# ASSESSMENT OF EXPOSURE TO DIOXINS OF THE SEVESO (MILAN, ITALY) AREA INHABITANTS

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## Introduction

Results of a monitoring program to investigate the levels of polychlorinated dibenzo-*p*-dioxins (PCDDs) and dibenzofurans (PCDFs) in the Seveso area [1-3] showed that residues of 2,3,7,8-tetrachlorodibenzo-*p*-dioxin (TCDD), arising from a well-known accident occurred in 1976, are still present in the top soil of some residential areas. In particular, in the ex Zone B, mean PCDD and PCDF concentrations, expressed as TCDD toxicity equivalents (TEQs), were in the order of 30 ngWHO-TEQ/kg soil, dry weight (d.w.), with TCDD concentrations about 80% of the total WHO-TEQs [1]. These values exceed the limit of 10 ngWHO-TEQ/kg soil (d.w.) established by the Italian law for residential areas.

In this study, an assessment has been carried out to estimate the PCDD and PCDF exposure of people living in Seveso Zone B and in a reference location not involved in the 1976 accident, by using environmental concentrations experimentally derived and from the literature. The purpose was to investigate the excess of exposure due a specific source such as contaminated soil and to assess the total PCDD and PCDF daily intake in relationship to the Tolerable Daily Intake (TDI) of 2 pgWHO-TEQ/kg body weight (b.w.) adopted by the *Scientific Committee on Food* (SCF) of the European Commission [4].

## Methods and Materials

The methodology described in the US EPA draft dioxin reassessment [5] to estimate exposure has been applied as follows: three different scenarios, characterised by different environmental concentrations (Table 1) and different exposure pathway parameters (e.g. soil ingested, air inhalated, etc.) were identified to estimate the exposure. In the first one, "*Zone B central scenario"*, the soil contamination was assumed to be the median value of the concentration values detected in Zone B and residents were assumed to live in houses with a garden, carry out gardening, and grow vegetables in their yards. In the second one, "*Zone B high-end scenario"*, soil contamination was assumed to be the 95th percentile of the concentration values detected in Zone B, whereas inhabitants were assumed to perform farming activity and consume home-raised vegetable and animal food products. Finally, the third selection, "*control central scenario"*, was defined as the first scenario for the exposure pathway parameters, whereas the soil TEQ concentration was assumed to be that of the regulatory limit value. The following exposure pathways were investigated:

1. soil ingestion;
2. soil dermal contact;
3. inhalation;
4. water ingestion;
5. diet;
6. vegetables grown in local yards;
7. locally reared animal (e.g., chicken) products (high-end scenario only).

As no experimental data were available for Zone B and the reference location concerning contamination level in water and in the general diet, data reported in the scientific literature were utilized for the three scenarios. The general equation utilized to estimate exposure was the following:

$$LADD = \frac{C \times CR \times CF \times ED}{BW \times LT}$$

Where:

- *LADD* = Life-Time Average Daily Dose;
- *C* = exposure media Concentration (WHO-TEQ concentration in soil, air, food, etc.);
- *CR*=Contact Rate of the environmental media (the rate of soil contact, of food ingested, air inhalated etc.);
- *CF*=Contact Fraction: this term, varying, between 0 and 1, reduces the contact rate in the specific exposure pathway equations;
- *ED*=Exposure Duration: this parameter has been assumed 30 years for the exposure pathways directly related to soil contamination (soil ingestion, soil dermal contact, and vegetable and animal products locally derived), and 70 years for diet, air inhalation, and water ingestion;
- *BW* = average Body Weight (60 kg);
- *LT* = average Life-Time period (70 years).

Table 1: Environmental concentration values of the three different scenarios utilized for the exposure assessment.

| | **Zone B** | | |
|---|---|---|---|
| *Environmental Compartment* | *Central Scenario* | *High-end Scenario* | *Control Central Scenario* |
| Soil (ngWHO-TEQ/kg d.w.) | 30.6 [a] | 107 [b] | 10 [c] |
| Air (pgWHO-TEQ/$m^3$) | 0.378 [d] | 0.378 [d] | 0.263 [e] |
| Water (pgWHO-TEQ/L) | 0.00056 [f] | 0.00056 [f] | 0.00056 [f] |

[a,b] 50th and 95th percentiles of soil concentration values in Zone B, respectively. [c] Regulatory limit concentration value for residential areas. [d,e] Average annual concentration in air in Zone B and Milan, respectively. [f] Concentration value utilized from the US EPA for exposure assessment of the general population in the United States[4]

For the soil ingestion pathway only, a childhood period (1–6 years) has also been considered. For exposure Pathways 6 and 7, the WHO-TEQ concentration in home grown vegetables and animal products was theoretically calculated starting from soil and air concentrations. Since some

experimental data were available for zucchini, such data were also utilised (Figure 1). To estimate the daily intake of PCDDs and PCDFs through the diet, the individual food ingestion rates [6] were multiplied for the dioxin concentration in the corresponding foodstuffs utilising data reported from the *Opinion of the SCF on the Risk Assessment of Dioxins and Dioxin-like PCBs in Food* [7]. As PCDDs and PCDFs values were originally expressed in I-TEQs, transformation to WHO-TEQs was performed by utilizing an empirical function derived from biological samples.

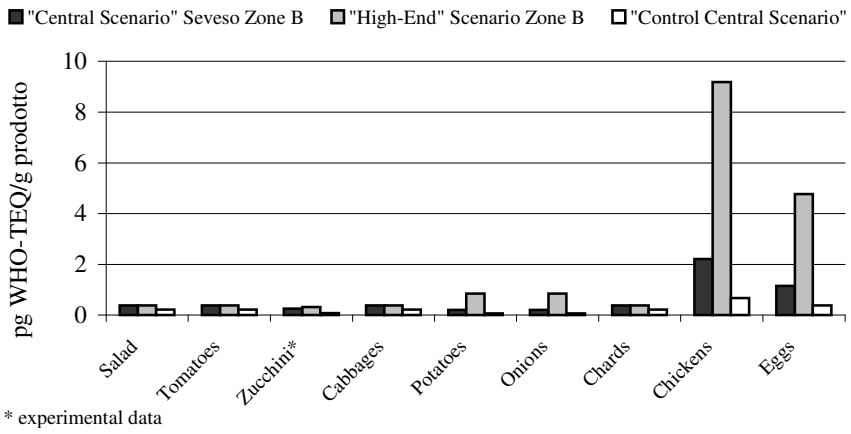


Figure 1. Estimated PCDD and PCDF concentrations in vegetables and animal products grown in Zone B soil (central and high end scenarios) and in a reference location (control central scenario).

**Results and Discussion**

The estimated LADDs for the three scenarios are shown in Table 2. The exposure pathways directly related to soil contamination (i.e., soil ingestion and soil dermal contact) are of minor importance: even in the "worst case" (high -end scenario), they represent altogether approximately 10% of the total exposure. This is mainly due to the application of the absorption fractions (0.3 and 0.03 for ingestion and dermal contact, respectively), which strongly reduces the LADDs for these two exposure pathways.

Even though the PCDD and PCDF air concentrations in Seveso and surroundings [2] were relatively high (Table 1) compared to the values reported in the scientific literature for urban air, inhalation pathway does not seem to be an important route as it represents between 4% and 6% of the total WHO-TEQ intakes estimated for the three scenarios.

As expected, water ingestion is not a significant route (<0.001% of the total daily intake), whereas the general diet represents 90% of the WHO-TEQ intake in the control central scenario and 82% in Zone B central scenario. In the present study, the average dietary daily intake has been estimated 73 pgWHO-TEQ/person per day, a value in the range of the average dietary intakes of PCDDs and PCDFs for the European population (29–97 pgI-TEQ/person per day) [8]. Finally, in the high-end scenario the consumption of locally raised vegetable and animal products causes a substantial increase of the LADD, whose value may be visibly greater than the TDI of 2 pgWHO-TEQ/kg b.w. Since the present assessment is not based on real information concerning if and how much home-grown products are directly utilized in the area, a survey to investigate such an issue would be recommended.

The WHO-TEQ total daily intake in Zone B and control central scenarios do not differ substantially and are both below the TDI. However, if the contribution of dioxin-like PCBs [9] were added, the TDI would be exceeded even in the central scenarios.

Table 2**:** PCDD and PCDF LADDs (pgWHO-TEQ/kg b.w.), due to the different exposure pathways, for Seveso Zone B residents (central and high end scenarios) and for residents of a surrounding reference area (control central scenario).

| | **Zone B** | | |
|---|---|---|---|
| *Exposure Pathways* | *Central Scenario* | *High-End Scenario* | *Control Central Scenario* |
| Soil ingestion | 0.02 | 0.23 | 0.01 |
| Soil dermal contact | 0.001 | 0.02 | 0.0005 |
| Inhalation | 0.08 | 0.13 | 0.05 |
| Water ingestion | $1 \times 10^{-5}$ | $2 \times 10^{-5}$ | $1 \times 10^{-5}$ |
| Diet | 1.18 | 1.15 | 1.18 |
| Vegetables (home derived) | 0.16 | 0.4 | 0.08 |
| Chicken and eggs (home derived) | — | 0.4–2.3 [a] | — |
| **Total** | **1.44** | **2.3-4.2** | **1.32** |

[a] Calculated using two different contact fraction values[5].

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