

DECREASED DIOXIN AND FURAN LOADINGS FROM BRITISH COLUMBIA PULP MILLS, ENVIRONMENTAL RESPONSE, FUTURE DIRECTIONS?

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1.0 Introduction

This session presents a summary of changes in dioxin and furan concentrations in B.C. pulp mill effluent over the past several years and resulting changes in environmental levels and concentrations in biota. The authors of the papers in this session have presented a detailed picture of the changes in the various environmental compartments. This paper evaluates the changes and discusses future directions for environmental monitoring.

Dioxin and furan levels in the environment have fallen rapidly, in response to the marked decrease in pulp mill effluent contamination. The draft Environmental Quality Guidelines for dioxins and furans being developed in part by BC Environment for the Canadian Council of the Ministers of the Environment (CCME)¹⁾ are a useful reference point and are summarized in Table 1. Various human health guidelines developed by Health Canada can also be used to assess the significance of some of the changes in dioxin and furan concentration.

Table 1: CCME (Draft) Environmental Quality Guidelines for PCDD and PCDF

2.0 Changes in Effluents

2.1 Liquid Effluent Discharges

		Freshwater	Marine
Water	<i>Aquatic Life</i>	0.06 ⁽¹⁾ pg/L	0.06 ⁽¹⁾ pg/L
Sediment	<i>Aquatic Life</i>	0.25 ^(1,2) ng/kg	0.25 ^(1,2) ng/kg
	<i>Wildlife</i>	0.3 ^(1,2) ng/kg	0.3 ^(1,2) ng/kg
Tissue	<i>Aquatic Life</i>	50 ^(1,3) ng/kg	50 ^(1,3) ng/kg
	<i>Wildlife (Dietary)</i>	1.1 ^(1,4) ng/kg	0.66 ^(1,4) ng/kg

1) 2,3,7,8-TCDD TEQs (using International Toxicity Equivalency Factors, I-TEFs)
2) at 1% organic carbon 3) ng/kg lipid weight 4) ng/kg fresh weight

The seventeen chlorine bleaching pulp mills in British Columbia have achieved an impressive decrease in the dioxins and furans discharged to the environment.

Between 1987 and 1995 total 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD) discharges have decreased from 163 to 4.2 mg/day, a 97 % decrease, and 2,3,7,8-tetrachlorodibenzofuran (TCDF) discharges have decreased from 8,867 to 29 mg/day, a 99.7 % decrease²⁾. Krahn³⁾ has also shown some of the differences between mills implementation of dioxin reduction processes, one step changes versus sequential changes, and how this can effect dioxin and furan levels in effluents. This may explain some of the variability seen in environmental monitoring data.

In 1994, many of the chlorine bleaching mills in B.C. reported TCDD in effluent as non-detectable (detection limit of 2 pg/L) while TCDF averaged 19.9 pg/L. If one assumes that non-detectable concentrations are

equal to one half the detection limit then it is not surprising that 2,3,7,8-TCDD TEQs in a kraft pulp mill effluent exceed 2 pg/L 2,3,7,8-TCDD TEQs or more than thirty times the proposed CCME aquatic life guideline for water of 0.06 pg/L (Table 1). By taking 10 L or larger samples and using new extraction techniques in place of the standard 1L sample, the detection limit would be well under 1 pg/L³⁾. This level of precision is necessary to avoid uncertainty around the true exceedance of the ambient environmental quality guideline.

2.2 Effluent Solids

Derksen⁴⁾ has clearly shown that TCDD and TCDF are present in pulp mill and municipal effluent solids. Figure 1 summarizes the temporal changes in the pulp mill data and shows that total dioxins and furans (2,3,7,8-TCDD-TEQs) decreased 98, 97 and 63 % in effluent solids at mills 1, 2 and 3, respectively. These decreases are similar to those reported by Krahn⁵⁾ except for mill 3 which had an unexplained high level of TCDD (47 pg/g) in the effluent solids. Two of three mills have dioxins and furans in pulp mill effluent solids in 1993/4 that are very close to the draft CCME⁶⁾ sediment quality guideline of 0.25 pg/g. The contribution of pulp mill effluent solids to sediment solids and the modeling of its impacts is a major point of research for the Fraser River at this time. Future research must also address the dioxins and furans from municipal waste discharges and other sources such as chlorophenol treated products and wood treatment sites.

3.0 Environmental Response

3.1 Environmental Levels

3.1.1 Suspended Solids

Sekala⁹⁾ has shown that at Marguerite downstream of pulp mills at Prince George and Quesnel, dioxins and furans in Fraser River suspended sediments has decreased by 68 % between 1990 and 1994 (Figures 1 and 2). However, Fraser River suspended solids continue to exceed the CCME aquatic life guideline for sediments. In 1994 the decreasing importance of pulp mill related TCDD and TCDF and the increasing importance of other more highly chlorinated dioxins and furans from non-pulp mill sources indicate loadings from these sources must be included in future monitoring^{4,9)}. The relative contribution of other more highly chlorinated dioxins and furans to bottom sediment and the food web contamination needs to be included in future studies.

Figure 1: Dioxins and Furans in Pulp Mill Effluent Solids and Fraser River Suspended Solids (Marguerite)

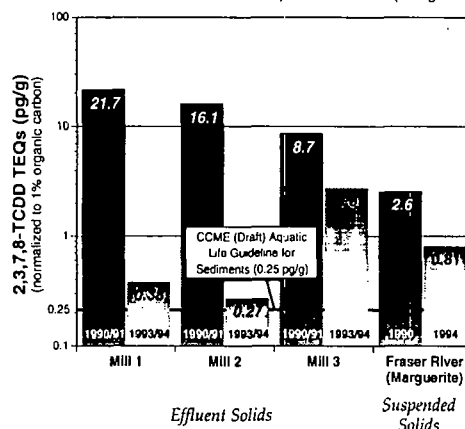
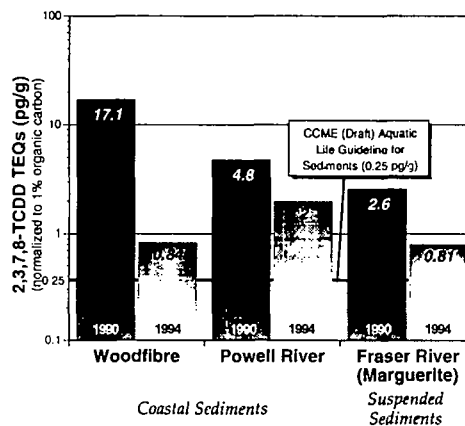


Figure 2: Dioxins and Furans in Coastal Sediments and Suspended Solids (Fraser River) 1990 and 1994



3.1.2 Bottom Sediments

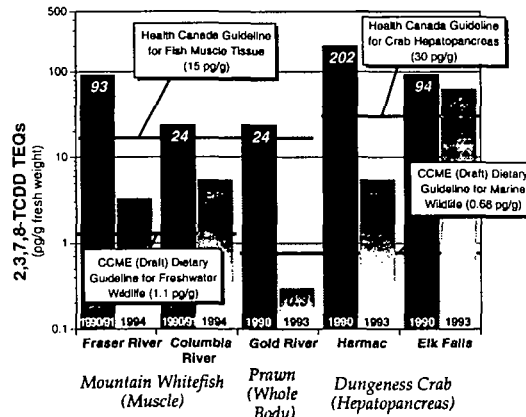
Hagen et al.⁶¹ showed that the location of the pulp mill had a marked effect on the dioxin and furan concentrations in bottom sediments. Pulp mills from fjords/embayments such as Woodfibre had a 98 % decrease in dioxins and furans levels between 1990 and 1994 (Figure 2). At a more exposed coastal location such as at Powell River a smaller decrease (59 %) was found over the same period. Marked decreases in shellfish contamination were reported at both locations and may be related to dietary preferences of crabs for filter feeders rather than sediment dwelling organisms⁶¹.

3.2 Levels in Biota

3.2.1 Freshwater Fish

The marked decrease in dioxin and furan loadings from pulp mill discharges to fresh water have caused large decreases in mountain whitefish(MWF) dioxin and furan contamination. The levels in the Fraser and Columbia River MWF decreased 97 and 77 %, respectively between 1990/91 and 1994 (Figure 3)⁷⁰. These levels of contamination in the MWF were lower than the Health Canada guideline for dioxins and furans in fish muscle tissues (15 pg/g 2,3,7,8-TCDD TEQs) and the Medical Officers of Health have removed the consumption advisories from Fraser and Columbia river MWF. MWF muscle tissues from the Fraser and Columbia rivers still exceed the CCME (Draft) Dietary Guideline of 1.1 pg/g for Freshwater Wildlife. This guideline applies to dioxins and furans levels in organisms consumed by piscivorous wildlife. In figure 4 it can be seen that the Fraser river MWF are now slightly below the CCME (Draft) aquatic life guideline of 50 pg/g lipid weight. The aquatic life guideline may be exceeded if whole body analyses were performed.

Figure 3: Dioxins and Furans in Fish/Shellfish Tissues (Fresh Weight Basis, 1990/91 and 1993/94)



3.2.2 Marine Shellfish/Fish

Some marine sites such as the Harmac outfall area showed marked decreases of 97 % in dioxins and furans in crab hepatopancreas while other pulp mill sites such as Elk Falls outfall showed a more moderate decrease of 32 % between 1990 and 1993(Figure 3)⁷⁰. Only one of these sites is below the Health Canada guideline for crab hepatopancreas. Neither of these sites had crab with hepatopancreas that were less than the CCME Dietary Guideline of 0.66 pg/g for Marine Wildlife. Muscle tissue levels of dioxins and furans in crabs at both of these sites (1992 : 0.1 - 0.4 pg/g 2,3,7,8-TCDD TEQs) are markedly lower than the hepatopancreas. This indicates the need for whole body analyses when evaluating Environmental Quality Guidelines. On a lipid weight basis both sites had crab hepatopancreas levels much higher than CCME Aquatic Life Guideline⁶¹(Figure 4).

3.2.3 Birds - Osprey/Eagles

The eagle and osprey data present a contrasting story, eagles on the coast show a downward trend while the osprey in the interior continue to exhibit high levels of TCDD and TCDF downstream of the pulp mills⁹. This is not likely due to differences in output of TCDD and TCDF by the various mills. For example, osprey downstream from the Celgar mill do not show a declining trend even though the mill had non-detectable levels of TCDD and TCDF since mid-1993. Whitehead et al.⁹ suggest that dietary differences may explain some of the inter-species variation. The continuing exceedance of environmental quality guidelines in compartments such as river suspended sediments and bottom sediments may also indicate a slower recovery from historical contamination than the effluent and MWF data indicate.

4.0 Future Monitoring Directions

Concerns for human health continue to drive the need for monitoring in a number of areas. Current research has shown that although human health guidelines have been met in some areas, the more stringent environment quality guidelines are often exceeded. Hence, monitoring programs must be designed to address the needs of environmental quality guidelines. Measurements of contaminant concentrations in dorsal fish muscle and liver have great relevance to human exposure. But measurements of whole body concentrations have more relevance to environmental quality guidelines. In addition, whole body measurements are less likely to overestimate body burden as in measurements of liver/hepatopancreas contamination or underestimate body burden as in measurements of muscle contamination.

Future research on dioxins and furans downstream of pulp mills should include loadings from other sources and consider the bioavailability/environmental chemistry of the more highly chlorinated dioxins and furans. Measurement of larger volumes of effluent and new extraction techniques will reduce uncertainty about environmental loadings.

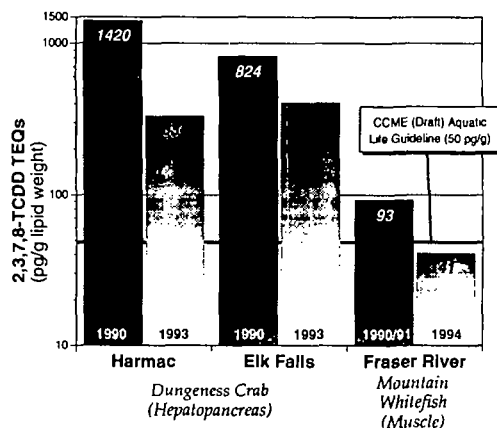
5.0 Acknowledgments

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6.0 References

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Figure 4: Dioxins and Furans in Fish/Shellfish Tissues (Lipid Weight Basis, 1990/91 and 1993/94)



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