Impacts of CCA-Treated Wood on Arsenic Concentrations in Soils and Plants

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Lena Q. Ma[1], Tait Chirenje[2], and Jorge Santos[1]

[1] Soil and Water Science Department, University of Florida
[2] B108 NAMS, Richard Stockton College of New Jersey, Pomona, NJ 08240

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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LIST OF ABBREVIATIONS AND ACRONYMS

ACMF: the Austin Cary Memorial Forest

As: arsenic

CCA: copper chromate arsenic

CEC: Cation Exchangeable Capacity

Cr: chromium

Cu: copper

DOC: Dissolved Organic Carbon

EPA: Environmental Protection Agency

FDEP: Florida Department of Environmental Protection

GFAAS: Graphite Furnace Atomic Absorption Spectroscopy

OM: Organic Matter

SSL: soil screening levels

EXECUTIVE SUMMARY

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Principal Investigators: Lena Q. Ma and Tait Chirenje

Affiliation:

Soil Water and Science Department, University of Florida, Gainesville, FL 32611

B108 NAMS, Richard Stockton College of New Jersey, Pomona, NJ 08240

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Abstract

This study evaluated the long-term impacts and fate of arsenic and other metals leached from CCA treated wood posts and stakes into the soil below and away from the wood and on plants after 44 or more years of ground contact. This was a unique opportunity to study long-term migration of CCA (Type B) sites A and C and CCA (type A) site B. The visual good condition of the stakes, at the Site A and C, after more than 50 years of exposure to the Florida climate is a good indicator of efficiency of the CCA product. However, on the Site B, several stakes treated with CCA type A are rotten. The distribution of leached CCA elements, As, Cr and Cu in the soil samples taken 1.5 m away from the posts around the stakes was affected by both vertical and horizontal proximity to the stakes, and stakes density in the three sites. Arsenic concentration in the surface of site C (3.1 mg kg^{-1}) was 5 times greater than the control soil (0.7 mg kg^{-1}). However, the As concentration in the sites A and B were lower than in the control background concentration. The higher arsenic concentration in the site C was attributed to the stakes density as well as some soil physical and chemical characteristics of that site that adds on arsenic retention. Arsenic concentration in the site A was constant in the whole profile (0.3 to 0.4 mg kg^{-1} As) but it increased vertically in the sites B (90 cm) and C (60 cm), ranging from 0.3 to 0.7 and 1.5 to 13.2 mg kg^{-1} , respectively. These results

indicate that arsenic migration may be occurring in all sites evaluated. However, the site C soil showed a great ability to retain arsenic especially in the clay layer. The accumulation and distribution of Cr and Cu in the sampled sites were also dependent on the type of CCA materials and sampling distance of the poles and the soil factor which will determine the depth to be reached by the contaminant. The effect of the soil arsenic also is reflected in the plants. Average arsenic concentration in the plants of the site C was greater than of the other sites. The higher concentration of CCA components on the barks also indicated that most of the chemicals originally used are still retained in the wood.

Objective

To investigate the long-term environmental fates of copper, chromium and arsenic (CCA) from CCA-treated wood.

Methodology

1. Soil (surface and profile), plant, wood and groundwater samples were collected from the Austin Cary sites where hundreds of CCA-treated wood stakes were installed in 1950's, and analyzed for copper, chromium and arsenic.
2. Soil (surface and subsurface) and vegetables samples were collected from areas adjacent to CCA-treated wood and analyzed for arsenic**.**
3. All samples were digested using USEPA method 3051 and analyzed using graphite furnace atomic absorption spectrophotometry.

Rational

This research addresses one important issue in Florida, i.e. CCA-treated woods. Up to 5,000,000 ft^3 CCA-treated wood was used in the year of 1996 alone. Therefore, it is critical to evaluate the environmental impacts of CCA-treated woods. The research on the fate of arsenic from CCA-treated wood assesses the long-term environmental impacts of CCA-treated woods. Our research should benefit FDEP, the public and various industries.

Results:

The distribution of leached CCA elements, As, Cr and Cu in the soil around the posts was affected by both vertical and horizontal proximity to the post, post density and soil type . Arsenic concentrations in the surface at site C (3.1 mg kg^{-1}) was ~4 times greater than the control (0.9 mg kg^{-1}). However, As concentration in the surface at site A (0.3 mg kg^{-1}) and B (0.3 mg kg^{-1}) were lower than in the control or background concentration.

Soil arsenic concentrations at site A were constant in the whole profile (0.3 to 0.4 mg kg^{-1} As) but increased vertically from 0.3 to 0.7 and 1.5 to 13.2 mg kg^{-1} at sites B (90 cm) and C (60 cm), respectively. For all depths evaluated, arsenic concentrations at site C were much higher than those at sites A (3 to 38 times) and B (4-33 times). The highest soil arsenic concentration at site C occurred at 30 to 60 cm depth (13 mg kg^{-1}). A substantial concentration of arsenic (7.3 mg kg$^{-1.}$) was found in Bh horizon at site C.

Chromium concentrations in the surface at site A (1.4 mg kg^{-1}) and site C (1.6 mg kg^{-1}) were approximately 40 and 60% greater than the chromium concentrations in the control sample (1.0 mg kg^{-1}). Despite the observed tendency of chromium to release from the wood post to the soil, the concentration of the element in the soil was very low.

The concentrations of copper in the control sample (6 mg kg^{-1}) was several times greater than that found in the surface soil at sites A (2 mg kg^{-1}) and B (4 mg kg^{-1}), but equal to those at site C (6 mg kg^{-1}).

Conclusions

Soil and wood analysis of southern pine sapwood post treated with CCA type A (Site B) and CCA type B (Sites A and C) sampled 1.5 m away from the posts revealed:

1- The protection provided by to the post from Sites A and C, as evaluated visually, withstand to the more of 50 years of exposure to environmental conditions under Florida climate. However, some posts from the site B were rotten.

2- The arsenic concentrations at Site C was 4 times greater than those in the control and 10 times greater than the arsenic concentration at Sites A and B.

3- Differences in pole density and soil and physical and chemical characteristics affected the mobility and altered the pattern of accumulation of CCA components in the soil. CCA components released from poles at Site C were retained in greater proportion than those at Site A.

4- The accumulation of CCA components in the clay layer indicated the mobility of Cu, Cr and As in soil and the importance of the soil characteristics to minimize the contaminant effect.

5- High accumulation of CCA components in the Bh horizon may cause environmental problem in a long run, if the factors that maintain the physical and chemical characteristics of that layer are modified.

6- The high metal concentrations in the pole bark indicated that most of the original components were still retained.

Key Words: Chromate copper arsenate, wood preservation, leaching, retention.

IMPACTS OF CCA-TREATED WOOD ON ARSENIC CONCENTRATIONS IN SOILS AND PLANTS

Lena Q. Ma[1] and Jorge Santos[1], and Tait Chirenje[2]
[1]Soil & Water Science Department, University of Florida, Gainesville, FL 32611-0290
[2]B108 NAMS, Richard Stockton College of New Jersey, Pomona, NJ 08240

Introduction

Chromate copper arsenate (CCA) has been used for years as a preservative to treat woods to extend the life of wood products. It is efficient in reducing bacterial, fungal and insect decay in wood (Warner and Solomon, 1990). Arsenic (As) and copper (Cu) act as the insecticides and fungicides respectively, while chromium (Cr) is used to fix the other two elements to the cellulose and other components of the wood (Dawson et al., 1991).

CCA-treated wood has attracted much attention in recent years mainly due to the adverse health impacts resulting from arsenic. The use of CCA-treated wood extends from playgrounds, fences, yard and general-purpose decks to public utility poles throughout Florida (Chirenje et al., 2003). Townsend et al. (2000) estimated that, in Florida, CCA-treated decks impact ~ 10 000 ha or 60 million tons of soil, and the volume of CCA-treated utility poles in use is 7×10^5 m^3. Although CCA-treated fences are about 25% in quantity as decks, their area of influence may even be greater because they are not as compact as decks. On the national level, 10.6 million m^3 of treated wood, mostly CCA, were produced in 1986 (Solomon and Warner, 1990). The figure for CCA-treated wood alone increased to 12.8 million m^3 by 1996 (AWPI, 1997), with Florida accounting for 6-15 % in a given year.

Research has shown that components of CCA leach from the wood surface, leading to elevated concentrations of As, Cr and Cu in the soil (Carey et al., 1996; Cooper and Ung, 1997; Lebow, 1996; Solo-Gabriele et al., 2000) and aqueous environments to the detriment of soil and aquatic organisms (Weis & Weis, 1996). Elevated metal concentrations are observed in soils near CCA-treated decks in Connecticut where As, Cr and Cu concentrations are 76, 43 and 75 mg kg^{-1} compared to background concentrations of 3.7, 20 and 17 mg kg^{-1}, respectively (Stilwell and Gorny, 1997). Cooper and Ung (1997) determined As, Cu and Cr concentrations in the vicinity of utility poles to be as high as 550, 200, and 1,000 mg kg^{-1}, respectively. Solo-Gabriele et al. (1999) determined the leaching and depletion of As, Cr and Cu from CCA-treated wood in Florida. Townsend et al. (2000) also determined the leaching of As, Cr and Cu from CCA-treated decks in public access areas in Florida and showed that the mean As, Cr and Cu concentrations below the decks were 28, 34 and 40 mg kg^{-1} compared to background concentrations of 1.5, 10 and 10 mg kg^{-1}, respectively. Our research showed elevation of As, Cr and Cu concentrations in soils under the structures of CCA-treated decks and adjacent to poles and fences, with mean As concentrations as high as 23 mg kg^{-1} close to utility poles compared to less than 3 mg kg^{-1} at distances of about 1.5 m away (Chirenje et al., 2003).

The United States Environmental Protection Agency (USEPA) soil screening levels (SSL) for As and Cr are 0.4 and 390 mg kg^{-1}, respectively for direct exposure (no federal SSL value for Cu). The soil cleanup target levels (SCTL) for As, CrVI and Cu in Florida are 0.8, 210, and 110 mg kg^{-1} for residential areas, and 3.7, 420 and 76 000 mg kg^{-1}, for commercial areas, respectively (FDEP, 1999).

Although much is known about arsenic concentrations in soils adjacent to CCA-treated wood, little information is available on the potential impacts of arsenic on plant uptake. We have conducted a greenhouse experiment to evaluate plant As uptake from soils near the CCA-treated utility poles and fences (Cao and Ma, 2004). We observed elevated As uptake of 44 mg kg^{-1} in carrot and 32 mg kg^{-1} in lettuce, far exceeding the typical As concentration ranges of 0.08-2 mg kg^{-1} in vegetables. So it is possible that plants growing in the soils near CCA-treated wood poles may have elevated concentrations of CCA.

Objectives

The overall objective for this study was to collect and analyze soil and wood samples to: 1) investigate the long-term environmental fates of CCA from CCA-treated wood post and stakes from Austin Cary sites; and 2) examine the impacts of CCA-treated wood on arsenic uptake by garden vegetables. Though this research focuses primarily on arsenic, other metals of environmental importance will also be monitored.

Methodology

Background history of the experimental area

The Austin Cary Memorial Forest (ACMF) is located in north-central Florida. The predominant soil types in this area are sandy siliceous, hyperthermic aeric hapludods and plinthic paleaquults. Although these soils are poorly drained, they are actually very sandy (average sand content of 95%) and are characterized as the Pomona sand series, with minor exceptions in areas where different fill materials were used (Chirenje, 2002).

The ACMF has been the site of several long-term tests involving various wood preservatives, among them CCA. This site has been studied by Huffman and Morrell (2003) and they have a description of the layout of the study site. Some test plots have outlived their original purpose and can be used to assess long-term preservative movement from treated wood into the soil. Southern pine posts and stakes treated with known amounts of CCA were installed in 1954 and 1957, respectively, and with one exception, remained essentially undisturbed for this project

The current Austin Cary experiment included investigation of: 1) arsenic uptake by surrounding vegetation; 2) arsenic distribution around CCA-treated poles; and 3) arsenic concentration within aged CCA-treated poles. In the experimental setup, 10 poles among the large pole section of the forest were randomly selected. The selection was accomplished by assigning random numbers to all poles (>60) within each site and selecting the first 10 poles after arranging the random numbers in ascending order

Soil and plant sample collection

This study was built upon the study of Huffman and Morrell (2003) and based on our preliminary research on the site (Chirenje et al. and Cardellino et al., unpublished data). For the study, we selected two groups of CCA-treated wood stakes based on their initial CCA concentrations (CCA type A on the Site B or CCA type B on the Site A and C). For each group, up to 20 CCA-treated wood stakes were sampled. Six, 4 and 4 samples were taken from sites A, B and C, respectively, at 4 different depths (0-30, 30-60, 60-90 and +90) or until a clayey layer was reached (a total of 56 samples) (Fig. 1).

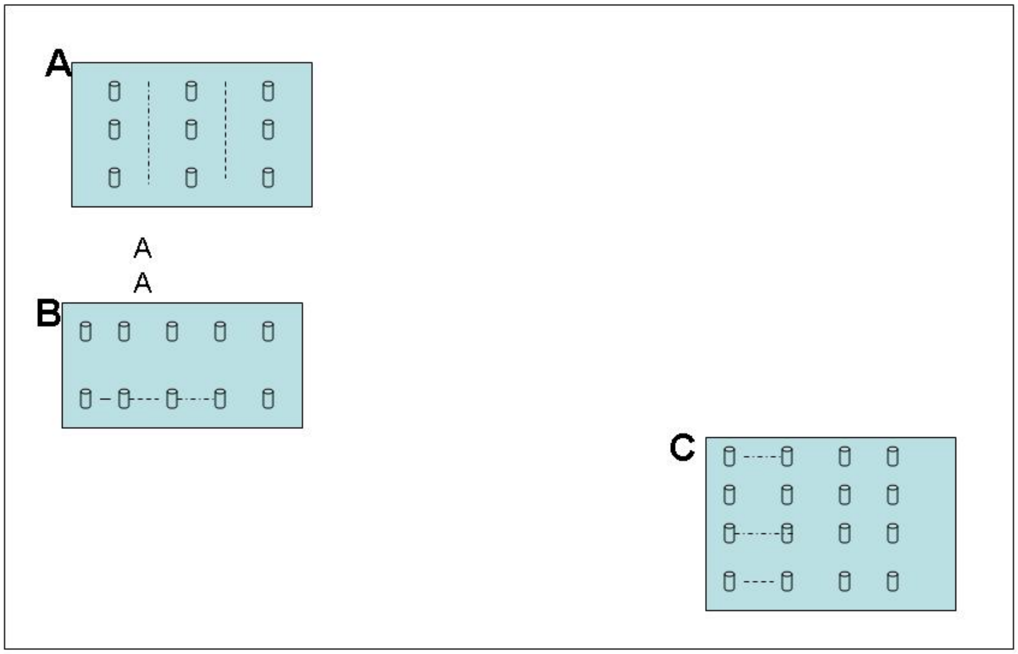

Figure 1. Sketch of the physical location of sites A, B and C in the Austin Cary Memorial Forest experiment site.

Surface soil was taken from the site to be analyzed as control. Various plants growing near and far from CCA-treated woods were also sampled. In site A, B and C the pools are set in 3.0 x 1.5 m, 3.0 x 0.80 m and 1.0 x 0.30 m apart and the samples were collected in between the poles columns (Figures 1 A, B. C).

The number of samples in this study will allow us to determine the fates of CCA that was present initially in the wood, i.e. relative distribution in wood, soil, plant and groundwater. It is expected that some of the CCA are leached from soil and cannot be accounted for.

Sample preparation and analysis

Soil samples were air-dried and screened through a 2-mm sieve (to meet usda definition of soil). soils were characterized for ph using 1:2 soil to water ratio, and electrical conductivity were determined in a extract of a soil paste using an accumet model 20 ph / conductivity meter (fisher scientific, pittsburgh, pa). organic carbon and nitrogen were determined in a leco truspec cn analyzer.

Plant samples collected in the experimental area of Austin Cary, where hundreds of CCA-treated wood stakes were installed in 1950s, were oven dried at 60^{o}C. The plant material was then ground using a Wiley mill to 60-mesh fineness for chemical analysis. The digestion and analyze of the material was performed as outlined in the next section.

Arsenic and trace metal analysis.

Plants and soils were digested using a modified epa method 3050a,the hot block digestion system (environmental express, MT. Pleasant, sc) and analyzed for arsenic on a graphite furnace atomic absorption spectrophotometry (GFAAS, SIMMA 6000; perkinelmer, norwalk, ct). soil and plant were also analyzed for Al, Cu, Fe and Cr by flame atomic absorption spectrophotometer (varian, model fs 220, Walnut Creek, CA). quality control of arsenic analysis was included using Montana soil 2710) (us nist, md). spikes, duplicates and reagent blanks were also used as a part of our quality assurance/ quality control.

Results and Discussion

Distribution of As, Cr and Cu in soils near CCA treated utility poles

Migration of preservatives into soil surrounding treated wood is not a new concern (Mortimer, 1991). The use of CCA-treated wood in Florida has highlighted the lack of data on migration of CCA components from treated wood into soil (Matus, 2001). The release of CCA constituents is governed by many factors. These include (i) the nature and surface area of the wood (Solo-Gabriele et al., 2000), (ii) the type (A, B, or C) and retention factor of the CCA (0.25 to 2.5 lb ft^{-3}, depending on whether it is aboveground, marine or belowground; Hingstrom et al., 2001), (iii) climatic conditions (temperature, humidity and rainfall; Chirenje et al., 2003b), and (iv) soil factors (texture, pH, organic matter content, cation exchange capacity [CEC], ammonium oxalate extractable iron [Fe] and aluminum [Al]; Cooper and Ung, 1997; Kaminski and Landsberger, 2000). A data base on migration of CCA preservatives into the soil can be developed by installing and monitoring metals levels in the surrounding soil of freshly CCA treated wood post or taking advantage of materials that have been previously installed. We took advantage of this second alternative. Most of the wood preservative research over the past 50 years, even prior the commercialization, has been carried out in sites of the ACMF at the University of Florida.

CCA treatment solutions are typically classified as type A, B, or C. Type C CCA is the most commonly used to treat dimensional lumber for aboveground residential applications. It is composed of 34.0% arsenic pentoxide (As_2O_5), 47.5% chromic acid (CrO_3), and 18.5% cupric oxide (CuO; Lebow, 1996). Type B is composed of 19.6 % As_2O_5, 35.3 % CrO_3, and 45.1% CuO. Type A is composed of 18.1% As_2O_5, 65.5% CrO_3, and 16.4 % CuO (American Wood Preservers Association [AWPA], 1999). The retention of As and Cr in the wood ranges from 0.25 to 2.50 pounds per cubic foot (pcf; using AWPA standards). Typical retention levels are: 0.25, 0.40, 0.60, 0.80, and 2.50, depending on the final use of the treated lumber (Lebow, 1996), with 0.40 pcf being the most widely used. In our study, we selected sites in which the post were treated with CCA type A, (Site B) and type B (Site A and C). Southern pine posts treated to retention of 8 or 12 kg m^{-3} with a formulation of CCA similar to but at twice the concentration of the currently used Type B were installed at the Austin Cary Memorial Forest in 1954. Type B-CCA contains higher levels of arsenic and lower levels of chromium than the more commonly used Type C-CCA formulation. The lower chromium concentration should make the system less strongly fixed and more prone to metal losses. The posts were air seasoned for 90 days after treatment to moisture content of 20% to insure maximum fixation of arsenic to the wood.

The distribution of leached CCA elements, As, Cr and Cu, in the soil around the posts was affected by both vertical and horizontal proximity to the post, post density in the three sites and soil type (**Figures 2, 3 and 4**, respectively). Arsenic concentration in the surface of site C (3.1 mg kg^{-1}) was ~4 times greater than the control (0.9 mg kg^{-1}). However, the As concentration in the sites A (0.3 mg kg^{-1}) and B (0.3 mg kg^{-1}) were lower than the control or background concentration. The background levels of arsenic that occur naturally in the United States soils range from 1 to 40 mg kg^{-1} with most levels found in the lower half of the range (O'Neil, 1990). For the sandy soils of Florida, the naturally occurring arsenic levels are less than 1 mg kg^{-1} (Chen et al. 1999). The arsenic concentration of our background control, therefore, was within the range reported to Florida

Because the poles of the sites A and C were treated with the same type B CCA, the higher arsenic concentration in the surface of the Site C was attributed to the greater posts density as compared with Site A. In site C, the poles are spaced at 30 cm apart while in the Site A the stakes distance was at least 3 times greater. The difference of post density was then detected in samples taken 1.5 m away from the posts. The concentration and distribution of Al and Fe in the soil profile, as well as the pH and organic carbon (OC) play a significant role in the availability and distribution of trace elements such as As, Cu and Cr. The lower arsenic in the Site A may be due to lower pole density and lower retention of CCA components in the soil. The higher soil pH (**Figure 5a**) and lower soil carbon (**Figure 5b**)in the site A than in the Site C may had contributed to lower arsenic retention of the Site A. The lower arsenic in the surface of the Site B was

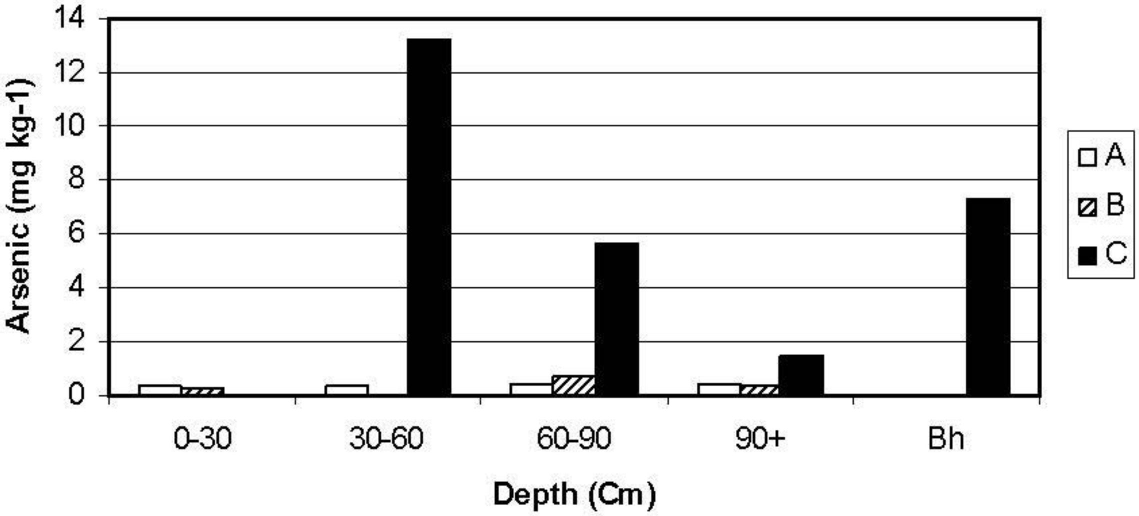

Figure 2. Influence of CCA-treated wood on soil arsenic concentrations at different depths in sites A, B and C.

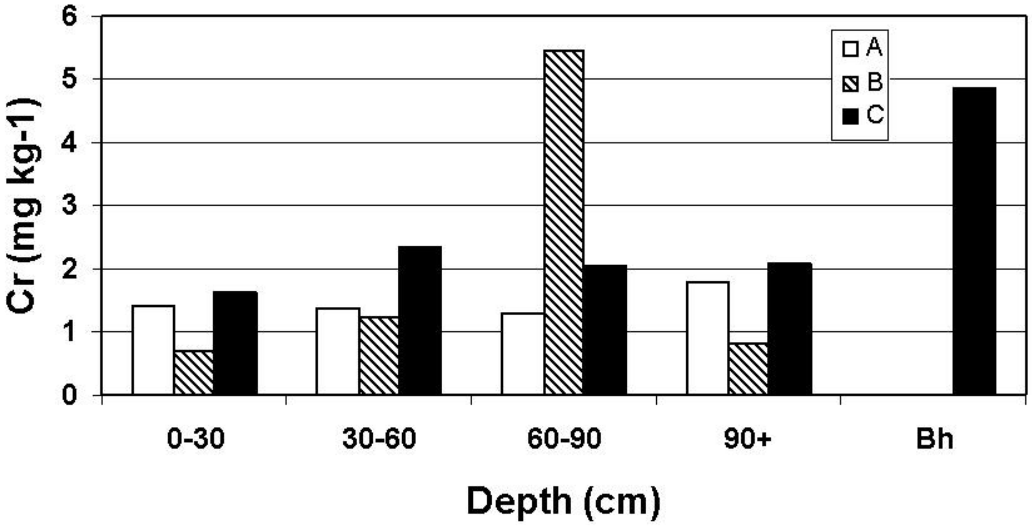

Figure 3. Influence of CCA-treated wood on soil chromium concentrations at different depths in sites A, B and C.

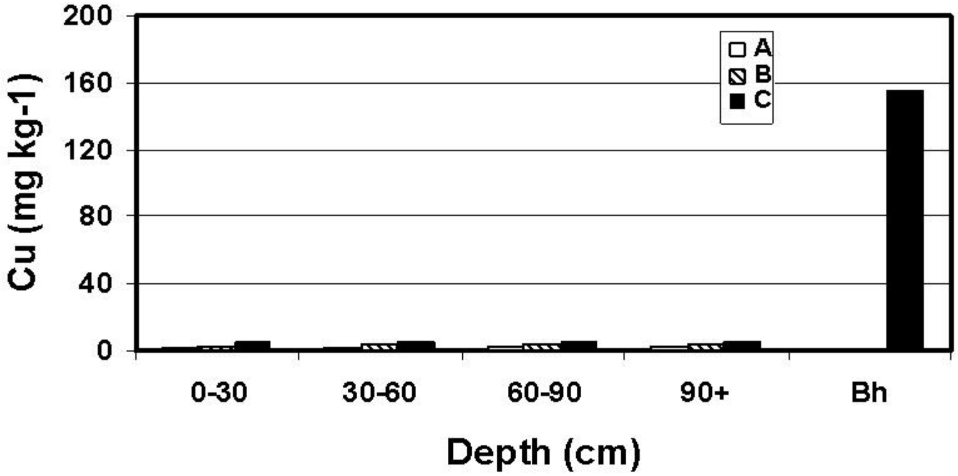

Figure 4. Influence of CCA-treated wood on soil copper concentrations at different depths in sites A, B and C.

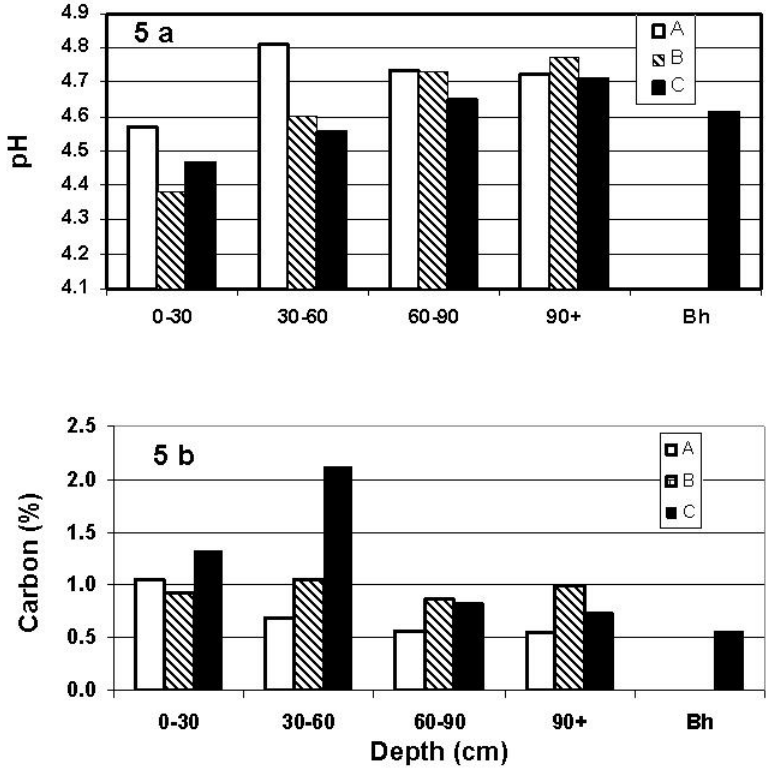

Figure 5. Influence of CCA-treated wood on soil pH (5a) and organic carbon content (5b) measured at different depth in sites A, B, and C.

expected, since the stakes in that Site were treated with CCA Type A, which has lower arsenic level.

Arsenic concentration in the site A was constant throughout the profile (0.3 to 0.4 mg kg^{-1} As) but it increased vertically in the sites B (90 cm) and C (60 cm). Arsenic concentration ranged from 0.3 to 0.7 and 1.5 to 13.2 mg kg^{-1} in sites B and C, respectively.(Figure, 2). For all depths evaluated, As concentration in site C was much higher than in sites A (3 to 38 times) and B (4-33 times). The highest arsenic concentration in site C occurred at 30 to 60 cm depth (13 mg kg^{-1}). A substantial concentration of arsenic (7.3 mg kg$^{-1.}$) was found in the Bh horizon of site C.

The distinct arsenic distribution pattern in the site C was likely due to the (greater) post density and the soil type which can strongly influence the metal solubility and retention characteristics. Given the low Fe concentration in the soil (**Figure 3 b**), the As distribution in the soil profile seems to be more influenced by the aluminum and carbon concentrations. Arsenic accumulation in the Bh horizon may be due to the long period of time that the poles and scattered wood fragments and chips are in the ground (over 45 years), leading to a more diffuse distribution; or to leaching of As beyond 90 cm.. The contaminant retention in the Bh layer, in a short term, has a positive effect, it prevents the ground water contamination. In a long run, there exist the potential risk of the clay layer saturation and subsequent released of the contaminants to groundwater

Chromium concentration in the surface of Sites A (1.4 mg kg^{-1}) and Site C (1.6 mg kg^{-1}) were about 40 and 60% greater than the chromium concentration in the control sample (1.0 mg kg^{-1}) (**Figure 3**). Despite the observed release of chromium from the posts, the concentration of the element present in the soil was very low. The United States Environmental Protection Agency (USEPA) soil screening levels (SSL) for direct Cr exposure is 390 mg kg^{-1} while the soil cleanup target levels (SCTL) for Cr^{VI} in Florida 210 mg kg^{-1} for residential areas, and 420 mg kg^{-1} for commercial areas, respectively (FDEP, 1999).

Chromium concentration ranged from 1.30-1.77 mg kg^{-1} in site A, 0.69 to 5.45 mg kg^{-1} in site B, and from 1.64 to 4.8 mg kg^{-1} in site C (**Figure 3**). The chromium concentration in the site A did not vary with depth. However, there was considerably higher Cr concentration in the site B at the 60-90 cm depth. The posts of the Site B were treated with Type A CCA, which has the highest chromium content (about 65.5% of CrO_3) among the CCA types. The gradual increase in chromium concentration from the surface up to 60-90 cm depth indicates that the metal is diffusing gradually and accumulating at 60-90 cm depth. It is interesting to notice that Cr concentration stayed at ~ 2 mg kg^{-1} throughout the profile in the site C but it doubled that value in the Bh horizon (4.9 mg kg^{-1}). These results indicate that Cr was leaching from the top soil and accumulating in the Bh horizon, in the site C, where it was being sequestered by OC (**Figure 5b**), aluminum and iron. (**Figures 6 a and 6 b**, respectively). Any change in the soil characteristics of the Bh may lead to Cr leaching into the groundwater. The lower Cr concentration in the Site A as compared with Site C further proves that the soil of the site A is more prone to CCA component leaching than the soil of the Site C.

The concentration of Cu (6 mg kg^{-1}) was several times greater in the control sample than that found in the surface soil of the Sites A (2 mg kg^{-1}) and B (4 mg kg^{-1}), but equal to the site C (6 mg kg^{-1}), (**Figure 4**).. As for the previous elements, the Cu concentration in the Site A was 3 times lower than in the site C, indicating the lower retention potential of the site A. Despite the difference in Cu concentration among the Sites, the values obtained were low. There is no federal SSL value for Cu and the soil cleanup target level (SCTL) for Cu in Florida is 110 mg kg^{-1} for residential areas, and 76, 000 mg kg^{-1} for commercial areas (FDEP, 1999). Therefore, the Cu concentration of the sites are well below the required by regulation.

For all Sites there was small change in Cu concentration in the profiles, exception for the Site C, which had 155 mg kg-^{1} of the element, suggesting significant leaching of the material from the soil profile.

In conclusion, samples taken 1.5m away from CCA treated posts buried over 50 years indicated that the levels of accumulation and distribution of CCA components in soil is a function of the type of CCA used, the density of the poles and soil characteristics. Greater the CCA component concentration used greater will be the movement of the components to the soil over time. The impact of CCA components will extend (horizontally and vertically) further away in places that stakes are used in greater density (fence, decks), The mobility of arsenic, chromium and copper in the soil is

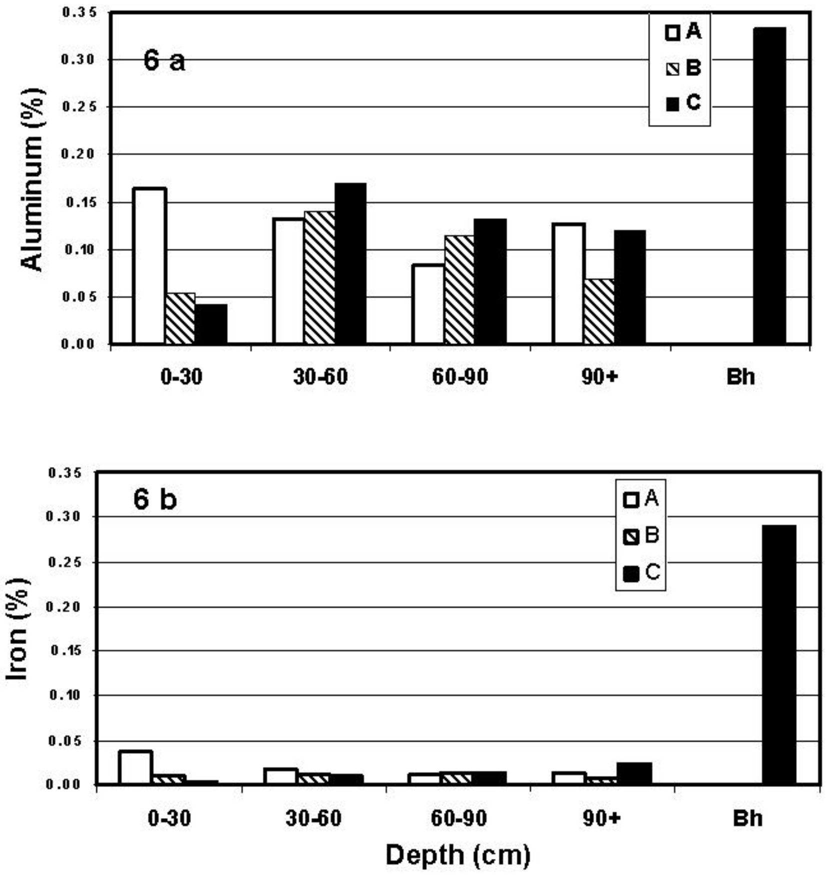

Figure 6. Influence of CCA-treated wood on soil aluminum (6a) and iron content (6b) measured at different depth in sites A, B, and C.

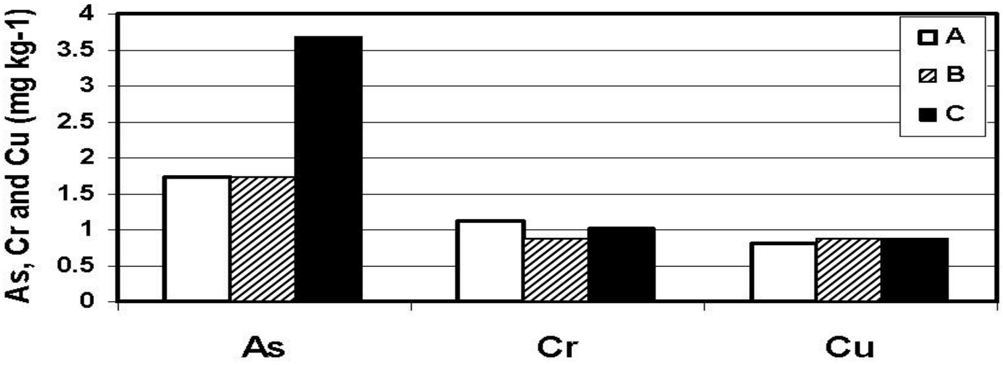

Figure 7. Influence of CCA-treated wood on arsenic, chromium and copper concentrations on weed tissue growing in sites A, B and C.

dependent on several soil components, with organic matter playing an important role in the adsorption of copper and chromium, and inorganic components such as iron and aluminum forming complex with arsenic (Alloway, 1990, Bergholm, 1990, Eliott et al. 1986). The physical and chemical heterogeneity of soils makes the accurate prediction of the fate of chemical very difficult. As a consequence, there may be a significant variation in the risk to groundwater from CCA contamination. The results of this study are also consistent with the preliminary results obtained by Chirenje et al. (unpublished data) showing that As concentrations in the lower soil layers are higher than those at the surface.

Plant analyses

Concentrations of CCA components in the plant tissues of the majority of plants evaluated were below detection limits (Cr <0.2, As <0.4, and Cu <5 mg kg^{-1}). Elevated As and Cr, however, were found in some plants in the sites.

Arsenic concentrations in the plants were relatively low (2 to 8 mg kg^{-1}) and it was related with the soil As. Arsenic concentration in the plants in the site A and B were about 50% less than in the site C. while Cr concentrations ranged from 0.9 to 4 mg kg^{-1}. No plant accumulation of Cu was detected (**Figure 7**). However, the concentrations of Cr and Cu for the plants collected at the sites were similar.

The highest As (463 mg kg^{-1}), Cr (1,144 mg kg^{-1}) and Cu (150 mg kg^{-1}) concentrations were found in the barks from the poles.

Conclusions

Soil and wood analysis of southern pine sapwood post treated with CCA type A (Site B) and CCA type B (sites A and C) sampled 1.5 m away from the posts revealed:

1- The protection provided by to the post from Sites A and C, as evaluated visually, withstand to the more of 50 years of exposition to environmental conditions of Florida climate. However, some posts from the site B were rotten.

2- The arsenic concentration in the Site C was 4 times greater than the control and 10 times greater than the arsenic concentration in the Sites A and B.

3- Differences in poles density and soil and physical and chemical characteristics affected the mobility and altered the pattern of accumulation of CCA components in the soil. CCA components released from Site C poles were retained in greater proportion than in the Site A

4- The accumulation of CCA components in the clay layer indicated the mobility of the Cu, Cr and As in the soil and the importance of the soil characteristics to minimize the contaminant effect

5- High accumulation of CCA components in the Bh horizon may cause environmental problem at long run, if the factors that maintain the physical and chemical characteristics of that layer are modified.

6- The high metal concentration in the pole bark indicated that most of the original components are still retained.

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