole-parmer-conductivity-meter-and-conductivity-tds-meter/20109>

Appendix F. Source for Proposed Soil Data Collection Methodology: Organic Matter
Determination

Reddy, K., & Suryakanta. (2015, December 03). HOW TO DETERMINE ORGANIC MATTER CONTENT IN SOIL? Retrieved June 11, 2019, from

<https://civilblog.org/2015/12/03/how-to-determine-organic-matter-content-in-soil/>

Appendix G. Map of King County areas affected by the Tacoma Smelter Plume

<https://www.kingcounty.gov/depts/health/environmental-health/toxins-air-quality/arsenic-lead/tacoma-smelter-plume/~media/depts/health/environmental-health/documents/toxins/areas-affected-by-tacoma-smelter-plume.ashx>

Appendix H. Sample analysis type, container used and laboratory that it was analyzed at.

Sample Analysis	Container	Laboratory Used for Sample Analysis
Diesel Range Organics (DRO)	1 (4 oz) glass jar per sample	TestAmerica
Total Arsenic and Lead	1 (4 oz) glass jar per sample	TestAmerica
Glyphosate/AMPA	1 (50 ml) plastic vial	HRI Lab
Physical Soil Characteristics	1 ZipLoc bag of at least 300 grams of soil per sample	UWB Campus Lab
DRO, Total Arsenic and Lead, Glyphosate/AMPA Compost	1 (4 oz jar) and 2 (50 ml) vials	TestAmerica and HRI labs

Appendix I. Sample type and amount of samples taken at each farm/garden.

	Yes Farm	Marra Farm	Beacon Food Forest	Jackson P-Patch	Georgetown	Renew Church	21 Acres	UWB	Danny Woo	Total Samples Analyzed from All Sites
Compost Samples	2	2	1	0	0	0	0	0	3	8

Soil Samples Analyzed for DRO	11	10	13	10	1	11	1	11	10	78
Soil Samples Analyzed for Arsenic	11	10	13	10	10	20	10	20	10	114
Soil Samples Analyzed for Lead	11	10	13	10	10	20	10	20	10	114
Total Samples	13	12	14	10	11	21	11	21	13	126

Table 1. Yes Farm Lab Results

Sample Name	Arsenic (mg/kg)	Lead (mg/kg)	Diesel #2 (mg/kg)	Motor Oil (mg/kg)
YS-1	ND	1.4	190	580
YS-2	2	15	27	100
YS-3	4.2	18	72	350
YS-4	6	110	87	450
YS-5	4.8	69	66	510
YS-6	7.2	88	18	70
YS-7	5.1	97	86	110
YS-8	6.9	98	5.5	41
YS-9	3.6	13	67	440
YS-10	3.7	12	100	480
YS-11	3.8	9.7	39	230
YCO-2	2.6	20	86	250

Table 2. Marra Farm Lab Results

Sample Name	Arsenic (mg/kg)	Lead (mg/kg)	Diesel #2 (mg/kg)	Motor Oil (mg/kg)
MS-1	6.2	30	ND	290
MS-2	4.1	25	ND	690
MS-3	6	23	ND	190
MS-4	5.7	27	41	240

MS-5	5.7	27	ND	260
MS-6	8.6	32	ND	110
MS-7	8	38	ND	180
MS-8	5.4	21	ND	95
MS-9	7.8	35	ND	120
MS-10	4	17	ND	420

Table 3. *Beacon Food Forest Lab Results*

Sample Name	Arsenic (mg/kg)	Lead (mg/kg)	Diesel #2 (mg/kg)	Motor Oil (mg/kg)
BS-1	6.4	39	16	95
BS-2	4	5.1	ND	8.1
BS-3	5.3	36	8.4	71
BS-4	5	18	49	170
BS-5	8.8	53	7.5	41
BS-6	5.8	30	17	60
BS-7	6.1	27	8.9	25
BS-8	3.4	9.2	29	61
BS-9	10	23	27	120
BS-10	4.5	15	26	63
BS-11	3.1	13	15	60
BS-12	3.6	12	38	93
BS-13	4.2	15	36	190

Table 4. *Jackson P-Patch Lab Results*

Sample Name	Arsenic (mg/kg)	Lead (mg/kg)	Diesel #2 (mg/kg)	Motor Oil (mg/kg)
JS-1	4.6	22	22	95
JS-2	7.5	24	22	120
JS-3	23	37	28	230
JS-4	18	16	20	130
JS-5	4.7	37	36	240
JS-6	16	16	31	250
JS-7	13	15	30	160

JS-8	15	19	37	300
JS-9	13	12	22	110
JS-10	3.5	16	39	150

Table 5. *Georgetown Lab Results*

Sample Name	Arsenic (mg/kg)	Lead (mg/kg)	Diesel #2 (mg/kg)	Motor Oil (mg/kg)
GS-1	-	-	340	1500
GS-2	5.5	24	-	-
GS-3	6.8	33	-	-
GS-4	5.8	57	-	-
GS-5	5.2	21	-	-
GS-6	13	21	-	-
GS-7	4.6	19	-	-
GS-8	5.6	30	-	-
GS-9	6.8	28	-	-
GS-10	5.9	25	-	-
GS-11	4.7	63	-	-

Table 6. *Renew Church Lab Results*

Sample Name	Arsenic (mg/kg)	Lead (mg/kg)	Diesel #2 (mg/kg)	Motor Oil (mg/kg)
RS-1	-	-	ND	270
RS-2	6.7	18	-	-
RS-3	6.7	21	-	-
RS-4	6.3	15	-	-
RS-5	7.3	14	-	-
RS-6	6.5	17	-	-
RS-7	5.8	16	-	-
RS-8	6.8	14	-	-
RS-9	5.1	13	-	-
RS-10	4.4	13	-	-
RS-11	6.7	18	-	-
RS-12	-	-	ND	120

RS-13	-	-	ND	140`
RS-14	-	-	ND	180
RS-15	-	-	ND	190
RS-16	-	-	ND	78
RS-17	-	-	ND	210
RS-18	-	-	ND	130
RS-19	-	-	ND	200
RS-20	-	-	ND	230
RS-21	-	-	ND	210

Table 7. 21 Acres Lab Results

Sample Name	Arsenic (mg/kg)	Lead (mg/kg)	Diesel #2 (mg/kg)	Motor Oil (mg/kg)
AS-1	-	-	ND	290
AS-2	8	13	-	-
AS-3	10	19	-	-
AS-4	8.7	16	-	-
AS-5	10	18	-	-
AS-6	11	19	-	-
AS-7	9.4	17	-	-
AS-8	12	21	-	-
AS-9	7.5	14	-	-
AS-10	6.3	13	-	-
AS-11	8.7	16	-	-

Table 8. UWB Campus Garden Lab Results

Sample Name	Arsenic (mg/kg)	Lead (mg/kg)	Diesel #2 (mg/kg)	Motor Oil (mg/kg)
CS-1	-	-	ND	570
CS-2	5.5	12	-	-
CS-3	5.1	15	-	-
CS-4	4.5	16	-	-
CS-5	4.9	23	-	-
CS-6	6.5	26	-	-

CS-7	9.4	19	-	-
CS-8	8.2	36	-	-
CS-9	5.9	32	-	-
CS-10	4.3	28	-	-
CS-11	5.4	28	-	-
CS-12	-	-	22	110
CS-13	-	-	28	120
CS-14	-	-	16	85
CS-15	-	-	34	170
CS-16	-	-	25	160
CS-17	-	-	31	170
CS-18	-	-	49	150
CS-19	-	-	42	180
CS-20	-	-	13	91
CS-21	-	-	13	98

Table 9. *Danny Woo Lab Results*

Sample Name	Arsenic (mg/kg)	Lead (mg/kg)	Diesel #2 (mg/kg)	Motor Oil (mg/kg)
DS -1	4.8	32	ND	190
DS-2	3.2	21	ND	240
DS-3	3.8	17	53	350
DS-4	6.6	12	85	410
DS-5	4.3	29	ND	460
DS-6	5	46	79	430
DS-7	4.6	42	ND	270
DS-8	5.1	49	ND	320
DS-9	4.3	31	79	340
DS-10	3.7	24	64	350

Table 10. *Key for Tables 1-9*

	A cell filled with this color indicates that the contamination level is equal to or above one of the soil screening levels.
	A cell filled with this color indicates that the contamination level is equal to or above two of the

	soil screening levels.
	A cell filled with this color indicates that the contamination level is equal to or above three of the soil screening levels.
	A cell filled with this color indicates that the contamination level is equal to or above four or more of the soil screening levels.
ND	Non Detect
DRO	Diesel Range Organics

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