# INCINERATION OF HOUSEHOLD WASTE AND HEALTH RISKS

## The current state of knowledge

Novergie
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# Contents




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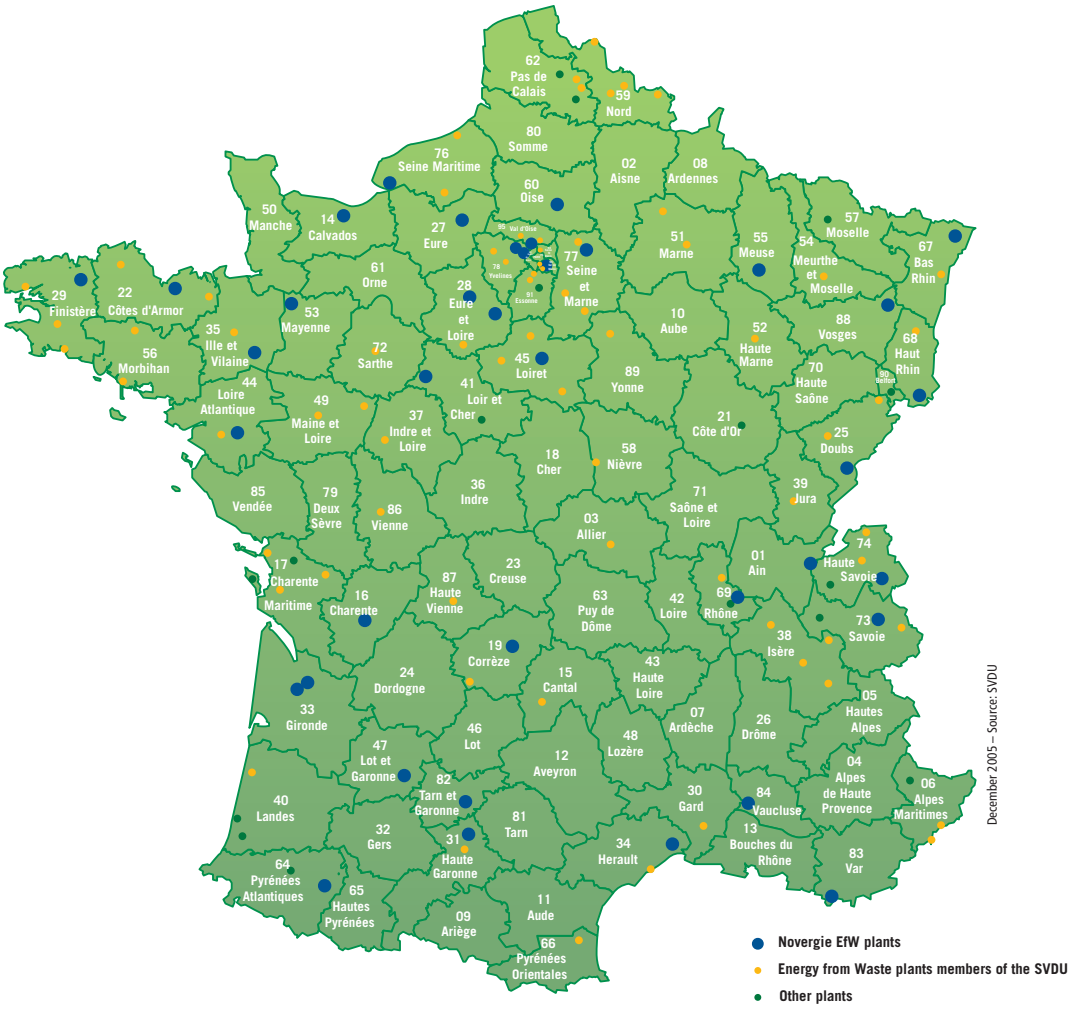
# Introduction

*France has the largest pool of Energy from Waste (EfW) plants in the European Union and yet awareness about the impact of environmental emissions from these installations has been late in developing compared with the other European countries, allowing, until the middle of the nineties, situations to develop that have contributed to giving incineration a negative image. This image has a tendency to persist, even if the conditions that gave rise to it now mainly belong to the past. Since this time, obsolete units have been closed and the pool of EfW plants has shrunk from 300 units in 1998 to 130 at the end of 2005.*

*The strictest European limit values on emissions have been applied in France, thus reducing by a factor of 5 dioxin emissions due to incineration in just a few years. At the same time, regular monitoring of the environmental impact of installations has been set up.*

*Over this period, several scientific analyses have been published. For the main part, they remain prudent about the past impact of incinerators — mainly due to the lack of data about the history of discharges — but relatively confident in the new generation of EfW plants.*

*We thought it useful to propose a summary of these scientific studies here in order to provide all the stakeholders with information for assessing risks.*




# Incineration of household waste: recent scientific publications

**Summary of the main scientific publications from 2003 to 2006, illustrating the progress made in knowledge about the relationships between household waste incineration and public health.**

## Publications in 2003

### Study of a cluster of non-Hodgkins lymphomas around the Besançon EfW plant

In 2000, J.-F. Viel published a study [2] of a cluster of cases of cancer (soft tissue sarcomas and non Hodgkins lymphomas (NHL) in the Doubs department, near the municipal EfW plant. The risk of developing a sarcoma or a NHL was respectively 1.44 and 1.27 greater than that of a reference population. In the past, studies have linked NHLs with exposure to dioxins. Therefore, the question of a link with the EfW plant was posed, all the more so because the EfW plant's emissions were 150 times greater than the current standard that has been in effect since the end of 2005.

In 2003, a further publication completed this data [3]. The surroundings of the EfW plant were divided up into 4 exposure areas using a modelling technique. The system used for the modelling is known as a first generation system. It is not very sophisticated, but it can be used to estimate the dioxins falling on the ground as a function of the meteorological parameters and the height of the unit's chimney. Each case of NHL was matched with 10 control cases of healthy subjects selected at random in the region. This study estimated that the risk of developing an NHL was 2.3 times greater for the populations living in the area of greatest exposure than for the least exposed populations. Conversely, a study published in 2004 by the same team did not find the same association for the soft tissue sarcomas [4].

### Validation study by N. Foret and J.-F. Viel (March 2006)

In March 2006, the same team published a study [5] with the objective of validating the exposure hypotheses by measuring the concentrations of dioxins in 75 samples of soil taken in the different exposure areas. The results were discordant: though the dispersal model gave good predictions of the concentrations of dioxins in the areas where the topography was simple (North-East of the incinerator), it heavily overestimated the concentrations in the areas with more complex topography (South-East of the incinerator), in particular in the areas with the greatest exposure.

# Publications in 2004

## Prevention and Precautions Committee Report [6]

In 2003, following the publication of the study by N. Floret and J.-F. Viel, the Ministry of Ecology and Sustainable Development (MEDD) referred the matter to the Prevention and Precautions Committee (CPP). The Minister at the time wanted the CPP, after examining the matter, to issue recommendations on the behaviour to adopt vis-à-vis the EfW plants in operation.

The CPP is a body of the MEDD council, created in 1996 on the initiative of Mme Lepage. Chaired by Professor Alain Grimfeld, it includes doctors, scientists and experts specialising in health problems linked with the environment (toxicologists, epidemiologists, physicists, chemists, economists, lawyers and sociologists).

In its statement issued in December 2004, the CPP, noting that the regulation of emissions of pollutants by EfW plants is increasingly strict, considered that overall ***"the current and future impact of incineration seems to be under control but there remain uncertainties that need to be resolved"***, in particular concerning the past emissions of relatively high levels of dioxins.

Basing itself on the conclusions of a report published in 1999 by the Société Française de Santé Publique (French Public Health Society) [7], the CPP admits that the respect of the current regulations should lead to zero risk for the health of people residing near EfW plants, under the hypothesis where there is an action threshold for the carcinogenic effect of dioxins. Under the opposite hypothesis of the absence of a threshold, it considers that the work carried out to date concludes that there is a very low additional risk, that it qualifies as negligible.

**For the CPP, the current issues concerning incineration can be summarised in 6 points:**

- **Promoting a prevention policy to halt the increase in the volume of waste.**
- **Applying and getting others to apply the regulations and improving them:**
  - **by limiting the instantaneous flow rates of discharges and specifying the concentrations that must not be exceeded in the environment.**
  - **by strengthening the training and qualification conditions for people operating EfW plants (as in the chemical and nuclear industries).**
- **Improving the assessment conditions by developing research efforts on the Toxicological Reference Values (TRV), transfer and exposure models.**
- **Developing the monitoring of EfW plants:**
  - **by determining the variable factors in the operation of EfW plants and their consequences on discharge levels. Note in particular that "semi-continuous measurements over relatively short periods should be coupled with measurements over long periods to better approach the variability in the discharges' pollutant contents".**
  - **by strengthening environmental monitoring near the installations.**
  - **by strengthening the monitoring of the installations' workers.**
- **Promoting a procedure for optimising waste streams.**
- **Promoting an ambitious participative policy of informing the public and raising its awareness.**

# Publications in 2005

## Afssa: assessment of the French population's exposure to dioxins and PCBs [8]

In June 2000, the Agence Française de Sécurité Sanitaire des Aliments (French Food Safety Agency) (Afssa), published the first assessment of the French population's exposure to dioxins and furans in food (the so called "dioxin-like" PCBs were not part of this study). This assessment was based on food contamination data collected between 1996 and 1998.

In 2005, this study was updated on the basis of samples taken between 2002 and 2004. This new study provided very valuable data on the changes to the levels of exposure of the French over the last few years. It also lets us compare the French population's exposure to those of the populations in other European countries and compare the average exposure doses to the permissible daily dose [9]. Furthermore, it completed the 2000 study by this time including the "dioxin-like" PCBs.

**The main results of the exposure study were as follows:**

- **Large reduction, of almost 60%, in the food exposure to PCDD/F in France between 2000 and 2006. This reduction is in part linked to the reduction in the atmospheric emissions of dioxins.**
- **The French population's exposure is in the same order of magnitude as those of the populations of other European countries for which we have recent studies (2004): Spain, Finland, United Kingdom and the Netherlands.**
- **The French population's average exposure is 1.8 pg TEQ / kg p.c. / d for adults and 2.8 for children. The total food exposure levels of the French population calculated for the PCDD/F and the PCB-DL over a whole lifetime are lower than the threshold set by the JEFCA (joint FAO/WHO Expert Committee on Food Additives). However, for 28% of the population, the exposure exceeds this threshold.**
- **The main contributing foodstuffs are marine products and milk products; meat products only contribute 8% of the total.**
- **The PCB-DLs, substances, very little of which are produced by EfW plants, represent almost 70% of this total.**

**The opinion given by the Afssa highlights the following assessments and recommendations:**

- **Given our current knowledge of the continuous decrease in exposures, the cases of exceeding the daily permissible dose for a fraction of the French population do not constitute a worrying situation in terms of public health. Nevertheless, the efforts to reduce the exposure should be continued.**
- **The decrease in discharges from EfW plants should contribute to further decreasing the exposure. However, the scattered sources (bonfires, ...) are difficult to control and make up a persistent background noise.**

# Publications in 2005

## Afssa: assessment of the French population's exposure to dioxins and PCBs

- **Recommendations:**

- **Continue with the monitoring of the contamination of foodstuffs by the PCDD/Fs, PCB-DLs and widen this monitoring to other Persistent Organic Pollutants.**
- **Collect monitoring data in the environment.**
- **Set target values for PCDD/Fs and PCB-DLs in human and animal food at community level.**
- **Develop the research on the biomarkers of effects (impact on health at low doses).**
- **Develop research programmes on the environmental origins of cases of exceeding the contents in PCDD/Fs and PCB-DLs.**

# Publications in 2005

## Académie de Médecine Report [10]

For the Académie de Médecine, the effect of the closure of obsolete EfW plants and the application of the emission standards has been to considerably reduce the emissions of dioxins linked with incineration [11]. These have been cut by a factor of almost 5 in 7 years, falling from 1,090 g annually in 1995 to 212 g in 2002. The forecast is that with the application of the European standards (2005), these emissions will be cut by a factor of 10 in the next 7 years, and will be located around 20 g in 2007. Thus, the EfW plants in France see their contribution to the dioxin emissions in France falling strongly. On this subject, the Afssa also considers that "bringing all of the EfW plants up to the European standards should continue to contribute to the decrease in emissions; the part attributable to the scattered sources (burning in open air, forest fires, bonfires, etc.) will become preponderant in terms of source of art contamination".

**Risks linked to dioxins: dose-effect relationship.** This relationship, along with the assessment of the population's exposure, is at the heart of all the environmental health questions. It is studied on laboratory animals. Yet, there are great inter-species disparities in terms of the sensitivity to dioxins (for example, at the same contamination doses, guinea pigs are 500 times more sensitive than hamsters). The Académie de Médecine considers that the modelling from animals to humans is still problematic and that extrapolations from animal tests should be handled with the greatest caution. It warns against using effects obtained on experimentally contaminated animals for denouncing the pathological effects on humans.

# Publications in 2005

## Report from the Académie de Médecine

**For the Académie de Médecine, "while there is no such thing as zero risk, the potential danger to health of dioxins seems today to be negligible at the permissible daily doses as they are defined by the European and international health authorities".**

Nevertheless, dioxins are still perceived as dangerous by the population because of their eco-toxicological properties. Due to this, they crystallise the anxieties of a contemporary society, which demands 100 % safety guarantees whereas science can never provide this. The media treatment of dioxins has increased the fears of many because it is difficult to match the scientific approaches with the psychological, sociological; and cultural behaviour of the population.

However, it is important not to let a climate of fear and confusion persist in the face of peremptory assertions about the risk of dioxins to human health and the future of the human race even though these fears are still expressed today by reference to well known catastrophes, Seveso [12] in particular, or to first generation EfW plants that have been dismantled. The second generation EfW plants, duly inspected and judged technically acceptable by the European and International health authorities, cannot, in the current state of knowledge and for the majority of experts, be the source of risks that could harm the health of the population.

# Publications in 2006

## InVS/Afssa assimilation and epidemiological study

In the context of the National Plan for Mobilising against Cancer, the Institut de Veille Sanitaire (Health Monitoring Institute) (InVS), in collaboration with the Agence Française de Sécurité Sanitaire des Aliments (French Food Safety Agency) (Afssa), launched a national study related to the assimilation of 3 substances by populations living near EfW plants. The objectives of this study, the first of its kind in France, were the following:

- To measure the assimilation by the French population of three substances: dioxins, lead and cadmium.
- To measure the impact of EfW plant emissions on the assimilation by populations. To allow for a comparison, populations living near several types of EfW plants were chosen according to the units ages — old or new generation — and their treatment capacities (less or more than 6 tonnes/hour).

# Publications in 2006

## InVS/Afssa assimilation study and epidemiological study

Eight sites were chosen: Pluzenet (22), Gilly sur Isère (73), Dijon (21), Cluny (71), Bessière (31), Vaux-Le-Penil (77), Fécamp (76) and Maubeuge (59).

The study was carried out on populations living within the range of influence of the EfW plant and on control populations, at a distance from the plants. All the subjects were volunteers chosen at random.

A blood sample was taken from each subject in order to measure the dioxins and the lead. A urine sample was used to measure the cadmium. They were all also precisely questioned about their dietary habits and their working and living environments.

At the same time, an epidemiological study was set up in the four departments where there is a Cancer Register: Haut-Rhin, Bas-Rhin, Isère and Tarn. This study looked at the health impact of old installations operating in the 70-80s. Its objective was to determine the increased risk of cancer (i.e. the frequency of the occurrence of new cases) linked to the past exposure to EfW plants. Each case of cancer listed in the registers was geographically positioned according to three categories: the whole population, unexposed population and population exposed to an EfW plant. A cohort of 400,000 people was thus built up.

**• Results:**

**The *"assimilation"* study showed that the levels of dioxins measured today in the blood of people living in near EfW plants are not higher, statistically, than those of unexposed people. However there was one exception, the specific population of farmers who consumed local animal products (meat, milk products and eggs) living near old EfW plants, who had higher dioxin levels, statistically, than the unexposed people. This difference is not found again near EfW plants conforming to the new European standards.**

**The *"Cancers"* study showed up a statistical link (exposure / risk relationship) between the fact of having lived under the plume of old EfW plants (operating between 1972 and 1985) and the occurrence of certain cancers in the 90s. This link results in a low but significant increase in risk.**

**The interpretation of this data still needs to be studied in depth. We should point out, in particular, that even though this study shows up a statistical link between a former residents near an EfW plant and the occurrence of certain cancers, it does not in itself mean that anyone can affirm a link of causality between the two events.**

**The InVS emphasises report that this statistical link found in the study *"reflects a situation of past exposure (70s to 80s), very different from the current situation, because today's EfW plants are better inspected and less polluting. The result of the assimilation study, which reflects more recent exposure (90s and 2000), illustrate this improvement"*.**

# Incineration of household waste: health risks assessment

## Tools available

**Over the last 10 years or so, several approaches have been developed for better assessing the possible health impacts of emissions, linked in particular to dioxins and to Persistent Organic Pollutants, POPs.**

**The epidemiological studies**

Epidemiology looks at the state of health of a population. It describes the frequency in the distribution of illnesses and mortality in time and space. It can also study the role of factors that determine that distribution (for example, exposure to pollutants).

The epidemiological studies called "incidence" studies, which aimed to determine the frequency of the occurrence of new cases of an illness in a population, take a long time to perform and require the existence of a register of the illness in the population studied, to be used as a comparator. The quality of the data collected, which must attempt to be exhaustive, is a determining factor. These methodological difficulties explain why epidemiological studies are not carried out as a routine. Furthermore, these studies look at the effects of exposure on health and are therefore not designed as forecasting tools.

**The health risk assessment studies (HRA)**

The health risk assessment studies work schematically in the opposite direction of an epidemiological study. Their starting point is the assessment of the exposure of populations to chemical substances discharged by an industrial installation. If you know the dose-effect relationships of these substances [1], you can assess the health risk posed to the populations exposed. You can measure the atmospheric fallout using pre-positioned sensors (gauges, lichens), and the pollutant contents of soils, foodstuffs, etc.

**Bio-monitoring studies in human populations**

Many studies have been made of the level of assimilation of dioxins in the populations living near EfW plants and in their workers. They are the subject of a collective summary in an InVS-Afssa document *"exposition aux dioxines de la population générale vivant à proximité des UIOM. Etat des connaissances et protocole d'une étude d'exposition"* (exposure to dioxins of the general population living near EfW plants. Current state of knowledge and protocol for an exposure of study). In the great majority of cases, it did not find a significant difference in comparison to the unexposed populations.

This type of approach has not been developed much in France up till now, but is part of the InVS-Afssa dioxin assimilation study whose results were published at the end of 2006.

# Definition and principles of a health risk assessment study (HRA)

**The assessment of health risks made within the context of an impact study is a decision-making support tool for the authorities responsible for authorisations. As such, it is an integral part of the 1976 law and its later modifications relating to classified installations.**

**The health impact study covers all of the installation's discharges when it is operating normally and estimates their consequences on the human health of the neighbouring populations. Thus, for different reasons, the risks to the flora and fauna, the risks to the employees and the health risks in an accident situation are excluded from the scope of this particular procedure. In practice, the health risk assessment takes an approach that allows it to structure all the available knowledge, necessarily interspersed with a number of uncertainties that are clearly pointed out by the assessor.**

**At European level, the health risk assessment procedure has been developed and imposed within the regulatory framework for any new installation in France, but not in the other countries where it remains applicable in particular situations, like in Belgium for example.**

## Stages of the HRA

### • Characterisation of the site and its environment

The first stage in the HRA procedure is based on an inventory, as complete as possible, of the substances emitted in the discharges identified, without these being limited to the regulated substances. This stage results in the selection of "health risk tracers", meaning the substances for which quantitative assessments of the health risks will be carried out, because they can be used as representative indicators of the overall impact. This choice is mainly based on the criteria of toxicity and quantities emitted. Other criteria such as persistence in the environment or the sensitivity of populations can also be important.

### • Identification of the dose-response relationship

The objective of the second stage in the HRA is to identify the dangers [13] associated with the substances discharged and the quantitative relationship between the dose administered and the incidence of the deleterious effect, for each health risk tracer, as a function of the appropriate channels and times of exposure.

### • Characterisation of the exposures

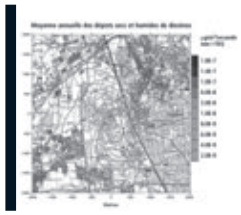
The characterisation of the exposures of neighbouring populations is done by elaborating exposure scenarios based, for each channel of exposure, on notions of frequency and dura-

tion. Daily inhaled and/or ingested exposure doses are calculated. Knowledge of the installation and its neighbourhood is needed as well as command of the modelling tools.

To determine the exposures, measuring and/or modelling are used, which are two complementary approaches.

From a practical point of view, the assessment of exposure to a substance is based on two complementary methods:

• Metrology (or measurement) is used to assess, at a given time, the level of contamination of the site, taking into account the discharges due to the industrial installation and those coming from other sources. Depending on the substances, whether they are persistent or not, and whether they can accumulate in different environments, these measurements reflect a more or less recent contamination.



• Modelling uses computer programs to reconstitute the dispersal of pollutants emitted by a source (for example, a chimney), taking into account their nature and quantities emitted as well as the site's environmental contacts (climatology, geology, etc.). The programs calculate the concentrations in the environments exposed: air, soils and foodstuffs mainly. Modelling is used to assess the impact of installation alone, its future operation and to give some information for assessing its past impact.

### • Quantification of health risks

The health risks are quantified by synthesising the information about the dangers linked to the substances emitted and the results of the characterisation of the exposure of neighbouring populations to these substances. In this final stage, the uncertainties and hypotheses made must always be recalled and discussed in order to accompany the conclusions submitted to the operator and the decision-makers.

## Principles of the HRA

The four main principles that have to be respected during a health risk assessment procedure are the following:

• **The principle of scientific caution**
in the absence of data, reasonable upper bound hypotheses are defined for each case studied.

• **The principle of proportionality**
(circular dated the 3rd of December 1993): this is a question of checking the consistency between the degree of depth of the study and the importance of the possible effects.

• **The principle of specificity**
(circular dated the 3rd of December 1993): the pertinence of the study in relation to the site's use and characteristics is fundamental.

• **The principle of transparency**
the choices made must be consistent and explained by the assessor. We can also mention traceability.

# Conclusion

In a few years, France has made considerable progress in the management of the health impact of its pool of EfW plants and has become one of the leading countries in this field, along with the United States, Canada and Sweden. In particular, France is the only European country that has set up a strict regulatory framework imposing health risk assessments (HRA) for all new EfW plants.

The HRAs provide precious data about any impact of an installation on the health of people living near it. They are long studies that require several months of data collection and analysis by experts. These studies form an integral part of the authorisation request files submitted to the Prefecture for new installations and are presented in the form of summaries to the local information and monitoring (CLIS) for existing installations.

In the case of new sites, the HRAs assess the initial state of the site's environment, evaluate the acceptability of the installation and formulate recommendations on the matter of environmental monitoring. They constitute an extremely useful reference point that helps us to perfect our knowledge of the health impacts of incineration and keep a continuous watch on emerging subjects.

In the case of existing sites, these studies provide better knowledge of the installation's history and may enable us to improve the environmental monitoring already set up. In the last analysis, it is the environmental monitoring that is the guarantor of the installation's acceptability.

# Notes

(1) Ever since Paraclesus, we have got used to saying "nothing is poisonous and everything is poisonous, it is the dose that make it poisonous". We now know that this maxim is not altogether true because certain toxins exercise their deleterious effects at infinitesimally small doses and not at large doses. Nevertheless, it seems to us that it very clearly expresses the central place that doses-effects relationships occupy in the questions of environmental health. The dose-effect relationships are used to define the Toxicological Reference Values or TRV for each substance, i.e. in a grossly simplified way, the exposure levels that must not be exceeded. These TRVs can be expressed in the form of Permissible Daily Doses (PDD) for products that only become toxic after a certain dose (threshold) or Unitary Excess Risk (UER) for carcinogenic substances that are toxic from the first molecule (with no threshold).

- LThe UER of a substance is the additional probability of developing cancer due to a lifetime exposure to 1 µg of that substance. We calculate an Individual Excess Risk (IER) by multiplying the UER by an individual's concentration of exposure. An IER is said to be acceptable if it is less than the reference value of one additional case of cancer for 100,000 individuals exposed.
- For the toxins with thresholds, we calculate a Risk Index (RI). The RI is the ratio between the exposure dose and the PDD. When it is less than the reference value of 1, there is no worrying health risk.

(2) Viel JF, Arveux P, Baverel J , Cahn JY.
Soft-tissue sarcoma and non-Hodgkin's lymphoma clusters around a municipal solid waste incinerator with high dioxin emission levels. Am J Epidemiol 2000 ;152:13-19.

(3) Floret N, Mauny F, Challier B, Arveux P, Cahn JY, Viel JF.
Dioxin emissions from a solid waste incinerator and risk of non-Hodgkin lymphoma. Epidemiology 2003 ; 14 :392-398.

(4) Floret N et al. Dioxin emissions and soft-tissue sarcoma: results of a population-based case control study. Rev Epidemiol Sante Publique. 2004.

(5) N Floret, JF Viel et al. dispersion modelling as a dioxin exposure indicator in the vicinity of a municipal solid waste incinerator: a validation study » . Environ. Sci. Technol. March 2006.

(6) Les incinérateurs d'ordures ménagères: quels risques ?, quelle politique? CPP, December 2004.

(7) Incinération et Santé Publique. SFSP - 1999.

(8) Dioxines, furannes et PCB de type dioxine: évaluation de l'exposition de la population française. Nov. 2005.

(9) In 2001, the JECFA (Joint FAO/WHO Expert Committee on Food Additives) set the permissible daily dose (PDD) for PCDD / furans and dioxin like PCBs at 2.33 pg TEQ/ kg p.c. /d.

(10) Dioxins and Health. Report on behalf of the XIII committee (Public Health – Epidemiology – Environment). Pierre Pène and André Aurengo. Report adopted unanimously on the 28/6/2005.

(11) Source: Centre Interprofessionnel Technique d'Etudes de la Pollution Atmosphérique (CITEPA).

(12) In 1976, the explosion of a chemicals factory at Seveso in Italy, caused the discharge of several kilos of dioxins into the atmosphere. Tens of thousands of people were contaminated, some of them massively. In the report 20 years later, Pier Alberto Bertazzi, one of the epidemiologists most involved in the study of the consequences of the accident, noted a slight increase in mortality from all types of cancers and from lung cancer in men but not in women. This difference between the sexes led some experts (A. Smith, Am J Epi 2001) to bring up the role of a confusion factor, tobacco, in the occurrence of cancers. In addition, an increase in the cases of lymphomas (x 2.8 in relation to the general population), an increase in the cases of endometriosis and an inversion of the sex ratio in children were observed. The Académie de Médecine stresses that these results cover limited population samples and that there is no consensus in the scientific community about their interpretation. It also mentions a feature article published in 2003 by Philip Cole, Professor of Biology at Johns Hopkins University (Regulatory toxicology and pharmacology. Dec 2003), that shows, on the basis of recent data, that dioxins are not very or not at all carcinogenic in the context of a general exposure of the population to a low dose.

(13) We need to differentiate between two distinct notions: danger and risk.

- **Danger** is a **qualitative** notion. We say that a substance is dangerous when it is capable of causing an undesirable health effect in people exposed to it; ex.: benzene can cause leukaemia in people exposed to it chronically.
- **Risk** is a **quantitative** notion. It is the probability of just such a secondary effect occurring under given exposure conditions; ex.: a "lifetime" exposure to air contaminated by benzene at the concentration of 1µg/m3 leads to an increase in the risk of leukaemia of about 6 cases per million individuals.

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