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# TCLP EVALUATION OF CCA AND PENTACHLOROPHENOL TREATED WOOD POLES

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## Abstract

Twenty-five out-of-service poles representing two preservatives (chromated copper arsenate (CCA) and pentachlorophenol (PCP)) were evaluated for their Toxicity Characteristic Leaching Procedure (TCLP) leaching properties according to the Ontario regulation 347 as amended by O.Reg. 558/00 procedure. Five CCA treated poles each of red pine and jack pine and five pentachlorophenol treated poles each of southern pine, red pine and jack pine were evaluated. In each case, samples were taken from the entire pole cross-section in three zones: below the ground-line, at mid-point and close to the pole top except for three CCA treated jack pine poles where only the mid-point and below ground zones were available.

For the CCA poles, TCLP leachate concentrations did not exceed the TCLP levels for chromium and were considerably below the listed level (5 mg/L). The probability that any CCA treated pole would fail TCLP limits for chromium is negligible. For arsenic, individual samples often exceeded the TCLP limit of 2.5 mg/L. For red pine, we can expect about 70 % of pole samples to fail the criteria, compared to about 22 % for the thinner sapwood species jack pine. No PCP treated samples had detectable hexachlorobenzene in the leachates and the probability of poles failing based on the HCB criterion is negligible. Similarly, none of the 45 samples evaluated exceeded the 6 mg/L limit for pentachlorophenol. Based on statistical evaluation of the data, it is predicted that 0.3 – 1.6 % of pole population might not meet the criterion. Dioxin/furan measurements were generally much lower than the TCLP limit suggesting that the probability of exceeding the TCLP limit is very low.

These results show that penta poles will meet the TCLP criteria in virtually all cases, and landfill disposal is not a concern or issue. Even though some CCA poles had TCLP arsenic levels above the limit, there is still an exemption for treated wood allowing normal landfill disposal. This has some justification, since poles will normally be disposed of in large pieces which have a low surface area to volume and will leach arsenic at a much lower rate than the particles produced for the TCLP test.

**Keywords:** TCLP, disposal, CCA, PCP, dioxin/furan, hexachlorobenzene

## 1.0 Background

Approximately 200,000 wooden poles are removed from service in Canada each year, mostly from electric utilities and telecommunications companies. Most of these poles are treated with pentachlorophenol in oil (PCP) or chromated copper arsenate (CCA). These poles are generally re-used or land-filled, since incineration is not recommended due to air emissions and contaminants in the ash.

Treated wood removed from service has traditionally been exempted from assessment by leachate toxicity criteria for landfill disposal. However, there is a concern that new Ontario regulation 347 as amended by O.Reg. 558/00 may be applied to treated wood. When leachate tests such as the EPA Toxicity Characteristic Leachate Procedure (TCLP) were applied previously to treated wood (e.g. EPRI 1995 and McNamara 1982), they generally met the concentration criteria in place at that time (PCP 100 mg/L and arsenic or chromium 5 mg/L). However, O.Reg. 558/00 defines lower concentration criteria: 2.5 ppm for arsenic vs 5 ppm in the EPA TCLP procedure; 6 ppm vs 100 ppm for pentachlorophenol; and 0.13 ppm vs 3.0 ppm for hexachlorbenzene. In addition, O.Reg. 558/00 specifies concentrations of dioxin/furan micro-contaminants of pentachlorophenol (1.5 ng/l or ppt or 0.0000015 ppm TEQ), which are not included in the EPA TCLP criteria.

A detailed analysis of TCLP leaching from pentachlorophenol poles was undertaken by EPRI (1995). However, as noted above, the criteria applied at that time were different than now required in Ontario and the wood species evaluated in this test was Southern yellow pine, a species not native to Canada and only occasionally used in Canada. Very few tests have been published on TCLP testing of chromated copper arsenate treated wood (McNamara, 1982). These tests also used different TCLP criteria, different wood species (Southern pine) and wood treated under very different systems to ensure CCA fixation than now used in Canada. Thus it is important to test poles treated with the two preservatives as they come out of service in Canada.

In this study, we evaluated the leaching characteristics of preservative treated poles removed from service from Bell Canada’s operations against these criteria.

## 2.0 Sampling Criteria

### *2.1 Sampling zone in poles*

There are some questions about how TCLP criteria would be applied to poles removed from service. Depending on the wood species, poles typically have a relatively small proportion of wood impregnated with preservative. Winters et al. (1999) showed that PCP concentrations in a new pole are highest at the pole surface and decrease linearly toward the centre of the pole. Concentrations of tetra and penta dioxins appear to migrate to the surface of the pole over time (1 – 34 years). This raises the question of whether test samples should represent the entire pole section or should be from the treated sapwood only. If poles are disposed of as whole pieces, the relative leaching will be low and the grinding of samples required for the TCLP test (particles to pass a 9.5 mm screen) will result in exaggeration of losses and a conservative estimate of its hazard in landfills. It would therefore seem appropriate to cut up the entire pole section, including untreated heartwood for the leachate sample.

For this study, samples were taken from representative cross-sections from different locations on each pole. Three of the jack pine poles had been topped before collection and only the middle and butt zones could be sampled.

### *2.2 Pole sampling*

It is not clear whether decisions on the acceptability of a material for landfill disposal will be based on the average leaching performance, or the performance of individual samples or even on the worst case leaching characteristics of poles removed from service. Thus it was important to test enough samples to have a reasonable estimate of the statistical leaching performance. Statistical analysis based on results of the EPRI (1995) study suggests that a sample size of 5 poles per wood species evaluated would be adequate to confirm with a high degree of confidence whether penta treated poles meet the Ontario TCLP criteria. Considering the CCA levels determined by McNamara (1982) a 5-pole sample should also be adequate for this treatment.

Another factor to consider is the effect of pole age on leaching. Generally, the preservative retention will decrease with pole age and more readily leached components will already be removed. However, it is possible that older CCA treated poles treated with the higher arsenic formulation CCA type B will have higher arsenic leaching properties. For PCP treated poles, prior to 1988, the preservative had an approximate dioxin/furan concentration of 3 mg TEQ/kg. After this date, the pentachlorophenol synthesis process was changed to reduce the dioxin/furan contamination level to about 1 mg TEQ/kg (EPA 2000). Thus older poles could have higher dioxin/furan releases. It was therefore important to include in the study, poles of a range of vintages to determine if these factors are important.

Since sapwood thickness, as well as interaction of wood with preservatives, depends on wood species, both thin sapwood (jack pine) and thick sapwood (red pine and southern pine) pole species were represented in the study.

## 3 Methodology

### *3.1 Sampling Procedure for Treated Distribution Poles*

Five full-length treated jack pine and 5 full length treated red pine, out-of-service ***chromated copper arsenate*** (***CCA) treated poles*** from the inventory returned from the field for disposal to storage sites located in Masson, Quebec and Scarborough, Ontario were sampled. Poles were selected to ensure that they represented the age distribution of the poles removed from service and included some older poles (CCA-A or CCA-B). Five representative age full-length treated Southern pine, jack pine and red pine, out-of-service ***pentachlorophenol (PCP)treated poles*** from the inventory returned from the field for disposal (located in Masson, Quebec and Scarborough, Ontario) were sampled. The sample included some pre-1988 poles (red pine and jack pine).

A 4-inch thick cross-section was cut out of each selected pole from just below the ground line (i.e., the section at 0.3 m below ground surface), from mid-length and from 1 meter from the top. In some jack pine poles, the top sections were not available, presumably due to “topping” during removal and samples were taken from only the butt and approximately mid-length.

Each pole section was sealed in a clean, heavy-mil plastic bag and labeled with a unique sample ID number. For each pole all relevant information was recorded (e.g., sample ID number, wood species, treatment type, service yard where sampled pole was located, age of pole, as determined from brand, other brand information).

### *3.2 Testing and analysis*

The entire cross-section of the pole samples was cut as described by EPRI (1995) to 9 mm cubes using a band-saw. The appropriate mass of a representative sample of the cut wood was extracted with the TCLP leach solution according to the TCLP procedure (20 parts solution to 1 part wood by mass). Leachate was collected in clean polyethylene containers and stored in a refrigerator.

CCA samples were analyzed by ICP spectroscopy at the University of Toronto ANALYST Laboratory. Copper, chromium and arsenic were measured with a precision of ∀ 0.01 ppm. For each pole section, the sapwood content was estimated to determine if the proportion of treated wood in the sample was related to the TCLP results. Also, a sapwood portion of each section was ground to pass a 20 mesh-per-inch screen and compressed in a pellet for analysis of CCA retention by X-ray fluorescence spectroscopy (Oxford Instruments Ltd.).

Pentachlorophenol-treated samples were shipped to Maxxam Analytics Inc. laboratory for analysis by GC-MS: pentachlorophenol (MDL = 0.05mg/L), dioxin/furan (MDL = 0.1 – 0.2 pg/L) and hexachlorobenzene (MDL 2.0 Φg/L).

Based on the average leachate values and their variability (standard deviation), the probabilities of pole samples not meeting the TCLP criteria were estimated assuming that the values were normally distributed using tabulated values for cumulative standard normal distribution (Ostle and Mensing 1975).

## 4 Results and Discussion

The TCLP leachate concentrations for the CCA treated poles are summarized in Figures 1-3 and for the pentachlorophenol treated poles in Figures 4 -5. For the Dioxin/furan analysis, the relative toxicity of the different isomers are considered by converting values to a Toxicity Equivilance Quotient (TEQ) relating the toxicity to that of the most toxic 2,3,7,8-tetrachlorodibenzo(p)dioxin. This was done according to two criteria: NATO Toxicity Equivalence Factors (TEF) and the World Health Organization (WHO) TEF’s.

### *4.1 CCA treated poles*

For all pole samples tested, the copper concentrations were highest of the three CCA components, arsenic values were intermediate and the chromium levels the lowest (Figures 1-3). Under the Ontario Regulation 558/00 (Schedule 4 TCLP levels), copper is not considered and the TCLP concentration limit for chromium is 5 mg/L and for arsenic 2.5 mg/L.

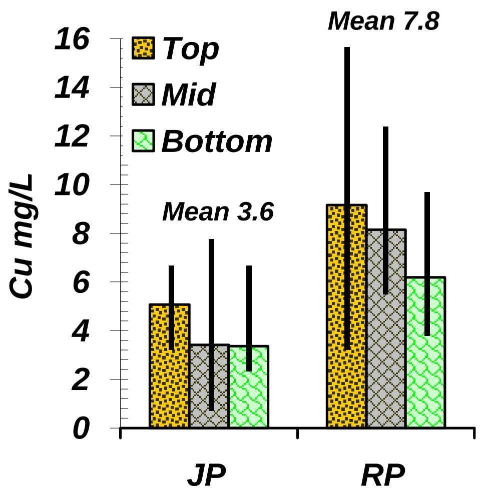


**Figure 1** Average concentration of copper from TCLP test on CCA poles. Vertical lines represent the range of values

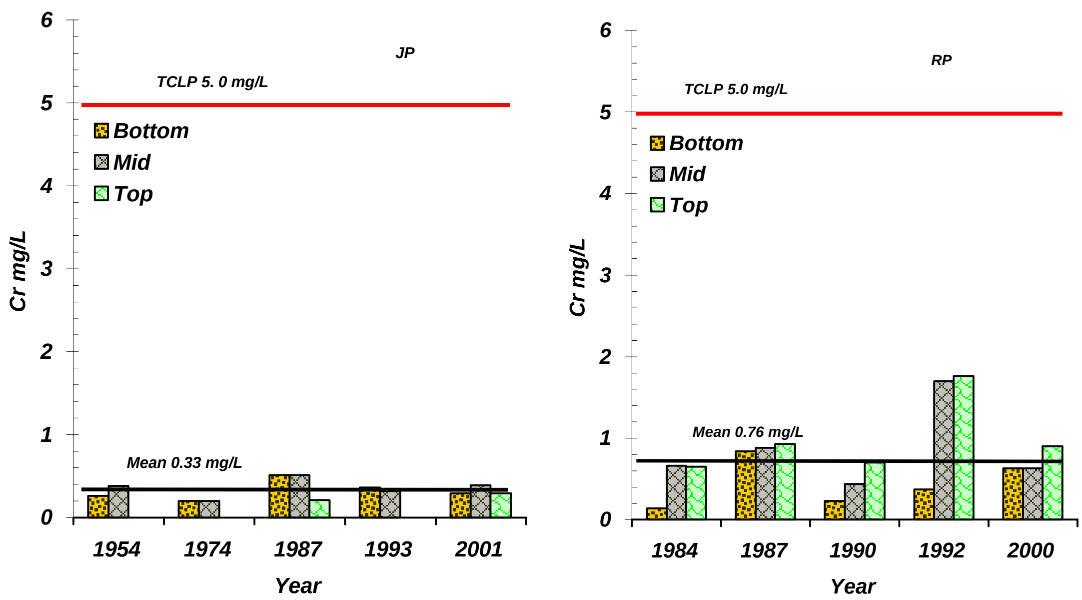


**Figure 2** **A**verage concentration of chromium from TCLP test on CCA poles.

The average concentration of chromium seen in this study was only 0.57mg/L (0.76 for red pine and 0.33 mg/L for jack pine) and the highest level was seen in a 1992 red pine pole top of 1.76 mg/L. It is clear that the chromium concentrations in the leachate will rarely if ever exceed the TCLP criterion. If the leachate concentrations of the pole populations are normally distributed, the probability that the leachate concentration will exceed 2.5 mg/L is less than 0.01 % for red pine and even lower for jack pine (Ostle and Mensing 1975).

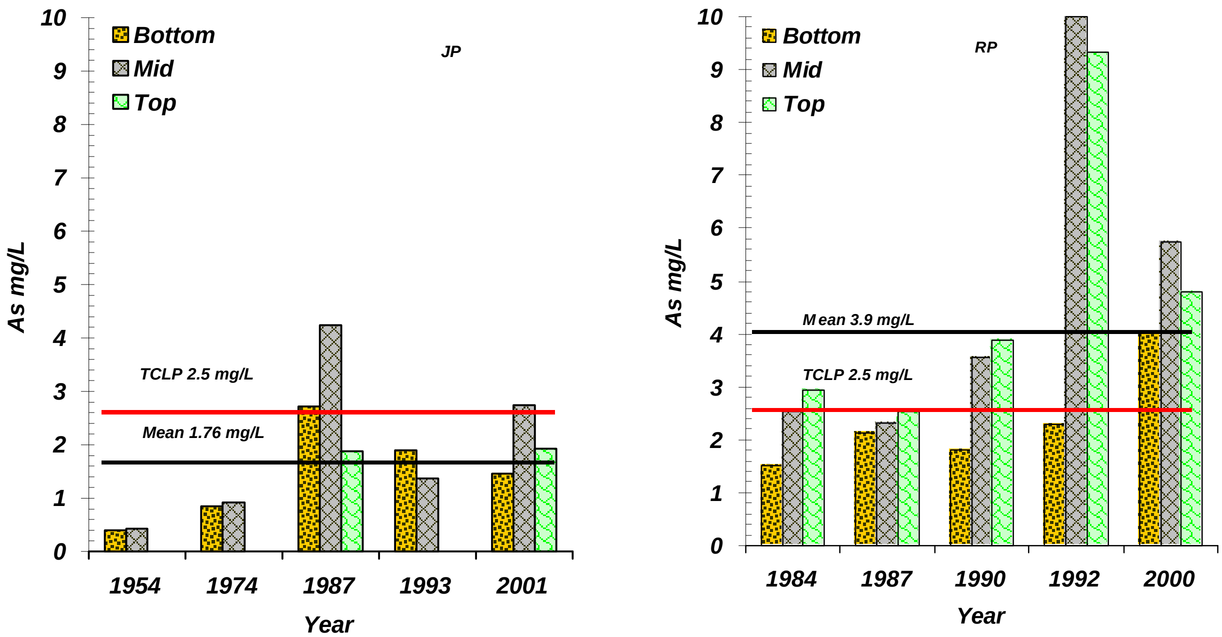


**Figure 3** Average concentration of arsenic from TCLP test on CCA poles.

For arsenic, individual samples often exceeded the TCLP limit of 2.5 mg/L. For red pine, 10 of 15 samples exceeded the limit with an average of 3.96 mg/L and in one pole the leachate concentration approached 10 mg/L. In the thinner sapwood jack pine, the average arsenic concentration was 1.76 with only 3 of 12 samples exceeding the TCLP limit.

For normally distributed populations, based on the measured standard deviations, about 71 % of red pine pole samples would be expected to fail the criterion of 2.5 mg/L. For the EPA level of 5 mg/L about 34 % of the red pine poles would be expected to exceed the criterion. For jack pine, about 22 % of the samples would be expected to fail the 2.5 mg/L criterion compared to about 0.2 % for the 5 mg/L EPA level.

Generally, newer poles had higher TCLP leachate concentrations. Thus, it is advisable for utilities to maintain in use and reuse CCA treated poles as long as possible before committing them to landfills. As a general rule, the butt sections of poles had lower

TCLP concentrations, probably due to proportionally less treated sapwood in this part of the pole (Table 1).

It is clear that within a species, there is no correlation between TCLP levels for arsenic and sapwood contents or retentions (Table 1), although as noted above, there may be a relationship with sapwood content within a pole. The 1992 red pine pole with the highest TCLP levels had an average sapwood content and CCA retention.

***Table 1: Sapwood contents and CCA retentions in sapwood of CCA poles***

| ***Species*** | ***Year*** | ***Position*** | ***% Sapwood*** | ***CCA Ret.*** % | ***% $CrO_3$*** | ***% CuO*** | ***% $As_2O_3$*** | Arsenic ***TCLP*** (ppm) |
|---|---|---|---|---|---|---|---|---|
| ***Rp*** | ***1984*** | ***top*** | *70* | *3.44* | *50.0* | *19.5* | *30.5* | *2.93* |
| | | ***mid*** | *67* | *2.56* | *50.0* | *19.1* | *30.9* | *2.53* |
| | | ***bot*** | *60* | *3.08* | *49.8* | *19.2* | *31.1* | *1.50* |
| ***Rp*** | ***1987*** | ***top*** | *42* | *3.13* | *48.9* | *18.2* | *32.9* | *2.54* |
| | | ***mid*** | *46* | *2.85* | *48.7* | *17.7* | *33.7* | *2.33* |
| | | ***bot*** | *56* | *3.52* | *48.2* | *17.2* | *34.6* | *2.14* |
| ***Rp*** | ***1990*** | ***top*** | *68* | *3.48* | *48.6* | *18.0* | *33.4* | *3.87* |
| | | ***mid*** | *64* | *2.77* | *49.5* | *18.4* | *32.1* | *3.56* |
| | | ***bot*** | *62* | *2.01* | *49.8* | *18.8* | *31.4* | *1.81* |
| ***Rp*** | ***1992*** | ***top*** | *60* | *2.51* | *49.4* | *18.7* | *31.9* | *9.33* |
| | | ***mid*** | *59* | *2.74* | *49.3* | *18.6* | *32.1* | *9.99* |
| | | ***bot*** | *58* | *2.18* | *50.0* | *19.3* | *30.7* | *2.28* |
| ***Rp*** | ***2000*** | ***top*** | *63* | *2.31* | *49.0* | *18.0* | *33.0* | *4.81* |
| | | ***mid*** | *79* | *1.72* | *50.6* | *19.7* | *29.8* | *5.73* |
| | | ***bot*** | *78* | *1.95* | *49.6* | *18.5* | *31.8* | *4.04* |
| ***Jp*** | ***2001*** | ***top*** | *26* | *1.65* | *50.1* | *19.2* | *30.7* | *1.93* |
| | | ***mid*** | *22* | *1.61* | *49.5* | *18.8* | *31.6* | *2.74* |
| | | ***bot*** | *20* | *1.67* | *49.2* | *17.9* | *32.9* | *1.46* |
| ***Jp*** | ***1993*** | ***top*** | *32* | *4.28* | *48.6* | *18.0* | *33.4* | *1.37* |
| | | ***bot*** | *30* | *3.91* | *49.2* | *18.4* | *32.4* | *1.90* |
| ***Jp*** | ***1987*** | ***top*** | *28* | *2.91* | *49.9* | *19.5* | *30.6* | *1.88* |
| | | ***mid*** | *35* | *2.73* | *49.9* | *19.3* | *30.8* | *4.24* |
| | | ***bot*** | *50* | *2.12* | *49.5* | *18.7* | *31.8* | *2.72* |
| ***Jp*** | ***1974*** | ***mid*** | *NA* | | | | | |
| | | ***bot*** | *NA* | | | | | |
| ***Jp*** | ***1954*** | ***mid*** | *NA* | | | | | |
| | | ***bot*** | *NA* | | | | | |

NA not analyzed

### *4.2 Pentachlorophenol treated poles*

For all species and samples, the hexachlorobenzene (HCB) concentration in the TCLP leachate was below the detection limit of 2 :g/L (2 ppb) compared to the TCLP criterion of 130 :g/L. Thus, HCB will effectively never exceed the TCLP limits in pentachlorophenol treated poles.

Pentachlorophenol concentrations in the leachate ranged from 0.3 to 5.5 mg/L compared to the TCLP limit of 6 mg/L, i.e. none of the 45 samples analyzed exceeded the TCLP limit (Figure 4). The average (standard deviation) values were 2.03 (1.44) for southern pine, 1.98 (1.75) for red pine and 2.30 (1.73) for jack pine. The expected lower levels from thin sapwood jack pine and higher values for thick sapwood southern pine were not observed.

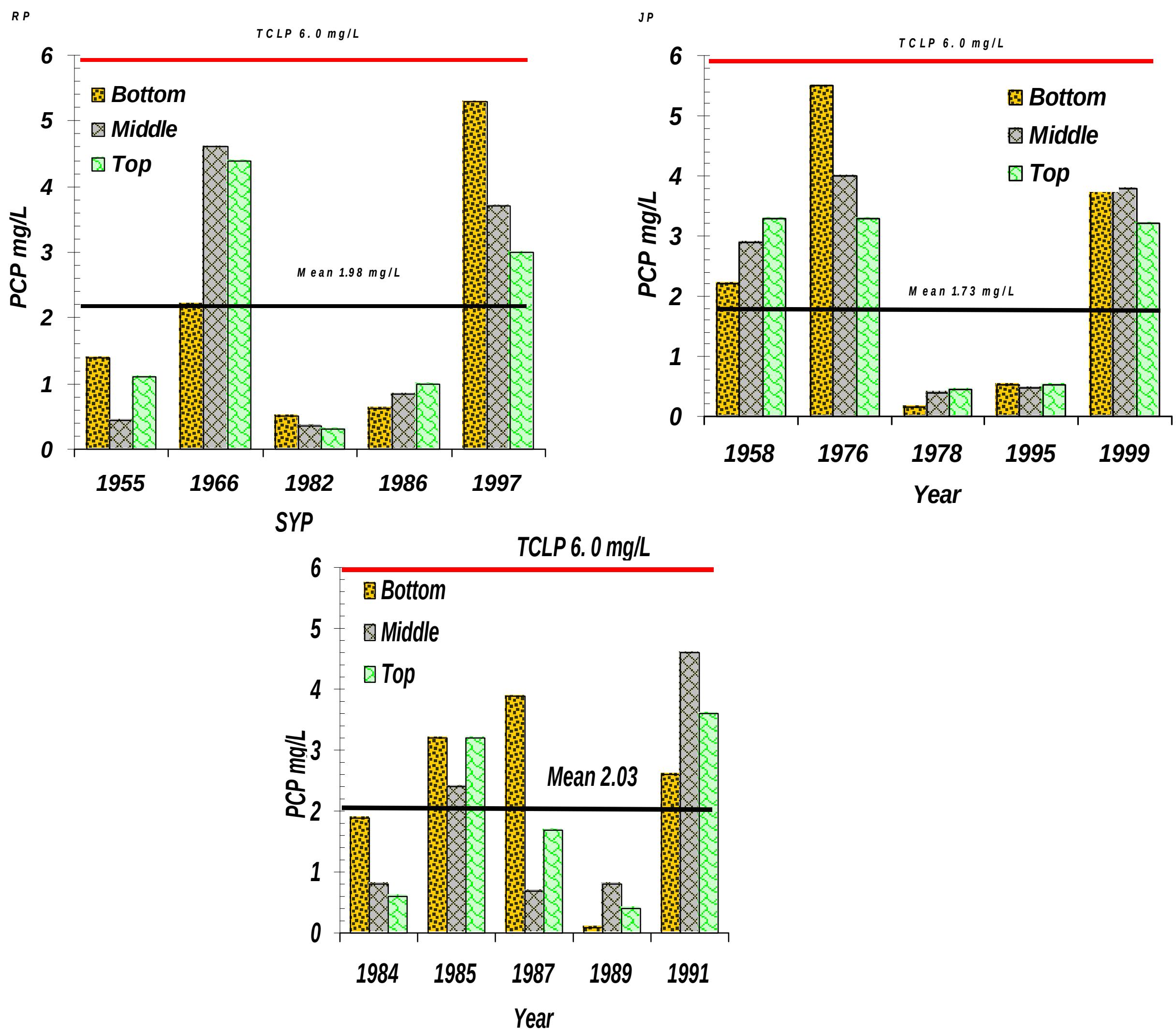


**Figure 4** Average concentration of PCP from TCLP test on PCP poles.

There was no consistent trend in pentachlorophenol concentration in leachate with height in the pole. EPRI (1995) found that leachate concentrations were not very sensitive to location in the pole (i.e., top, middle or butt; entire cross-section or outer 1 or 2.5 inch layer). Similarly there was no consistent trend with pole age. Assuming normal distributions for the TCLP concentrations for each species, the expected number of pole samples that could fail to meet the 6.0 mg/L TCLP criterion for pentachlorophenol is 0.3 % for southern pine, 1.1 % for red pine and 1.6 % for jack pine. Using the EPA limit of 100 mg/L all poles would pass the TCLP limit.

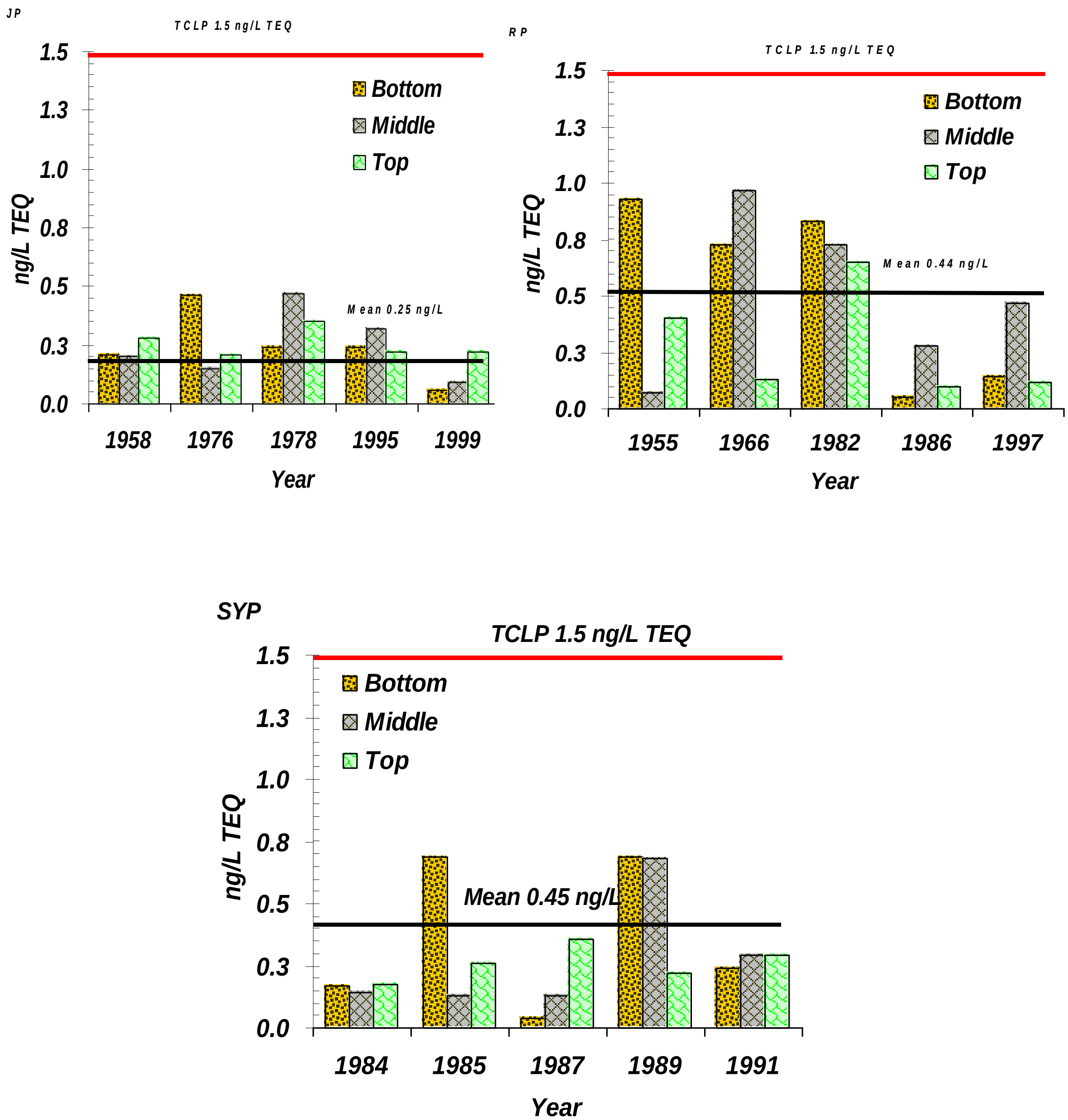


**Figure 5** Average concentration of dioxin/furan TEQ from TCLP test (PCP poles)

Only one of the 45 dioxin/furan measurements came close to the TCLP limit of 1.5 ng/L TEQ. This sample (butt of 1985 southern pine) exceeded the value (2.93 ng/L) as a result of high measured octachlorodibenzo(p)dioxin and 1,2,3,4,6,7,8-heptachloro-dibenzo(p)dioxin. This value was more than 100 times greater than the values for the mid-point and top of the same pole which had similar PCP levels in the leachate as the butt sample and it was suspected that it is an erroneous value. The TCLP leaching process was repeated on samples cut from the same butt section and a second pole (Pole 16 top) and the leachate sent for analysis. This re-analysis confirmed that there was likely an error in the initial reading, as the TEQ on the re-measurement was 0.69/0.51 (NATO/WHO) well below the TCLP limit. With this new value, the average leachate concentrations are 0.30/0.22 (NATO/WHO) ng/L TEQ. Using these values, the probability of a pentachlorophenol treated pole of any species tested failing to meet the dioxin/furan TEQ level is less than 0.01 %.

Generally, leachate from the thin sapwood jack pine had lowest and least variable dioxin/furan TEQ concentrations. There was little difference between red pine and southern pine. There was no consistent trend in dioxin/furan concentration with height in the pole. Generally the highest dioxin/furan values were in the older poles, most likely due to the higher levels of contaminants in pentachlorophenol solutions from these vintages. However, Cui and Ruddick (2000) found lower D/F levels in the assay zone of a 1956 vintage jack pine pole compared to a 1979 vintage pole suggesting that this effect may be balanced in older poles by significant depletion of all PCP components by bleeding.

## 5 Summary and Conclusions

***CCA treated poles***

1. Thin sapwood jack pine had lower TCLP levels than thick sapwood red pine
2. TCLP leachate concentrations did not exceed the TCLP levels for chromium and are considerably below the listed level (5 mg/L). The probability that any CCA treated pole would fail TCLP limits for chromium is negligible.
3. For arsenic, individual samples often exceeded the TCLP limit of 2.5 mg/L. For red pine, we can expect about 70 % of pole samples to fail the criteria, compared to about 20 % for the thinner sapwood jack pine.
4. TCLP concentrations were generally higher at the pole tops and at mid-height (higher proportion of sapwood) than at the butts.
5. As a general rule, older poles had lower leachate concentrations than newer poles, although there were exceptions with some specific poles having anomalous high leaching.

***Pentachlorophenol treated poles***

6. No PCP treated samples had detectable hexachlorobenzene in the leachates and the probability of poles failing based on the HCB criterion is negligible.
7. None of the 45 samples evaluated exceeded the 6 mg/L limit for pentachlorophenol. Based on statistical evaluation of the data, it is predicted that

0.3 – 1.6 % of pole population might not meet the criterion, with southern pine poles having the highest probability of meeting the criterion (99.7 %).

8. Only one of 45 dioxin/furan measurements exceeded the TCLP limit. All other measurements were much lower than the TCLP limit suggesting that the probability of exceeding the TCLP limit is very low. When this sample was re-tested, the level was below the TCLP limit and using the re-test value, the probability of not meeting the dioxin/furan TEQ limit was less than 0.01 % for all pole species evaluated.
9. Thin sapwood jack pine had lower TEQ values and lower variation in the values indicating that the probability of exceeding the TCLP limits for dioxin/furan TEQ is negligible for this species.
10. There was no consistent trend in pentachlorophenol concentrations with the age of the pole or location in the pole. However, dioxin/furan levels were generally higher in older poles.

## Recommendations

1. For both preservatives, poles should be maintained in service as long as possible through inspection and remedial treatment programs. Poles removed from service should be inspected and evaluated for their potential for re-use in a different location. Recycling opportunities such as lumber, posts and in the case of PCP poles, energy recovery should also be sought and promoted. These approaches not only minimize potential load on landfills but extend the exposure time of the treated wood, reducing the amounts of contaminants in the leachate.
2. These results show that PCP poles will meet the TCLP criteria in virtually all cases, and landfill disposal is not a concern or issue. Even though some CCA poles had TCLP arsenic levels above the limit, there is still an exemption for treated wood allowing normal landfill disposal. This has some justification, since poles will normally be disposed of in large pieces which have a low surface area to volume and will leach arsenic at a much lower rate than the particles produced for the TCLP test.

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