HAWAII STATE
DEPARTMENT
OF HEALTH

HOMEOWNER'S GUIDE to SOIL TESTING FOR ARSENIC

Soil Sampling Strategy and Planning

Arsenic is a naturally occurring element in Hawaiian soils, and can be found in native soils at concentrations up to about 20 milligrams per kilogram (mg/kg; also referred to as "parts-per-million" or "ppm"). However, some areas may have elevated levels of soil arsenic as a result of past human activities, most notably the historic use of arsenic-based herbicides in the sugar industry (1920s – 1950s). Arsenic distribution in soils can be quite variable from one place to another throughout a neighborhood, or even from one area to another on an individual residential property. Variations in how arsenic herbicides were applied, complicated by subsequent soil disturbances (such as grading, house building, or landscaping) can further alter the distribution of arsenic in soils on residential sites. For example, arsenic applied as an herbicide to the ground surface (years ago) would be expected to remain in the surface soils and not tend to leach downward; however, past grading, tilling, and digging activities may have buried soil arsenic below today's soil surface. To determine if levels of soil arsenic may or may not be elevated above natural background levels on your property, you must take this variability in soil arsenic distribution into account when testing your soil.

Obtaining good data on soil arsenic levels on your property requires a significant effort, close attention to details during the soil sample collection, and resources to pay for the processing and analysis of your soil at a laboratory. Because of the expected variation in soil arsenic distribution, a "multi-increment" sampling approach for soil arsenic testing is advised. This is a similar approach used for testing soils in agriculture, where average nutrient levels in a field are evaluated through multiple soil samples mixed together and then sub-sampled, not with a single "grab" sample. A multi-increment sample is made up of 30 individual soil samples or "increments" collected across the area of interest. The multiple soil increments are combined to form a single multi-increment sample. Laboratory analysis results from the multi-increment sample should provide a good estimate of the average concentration of arsenic in the soil of the specific area sampled. The individual soil increments collected should be spaced out across the entire area of the lot or section of the lot you are sampling.

All 30 individual soil increments should be taken at the same approximate depth of soil. Most often, people are interested in evaluating the arsenic levels in "surface soils". Surface soil samples are collected from the ground surface down at least 2 inches, or if the soil is generally not too rocky or too compacted, from the ground surface down to as much as 6 inches below the surface. Samples deeper than a 6-inch depth should not be included in a multi-increment surface sample. The depth of your soil increments (whether 0-2 inches deep, 0-6 inches deep, or somewhere in-between) should be based on the depth of soil you expect you or your family to most likely contact through play, gardening, or other activities on your lot. Although most individuals are more likely to be exposed to surface soils, there are circumstances where deeper soils (for example, 6 to 12 inches below ground surface) may be of interest/concern, such as within vegetable gardens that are regularly maintained, or on land that you know may be graded to a different level in the future. To sample deeper soils, you can first collect the surface soil increments then collect deeper soil increments from the same holes, being careful not to mix soils from one depth-interval to another. All of the surface soil increments should be combined in one container, and all of the deeper soil increments combined into a separate sample container.

The individual sample increments for each multi-increment sample are collected and mixed together, typically using a large zip-type plastic bag. The bag is carefully labeled with the date, name of the collector, and a unique number or code representing where the sample was collected (and the depth interval of soil collected). The sample is then ready for delivery to a laboratory for processing and analysis.

An example of the sample bag label is given below. You would also want to write the information for each of the labels on a piece of paper or in a notepad to save at home for your future reference:

Date: January 30, 2008
Collector: Maile Doe
Sample ID: A1
Depth: 0-2 inches
Area Sampled: Back yard of 321 Aloha Street

Your choice about where to collect multi-increment samples depends on the soil arsenic exposure issues most important to you. For example:

- If you want an estimate of the average arsenic concentration in the back yard where you spend most of your time, then you should collect a multi-increment sample (composed of 30 individual increments) from across the entire back yard area.
- If you want to estimate the average arsenic concentration in a more specific area, for example a garden area or an area used by your children

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to play regularly, then you would collect your multi-increment sample (again, 30 sample increments) from just within these particular areas.

- If you spend most of your time not in one area but across different areas of the front yard, back yard, and side yards, then you may want to collect a multi-increment sample from across your entire property, where the multi-increment sample represents the average soil across the property.

Start your sampling effort by making a simple sketch of the outer boundaries of the area you have chosen to sample, including predominant landmarks such as the location of the edges of the house, garage, fences, or property boundaries. Measure and record the length and width of the area(s) you have selected to sample. Next, determine how you will space out the individual soil increments (30) to be collected across the entire sample area. Typically, if the area is a simple shape like a rectangle, you would start from one side boundary of the sample area and lay out 3 to 6 parallel lines across the length or width of the sample area, and collect increments at roughly equal distances along these lines. Mark the sample locations with numbered (1-30) stakes, pin flags, or even pieces or paper held in place with a rock. Do your best to spread the 30 sample locations out so that they are roughly equal-distance apart along the 3 to 6 parallel lines, as well as between the lines selected. Distances can be estimated by pacing, you do not have to measure them out exactly. If the area to sample is irregular in shape, use your best efforts to place 30 sample locations spread out evenly across the area; again, it doesn't have to be a perfect pattern (see Figure 1 below). The approximate location of each individual sample increment can be indicated on the hand drawn map to further document your sampling effort, and aid in later identification of the locations tested for the laboratory results.

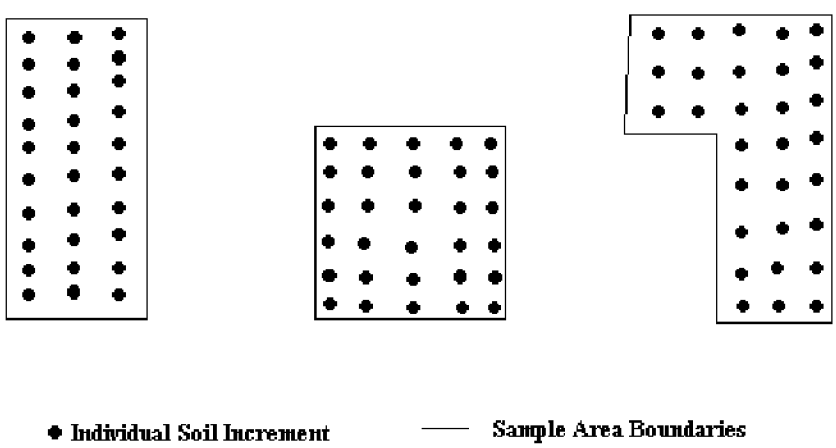

Figure 1. Three examples with approximate locations of 30 soil sample increments spread across the specific sample areas. The 30 sample increments are combined to make up a single multi-increment soil sample.

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Collecting Soil Samples

Wear clean gloves while sampling (plastic gloves, or cloth or leather garden gloves). At each of the 30 sample locations collect a soil sample increment using a clean stainless steel or plastic trowel. For surface soil samples, you may need to remove some grass or surface vegetation with your shovel, then sample the soil directly beneath (being careful not to remove significant amounts of soil associated with plant roots). Try to collect a small round "core shape" of soil with equal amounts of material from all depths within your sample interval. For example, if you're sampling the 0-2 inch interval, make sure to get the same amount of soil from 0-1 inches as from 1-2 inches. At each of the 30 sample locations, you'll want to collect approximately the same amount of soil – typically around 1-2 ounces (~30-50 grams), about the volume of a golf ball. The entire multi-increment sample (made up of 30 increments) will weigh about 2 to 3 pounds (1,000 – 1,500 grams).

In certain cases, deeper soil samples may be of interest, and can be collected by digging a hole to a specific depth (or first collecting surface soil increments), then collecting the soil from the deeper interval, just as described above for surface soils.

All 30 individual soil increments should be placed together in the same re-sealable plastic bag (use one-gallon size freezer-weight bags). It is important to send the entire multi-increment soil sample(s) collected to the laboratory, don't discard any portion, even if you think you've collected more sample than necessary. To make the sample collection more efficient, support the multi-increment sample collection bag during sampling by placing it inside a clean one-gallon paint can or one gallon plastic water jug with the top cut off. Excess grass, roots, or rocks collected with soil can be hand picked out of the trowel or plastic bag, although this is not critical.

After collecting all of the 30 sample increments, seal the bag and write the label information (Date, Collector, Sample ID, Soil Depth, Area Sampled) on the bag using a permanent marking pen rather than a ballpoint pen. Then place the bag inside a second bag for safety against accidental breakage. Remember, the unique label ID Code information will be your means to identify where the multi-increment sample was collected when the laboratory analysis results are returned to you.

To verify that the arsenic levels measured in a specific area of your property is accurate and precise, you could choose to take a second or "replicate" sample from one of the sampling areas. To collect a replicate sample, you would use the same soil collection procedures described above to sample the same specific area twice, but choose 30 completely different spots across the area to create a second multi-increment sample. Make sure to give this sample a new and unique ID Code, and note in your record that it is a replicate for the specific area

sampled. If the results from the original and the replicate samples are reasonably similar to one another, the results can be trusted with greater confidence. Reasonably close or precise when comparing replicate soil sampling results of contaminants is generally considered within about 35%. Although replicate sampling takes more time and involves greater costs for an additional laboratory analysis, it provides verification that you have reliable data to make decisions. If you collect a replicate multi-increment sample, be sure and label it in a manner that you will know it is a separate sample for the same area. It is not necessary to label the sample in a manner that the laboratory will know it is a replicate (and can be considered a better test if only you, and not the laboratory, know that the soil sample is a replicate for a specific area).

Selecting and Working with a Laboratory

You will need to select a laboratory to perform the chemical analysis of your samples. It is best to identify and communicate with the laboratory you will be using before you collect your samples, to facilitate appropriate shipping arrangements, ensure your analyses will be conducted in a timely manner, and agree on the costs for the lab work. Be sure and check with the laboratory about a state Department of Agriculture permit for shipping soil inter-island – the lab should be able to provide a copy of their permit to enclose when shipping the samples.

There are laboratories located in Honolulu that offer soil analyses for arsenic, other metals, and other environmental contaminants. However, some environmental laboratories specialize in only water samples, food samples, or certain types of chemical analyses, so you need to talk with them to ensure that they can perform the soil processing and analysis you need. Check the Honolulu yellow pages under "Laboratories – Analytical" for a list of laboratories that may be able to analyze your samples. There are also laboratories on the mainland that could be used for conducting your soil analyses. You could also call the Hawai`i Department of Health, Hazard Evaluation and Emergency Response Office (HEER Office) in Honolulu (586-4249) or Hilo (933-9921) for advice on selecting a laboratory. Here are the key things you want the laboratory to do with your soil samples:

1. Dry the entire multi-increment soil sample (typically air-dry for 1-2 days depending on how wet the soil is),
2. Sieve the entire multi-increment soil sample to a less than 2 millimeter (<2mm) particle size,
3. Take at least a 10-gram representative sub-sample from the dried and sieved (<2mm) multi-increment soil sample for extraction and analysis (using multi-increment sub-sampling methods, or a rotary sectorial splitter),

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4. Digest and analyze the sub-sample for total inorganic arsenic using EPA SW-846 methods.

Check with the lab you have selected regarding total soil processing and analysis costs as well as the sample packaging and delivery requirements. Costs can vary between laboratories, but are in the range of $100 - $150 for processing and analysis of each multi-increment soil sample for arsenic. Costs will be higher if additional metals are requested to be analyzed in the same soil sample (for example, lead), however it may be possible to request a number of other metal analyses from the same soil sample if you suspect or are interested in testing for these. Laboratories can also provide advice, procedures, and supplies for handling, storing and shipping the samples. Laboratories generally provide results within 10-15 days of receipt of the sample(s).

In addition to reporting the arsenic concentration in each of your soil samples (under the unique ID Code you have provided), the lab will also run and report the results of basic laboratory quality control measures. These typically include a blank (BLK) analysis to ensure that no contamination has been introduced by the lab procedures, a "duplicate analysis" (LCS) to report the precision or reproducibility of the lab measurements, and a "spike analysis" (MS) to assess the accuracy of the results by measuring a known quantity of chemical substance added to a sample. The laboratory should detail the quality control results in their report, and let you know if they did or did not meet the laboratory's quality control criteria.

Evaluating Soil Sample Test Results

Some useful ways to evaluate the soil sample test results that the laboratory provides include the following:

- Comparison of the results to the range of natural background concentrations of arsenic in Hawaiian soils – these have been reported in the range of about 5-20 mg/kg.

- Comparison of the results with the initial arsenic "screening levels" used by the Hawai`i Department of Health HEER Office when evaluating hazardous substance release sites. For residential areas, the total inorganic arsenic "screening level" that the HEER Office uses is 20 mg/kg. If arsenic levels are below this initial screening level, then no further evaluation or assessment of a site is typically required.

- Comparison of results with guidance provided by the Hawai`i Department of Health HEER Office, such as the August 2006 "Soil Action Levels and Categories for Bioaccessible Arsenic" guidance document available at: http://www.hawaii.gov/health/environmental/hazard/pdf/arsenicactionlevelsaug2006.pdf

This guidance document also provides advice on appropriate actions to take to reduce or eliminate soil arsenic exposure, if levels are found to exceed natural background.

Finally, the Department of Health HEER Office is interested in compiling results of soil arsenic analyses from across the state. If you do sample your property for soil arsenic levels and are willing to share your results, please call the HEER Office in Hilo (808) 933-9921. Accumulated analysis data can help the HEER Office identify areas where more sampling may be appropriate, as well as areas where there appears to be no issue with elevated levels of soil arsenic. In addition, sampling data can help the HEER Office identify areas where residents need to be alerted to potential elevated levels of soil arsenic and ways to avoid exposure.

Note: These recommendations are general in nature and not intended to be used as a substitute for appropriate professional advice. Recommendation on the use of a multi-increment soil sampling strategy is generally applicable for evaluations of other soil contaminants. However, specific details in this guide are intended for soil arsenic evaluations in former agricultural fields only, such as the number of increments to include in a multi-increment sample, sample handling in the field and lab, and the sample mass recommended for extraction and analysis in the lab. You can call the Hawai`i Department of Health, Hazard Evaluation and Emergency Response Office (HEER Office) at (808) 586-4249 in Honolulu or (808) 933-9921 in Hilo with questions or for more information.

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