

## EXPOSURE FACTORS INFLUENCING SERUM DIOXIN CONCENTRATIONS IN THE FRENCH DIOXIN AND INCINERATORS STUDY

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### Abstract

The aim of the French Dioxin and Incinerators Study was to evaluate the serum PCDDs, PCDFs and PCBs concentration distribution in 1030 randomly selected residents living in the vicinity of 8 municipal solid waste incinerators and its association with dioxin exposure, particularly with intake of local food produced under the incinerator's plume. The geometric mean of serum concentrations for the study population was 13.7 pg TEQ/g for PCDD/Fs lipids and 27.7 for the total TEQ.

Globally, we did not observe any difference in geometric mean of serum dioxin levels between the residents living around incinerators and the residents living far from any known source of dioxins. Nevertheless, the analysis of the local consumers showed an increase of their serum dioxins levels with the consumption of local products from animal origin such as dairy products, eggs and more generally lipids. It is important to stress that this influence was observed for old incinerators, but not for the recent ones. Contamination by inhalation seemed negligible in regard to dietary intake.

### Introduction

Several studies have showed that emissions of municipal solid waste incinerators (MSWI) had little influence on serum dioxin concentrations of the populations living around.<sup>1,2,3,4</sup> Nevertheless, they did not take into account neither the area of the incinerator's plume, nor the main route of dioxin exposure, food consumption. Two studies took into account the local food consumption of populations living in the vicinity of MSWI with high dioxin emission levels: a) a Taiwanese study<sup>5</sup> which showed slight higher dioxin serum concentrations for the residents living around incinerators and eating local food products and lower concentrations for the vegetarians and b) a Belgian study<sup>6</sup> which showed higher serum dioxin concentrations for residents eating animal lipids locally produced in the impact area of the incinerator's plume (meat, eggs or dairy products).

Concerns over contamination by dioxins from waste incinerators have risen in the French population, since France has the greatest number of incinerators in Europe and some of them had high emissions by the past.

In 2005, the National Institute of Public Health Surveillance (InVS) launched a national study in collaboration with the French Agency of Food Safety (Afsa). The objective of the French Dioxin and Incinerators Study was to determine whether the emissions of municipal solid waste incinerators contribute to the body-burden of PCDDs, PCDFs and PCBs in the surrounding population in comparison to non exposed people, and to know if some factors, such as local food consumption could influence their serum levels.

### Materials and Methods

1030 adults (30-65 years old) have been included between March and July 2005 in 8 different areas in France around municipal solid waste incinerators. They were selected through a stratified two stage random sampling. In each of the 8 areas (Cluny, Fécamp, Gilly sur Isère, Vaux-le-Pénil, Maubeuge, Dijon, Pluzunet, Bessières) about 130 people falling within the following criteria were studied: living for at least 10 years around the incinerator, without occupational exposure, and no breastfeeding in the past 15 years for women. Exposed people were defined as living in the impact area of the incinerator's plume and non-exposed people were living beyond 20 km of the incinerator and not exposed to known dioxins sources (referents). In each of the exposed and non exposed study groups, the population studied was divided in two groups:

- 1) people eating home-grown or food produced locally (poultry, meat, eggs, milk, fruit and vegetables...);
- 2) people not eating home-grown or locally-produced food.

After having given their informed consent, the participants provided about 200 ml of blood under fasting conditions in the morning with the assistance of the staff of the French National Agency for Blood.

Exposure was assessed by serum concentrations of the 17 classical dioxins, furans (PCDDs and PCFs), 12 DL-PCBs and 4 marker PCBs (IUPAC 118, 138, 153, 180) analyzed by GC-HRMS. The total lipids content was measured by enzymatic summation method. Concentrations of dioxins and PCBs are expressed in pg WHO<sub>1998</sub>-TEQ per gram of lipids. Total TEQ corresponds to the TEQ sum for PCDDs, PCDFs and the 12DL-PCBs.

The questionnaire consisted of a one hour face-to-face interview with different sections: questions to determine the eligibility of each participant, socio-demographic, environmental and food consumption (total food intake and food locally-produced) questionnaires. Basic demographic (age, gender, education, marital status) and health questions (height, body weight, recent change in body weight, smoking status (smokers, ex-smokers, non smokers), childbearing and breastfeeding) were included. The participant was asked to recall possible dioxin exposure pathways in the past. Questionnaires included a full residential history (since the incinerator installation), occupations, leisure activities and environmental exposure: urbanism (rural, suburb, city), type and date of construction of the household, barbecue, type of heating, burning, exposure to a fire, number of minutes per week in a vehicle.

The originality of this study lies in its relatively detailed study of local food consumption. Food intake was quantified by a validated food frequency and portions questionnaire detailed for the food vectors of animal lipids, which are also the food vectors of dioxins. There were 3 questionnaires : 1) on the general diet involving 109 frequencies of consumption of food products combined with several items on portions (food groups : meat (beef, pork, poultry,...), fish, sea shell & shellfish, eggs, milk & dairy products, oils & fats, vegetables (leafy, roots), fruit, starchy food, 2) on locally-produced food diet (132 items; frequency, portion, duration per year, etc) and 3) on production of cattle, poultry, eggs, milk in the area of the plume. Food consumption was expressed in grams of food products or in grams of lipids of the food products for food from animal origin per day.

To investigate whether living around the incinerator was associated with the elevated blood dioxin, furan and PCB levels, univariate and multivariate analyses were used taking into account the confounding factors (age, gender, background food intake, duration of residence, etc.). All analyses were adjusted for survey sampling weights. We used the log-transformation for blood levels of dioxins furans and PCBs, since the preliminary investigation indicated that serum dioxins, furans and PCBs levels were consistent with a log-normal distribution. SAS, R, and Stata softwares were used for statistical analysis.

## Results and discussion

### Serum concentrations

The geometric adjusted mean serum concentration for the entire population was 13.7 and 13.6 pg TEQ/g lipids for respectively PCDD/Fs and DL-PCBs. For total TEQ the geometric mean concentration was 27.7 pg TEQ/g lipids if expressed in WHO<sub>1998</sub>-TEQ and 18.5 in WHO<sub>2005</sub>-TEQ. Contamination levels in human serum from France reported here was low compared to the previously reported dioxin data from other European countries.<sup>7,8</sup> However our data are more recent and serum levels are known to be decreasing over time.

The geometric means and the factors associated with incinerators were studied after taking into account confounders previously identified: age, BMI, recent body weight change, gender, smoker status, location of the incinerator, background food intake, urbanization, occupation, leisure activity, burning activity (chimney use)<sup>9</sup>.

### Area of exposure

In general, similar geometric means of serum dioxin levels were observed among inhabitants residing in the vicinity of an incinerator and those living in referent areas. This observation is coherent with previous studies, such as in Germany<sup>4</sup> and Spain in the Catalan area.<sup>2,10</sup>

Living in the vicinity of an incinerator could expose to the pollution of the incinerator by inhalation and/or ingestion of local products.

### Exposure by inhalation

We first studied the impact of contamination of the incinerators on residents by inhalation only; we compared dioxin levels between the exposed and non-exposed groups in residents who did not eat any food produced locally. The difference between the two groups was not statistically significant for the total TEQ (27.2 pg TEQ/g lipids [exposed] versus 25.7 [non-exposed]), nor for PCDD/Fs (13.5 pg TEQ/g lipids [exposed] versus 12.9

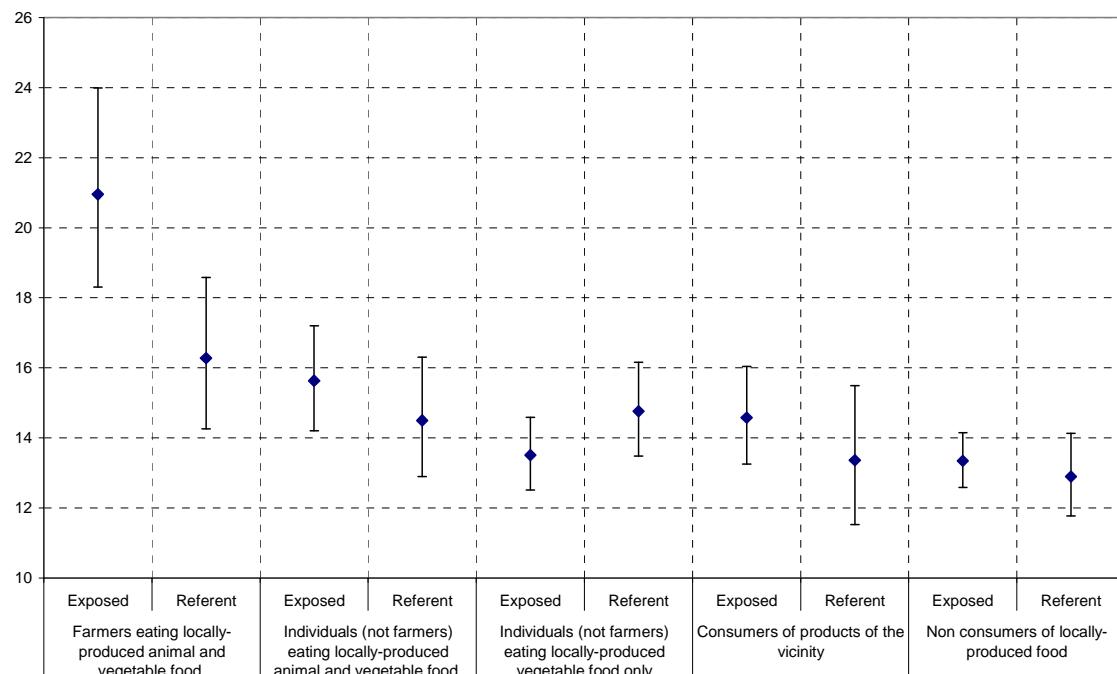
[non-exposed]). Except for occupational or accidental dioxin source, it is admitted by scientists that dioxin exposure by inhalation contributes slightly to the total contribution (approximately 5%). In this case of a point source due to an incinerator, exposure by inhalation seems negligible.

*Exposure by intake of food produced locally*

Secondly, we studied exposure to incinerators due to local food intake. It is worthwhile to underline that the foreign studies which observed similar results between exposed and non-exposed groups, had not taken into account the possible impact of consumption of local products.<sup>1,2,3,4</sup>

Five types of consumers have been defined: Farmers eating locally-produced animal and vegetable food, Individuals (not farmers) eating locally-produced animal and vegetable food, Individuals (not farmers) eating locally-produced vegetable food only, Consumers of products of the vicinity (neighbours, family living under the plume), Non consumers of locally-produced food. In figure 1, the average of PCDD/Fs is presented according to the type of consumers and the exposed and non-exposed areas. The geometric mean for each class of consumer and area of exposure is represented by a lozenge and its precision by a vertical line (IC95%); the vertical axis from 10 to 26 indicates the serum concentrations of PCDD/Fs in pg TEQ/g lipids. The geometric mean of serum dioxin was statistically higher among farmers eating locally-produced food and living around an incinerator than in farmers living in the non-exposed area. For consumers (not farmers) living around incinerators, their PCDD/Fs serum concentrations were on average higher among those eating locally-produced animal and vegetable food than those eating only local vegetables. This is coherent with the lipophilic character of dioxins. The consumption of vegetables does not really increase dioxin levels, since similar geometric mean serum concentrations were observed for consumers of local vegetables and non consumers of local products. The type of incinerator is important; in the exposed areas, no statistical difference in serum dioxin levels between consumers of local animal food and non local consumers was reported for residents living around recent incinerators (respecting environmental directive, < 0,1 ng/Nm<sup>3</sup>), while a difference was reported for residents living around old incinerators.

Figure 1 – Means of PCDD/Fs serum concentrations (in pg TEQ/g lipids) for different types of consumers in exposed and non-exposed areas to an incinerator  
(Geometric means are adjusted on confounders (see above) and presented with CI 95%)



So, as we observed an influence of animal food produced locally, we studied more precisely the quantity eaten of lipids of animal origin produced locally on PCDD/Fs serum levels. The daily average consumption of these lipids was generally low in the concerned consumers (7.7 g of lipids per day from animals produced locally) but could reach higher values punctually. Eight grams of lipids per day separate the level of consumption reached by the quarter of the population defined as lowest consumers of local products (1<sup>st</sup> quartile) and the quarter of the highest consumers (3<sup>rd</sup> quartile). The increase in the consumption per day of one egg or a cup of milk from local origin (which corresponds to 8 grams of lipids) was associated with a moderate increase in the dioxin levels: 6.1% for the inhabitants of the exposed areas and of 3.0% for the non exposed ones. This increase of dioxin levels in people eating local food, particularly animal food, and living around incinerators was recently reported in a Taiwanese study<sup>5</sup> and a Belgian study<sup>6</sup>. Moreover, this increase, although less important than for exposed people, was also observed in our study for people living far from incinerators (non exposed). This result is coherent with contamination of food, already noted in particular for the poultries and eggs, and resulting from family breeding.

**In conclusion**, globally we did not observe any difference in geometric mean serum dioxin levels between the residents living around incinerators and the residents living far from a known source of dioxins. Nevertheless, the analysis of the local consumers shows the influence on serum dioxins of the consumption of local products from animal origin such as dairy products, eggs and more generally lipids. It is important to stress that this influence was observed for old incinerators, but not for the recent ones. Contamination by inhalation seems negligible in regard to dietary intake. In addition, the mean of the French serum dioxin levels is in the average of the European values, and even among the lowest in comparison with less recent studies, probably partly due to the decrease of the dioxin exposure in European populations. The results of this study show a great coherence with what is known in the international scientific studies.

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