# PCBs and PCDD/Fs in white-tailed deer near a smelter: Distance effects and human health risk assessment

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## Introduction

The main objective of this study was to determine whether a smelter located in Danville Quebec, Canada, was a source of persistent organic pollutants to the surrounding environment. PCBs and PCDD/Fs were produced as by-products of magnesium extraction, and tests conducted by the Ministry of the Environment in Quebec reported average annual releases of 0.3kg/year of ∑PCBs and 3.0g/year of ∑PCDD/Fs. [1]

Studies have shown that pollutants in the atmosphere can enter the terrestrial food chain via an air -vegetation - herbivore pathway. [2,3] In this study, contaminant concentrations were measured in white-tailed deer near the smelter, and distance, age, and wind direction were considered as explanatory variables.

Cytochrome P450 1A activity was measured in deer livers. Induction of Cytochrome P450 (CYP1A) enzymes is a well-known response in vertebrates to dioxin / furan and co-planar PCB exposure. Cytochrome P450 expression, as measured by ethoxyresorufin-*O*-deethylase activity (or EROD), has recently been measured in deer liver.[4]

The smelter's location in Danville is a very popular hunting area, and venison is often an important staple in local diets. A risk assessment was conducted by applying contaminant levels measured in this study to consumption guidelines.

## Materials and Methods

Two groups of deer were analyzed for PCBs: (1) those captured before the smelter opened (1999 deer n=33); and (2) those captured after two years of operation (2002 deer n=43).Twelve samples were analysed for PCDD/Fs and coplanar or non *ortho*– PCBs (denoted as no-PCBs). The analytical procedure was adopted from the National Wildlife Research Centre (NWRC).[5] EROD activity was measured in thirteen liver samples according to the NWRC method.[6] Consumption recommendations were calculated based on Health Canada and WHO (World Health Organization) guidelines and modelled after an assessment using salmon.[7,8,9,10]

## Results and Discussion

Total PCB concentrations in the 2002 deer showed a significant inverse relationship with distance($r^2$= 0.21 $p<0.001$) and the slopes of the 1999 and 2002 regressions lines were significantly different ($p<0.001$) as shown in Figure 1. ∑PCDD/F congeners did not show a significant decline with distance from the smelter. The most toxic congener (2,3,7,8-TCDD) demonstrated the most significant relationship relative to the others ($r^2$=0.19, p=0.099). ∑no-PCBs showed a significant decline with distance ($r^2$=0.37, p=0.018), with PCB-126 being the most highly significant ($r^2$=0.4, p=0.014) followed by PCB-169 ($r^2$=0.3, p=0.033) and PCB- 77 which was close to significance ($r^2$=0.2, p=0.072) (Figure 2). EROD activity measured in the liver also showed a significant decline with distance from the smelter as shown in figure 3 ($P<0.05$, $r^2$=0.38) and activity was correlated with ∑PCB (r=0.38).

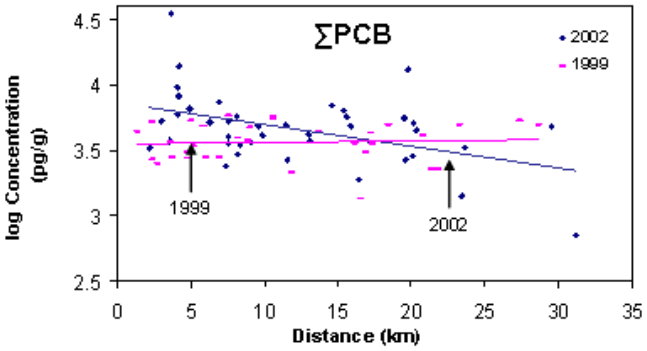


Figure 1.Relationship between∑PCB concentration and distance from the smelter in 1999 (n=33) and 2002 (n=43)**.** Points represent the log concentration (pg/g wet weight) of each deer at a specified distance (km) from the smelter. Lines of best fit were drawn for both years.

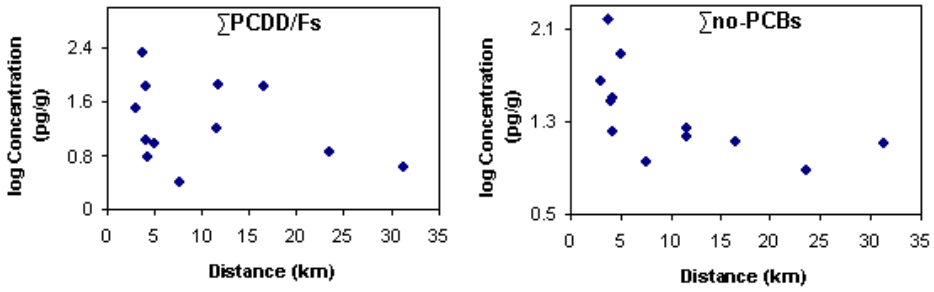


Figure 2.Relationship between ∑PCDD/F and ∑no-PCB concentrations and distance from the smelter in 2002. Points represent the log concentration (pg/g wet weight) of each deer at a specified distance (km) from the smelter (n=12).

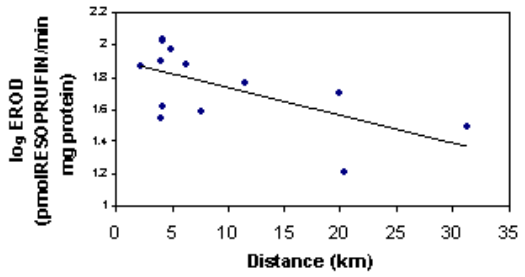


Figure 3. EROD activity and distance from the smelter. EROD activity was measured in pmol RESORUFIN $min^{-1}$ $mg^{-1}$ proteins from 13 deer liver samples.

In the risk assessment PCDD/F and no-PCB samples were grouped into categories to best represent the different levels of risk associated with deer at varying distances from the smelter (Table 1). The first sample was in a “hotspot” region being the only sample within 5km in the prevailing wind direction. According to the lower-bound range of WHO guidelines, more than three 227g portions per week of venison from the hotspot region would exceed safe limits in contrast to unrestricted consumption for deer beyond 20km from the smelter. It should be noted that the calculated number of portions is determined for uncooked meat. Employing various cooking treatments may, or may not, reduce the total concentration of some contaminants in other food sources.[11]

Table 1. Comparison of deer portions required per week to exceed WHO (1998) – 1 pg TEQ/kg bw/day – safety levels. Contaminant levels from samples are presented and grouped according to proximity to the source. Lipid content in deer muscle was approximated at 1.87%, a value adopted from laboratory tests on deer muscle tissue. The weekly meat portion was corrected for lipid content by multiplying the portion (227g) by the % lipid resulting in 4.25 g lipid content per portion. Estimates are calculated for a 70 kg person.

| Sample Group<br><br>Sample sizes (n) are denoted in brackets | PCDD/Fs and nPCBs (pg TEQ/g) | PCDD/Fs + nPCBs (pg/TEQ/portion) | Single portion intake of PCBs+PCDD/Fs (pgTEQ/kg bw) | # portions to exceed WHO (1998) 7pgTEQ/kg bw/wk |
|---|---|---|---|---|
| Hotspot (1) | 38.79 | 164.86 | 2.36 | 3 |
| < 5km (6) | 11.19 | 47.56 | 0.68 | 10.3 |
| >5km (6) | 3.93 | 16.7 | 0.24 | 29 |
| >20km (2) | 1.15 | 4.93 | 0.07 | 100 |
| Avg (12) | 7.56 | 32.13 | 0.46 | 15.2 |

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