Exposure Assessment To Dioxin And Furan Emissions From An Ethylene Dichloride/Vinyl Chloride Monomer Production Facility

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Objectives

This study presents new information on the emissions of PCDDs/PCDFs from the vent stacks of an ethylene dichloride/vinyl chloride monomer (EDC/VCM) production facility. The objectives of the study are:

- to provide an improved understanding of the levels of emissions to air of PCDD/PCDF under defined conditions of plant/process operation, and
- to assess the exposure level of nearby residents and workers to facility emissions.

This information contributes to the emission inventory for dioxins and furans, and provides some measure of the impact of these facilities on local communities.

Approach and Method

In the production of ethylene dichloride and vinyl chloride monomer the waste streams are collected as "light ends" and "heavy ends". Some of the light and heavy ends can be used as feedstocks for other chlorination processes. Fractions, residues and vents not directly reusable are destroyed under controlled high temperature conditions into water, carbon dioxide, and hydrochloric acid.

In this operation the "light ends" were incinerated using two Thermal Heat Recovery Oxidizer units (THROXs). The "heavy ends", made up of viscous tars from the processes, are incinerated in the Thermal Oxidizer unit (TOX). The incineration is a controlled combustion process with fuel gas and excess oxygen added to maintain the flame at temperatures of greater than 900°C. The exit gases are treated using HCl absorbers and gas scrubbers. The stack conditions are listed in Table 1.

Sampling and Analysis: In July of 1994, a source sampling consultant conducted stack sampling on the vent stacks from Dow Chemical Canada EDC/VCM facility. The sampling protocol was developed and agreed to by a tripartite group made up of representatives of Alberta Environmental Protection, Environment Canada, and Dow Chemical Canada Inc. The vent stack samples were analyzed for dioxins and furans by two laboratories; Environment Canada, and Dow Chemical laboratories.

Table 1: Conditions For The EDC/VCM Unit TOX/THROX Scrubber Stacks

Stack Parameters			Stack Conditions*		
Incin'r Type	Stack Height (m)	Stack Diameter (m)	Flow** (m^3/min)	Temp (oC)	Feedrate (kg/sec)
THROX	27.43	0.61	154	78	0.264
THROX	27.43	0.61	120	66	0.295
TOX	27.43	0.76	177	92	0.664
* Stack conditions as measured during tests					
** Flow corrected to 25°C and 760 mm Hg.					

Exposure Assessment: Air dispersion modelling of the vent stack emissions has been conducted and the concentration of airborne dioxins and furans at the locations of local populations in the vicinity of the Dow Chemical Fort Saskatchewan EDC/VCM facility have been estimated. Of the seven specific receptors that were studied, four are residential and two are industrial work sites (including the Dow workers), and one is a "unique" receptor; a hobby garden located on-site and used by some Dow employees to grow produce for their own consumption.

This study assesses the intake of dioxins and furans by these seven population groups from environmental and dietary sources. The direct consumption of the deposition on the hobby garden produce is estimated for the unique receptor. The total intake for individuals in these groups is compared to current health guidelines expressed as a "tolerable daily intake". This health guideline has been established by the Government of Canada to assess the risk to human health from dioxins and furans[1].

It is assumed that the intake of dioxins and furans occurs through a number of pathways. Intake may occur through the following routes:

- inhalation of particulate and vapours in the air,
- ingestion of deposited contaminants within dusts and soils,
- intake of contaminants in drinking water, and
- ingestion of contaminants through the consumption of food.

To assess the total intake of dioxins and furans, the background levels of the contaminants in the environment and diet must first be assessed (see Table 2 for "background" levels of dioxins and furans). The "incremental intake" due to the EDC/VCM facility emissions are added to the intake from "background" sources to determine a total intake that can be compared to current health guidelines.

Table 2: Summary Table Listing "Background" Levels Of Dioxins And Furans Used In This Assessment

Media	Value
Air	0.20 pg TEQ/m^3
Soil	10 pg TEQ/g
Drinking water	0.07 pg TEQ/litre
Cow's milk	0.15 pg TEQ/g
Human breast milk	15.6 pg TEQ/g fat
Beef, pork, poultry, and eggs	0.29 pg TEQ/g
Fish/Shellfish	2.4 pg TEQ/g
Vegetables	0.002 pg TEQ/g
Fruits	0.004 pg TEQ/g
Cereals	0.0007 pg TEQ/g

Estimation Of The Lifetime Average Daily Exposure (LADE): The estimation of exposures to long-term emissions assumes exposures are averaged over the lifetime of an individual. The contaminant exposure and intake during each of five age groups (ie. neonate, infant, child, adolescent, and adult) are calculated and then time-averaged to develop a lifetime average daily exposure.

Summary Of Intakes From Environmental Background Sources: These calculations indicate the intake pathways for dioxins and furans in air, water, and soil deliver less than 0.1 pg TEQ/kg body weight per day (0.077 pg TEQ/kg/day) to the average individual.

Summary Of Intakes From Dietary Background Sources: The calculations of lifetime intakes in this study are designed to estimate the body burden for each separate age group. The intakes for each age are then averaged with an appropriate weighting given to each age group on the basis of the duration of the age group over a seventy year lifetime[2].

Due to this difference in methodology, the dietary intakes in this study are generally higher than those documented in other studies [3,4,5]. Some other factors that affect the magnitude of the final calculations are:

1) The addition of fish consumption to the dietary intake in this study. The dioxin/furan concentrations in fish and shellfish are approximately eight times that found for meats and eggs.

2) A 48% increase in the consumption of meats and eggs in the diet of adults for the most recent food consumption analyses from Health Canada[6].

3) The addition of human breast milk to the diet for neonates. The dioxin/furan concentration in breast milk is higher than the levels found in cow's milk.

The analysis estimates a lifetime dioxin/furan intake of 3.1 pg TEQ/kg/day.

Total Background Intake Of Dioxins and Furans: To estimate the total background intake of dioxins and furans the average intakes from the environmental and dietary intakes are summed. "Environmental intake" is considered to be the dioxin and furans that enter the respiratory and digestion system of an individual from air, water, and soil media directly.

Estimation Of Total "Background" Intake:
Total Background Intake = Dietary Intake + Environmental Intake
= 3.1 pg TEQ/kg body weight/day + 0.1 pg TEQ/kg body weight/day
= 3.2 pg TEQ/kg body weight/day

Estimation Using Minimum, Mean, and Maximum Emission Conditions: Three different emission concentrations are listed for each incinerator in Table 3. They are based on measurements provided by Environment Canada's dioxin laboratory, the Dow Chemical dioxin lab, and the mean of the two.

Table 3: Vent Stack Emissions Of PCDDs and PCDFs From The Dow EDC/VCM Facility

Vent Stack	Emission Concentration (in ng TEQ/m³)		
	Minimum	Mean	Maximum
TOX (F-600)	4.42	5.28	6.14
THROX (F-390)	7.52	9.00	10.48
THROX (F-391)	7.52	9.00	10.48

The operation of the two THROX units are considered to be identical. Consequently, only one unit was sampled and the results of the analysis are applied to both units. The ambient air concentration of dioxins and furans originating from the EDC/VCM facility have been estimated using USEPA's Industrial Source Complex Short Term model.

Incremental Intake of Dioxins Due To EDC/VCM Emissions: The incremental intake of dioxins and furans by local receptor groups has been found to be significantly less than background dioxin intake levels. The residential receptors all had an incremental intake of less than 0.005 pg TEQ/kg/day. This included the nearest neighbouring community

located 1.83 km. to the northwest of the vent stacks. The incremental intake of dioxins and furans to site employees from this emission is estimated to be less than 0.008 pg TEQ/kg/day. For this receptor group, the emissions are the source of approximately 0.25% of their total dioxin intake. The intake of dioxins and furans by consumers of the hobby garden is estimated to be equivalent to 0.2 pg TEQ/kg/day.

Summary

This study indicates that the intake of dioxins and furans emitted from this EDC/VCM facility are below "Tolerable Daily Intake" guidelines established by Health Canada. For local populations, the estimated background dioxin and furan intake from diet and background environmental sources is 3.2 pg TEQ/kg/day. This estimate uses Canadian average food consumption data in the calculation of background dioxin and furan intake. This estimated typical background intake value is approximately one third of the "tolerable daily intake" guideline defined by Health Canada. The consumers of the hobby garden produce are estimated to have an incremental intake of 0.2 pg TEQ/kg/day. The incremental intake for residential and employee groups in the region of the facility are estimated to be less than 0.01 pg TEQ/kg/day.

References

1) CEPA, *Canadian Environmental Protection Act "CEPA" Priority Substances List Assessment Report No 1, Polychlorinated Dibenzodioxins and Polychlorinated Dibenzofurans,* Minister Of Supply And Services, 1990, Catalogue No. En40-215/1E, ISBN 0-662-17644-8, 1990.

2) HWC, Health and Welfare Canada, *Determination of "Toxic" under paragraph 11c) of the Canadian Environmental Protection Act,* First Edition, 20 November, 1992.

3) MAF *"Polychlorinated dibenzo-p-dioxins and dibenzofurans and other organochlorine contaminants in food"* produced by the Ontario Ministries of Agriculture and Food, and of Environment (dated August, 1988).

4) Ono, M., Kashima, Y., Wakimoto, T., and Tatsukawa, R., *"Daily intake of PCDDs and PCDFs by Japanese through food"* Chemosphere 16, 1823-1828, 1987.

5) Beck, H., Eckart, K., Kellert, M., Mathar, W., Ruhl, C., and Wittowski, R. *"PCDD and PCDF body burden from food intake in the Federal Republic Of Germany"* Chemosphere, 18, 587-592, 1989.

6) HWC, Health and Welfare Canada, *"Reference values for Canadian populations"*, May, 1993.