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Ithaca Community Gardens Soil and Plant Tissue Testing

Summary Report, *Revised 30 April 2010*

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Previous Testing (before CWMI involvement)

- In 1997, the Board decided to pursue soil testing in the Ithaca Community Gardens because of concerns due to the Gardens' proximity to Rt. 13.
- One composite soil sample from the Rt. 13 side of the garden was sent to the Cornell Nutrient Analysis Laboratory for heavy metal analysis. Soil lead (Pb) was 127.9 ppm; cadmium (Cd) was 1.1 ppm.
- Six samples from 6 different garden quadrants were sent to Life Science Laboratories, Inc. in Syracuse. Each was a composite of samples from 5 locations. Pb levels were 15-84 ppm; Cd levels were <1 ppm.
- Maps, data sheets, emails and recommendations to gardeners from Nina Bassuk are available to refer to as needed.
- In 2003, additional samples were collected for heavy metal analysis.
- In July, soil samples were taken from 6 plots nearest Rt. 13. These were composite samples of 8" soil plugs from several plots along the row. Pb levels ranged from 75-144 ppm.
- In August, plant samples were also collected.
- Notes and data from 2003 sampling are available to refer to as needed.

Note: ppm = parts per million

June 2008 Data

Sampling procedure:

Soil samples from 58 garden locations were collected on June 17, 2008 by Hannah Shayler and Murray McBride from the Cornell Waste Management Institute. Samples were subsequently analyzed for total metals and general soil fertility by the Cornell Nutrient Analysis Laboratory. Out of 149 total garden plots, approximately every 3rd plot was sampled. Within each plot, samples from 5 locations (center of the plot and midway to each edge from the center) were collected from approximately 6" deep and composited. Seven additional locations of interest (4 from the area closest to Rt. 13, and 3 by the Master Composters' area; see #60-62, 184, and 267-269 on map) were also sampled using the same procedure as for the existing garden plots.

Soil Results for Lead, Arsenic, and Cadmium:

Note: 2008 soil samples were also analyzed for general soil fertility properties (e.g., nutrient levels, pH, organic matter content) as well as levels of other metals.

Lead (Pb)

- Soil Pb concentrations ranged from 23-244 ppm, with a mean of 113 ppm.
- In the garden area farthest from Rt. 13 (i.e., on the far side of Carpenter Circle), 12 samples had Pb concentrations <100 ppm. The remaining 3 samples had Pb concentrations ranging from 100-150 ppm.
- In the garden area on the side of Carpenter Circle closer to Rt. 13, 13 samples had Pb concentrations <100 ppm. Sixteen samples had Pb concentrations of 100-150 ppm. Eleven samples had Pb concentrations of 150-200 ppm, and the remaining 3 samples had Pb concentrations between 200-250 ppm.
- Most of the plots with measured Pb concentrations >150 ppm were located in the southern part of the garden, NOT in the areas closest to Rt. 13.

Arsenic (As)

- Arsenic soil concentrations ranged from 0-18 ppm, with a mean of 8 ppm.
- No particular trends in As concentration are apparent.

Cadmium (Cd)

- Reported Cd concentrations ranged from 0 to 2.9 ppm.
- However, reported Cd levels are likely overestimated, with actual levels being below the detection limit of the laboratory's analytical methods.

August 2009 Data

Sampling Procedure:

The sampling completed in 2009 took a more focused view of the Gardens than the previous 2008 sampling. Additional soil testing was paired with plant tissue testing from locations selected from gardens areas with the lowest and highest lead levels. Soil and tissue samples were collected from 21 garden plots, 3 soil samples were collected from the Kids' Plot area, and 1 sample was taken from the compost area. Soil samples were tested for total metals by the Cornell Nutrient Analysis Laboratory, while the plant tissues samples were analyzed for Pb, As, and Cd by the Federal Nutrition Laboratory at Cornell University.

Soil Results for Lead, Arsenic, and Cadmium:

Note: 2009 soil samples were also analyzed for levels of other metals.

Lead (Pb)

- Soil Pb levels in the 36 samples ranged from 21-206 ppm, with a mean of 104 ppm.
- In the area farthest from Rt. 13, all 7 samples had Pb concentrations <100 ppm.
- Of the 3 samples from the Kids' Plot, 2 were <100 ppm (82, 75 ppm) and the third was 106 ppm.
- The compost sample was below 100 ppm, measuring 74 ppm.
- The 2008 trend in Pb levels continued. Of the 2009 samples, all of the plots with measured Pb concentrations >150 ppm (11 samples) were located in the southern part of the garden, NOT in the areas closest to Rt. 13.

Arsenic (As)

- Soil As levels in the 36 samples ranged from 4-10 ppm, with a mean of 7 ppm.
- No particular trends in As concentration were apparent.

Cadmium (Cd)

- Cadmium soil concentrations for all of the 36 samples were low enough to be reported at the detection limit of the lab equipment.
- Together with data from previous testing efforts, these results suggest that Cd levels in the garden are likely near the detection limit of the laboratory's analytical methods.

There is no single standard that defines acceptable levels of metals or other contaminants in soils. However, regulations issued by the New York State Department of Environmental Conservation and soil screening guidance from the US Environmental Protection Agency provide some basis for comparison. See CWMI's "Fact Sheets - Resources for Healthy Soils" at <http://cwmi.css.cornell.edu/soilquality.htm>.

Table 1: Concentrations (in ppm) of lead, arsenic, and cadmium in soils collected from the Ithaca Community Gardens in 2008 and 2009.

	Soil Pb		Soil As		Soil Cd	
	2008	2009	2008	2009	2008	2009
Mean	113	104	8.48	7.01	1.44*	<det
Min	23.0	20.8	0	4.09	0*	<det
Max	244	206	18.3	12.9	2.94*	<det

* 2008 soil Cd data likely overreported; Cd levels in the Ithaca Community Gardens most likely fall below the laboratory's detection limit.

Tissue Results:

31 plant samples were collected from plots across the garden in 2009 and analyzed for Pb, As, and Cd. Those crops included: amaranth, beet greens, carrots, chard, comfrey, tomato, and turnip greens.

Table 2: Average heavy metal concentrations (in ppm) in plant tissue collected from the Ithaca Community Gardens in 2009, on an estimated fresh weight basis.

	Mean Pb (min-max)	Mean As (min-max)	Mean Cd (min-max)
Carrots 6 samples	.090 (.030-.28)	.0035 (.0024-.0049)	.010 (.0069-.021)
Chard 9 samples	.014 (.0036-.031)	.0023 (.0016-.0035)	.013 (.0068-.031)
Tomato 12 samples	.0063 (.0028-.012)	.00031 (.00017-.00055)	.0059 (.0028-.013)
Amaranth 1 sample	.036	.0055	.0031
Beet Greens 1 sample	.055	.0041	.019
Comfrey 1 sample	.038	.0033	.0013
Turnip Greens 1 sample	.054	.011	.0067

While the United States does not have specific values for allowable heavy metal levels in food items, the European Union, the FAO & WHO, and Australia & New Zealand do have such standards. Although these values are not directly applicable to garden vegetables in the United States, they can provide some basis for comparison.

Lead (Pb)

- Lead standards from the above organizations are:
0.1 ppm fresh weight for vegetables (excluding brassicas and leafy vegetables)
0.3 ppm fresh weight for brassicas and leafy vegetables
- Lead tissue concentrations in the 31 samples ranged from 0.0028 ppm in a tomato to 0.28 ppm in a carrot on an estimated fresh weight basis.
- One carrot sample had a measured Pb concentration that exceeded the vegetable standard referenced above. The next highest carrot Pb level was 0.077 ppm. Another sample of the 0.28 ppm tissue was sent for a second analysis; the results of this retest confirm that the Pb level in this sample was higher than those of the other carrot samples.

Arsenic (As)

- Arsenic tissue concentrations in the 31 samples ranged from 0.0016 ppm in a chard sample to 0.011 ppm in the turnip greens sample on an estimated fresh weight basis.
- No particular standard for As in food has been solidified.

Cadmium (Cd)

- Cadmium standards vary slightly across the EU, the FAO & WHO, and Australia & New Zealand:

EU

0.05 ppm fresh weight for fruits and vegetables (excluding leafy, stem, and root vegetables)

0.2 ppm fresh weight for leafy vegetables and fresh herbs

0.1 ppm fresh weight for stem and root vegetables (including peeled potatoes)

FAO/WHO

0.1 ppm fresh weight for vegetables (excluding brassicas)

Australia & New Zealand

0.1 ppm fresh weight for ALL vegetables

- Cadmium tissue concentrations in the 31 samples ranged from 0.0013 ppm in the comfrey sample to 0.031 ppm in a chard sample on an estimated fresh weight basis.

Preliminary Recommendations

- Lead levels in Ithaca Community Garden soils are generally above typical rural background levels in NY State. Lead levels in plant tissue are generally not of concern, with the exemption of one carrot sample that exceeds the standards outlined above. Future research and the collection of additional vegetable tissue for analysis will help us to better understand the factors contributing to Pb levels in carrots.
- Cadmium levels in the Gardens' soils are likely above typical background levels in NY state (pristine soils may be as low as 0.1- 0.2 ppm of Cd), although levels are below the laboratory's detection limit. However, tissue results verify that levels in garden crops are not significant, and existing levels of Cd can be easily managed by maintaining garden soils at or above a neutral pH.
- Arsenic levels in the Gardens' soils are generally within the range that is typical of background levels in NY State. No significant amounts of As were found in tissue samples.
- Although contaminant levels in the Ithaca Community Gardens do not dictate that any particular management or mitigation regime be followed, gardeners may choose to follow recommended best management practices for promoting healthy soils and minimizing possible exposures to soil contaminants. See CWMI fact sheets at: <http://cwmi.css.cornell.edu/soilquality.htm>

Next Steps

- 1) Experimental / research plots in 2010 growing season
 - On a volunteer basis, additional plant tissue testing will take place in small (approximately 1-2 sq. ft.) sub-plots of gardener's plots. CWMI staff will maintain these plots, and vegetables (carrots, lettuce, beans, and tomatoes) will be harvested for tissue testing. We hope to include about 10-15 plots in this study.
 - In addition, gardeners can also volunteer limited tissue samples from their gardens without having a CWMI maintained sub-plot.
- 2) Sharing of results to date
 - CWMI staff Hannah Shayler and Leigh Kalbacker presented a summary of project activities to date at the spring gardener orientation meetings on April 6 and 14, 2010.
 - Summary reports and other information (including the PowerPoint presentation from the meetings) will be distributed to gardeners via the Ithaca Community Gardens website.
- 3) PAH (Polycyclic Aromatic Hydrocarbon) sampling
 - Samples will be collected from the southern area of the garden where "clinkers" have been found, which may indicate coal ash or slag.
 - Composite samples from a few beds in other garden areas will also be collected for comparison.
- 4) Educational opportunities and sharing of future results
 - Workshops and/or discussion forums will also be offered on an as-desired basis.
 - Information will continue to be shared through the Cornell Waste Management Institute and Ithaca Community Gardens websites.