DIOXINS EMISSIONS FROM FRENCH CREMATORIA AND ASSOCIATED HEALTH IMPACT ASSESSMENT

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Introduction

Dioxin refers to 210 compounds – 75 polychlorinated dibenzo-p-dioxins (PCDD) and 135 polychlorinated dibenzofurans (PCDF) – with similar structures and properties. Only 17 of the 210 compounds are considered toxic, and these differ considerably in their potency. Toxicity, with respect to carcinogenicity, is commonly expressed in terms of the Toxicity Equivalency Factor (TEF), i.e., relative to the most toxic of the dioxin compounds: 2,3,7,8-tetrachloro-dibenzo-p-dioxin (2,3,7,8-TCDD). Dioxins are unintentional by-products released from a wide range of manufacturing processes including metal smelting, bleaching of paper pulp and the manufacturing of some pesticides. In terms of dioxin release into the air, in France, municipal solid waste incinerators (MSWI) have been the major source for many years. Since 1994, emissions from MSWI have decreased by more than 95% and should reach 20 g TEQ / year in 2006, as the Waste Incineration Directive 2000/76/CE has now entered into force. Moreover, emission reductions have also occurred in iron ore sintering plants which have been the second French major source. Emissions from this category have been divided by six since 1990[1]. As emissions from large sources have considerably decreased, diffusive sources such as crematoria or cupola used in the foundry sector are now taken into account, in terms of global emissions but also and mainly in terms of local impacts.

Cremation is a growing practice in France. In less than 10 years, the number of cremations has increased by 65% (table 1). In 2004, it concerned almost 24% of all funerals in 110 locations. Whereas it exists now 110 crematoria, 150 are expected to be in operation in 2010.

Year	1979	1988	1997	2004
Cremations	4996	25 000	73 024	121 193
Cremations/Funerals %	Unknown	Unknown	14	23,8

Table 1. Cremation rates between 1979 and 2004

Mostly for cultural reasons, French crematoria are small devices, and the average annual number of cremations is around 1,000 cremations / year / crematorium. At the national level, the crematoriums are required to comply with a French regulation (" Arrêté du 29 décembre 2004") published by the French Ministry of Health, which sets emission limit values (ELVs) for the following pollutants : total organic compounds, nitrogen dioxide, carbon monoxide, dust, hydrogen chloride and sulphur dioxide (table 2). Dioxin emissions are not considered under this regulation.

The French High Council of Public Health (Conseil Supérieur d'Hygiène Publique - CSHP), the national competent body for public acting on behalf of the Ministry of Health, is aware of the need to consider every PCDD/F emission sources and therefore required to collect information about dioxin emissions from crematoria. This stresses the importance of a systematic approach to identify emission sources including both an inventory of operating facilities and a measurement programme. In doing so, the gathered data will address both national and international requests (2001 EU strategy on dioxins and PCBs, 2003 OSPAR recommendation) about a dioxin strategy whose aim is to identify, prioritise, monitor and control the dioxins emissions sources.

Pollutants	**Emission limit values (normal conditions, dried gas, 11% O_2)**
Total organic compounds (TOC)	20 mg equ. C/m^3
Nitrogen oxides	700 mg equ. NO_2/m^3
Carbon monoxide	100 mg/m^3
Dust	100 mg/m^3
Hydrogen chloride	100 mg/m^3
Sulphur dioxide	200 mg/m^3
Gas velocity	> 8 m/s

Table 2. ELVs for atmospheric pollutants considered by the French regulation on crematoria

The national programme (2003 – 2005)

A nationwide monitoring program was carried out from March to June 2005. This programme has enabled to measure regulated pollutants with a measurement protocol fitted with French crematoria characteristics as well as two unregulated pollutants, namely dioxins and mercury. This programme was part of a larger study (2003 – 2005) commissioned by funeral and cremation professionals, in order to review the used protocol for measuring emissions. The program was led by the French Technical Centre for Wood and Furniture (CTBA), with technical support of two French institutional laboratories (CETIAT and INERIS) and financial and technical support of the French Agency for Environment and Energy Management (ADEME). The first objective of the study (Phase 1) was to review the protocol for measuring air pollutant emissions from cremations.
Expertise from CETIAT and INERIS was collected to identify major problems encountered due to the application of a non adapted protocol:

- Range measurements of TOC (the calibration of analysers was suitable for one measurement range only)
- Durations of control were not adapted, and were reduced to 80 minutes
- Surrounding pollution due to TOC which was supposed to have an influence was finally not taken into account (as maximum concentration were 2 ppm)
- Measurement platforms do not comply with requirements of the EN 13284-1 standard (grid samplings are not possible).

The suggested protocol was successfully tested on a crematorium site in October 2003. Then the adapted protocol was formally established and enlightened by a guide to the attention of cremation managers. This guide (available upon demand at CTBA) describes:

- The methodology to use for pollutants measurements,
- The uncertainty calculations related to these measurements,
- The recommendations regarding results and reporting.

A guide describing this protocol has been published to assist control laboratories to ensure that best available standards are correctly used specifically in the case of crematoria. This guide has also been developed to assist crematoria operators to achieve their ‘general environmental duty’.

In October 2004, the French High Council of Public Health approved, on behalf of the Ministry of Health, the reviewed protocol, and required:

- To provide scientific and technical support to the development and implementation of the dioxin and mercury measurements.
- To promote the harmonization, comparability of dioxin measurements.
- To provide a forum for the exchange of information through training courses, workshops and conferences.

Results and discussion

The design of this monitoring programme required a preliminary work that consisted in a selection of sampling sites. The criteria used were both the location of the crematorium and the rate of cremations (expressed as number of cremations per year). Air emissions measurements have been achieved on a sample of 10 crematorium units. The map on figure 1 shows the location of all the sites.

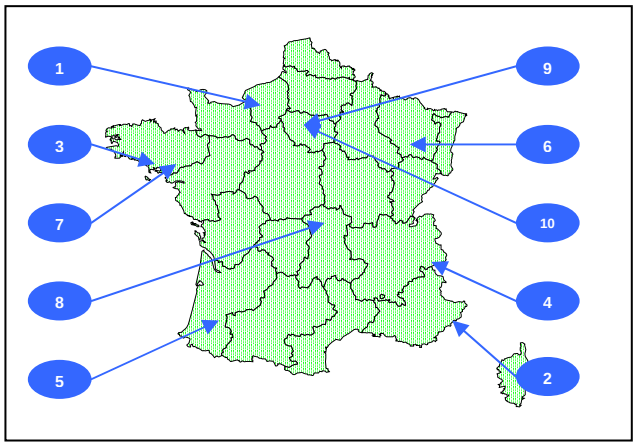

Figure 1. Location of crematoria sites covered by the programme

The study sample contributes to over 15% of the national cremation activity for 2003 (15 082 / 110 000). The monitoring tests were carried out by local teams of two laboratories (Bureau Veritas and LECES/Séchaud Environnement), whose quality assurance programs ensure that data remain accurate and precise. In addition, operators have been supervised by INERIS and CETIAT to control the strict procedure described above. Measurements costs vary according to the type of sample, but range from 1,200€ to 1,500€ for the comprehensive assessment of release from stack. Considering costs, the sample was limited to a number of 10 crematoria located in rural or urban area (two cremations / crematorium).The results are detailed in table 3. This table also reports the results obtained on the first crematorium when the protocol was tested. All these crematoria are equipped with an after-burner which oxidizes organic compounds (minimum temperature 850°C, minimum residential time 2 seconds, at least 6% O_2). No further air pollution control device is used.

Results show that:

- Concentrations generally ranged from 0.1 to less than 1 ng I-TEQ/m³. However, a high concentration of 4.18 ng I-TEQ/m³ was found at one crematorium. This exceptional high emission could not be explained.
- For crematoria, the concentration of dioxins emitted is higher than the ELV for MSWI (0.1 ng I-TEQ /Nm^3).
- Factors that influence dioxin emissions from crematoria could not be identified.

In addition, based on the set of data gathered, an ad'hoc working group asked Vincent Nedellec Consultants to carry out a human health impact assessment for two French crematoria. The impact of crematorium emissions was determined using ADMS3-Industrial Models developed by Cambridge Environmental Research Consultants. Stack parameters and emissions data were collected from the monitoring program described above such as: emission rate of pollutant, stack heights and diameters, effluent velocity, temperature, building dimensions. The model was then run and used to predict the pollution concentrations at near ground level and deposit on the ground. This study evaluated the health impact of major toxic pollutants released from crematoria. Thus it has concerned dioxins as well as CO, dust, Cd, Hg, HCl, SO_2, and NOx. The following pathways of exposure to the general population have been taking into account: atmospheric dispersion to evaluate respiratory effect, accumulation in the food chain to evaluate the human intake via ingestion of food. It has to be noted that in the UNEP document "Dioxin and Furan Inventories" (May 1999), the consensus views on the exposure routes

of dioxins are as follows: “Scientists today agree that the major pathway of human exposure to PCDD/PCDF accounting for >95% of the human intake is via ingestion of food. Uptake of dioxins through water and soil (toddlers), inhalation, and dermal contact are of minor concern.” Considering both pathways for human exposure, the author emphasized that the dioxins released from crematoria represent a tolerable intake and have acceptable consequences.

Crematorium n°	**Cremation per year (2003)**	**PCDD/F concentrations (ng I-TEQ / m^3, dry, 11% O_2)**	**Coffin characteristics**	**Weight (kg)**	**Medical care?**
1	1400	**0.757**	Pine tree Pine tree	n.d. n.d.	n.d. n.d.
2	1200	**0.237**	Tinted pine tree Particle board	>80 >50	No No
3	1600	**0.635**	Tinted fir tree Tinted fir tree	60 90	n.d. n.d.
4	800	**0.12**	Fir tree Fir tree	120 80	No No
5	850	**0.098**	Tinted pine tree Tinted pine tree	90 90	Yes Yes
6	800	**0.183**	Fir tree Tinted pine tree	70 70	Yes Yes
7	1450	**0.276**	Fir tree Fir tree	65 75	No No
8	400	**0.133**	Tinted pine tree Tinted fir tree	80 60	Yes n.d.
9	4600	**4.18**	Tinted pine tree Solid wood	n.d. n.d.	n.d. n.d.
10	1800	**0.331**	Poplar Particle board	100 70	Yes No
11	n.d.	**0.173**	n.d.	n.d.	n.d.

Table 3. PCDD/Fs emissions from 11 French crematoria

Conclusion

The conclusions are based on a restricted number of data. However, dioxins measurements are now included in the annual regulatory control of cremations. The implementation of data collection will allow to strengthen our first conclusions, especially for crematoria located in urban area. This study showed that dioxin emissions from crematoria did not seem to contribute substantially to the overall French air dioxin emissions on the one hand and that crematoria emissions seem to represent a tolerable intake at a local scale on the other hand. Nevertheless, the continuous minimization of POPs releases is still a long term objective, in line with the Stockholm Convention article 5 objectives. Hence, the next step is to explore fair solutions to reduce emissions from existing crematoria according to their environmental impact and to techno-economical aspects (linked with their respective capacity). As such a decision considers possible global gas cleaning devices for crematoria, the study have also addressed emissions of mercury. Hg emissions were measured from 20 cremations. The measurements showed great variations from a cremation to another. An average emission of 2.0 g Hg per cremation was considered.

References

1. Beguier S. In: *Proceedings of the ADEME French national symposium on dioxins and POPs (10-11 march 2004)*, ADEME (ed.), Angers, 2004:4883.