PROJECT SUMMARY SHEET

TITLE: Environmental Impacts of CCA Contaminated Mulch
COMPLETION DATE: October 31, 2004
PRINCIPAL INVESTIGATOR: Helena Solo-Gabriele, Associate Professor
AFFILIATION: Univ. of Miami, Dept. of Civil, Arch., & Environ. Engineering
ASSOCIATE INVESTIGATOR: Timothy Townsend, Associate Professor
AFFILIATION: Univ. of Florida, Dept. of Env. Engrg. Sci., Solid & Haz Waste Prog.
STUDENTS: Upon initiation of the study, both Drs. Solo-Gabriele and Townsend will recruit students for this project. It is likely that students working on current and past CCA projects (e.g. Bernine Khan, Gary Jacobi, Tomoyuki Shibata from U.Miami and Jenna Jambeck, Brajesh Dubey, Thabet Tolaymat from U.Florida) will be involved in the proposed project described herein.

OBJECTIVES: The objectives of this study are: a) to determine the extent to which mulch purchased by the Florida consumer is contaminated with CCA, b) to determine the adequacy of visual methods in establishing whether or not a mulch contains CCA-treated wood, and c) to evaluate the role of colorants in potentially decreasing the rate at which metals leach from CCA contaminated mulch.

METHODOLOGY: Mulches will be collected from retail establishments located throughout Florida and from mulch currently in use. Analysis of these samples will include quantifying the fraction of CCA-treated wood within these mulches and the amount of leachable As, Cr, and Cu as per standard SPLP tests. All of the mulches will be visually inspected. Visual inspection will focus on documenting the presence of remnants of engineered wood and the particle size distribution of the wood. The role of colorants on leaching rates will be evaluated through SPLP tests and a set of controlled field experiments where mulches both with and without colorants are subjected to natural rainfall conditions. The rainfall leachate will be analyzed for metals concentrations to determine the relative quantity of leachable metals.

RATIONALE: Concern has been voiced by consumers about the potential contamination of mulch existing within their homes. This study will document the extent to which CCA contaminated mulch is sold within the state and it will document the extent to which colorants possibly reduce leaching of the arsenic from CCA-contaminated mulch. If visual inspection is found to be successful, in particular the inspection based upon the presence of engineered wood, the results of this project will go a long way in helping retail establishments and consumers in making informed decisions concerning the quality of the mulch that they purchase. The results from this study can be used by regulatory agencies to enforce policy which prevents mulch contamination.

ACCOMPLISHMENTS: Drs. Solo-Gabriele and Townsend have worked on CCA-treated wood projects for the Center for the past six years. They have presented their research results at many conferences and meetings, have produced six technical reports on the subject for the Center, and have published their work in peer-reviewed journals. They have collectively graduated 6 masters students on Center sponsored CCA projects and have 1 masters and 3 Ph.D. students currently working on the existing Center projects.

Environmental Impacts of CCA Contaminated Mulch
(2003 – 2004)

A Research Proposal Submitted to
The Florida Center for Solid and Hazardous Waste Management (FCSHWM)
March 20, 2003

ABSTRACT

Studies have shown that some commercially-available mulches leach excessive concentrations of chromium and arsenic, presumably due to contamination from CCA-treated wood. During the last funding cycle (2002-2003), a pilot scale project ($10,000 budget) was funded by the FCSHWM to evaluate a total of 20 mulch samples collected from south Florida, only. The purpose of the proposed project for the 2003 to 2004 funding cycle is to request funds to expand our mulch study. The proposed expansion consists of two primary phases. The first phase is to expand the 2002 – 2003 pilot study to evaluate an additional 25 samples (45 total) from cities located throughout Florida. This task will increase the applicability of the results to the remainder of Florida. The second phase of the proposed project focuses on evaluating the role of colorants in retarding the leaching of metals from CCA contaminated mulch. The colorant most widely used in Florida is composed of an iron oxide. Iron oxide is known to bind metals in soils and as such, the colorant agents may decrease the leaching rate of metals from CCA contaminated mulch. Results from both objectives will be helpful in establishing policies concerning mulch production and clean-up of sites containing contaminated mulch.

INTRODUCTION AND MOTIVATION

The potential for recycled C&D wood to contain CCA-treated wood has been well documented (Solo-Gabriele and Townsend 1999; Tolaymat et al. 2000; Blassino et al. 2002; Solo-Gabriele et al., 2001). In some cases this wood is used for the production of mulch. As such, there is a high likelihood that mulch contaminated with CCA, specifically mulches made from recycled C&D wood, are being sold to unsuspecting Florida consumers. Typically, C&D wood used for mulch is dyed to mask the typical grayish color associated with recycled C&D wood. In particular, the use of the red-colored mulch and to a lesser extent green-, gold-, and black- colored mulch, has become very popular in Florida. The red mulch has become so popular that even wood made from virgin vegetative wood, from non-C&D sources, is now available in dye-enhanced colors.

A preliminary study was conducted to evaluate the leaching characteristics of commercially-available mulch (Townsend et al. 2000). The samples evaluated included 6 mulches purchased from retail stores. Three were red colored and 3 were not colored. These samples were subjected to SPLP tests only. Results from this test showed that two of the three red mulches purchased from retail establishments exceeded the Groundwater Cleanup Target Level (GWCTL) for arsenic. None of the non-colored mulch samples exceeded the GWCTL's. The results from this preliminary study are troubling given that it documents that contaminated mulch, in particular red-colored mulch, is being sold at retail establishments to unsuspecting consumers. It is important to note that these 6 samples were evaluated only for their leaching characteristics. No determination was made as to the fraction of CCA-treated wood within these samples.

As part of the pilot project funded last year (2002-2003), the research team has collected a set of 35 mulch samples (which meets the minimum of 20 specified in the prior proposal) and has begun to process them in preparation for analysis. These mulch samples have been purchased from retail stores or were collected from local playgrounds or schools in South Florida. The preliminary results for 9 of these samples are provided in table 1. The results from the remaining samples collected for this study are pending since they are in various stages of ashing and analysis. The 9 samples analyzed to date include 2 red-colored mulch samples, 4 non-colored mulch samples, a sample collected from a playground, a sample of refuse derived fuel, and a soil-wood blend. The refuse derived fuel and the soil-wood blend both contain shredded wood and for this reason were included within the 2002-2003 study. Within the 9 samples analyzed to date, the highest concentrations of metals were observed among one of the red-mulch samples (sample #4). Based upon computations this sample contained between 4 and 6% CCA-treated wood assuming that the CCA-treated wood had an average retention level of 0.4 pcf. The second red-colored mulch sample contained measurable concentrations of copper and chromium, but no detectable levels of arsenic. Arsenic concentrations for all 4 non-colored mulch samples were below the detection limit. The remaining two samples, refuse derived fuel and a soil-wood blend, contained measurable amounts of arsenic. Of note, is the elevated concentration of copper in the refuse derived fuel which probably comes from sources other than CCA.

Again the preliminary data provided in table 1 below further emphasize the fact that CCA-contaminated mulches are being sold to Florida consumers (e.g. sample #4). There is a need to determine the extent of this problem and to determine whether or not this is a problem associated with colored mulch, only.

#	Generic Description	Cu (mg/kg)	Cr (mg/kg)	As (mg/kg)	%CCA
4	Red Colored Mulch, Open Bin	106	129	118	4.2-5.8
33	Red Colored Mulch, Bagged	3	2	BDL	< 0.05
17	Non-colored Mulch (Pine Bark)	1	BDL	BDL	< 0.05
19	Non-colored Mulch (Pine Bark)	3	BDL	BDL	< 0.05
20	Non-colored Mulch (Pine Bark)	3	1	BDL	< 0.05
18	Non-colored Mulch (Cypress)	1	BDL	BDL	< 0.05
32	Mulch from Playground	1	1	BDL	< 0.05
16	Refuse Derived Fuel	276	12	4	0.2-0.3%
28	Soil – Wood Blend	1	1	1	< 0.05

BDL = Below Detection Limit

Table 1: Results to Date for Samples Collected as Part of the 2002 – 2003 Study

OBJECTIVES

This study has been separated into two phases: phase I, evaluate mulches sold to the consumer and phase II, evaluate impacts of colorants on leaching rates from CCA contaminated mulches. The objectives of the first phase of the project are to determine the extent to which mulch purchased by the Florida consumer is contaminated with CCA and to determine the adequacy of visual methods in establishing whether or not a mulch contains CCA-treated wood. Specifically, mulches will be purchased from both retail establishments located *throughout* Florida and from mulch currently in use, such as that found at playgrounds. Analysis of these samples will include quantifying the fraction of CCA-treated wood within these mulches and the amount of leachable As, Cr, and Cu. The mulches will be visually inspected prior to analysis. The visual inspection will be used to determine whether CCA-contaminated mulches are easily identified at the point of purchase or use. The second objective of this study is to evaluate the role of colorants in potentially decreasing the rate at which metals leach from CCA contaminated mulch. Experiments will include the preparation of specially mixed mulches both with and without colorants. These mulches will be separated into two sub-samples. One sub-sample will be analyzed by SPLP and the other will be analyzed under controlled field conditions. Rainwater leachate will be collected from the field tests to determine relative quantities of metals leached.

METHODOLOGY - Scientific Approach

This study is separated into two phases: phase I, evaluate mulches sold to the consumer and phase II, evaluate impacts of colorants on leaching rates from CCA contaminated mulches.

Phase I: Evaluate Mulches Sold to the Consumer

Phase I.a: Sample Collection

Sample collection will continue as specified in the pilot study funded for 2002 to 2003. In this case, however, samples will be collected from retail establishments located throughout Florida. Samples will be collected from a minimum of 6 different cities. Relevant information concerning each sample will be carefully documented including the date and time of purchase, store name, street address of store, brand of mulch, color, and price. In addition to samples collected from retail establishments and from landscape uses, controls will be included within the analysis, including untreated wood, and CCA-treated wood at known retention levels.

Phase I.b: Sample Pre-Processing

Pre-processing of the samples will consist of the following:

- Visual inspection for evidence that it came from C&D wood. This includes inspection for the presence of engineered wood (e.g. plywood, particle-board, and painted wood).
- Evaluate wood-chip size-distribution. Representatives of the mulch industry suggested that mulches with more fines may contain a higher fraction of C&D wood.
- Ash a sub-sample of the mulch in the laboratory. Ashing is a necessary step in the analytical method used to determine the fraction of CCA-treated wood within the mulch sample.

Phase I.c: Sample Chemical Analysis

For every mulch sample collected, there will be a set of paired processed sub-samples. This will include a sub-sample of the unburned mulch as purchased at the store and a separate ash sample. The unburned mulch sample will be subjected to standard SPLP (Synthetic Precipitation Leaching Procedure) (USEPA 1996) to determine the amount of leachable arsenic, chromium, and copper. The ashed samples will be digested and analyzed for the same metals as per protocol developed by Tolaymat et al. 2000. The ashing step is needed to determine the fraction of CCA-treated wood within each mulch sample. All analyses will follow standard quality control/quality assurance protocols including the analyses of blanks, replicates, and spikes, as per University of Florida Dept. of Solid and Hazardous Waste Quality Assurance Plan.

Phase II: Evaluate Impacts of Colorants on Leaching Rates From CCA Contaminated Mulches

Phase II.a: Composition of Mulches

The wood used to make the mulches will be collected from a C&D processing facility. At the C&D facility, wood will be sorted into untreated or CCA-treated wood using a set of chemical stains established for this purpose (Blassino et al. 2002). Once sorted, the wood will then be mulched using an industrial shredder which will be rented.

Experimentation will be performed on three sets of mulches: untreated wood mulch, CCA-treated wood mulch, and a mixture of untreated and CCA-treated wood mulch. The relative proportion of untreated and CCA-treated wood within the mixture will be representative of the proportion found in the commercial mulches as evaluated through phase I.

Phase II.b: Collection and Application of Colorants

Colorants used for commercial mulch can be separated into three categories: "carbon-based" colorants used to produce brown and black colored mulches, "organic-based" colorants used to produce blue, green, orange, and yellow colored mulches, and "iron-oxide based" colorants used to produce red mulches. Iron-oxide based colorants are by far the most common colorants used in Florida. Colorants used in this study will be provided by Becker Underwood and the application of the colorants to the mulch will follow manufacturer instructions.

Phase II.c: Colorant-Mulch Combinations to Be Evaluated

A total of 6 colorant-mulch combinations will be evaluated. These combinations are summarized in table 2 below. Please note that each colored mulch sample is paired with a corresponding uncolored sample for comparison purposes.

Colorant-Mulch Combination ID	%Untreated Wood	% CCA-Treated Wood	Colorant Used
Untreated-U	100%	---	None
Untreated-C	100%	---	Iron-Oxide
Treated-U	---	100%	None
Treated-C	---	100%	Iron-Oxide
Mix-U	X[a]	100-X	None
Mix-CI	X	100-X	Iron-Oxide

[a] The percentage "X" will correspond to a representative percentage found in commercially-available mulch as determined in phase I.

Table 2: Proposed Colorant-Mulch Combinations for Experimentation

Phase II.d: Experimental Design

Each colorant mulch combination will be subjected to two tests: an SPLP test and a field leaching test. The SPLP test will follow standard EPA procedures. The field leaching test will involve the use of a square plastic container (i.e. Tupperware) with a minimum surface area of 1 square foot. The lid of the container will be fitted with a fine mesh which will allow water to pass but which will contain the mulch. The containers will be placed outside so they are subjected to natural rainfall and solar radiation. A water sample will be collected weekly from the reservoir below the lid and this sample will then be analyzed for chromium, copper, and arsenic. The water volume found in the reservoir in conjunction with the metal concentration will be used to provide the mass of metals (in grams) leached over time.

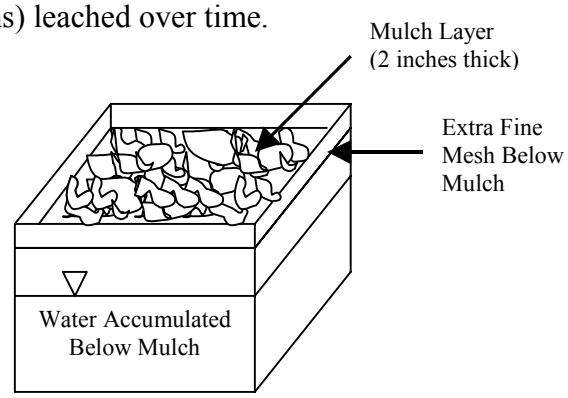

Figure 1: Example of Experimental Set Up

SEPARATION OF WORK AMONG THE UNIVERSITIES

Helena Solo-Gabriele will be responsible for all administrative activities required by the Center, for coordinating TAG meetings, and for all deliverables. She will also be responsible for directly supervising Phases I.a, I.b and II of the project. Tim Townsend will be responsible for supervising Phase I.c and the SPLP tests for II.d. Tim Townsend will also prepare an internal report that will be used in the final report for the project. Although both PIs have separate work phases, they plan to coordinate their research efforts in the most effective manner possible.

DELIVERABLES

A technical awareness group (TAG) will be established for the project and will likely include the 20 members that participated during the year 2003 project. A minimum of two TAG meetings will be held per year. TAG meetings have been very successful in the past. The last three TAG meetings held on the CCA-treated wood research had between 40 to 50 attendees. A final report will be prepared which documents the methods and results from both phases of the research. Essential information will be included in the main body of the final report and less essential information will be included in an appendix. The current web site, www.ccaresearch.org, will continue to be maintained and updated throughout the duration of the project. Quarterly progress reports, minutes of the technical advisory group meetings, technology transfer plan, etc.. will be submitted to the Center as required.

TIMELINE

Project Duration: 1.3 years

Project Start Date: July 1, 2003 Project End Date: October 31, 2004

Description	2003							2004									
		J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O
Phase I: Evaluate Mulches Sold to Consumer		o	o	o	o	o	o	X									
Phase II: Evaluate Impacts of Colorants					o	o	o	o	o	o	X						
Progress Reports				X			X			X			X			X	
TAG Meetings								X						X			
Draft Report													o	o	X		
Final Report															o	o	X

A draft of the final report will be available in August 2004. The report will be finalized by October 2004, after comments are received from the Center and from the TAG.

EXPECTED TECHNICAL RESULTS

The technical results from this study will include a "snap-shot" of mulch quality throughout Florida. This "snap-shot" will include the concentrations of chromium, copper, and arsenic within the mulch, the fraction of the mulch that is composed of CCA-treated wood, and the SPLP data for each corresponding mulch sample. The "snap-shot" will also include information concerning the visual characteristics of the mulch (particle size, presence of engineered wood, etc…). The information concerning the visual characteristics will be compared with the metals concentrations from the mulches to determine if there is a correlation between CCA contamination of the wood and readily visible properties of the mulch. Visual inspection may be one method of quickly identifying suspect mulches, assuming that a correlation is observed. This study will also provide comparative results for leaching rates between uncolored mulches and mulches dyed with different types of colorants. This information is useful for evaluating the extent to which colorants can potentially bind metals and possibly retard the rate at which metals leach from CCA-contaminated mulches. Results will be provided for metals concentrations in the leachates (SPLP and from controlled field tests) for untreated wood, for CCA-treated wood, and for mixtures of untreated and CCA-treated wood. Data will include leachate concentrations from un-colored and from mulches dyed with iron-oxide, carbon, and organic-colorants.

PRACTICAL BENEFITS FOR END USERS

This study will be very practical. The results will quantify the extent to which CCA-treated wood is found in commercially-available mulch in Florida. Furthermore the results will indicate the extent to which the iron-oxide coatings on CCA-contaminated mulches slow the release of metals from wood. These results can be used by the State regulatory agencies to develop strategies by which to minimize the amount of contaminated mulch that is sold to consumers. If the visual inspection of the mulch (e.g. size distribution and presence of plywood and particle-board) is found

to be helpful in establishing the potential presence of CCA, then such a practice can be invoked through-out the state to screen mulch for the presence of CCA. Such a screening method, due to its simplicity, can be used by the regulatory agencies, retail stores, and consumers.

Most importantly, the results of this study will provide consumers with some peace-of-mind concerning the use of mulch. Extreme concern has been voiced by citizens to members of the research team concerning mulch quality. It is important for the State to evaluate this problem in a systematic fashion so they can provide the consumer with guidance concerning how to handle their existing landscape mulch and the mulch they plan to purchase in the future.

RELATED WORK

The work most closely related to the proposed project includes the project funded last year at $10,000 which focused on conducting SPLP tests and measuring the proportion of CCA within commercially available mulches collected from the South Florida area. This proposed project will build upon the results from the prior study. Other related work includes an earlier study by Townsend et al. 2003 which focuses on SPLP results from mulches collected at C&D facilities plus three samples collected from retail stores.

The results from the proposed study could be also used to evaluate the impacts of CCA-treated wood mulch on soil. Results can be coupled with the data generated in the currently funded Center projects to evaluate overall impacts of CCA-contaminated mulches on soil quality within Florida. These other Center projects include, "Long-term Mobility of Chromate Copper Arsenate Components in Florida Soils" by Huffman and Morrell and "Developing Retention Indices and Modeling Transport of CCA in Florida Soils at Unlined Landfills" by Clark et al.

POSSIBLE FOLLOW-UP

If the results from this study indicate that mulches sold in Florida are excessively contaminated, an important follow-up task would be to visit mulching facilities throughout the State to educate mulch operators how to screen for CCA-treated wood including tests that use an easily applied chemical stain as a more definitive test for CCA contamination. Another possibility is to continue with efforts to develop effective sorting technologies at wood recycling facilities. The research team is currently considering teaming-up with a County to pursue a second Innovative Recycling Grant. The purpose of such a grant application would be to test X-ray and perhaps laser technologies for sorting operations at a wood recycling facility. An earlier grant was awarded to the research team to evaluate sorting on a pilot-scale basis. The purpose of a future grant would be to demonstrate the effectiveness of the technology during full-scale operation. The pursuit of such a grant will depend highly upon continued funding of the Innovative Recycling Grants Program through the State.

Additional follow-up can be in the form of extending the controlled field-scale mulch leaching project for an additional period of time, say 8 months to a year to evaluate the effects of time on metals leaching rates from CCA-contaminated mulches. Also, additional mulches beyond the 50 proposed in this study can be collected and analyzed throughout the State from "hot-spot" cities, assuming that contaminated mulches are found.

PERTINENT LITERATURE AND REFERENCES

Blassino, M., Solo-Gabriele, H., and Townsend, T., 2002. "Pilot scale evaluation of sorting technologies for CCA treated wood waste." *Waste Management Research,*20: 290-301.

Solo-Gabriele, H.M., and Townsend, T., 1999. "Disposal Practices and Management Alternatives for CCA-Treated Wood Waste. " *Waste Management Research*, 17: 378-389.

Solo-Gabriele, H., Townsend, T., Kormienko, M., Stook, K., Gary, K., and Tolaymat, T., 2000. *Alternative Chemicals and Improved Disposal-End Management Practices for CCA-treated Wood.* Final Technical Report #00-03. Florida Center for Solid and Hazardous Waste, Gainesville, FL.

Solo-Gabriele, H.M., Townsend, T., Hahn, D, Hosein, N., Jacobi, G., Jambeck, J., Moskal, T., Iida, K., 2001. *On-Line Sorting Technologies for CCA-Treated Wood*. Florida Department of Environmental Protection, Innovative Recycling Grants Program, Tallahassee, FL.

Tolaymat, T.M., Townsend, T.G., and Solo-Gabriele, H., 2000. Chromated copper arsenate Treated wood in recovered construction and demolition waste recycling facilities. *Environmental Engineering Science*, 17(1): 19-28.

Townsend, T., Solo-Gabriele, H., Stook, K., Hosein, N., Tolaymat, T., Khan, B., Song, J.K., 2000. New Lines of CCA-Treated Wood Research: In-Service and Disposal Issues, Report #00-12. Florida Center for Solid and Hazardous Waste Management, Gainesville, Florida.

Townsend, T., Solo-Gabriele, H., Tolaymat, T., and Stook, K., 2003. Impact of chromated copper arsenate (CCA) in wood mulch. *The Science of the Total Environment*, (in press).

U.S. Environmental Protection Agency, 1996. Test Methods for Evaluating Solid Waste, SW846, 3rd Edition. Office of Solid Waste and Emergency Response, Washington D.C.