REUSE/RECYCLING OF TREATED WOOD

by

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Summary

Reuse and recycling are considered highly acceptable strategies for managing treated wood removed from service. However, the opportunities are limited at this time, especially for waterborne preservative treated residential construction. Two possible areas for reuse and recycling are the processing of poles for sawn products and incorporation of CCA treated wood fiber in wood-cement composites.

1. Introduction

In considering the total environmental and other social costs and benefits of using treated wood, the entire life cycle from "cradle to grave" must be considered. Obviously, if the "grave" component of a product's life cycle can be postponed through reuse or recycling, environmental costs are deferred and even reduced or eliminated, to the extent that the reuse reduces the need for new treated wood.

Treated wood that has reached the end of its first life cycle, through obsolescence, mechanical damage, decay etc. may be managed in a number of ways other than by reuse or recycling. Some of these are discussed in the other papers in these procedings. In the hierarchy of waste management alternatives (e.g., OWMC 1982), disposal, as in a landfill is considered the least desirable option (Table 1). Economic and environmental incentives for the owners of non-functional treated wood products to move up this hierarchy include the escalating costs of treated wood products, the costs of disposal and the increasingly restrictive nature of environmental legislation related to disposal.

The reuse and recycling options depend on the nature of the material removed from service, i.e., the size and condition of the wood, the amount available and the amount and type of residual preservative in the wood. Some of these factors are discussed below for each of the main preservative types.

2. Reuse and Recycling of Treated Wood

2.1 Creosote Treated Wood Products

The volume of wood treated annualy with creosote has decreased slightly as other preservatives were substituted for creosote for specific products, such as poles, lumber and posts. At this time, about 75% of the creosoted volume consists of cross, switch and bridge ties compared to about 50 % in 1970. In the past, a higher proportion of the creosoted wood was poles and other products such as wood block flooring. Thus, the nature of creosoted wood removed from service will change with time, with ties becoming a larger component of this material.

Most of the creosote in wood removed from service is contained in decommissioned railway ties. In Canada, about 2.5 million ties are removed annually (Cooper and Ung 1989), representing a volume of about 0.24×10^6 m^3. Most of these ties are treated with 50/50 creosote/petroleum solution. The remainder is in marine or land piling, retaining walls, bridge timbers, poles, etc.

Several studies have measured the residual levels of creosote in treated wood removed from service. The % lost in service can only be estimated, since the original levels are only approximately known. Our studies on the residual amounts of preservative in poles removed from service (Cooper 1993) show that creosoted poles of all ages retain about 50% of the assumed (AWPA) initial loadings. Other limited studies on railway ties removed from service (Pfaff et al, 1992) suggest that even higher losses may occur from ties. Marine piling, which is treated to much higher creosote levels appears to lose a lower proportion of the original loadings. Bramhall and Cooper (1972) observed creosote retentions at about 75% of the presumed initial loadings in marine piling in service 40 years. It is known that the creosote lost in service is from the lower part of the distillation range (e.g., Bernuth 1987). These components are more volatile and water soluble and less viscous and therefore prone to evaporation, leaching and bleeding losses. Thus the amount of creosote in wood removed from service is reduced and the stability of the remaining creosote components in the wood is greater than when freshly treated.

2.2 Pentachlorophenol

The use of pentachlorophenol has decreased slightly in Canada. Future usage will probably continue to drop, depending on the future registration status of penta and the development of suitable alternative chemicals. The largest use of penta is for utility poles. Thus, in the future, poles will comprise an increasing proportion of penta treated wood removed from service.

It is estimated that more than 250 000 poles are removed from service each year in Canada (Cooper and Ung 1989) and more than ten times that volume in the USA (Nowak 1991). Of these, it is estimated that 70% of the poles removed in Canada are penta treated (Cooper 1993), compared to about 40% in the USA (Nowak 1991). In both cases, poles and crossarms represent the bulk of penta treated wood removed from service. Other penta treated products include timbers, posts, land and freshwater piling etc. As with creosote, the volumes of decommissioned wood containing pentachlorophenol are expected to decrease over the next 30 years. Ruddick (1990) and Cooper (1993) have determined that residual penta retentions in poles removed from service are much lower than originally in the wood.

2.3 Potential for Reuse and Recycling of Creosote and Pentachlorophenol Treated Wood

Treated wood may have a number of uses, such as reuse for its original purpose in applications with less rigorous specifications or performance requirements, or for different applications. The origional owner of the treated wood may have uses for the wood, or it may be given or sold to farmers, homeowners or contractors. Some examples of reuse of industrial products are:

- Reuse poles removed to upgrade or replace lines on new line construction, provided the poles are in good condition and contain enough preservative.

- Use poles or parts of poles for light standards or residential service poles, low service lines, fence posts, building posts, etc.

- Use portions of poles as stubs, anchors, cribbing, laydowns, etc.

- Reuse poles for sawn products (discussed below).

- Use railway ties on secondary lines, for landscaping timbers, retaining walls, rustic steps, fences posts, etc.

The reuse of poles, ties and other industrial products appears to be decreasing as the owners of this material become concerned about possible liability if the decommissioned wood is not reused properly e.g., burned as firewood, used in residential construction, or used where contamination of food is possible. Most Canadian utilities require individuals using poles removed from service to sign a waiver of responsibility form, certifying that they are aware of the presence of wood preservatives and absolving the utility of responsibility for problems that develop from the misuse of the material.

There has been some success in reconstituting used railway ties into composite ties in the USA. The ties are ground up and bonded together with an adhesive in a baking process. This patented "Cedrite" process has been commercialized, although the company has now gone out of business. In Canada, the low density of rail lines makes collection and transport of the quantity of ties needed to support a composite tie facility unfeasible.

There does not appear to be many options for reuse and recycling of marine structures.

There is an obvious need for controlled commercialized processes that can safely and efficiently reprocess these treated wood products.

Processing creosoted wood for the recovery of energy is accepted in the USA and is a legitimate alternative to help dispose of creosoted wood that cannot be used for other purposes.

2.4 Inorganic Waterborne Preservatives - CCA and ACA

Before 1975, use of waterborne preservatives was relatively low compared to the oilborne treatments and current disposal is mainly confined to wood that has mechanically failed in service (auto accidents etc.) and off-cuts generated during construction. However, the markets for waterbornes, particularly CCA, have expanded greatly in the last decade and much larger volumes of decommissioned wood can be expected in the future. Much of the current CCA treated wood is used in residential construction and its disposal is more difficult to monitor and control compared to commercial products such as railway ties and poles.

Leaching studies on CCA and ACA treated wood suggest total chemical losses from treated wood in the order of 10-30%, with higher losses of arsenic and copper than chromium (Cooper and Ung 1989).

2.5 Potential for Reuse and Recycling of CCA and ACA Treated Wood

Industrial products such as poles and piling can be reused and recycled for similar uses as creosote and penta treated material. However, the anticipated large volume of construction waste and residential decks and fences taken out of service creates a much greater challenge.

Limited use can be made of CCA-treated off-cuts for general construction use, shims, braces, etc. CCA treated wood may be chipped for furnish for decay resistant composite products (Henningsson 1980). Initial studies on incorporation of CCA treated wood in wood-cement composites (discussed below) also shows some promise.

3. University of Toronto Studies on Reuse and Recycling of Treated Wood

3.1 Reuse and Recycling of Poles

Most of the estimated 250 000+ poles removed from service annually in Canada have been pressure or thermal treated with one of the wood preservatives, creosote, pentachlorophenol (PCP), chromated copper arsenate (CCA) or ammoniacal copper arsenate (ACA). Poles are taken out of service for many reasons. Relatively new poles removed to upgrade lines are still serviceable and should be reused by the utility. Other poles may be damaged in localized areas but are still suitable for reuse as other products such as reinforcing stubs and lay-downs. In some cases, used poles are disposed of at landfill sites. This option is becoming increasingly expensive, and some jurisdictions have banned treated wood products from sanitary landfill sites because of concerns about potential leachates.

We recently undertook a study, supported by LPB Poles Ltd., and the Ontario Ministries of Transportation and the Environment, to investigate the feasibility of reusing or recycling poles or parts of poles. Of particular interest was the feasibility of converting poles of structural wood species to sawn products that could be used by MTO as components of bridges, as guiderail posts or for other wood uses. 456 poles or pole sections removed from service in Ontario and Quebec, were characterized by age, wood species, preservative type, residual preservative, dimensions and condition. Based on this characterization, the potential for reuse as round poles or posts, sawn posts, timbers and lumber, cedar roof shingles and firewood was assessed using the criteria listed in Table 2. For lumber and shakes and shingle products, the amounts of useable product were estimated from an appropriate conversion formula: for lumber, the 1/4" International Log Rule and for shingles, an assumption of 40 % recovery of log volume (16.1 cubic feet per square or 4.9 m^3 of log required to roof 100 m^2 of roof) (Dobie and Wright 1972).

There was a wide variety of pole species/treatment combinations in the sample (Fig. 1). Western red cedar and red pine poles predominated; obviously, this distribution would be different for other Utilities and geographic locations. The average age of poles in this sample was about 28 years (Fig. 2), although many newer poles were also removed and age stamps were visible on some poles more than 60 years old. This estimate is biased in that only the approximately 100 poles with legible brands are included and the other heavily weathered or otherwise damaged poles are probably older.

Although creosote has not been used for utility poles for many years, about 30 % of the wood volume represented creosoted poles. Thus, there is a large number of creosote treated poles still in service which will form a significant component of pole removals for some time. Most of the creosote wood volume was in poles in service at least 25 years.

Western redcedar had the greatest potential for economic recovery of products since high value shakes and shingles, as well as lumber could be produced from much of the material. The portions of the poles not assigned to these products could be converted to poles, posts and firewood. Thus, this species has good potential for reuse. Poles of other species (most notably red pine and jack pine) were suitable for lumber, poles or posts. A small percentage (about 10%) was judged suitable for landfill only due to decay, preservative bleeding, excessive hardware or mechanical damage (Fig. 3).

Approximately 100 of these poles with legible brands (so the age of the pole was known) were analyzed for preservative gradient at locations approximately 1 m above and 1 m below groundline. Samples were taken at 2 cm radial increments for analysis. Creosote contents were estimated by mass change of dry wood following toluene extraction, penta samples were analyzed by neutron activation analysis and CCA samples by X-Ray fluorescence (ASOMA Instruments Ltd.).

Creosote and pentachlorophenol levels in poles older than 20 years had levels approaching or below toxic thresholds for decay fungi (Figs. 4 and 5) and should be retreated before reuse in applications of high decay risk. The CCA treated sample was small, but initial indications are that residual levels are adequate to protect wood and retreatment is not required (Fig.6).

A pilot study was conducted to evaluate the recovery and grade of lumber produced from typical poles and to assess the feasibility of handling the contaminated sawdust produced. Two meter long pole sections were cut from the above ground and below ground portions of 22 poles representing a range of pole species, ages, conditions and treatments. The sections were scanned with a metal detector and all observed hardware removed. Poles were washed with a high pressure water sprayer before milling. These sections were taken to a small portable band saw mill ("Wood Miser") and cut into dimension lumber and timbers. The lumber was scaled for recovery calculations and graded.

Used poles could be sawn into lumber with good grade and volume recovery, using a small portable band saw. The used poles produced high quality lumber in most cases. There was a slight down-grading of lumber for some pieces from close to the surface as a result of drying checks that cause through-splits in the lumber. However, the grade recovery was as high or higher than expected from fresh saw logs of the same size and species. Quantity recovery was higher than predicted from the International Board Rule because of the very thin kerf and good sawing accuracy of the portable bandsaws. The quantity of sawdust generated by this type of saw is relatively low and the sawdust is fine enough to be easily and cleanly collected by conventional dust collection systems. Despite the attention paid to detection and removal of hardware using a portable metal detector, some metal escaped detection and bandsaw blades required frequent resharpening and some blades were destroyed.

The feasibility of retreating the sawn material was also evaluated. Boards were weighed and their dimensions measured, then sealed in a pressure retort and a vacuum of 24 in. Hg applied for 20 minutes. The 2 % CCA-C solution was drawn in by the vacuum and the pressure increased to 150 psi for 1 hour. The solution was drained and a final vacuum of 24 in. Hg applied for 20 minutes to remove drippage. The fresh treated lumber was reweighed and the CCA-C retentions determined from the mass absorbed, the solution concentration and the board volumes. In total, six charges of lumber and timbers were treated in our 16" retort. After treatment, the working solution was inspected for signs of oil contamination or other deterioration in quality.

Treated poles with depleted reserves of creosote or pentachlorophenol could be retreated with CCA preservative to full sapwood penetration and retentions similar to those possible with new wood (Table 3). We also showed that the wood could be retreated with creosote.

3.2 Recycling of CCA Treated Wood in Wood/Cement Composites

Wood/cement composites are finding increased use internationally, as a building material, because of their good combination of decay, termite and fire resistance, relatively low density and higher thermal insulation properties. In Canada, one important use is in highway sound barriers.

In a study of the compatibility of treated wood removed from service with Portland cement, one of our students found that creosote and penta-in-oil interfered with the wood-cement bond (Schmidt 1993). However, CCA treated wood from poles removed from service formed a product with better properties than one using untreated wood. This was confirmed by a follow-up series of studies (Schmidt et al 1993). Wood cement compatibility studies, using a stick withdrawal test showed that the force required to pull CCA or chromic acid treated sticks from a Portland cement block was more than double that for untreated wood (Table 4). Similarly, both flexural toughness and compression strength of wood cement composites were increased if wood particles were pretreated with CCA or chromic acid (Table 4).

4. Conclusions

Several options exist for reuse and recycling of treated wood removed from service. However, as quantities of residential treated wood increase, other options for reuse or otherwise managing this resource must be found.

The health and environmental implications of various reuse and recycling options, such as landscaping use of railway ties, sawn product manufacture of poles and manufacture of composites using treated wood must be explored.

Resawing of poles for a range of products appears to be a feasible option.

Recycling of CCA treated wood in wood-cement composites may also be feasible.

5. Literature

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Table 1: Hierarchy of Waste Management Strategies (OWMC 1982)

Most desirable options	WASTE ABATEMENT OR ELIMINATION (Zero Discharge)
	WASTE REDUCTION OF MODIFICATION
	WASTE REUSE
	WASTE REFINING FOR RECYCLING
	WASTE TREATMENT AND DESTRUCTION
Least desirable option.	WASTE DISPOSAL

Table 2: Hierarchy of Preferred Uses for Poles Taken Out of Service.

Priority or rating	Proposed Use	Criteria
Highest	Reuse as is as a pole	Less than 10 years old, good condition, greater than 35' (10.7 m) long.
.	Cedar Roof shakes or shingles	Western redcedar only, top diameter 12 " (25.4 cm) or greater, few knots.
.	16 ' (4.9 m) sawlog	Top diameter 6" (15 cm) or greater, sound, minimal hardware.
.	8' (2.4 m) sawlog	Top diameter 6" (15 cm) or greater, sound, minimal hardware.
.	Round building poles or posts	6' (2 m) or longer, sound.
.	Firewood	Untreated northern white cedar or western redcedar.
Lowest	Landfill disposal	Excessive rot or mechanical damage, excessive hardware, heavy preservative bleeding.

Table 3: Results of CCA-C Retreatment of Lumber and Timbers

Material	# Treated	Species	Previous Treatment	Age Range (y)	CCA Retention (kg/m^3) Ave.	S.D.
2" lumber	16	red pine	Penta	20 - 37	5.97	2.05
"	10	red pine	Creosote	21 - 61	7.54	3.68
"	14	jack pine	Penta	18 - 30	3.33	1.68
"	7	jack pine	Creosote	26 - 47	1.97	0.53
8" timbers	2	red pine	Penta	15	6.80	1.36
"	2	jack pine	Penta	20	2.88	0.32

Table 4: Effect of CCA or Chromic Acid Treatment on Wood-Cement Compatibility and Composite Strength.

Property	Sample Description	Ret. kg/m^3	Average Value	s.d.
Stick	Red pine untreated	0	0.303 kg/m^2	0.103
pull-out Resistance	Red pine CCA treated	11.5	0.834 "	0.165
	Lodgepole pine untr.	0	0.172 "	0.048
	Lodgepole pine CCA tr.	14.0	0.476 "	0.048
	Jack pine untreated	0	0.090 "	0.021
	Jack pine CrO_3 tr.	4.8	0.356 "	0.044
Flexural first crack toughness	Red pine untreated	0	706 N.mm	0.0
	Red pine CCA treated	15.1	1056 "	50
Ultimate stress	Red pine untreated	0	0.65 N/mm^2	0.0
	Red pine CCA treated	15.1	0.91 "	0.11
Maximum compression	Jack pine untreated	0	1.07 N/mm^2	0.03
	Jack pine CrO_3 treated	8.8	2.56 "	0.04

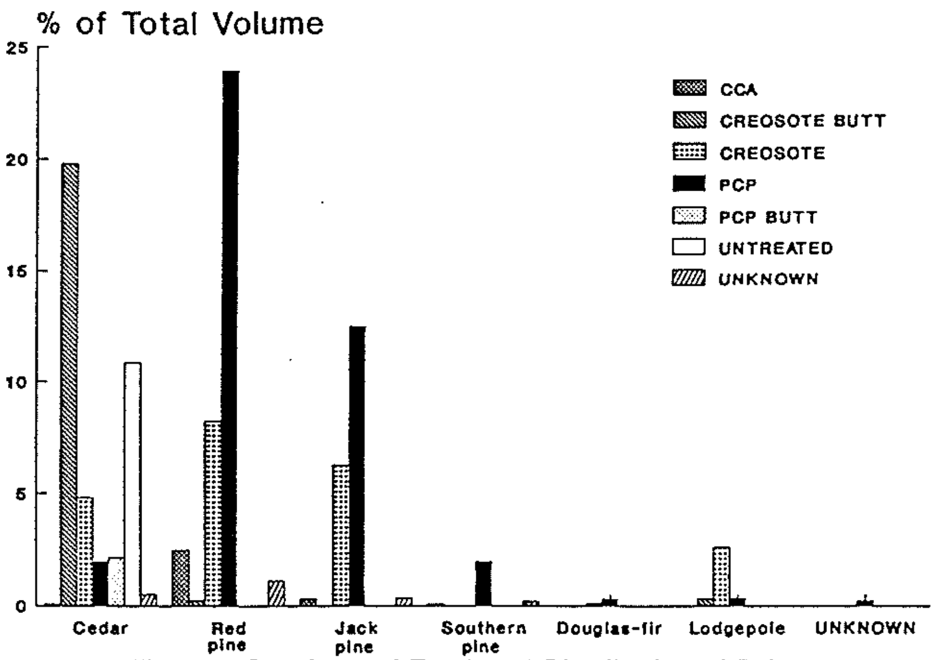

Figure 1: Species and Treatment Distribution of Poles Evaluated (by Volume), (456 pole samples).

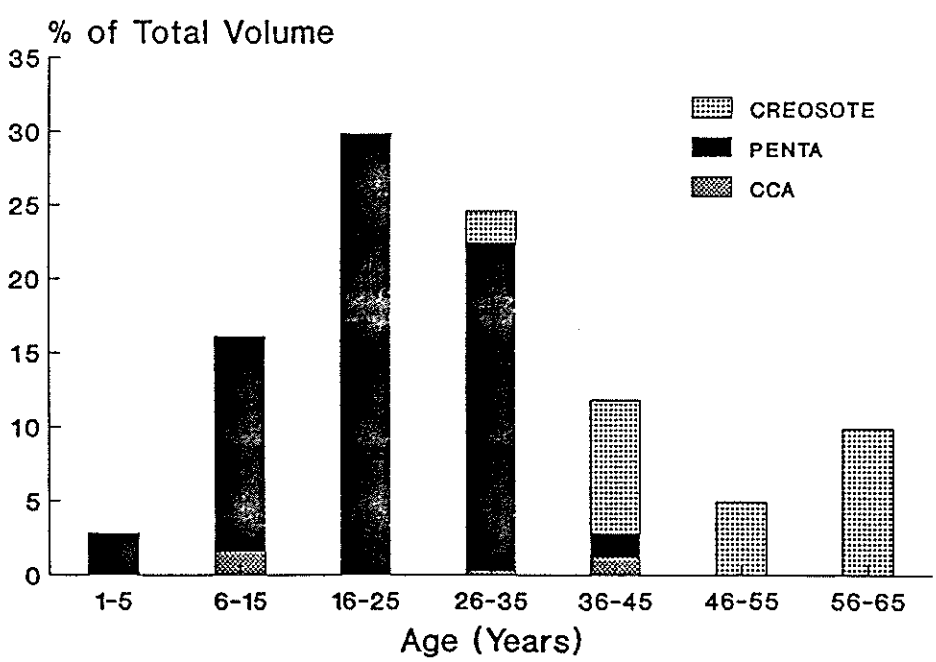

Figure 2: Age Distribution of Poles Removed from Service.

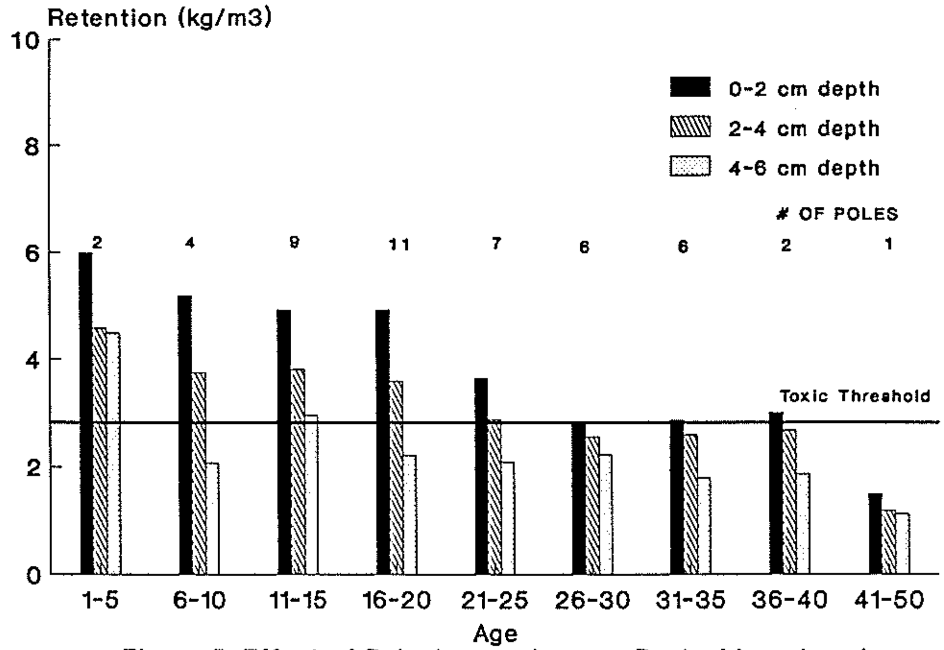

Figure 5: Effect of Pole Age on Average Pentachlorophenol Preservative Gradients for Below Ground Portions of Poles.

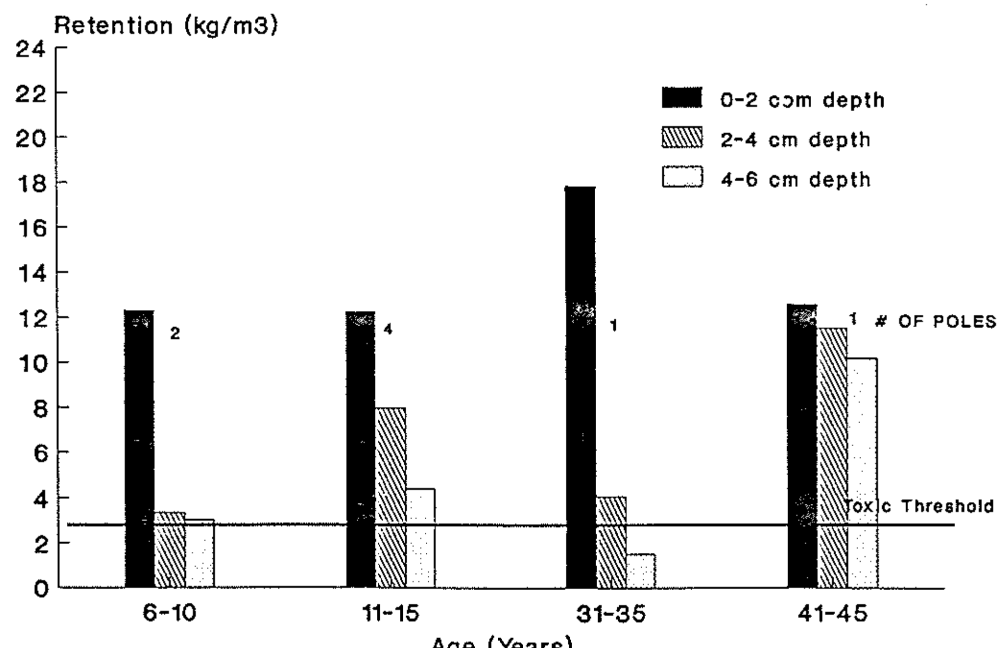

Figure 6: Effect of Pole Age on Average CCA Preservative Gradients for Below Ground Portions of Poles.

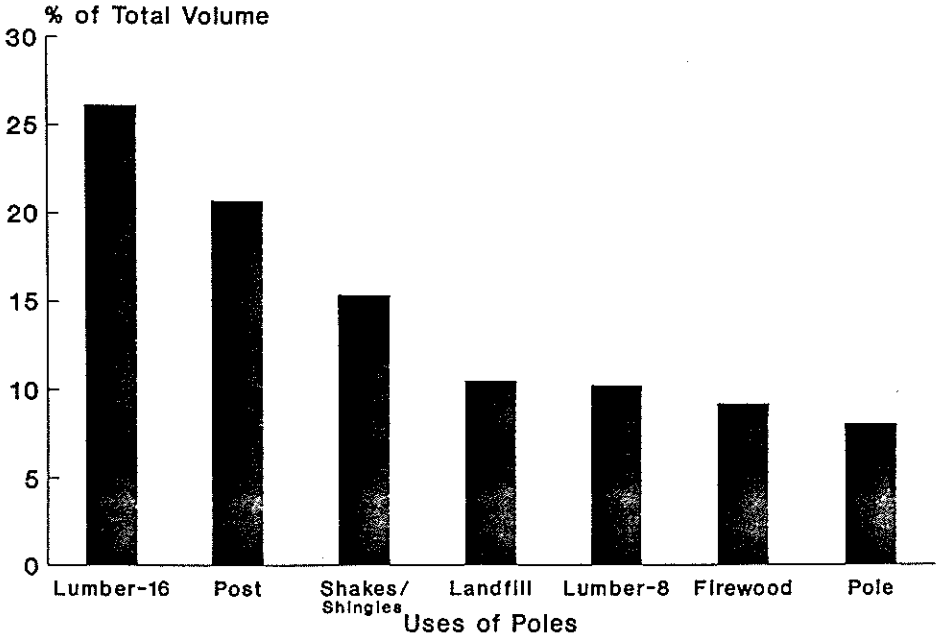

Figure 3: Breakdown of potential End Uses of Poles According to the Criteria of Table 1 (456 pole samples).

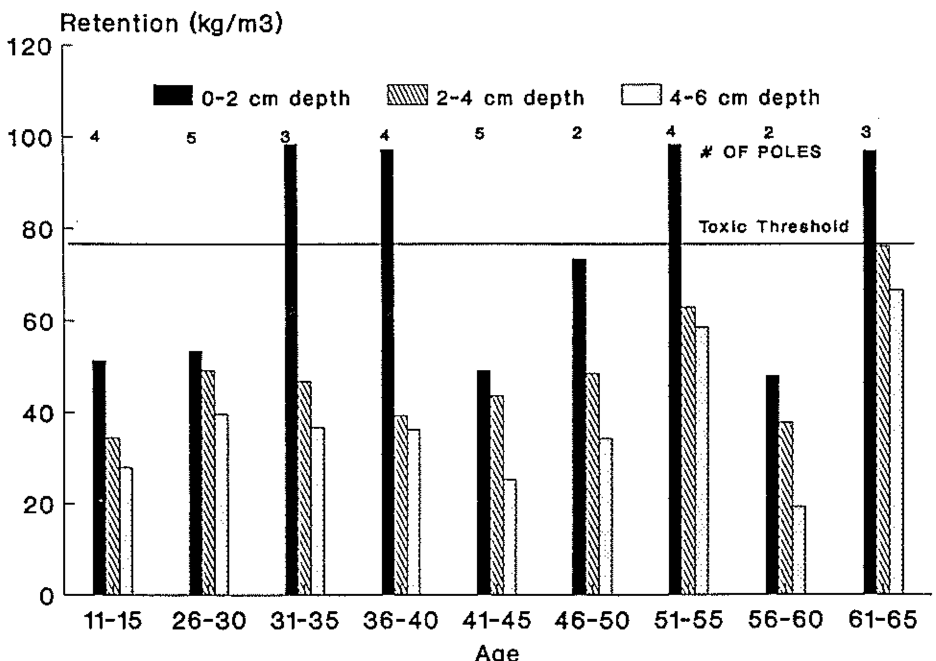

Figure 4: Effect of Pole Age on Creosote Preservative Gradients for the Below Ground Portions of Treated Poles.