Arsenic Uptake Released from CCA Treated Lumber by Florida Vegetable Crops

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Aziz Shiralipour, Ph.D.
Department of Agronomy
University of Florida

State University System of Florida
Florida Center for Solid and Hazardous Waste Management
University of Florida
2207-D NW 13th Street
Gainesville, FL 32609
www.floridacenter.org

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Project Leader: Aziz Shiralipour, Department of Agronomy, University of Florida, Gainesville, Florida

Introduction

Untreated lumber can be decayed and destroyed by insects, fungi and other microorganisms when in contact with the ground or exposed to the outdoor environments. To prevent wood decay and destruction and to increase life expectancy, chemical methods of wood preservation have become increasingly popular during the last 60 years (Stehouwer, 2001). Inorganic waterborne preservatives, such as chromated copper arsenate (CCA), have proven to effectively protect wood from bacterial, fungal, and insect attack (Hingston *et al*., 2001). Copper (Cu) is an effective fungicide, arsenic (As) is an effective insecticide, and chromium (Cr) serves to bind chemical preservative to the wood. In the United States, CCA was used on more than 98% of the approximately 12,390,600 m^3 (437,657,000 ft^3) of wood that was treated in 1990 (Lebow, 1996, in Alamgir, et al, 2001). Chromated copper arsenate is the most popular water-born wood preservative used today. This widespread use of CCA-treated wood has increased concerns about possible disposal of arsenic into the environment (Kelsall et al., 1999; Stilwell and Gorny, 1997).

Arsenic has long been identified as a carcinogen, and its elevated concentration in an ecosystem is of great concern for public health and the environment (Hingston *et al*., 2001; Ma *et al*., 2001). Arsenic contamination in soils results from various human activities including milling, combustion, wood preservation and pesticide application. High concentration of inorganic arsenic in drinking water has been associated with skin cancer and other disorders (U.S. EPA, 1988). Several studies suggest that drinking water with high levels of arsenic can also lead to bladder and lung cancer, which are more likely to be fatal (Abernathy et al., 1997; Bate and Smith, 1992; U.S. EPA, 1988). Inorganic arsenic, the form most likely to cause cancer, is a naturally occurring element in the earth crust. Irrigation and rainfall are the most important factors in releasing arsenic into ground water that travels through underground rocks and soil.

The potential pathways for human exposure to arsenic include physical contact with treated wood surfaces, followed by ingestion via hand to mouth, exposure during construction involving inhalation of sawdust and ingestion, consumption of plants grown in the vicinity of CCA wood (such as raised beds, around decks or near fences), and by exposure to contaminated soil where the arsenic could be taken up by edible plants.

Except for a few studies including David Stilwell and co-workers (personal communications, Connecticut Agricultural Experiment Station), the information about absorption of inorganic arsenic by the edible parts of vegetables grown in raised beds or around decks built with the CCA treated wood is limited.

In a previous study (Cao et al., 2003), we investigated the effects of compost and phosphate rock amendments on As mobility in soils, and As uptake by the hyperaccumulator, Chinese Brake fern. The fern plant was grown for 12 weeks in a CCA contaminated soil and an As spiked contaminated soil (ASC), which were treated with phosphate rock (1.5% by weight), composted municipal solid waste, and composted biosolids. Phosphate amendments significantly enhanced plant arsenic uptake from soils. Compost treatments facilitated As uptake from the CCA soil, but decreased As uptake from the ASC soil. Replacement of As by P in the two tested soils was responsible for the enhanced As uptake by phosphate application. Elevated As uptake in the compost-treated CCA soil was related to As (V) transformation into more available As (III) or organo-As. Reduced As uptake in the ASC soil was attributed to As adsorption on the compost.

Chinese Brake took up As mainly from fractions associated with Fe and Ca in the CCA soil and exchangeable As in the ASC soil. Compost and phosphate amendments increased As leaching from the CCA soil without the presence of the plant, but decreased when the plant was present. For the ASC soil, both treatments reduced As leaching regardles of the presence of fern.

The objectives of this investigation are to determine the amounts and conditions which cause edible plants to take up arsenic released from CCA-treated wood.

Purpose

This is a three-year project and is intended to provide experimental data to evaluate the concerns about the possible exposure to arsenic from gardening use of CCA-treated lumber. In particular, the effect of CCA-treated lumbers used to construct raised garden beds or fences by homeowners growing vegetables in those beds or close to those fences is being investigated under Florida's climate and soil conditions. The final results could be used to develop an exposure model for the risk assessment of the use of CCA in a garden environment.

Special tasks:

1. Determine the uptake of As released from CCA-treated wood by garden plants in test mini raised beds in greenhouse.

2. Determine the uptake of As released from CCA-treated wood by garden plants in raised garden beds under field conditions.

3. Evaluate the effects of composted material, phosphate rock and iron oxide (Fe_2O_3) Additives on uptake of inorganic arsenic by edible vegetables

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***WORK ACCOMPLISHED DURING THE FIRST YEAR*:**

Task one and a portion of the task two were completed during this period:

Methodology

Task 1. Determine the uptake of Arsenic released from CCA-treated wood by garden plants in test mini raised beds in greenhouse.

This task of the project involved growing leaf lettuce, turnip green and carrot in a temperature-controlled greenhouse started on 10/28/03 in Gainesville. These plants were selected because lettuce is a good indicator for the As uptake and turnip green can absorb higher quantities of As compared to other vegetables. Carrot was selected because the edible part is in contact with the soil. Plant seeds were germinated in plugs of growth media in seedling pot trays. The growth media was consisted of 50% peat moss, 25% vermiculite, and %25 perlite. Two weeks after germination, uniform seedlings were transplanted to two series of small pots (mini raised beds) and 5-10mL 15-30-15 Miracle Grow fertilizer applied to trays periodically. Water was being added when needed (every 2 or 3 days). Uniform seedlings (about 5 cm tall) were transferred to two series of pots:

A. The first series was consisted of small pots (3x2 inches) made from 3/8-inch diameter CCA wood. The soil for the pots in this series and the experimental controls were collected at about 135-cm distance from a 10-year-old CCA-treated fence. The As source is from the leaching of CCA preservatives in wood.

B. The second series consisted of pots similar to the first series except that they Were made from regular wood (non-treated). The soil for this series was collected from the top 6 inches of the following distances from the same fence used in part A:

1. From directly under a CCA-treated fence (0 cm from the fence),
2. 15 cm from the fence,
3. 30 cm from the fence,
4. 45 cm from the fence,
5. 60 cm from the fence.

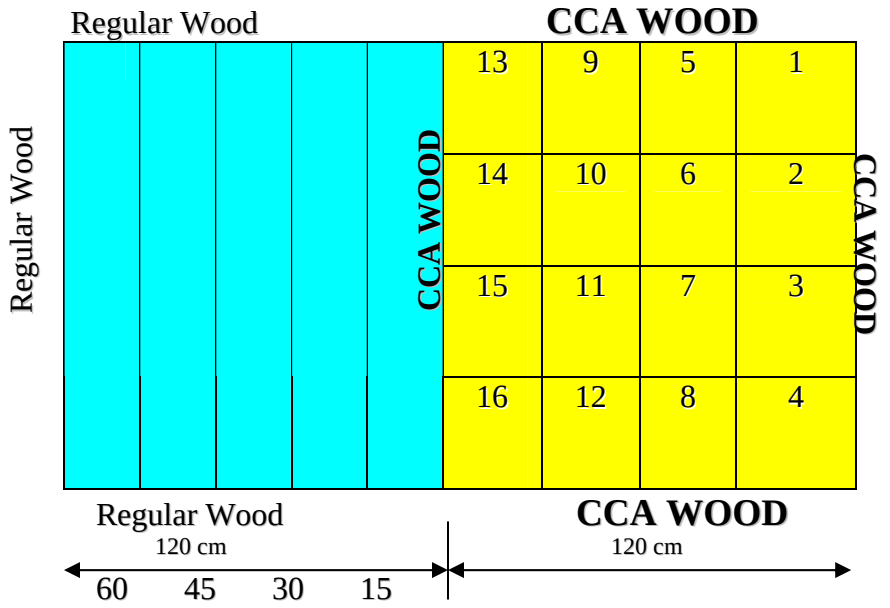
Soil from each distance was transferred to 4 pots for the growth of each vegetable type. Also, portions of soils which were collected from the different distances from the fence were collected for the measurement of As content. The vegetables were harvested on 1/19/04. They were transferred to paper bags and dried in a

drier with 75° C temperature for 4 days. After drying, the plants were transferred to laboratory and grinded in preparation for As content.

Task 2. Determine the uptake of Arsenic released from CCA-treated wood by garden plants in raised garden beds under field conditions.

The experimental procedures for this task were conducted in the field. Two sites were chosen. One is located in Gainesville (University of Florida-Agronomy Field) and the second one is in the Palm Beach area (Cook Lumber Field). The experimental design was as follows:

Turnip green, leaf Lettuce, carrot and broccoli were planted in Gainesville on10/29/03, and Palm Beach sites on 10/31/03. The seedlings from these crops were prepared in a manner described in Task 1. Vegetables were grown near CCA wood in conditions similar to those of commonly employed in raised beds in gardens. The design of these test beds is a modified version (Fig.1) of the design described by David Stilwell (personal communications, March 13, 2003).



(Fig. 1)

Vegetable crops were grown either with CCA wood on all four sides in 30x30 cm squares (Fig.1, # 1-16), or the uptake was measured in the attached regular wood section as a function of distance (15, 30, 45, 60 -cm) from the CCA wood (Fig. 1). All maintenance procedures for the plants are the same as those in the Task 1.

The vegetables grown in Gainesville were harvested on 1/13/04, and those of Palm Beach were harvested on 1/15/04. They were transferred to paper bags and dried in a drier with

75^{o} C for 4 days. After drying, the plants were transferred to laboratory and grinded in preparation for As content determination.

Results of Gainesville Experiments

Task I. Greenhouse Results

Greenhouse experiment consisted of two series:

A. This task includes determining the uptake of Arsenic released from CCA-treated wood by vegetables in test mini raised beds in first series: The As source is from the leaching of CCA preservatives in wood. The soils for all pots were taken from 135 cm from a fence with As content of 1.33 mg/kg (Table 1A).

Table 1A. Arsenic Contents in Soils from Different Distances from a CCA-Fence

Distance From the Fence (cm)	Arsenic Concentration (mg/kg)
0	31.20
15	28.30
30	11.40
45	7.44
60	6.04
135	1.33

The results of As contents in different plants parts are shown in Table 1B. Arsenic uptake by turnip green roots and leaves was higher than those of carrot roots and leaves. In both crops As concentrations in roots were higher than leaves. However, As concentration in lettuce leaves was the highest among all three crops (Table 1B). The high concentration in these series is due to closeness of the plant roots to CCA-treated woods from 4 sides in mini raised beds.

Table 1B. Arsenic Concentrations in Different Vegetable Parts Grown in Soils Taken from 135 cm Distance of a CCA-Treated Fence Placed in Small Raised Beds Made from CCA-Treated Woods*

Crop Type	Arsenic Concentration (mg/kg)

	Roots	Leaves
Turnip Green	4.9	2.7
Lettuce	-	6.8
Carrot	1.6	1.2

∗ Average of 4 plants

B. The second series consisted of pots similar to part A except that they were made from regular wood (non-CCA-treated wood). The soils for this series were collected from the top 6 inches of various distances of a CCA-treated fence. Turnip green, lettuce and carrot vegetables were used in this part. Arsenic contents of soils at different distances from the fence are shown in Table 1A. Soil arsenic concentration was the highest directly under the fence (0 cm distance). Concentration of As gradually decreased by distances from the fence (Table 1A).

Uptakes of As by various vegetables from different distances from the fence were as follows:

Turnip Green

Arsenic uptake and concentrations in roots and leaves of turnip green plants are shown in Table 2. Arsenic contents in roots were higher than leaves of the crops grown in mini raised beds with soils from all distances from the CCA fence. Plants grown in mini raised beds with soils from under the fence (0 cm) had maximum As concentration than those grown in soils from other distances from the fence (Table 2). Arsenic concentrations in plant tissues gradually decreased by distances from the fence.

Table 2. Arsenic Concentration in Roots and Leaves of Turnip Green Grown in Soils from Various Distances of a CCA-Treated Fence in Gainesville, Florida∗

Distance From the Fence (cm)	Arsenic Concentration (mg/kg)	
	Roots	Leaves
0	6.00	3.90
15	1.30	1.00
30	0.90	0.50
45	0.50	0.20
60	0.40	0.20

∗ Average of 4 plants

Lettuce

Arsenic concentration was the highest in the leaves of lettuce grown in soils from the 0 cm distance from the fence (directly under the fence). Arsenic concentration in lettuce leaves grown in soil 15 cm from the fence was still relatively high (2.4 mg/kg). Concentrations of As in leaves grown in soils from further distances from the fence was

much lower (Table 3). It appears that there is a direct relationship between the As uptake by lettuce plant and the soil As content (Table 3).

Table 3. Arsenic Concentration in Lettuce Leaves Grown in Soils Taken from Various Distances of a CCA-Treated Fence in Gainesville, Florida∗

Distance From the Fence (cm)	Arsenic Concentration (mg/kg)
0	5.70
15	2.40
30	0.50
45	0.30
60	0.20

∗ Average of 4 plants

Carrot

Carrot roots grown in soils from all distances from the fence were higher in As contents than those of the shoots (Table 4). Again, both roots and shoots of plants grown in soils taken from directly under the fence (0 cm distance) were much higher in As content than the others.

Table. 4. Arsenic Concentration in Roots and Leaves of Carrots Grown in Soils from Various Distances of a CCA-Treated Fence in Gainesville, Florida∗

Distance From the Fence (cm)	Arsenic Concentration (mg/kg)	
	Roots	Leaves
0	3.90	3.10
15	0.90	0.70
30	0.40	0.30
45	0.40	0.30
60	0.30	0.20

∗ Average of 4 plants

Task 2 Field Results:

This task includes determination of As uptake released from CCA-treated wood by garden vegetables in raised garden beds under field conditions (Fig.1). In the field experiment, in addition to turnip green, lettuce and carrot, broccoli was also included. Arsenic content of the soil in the field experiment was 0.7 mg/kg. The results of As uptake by different vegetables were as follows:

Turnip Green

The average As content in roots and shoots of plants grown in garden raised beds in the field was lower than those of mini raised beds in green house experiment. This is probably because CCA- treated woods in mini raised beds are closer to plants than those in the field. Average uptake for roots was 1.0 mg/kg and for the leaves was 0.8 mg/kg (Table 5A).

Table 5A. Arsenic Concentration in Roots and Leaves of Turnip Green Grown in Raised Beds Made from CCA-Treated Woods with Regular Soil in Gainesville, Florida∗

Plot Number	Arsenic Concentration (mg/kg)	
	Roots	Leaves
1-4	1.10	0.90
5-8	0.90	0.70
9-12	1.00	0.80
13-16	1.00	0.80

∗ Average of 4 plots

Arsenic content in roots and leaves of the plants grown in raised beds made from non-treated woods attached to the part A was minimal at all distances from the CCA-treated wood side of the A part (Table 5B). This is due to the fact that plants grown in 15 cm from the treated side are only exposed to CCA-treated wood from one side. Other plants grown in further distances were less exposed to CCA-treated wood and had minimal As content (Table 5B).

Table 5B. Arsenic Concentration in Roots and Leaves of Turnip Green Grown in Raised Beds Made from Non-Treated Wood Attached to the Part A

Distance from the end of the Part A (cm)	Arsenic Concentration (mg/kg)	
	Roots	Leaves
15	0.30	0.20
30	0.20	0.20
45	0.20	0.20
60	0.20	0.20

∗ Average of 4 plants

Lettuce Leaves

Average As content of lettuce leaves grown in field raised beds was 0.75 mg/kg. This concentration is much less than the As content in lettuce leaves grown in greenhouse mini raised beds (Table 6A). Again, size of the raised beds and the distance of the plants from the CCA-treated woods could be the main factor.

Table 6A. Arsenic Concentrations in Lettuce Leaves Grown in Raised Beds Made from CCA-Treated Woods with Regular Soil in Gainesville, Florida∗

Plot Number	Arsenic Concentration (mg/kg)
1-4	0.80
5-8	0.70
9-12	0.70
13-16	0.80

∗ Average of 4 plots

Arsenic content in roots and leaves of the plants grown in Raised Beds Made from Non-Treated Woods Attached to the Part A was minimal at all distances (Table 5B).

Table 6B. Arsenic Concentrations in Lettuce Leaves Grown in Raised Beds Made from Non-Treated Woods Attached to the Part A

Distance from the end of the Part A (cm)	Arsenic Concentration (mg/kg)
15	0.20
30	0.20
45	0.20
60	0.20

∗ Average of 4 plants

Carrots

Arsenic concentrations in roots and shoots of carrots ranged from 0.5 to 0.7 (Table 7A). Again, these concentrations were lower than As contents in those plants grown in mini raised beds. Like turnip green, As concentrations in roots were higher than the leaves.

Table 7A. Arsenic Concentrations in Roots and Leaves of Carrot Grown in Raised Beds Made from CCA-Treated Woods with Regular Soil in Gainesville, Florida∗

Plot Number	Arsenic Concentration (mg/kg)	
	Roots	Leaves
1-4	0.60	0.50
5-8	0.70	0.60
9-12	0.70	0.60
13-16	0.60	0.50

∗ Average of 4 plots

Like the other crops, arsenic content in roots and leaves of the plants grown in Raised Beds Made from Non-Treated Woods Attached to the Part A was minimal (Table 7B).

Table 7B. Arsenic Concentration in Roots and Leaves of Carrot Grown in Raised Beds Made from Non-Treated Woods Attached to the Part A∗

Distance from the end of the Part A (cm)	Arsenic Concentration (mg/kg)	
	Roots	Leaves
15	0.30	0.20
30	0.20	0.20
45	0.20	0.20
60	0.20	0.20

∗ Average of 4 plants

Broccoli

Arsenic content in broccoli heads was only 0.2 mg/kg in all plots. These concentrations were the lowest among all eatable parts of plants tested in these experiments (Table 8A). Apparently, broccoli absorbs lower As in its tissues in comparison to other crops used in these experiments.

Table 8A. Arsenic Concentrations in Broccoli Head Grown in Raised Beds Made from CCA-Treated Woods with Regular Soil in Gainesville, Florida∗

Plot Number	Arsenic Concentration (mg/kg)
1-4	0.20
5-8	0.20
9-12	0.20
13-16	0.20

∗ Average of 4 plots

Arsenic content in broccoli heads grown in raised beds made from non-treated woods Attached to the Part A was minimal (Table 8B).

Table 8B. Arsenic Concentrations in Broccoli Heads Grown in Raised Beds Made from Non-Treated Woods Attached to the Part A∗

Distance from the end of the Part A (cm)	Arsenic Concentration (mg/kg)
15	0.20
30	0.20
45	0.20
60	0.20

∗ Average of 4 plants

Results of Palm Beach Experiments

Turnip Green

Arsenic concentration in roots and leaves of turnip green grown in garden raised beds in Palm Beach Florida are shown in Table 9A. Arsenic contents in roots and leaves of turnip green in this experiment followed the same patterns as those planted in Gainesville. However, the As concentrations in Palm Beach plants were higher than those of Gainesville (Tables 9A and 5A). Since soil types in both places were sandy soil but As content of Palm Beach soil was higher (0.7 mg/kg in Gainesville vs. 1.3mg/kg in Palm beach), it is possible to conclude that soil As concentration was one of the main factor for this difference. Other factors such as the amount of rainfall to remove As from the CCA-treated wood in raise beds and the temperature effect on plant growth could be important factors. Arsenic content in irrigation water of Gainesville and Palm Beach was not a factor since As content in both water was <5 μ/kg.

Table 9A. Arsenic Concentration in Roots and Leaves of Turnip Green Grown in Garden Raised Beds Made from CCA-Treated Woods with Regular Soil in Palm Beach, Florida∗

Plot Number	Arsenic Concentration (mg/kg)	
	Roots	Leaves
1-4	1.30	1.00
5-8	1.20	0.90
9-12	1.30	1.00
13-16	1.40	1.10

∗ Average of 4 plots

Arsenic concentrations in turnip green roots and leaves grown in raised beds made from non-treated woods attached to the Part A are shown in Table 9B. Palm Beach plants grew closer to treated wood of part A had higher As concentrations than the similar plants grew in Gainesville (Table 9B and 6B). However, As contents in plants grown in further than 30 cm from the part A were minimal.

Table 9B. Arsenic Concentration in Roots and Leaves of Turnip Green Grown in Raised Beds Made from Non-Treated Woods Attached to the Part A∗

Distance from the end of the Part A (cm)	Arsenic Concentration (mg/kg)	
	Roots	Leaves
15	0.50	0.30
30	0.3	0.20
45	0.20	0.20
60	0.20	0.20

∗ Average of 4 plants

Lettuce Leaves

Arsenic contents in lettuce leaves grown in Palm Beach are shown in Table 10 A. Again, As contents in plants grown in Palm Beach were higher than similar plants grew in

Gainesville (Tables 10A and 6A). Similar reasons used for higher As content in turnip green grown in Palm Beach can be used for lettuce leaves too.

Table 10A. Arsenic Concentrations in Lettuce Leaves Grown in Raised Beds Made from CCA-Treated Woods with Regular Soil in Palm Beach, Florida∗

Plot Number	Arsenic Concentration (mg/kg)
1-4	1.10
5-8	1.00
9-12	0.90
13-16	0.90

∗ Average of 4 plots

Like the turnip green, lettuce leaves of plants grown closer to CCA-treated wood of part A in Palm Beach had higher As concentrations than the similar plants grew in Gainesville (Tables 10B and 6B).

Table 10B. Arsenic Concentration in Lettuce Leaves Grown in Raised Beds From Non-Treated Woods Attached to the Part A∗

Distance from the end of the Part A (cm)	Arsenic Concentration (mg/kg)
15	0.3
30	0.20
45	0.20
60	0.20

∗ Average of 4 plants

Carrots

The As contents for carrot roots and leaves followed a similar patterns as carrot plants grown in Gainesville except with higher As contents in plant tissues (Tables 11 A and 7A). Similar reasons used for higher As content in turnip green grown in Palm Beach can be used here.

Table 11A. Arsenic Concentration in Roots and Leaves of Carrot Grown in Raised Beds Made from CCA-Treated Woods with Regular Soil in Palm Beach, Florida∗

Plot Number	Arsenic Concentration (mg/kg)	
	Roots	Leaves

1-4	0.80	0.80
5-8	0.80	0.70
9-12	0.70	0.70
13-16	0.90	0.80

∗ Average of 4 plots

Like the turnip green and lettuce, plants grown in raised bed attached to part A, closer to CCA-treated wood of part A in Palm Beach raised beds had higher As concentrations than the similar plants grown in Gainesville (Tables 11B and 7B).

Table 11B. Arsenic Concentration in Roots and Leaves of Carrot Grown in Raised Beds Made from Non-Treated Woods Attached to the Part A∗

Distance from the end of the Part A (cm)	Arsenic Concentration (mg/kg)	
	Roots	Leaves
15	0.40	0.30
30	0.20	0.20
45	0.20	0.20
60	0.20	0.20

∗ Average of 4 plants

Broccoli Heads

Arsenic contents in broccoli heads grown in Palm Beach are shown in Table 12 A. Arsenic concentrations in heads grown in Palm Beach were higher than similar heads grown in Gainesville (Tables 12A and 8A). Similar reasons used for higher As content in turnip green, lettuce and carrot plants grown in Palm Beach can be used for broccoli head's higher As contents.

Table 12A. Arsenic Concentrations in Broccoli Head Grown in Raised Beds Made from CCA-Treated Woods with Regular Soil in Palm Beach, Florida∗

Plot Number	Arsenic Concentration (mg/kg)
1-4	0.40
5-8	0.40
9-12	0.50
13-16	0.20

∗ Average of 4 plots

Unlike the turnip green, lettuce and carrot, broccoli heads of plants grown closer to CCA-treated wood of part A in Palm Beach raised beds had the same As concentrations as the similar plants grown in Gainesville (Tables 12B and 8B). In these experiments broccoli heads adsorbed a similar low As amounts when soil As content was relatively low.

Table 12B. Arsenic Concentrations in Broccoli Heads Grown in Raised Beds Made from Non- Treated Woods Attached to the Part A∗

Distance from the end of the Part A (cm)	Arsenic Concentration (mg/kg)
15	0.20
30	0.20
45	0.20
60	0.20

∗ Average of 4 plants

Conclusions

The results of first year experiments indicate that:

A. Arsenic absorption from soil varies among vegetable crops tested both in Gainesville and Palm Beach.
B. In general, crops absorbed more As when Soil As content was higher.
C. Arsenic content in soil was a function of distance from CCA-treated fences, Therefore, plants grown closer to fences may absorb more As.

Human Health Implication

World Health Organization (WHO) suggests 15 μg/kg As/kg body as a limit of provisional tolerable weekly intake (PTWI) for inorganic arsenic [WHO, 1989#284]. Assuming a body weight of 65 kg, then the PTWI is 975 μg (65 x 15 = 975). It is recommended that each person consume 200g (fresh mass) of vegetable per day (1400 g/wk =1.4 kg/wk) from the nutrition point of view [Schoof, 1999#95]. Assuming conservatively that this vegetable consumption is all from lettuce grown in the soil directly under a similar fence used in this experiment, then consumption of this vegetable would induce exposure of 732 μg/kg (this figure was obtain after converting the fresh mass weekly limit into dry wt):

Dry wt of lettuce was 9.17%, therefore, 1400 g/wk fresh wt x 9.17% = 128.42 g/wk dry wt = 0.128420 kg/wk

Arsenic content in lettuce dry wt = 5.7 mg/kg = 5700 μg/kg
5700 x 0.128420 = 732 μg/wk

This figure is close to limit of provisional tolerable weekly intake. This figure depends on As concentration in eatable part of plant and As content in plant tissues depend on soil As content.

EPA Limit for Non-Cancer Effect

EPA's limit for non-cancer effect is 0.0003 mg/kg As/kg body as a limit of provisional tolerable daily intake. This is equal to 0.3 μg/kg per day, or 2.1 μg/kg per week. Assuming a body weight of 65 kg, then the weekly limit would be 136.5 μg (65 x 2.1). Again, assuming conservatively that the vegetable consumption is all from lettuce grown in the soil directly under a similar fence used in this experiment, then consumption of this vegetable would induce exposure of 732 μg/kg which is 5.36 time (732/136.5 = 5.36) higher than the limit.

Next experiments will include growing these crops from different distance from a CCA treated fence in the field and measure the effects of various additives on As uptake by Florida vegetables.

Table 13. Project Milestones for Task 1 and task 2, year 1

Tasks 1 & 2	1st quarter	2nd quarter	3rd quarter	4th quarter
Site selection	+			
Experiment setup and planting	+	+		
Soil chemical Analyses				+
Crops Maintenance		+	+	
Crops Harvesting			+	
Crops Arsenic measurements				+
Total Plant arsenic analyses				+
Potting soil chem. analysis				+
Data analysis				+
Quarterly reports	+	+	+	
Annual report				+

+: Tasks that has been accomplished according to the proposed timeline for year 1.

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Fig. 2. Raised garden beds in Gainesville with turnip green, lettuce, carrot and broccoli.

Fig. 3. Raised garden beds in Palm Beach with turnip green, lettuce, carrot and broccoli. Raised bed with lettuce and part of broccoli raised bed is shown in this picture.