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Potential for Introduction of Preservative Treated Wood in Wood Waste Recycling Streams and its Prevention

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1. Introduction

The public desire to reduce, reuse and recycle has led to substantial investments in recycling programs. Metals, paper, plastics and a host of other materials are now recycled, thereby conserving precious landfill space. One particularly important waste diversion is in the area of wood and garden waste [1]. These materials tend to be bulky and, more importantly, contribute to the production of methane as they degrade under anaerobic conditions in the landfill. Many communities now divert this material to be composted, separated and burned for energy production or, if the resource is sufficiently free of contaminants, even used to produce composite wood products. Composting has become especially attractive because this material can be combined with more putrescible wastes such as food compost to produce a very rich composted material.

One aspect of wood recycling operations that is often overlooked is the presence of contaminants in the chipped mixture. Metal fasteners can be removed using magnets, but many other materials wind up in this mixture. One of the more important potential contaminants is preservative treated wood [2,3]. Preservative treated wood is typically impregnated with combinations of heavy metals to provide resistance to biological attack. For decades, the most commonly used preservative for residential applications was chromated copper arsenate (CCA). CCA is no longer used for residual applications, but the replacement systems are primarily copper based including alkaline copper quaternary compound (ACQ) or alkaline copper azole (CA). The U.S. Environmental Protection Agency generally recommends that, wherever possible, treated wood be reused in a similar application. Once this is no longer possible, the wood should be disposed of in a licensed municipal solid waste facility with the appropriate liners and leachate management technology. The EPA specifically prohibits the burning of treated wood except in specially licensed facilities. The most common use of

combustion for disposal of treated wood is with creosote, although it is technically possible to combust other treated wood products. These activities are generally associated with industrial products such as railroad ties or utility poles.

While industrial products are an important component of the potential treated wood disposal stream, the users of these products are generally aware of the requirements for disposal. However, a large amount of preservative treated wood is employed in residential applications for decking, fencing, and a host of other uses. These products have varying service lives and eventually find their way into the waste stream. As with other treated wood products, the EPA recommends reuse following by landfill disposal for these products at the end of their service lives; however, there are several factors that can make this difficult. First, treated wood in many parts of the country tends to fade and weather as it is exposed to ultraviolet light. In many cases, it is virtually impossible to visually distinguish between treated and non-treated wood once it has weathered. In addition, many homeowners do not know that treated wood needs to be disposed of in a landfill and therefore tend to place this material into their yard recycling container where they already place other woody debris. Finally, there is no specific collection pathway for treated wood products, making them difficult to assemble as a single material.

2. Level of contamination in recycled wood

The potential for contamination of wood recycling streams was brought to light over a decade ago in Florida. Energy recovery facilities that used mixtures of bagasse and waste wood obtained from construction and demolition landfills as fuel sources discovered that their resulting ash contained very high levels of copper, chromium and arsenic. Further investigation revealed that high percentages of wood entering construction and demolition debris (C&D) facilities were treated with CCA. However, the wood had weathered to the extent that it was no longer possible to visually detect this material. The Florida situation is unique in a number of ways. The higher risk of decay in this state means that treated wood represents a much higher percentage of the total volume of wood used. In addition, these more severe exposure conditions lead to a shorter overall service life for a given product. The severe UV exposure conditions typically found in Florida tend to reduce the surface appearance of the material, leading to premature removal of wood that is structurally sound, but has a poor appearance. Florida also has a very limited landfill capacity and, at the time had a number of non-lined C&D facilities. This led to large amounts of materials entering combustion facilities. The occurrence of elevated metal levels stimulated a large research effort at the University of Miami and University of Florida to determine the levels of treated wood entering the recycling stream, and, once it became evident that a substantial volume of treated wood was present, how to rapidly detect it.

Copper based systems are currently the most commonly used wood preservatives, but older wood can also contain chromium and arsenic. The EPA labels associated with these chemicals specifically indicate that disposal of products treated with wood preservatives should be in a lined landfill; however, it can sometimes be difficult to determine if wood that has been

subjected to extensive ultraviolet light contains preservative treatment. As a result, there is a risk that treated wood can enter the recycling stream. In the case of woody debris used for biofuels, the presence of metal based preservative can result in air-emissions as well as elevated metal levels in the resulting ash. Inadvertent inclusion of treated wood in composting operations could result in elevated metal levels in the subsequent compost. While this is unlikely to pose a risk to plants, it could lead to difficulties if the materials are marketed as being organic.

In either case, quantifying the amounts of treated wood entering a waste stream can help producers determine the level of risk so that they can develop appropriate mitigation measures. This risk is likely to differ regionally because of the differing degrees to which treated wood is employed and the length of time it remains in service. The Pacific Northwest is an excellent area in which to determine treated wood incidence in recycling streams because it has well developed recycling programs and the treated wood has distinctive features that make it easier to detect. In this chapter, we will discuss surveys of treated wood incidence in a wood recycling center over a 10 year period and then discuss possible methods for limiting the incidence of such materials [12].

Surveys were conducted at a recycling facility located near Corvallis, Oregon [4]. The facility is a regional composting and recycling facility that processes over 28,000 metric tons of material per year. The facility receives regular yard waste that includes branches, grass, brush, and seasonal influxes such as leaves and Christmas trees. The facility also accepts wood waste from various sources. These materials were formerly chipped separately with the yard debris being composted and the wood debris going to various facilities for combustion for either steam or electricity. This situation has recently changed as a result of the introduction of generation of food waste composting coupled with changes in wood demand in the surrounding area. The food composting operation has resulted in an increase demand for woody debris as a media for the composting, while lower natural gas prices have sharply curtailed the use of woody biomass for energy production. As a result, nearly all wood entering the facility now ends up in the compost mixture.

Most materials arrive at the facility by commercial haulers, but nearby residents can also drop off materials for a fee. Loads can be inspected at the gate house, but it is not feasible to inspect every load. As a result, it is possible for contaminants to enter the recycling stream. Wood entering the facility is segregated into a separate pile for chipping. Chipping occurs as equipment becomes available and the resulting wood chips are stored until needed for constructing a compost pile. Once the wood is chipped, it is virtually impossible to detect the presence of treated wood.

Detecting treated wood prior to chipping is relatively simple. The wood is normally piled in such a way that the vast majority of the pile is accessible. Treated wood in the Pacific Northwest is much easier to detect because it is generally stained with a brown pigment to makes it appear like western redcedar. In addition, a large percentage of the material is incised. This process drives metal teeth into the wood to improve the depth of preservative treatment. Incision marks are easily seen, even in older wood, making detection of treated wood in a pile relatively simple (Figure 1).

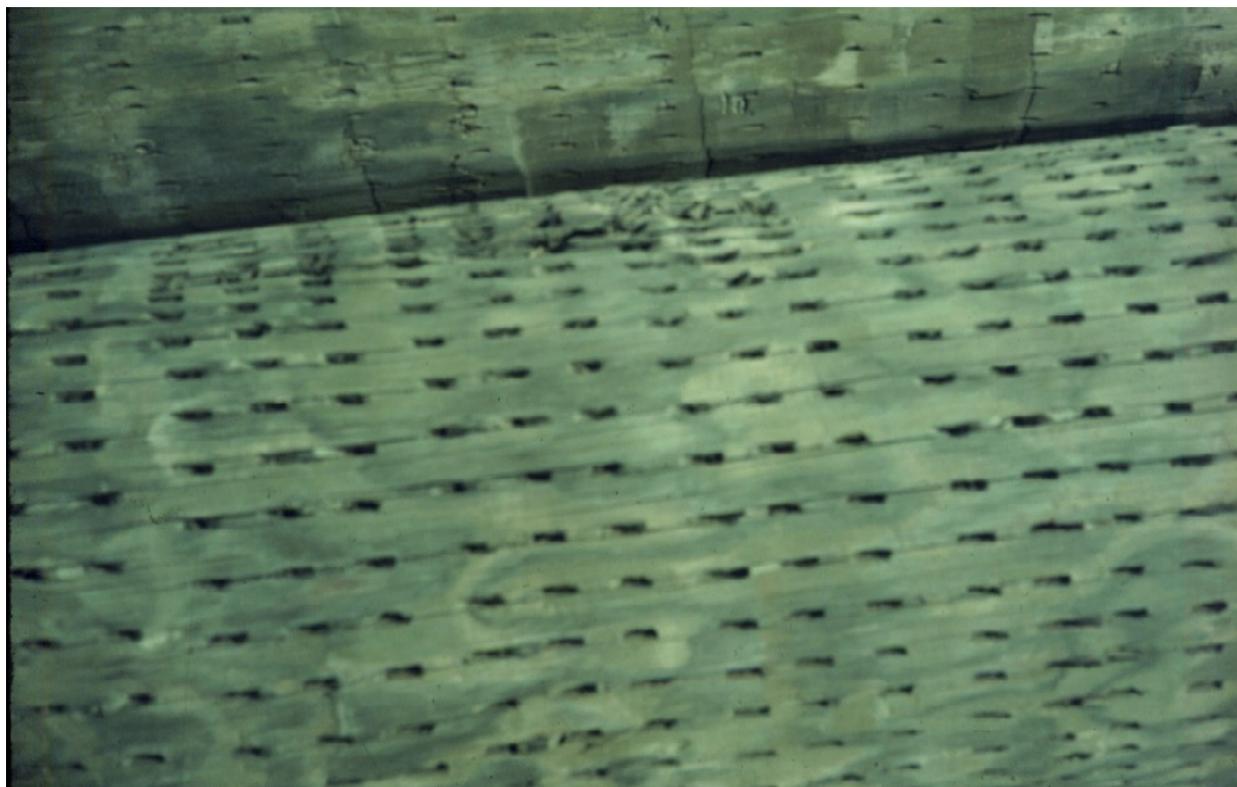


Figure 1. Example of wood with incisions that make it relatively easy to detect preservative treated wood in recycling facilities in the Western U.S.

The amount of treated wood has been visually assessed 168 times over the 12 year period [10]. At each time point, the size of the entire pile was estimated. The presence of treated wood of a given dimension in the pile was then visually determined (for example 4 by 4 inches, 2 by 4 inches, etc.) and the length was estimated to the nearest 300 mm. As mentioned, treated wood is readily detected in this part of the United States because of the distinctive brown stain and/or the presence of incisions. Depending on pile size, visual detection of treated wood is possible 1 to 3 m inward from the outside of the pile. In addition, we estimated the relative proportions of yard debris, pallets, panels, and demolition debris. This latter categorization only began after we had performed for the first 40 observations.

Ideally, wood mass would be used to estimate treated wood proportions, however, this was not possible because of safety issues related to the placement of the materials in a pile. Instead, the lineal footage of each piece of dimension material detected was used to determine overall volume of wood using actual dimensions. Lumber for residential applications was primarily treated with chromated copper arsenate (CCA) until 2003 when this material was withdrawn from the market. Alkaline copper quaternary (ACQ) compound or copper azole (CA) largely replaced CCA for this application [5]. It is not possible to visually distinguish wood treated with these three chemicals because of the brown pigments. The use of a copper indicator also would not help since all three systems contain copper as the primary biocide. For the purpose of determining chemical loading, we assumed that all of the wood had been treated to the American Wood Protection Association Standards ground contact retention for treatment of

lumber with any of the water borne materials (6.4 kg/m^3 for ACQ or CCA) and that the entire cross section had been treated to that level. Average wood densities were then used to calculate the total amount of metal present in the material [6,7]. This is an extremely conservative approach because wood in this region is difficult to penetrate with preservatives. As a result, somewhere between 40 and 60 % of the cross section is actually preservative treated and not all wood is treated to the higher retention level. However, since we could not visually assess treatment depth or retention, we used the conservative approach. As a result, the estimates of total chemical in the wood were intentionally high.

Pallets, yard debris, and demolition debris were the most abundant materials detected in piles at the site (Figure 2). The average volume of material present at any given inspection was 338.8 m^3 . Pallets were the most abundant manufactured material at the site (39 of 128 times), while yard debris, which include branches and leaves was the most common 68 times [10]. A variety of other materials were also present including panel trim scraps and shingles, but these represented minor volumes compared to the two most common materials. For example, Christmas trees were seasonally abundant, but represented an overall low percentage of the total mass delivered to the site.

Frequency of dominant material

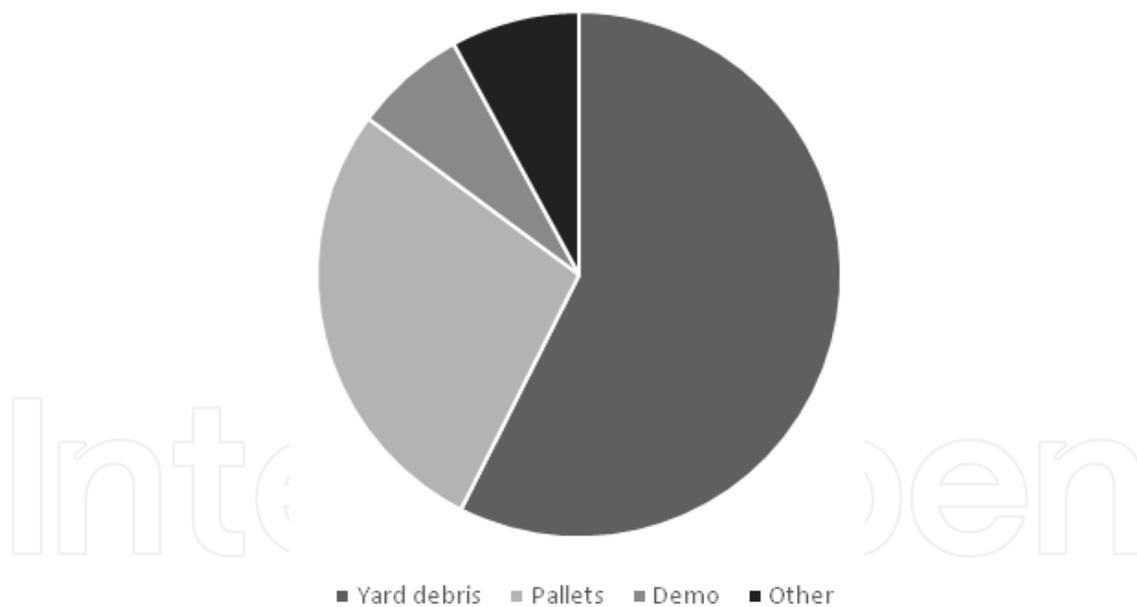


Figure 2. Frequency of a given woody material being the dominant substrate present at the recycling center (from 10)

Treated wood was present in 155 out of 168 inspections or 92.3 % of the samples (Figure 3). The percentages of treated wood were generally low in the samples, ranging from $<0.01 \%$ to 2.0% of the estimated volume (Figure 4). Levels at or above 1% were only detected 3 times over the 12 year period. The average volume of treated wood present was 0.15% over the 12 years. Treated wood levels were $> 0.2 \%$ of the volume in 20.5% of the inspections, while they were between 0.1 and 0.2% of the volumes in another 16.1% of the inspections. Treated wood

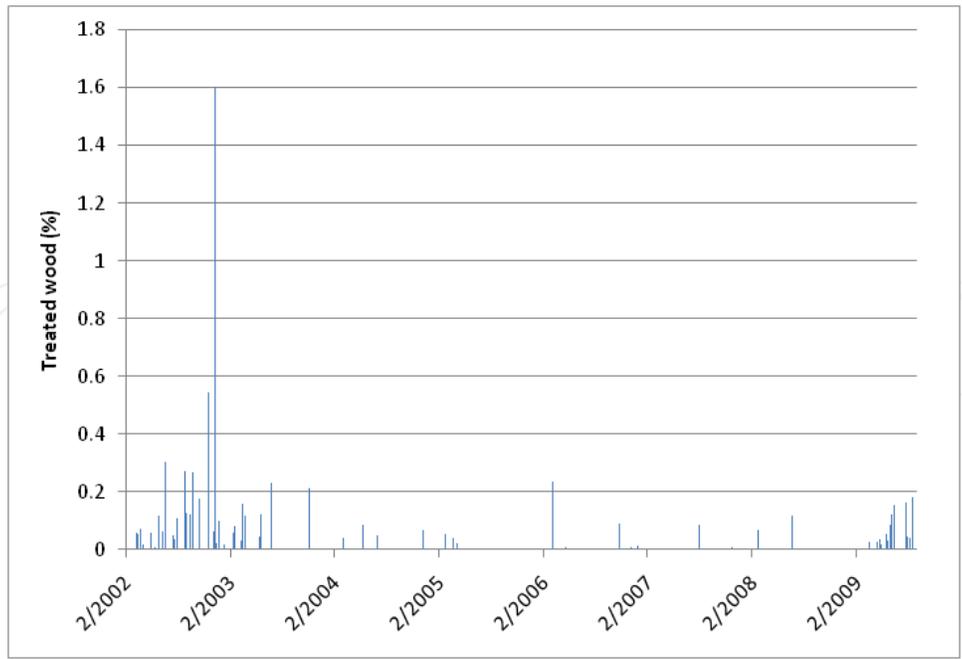


Figure 3. Percentages of treated wood detected in a recycling facility located in Western Oregon as determined by period visual surveys over a 12 year period.

Relative Frequency of Treated Wood

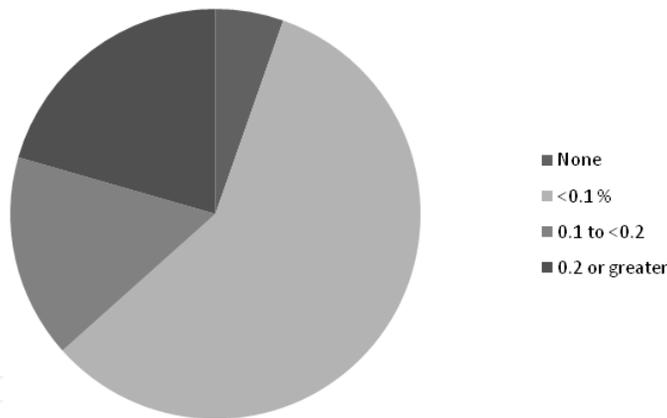


Figure 4. Frequency of different levels of treated wood in a wood recycling center in Western Oregon assessed over a 10 year period. Values are based upon 112 surveys (from 10).

represented less than 0.1 % of the volume in a majority of inspections (63.4%), indicating that this material was a relatively small proportion of the recycling stream.

3. Implications of treated wood contamination

These data provide an example of the potential for inadvertent presence of treated wood in the recycling stream and a relatively simple method for assessing the extent. However, it is

important to recognize that every site is different. In some cases, the overall volumes of wood in a facility are too great for this approach or the materials are processed directly and not available for inspection. In addition, the proportions of treated wood at this site were relatively low and the treated products were relatively easily detected. Never the less, it is important to develop reliable estimates of the levels of treated wood entering recycling streams. In the cases of materials that are combusted for energy production, excess amounts of treated wood in the feedstock can lead to releases of arsene gases and produce residual ash with excessively high metal contents that can pose a disposal hazard. This becomes quite important in some facilities. For example, previous studies of wood recycling facilities have shown that 5.9 % of volume at a C&D facility in Florida was treated wood [8], while 2.5 % of the wood entering the waste stream in Virginia was treated [9]. The risk can be examined by considering the potential inputs of metals into ash resulting from combustion of the materials. If we used the Oregon facility data indicating that if an average of 0.15 % of the incoming wood was CCA treated, then As, Cr and Cu levels would be 2380,2640 and 1580 ppm in the resulting ash [10]. Cu levels would be much higher if the wood was treated with either alkaline copper azole or alkaline copper quat but no arsenic or chromium would be present. It is important to realize that material from this particular facility was used to supplement other fuel supplies at local wood processing facilities. As a result there is likely to be considerable dilution with non-treated wood so that the resulting ash would not pose a disposal issue. However, the results do illustrate the potential for creating metal contaminated ashes in areas where large amounts of treated wood are employed. For example, if the treated wood levels present in the C & D facility in Florida were used, then As, Cr and Cu levels in the resulting ash would be 92820, 102,960, and 61620 ppm, respectively, and ash disposal would pose a major challenge. It is important to remember that metals do not disappear from compost. Thus, these same metal input levels would be present in any compost. The Oregon facility received 1318.2 metric tons of wood waste in 2013 along with other materials. If we use the 0.15 % treated wood composition figure, this material would result in an input of 28.2 kg of CCA. CCA Type C is composed of 47.5 % chromic acid, 18.5 % copper oxide and 34 % arsenic pentoxide [5]. These elements are expressed on an oxide basis. If we convert the total CCA input to elemental metals, the treated wood would input 6.97 kg of Cr, 4.50 kg of copper and 4.61 kg of arsenic into the system. The facility produced over 58,707,273 kg of compost (wet weight) from all of the inputs. If we use a 50 % moisture content for the compost, then the metal inputs would represent potential increases of 0.119 ppm, 0.077 ppm, and 0.079 ppm for Cr, Cu and As, respectively. Obviously, the potential impacts of such small inputs would be lost within the inherent variability of other material inputs such as the components of the food compost (for example, some seafoods contain elevated levels of arsenic). The results illustrate the minimal impact of treated wood on either combustion or composting of the incoming material at the Oregon site. A comparative operation in Florida where the treated wood input was estimated to be 39 times higher would increase metal levels in the resulting compost by 4.6, 3.0 and 3.1 ppm respectively. There are limited publically available data on metal levels in compost from facilities such as these, but a survey of Florida composting operations suggests that these inputs would not markedly alter the metal levels in the compost [11]. Some Florida soils have extremely low metal levels and these concentrations would certainly have the potential to increase overall soil metal levels if

compost were repeatedly used on the same site; however, these inputs would likely be balanced by plant uptakes. It is important to note that these levels would still be well below those found in soils from most other locations in North America.

4. Preventing contamination of recycled wood

The volumes of treated wood entering the facility we surveyed were 1.9 to 4 % of those found at other sites. Furthermore, the levels have actually declined slightly over the past decade. The reasons for the decline are unclear since the facility made no specific effort to exclude materials. While attempts should be made to divert as much of this material as possible from the recycling stream and into a lined landfill, it is obvious that there is a far greater need to accomplish this at the other sites.

Diverting this material; however, is problematic because most of those disposing treated wood materials are homeowners or small contractors who have little basic knowledge about wood treatments. While end-tags on most treated lumber do warn against burning the product, few read these tags and most of the tags are no longer on the wood at the end of its service life. Thus, recycling facilities need to consider alternative methods. Detection at the recycling center would be ideal because it would eliminate the need for consumers to be aware of proper disposal. However, this approach requires that the material be processed so that every piece of wood can be examined. In the case of the Oregon facility, the chipper is mobile and has a relatively short conveyor system that would make it difficult to assess every piece of wood. Even when assessment is possible, problems arise because of the difficulty in sorting individual samples. A number of approaches have been examined for detecting wood treated with waterborne preservatives which would most likely be present in a recycling stream. As mentioned earlier, metal treated wood in many locations tends to weather to a greyish colour that makes it virtually indistinguishable from weathered non-treated wood. Thus, visual detection is likely to be very inaccurate except where other factors, such as the use of dyes or incising in the western U.S. make the wood more recognizable. Nearly all of these systems are copper-based and there are several very sensitive indicators that might be useful. These indicators would have to be sprayed on all of the wood pieces in order to be used. That would require sizable quantities of indicator and some time for the reaction to become evident. This would make it difficult to apply in an industrial environment. There are similar indicators capable of detecting arsenic but these systems would suffer from the same problems. These indicators would also not be suitable for newer materials entering the waste stream, since arsenic based systems were phased out of the residential market in 2003 and will therefore represent an ever-decreasing percentage of the treated material of potential concern.

Heavy metals can also be detected using x-ray technologies, notably x-ray fluorescent spectroscopy (XRF). XRF is widely used in quality control programs for assessing the amounts of copper, zinc, arsenic and chromium in preservative treated wood. It is fairly sensitive to low levels of metal and preliminary studies indicate that the method even detected residual metals in wood through surface coatings [12, 13]; however, it does use ionizing radiation and most

current systems use x-ray tubes that may be somewhat fragile for operations within an industrial environment with a great deal of contamination. These are, however, technical issues that could be overcome if there were sufficient levels of treated wood in a waste stream. At present, routine x-ray screening for the presence of treated wood is probably not feasible or economical given the low value of the resulting compost or biomass chips.

An emerging technology for sorting treated wood is laser induced breakdown spectroscopy (LIBS), which uses a laser beam to degrade a segment of the wood surface to produce plasma. The wavelength of the emission from this plasma flash can be characterized spectroscopically to detect the presence of specific elements of interest. This system can also detect coatings, including those with lead based paints, and, if additional pulses are used, can remove the surface coating to detect a preservative underneath [12]. However, each additional laser pulse adds to the time required to assess each sample, thereby slowing production. The system is also sensitive to moisture, which requires additional laser pulses. This technology, while promising, would require additional research to more fully develop it for this application and is probably not feasible given the relatively low value of the resulting products.

While these technologies have the potential to remove treated wood from the recycling stream, they are less efficient because they operate at the end of the disposal path and must, therefore process large quantities of material that do not contain any treatment. Most of these techniques require additional employees or a substantial investment in sophisticated equipment. This renders such approaches inherently inefficient and costly. It is not clear that such approaches would be necessary in cases where the levels of treated wood present are low.

A far better approach to minimizing the presence of treated wood in the recycling stream would be prevention. It is not practical for haulers to remove treated wood during collection. Most haulers have nearly fully automated collection, making it extremely difficult and unsafe to attempt to remove specific contaminants during collection. However, it is possible to begin an education process for homeowners and contractors to make them more aware of the proper disposal of treated wood. For example, many haulers send notices to customers, either in conjunction with their monthly bills or as separate newsletters. These could provide venues for a gradual education of the customer base concerning disposal of treated wood. Publically operated haulers can use their local government newsletters for the same purpose. Most consumers are willing to take positive steps for the environment, provided they are not too onerous. Placing waste in different containers should fit within this arena. Informing customers about the reasons for these efforts may require a bit of education about what treated wood is and why it does not belong in the recycling bin. This would need to be coupled with regular reminders and education as the customer base changes. It may also be useful to educate contractors about proper disposal of decking removed during renovations and to prepare any information in multiple languages in recognition that many employees do not speak English as their first language.

At the same time, where facilities allow customers to drop off materials, creating signage about sorting treated wood could help better inform facility users. In addition, creating a space where customers can drop off material inadvertently mixed into their waste will reduce the need

to “sneak” materials. While these efforts are unlikely to eliminate treated wood from the recycling stream, they can reduce the incidence to the point where it does not pose a risk to the final product.

One longer term concern about the incidence of treated wood in the recycling stream will be the gradual introduction of non-metal based systems, particularly for above ground application such as decking. These so-called “organic” preservatives are just emerging in the market and require much more sophisticated instrumentation to detect in treated wood. Most cannot be detected visually or through the use of chemical indicators. In some cases, traces of metals or boron to overcome the problem of using indicators to detect these components; however, it is unclear whether these materials will remain for long periods in the treated products. On the positive side, many of these preservative systems are more rapidly degraded in soil and should not pose a risk of long term accumulation. Some of these systems can also be burned provided the proper temperatures are maintained to ensure complete thermal destruction.

5. Conclusions

Treated wood appears to be a consistent presence in the recycled wood stream. Ideally, systems would be developed to sort and exclude this material; however, the low value of the resulting wood makes it difficult to justify the costs for sophisticated instrumentation required to accurately distinguish between treated and non-treated wood. The relatively small amounts present at some facilities also make it difficult to justify major capital expenses to remove a minor contaminant. Continuing customer education appears to have the greatest potential for reducing the amounts of treated wood entering the waste stream and can be accomplished with minimal cost.

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