Environmental Health

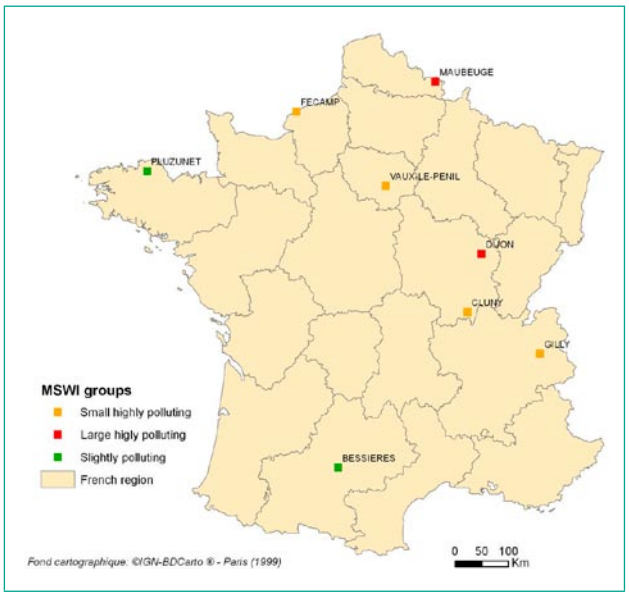
The French dioxin and incinerators study

The National Institute for Public Health Surveillance (*Institut de veille sanitaire, InVS*) in collaboration with the French Food Safety Agency (*Agence française de sécurité sanitaire des aliments, Afssa*) conducted a national study on serum dioxins and PCB levels in the population. This study commissioned by the Ministry of Health was financed by the Cancer plan. Its main objective was to clarify whether people living around municipal solid waste incinerators (MSWI) had higher levels than those who lived far from a MSWI, and to assess how food produced locally contributed to this exposure (InVS, Afssa 2003). The second objective of this study was the assessment of lead and cadmium exposure in these populations, as incinerators also reject these metals in the environment.

Method

The study is multicentric and concerns eight sites located near MSWI spread throughout several French districts: Bessières (31), Cluny (71), Dijon (21), Gilly-sur-Isère (73), Maubeuge (59), Pluzunet (22), Senneville-sur-Fécamp (76) and Vaux-le-Pénil (77). These eight sites were chosen after an inventory of French MSWI, classified by operating characteristics, existence of both emission and food contamination data, and presence of local products consumers. These eight sites correspond to three categories of MSWI:

- small and old MSWI (≤ 6 tons/h) polluting heavily in the past;
- large and old MSWI (> 6 tons/h) strongly or moderately polluting in the past and;
- large and recent MSWI having complied with current emission regulation.



The identification of the study area near MSWI was obtained by modeling atmospheric dispersion plumes by Afssa and Aria Technologie, with the contribution from Inéris, and from surface deposits accumulated from 1994 to 2004. Some areas not exposed to the plume were also selected to compare chemical levels between people who were exposed and those who were not exposed. A total of forty communes were thus selected.

The study focused on 1,053 adults aged 30 to 65 years who were included from a two-degree stratified random sample (including 1,030 participants used in the dioxins and PCBs study, 1,029 in the blood-lead levels study and 1,033 for urinary cadmium levels). The field study was conducted from February to June 2005 and was implemented by the InVS department of environmental health, and coordinated locally by the Inter-regional Epidemiology Cells (Cire, regional branches of InVS). A first check of inclusion and exclusion criteria in the population (such as age, lack of occupational exposure) for persons living in study areas was conducted by telephone contact; the list of people and their addresses were obtained from municipal electoral lists and from France Telecom data. The overall participation rate is 51% (participants randomly selected who are reachable and meet inclusion criteria), which represents a very good rate compared to other similar studies.

For each site, about 130 people were included. They had resided in the study area for at least 10 years (at least for old household waste incineration plants), were not occupationally exposed to dioxins, lead, cadmium, and as regards women, they had not breastfed during the last 15 years (or very little). The groups studied were composed of:

- people living in the impact area of the incinerator plume:
  a) eating food produced locally (poultry, cattle, eggs, milk, vegetables…), i.e. foodborne and air exposures;
  b) with no consumption of locally produced food, i.e. air exposure only;
- people (consumers or not of local food products), living beyond 20 km of any incinerator and not exposed to known sources of dioxins ('unexposed area'), for each site; unexposed persons were included in order to take into account specific local conditions that may have an impact on the usual exposure, excluding the possible influence of incineration: 'background contamination for frequent food products, dietary habits.

Prior agreements from the French Data Protection Authority (Cnil) and the Consultative Committee for the Protection of Persons involved in Biomedical Research (CCPPRB) were obtained for this study. Participants were invited by mail and by telephone to attend a personal interview, in a place close to their home. A face-to-face questionnaire was administered to collect socio-demographic data

as well as data on their food habits (usual consumption and local products), on occupational exposure, and on environment. One of the strengths of this study was to assess the food consumption of participants with as much detail as possible. A blood sample was taken by the staff of the French Blood Agency in order to determine the body's most toxic dioxins (a mixture of 17 substances, PCDD/Fs), PCBs (polychlorinated biphenyls, other persistent substances often associated with dioxins: 12 PCBs called "dioxin-like" (DL-PCBs) which have the same biological mechanisms of action as dioxins) and four PCBs (118, 138, 153, 180), called indicators) and blood lead levels. A urine sample was also collected in order to measure cadmium, a metal other than lead that may be emitted by incinerators. The results of dioxins are generally expressed in TEQ picograms per gram of fat (pg TEQ_{98}/g fat), the TEQ, international toxic equivalent, is an index which summarizes in a single value contamination of the mixture; it is the sum of each substance concentration in the mixture multiplied by its toxic equivalency factor (TEF). A picogram (pg) is 10^{-12}g.

To study whether the fact of living near an incinerator was associated with increased serum concentrations of dioxins and PCBs, and metals, univariate and multivariate analyses (crossing several data) were used. The statistical analysis was performed with SAS software, R and Stata. As a first step, the confrontation of personal characteristics (age, sex, body mass index (BMI)...) or lifestyle habits (smoking, dietary habits…) with blood (or urinary) levels contributed to identifying their influence, and thus to isolate the role of risk factors related to the environment of the MSWI and to the consumption of local products. Data on dioxins and metals, which have an asymmetrical statistical distribution in the population, were described in terms of geometric mean, rather than in terms of arithmetic mean, the latter may be affected by extreme values.

Population

The study population was around 52 years of age and included 54.7% of women. For residents living close to MSWI, the median distance from the place of residence to the plant was 2.2 km. The length of residency under the impact area of the plume of the incinerator was at least 18 years for more than 50% of people, depending on the sites because of widely varying operational periods of incinerators. The populations of both areas of study (exposed and unexposed) were comparable for socio-demographic data (age, sex, education level, marital status), and smoking habits. Nevertheless, people from unexposed area more often lived in rural areas, which resulted from the will to select locations far from any source of dioxin emissions. This population included more farmers and owned more often a vegetable garden.

Food consumption

Overall, the food products eaten not obtained from local production were very similar between the two areas. It was particularly the case for animal products, and therefore for fat of animal origin, which is known to be the main contributor to PCDD/F exposure, lipophilic substances accumulating in the animal food chains. The quantities of food and fat consumed were very consistent with those observed during the pilot study and a little higher than those found in the national study INCA1 (Volatier, 2000). The objective of targeting sites where the consumption of local products was sufficiently frequent has been reached, since over 83% of participants consumed local products and nearly 68% of participants consumed products from their own production. This local consumption concerned mainly vegetables and fruits (respectively 70.1% and 66.6% of consumers), but also animal products (meat, eggs, dairy products), mainly eggs and poultry (respectively 34.8% and 28.8% of consumers). The proportion of those consuming animal products of local origin, and thus fat of animal origin, was higher in unexposed areas than in exposed ones, especially in rural sites with a predominant presence of farmers. However, the quantity of animal fat of local origin consumed remained low compared to the total amount consumed daily (averaging about 8 grams versus approximately 100 grams).

Blood dioxin levels

Serum levels of dioxins and PCBs in the study population

The values of dioxins observed in this study were similar to those of other European countries. The average serum concentration of dioxins and "dioxin-like" PCBs (PCDD/Fs + DL-PCBs: total TEQ) estimated in the study population was 27.7 pg TEQ_{1998}/g fat expressed with the 1998 TEF, whereas it reached only 18.5 pg TEQ_{2005}/g. fat with the new 2005 TEF, since the toxicity of certain substances has been revised downwards. The PCDDs accounted for 56% of PCDD/Fs and DL-PCBs 51% of the total TEQ. Congeners profiles (concentrations of each substance in the mixture) were similar inside each exposure area and study site, and therefore did not allow to identify an incinerator with a particular emission. The characteristics of people with the highest values of dioxins and PCBs indicated that these people were older, often overweight, were more often men and consumed fishery products to a greater extent than the average (the coastal site of Senneville-sur-Fécamp was overrepresented). The exposure area did not seem to be a determining factor. These high levels remained below those seen in highly exposed populations such as fishermen in the Baltic sea (Kirivanta *et al.* 2002).

Factors that influence the dioxin and PCB levels regardless of MSWI

The participants' personal characteristics had a main role on dioxins and PCBs concentrations. Those which significantly influenced dioxins and PCBs were age, sex, body mass index, recent fluctuation of weight, smoking status, current socio-economic group and geographical location. The serum dioxin levels increased with age, 10% every 5 years for PCDD/Fs, representing an average increase of about 0.3 PCDD/Fs pg TEQ/g of fat per year of age; this result was also found in a recent American study (Collins *et al.* 2006). It is known that these substances accumulate in the body over time, especially in fats. The serum levels also increased with the body mass index (slower elimination of dioxins), a recent loss of weight and it was higher among women and non-smokers (relationship a little surprising but well known, Garabrant *et al.* 2007).

Other exposure factors unrelated to the incinerator could affect dioxins and PCBs: the presence of an open fireplace or a wooden stove in the house, the practice of a leisure activity likely to expose to dioxins, urbanization (downtown, suburb, rural) and the consumption of certain non locally produced food products under the plume of the incinerator. Domestic burning of wood being a well known source of dioxins, it was not surprising to observe slightly higher serum levels of dioxins in people with an open fireplace or wooden stove at home. The serum

levels increased with the usual consumption of certain foods from animal origin (offal, seafood, dairy products). However, consumption of major food groups which vehicle dioxins in food, such as fish, seafood and dairy products, was only partly related to serum levels. The consumption of seafood was correlated with the serum dioxin levels only in coastal districts (Pluzunet and Senneville-sur-Fécamp).

Factors associated with MSWI

Area and duration of exposure

Serum dioxin levels were not statistically higher in populations living in the impact area of the plume of MSWI compared to those of unexposed populations. Moreover, serum dioxins levels were not associated with the length of residency under the plume nor with the accumulated deposits in the area of the plume, or with the distance to the plant, except for farmers in whom serum dioxin levels increased with the proximity of residence to an incineration plant, and also with the duration of residence under the plume. Similar levels of dioxins were observed in our study between exposed and unexposed areas, which was consistent with results of various foreign studies; those studies did not take into account local consumption and concluded that living around a MSWI had little influence on serum concentrations of dioxins in residents (Evans 2000, Schumacher 1999, Deml 1996, Gonzalez 1998). However, the lowest averages of serum dioxin levels were observed at Bessières and Pluzunet, both sites corresponding to incinerators which have respected environmental regulation. The highest average of serum dioxin levels was observed for the Senneville-sur-Fécamp site, in both exposed and unexposed areas; this seems to show that the impact of seafood consumption on serum dioxin and PCB levels is more important than the factors linked to incinerators. In this site, the consumption of seafood was the highest. In this part of the East Channel, seafood contamination by dioxins and PCBs is known to be a little higher than that observed in other parts of the coastline (Leblanc *et al.* 2004).

Among those who had not consumed locally-produced food (namely under the incinerator plume), serum levels of dioxins and PCBs were similar between exposed and unexposed areas, and this result is not in favor of the role of inhalation exposure (question strongly raised initially), which is consistent with the results of studies conducted abroad (Huang 2007, Adriaens *et al.* 2007).

Consumption of locally produced food

The relationship between serum dioxin levels and exposure to MSWI may exist only in certain population groups; a study was therefore conducted among consumers of locally-produced food, since food is usually the major route of exposure to dioxins. Serum dioxin and PCB levels were higher among farmers living in exposed areas compared to those in unexposed areas to the plume of an incinerator. Farmers, who usually eat more locally-produced food, had higher dioxin and PCB levels than all other groups of consumers in exposed areas (individuals eating food from animal origin and/or vegetables, not consumers of local products).

In areas only exposed to emissions from incinerators, the average dioxin levels of individuals eating animal products (such as dairy products and eggs) and vegetables were statistically higher than that of people eating vegetables only. Moreover, the levels of the latter were similar to those of people who do not consume local products. Thus, the dioxin intake by fruits and vegetables from the garden or orchards exposed to deposits from the plume of MSWI does not contribute significantly to the contamination of the population. Vegetables are poor in lipids and so less contaminated by dioxins than animal products.

The study shows that contamination of the population associated with emission from MSWI is mainly through the intake of animal fat from food produced under the plume (dairy products, eggs, meat). The increase of 8 grams per day of fat intake from local origin (corresponding to the consumption of an egg or a cup of milk per day) was associated with a moderate increase of serum dioxin and DL-PCB levels (total TEQ): 5.8% for those living in exposed areas (equivalent to 1.6 pg/g. fat on average) and 2.6% for those in control areas. Low daily intakes of local animal fat probably partly explained why the local consumption of food (possibly contaminated by deposits from the plume) had such small impact on the serum dioxin levels of populations. In a study conducted among Belgian populations living near highly polluting incineration plants, Fierens *et al.* (2003) have also observed an increase of serum dioxin levels associated with intake of fat from local cattle or poultry In our study, we found that the increase of serum dioxin levels with the intake of animal products originating from exposed areas was more pronounced for old incinerators than for recent ones. The regulatory measures taken to reduce emissions from incinerators were apparently relevant and reflect lesser serum levels of residents living close to recent incinerators that complied to emission regulation.

To conclude, this study has shown that the fact of living near a municipal solid waste incinerator has no significant effect on serum dioxins levels, except for consumers of local animal products (including dairy products and eggs), especially for those who lived near old incinerators that have polluted in the past. This observation was more marked among farmers. Personal factors and the usual food consumption, in particular of fishery products, were the critical determinants of serum levels.

Blood lead levels

Blood lead levels in the study population

The average of blood lead levels in the study population was 28.7 µg/L, which represents a normal value for the general population; it is lower than that measured in young adults in France ten years ago, this is probably due to the reduction of lead emissions in France (RNSP 1997, Inserm 1999). In comparison, blood lead levels found in the Belgian adult population living around MSWI were a little higher, around 43 µg/L (Fierens 2002). The characteristics of people with high blood lead levels (above 100 µ/L) were those usually observed: relatively high age (more than 55 years), male, residence or activity related to old dwelling. These people were in all sites, except for Vaux-le-Pénil and lived in both exposed and unexposed areas.

Factors that influence blood lead level regardless of MSWI

The factors generally known to be linked to blood lead levels were found in this study: age, sex, level of education, consumption of tobacco and alcohol, the practice of a recreational exposure to lead, living in an old dwelling and drinking tap water. They have also been found partly by Fierens who studied blood lead levels in populations living around MSWI (2007).

It is known that lead is a cumulative toxic substance, which accumulates in the body with age. Thus, blood lead levels of the study population increased by 2.5% per year, representing an average annual increase of about 0.7 µg/L. Men's blood lead levels are usually higher than

women's (Staessen *et al.* 1996, Inserm 1999), this result was found in our study with a difference of about 5 µg/L. In addition, increasing blood lead levels were observed in a context of lower education levels, which is common in studies and reflects the fact that the socio-economic context can promote exposure. Blood lead levels were on average 3 µg/L higher in people living in houses built before 1948. It is known that old dwelling (dating from before 1948) can be a source of lead exposure due to the presence of old lead paint which can be found in dust. Thus, among people with the highest blood lead levels, we often found a renovation activity regarding an old dwelling. In general, the practice of a recreational activity which exposes to lead (such as shooting, painting, enamels, pottery, renovation of an old dwelling (scraping of doors,…)) increased blood lead levels to 5 µg/L on average. Old dwelling can also be a source of lead through the presence of lead pipes providing drinking water. In our study, blood lead levels increased by approximately 1.3% (an average of 0.4 µg/L) for a daily intake of tap water increased by 100 ml. On the other hand, associations between blood lead levels and consumption of tobacco and alcohol are consistent, since the latter are also known as sources of lead (Huel *et al.* 1986).

The usual consumption of dairy products or leafy vegetables (such as salads) seemed to preserve from high blood lead levels, whereas consumption of shellfish, pork or cooked pork meat, increased them. We know that food products most contaminated by lead are crustaceans, mollusks and offal, and that furthermore; lead is absorbed from the gastrointestinal tract in competition with calcium, which is very present in dairy products.

Factors associated with MSWI

Area and duration of exposure

Blood lead levels of populations in the vicinity of incinerators were not higher than the levels of controls, except for the site of Vaux-le-Pénil for which blood lead levels of inhabitants in the control area were in fact the lowest. Even if scientific publications indicate the persistence of soil contamination by lead around industrial sites that have emitted lead (Declercq *et al.* 1990), exposure to the incinerator influenced much less the levels of blood lead than the usual variation factors mentioned above. In addition, other factors of exposure to MSWI (distance from place of residence to incineration plant, length of residency under the plume) were not associated with blood lead levels. Morevoer, exposure to pollution from the incinerator by inhalation alone, i.e. by living in the vicinity of MSWI without intake of local products, did not seem to influence blood lead levels.

Consumption of locally-produced food

The observed impact of local food on blood lead levels was moderate. Food products associated with an increase in blood lead levels were mainly of animal origin, whereas leafy vegetables seemed to be protective. Due to the low transfer of lead from the soil into the vegetable, the major lead intake from vegetables comes from the air, and lead is mostly eliminated during peeling and washing (CSHPF).

The local intake of meat (beef, lamb, veal, affal) and dairy products increased blood lead levels mainly for consumers living under the plume of incinerators. The intake of local eggs significantly influenced blood lead levels only in residents from exposed areas beyond a certain level of soil surface deposit, of about 0,2 µg/m^2 and in the case of old incinerators that did not comply to emission regulation. In contrast, seafood intake increased blood lead levels independently of the exposure area. The Belgian study conducted in the population living around MSWI did not show higher blood lead levels in people living near incinerators (Fierens, 2002).

In conclusion, personal factors and usual diet had much more influence on blood lead levels than factors related to the incinerator. Even if the consumption of certain local food products affected blood lead levels, this influence remained moderate. In addition, blood lead levels values remained normal in the general population.

Urinary cadmium

Urinary cadmium in the study population

The mean concentration of urinary cadmium in the study population is 0.27 µ/g creatinine, which is consistent with levels found in France during previous investigations by InVS, previously called RNSP, (approximately 0.3 µg/g creatinine in Salsigne, RNSP 1997, and Marseilles, InVS-ORS PACA 2002). A very low proportion of people had high cadmium values, mostly women aged 50 to 55 years.

Factors that influence urinary cadmium levels regardless of MSWI

Four factors, usually associated with urinary cadmium, have been identified in the study population: age, sex, smoking status and current socioprofessional category.

Because of its low elimination after absorption by the body, cadmium accumulates over time and its concentration in urine increases with age. Thus, in our study we observed a urinary cadmium increase of 6.8% every 5 years. The absorption of cadmium is facilitated in case of iron deficiency, a situation which is more common among women. This explains why urinary cadmium is generally higher among women than among men. Smoking is the main source of airborne cadmium in the general population, and thus increases urinary cadmium in smokers; 20 cigarettes are estimated to bring 1 to 4 µg of Cd. The socio-professional category also influenced concentrations, with the highest levels among farmers. This can probably be partly explained by practices. The usual consumption of leafy vegetables also increased urinary cadmium, but to a lesser extent compared to the previous factors. It is known that cadmium exists naturally in soils and that it is easily transferred from soil to plants.

Factors associated with MSWI

Area and duration of exposure

There was no statistical difference in levels of urinary cadmium between people living in the exposed and unexposed areas. As a first step, levels of urinary cadmium in people living near incinerators seemed higher compared to those who were not exposed (p=0.10). In fact, this difference, though not statistically significant, disappeared after excluding the Vaux-le-Pénil site, although mean of urinary cadmium levels of the different sites remained slightly higher in exposed areas. The difference of urinary levels between the two exposure areas observed on the site of Vaux-le-Pénil came mostly from very low cadmium levels found in the control area rather than pollution from the incinerator. This site had the lowest urinary cadmium levels compared to all the study sites. In fact, cadmium level variations found

between the eight study sites were more important than those found among exposed and unexposed areas. Other exposure factors to MSWI (distance, deposit, duration) have not been found to be associated with urinary cadmium levels. In his study, Fierens (2002) did not find higher concentrations of urinary cadmium among people living near MSWI, after taking into account individual factors. Among those who do not consume local products, no marked difference for urinary cadmium levels was found between exposed and unexposed areas, which does not suggest exposure through inhalation.

Consumption of locally-produced food

A study on vegetable gardens was performed, considering that cadmium intake can be greatly influenced by the consumption of vegetables and the use of fertilizers which are rich in cadmium. To have a vegetable garden did not influence significantly levels of urinary cadmium, whether in exposed or unexposed areas. In addition, the duration of use of the garden under the plume of a MSWI did not increase urinary cadmium levels. Somewhat unexpected and paradoxal associations were observed between local diets and urinary cadmium levels. They were not in favour of the hypothesis that a MSWI could contaminate locally-produced food and increase urinary cadmium levels in the population (eg.: increased urinary cadmium levels with the consumption of dairy products, especially in unexposed areas).

In conclusion, residents living near incinerators did not show higher urinary cadmium levels. Their cadmium levels remained normal for the general population, not occupationally exposed, and they were not linked to the consumption of local products.

Recommendations

These results do not lead to advocate new management measures, because the reduction of incinerator emissions and regulations have already been implemented. Morevoer, the control of commercial products from animals obtained under incinerators' plumes has been conducted by the Directorate General of Food (DGAL). However, local stakeholders should remain cautious in terms of egg intake from hens raised on soils still contaminated by a former MSWI that did not comply to regulation. This is particularly true for eggs that are not commercialized (outside the official controls), but destined to personal intake.

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BIBLIOGRAPHIC REFERENCES

Adriaens P, Towey T, Barabas N, Chang SC, Hedgeman E, Zwica L, Garabrant D. Multivariate statistical analysis of dioxin profiles to explain Source contributions to serum dioxins. Organohalogen Compounds[1]. 2007; 69.

Collins JJ, Bodner K, Burns CJ, Budinsky RA, Lamparski LL, Wilken M, Martin GD, Carson ML. Body. Body mass index and serum chlorinated dibenzo-p-dioxin and dibenzofuran levels. Chemosphere. 2007; 66: 1079-1085.

CSHPF (Boisset M. et coll.) Plomb, cadmium et mercure – Conseil supérieur d'hygiène publique de France – Section de l'alimentation et de la Nutrition. Paris. 1996, 287 p.

Declercq C, Lahoute C, Mercier JF, Haguenoer JM. Évaluation de l'exposition au plomb de deux groupes d'enfants de la région Nord-Pas-de-Calais. ORS Nord-Pas-de-Calais. 1990.

Deml E, Mangelsdorf I, Greim H. Chlorinated dibenzodioxins and dibenzofurans (PCDD/F) in blood and human milk of non-occupationally exposed persons living in the vicinity of a municipal waste incinerator. Chemosphere, 1996; 33:1941-1950.

Evans RG, Shadel BN, Roberts DW, Clardy S, Jordan-Izaguire D, Patterson DG, Needham LL. Dioxin incinerator emission exposure study Times Beach. Missouri. Chemosphere, 2000;40:1063-1074.

Fierens S, Mairesse H, Bernard A. Évaluation de l'exposition environnementale aux dioxines et polluants associés en région wallonne. Rapport de l'unité Toxicol. Ind. Méd. Du Travail. Univ. Cathol. De Louvain ; Nov 2002 ; 84 p et annexes.

Fierens S, Mairesse H, Hermans C, Bernard A, Eppe G, Focant JF, De Pauw E. Dioxin accumulation in residents around incinerators. J. Toxicol. Environ. Health, 2003; Part A, 66: 1287-1293.

Fierens S, Mairesse H, Heilier JF, Focant JF, Eppe G, De PE *et al.* Impact of iron and steel industry and waste incinerators on human exposure to dioxins, PCBs, and heavy metals: results of a cross-sectional study in Belgium. J Toxicol Environ Health A. 2007; 70(3-4):222-226.

Garabrant D, Hong B, Chen Q, Franzblau A, Lepkowski J, Adriaens P, Demond A, Hedgeman E, Knutson K, Zwica L, Chang CW, Lee SY, Olson K, Towey T, Trin H, Wenger Y, Luksemburg W, Maier M, Gillespie BW. Factors that predict serum dioxin concentrations In Michigan, USA. Organohalogen Compounds. 2007; 69: 206-209.

Gonzalez CA, Kogevinas M, Huici A, Gadea E, Ladona M, Bosch A, Bleda MJ. Blood levels of polychlorinated dibenzodioxins, polychlorinated dibenzofurans and polychlorinated biphenyls in the general population of a Spanish Mediterranean city. Chemosphere, 1998; 36:419-426.

Huang HY, Jeng TY, Lin YC, Ma YC, Kuo CP, Sung FC. Serum dioxin levels in residents living in the vicinity of municipal waste incinerators in Taiwan. Inhal Toxicol 2007; 19(5): 399-403.

Huel G, Boudène C, Jouan M, Lazar P. Assessment of exposure to lead of the general population in the French community through biological monitoring. Int. Arch Occup. Envir. Health. 1986; 58: 131-139.

Inserm. Plomb dans l'environnement – Quels risques pour la santé ? Expertise collective. Ed. Inserm. 1999 ; 461 p.

InVS-Afssa. Incinérateurs et santé. Exposition aux dioxines de la population vivant à proximité des UIOM – État des connaissances et protocole d'une étude d'exposition. Ed. InVS. Novembre 2003, 198 p.

Kiviranta H, Vartainen T, Tuomisto J. Polychlorinated dibenzo-p-dioxins, dibenzofurans and biphenyls in fishermen in Finland. Environ Health Perspect. 2002; 110(4): 355-361.

Leblanc JC, Sirot V, Volatier JL, Bemrah-Aouachria N. Étude des consommations alimentaires de produits de la mer et imprégnation aux éléments traces, polluants et oméga 3, Afssa, 2006, 160 p.

ORS PACA-InVS. Évaluation des conséquences sanitaires et environnementales de la pollution d'origine industrielle au cadmium autour du site TLM dans le 15e arrondissement de Marseille. Nov. 2001. 146 p et annexes.

Réseau national de santé publique (RNSP) – Institut national de la santé et de la récherche médicale (Inserm). (Huel G, Jouan M, Fréry N, Huet M). Surveillance de la population française vis-à-vis du risque saturnin. Édition insem. Déc 1997 ; 90 p.

Réseau national de santé publique (RNSP), Ddass de l'Aude. (Fréry N, Ohayon A, Quénel P) Enquête sur l'exposition de la population aux polluants d'origine industrielle – Région de Salsigne (Aude). Déc. 1998; 50 p et annexes.

Schuhmacher M, Domingo JL, Llobet JM, Lindstrom G, Wingfors H. Dioxin and dibenzofuran concentrations in adipose tissue of a general population from Tarragona, Spain. Chemosphere. 1999; 38(11): 2475-2487(13).

Staessen JA, Buchet JP, Ginucchio G, Lauwerys RR, Lijnen P et coll. Public health implications of environmental exposure to cadmium and lead: an overview of epidemiological studies in Belgium. Working groups. J. Cardiovasc. Risk. 1996; 3: 26-44.

Volatier JL (coord.). Enquête Inca (Individuelle et nationale sur les consommations alimentaires). Éditions Tec & Doc. 2000; 192 p. ISBN 2-7430-0426-6.

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