A compilation of anti-sapstain chemical leaching studies, stormwater runoff data and covered storage time

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ENVIRONMENT CANADA

COMMERCIAL CHEMICALS DIVISION

ENVIRONMENTAL PROTECTION BRANCH

PACIFIC AND YUKON REGION

A COMPILATION OF ANTI-SAPSTAIN CHEMICAL LEACHING STUDIES, STORMWATER RUNOFF DATA AND COVERED STORAGE TIME

BY

AUDREY WAGENAAR

JANUARY 18, 1994

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Summary

The leaching studies reviewed in this report show that 30 minutes of covered storage time is not sufficient for the stormwater runoff, from high pressure sprayed lumber treated with NP-1, Timbercote or F-2, to meet B.C. Environment (BCE) stormwater limits for DDAC (700 ppb) and IPBC (120 ppb).

The stormwater runoff and covered storage data assembled in this report (Figure 1) show that 30 min of covered storage time appears to be adequate to meet BCE stormwater limits for DDAC and IPBC. There is a degree of uncertainty in interpreting the chemical compliance results due to the consistently high percentage of samples which are shown to be toxic. The cause of the toxicity remains unknown and further study has been recommended to isolate the specific factors which are responsible.

Figure 1-A Compilation of Stormwater Runoff and Covered Storage Time Data for the Lower Mainland and Vancouver Island.

Area	Covered Storage Time (min)	NP-1 Compliance		Timbercote Compliance	
		# of samples	% of samples	# of samples	% of samples
Lower Mainland	> 30	44/48	92%	9/10	90%
	< 30	11/12	92%	3/3	100%
Vancouver Island	30	32/37	86%	4/4	100%
	<30	19/24	79%	-	-

Leaching of Anti-sapstain Chemicals into Stormwater Runoff

1) Introduction

In the first draft of the revised recommendation document for Anti-sapstain Wood Protection (1993), a two-hour optimal covered storage time for treated (i.e. dipped as well as low and high pressure sprayed) lumber is suggested. The reference which substantiates this statement is based on a personal communication with Peter Krahn. Members of the Sapstain Forum indicated to Environment Canada that such an important recommendation must not be based solely on the two references because i) a personal communication is not a suitable reference and ii) the actual stormwater data must be considered.

Before making a final recommendation on covered storage time in the recommendation document, Environment Canada agreed to conduct a thorough review of all available leaching studies and stormwater reports (see Section 5), and data on covered storage time at the mills.

2) Leaching Studies of Anti-sapstain Chemicals Used in British Columbia

In the past, anti-sapstain chemicals such as chlorophenates (TTCP/PCP), TCMTB, Ecobrite and Cu-8 were widely used in B.C. In 1993, the two most widely used anti-sapstain chemicals in B.C. are DDAC and/or IPBC based formulations, namely NP-1 (26 mills), Timbercote II/Timbercote 2000 (12 mills), and F2 (7 mills). In 1993, Ecobrite, Rodewod 200EC and TCMTB forumulations were used in six mills, three mills, and one mill respectively.

B.C. Environment's (BCE) stormwater limits for DDAC, IPBC, Cu-8, TCMTB, and TTCP/PCP are 700, 120, 15, 6, and 6 ug/L respectively. In addition to the individual chemical concentration limits, the stormwater must not be toxic to fish. The active ingredients (ai) in Ecobrite and Rodewod are presently not regulated by BCE. The 96-hr LC_{50} of sodium borate to fish (minnows) is about 3,000 ppm.[1]

2.1. NP-1 Leaching Study

The two ai in NP-1 are DDAC (64.8% w/w) and IPBC (7.6% w/w). Ethyl alcohol (8.1% w/w), dimethyl sulphoxide (2.8% w/w), dipropylene glycol and super high flash naptha (containing 1,2,4-trimethylbenzene, xylene and cumene) are some of the other ingredients in NP-1. NP-1 is miscible in water and the manufacturer's recommended ai retention on wood is 80 $\mu g/cm^2$.

The only NP-1 leaching study (3) was conducted by MacMillan Bloedel (MB). The Standard

[1]California State Water Resources Control Board, Water Quality Criteria, 1963, pg.262

Leaching Protocol developed by Environment Canada (6) was followed by MB. In the study, treated (high pressure sprayed) packages of lumber were exposed to the first of eight leaching cycles (each cycle is five hours in duration and separated by 24 hr, during which time the lumber packages are covered with a tarpaulin) either 30 minutes or 24 hours after anti-sapstain treatment. Since it took 60 to 90 minutes to set up the test structures, the 30-minute covered storage time is in reality 60 to 90 minutes. Control packages were also subjected to the same leaching cycles.

DDAC/IPBC analyses were carried out to determine the retention on the treated lumber and the concentration in the leachate. DDAC was analyzed by a colorimetric method developed by MB Research. IPBC was analyzed by a HPLC method developed by Environment Canada and later adopted for general use by BCE. DDAC in the leachate of the treated packages from the first four cycles was also analyzed by Environment Canada, using a GC method. Resin acid analyses and 96-hr LC_{50} bioassay tests were also conducted on the leachate from the control and treated packages. A dilution formula (6: paragraph 4.1) was used to calculate the corresponding stormwater toxicity and concentration of DDAC/IPBC. The formula takes into account the mixture of ages of the treated lumber in the storage yard as well as the average dilution that occurs before entering the stormwater drain.

The average ai retention on the wood was found to be 150 $\mu g/cm^2$, which is almost twice the target amount. The leachate results show that DDAC leached at a much higher rate in the first two cycles than in the later cycles. DDAC also leached at a much higher rate in the first two cycles from the treated packages which were only subjected to 60 to 90 minutes of covered storage than from treated packages subjected to 24 hours of covered storage. After the first two cycles, DDAC leaching rates for all treated packages were fairly similar. IPBC leaching rate was quite similar for all cycles and does not appear to be dependent on the covered storage time of the treated lumber. Based on the dilution formula, the calculated stormwater runoff concentrations ranges are listed below:

Figure 2 - DDAC/IPBC Calculated Stormwater Concentrations.

Covered Storage Time	60-90 minutes	24 hr
DDAC (ppb)	114-663	108-582
IPBC (ppb)	57-348	70-339

The leachate from the untreated packages was less toxic than that from treated packages. Based on the same dilution formula, the calculated stormwater bioassay test results would be non-toxic. Resin acid concentration in leachate from treated packages were lower than that from the control packages. In most cases, for both the treated and control packages, resin acid concentrations in the leachate were lower for packages which had 24 hours of covered storage than packages which had 60 to 90 minutes of covered storage.

2.2 Timbercote Leaching Study

Timbercote II is a DDAC based formulation which contains DDAC (20% w/w) as its ai in a vinyl acetate/water (76.7% w/w) carrier. Timbercote 2000 contains 28% DDAC and correspondingly less of the carrier than Timbercote II. The carrier is said to encapsulate the ai to form a spherical molecular structure which is supposed to aid in penetration of the chemical into the wood as well as forming a physical barrier so that the ai is not easily washed off from the treated lumber by rainfall. Both Timbercote formulations are dispersable in water and target DDAC retention on wood is 100 $\mu g/cm^2$.

The only leaching study conducted on Timbercote was undertaken by Environment Canada (5), using the Standard Leaching Protocol (6). In this study, Timbercote II high pressure sprayed Douglas Fir lumber was allowed to stay under covered storage for three days prior to the first leaching cycle. DDAC analyses were performed using the Modified Lonza Standard Analytical Method NR-171 because Environment Canada's GC method was still under development at the time. The retention of DDAC on the treated lumber was not analyzed. Resin Acids in the leachate from both treated and untreated lumber were also analyzed in an attempt to determine the effect of resin acids on the toxicity of the stormwater runoff. Bioassay samples were analyzed for the fourth and seventh leaching cycles.

DDAC was not found in the leachate from the untreated lumber packages. The leaching cycles showed higher DDAC concentrations in the first five cycles (ranging from 73.2 ppm in the first cycle to 9.5 ppm in the fifth cycle) than in the last two cycles (5.8 ppm and 6.1 ppm in the sixth and seventh cycle respectively). Test results on the leachate from the treated packages indicate that most of the DDAC was leached out after five leaching cycles which is equivalent to 76 mm of rainfall.

The predicted yard runoff using the dilution formula would range from 625 ppb to 2,397 ppb with an average of 959 ppb (depending on the lumber inventory and the application rate of anti-sapstain chemical). The mill where the study took place would have a predicted stormwater runoff value of 843 ppb (total absorption) and 734 ppb (average absorption), as a result of its average wood inventory and area of treated lumber storage.

The bioassay sample taken for the fourth leaching cycle was found to have a DDAC concentration of 30,300 ppb which is 43 times the reported LC_{50} value. After the seventh leaching cycle, the LC_{50} was 14.3 % which corresponds to a DDAC concentration of 6,100 ppb. The control sample for the seventh leaching cycle did not contain detectable amounts of DDAC but showed an LC_{50}value of 10%. Stormwater dilutions have not been calculated for these bioassay results as an insufficient number of samples were collected.

The contribution of resin acids to leachate toxicity can not be determined due to problems with the resin acid analytical method used and the small number of samples that were taken. This study does not take into account degradation of DDAC (on the lumber surface) by ultraviolet light or its affinity for soil. In reality, such factors may actually lower the amount of chemical found in the stormwater runoff.

2.3 F-2 Leaching Study

F-2 contains DDAC (11.4% w/w) and sodium borate (16.8% w/w) as its ai. The ratio of DDAC to sodium borate in the F-2 formulation is 1:1.5. DDAC is toxic to mould and fungi while the sodium borate causes the wood surface to become unsuitable for mould growth. F-2 is water soluble and its target ai retention on wood is 230 $\mu g/cm^2$.

The only F-2 leaching study (8) was conducted by Forintek Canada Corp. for Walker Brothers. The Standard Leaching Protocol (6) was not developed at the time of the F-2 leaching study. The study compared the leaching from F-2 high pressure sprayed lumber packages that had covered storage time of 30 minutes and 24 hours prior to the start of the first leaching cycle. DDAC concentrations in the leachate were analyzed by using a modified version the Lonza Standard Analytical Method "Colorimetric Determination of PPM Levels of Didecyldimethylammonium Chloride in Rodent Chow". Boron Analyses were conducted by an ICP spectrophotometric method. Sodium borate is determined by the percentage of boron in the sample. Resin acid analyses and fish toxicity tests were not conducted on the leachate.

The method used to calculate the predicted mill stormwater concentrations was slightly different than the dilution formula used in the Standard Leaching Protocol (6). The range of concentration of antisapstain chemicals in the mill stormwater could not be determined using the Standard Leaching Protocol as the level of rainfall applied was much higher (132 mm in 24 hours) than that recommended in the standard protocol (16 leaching cycles per month at a rate of 15mm per day with a target intensity of 3mm per day). In the F-2 leaching study, the predicted stormwater concentrations were determined by applying a reduction factor of one tenth to the DDAC and boron concentrations in the leachate from individual lumber packages. The reduction value depends on the number of packages stored in the mill yard.

The prediced DDAC/boron stormwater concentrations were then compared to rainbow trout 96-hr LC_{50} bioassay values supplied by the USEPA: 2.81 (1.80-5.60) ppm for DDAC, 5-3000 ppm for boron in fresh water and 19-90 ppm for boron in salt water. A check on the USEPA data indicates that the 2.81 ppm 96-hr LC_{50} value for DDAC is based on a 1980 bioassay test on a technical formulation with unknown concentrations of ai. As such, the conclusions reached by the authors of the F-2 leaching study have to be adjusted to reflect the 96-hr LC_{50} DDAC value that was reported by Environment Canada in 1988 (i.e. 700 ppb).

With 30 minutes of covered storage, DDAC concentrations in leachate fell from 48 ppm initially to <10 ppm after 12 hours of rainfall, which is equivalent to 66 mm of rain. DDAC concentration dropped to 6 ppm after 24 hours of rainfall (132 mm rain). The corresponding sodium borate concentrations taken at the same intervals were 912 ppm (initially), 36 ppm (after 12 hours) and 18 ppm after 48 hours.

With 24 hours of covered storage, the initial DDAC concentration in leachate was reduced to

15 ppm. However, the final (after the 24-hour leaching cycle) DDAC concentration was similar to that of the uncovered wood package. Sodium borate concentrtion in leachate were as follows: 292 ppm (initially), 53 ppm (12 hours) and 30 ppm (24 hours).

The ratio of DDAC to sodium borate in leachate after 30 minutes of precipitation was 1:18. This is to be expected as DDAC binds relatively stronger to wood in comparison to sodium borate, which is known to have a high leachability from wood. After 48 hours, the ratio dropped to 1:3 as the remaining sodium borates either diffused into the wood or were completely washed away from the surface layer of the wood.

Based on the correct fish toxicity value for DDAC, the predicted DDAC stormwater concentration for packages with 30 minutes covered storage time would reach the 96-hr LC_{50} value (700 ppb) after 21 hours of rainfall. Lumber that had a covered storage time of 24 hours, would result in a predicted DDAC stormwater concentration equal to 700 ppb after 39 hours of rainfall. The predicted stormwater sodium borate concentrations for packages with either 30 minutes or 24 hours covered storage time would not be expected to be toxic to fish.

2.4 Ecobrite Leaching Study

Ecobrite contains disodium tetraborate decahydrate (4.0% w/w) and sodium carbonate (20% w/w) as its ai. Ecobrite is the least toxic anti-sapstain formulations currently available. It does not kill mold and fungi but acts as a barrier between the mold/fungi and the lumber which it uses as a food source.

The only Ecobrite leaching study was conducted by Diachem Industries Ltd. as a portion of an Ecobrite Progress Report (11). It did not, however, correlate leaching with covered storage time. Two 5-day periods of heavy rainfall were simulated. Rainfall was collected on the top of the test structure and leachate was collected underneath the test structure. The pH was measured for both sprinkler water (pH 6.8) and the leachate (pH 7.3-7.5). Based on the pH values obtained, it was concluded that Ecobrite was well retained onto the wood as its pH is 10.5. Trace amounts of chemicals were detected in the last three measurements of the leachate, however, concentrations were not specified. Resin acid analysis and bioassay tests were not conducted on the leachate. The 96-hr LC_{50} Bioassay value given in this report is 22,300 ppm. This value , however, was determined using a neutralized solution of Ecobrite. This does not accurately reflect the situation in the stormwater runoff and, therefore, Environment Canada conducted a bioassay test on a non-neutralized solution of Ecobrite (24% ai). The 96-hr LC_{50} value obtained was 502 ppm and this is a more appropriate value to use for the determination of stormwater runoff toxicity.

2.5 Other Anti-sapstain Chemicals

There are several other anti-sapstain chemicals such as chlorophenols, Rodewood 200EC, Cu-8 and TCMTB which are used very infrequently in British Columbia and were, therefore, not included in this review of leaching studies.

3) Stormwater Runoff and Covered Storage Time Data for Mills in the Lower Mainland and Vancouver Island

3.1 Lower Mainland

The majority of the data for the Lower Mainland were obtained from an Envirochem Study (1). Additional data were obtained from Dave Robertson (582-5307) of BCE in Surrey. The data obtained are summarized in Figure 3. DDAC and IPBC were analyzed using the methods developed by B.C. Research. For the most part, 30 min covered storage time seems sufficient for compliance with the BCE stormwater limits for DDAC and IPBC. This only applies when a high pressure spray system is used to treat the lumber. Dip treatment of the lumber requires a longer drying period as the wood becomes very wet and the chemical can become trapped within the lumber bundles. The Lower Mainland mills in this study that used the dip treatment method are no longer operational or are using a non-chemical method of anti-sapstain protection.

There are some anomalies to the general statement that 30-min covered storage time is adequate as there are a few mills with covered storage times of > 30 min that do not comply with the stormwater limits and there are also a few cases of mills where the lumber is covered for < 30 min which do comply with the regulations. The Envirochem Study indicates that only two out of nineteen mills were in noncompliance with the DDAC requirements and three out of eleven were in noncompliance with the IPBC requirements. From the data in Figure 3, mills with > 30 min covered storage time were able to meet chemical compliance 92% (44/48 samples) using NP-1 and 90% (9/10 samples) of the time with Timbercote. For covered storage times of < 30 min, mills using NP-1 showed 92% (11/12 samples) chemical compliance and mills using Timbercote showed 100% (3/3 samples) chemical compliance. There is very little correlation between toxicity and DDAC/IPBC compliance as 45.8 % of the samples failed the 96-hr LC_{50} bioassay test. The only correlation occurs at high chemical values. When DDAC concentrations exceed the BCE limit, the result is a toxic discharge from the stormwater sewer. If, however, IPBC concentrations exceed the BCE limit the result is not necessarily toxic, unless it is coupled

Figure 3-Lower Mainland Anti-sapstain Chemical Stormwater Runoff Results Correlated with Covered Storage Time.

Mill	Anti-Sapstain Chemical Used	DDAC (ppb)	IPBC (ppb)	96 hr Bioassay	Dip or Spray Treated Lumber	Covered Storage time(hr)			
						< 0.5	> 0.5	2.5	> 2.5
Canadian Forest Products-Eburne	NP-1	39 210 110	<10 <10 <10	61.90% N.T N.T	High Pressure Spray		P,S		
Doman Forest Products-New westminster	NP-1	**660** 67	**370** 110	15.80% 55.40%	High Pressure Spray	X			
Doman Forest Products-Vancouver	NP-1	<10 220 36	<10 24 27	N.T. N.T. N.T.	High Pressure Spray		P,T		S
Elkwood Specialty Products	- (TCTMB)	350	<10	59.50%	Dip				X
Fletcher Challenge-Boston Bar	TMBRCT	63 19	- -	N.T. N.T.	Spray		X		
International Forest Products-Bay Lumber	NP-1	140 130	33 <10	28.60% 40.00%	High Pressure Spray		P,S,T		
International Forest Products-Fraser Mills	NP-1	110 56	<10 20	N.T. 50.20%	High Pressure Spray		P,S		
International Forest Products-Mackenzie-Seizai	NP-1	340 100 150 <10	<10 <10 <10 <10	35.90% 25.00% 20.30% 38.20%	High Pressure Spray		S		P
International Forest Products-Pioneer Division	(-) was NP-1	**1100**	**140**	14.40%	Dip and Spray		Spray		Dip
International Forest Products-Western Whitewood	NP-1	450 480 220 220 87	87 32 44 23 64	N.T. N.T. 36.10% N.T. N.T.	High Pressure Spray		S		

* **bold** print indicates chemical noncompliance with the B.C. Environment Stormwater Runoff Limits
P= planer, S=sawmill, T=timberdeck, Tr=transverse spraybox, L=linear spraybox, A=mill "A", B=mill "B", D=mill "D", N.T.=non toxic, X=✓

Figure 3(cont)-Lower Mainland Anti-sapstain Chemical Stormwater Runoff Data Correlated with Covered Storage Time.

Mill	Anti-Sapstain Chemical Used	DDAC (ppb)	IPBC (ppb)	96 hr Bioassay	Dip or Spray Treated Lumber	Covered Storage time(hr)			
						< 0.5	> 0.5	2.5	> 2.5
MacMillan Bloedel-Powell River	NP-1	55 <10 60 <10	10 <10 <10 <10	70.00% N.T. N.T. N.T.	High Pressure Spray	S,T			
MJS Sawmills-Surrey	(-) was TMBRCT	12	-	N.T.	Dip	X			
Pt. Mann Remanufacturing -Coquitlam	F-2	<10 <10	- -	N.T. N.T.	High Pressure Spray	X			
S&R Sawmills-Surrey	NP-1	200 250 22 67	150 200 50 10	N.T. N.T. 18.70% N.T.	High Pressure Spray		A,B ,P, D		
Sawarne Lumber-Mitchell Island	F-2	120 11	- -	N.T. N.T.	High Pressure Spray		X		
Stag Lumber-Surrey	TMBRCT II	33 54	- -	70.10% 86.50%	Spray	T			S
Terminal Forest Products-Mainland Sawmills	TMBRCT 2000	1500	-	32.00%	High Pressure Spray				Tr,L
Terminal Forest Products-Terminal Sawmills	NP-1, TMBRCT 2000	35 37 38	- - -	N.T. N.T. 60.20%	High Pressure Spray		X		
Weldwood-Squamish	TMBRCT	47 160 490 130	- - - -	20.90% N.T. 35.90% 34.60%	Spray		S,P, T		

with a noncompliance DDAC discharge. There are many possible explanations for the bioassay noncompliance which include: i) the presence of resin acids and other wood extracts, ii) hydrocarbons (oil and grease) arising from the machinery used to move the lumber in the storage yard, iii) additives or emulsifiers used in the anti-sapstain formulation, iv) residual amount of previously used highly toxic anti-sapstain chemicals v) metals in the stormwater runoff, vi) the presence of undetected DDAC/IPBC, and vii) DDAC/IPBC degradation products.

The stormwater samples taken were also analyzed for total inorganic carbon and total organic carbon as it was expected that organic compounds such as resin acids and hydrocarbons would be identified, thereby, offering an explanation as to why a discrepancy occurs between the DDAC/IPBC compliance and bioassay results. There is no evident relationship between the total organic carbon results, the bioassay results and the chemical concentrations found. It is possible that there are still amounts of previously used anti-sapstain chemicals such as chlorophenols which are highly toxic. Analysis of residual chemicals were not carried out. There is also little information regarding leaching rates and toxicities of the additives and emulsifiers which are incorporated into anti-sapstain formulations for various purposes. Heavy metals could arise from many sources and are also not accounted for by the current test method.

It could be, however, that the cause of the toxicity is actually chemical and that the analytical procedures used to determine the chemical concentrations are not accurate or sensitive enough. DDAC is quite stable in water with an aerobic half-life of 17 years and an anaerobic half-life of 23 years (first draft, recommendation document). IPBC biodegradation studies in water have not been done and it is assumed that it is similar to biodegradation in soil. Aerobic degradation of IPBC has a half-life of 2 hours and forms propargyl butyl carbamate. Degradation is probably not leading to lower amounts of IPBC being determined by the chemical analysis, but it may explain why excessive amount of IPBC do not appear to be toxic in bioassay tests. It would be useful to determine the toxicity of propargyl butyl carbamate and other chemical degradation products.

The analytical methods used to analyze DDAC and IPBC in this study have just been recently developed. The quality assurance/quality control (QA/QC) portion of this study was designed to evaluate the level of confidence with which the methods are able to determine the chemical concentrations of DDAC and IPBC in the stormwater samples. The levels of DDAC and IPBC specified in the compliance regulations are very close to the detection limits of the methods used. The analyses were performed by two labs and the QA/QC results show that there were some differences between the labs. The QA/QC results for the Envirochem study are shown in Figures 4 and 5. It can be seen that in some cases the correlation is good such as for Spike Sample # 1 in Figure 4, but in the majority of the cases there is a discrepancy between the labs. The labs are not consistently low or high, so it is difficult to ascertain where the discrepancy arises. It is possible that there are differences in sample handling and preparation before analysis between the two labs. Further work has been suggested in order to determine optimal storage time and handling protocols. The Envirochem study also states that the results are further complicated by the fact that both DDAC and IPBC are readily absorbed onto glass, therefore, part of the sample may be lost before the analysis is completed.

Figure 4-Quality Assurance and Quality Control Test Results
Duplicate Field Sample Analysis (ppb)

Chemical Spike Analysis	Actual Site ID	Chemical	Field Zenon DDAC	Field Zenon IPBC	Field BCR DDAC	Field BCR IPBC
Spike Sample #1	Mill C-1	NP-1	<10	<10	<10	<10
Spike Sample #2	Mill R-1	TMBRCT	35	-	9	-
Spike Sample #3	Mill 0-1	TMBRCT	120	-	31	-
Spike Sample #4	Mill I-1	NP-1	1100	140	1740	344
Spike Sample #5	Mill F-1	NP-1	140	33	224	55
Spike Sample #6	Mill N-4	NP-1	67	10	24	<10
Spike Sample #7	Mill N-4	NP-1	-	-	<5	<10

Figure 5- Quality Assurance and Quality Control Test Results
Spiked Field Sample Analysis (ppb)

Chemical Spike Samples	Chemical	Actual BCR Spike DDAC	Actual BCR Spike DDAC	Spike Zenon DDAC	Spike Zenon IPBC	Spike BCR DDAC	Spike BCR IPBC
Spike Sample #1	NP-1	305	46	90	<10	289	39
Spike Sample #2	TMBRCT	378	-	120	-	319	-
Spike Sample #3	TMBRCT	410	-	10	-	396	-
Spike Sample #4	NP-1	No Spike	No Spike	2800	420	2300	192
Spike Sample #5	NP-1	No Spike	No Spike	330	15	530	20
Spike Sample #6	NP-1	No Spike	No Spike	16	<10	162	<10
Spike Sample #7	NP-1	780	195	830	110	936	99

3.2 Vancouver Island

A similar set of stormwater data for Vancouver Island (Figure 6) was obtained from Paul Rideout (751-3100) of BCE in Nanaimo. The mills were generally in good compliance in regards to the amount of DDAC and IPBC that they were discharging into the environment. Only two out of seventeen mills were in noncompliance with the DDAC regulations while four out of twelve mills were in noncompliance with the IPBC regulations. There are cases where amounts of IPBC in excess of the stormwater limit are discharged into the environment but the stormwater is not toxic to fish in the 96-hr LC_{50} bioassay.

Figure 6-Vancouver Island Anti-sapstain Chemical Stormwater Runoff Data Correlated with Covered Storage time.

Mill	Anti-sapstain Chemical Used	DDAC (ppb)	IPBC (ppb)	96 hr Bioassay	Dip or Spray Treated lumber	0.5 hr Covered Storage Time
C&C Lath-Duncan	NP-1	35	10	75%	auto elevator dip tank	yes
Canadian Pacific Forest Products-Ladysmith	NP-1	**1034** 61 26	108 18 5	40% 18% 100%	high pressure spray	yes
Canadian Pacific Forest Products-Tahsis	NP-1	320 10 82 370	**210** 57 **190** **320**	- - - -	high pressure spray	yes-mill/planer no-timberdeck (less than 0.5 hr)
Chemainus Forest Products-Chemainus	TMBRCT II, NP-1	33	18	61%	high pressure spray	no (less than 0.5 hr)
Doman Forest Products-Chemainus	NP-1	87 24	102 18	100% 75%	high pressure spray	no (less than 0.5 hr)
Doman Forest Products-Cowichan Bay	- (NP-1)	76	10	38%	- (spray)	yes (80% of the time) no (20% of the time)
Doman Forest Products-Ladysmith	NP-1	80 43 25 90	10 10 10 10	47% 52% 55% 93%	high pressure spray	yes
Doman Forest Products-Nanaimo	NP-1	53 47 32 47	10 10 10 10	100% 100% 100% 100%	high pressure spray	no (less than 0.5 hr)
Fletcher Challenge -Campbell River	TMBRCT 2000	25 25	- -	- -	Spray	?
Fletcher Challenge -Youbou	NP-1, TMBRCT 2000	360 50	**130** 20	100% 100%	high pressure spray	yes
MacMillan Bloedel -Alberni Pacific	NP-1	150 500	**350** **320**	60% 32%	high pressure spray	no (less than 0.5 hr)

* **bold** print indicates chemical noncompliance with B.C. Environment Stormwater Runoff Limits

Figure 6(cont)-Vancouver Island Anti-sapstain Chemical Stormwater Runoff Data Correlated with Covered Storage Time.

Mill	Anti-Sapstain Chemical Used	DDAC (ppb)	IPBC (ppb)	96 hr Bioassay	Dip or Spray Treated Lumber	0.5 hr Covered Storage Time
MacMillan Bloedel-Chemainus	NP-1	43 166 - 122	10 74 67 71	100% 67% - 68%	High Pressure Spray	yes
MacMillan Bloedel -Nanaimo	NP-1	300 300 300	**145** **650** **932**	100% 100% 100%	High Pressure Spray	no (less than 0.5 hr)
Nagaard Sawmills-Surrey	TMBRCT 2000	100 10	-	-	High pressure spray	yes (stored under a roof if raining)
Paulcan	TCTMB	-	-	-	-	yes
Primex Forest Products-Courtenay	F-2	**844**	-	52%	spray	no (less than 0.5 hr)
Raven Lumber-Campbell River	F-2	200 10	-	-	spray	yes (planer,green chain) no (timberdeck, less than 0.5 hr)

As for covered storage time, eight mills out of seventeen always cover their lumber for 30 minutes while six mills do not meet the minimum 30 min required covered storage time. An additional three mills provide 30 min covered storage for a portion of their lumber stocks or comply a certain percentage of the time. Only one mill is using a dip tank (auto elevator dip tank) to treat its lumber and it seems to be able to meet the stormwater limits with 30 min covered storage. Mills with 30 min covered storage time showed 86% (32/37 samples) compliance to stormwater limits with NP-1, while mills using Timbercote showed 100% compliance (4/4 samples). Those mills with less than 30 min covered storage time showed 79% (19/24 samples) chemical compliance for NP-1. As seen with the results from the Envirochem study, there is very little correlation between chemical compliance and toxicity as measured by the 96 hr LC_{50} Bioassay test. 55.5 % of all the samples taken on Vancouver Island were shown to be toxic by the bioassay test. The possible causes for this toxicity are the same as those outlined for the Lower Mainland results.

4) Conclusion

4.1 Leaching Studies

The MacMillan Bloedel NP-1 leaching study (3) on high pressure sprayed lumber shows that 60-90 minutes of covered storage time is adequate for stormwater runoff to meet BCE's DDAC stormwater limit and non-toxic requirement. However, 60-90 minutes of covered storage would probably not be adequate (based on the range of error) to meet BCE's IPBC stormwater limit. Only minor differences in DDAC/IPBC stormwater concentrations can be expected between 60-90 minutes and 24 hours of covered storage time. Extending covered storage time limit to 24 hours would still not enable a mill to meet BCE's IPBC stormwater limit.

The Environment Canada Timbercote II leaching study (5) on high pressure sprayed lumber shows that three 3 days of covered storage time is not adequate to meet BCE's DDAC stormwater limit.

The Forintek F-2 leaching study (8) on high pressure sprayed lumber shows that neither 30 minutes nor 24 hours of covered storage time is adequate for stormwater to meet BCE's DDAC stormwater limit. However, the study does indicate that sodium borate leached from the treated lumber with 30 minutes of covered storage time would not be toxic to fish.

The Ecobrite leaching study (11) did not correlate leaching with covered storage time and as a result it is difficult to determine any significant conclusions from this study.

4.2 Stormwater Runoff Data

From the stormwater runoff data assembled in this study, mills in the Lower Mainland with greater than 30 min covered storage time were able to meet stormwater limits 92% (44/48 samples) of the time using NP-1 and 90% (9/10 samples) of the time with Timbercote. For covered storage times of less than 30 min, mills using NP-1 showed 92% (11/12 samples) chemical compliance with stormwater limits and mills using Timbercote showed 100% (3/3 samples) chemical compliance with stormwater limits.

On Vancouver Island, mills with 30 min covered storage time showed 86 % (32/37 samples) chemical compliance with NP-1, while mills using Timbercote showed 100% (4/4 samples) chemical compliance. It should be kept in mind, however, that statistics based on very small sample sizes are generally not considered significant. Those mills with less than 30 min covered storage time showed 79% (19/24 samples) chemical compliance for NP-1.

The effluent which is discharged is usually toxic despite meeting compliance regulations (45.8 % of the samples taken in the Lower Mainland were toxic and 55.5 % of the samples taken on Vancouver Island were found to be toxic). There are several possible explanations for this toxicity and they include: a) the methods used for DDAC and IPBC determination are not accurate enough, b) the presence of other substances such as resin acids from the wood, oil and grease from the lumber yard machinery, chemical additives from the anti-sapstain formulations, residual amounts of previously used toxic chemicals and heavy metals which are not being accounted for by the analysis methods that are currently used and c) degradation of IPBC and DDAC during storage/handling periods or during the bioassay test (IPBC only). It is possible that some of the DDAC/IPBC is being degraded by UV light or it is being lost into the soil.

4.3 Conclusion

It is difficult to make any definite conclusions regarding optimal covered storage time without knowing what is causing the toxicity that is observed in the stormwater runoff data. There appears to be very little correlation between the leaching studies and stormwater runoff data. The leaching studies indicate that covered storage is, indeed, beneficial to reducing the the concentration of anti-sapstain chemical found in the stormwater runoff. It would appear, however, from the data assembled here that 30 min of covered storage time is adequate to meet the BCE Regulation for anti-sapstain chemical (DDAC/IPBC based formulations) release for high pressure spray treated lumber.

Further studies should be conducted to isolate the factors which are causing the toxicity observed. A Round Robin program could be initiated for the private labs which perform DDAC/IPBC analyses, in order, to ensure that the method used and handling practises are standardized between the different labs. This will also act as a method of quality assurance/quality control to determine how comparable the results obtained from the different labs are.

5) Anti-Sapstain Leaching and Stormwater Monitoring Studies

1) Lower Mainland Region Anti-sapstain Facilities: Assessment of Operational Practices and Environmental Discharges Study, vol. 1-2, Envirochem Special Projects Inc. for B.C. Ministry of the Environment, Lands & Parks-Lower Mainland Regional Office, May 1992.

2) Work Program for Efficacy and Leaching Studies for Nytex 10, B.C. Research and Maag Agrochemicals, August 1991.

3) Leaching Study on NP-1 Antistain, Project BF-529, Report #1, MacMillan Bloedel Research, May 1991.*

4) Determination of the Leachability of Oxine Copper from Freshly Sawn Lumber Treated with Nytek GD, Nytek GD with Added Sticker and an Electrostatically Applied Oil Based Formulation, Forintek Canada Corp. and Maag Agrochemicals, October 1990.

5) Leaching of Didecyldimethyl ammonium chloride from Timbercote II Surface Treated Lumber, Environment Canada, Conservation and Protection, Regional Program Report 91-01, October 1990.

6) Standard Leaching Test for Anti-sapstain Chemicals, Environment Canada, Conservation and Protection, Regional Program Report 90-10, September 1990.

7) Leaching of 2-(Thiocyanomethylthio)Benzothiazole (TCMTB) from Surface Treated Lumber, Environment Canada, Conservation and Protection, Regional Program Report 90-06, May 1990.

8) Leaching of Didecyldimethyl ammonium chloride and Borates from F-2 Spray Treated Lumber, Project # 17-43-K-206, Forintek Canada Corp. and Walker Brothers, October 1989.

9) An Estimate of the Concentration of 2(thiocyanoomethylthio)benzothiazole (TCMTB) in Stormwater Runoff from Treated Lumber Storage Yards Which Comply to the Code of Good Practice, Environment Canada, Conservation and Protection, Regional Report, August 1988.

10) Controlling Stormwater Discharges of Anti-sapstain Chemicals from Treated Wood Storage Areas, vol. 1-2, B.C. Ministry of the Environment, June 1988.

11) Ecobrite Progress Report, Diachem Industries, June 1988. (Leaching Study)

12) CFST Leaching and Weathering Research, Canfor Research, October 1987.

5) Anti-Sapstain Leaching and Stormwater Monitoring Studies (cont.)

13) Leaching of Chlorophenols from Lumber Packaged with Polyethylene under the Top Tier, Project # 02-17-43-K-105, Forintek Canada Corp., September 1987.

14) Assessment of Storm Water Related Chlorophenol Releases from Wood Protection Facilities in British Columbia, Environment Canada, Conservation and Protection, Regional program Report 87-15, August 1987.

15) Mill Antistain Treatment using TCMTB, Project BD-301, Report #2, The Leaching of Busan 1030 from Dip Treated Lumber, MacMillan Bloedel Limited, December 1986.*

16) Determination of Chlorophenate Leaching from Spray Treated Lumber, Project # BT-261, MacMillan Bloedel Research, August 1984.*

17) Simulated Rainwater Leaching Tests of Lumber, Spray Treated with Sodium Tetrachlorophenate and Sodium Tetrachlorophenate/Wax Solutions, Forintek Canada Corp. for Environment Canada, Environmental Protection Service, February 1984.

18) Simulated Rainwater Leaching of Chlorinated Phenols from Dip-Treated Lumber, Forintek Canada Corp., January 1984.

19) Computer Simulations of the Use of Diffusers to Reduce the Toxicity of Contaminated Storm Water Runoff from Treated Lumber Storage Yards, Regional Data Report DR-88-02, Environment Canada, Conservation and Protection, February 1983.

* Reports must be obtained from the author.