PROJECT SUMMARY SHEET

TITLE: Environmental Impacts of CCA-Treated Wood

COMPLETION DATE: September 30, 2002

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AFFILIATION: University of Miami, Dept. of Civil, Arch., & Environ. Engineering
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OBJECTIVES: There are three objectives associated with this study. The first objective is to evaluate the impacts of CCA-treated wood within simulated landfill conditions. Specifically, the purpose is to measure the arsenic species in leachate generated from lysimeters filled with wastes that include CCA-treated wood. Second, the impacts of CCA-treated wood *ash* will be evaluated by measuring the concentration of different arsenic species in TCLP and SPLP extracts. The third objective of this study is to develop an arsenic mass balance for the state of Florida. This mass balance will identify the major arsenic inputs and reservoirs (in addition to CCA-treated wood) that exist within the State.

METHODOLOGY: As part of a separate but complimentary study, a set of five lysimeters will be installed in Alachua County. These lysimeters will be filled with C&D and MSW waste in addition to CCA-treated wood. Leachate samples will be collected from these lysimeters and analyzed for arsenic species. CCA-treated wood ash that was produced as part of an earlier study will be subjected to TCLP and SPLP tests as per standard protocols. The leachate from these tests will be also analyzed for arsenic species using HPLC-HG-AFS. The mass balance for different arsenic reservoirs will be established from readily available data. Potential sources of data include the Florida Department of Environmental Protection, the Florida Department of Agriculture and Consumer Services, Florida's Water Management Districts, the U.S. Geological Survey, and the U.S. Department of Energy.

RATIONALE: Arsenic speciation of leachates from CCA-treated wood and CCA-treated wood ash can be used to determine whether current disposal pathways for CCA-treated wood are acceptable. If it is found that significant amounts of arsenic are leached as As(III) (the more toxic form of arsenic), the disposal pathway corresponding to that leachate should not be encouraged. Results from the mass balance will be used to determine the relative contribution of arsenic to the State from CCA. The results will be helpful in prioritizing which arsenic inputs or reservoirs should be targeted if the goal is to minimize the impacts of arsenic within the Florida environment.

ACCOMPLISHMENTS: Drs. Solo-Gabriele and Townsend have worked on CCA-treated wood projects for the Center for the past four years. They have presented their research results at many conferences and meetings, have produced four technical reports on the subject for the Center, and have published their work in peer-reviewed journals. They have collectively graduated 4 masters students on Center sponsored CCA projects and have 2 masters and 2 Ph.D. students currently working on the existing Center projects.

ENVIRONMENTAL IMPACTS OF CCA-TREATED WOOD
(2001 – 2002)

A Research Pre-Proposal Submitted to
The Florida Center for Solid and Hazardous Waste Management (FCSHWM)
May 18, 2001

Introduction and Objectives

Earlier research has shown that there is a large reservoir of arsenic within the State associated with CCA-treated wood (Townsend et al. 2000). Since the 1960s, approximately 29,000 tons of arsenic have been imported and roughly 2,000 tons have been disposed, leaving 27,000 tons of arsenic associated with CCA-treated wood currently in service within Florida. Thus data indicate that the majority of the CCA-treated wood imported into the State has not yet been disposed. This represents an opportunity for the State to recapture and properly dispose of this waste stream so that the environmental impacts can be minimized. Possible disposal options for CCA-treated wood include disposal within landfills or through inadvertent incineration at cogeneration facilities (Solo-Gabriele 1998; Tolaymat et al. 2000). Such disposal options can result in the leaching of the CCA chemical, including arsenic, into the environment. The toxicity of the arsenic within the leachates is strongly a function of the species or chemical form of the arsenic. Forms of arsenic typically found in the environment in order of decreasing toxicity include: As(III), As(V), and MMA (monomethylarsonic acid), and DAA (dimethylarsinic acid). Limited data is available concerning the arsenic species in leachates from landfills and/or from ash containing CCA-treated wood. The first two objectives of this proposed project are to analyze the leachates from simulated landfill conditions (phase I) and from CCA-treated wood ash (phase II) for the arsenic species including As(III), As(V), MAA and DAA. Results from these objectives will be used to determine the amount and species of the arsenic released and whether the disposal options described above should be encouraged into the future.

One of the criticisms of the earlier work which focused on quantifying the amount of arsenic from CCA-treated wood imported into the State were the scaling computations which were used to relate the arsenic quantities to potential impacts on Florida soils and major water reservoirs. Such scaling computations indicate that the quantities of arsenic associated with CCA-treated wood have the capacity to significantly impact Florida's environment. The major criticism of the scaling computations, however, is that the research team has not shown that the relative magnitude of arsenic from CCA-treated wood is large versus that from other sources. It has been argued, for example, that the amount of arsenic associated with phosphate mines, coal, and shellfish is large compared to the quantity from CCA and thus efforts should focus on minimizing the impacts from these other sources rather than focusing on CCA-treated wood. The third objective of this study is to develop a mass balance for arsenic within the State of Florida that includes arsenic from all major sources and reservoirs within the State (phase III).

Such a mass balance is necessary to determine the relative importance of CCA in the overall arsenic budget for the State.

Methods - Scientific Approach

Phase I: Continuation of Lysimeter Research

As part of Dr. Townsend's project funded by Alachua County, a set of five lysimeters will be installed which are designed to evaluate the impact of CCA-treated wood on leachate quality. These lysimeters include:

- C&D debris with untreated wood (control)
- C&D debris with CCA-treated wood
- Untreated wood only (control)
- CCA-treated wood only
- MSW with CCA-treated wood

The materials for the lysimeters have been purchased and construction began in mid-April 2001. Leachate collection and analysis is scheduled to begin mid-May 2001. The lysimeters have been installed in Alachua County. They are 1 foot in diameter and 21 feet high. Natural rainwater will be captured and drained into the lysimeters. The leachates from the lysimeters will be analyzed for general water quality and field parameters including ORP, temperature, pH, conductivity, total dissolved solids, and total organic carbon. They will be also analyzed for total arsenic, chromium, and copper. Funding from this pre-proposal will be utilized to analyze the samples for arsenic species. Leachates will be shipped from Gainesville to the University of Miami for analysis. As part of last year's study (2000-2001), arsenic species will be analyzed monthly for the May to December 2001 time frame. The funds from this pre-proposal (2001-2001) will be used to analyze the arsenic species in the leachates from January to August 2002. Samples collected for arsenic speciation analysis will be split. One split will be digested and analyzed for total arsenic. The second split will be filtered. The filtrate, or dissolved phase, will be analyzed for As(III), As(V), MAA, and DAA. The filter will be digested as well and total arsenic will be analyzed in the digestate to provide a measure of the total arsenic in the particulate phase. The sum of the dissolved plus the particulate phase will then be compared to the total arsenic concentration (from the first split) to obtain a measure of the reproducibility of the analysis. Arsenic analysis will utilize an HPLC-HG-AFS (High Performance Liquid Chromotagraphy – Hydride Generation – Atomic Fluorescence Spectroscopy).

Phase II: Arsenic Speciation of CCA-Treated Wood Ash

Earlier arsenic speciation work focused on evaluating groundwater and leachate samples from MSW and C&D landfills or TCLP and SPLP extracts from unburned CCA-treated wood. In this proposal an additional set of samples are proposed for speciation. These samples include CCA-treated wood *ash*. CCA-treated wood ash is available from a pilot burn conducted during 1998. This burn was conducted using an industrial incinerator owned and operated by Florida Power and Light, Co. The seven samples available include ash samples made from: untreated wood, CCA-treated wood treated at 0.25, 0.60, and 2.5 pounds per cubic feet, weathered wood, and two wood waste samples collected from C&D recycling facilities. Samples will be subjected to standard TCLP and SPLP protocols (SW-846 Method 1311 and Method 1312, USEPA 1996).

The TCLP and SPLP tests require that the leachates be digested prior to metals analysis. Such digestion will impact the speciation of the arsenic. In order to address this problem, the TCLP and SPLP leachates will be split. One split will be digested as per TCLP and SPLP protocols and analyzed for total arsenic. The second split will be not be immediately digested. Rather, the undigested leachates will be filtered and the filtrate (dissolved phase) will be analyzed for arsenic species using an HPLC-HG-AFS (High Performance Liquid Chromotagraphy – Hydride Generation – Atomic Fluorescence Spectroscopy), which is capable of analyzing samples for various arsenic species including As(V), As(III), DAA (dimethylarsinic acid), and MMA (monomethylarsonic acid). The filter which will capture the particulate phase will be digested and analyzed for total arsenic. In this way the TCLP and SPLP leachates from ash containing CCA-treated wood will be analyzed for As(V), As(III), DAA, and MMA in the dissolved phase and total As in the particulate phase.

Phase III: Arsenic Mass Balance for the State of Florida

The mass balance for the State of Florida requires that major arsenic inputs, reservoirs, and outputs in the State of Florida be quantified. These quantities must be estimated over a long time period, from when the inputs were first initiated. The purpose of this analysis is to determine the relative magnitude of arsenic from CCA-treated wood versus the amounts from other arsenic sources within the State. Arsenic inputs will be quantified from available data for:

- CCA-treated wood, from wood treated outside the state and then brought in
- The CCA chemical, which is used to treat wood within the State
- MSMA (monosodium methylarsonate) which is an herbicide/pesticide that contains arsenic
- Coal and other fuels that are imported into the State
- Shellfish that is consumed within the State
- Arsenic associated with rainwater, atmospheric deposition, and inflows from major rivers

Reservoirs of arsenic to be evaluated include:

- Arsenic associated with phosphate mines located within the State
- Arsenic within Florida's major water reservoirs (major lakes, rivers, and aquifers)
- Arsenic located within the aquifer media (soil)
- Arsenic located in surface soils
- Arsenic associated with wastewater and wastewater biosolids/sludges

Output of arsenic to be considered include:

- Arsenic exported with fertilizer produced within the State
- Emissions of arsenic from incinerator facilities
- Arsenic that is lost to the ocean from runoff (river flow)

Potential sources of data include the Florida Department of Environmental Protection, the U.S. Department of Agriculture, the Florida Department of Agriculture and Consumer Services, Florida's Water Management Districts, the U.S. Geological Survey, and the U.S. Department of

Energy. It is recognized that obtaining some of the information required for the mass balance will be very difficult. It will be especially difficult to obtain historic data. The research team will obtain the available data and will make educated estimates for data that are not available. Once the tons of arsenic are estimated for each major reservoir, the relative quantities of arsenic will be compared between reservoirs, with a special focus on estimating the relative contribution of CCA-treated wood to the arsenic burden within the State.

Timeline

Project Duration: 1.3 years
Project Start Date: July 1, 2001, Project End Date: September 30, 2002

Description	2001						2002								
	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S
Phase I: Continuation of Lysimeter Research	o	o	o	o	o	o	o	o	o	o	o	o	o	X	
Phase II: As Speciation of CCA-Treated Wood Ash	o	o	o	o	o	o	o	o	o	o	X				
Phase III: Arsenic Mass Balance for the State of Florida	o	o	o	o	o	o	o	X							
Progress Reports			X			X			X			X			
TAG Meetings							X						X		
Draft Report											o	o	X		
Final Report														o	X

Phase III will be completed by February 2002 and will be finalized after the presentation of the results at the TAG meeting scheduled for January 2002. Phase I and II will be completed by the summer of 2002. A draft of the final report will be available in July 2002. The report will be finalized by September 2002, after comments are received from the Center and from the TAG. Four progress reports will be prepared for the Center and two TAG meetings will be held throughout the duration of this project.

Deliverables

A technical advisory group (TAG) will be established for the project and will likely include the 20 members that participated during the year 2001 project. TAG meetings have been very successful in the past. The last three TAG meetings held on the CCA-treated wood research had between 50 to 60 attendees. A significant fraction of the attendees included Florida regulators and personnel from the Florida solid waste industry. The bulk of the attendees are from the wood treatment industry. Wood treaters and CCA-chemical manufacturers from the entire southeast of the U.S. attend these meetings and even include treaters from as far as Michigan. These meetings have been instrumental in developing dialogue between the different parties involved and comments/suggestions received at these meetings have been very beneficial to the

productivity of the research. It is also important to note that anyone interested in the research is given ample opportunity to comment on draft copies of the final technical report. The research team receives comments and suggestions concerning the draft reports during TAG meetings and between meetings. The large amount of feedback received has played an important role in validating the results of the studies.

A final report will be prepared which documents the methods and results from each phase 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. Both draft and final copies of the final technical report will be posted on the web. The current web site, www.ccaresearch.org, will continue to be maintained and updated throughout the duration of the project. This web page includes each of the research team's CCA research proposals and technical reports. It also includes a list of the TAG members, a list of meeting attendees, minutes of the TAG meetings, Powerpoint presentations used at prior TAG meetings, and information concerning upcoming TAG meetings. It is of interest to note that this web site has been very popular. Roughly 51,000 total hits (or 4,500 hits/month) were recorded on www.ccaresearch.org between June 1, 2000 to May 7.

Other required documents will be submitted to the Center in a timely fashion. These documents include quarterly progress reports, minutes of the technical advisory group meetings, a technology transfer plan, etc..

Expected Technical Results

Technical results anticipated from this proposed research include a time history of arsenic releases from simulated landfill conditions. Data will provide conclusively the additional arsenic burden due to the presence of CCA-treated wood. This proposal study differs from Dr. Townsend's earlier lysimeter research in that these lysimeters are designed to accept natural rainfall and to evaluate the impacts from CCA-treated wood specifically. As a result, the chemistry and timing of the influent water would be difficult to question. Furthermore, the lysimeters in the proposed study include controls which will indicate with certainty the impacts from the CCA-treated wood. Dr. Townsend's earlier lysimeters were designed to evaluate the impacts from C&D waste. Although the impacts from CCA-treated wood were observed from the earlier lysimeters, the interpretation of the data was questioned by the wood treatment industry. The lysimeters included within the proposed research, will once and for all, provide definitive data needed to evaluate the impacts of CCA-treated wood on the metal quality of the leachates from simulated landfill conditions.

This project will also provide data concerning the amount and species of arsenic found in leachates from CCA-treated wood ash. The formulation of CCA requires the use of arsenic as As(V), the second most toxic form of arsenic typically found in environmental samples. Upon the burning process, it is anticipated that arsenic would remain as As(V). It would be of interest to confirm whether this species is found in CCA-treated wood ash. Once confirmed, more informed judgments can be made concerning the potential environmental impacts of wood ash contaminated with CCA.

Technical results will also include the amount of arsenic associated with different reservoirs in Florida's environment. Such data can be used to rank order sectors that contribute to Florida's arsenic burden. The rank order can be separated into "natural" arsenic burdens and "anthropogenic" arsenic burdens. If the objective is to minimize arsenic inputs to the State, the rank order will be helpful in identifying sectors that should be the focus of arsenic reduction efforts.

Anticipated Benefits

Results of the research are practical. Quantifiying the amount metals leached from lysimeters containing CCA-treated wood and ash containing CCA will be used to determine whether current disposal pathways for CCA-treated wood are acceptable. If it is found that significant amounts of arsenic are leached as As(III) (the more toxic form of arsenic), for example, the disposal pathway corresponding to that leachate should not be encouraged. Furthermore, the results from the arsenic leachate study can also be used with FDEP risk models for establishing arsenic regulatory limits associated with different disposal pathways. Results from the mass balance (phase III) will be used to determine the relative contribution of arsenic to the State from CCA. The results will be helpful in prioritizing which arsenic inputs or reservoirs should be targeted if the goal is to minimize the impacts of arsenic within the Florida environment.

Related Work

Outside the work of the research team, no known research has been conducted evaluating arsenic species in leachates from CCA-treated wood. The research team's most relevant related studies include the on-going research that focuses on measuring arsenic species in landfill leachates and in groundwater in the vicinity of un-lined C&D landfills. Also, arsenic speciation analysis is planned for leachates from TCLP and SPLP tests conducted on unburned CCA-treated wood. The proposed research evaluating CCA-treated *ash* would compliment the funded research evaluating unburned CCA-treated wood.

The research team has also placed a considerable effort on mass balance computations for CCA-treated wood, and the associated arsenic quantities, for the State of Florida. The first CCA mass balance for the State was developed in 1996 (Solo-Gabriele et al. 1998). This mass balance was recently updated for the year 1999 (Townsend et al. 2001). The CCA component of the arsenic mass balance for the State of Florida has already been well characterized through previous research. Other studies will be referenced in order to obtain quantities of arsenic associated with other sectors. For example, the Florida Department of Agriculture and Consumer Services compiles statistics concerning fertilizer quantities and characteristics within the State of Florida. The Florida Department of Environmental Protection compiles information concerning air emissions within the State. Florida's Water Management Districts compile data concerning water quantities, water quality, and potentially soil quality within the State. Soil quality data is complimented by Ma et al., 1997 study evaluating the natural background metals concentrations in Florida's soils. The U.S. Geological Survey compiles data concerning water flows through Florida's major waterways and issues reports concerning the characteristics of Florida's major aquifers.

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 Phase II and III of the project. Tim Townsend will be responsible for supervising Phase I and for preparing 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. For example, samples from phase I of the project (lysimeters located in Gainesville) will be shipped to the University of Miami for arsenic speciation analysis. Also, the work for phase III of the project will be split between the two Universities. The University of Florida will be responsible for quantifying arsenic outputs associated with incinerator facilities, associated with fertilizer produced within the state, associated with phosphate mines, and associated with wastewater sludge. The University of Miami will be responsible for the remaining components of the mass balance.

Possible Follow-up

A considerable amount of attention has been recently given to the impacts of CCA-treated wood during its service life. Specifically questions have been raised concerning the impacts of storm water runoff associated with CCA-treated wood, the impacts of water repellants and paints in minimizing leaching from CCA-treated wood, and the amount of CCA leached during the service life of CCA-treated structures.

Future research focusing on disposal should focus on methods of separating CCA-treated wood from other wood types. Efforts should focus on separation at construction sites, at demolition sites, and at C&D recycling facilities. The effectiveness centralized facilities that accept treated wood should be evaluated for the State. In addition to focusing on the recovery of discarded CCA-treated wood, research efforts should focus on methods of ultimate disposal, and potential reuse and recycling opportunities for the treated wood. Wood-cement composities, wood-based composite materials, and pyrolysis methods should be further explored as a means to handle at least a portion of the treated wood waste once disposed. As a final note, it is also important to mention that CCA-treated wood is also inadvertently used for producing mulch in the State of Florida. It would be of interest to sample mulches from retail establishments throughout the state to determine what fraction of the mulch, by weight, is composed of CCA.

Pertinent Literature and References

Ma, L.Q., Harris, W., and Hornsby, A., 1997. *Background Concentrations of Trace Metals in Florida Surface Soils*, Report #97-4. Florida Center for Solid and Hazardous Waste Management, Gainesville, FL.

Solo-Gabriele, H.M., Townsend, T., Penha, J., Tolaymat, T., and Calitu, V., 1998. Generation, Use, Disposal, and Management Options for CCA-Treated Wood. Final Technical Report #98-01. Florida Center for Solid and Hazardous Waste Management, Gainesville, Florida.

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., Calitu, V., Messick, B., and Kormienko, M., 1999. *Disposal of CCA-Treated Wood: An Evaluation of Existing and Alternative Management Options. Final Technical Report #99-06*. Submitted to the Florida Center for Solid and Hazardous Waste, Gainesville, FL.

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

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., 2001. 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.

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.