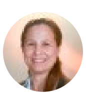
Knock on Wood



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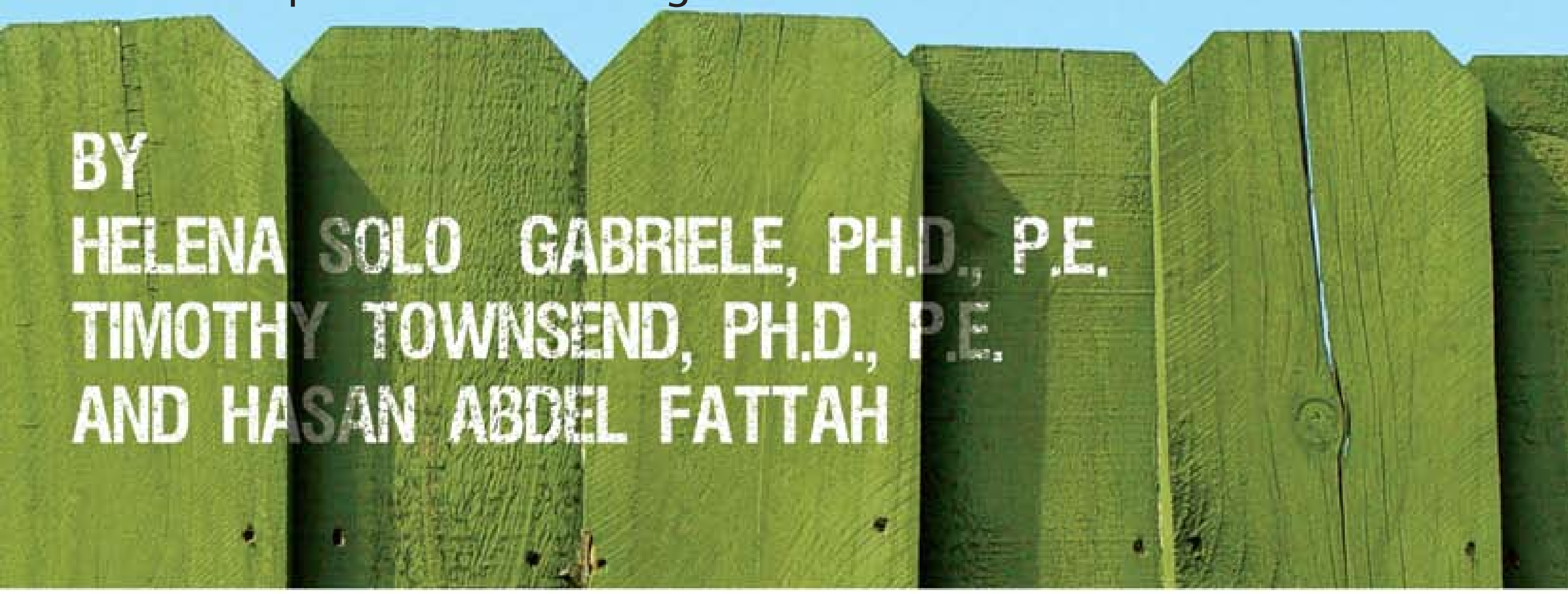
KNOCK ON WOOD

Research details how X-ray fluorescence technology could be the most suitable option for the sorting of recovered treated wood waste.



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It's resistant to decay and annoying insects. Suitable for countless ground and non-ground-contact applications, such as decking, fencing, sills, railings, joists, posts, wood foundations, building poles, retaining and pilings; it can also last as much as 10- to 20-times longer than untreated lumber. However, unlike regular wood, which has an abundance of post-consumer end-uses, pressure-treated wood can only be reused in specific post-consumer applications, including use as aggregate particles in concrete, in some forms of commercial landscaping, as agricultural fencing, or as a raw material in the manufacture of such wood materials as particleboard.

Treated wood manufactured throughout North America, as well as in other countries, is produced by impregnating the timber with certain pesticides, and can be done via numerous processes, including brushing, spraying, dipping, soaking, steeping or by means of hot and cold bath. The most notable process for protecting wood from biological deterioration, however, involves the pressurized injection of pesticides into the wood – giving the lumber a retention level between 0.25 to 2.5 pounds of preservative per cubic foot of wood.

Historically, the most common preservative utilized for such processes was arsenic (As)-based chromated copper arsenate (CCA). However, at the end of 2003, the wood treatment industry, in a voluntary agreement with the U.S. Environmental Protection Agency, stopped treating residential lumber with CCA, and began to phase out its use in most U.S. residential applications. CCA was replaced by copper (Cu)-based pesticides, with exceptions for certain industrial uses. And, due to this phase-out of arsenic preservatives, Cu-based preservatives are expected to dominate the residential treated wood market.

Arsenic, chromium (Cr) and copper from the treated wood can be released to the environment or indirectly routed to humans by many different mechanisms, including direct touching of wood, the inhaling of wood dust during cutting, or through contamination of water and soil by leachates produced when the wood is in contact with rainfall and moisture. Each of these three elements has negative impacts on the environment and human health, and each is characterized by different toxicity levels to targeted species. In some cases, treated wood is inadvertently recycled as mulch or as fuel for the production of energy. These recovered forms of treated wood are believed to leach metals more quickly and thus efforts are needed to avoid contamination of recycled wood with treated wood.

The research

Over the last decade, numerous studies conducted by researchers with the University of Florida and the University of Miami, Coral Gables, have looked to uncover the environmental impacts of using, and disposing of, pressure-treated wood products. The focus of these projects was to develop and implement several technologies to sort the treated wood from the construction and demolition (C&D) materials stream being collected. Research involved analyzing the components of recovered C&D wood waste received by recycling facilities located throughout South Florida. The projects revealed that facilities receiving non-source separated wood loads may include up to 30-percent treated wood based on weight; the fraction can decrease to five percent if efforts are put in place to omit wood loads containing visually identifiable loads of treated wood.

Visual identification of treated wood includes evaluating the potential origin of the wood. In other words, all wood used in outdoor applications should be considered treated and, as such, remnants of outdoor fences, decks, pilings, utility poles, etc., should be considered treated. Visual inspection also includes looking at the product's end-tag – the stapled-on label that identifies the type of preservative used, plus its retention level. If the wood is olive green in color, this is an indication that the product has been treated with copper, a component of CCA. Conversely, although sorting based upon visual methods is helpful in reducing the proportion of treated wood in the recycled wood waste stream, it's not adequate for situations where wood may be weathered, painted or covered with dirt and dust, all common components of the C&D wood waste stream. In these situations, however, sorting based upon visual methods should be augmented. Via the aforementioned study projects, researchers introduced several augmentation methods for identifying treated wood from C&D waste wood. These methods included use of PAN stain, hand-held X-ray fluorescence (XRF) analyzing units, laser-induced breakdown spectroscopy (LIBS) and on-line detection and sorting by XRF.

PAN stain

Chemical PAN indicator stain is a useful tool for identifying small quantities of CCA-treated wood, as, when applied, the wood stains a magenta color if treated with Cu and orange if untreated. Initially, this was a popular, and practical, method for field use, due to its relatively quick reaction time (12 seconds); however, because of the increasing use of non-arsenical copper-based preservatives in treated wood, the development of other chemical stains would be needed. Some disadvantages of using PAN indicator stain include the stain not being capable of distinguishing between CCA and other copper preservatives, such as alkaline copper quat (ACQ) and copper boron azole, and that applying the stain can be laborious and expensive, with a direct labor cost ranging from $44 to $84 per U.S. ton, depending on the contamination level of wood loads.

Laser-induced breakdown spectroscopy

LIBS technology was found to be a useful tool for identifying CCA-treated wood, targeting wood pieces with a laser beam – through a series of mirrors and lenses that create a small microplasma on the surface of the targeted piece – causing a vaporization of the surface material. The vaporized atoms emit energy in the form of light, with a wavelength that is a characteristic of the targeted element. Although LIBS technology is capable of identifying the metals in treated wood and can be equipped to an online system, the system evaluated was subject to interferences from coated and wet wood (as LIBS detects elements at the wood surface). Further research is needed before this technology can be applied at the field scale.

X-ray fluorescence analyzers

Among all of the technologies evaluated, XRF technology appears to be the closest to possible implementation, due to its ability to identify elements in wood, even in wet, painted or dirty wood, in a fraction of a second. XRF is based upon the use of high-energy X-rays, which knock electrons out of the innermost orbital of atoms in the treated wood, changing the atoms into unstable ions. A more energetic electron from outer orbital will move into the newly-vacant space, within the inner orbital, in order to reach the lowest stable energy state and release the extra energy possessed before. The emitted energy, a characteristic of the element fluorescing, is then measured by an X-ray analyzer.

On-line detection and sorting by XRF

The most recent research using XRF technology focused on evaluating the feasibility of on-line sorting of treated wood from untreated wood at a full-scale recycling facility. The study was conducted at Florida Wood Recycling in Medley, Florida.

The sorting equipment consisted of an infeed motorized belt-conveyor, as well as an inclined conveyor that was installed perpendicular to the discharge end of the infeed conveyor. The infeed conveyor was designed to convey wood to the XRF detection unit installed on top of the infeed conveyor, with the inclined conveyor moving the untreated wood to a separate pile for further processing as mulch. The belt motors were wired to a three-phase, 480-volt generator through a variable frequency (zero to 60 hertz) drive that controlled the belt speed.

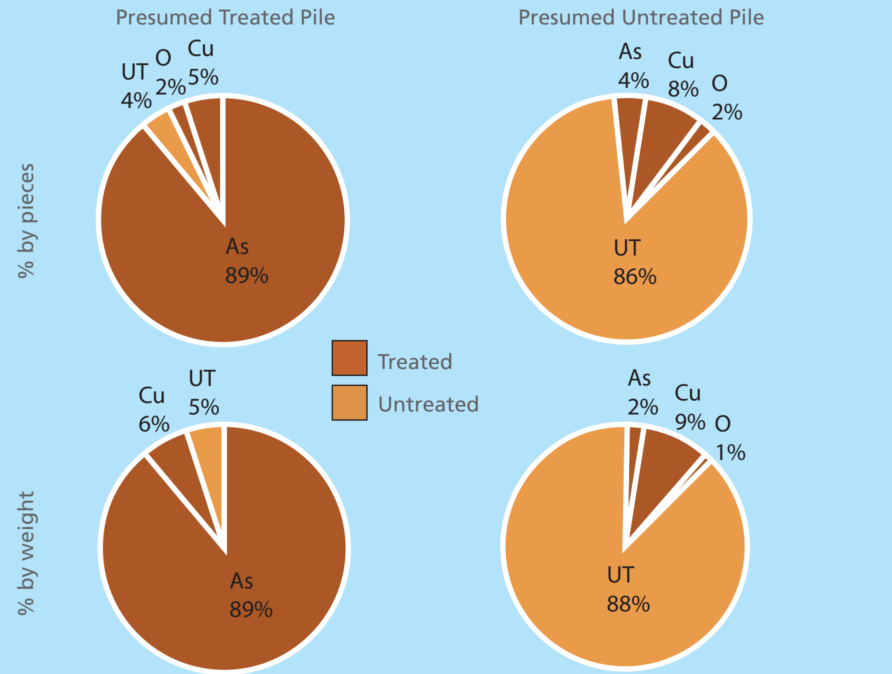
The XRF inspection system consisted of an X-ray tube operated at 44 kilovolts and one mili-amp, mounted at a distance of 1.3 feet from the belt. In order to overcome the proximity problems of earlier systems, the X-ray detection system was mounted at a 45-degree angle from the horizontal, at an approximate distance of one foot above the wood pieces. Doing this significantly increased the proximity requirement from nearly one inch in earlier models, which allowed for inspection of the wood to be conducted from the top-down, instead of from the bottom-up. The detector was also connected to a digital pulse processing unit that was linked to a control panel. The control panel had a central computer controlled by customized software. After examination, wood pieces were passed through the rest of the inspection chamber mounted on the infeed conveyor, with treated wood being discharged from the end of the infeed conveyor by a slide-way diverter (operated pneumatically by a driving piston connected to an air compressor), thereby bypassing the inclined conveyor.

The results

With this project, wood sorting by XRF focused on the inspection of arsenic and/or copper presence in wood. The presence of As and Cu indicated the presence of arsenical preservatives in the wood, most likely CCA. The presence of Cu-only indicated the presence of such copper-based preservatives as ACQ. In all, 13 experiments were conducted utilizing wood pieces – untreated, treated with arsenic and treated with copper, no arsenic – from the Florida Wood Recycling facility, with each experiment consisting of a feed of 1,000 wood pieces.

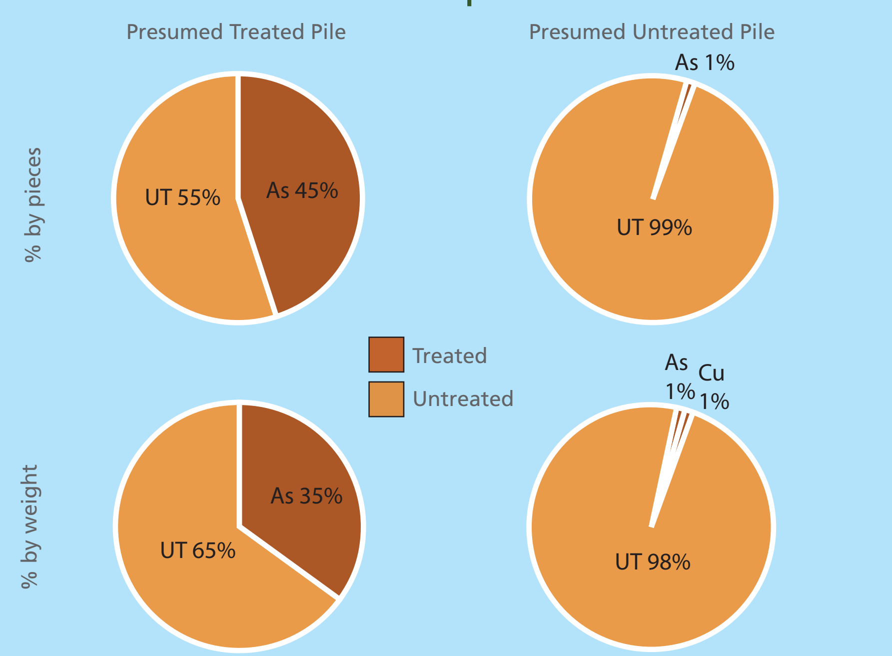
Two sets of infeeds were used for

Figure 1 | Composition of presumed treated and presumed untreated pile of 50-percent contaminated infeed wood pile



Source: University of Florida and University of Miami, 2008.

Figure 2 | Composition of presumed treated and presumed untreated pile of five-percent contaminated infeed wood pile



Source: University of Florida and University of Miami, 2008.

experimentation. One set consisted of an infeed composition of 50:50 (50-percent untreated wood and 50-percent treated wood), with the other set consisting of a 95:05 makeup (95-percent untreated wood and five-percent treated wood). The 50:50 infeed was used to more adequately observe sorting efficiencies, given the significant fractions of both treated and untreated wood. The 95:05 infeed most likely represents the infeed at recycling facilities that practice visual sorting of C&D wood waste. Experimental results showed that commercially-motorized belt conveyor speeds ranging from 50 to 100 feet per minute can be used for on-line wood sorting via XRF technology. Sorting efficiencies of the 50:50 infeed were found to be between 92 percent and 99 percent for removal of As, between 90 percent and 97 percent for the removal of Cr and between 75 percent and 92 percent for removal of Cu.

By analyzing the two separated piles after the detection and sorting process, researchers found that the presumed treated pile, which is to be diverted to landfill, consisted of between 72-percent to 97-percent treated wood and four-percent to 28-percent untreated wood, with figures being based on both the number of pieces and weight (80 percent to 97 percent and three percent to 20 percent). The presumed untreated pile, which is to be recycled for mulch or energy production, consisted of 78-percent to 86-percent untreated wood and 14-percent to 22-percent treated wood, with figures being based on both the number of pieces and weight (75 percent to 88 percent and 12 percent to 25 percent). Figure 1 shows the wood distribution in the presumed treated and presumed untreated piles for one of the experimental runs (50:50 infeed, belt speed = 0.25 meters per second, feeding rate = 20 pieces per minute). Figure 2 shows results for the same experiment with a 95:05 infeed.

As noted, sorting efficiencies for the 95:05 infeed were observed at 81 percent to 96 percent for arsenic, 80 percent to 96 percent for chromium and 72 percent to 91 percent for Cu. By analyzing the two separated piles after the detection and sorting process, researchers found that the presumed treated pile consisted of 35-percent to 57-percent treated wood and 43-percent to 64-percent untreated wood, with figures based on both the number of pieces and weight (32 percent to 52 percent and 48 percent to 68 percent).

The presumed untreated pile consisted of 98-percent to 99-percent untreated wood, and one-percent to two-percent treated wood, with figures based both on the number of pieces and weight (98 percent to 99 percent and one percent to two percent).

To conclude

In order to evaluate the significance of these results, researchers considered a case where the recovered wood waste was to be recycled as mulch. In Florida, land-applied materials have to meet certain soil clean-up target levels (SCTL), and these are generally lower for arsenic by roughly a factor of 100 relative to Cu and Cr thus arsenic is the most stringent criteria that will typically govern the design of a particular system. The specific As guideline level for land application of materials in residential areas is 2.1 milligrams (mg) of arsenic per kilogram (kg) of applied material. The 95:05 infeed used in this study had 164 mg of arsenic per kg of wood. With the XRF sorting system used in the current study, the presumed untreated pile reduced the arsenic levels to between seven and 37 mg/kg, which is within the commercial SCTLs. Thus, the technology achieved considerable improvements in the quality of the wood that could ultimately be used for recycling purposes; however, additional improvements are needed to the system to achieve the strict 2.1 mg/kg level needed for residential applications.

In the end, researchers believed these improvements could be achieved through the redesign of the wood conveyance system. By doing this, it will minimize the tendency for wood to bounce when sorted into treated versus untreated wood piles, as the majority of the inaccuracies associated with sorting were due to mechanical conveyance issues, and not the detection of the metals by the XRF.

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CORRECTION:

Resource Recycling would like to acknowledge some concerns with the "Knock on wood" article, which appeared in the May issue of *RR.* First, the byline order for the article should have read A. Rasem Hasan, Helena Solo-Gabriele Ph.D., P.E. and Timothy Townsend, Ph.D. P.E., not Solo-Gabriele, Townsend and Hasan. Second, A. Rasem Hasan, not Hasan Abdel Fattah, has already earned his Master's of Science and is currently working toward his P.h.D. at the University of Miami, Coral Gables. Lastly, with the author's consent and for the benefit of our readers, the opening section of the article was researched, and written, by *Resource Recycling* staff, and should not be credited to the above authors. The authors' content begins with the section titled "The research." *Resource Recycling* regrets the errors.