TREATED WOOD AS A SOURCE OF DIOXIN/FURAN RELEASES

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1. Introduction

Commercial chlorophenols (CP) sold in Canada contain about 0.9% chlorinated dibenzo-p-dioxins (dioxins) and chlorinated dibenzofurans (furans) impurities[1,2]. Of these impurities, the estimated ratio[3,4] of total dioxins:furans is 3:1. In British Columbia, CP in mixtures of creosote are used mainly in heavy duty wood preservation and protection, especially in railway ties, trestles, and utility and telecommunication poles. This use pattern created a potential for these structures to contaminate adjacent ditches with dioxin and furan residues. The objectives of this study were: (1) to determine the occurrence/levels of dioxins and furans in selected rights-of-way (ROW) ditches containing CP/creosote treated power/telecom transmission line poles or waterways adjacent to treated railway ballasts, and (2) to determine whether these structures are a potential source for dioxins and furans releases to the aquatic environment.

2. Method

The sample collection methods outlined in 1992[5] and 1994[6] were applied in this study[7]. Selected railway and utility ROW ditches (Fig. 1) were sampled to determine dioxin and furan occurrence/levels. Farmland and parkland ditches were sampled to determine background dioxin and furan levels. Sampling was timed to occur 24-48 h after major rainfall events in 1990 and 1991. Grab water and sediment samples were obtained at selected points from ditches. Ten sub-samples were pooled to form a composite for each sediment and water sample. Samples of CP/creosote treated wood chips/scraps were also collected from railway ties and utility poles from different sites. Dioxin and furan residue analyses were conducted by Axys Analytical Services, Sydney, B.C (water analysis) and Zenon Environmental Lab, Burnaby (sediment analysis). A QA/QC program was implemented by B.C. Research Corporation, Vancouver, to check the recovery efficiency of analytical laboratories. The method of analysis was outlined in 1995[7]. This study limits its scope to 5 representative groups/isomers (Table 1).

3. Results

Total dioxins (76,737 μg/kg) and furans (18,720 μg/kg) detected (detection limit = 1 μg/kg) in CP/creosote treated utility poles were about 6 and 8 times, respectively, higher than the concentration of total dioxins and furans found in CP/treated treated railway ties. High concentrations (range, 1 - 60,000 μg/kg) of P5CDD, H6CDD, H7CDD, O8CDD and the corresponding CF cogeners were found. Although T4CDD was not detected, T4CDF (1.2 μg/kg) was found.

Since dioxins and furans were not detected (detection limit = 0.01 ng/L) in the parkland ditch water (Table 2), total dioxins (2.2 ng/L) and furans (0.4 ng/L) found in farm ditch water were used as background levels for comparison. Total dioxins found in railway ditch water without power poles were approximately 20 times higher than the background level, while total dioxins in railway ditches with power poles was 4300 times higher. Railway ditches without power poles contained furan level 13 times higher than background, whereas ditches adjacent to poles were 8500 times higher than background. Total dioxins in ditches adjacent to, and 4 m downstream of, utility poles were about 5900 and 2200 times, respectively, higher than background level (Table 3). In ditches adjacent to, and 4 m downstream of power poles, total furans for the same sites were about 8100 and 1700 times, respectively, higher than background level. Both T4CDD (range, 0.01 - 0.32 ng/L) and T4CDF (range, 0.01 - 1.58 ng/L) were detected in railway and utility ROW ditch water.

Total dioxins (3.7 μg/kg) and total furans (0.7 μg/kg) detected (detection limit = 50 ng/kg) in farm ditch sediments were used as background levels for comparison. Total dioxins found in ditch sediments of railway (Table 4) and ditch sediments adjacent to utility poles (Table 5) were about 5 and 700 times, respectively, higher than background level, while total furans were about 9 and 1800 times, respectively, higher than background level.

Both dioxins and furans were found in utility ditch sediments 4 m downstream of treated power poles, but at levels of 200 and 400 times, respectively, lower concentrations than those found adjacent to poles, indicating that they were transported from point sources of contamination (Table 5). Total dioxins in farm, railway, and utility ditch sediments were about 25, 130, and 18,400 times, respectively, higher in concentrations than total dioxins found in the sediments of Georgia Strait/Fraser estuary[8] (dioxins = 0.14 μg/kg; furans = 0.16

μg/kg). The corresponding values for furans were 5, 40, and 8,000 times, respectively, higher in concentration. These findings suggest that dioxins and furans from railway and utility ROW ditches entering small streams may impact aquatic organisms due to the low dilution factors in these enviroments.

4. Conclusions

Dioxins and furans were detected in ROW ditches adjacent to CP/creosote treated utility wood poles and railway ballasts in the Lower Mainland of British Columbia. This study indicates that these structures are a potential constant release source of dioxins and furans to fish habitat areas and to the general aquatic environment. Dioxin and furan concentrations in ditches varied. Both T4CDD and T4CDF were found only in ditch water near, and at 4 m downstream of, utility poles and adjacent railway ties, but at very low concentrations.

5. References

1) Environment Canada. 1990. Canadian Environmental Protection Act: Priority Substances list assessment report No. 1 - poly-chlorinated dibenzodioxins and polychlorinated dibenzofurans. ISBN 0-662-17644-8. 56 p. Beauregard Printers Ltd., Ottawa, Canada.

2) Jones, P.A. 1981. Chlorophenols and their impurities in the Canadian environment. Economic and Tech. Rev. EPS 3-EC-81-2. Environment Canada, Ottawa.

3) Firestone, D. 1977. Chemistry and analysis of pentachlorophenol and its contaminants. U.S. Food and Drug Admin. FDA By-lines No. 2. Sept. 1077. p. 57-89.

4) Goldstein, J.A., M. Friesen, R.E. Linder, P. Hickman, J.R. Hass, and H. Bergman. 1977. Effect of pentachlorophenol on hepatic drug metabolizing enzymes and porphyria related to contamination with chlorinated dibenzo-p-dioxins and dibenzofurans. Biochem. Pharmacol. 26:1549-1557.

5) Wan, M.T. 1992. Utility and railway right-of-way contaminants in British Columbia: chlorophenols. J. Environ. Qual. 21:225-231.

6) Wan, M.T. 1994. Utility right-of-way contaminants: polychlorinated aromatic hydrocarbons. J. Environ. Qual. 23:1297-1304.

7) Wan, M.T., and J. Van Ootsdam. 1995. Utility and railway rights-of-way contamiants: dioxins and furans. J. Environ. Qual. 24:257-265.

8) Harding, L.E. 1990. Dioxin, furan and chlorinated phenolic levels in sediments from the Fraser River estuary and British Columbia West Coast reference sites. Regional Data Report: DR 90-3. Environmental Protection. Pacific & Yukon Region, Vancouver. 18 p.

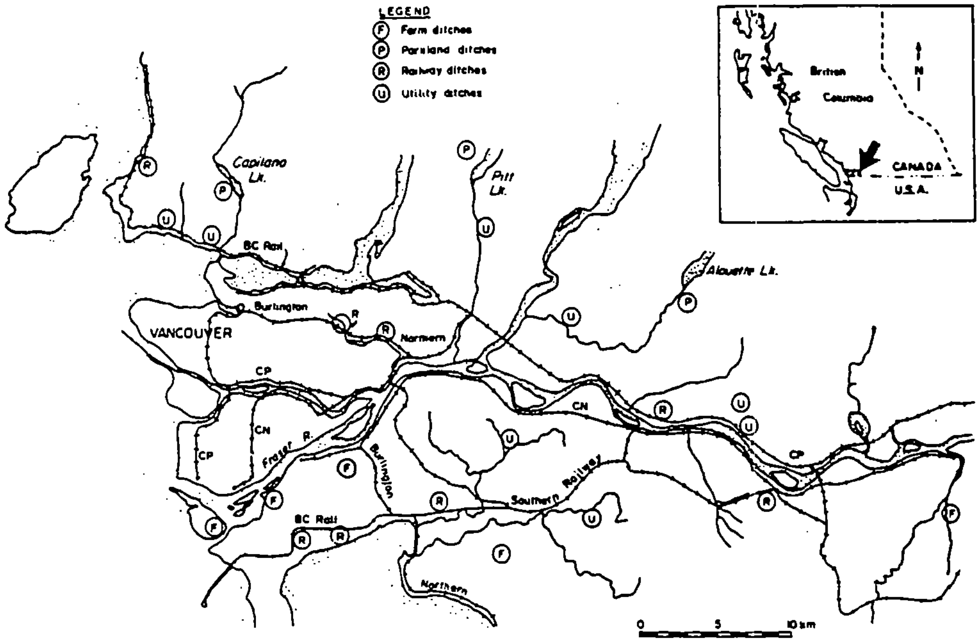

Fig. 1. Location of survey and sampling sites.

Table 1. Recovery of dioxins and furans from fortified sediment and water samples

Chemicals	Spiked levels[1]	Recovery (%, mean ± SE) Sediment	Water
Dioxins			
T4CDD (2,3,7,8-tetrachlorodibenzo-p-dioxin)	1-100	111 ± 13	82 ± 6
P5CDD (1,2,3,7,8-pentachlorodibenzo-p-dioxin)	1-100	131 ± 18	85 ± 7
H6CDD (1,2,3,4,7,8-hexachlorodibenzo-p-dioxin)	1-100	96 ± 15	92 ± 7
H7CDD (1,2,3,4,6,7,8-heptachlorodibenzo-p-dioxin)	1-100	130 ± 4	84 ± 5
O8CDD (1,2,3,4,6,7,8,9-octachlorodibenzo-p-dioxin)	1-2000	127 ± 35	93 ± 4
Furans			
T4CDF (2,3,7,8-tetrachlorodibenzofuran)	1-100	84 ± 9	81 + 7
P5CDF (1,2,3,7,8-pentachlorodibenzofuran)	1-100	102 ± 4	77 ± 7
H6CDF (1,2,3,4,7,8-hexachlorodibenzofuran)	1-100	144 + 9	83 ± 4
H7CDF (1,2,3,4,6,7,8-heptachlorodibenzofuran)	1-100	131 ± 19	106 ± 4
O8CDF (1,2,3,4,6,7,8,9-octachlorodibenzofuran)	1-1000	123 ± 20	95 ± 7

[1] - Four samples fortified at 1-5 ng/L of water, 50-1000 ng/kg of sediment with each compound, except for O8CDD and O8CDF, which were fortified at 1-2000 ng/kg of water and 1-1000 ng/kg sediment, respectively. Detection limits were 50 ng/kg sediment and 0.01 ng/L water for each compound.

Table 2. Dioxins and furans in railway and other rights-of-way ditch water in the Lower Mainland of British Columbia

Chemical	Concentration[1] (ng/L)			
	Parkland	Farm	Railway (-poles)	Railway (+poles)
T4CDD[2]	ND[3]	ND	ND	0.32
P5CDD	ND	ND	0.01	0.45
H6CDD	ND	0.05	0.16	35.9
H7CDD	ND	0.31	3.2	952
O8CDD	ND	1.58	36.2	8066
Dioxins[4]	ND	2.22	45	9627
T4CDF	ND	0.01	0.01	0.38
P5CDF	ND	0.02	0.01	0.29
H6CDF	ND	ND	0.05	33.8
H7CDF	ND	0.12	0.5	330
O8CDF	ND	0.14	2.42	1421
Furans[4]	ND	0.39	5	3295

[1] - mean concentration of positive occurrence of 2-15 samples
[2] - see abbreviation in Table 1
[3] - ND ≈ not detected; detection limit see Table 1
[4] - Mean total dioxins or furans, including isomers not listed.

Table 3. Dioxins and furans in ditch water of utility right-of-way in the Lower Mainland of British Columbia

Chemical	Concentration[1] (ng/L)		
	4 m upstream of pole	Adjacent (0-0.3 m) to pole	4 m downstream of pole
T4CDD[2]	ND[3]	0.02	0.01
P5CDD	ND	0.65	0.13
H6CDD	ND	44.6	8.16
H7CDD	0.18	2038	322
O8CDD	2.3	10108	4396
Dioxins[4]	2.72	13142	4880
T4CDF	ND	1.58	0.06
P5CDF	ND	0.39	0.04
H6CDF	ND	18.73	3.76
H7CDF	0.04	254	34
O8CDF	0.3	1531	422
Furans[4]	0.5	3175	664

[1, 2, 3, 4] - see Table 2

Table 4. Dioxins and furans in railway and other rights-of-way ditch sediments in the Lower Mainland of British Columbia

Chemical	Concentration[1] (µg/kg dry wt.)			
	Parkland	Farm	Railway ballasts	Railway ditches
T4CDD[2]	ND[3]	ND	ND	ND
P5CDD	ND	ND	ND	ND
H6CDD	ND	ND	1.8	0.1
H7CDD	ND	0.4	16.4	1.5
O8CDD	ND	1.6	217.7	12.4
Dioxins[4]	ND	3.7	277	18.8
T4CDF	ND	ND	ND	ND
P5CDF	ND	ND	0.2	0.1
H6CDF	ND	ND	0.9	0.4
H7CDF	ND	ND	0.5	0.1
O8CDF	ND	0.3	42.5	1.9
Furans[4]	ND	0.7	93.4	6.5

1, 2, 3, 4 - see Table 2

Table 5. Dioxins and furans in ditch sediments of utility right-of-way in the Lower Mainland of British Columbia

Chemical	Concentration[1] (µg/kg dry wt.)		
	4 m upstream of pole	Adjacent (0-0.3 m) to pole	4 m downstream of pole
T4CDD[2]	ND[3]	ND	ND
P5CDD	ND	0.5	ND
H6CDD	ND	24.5	0.2
H7CDD	ND	208	1.2
O8CDD	ND	1754	10.1
Dioxins[4]	ND	2576	14
T4CDF	ND	2	ND
P5CDF	ND	2	0.1
H6CDF	ND	5.1	ND
H7CDF	ND	94	0.3
O8CDF	ND	732	1.5
Furans[4]	ND	1278	3.2

1, 2, 3, 4 - see Table 2