

# Exposure of the French population to environmental pollutants

Environmental component of the French National Survey on Nutrition and Health - Initial results



Water



Biology



Food



Measurements



Pollutants



Health

**For the first time in France, biological concentrations of environmental pollutants have been measured across a representative sample of the population.**

The exposure of the French population to various environmental pollutants has been estimated by measuring 42 biomarkers of exposure. These correspond to chemical contaminants of food and the environment and were selected according to their relevance in terms of public health: 11 metals, 6 PCBs and three chemical families of pesticides (organochlorine, organophosphorus and pyrethroid compounds). These chemicals or their metabolites have been measured in samples of blood, urine and hair collected from a sample of the population in the French National Nutrition and Health Survey (ENNS – Étude nationale nutrition santé).

The results indicate that the French population has exposure levels to heavy metals and organochlorine pesticides that are, overall, low and consistent with levels observed in other countries. For polychlorinated biphenyls (PCBs) and other pesticides (para-dichlorobenzene and pyrethroids) the levels recorded in France are notably higher than those observed in the United States and in Germany. However, for PCBs, levels exceed health thresholds in only a small proportion of the population. French specificities regarding food and the use of products need further clarification.

## Human biomonitoring at the French Institute for Public Health Surveillance (InVS)

InVS conducts human biomonitoring (HBM) studies on the population exposure to environmental pollutants through the direct measure of the pollutant or its metabolites in the human body. The substances thus measured are known as "biomarkers".

HBM allows an integrated approach of the different sources and exposure pathways, contributing to better understand overall exposure, the internal dose and potential health risks. It provides information to public health professionals, practitioners and scientists to help them identify the exposure to certain environmental pollutants, facilitate the identification of their sources and prevent the diseases or symptoms that can arise from such exposure.

### For more information:

Human biomonitoring and environmental health  
"Bull Epidemiol Hebd"<sup>1</sup> 2009; (special edition): 1-32.  
[www.invs.sante.fr/beh/2009/hs/160609/index.htm](http://www.invs.sante.fr/beh/2009/hs/160609/index.htm)  
[www.invs.sante.fr/surveillance/biosurveillance/default.htm](http://www.invs.sante.fr/surveillance/biosurveillance/default.htm)

<sup>1</sup> Weekly Epidemiological Journal.

This study represents a cornerstone of the national HBM strategy.

The pollutants studied in the ENNS were selected on the basis of scientific data and taking into account possible levels of exposure in France.

This document provides, for each of the chemical substances included in the study, a summary of the distribution of the levels of concentration among the population (in blood, urine or hair, depending on the substances), which will, in particular, represent a reference tool and may be used for comparisons.

This executive summary not only presents general information on current uses and associated factors, but also a comparison with other results observed in France and abroad (mostly German and American data).

**An initial  
reference step  
in the HBM strategy**

**Results should be  
interpreted based on  
the few management or  
health thresholds which  
have been developed and  
must be supplemented  
by other studies**

All of this data may also serve to constitute recommendations for the management of risks.

However, the interpretation of potential health risks depending on biomarker concentrations is only known for very few biomarkers such as: blood lead, hair mercury, urinary cadmium and serum PCB levels. For these biomarkers (except perhaps the concentration of mercury in hair), threshold levels are exceeded in a more (PCBs) or less (cadmium) significant proportion of the population; this indicates that efforts to reduce exposure to these pollutants must continue. The other biomarkers were only compared with the results of other French and foreign studies.

The detailed results of descriptive and multivariate analyses on the risk factors will be published in future reports. However, additional studies and research are still needed.

## The environmental component of the ENNS: describe the exposure of the population to some metals and pesticides and their determinants

ENNS is carried out on a representative sample of the population living in continental France over the period 2006-2007 [Usen, 2007]. The study was conducted by InVS and the University of Paris 13.

Its principal objective was to evaluate the food consumption, the nutritional status and physical activity related to health data among a representative sample of approximately 3,100 adults aged between 18 and 74 years and 1,700 children aged between 3 and 17 years in continental France. It was carried out under the framework of the French National Nutrition and Health Programme (PNNS – Programme national nutrition santé).

This study includes an environmental component, the purpose of which is to describe the exposure of the population to certain metals and pesticides (the latter being obtained from a subsample) and to understand the determinants of this exposure.





The information obtained, the types of samples taken and the measurements are presented in table 1.

The measurements relate to the chemical contaminants in food and in the environment: 11 metals, 6 PCBs and three chemical families of pesticides (organochlorines, organophosphorus compounds and pyrethroids).

The clinical and biological component of the survey was carried out either in a Centre for Health Examinations (CES – Centre d'examen santé) for Health Insurance or at home by a nurse commissioned by InVS. The biological samples were sent to various laboratories.

| TABLE 1 |

### ENNS Study: information obtained, population studied and substances measured (42 biomarkers of exposure: 11 metals, 6 PCBs and three families of pesticides)

| Information obtained   | Population<br>(random sampling) | Matrix          | Chemicals measured   | Number of<br>measurements |
|--|---------------------------------|-----------------|--|---------------------------|
|  Food survey  | Adults<br>(18-74 years)         | Blood and urine | 11 metals  | 2,000                     |
|  Questionnaires<br>(face-to-face and self-administered)<br>Sociodemographic characteristics<br>Occupation<br>Environment (domestic use of pesticides, etc.) |                                 | Blood and urine | Pesticides<br>(organochlorines,<br>organophosphorus<br>compounds and<br>pyrethroids) | 400                       |
|  Clinical examination<br>(anthropometric measurements, blood pressure)  |                                 | Blood           | PCB Non dioxin like  | 400                       |
|  Biological samples (blood, urine, hair)  |                                 | Hair            | Mercury  | 400                       |
|  | Children<br>(3-17 years)        | Hair            | Mercury  | 1,400                     |

## Metals and metalloids

The various metals measured in the biological samples are as follows: antimony, arsenic, cadmium, chromium, cobalt, tin, mercury, nickel, lead, uranium and vanadium.

### 1 – THEIR USE

Metals and metalloids are present naturally in the environment. Due to their many uses, they can enter and accumulate in the body depending on the route of exposure and chemical form.

The various uses of these elements are presented on the following page.

### 2 – RESULTS OF THE STUDY

The mean blood lead concentration among adults aged between 18 and 74 years is **25.7 µg/L**. Note also that the blood lead concentration has dropped sharply (to the order of 60%) since the study carried out on adults in 1995 [Huel, 1997]. This result is the effect of efforts to reduce exposure to lead in France. However, high levels of lead are still being found, particularly among people who have carried out renovation work in old housing that may contain old lead-based paint. Only 1.7% of the adults participating in the ENNS had a blood lead concentration above 100 µg/L, which is the regulatory threshold for infantile lead poisoning and exposure of pregnant women.

DECREASE OF BLOOD  
LEAD CONCENTRATION

CADMIUM:  
COMPARABLE LEVELS  
IN EUROPE

The mean urine cadmium concentration is **0.29 µg/g** of creatinine, which is quite similar to those observed in previous French studies (in 1997, 2000 and 2005) and in other studies carried out in Europe and the United States. Urine cadmium levels increase with age, as cadmium is a cumulative toxin. It is higher among women than among men and is heavily influenced by smoking. The threshold of 2.5 µg/g of creatinine corresponding to an increased risk of kidney problems was only exceeded in 1.5% of cases.

Concentrations of mercury in hair are relatively low (**0.59 µg of mercury/g of hair among adults and 0.37 µg/g of hair among children**) and are all lower than 10 µg/g (the WHO threshold); in relation to the threshold proposed by the CDC (1 µg/g), 9.2% of children and 19% of adults, including 3.9% of women aged between 18 and 45 years, had concentrations exceeding 1 µg/g of hair. These levels are low when compared to those observed in French Guyana, where biomonitoring of mercury exposure has been carried out for more than 15 years [Cardoso, 2010]. They are higher than those observed in Germany and the United States but lower than the levels in Spain. These results are most likely the effect of the differences in the consumption of fish in these countries: the concentration of hair mercury is an indicator of the internal levels of organic mercury and fish is the principal contributor of organic mercury among the general population; fish consumption in France is only half as much as in Germany and in the United States, but is higher in Spain.

MERCURY AND  
FISH CONSUMPTION

INORGANIC ARSENIC:  
LEVELS RELATIVELY LOW

The mean concentration of inorganic arsenic (the most toxic form of arsenic) and its methylated metabolites is **3.3 µg/g** of creatinine (12 µg/g for total arsenic). Ninety-six percent (96%) of the population who had not consumed any seafood products during the 72 hours prior to the collected sample had creatinine levels below 10 µg/g. In most international studies, 90-95% of the populations studied had levels below this figure. While concentrations of arsenic in urine are influenced by the consumption of seafood products, they also increase with the consumption of wine.

The concentrations of other metals in urine, as measured among adults aged between 18 and 74 years, are quite similar to those observed in other countries. Mean concentrations are as follows: **0.075 µg/g** of creatinine for antimony, **0.17 µg/g** for chromium, **0.21 µg/g** for cobalt, **0.51 µg/g** for total tin, **1.23 µg/g** for nickel, **4.4 ng/g** for uranium and **0.85 µg/g** for vanadium.

Concentrations of metals found in the body are very often linked to age and gender. Some other specific factors may influence biomarker levels, such as the degree of urbanisation for vanadium, since this metal is emitted by catalytic converters on motor vehicles.

OTHER METALS

## ANTIMONY

- Micro-electronics
- Medicines
- Munitions
- Alloys (seals, munitions, etc.)
- Accumulators
- Domestic tin items
- Pigments
- Fireproofing materials
- Plastics

## ARSENIC

- Manufacturing
  - Metal alloys
  - Glass
  - Electronic components
  - Pigments (enamels, paints, glazes)
  - Tanning of hides, taxidermy
  - Protective wood treatments
  - Medicines (human and animal)
  - Pesticides (until 2001)

## CADMIUM

- Protection of steel against corrosion (cadmium plating)
  - Alloys (cables, ball bearings, seals)
  - Manufacturing of batteries (Cd/Ni)
  - Micro-electronics
  - Dyes and colouring agents
  - Stabilising agents for plastics
  - Production of other metals (zinc, lead, copper)
  - Tobacco smoke

## CHROMIUM

- Metallic form: alloys (stainless steel)
- Chrome VI and III
  - Chrome electroplating
  - Dyes and pigments
  - Tanning of hides
  - Preservation of wood
  - Cement

## COBALT

- Manufacturing
  - High-resistance alloys (aircraft industry, car industry)
  - Magnets
  - Cutting tools (saws, drills)
  - Kitchen utensils
  - Dental and surgical alloys (prostheses)
  - Polishing discs
- Cobalt salts
  - Blue pigments (enamels, inks, paints, glass, porcelain)
  - Paint drying agents
  - Polyester resins

## LEAD

- Metallurgical, automotive, printing industries
  - Insulation
  - Coverings for roofs, terraces and balconies
  - Protection against noise and radiation
  - Batteries
  - Alloys (brass, bronze, steel), wires and solder sticks
  - Tinning
  - Plumbing (old pipework)
  - Plastics (pigments or stabilising agents)
  - Munitions (lead bullets)
  - Glass (crystal), enamels (ceramics, medals)
  - Manufacture and use of pigments
  - Varnishes, mastics, paints (minium, ceruse (paints previously used in residential buildings))
  - Antiknock in petrol (now banned)

## MERCURY

- Industrial applications
  - Electrical equipment
  - Lamps (including energy-saving bulbs)
  - Measuring devices (manometers, barometers, previously thermometers)
  - Dental amalgams
  - Production of chlorine and sodium hydroxyde
  - Biocides
  - Explosives
  - Recycling of precious metals
  - Gilding

## NICKEL

- Alloys (stainless steel)
- Kitchen utensils
- Coins
- Jewellery (now banned), buttons
- Motor mechanics
- Aviation
- Plumbing
- Household equipment
- Agrifood
- Dental and surgical prostheses
- Protective coverings
- Manufacture of magnets
- Manufacture of batteries (Cd/Ni)
- Pigments (émaux, céramiques)
- Inorganic derivatives of nickel
  - Catalysers
  - Pigments (enamels, ceramics)

## TIN

- Metallic tin
- Composition
  - Tinning (tin plating)
  - Alloys (bronze)
  - welding materials
- Applications
  - Plumbing, electricity
  - Jewellery
  - Dental amalgams
  - Containers for food and drinks, aerosol cans
- Organic tin salts
- Biocides (use to be abandoned)
- Additives, dyes
- Catalysers
- Textile industry

## URANIUM

- Nuclear fuel, source of ionising radiation
- Uranium salts
  - Pigments (ceramics, glass, luminescent paints, electronic microscopes, photography, etc.)
- Impoverished uranium
  - Ballast for boat keels, planes
  - Weaponry (antitank missiles)

## VANADIUM

- Alloys (special steels)
- Catalysers in the chemicals industry
- Catalytic converters
- Colour modifiers (mercury vapour lamps)
- Part components (electrical and electronic industries)
- Paints, lacquers, varnishes, inks and dyes industries

| TABLE 2 |

### Distribution of biomarkers of metals in the population studied

| Biomarkers          | Matrix | Unit      | n     | Mean level* | Percentiles    |       |       |       |       |       |
|---------------------|--------|-----------|-------|-------------|----------------|-------|-------|-------|-------|-------|
|                     |        |           |       |             | 10             | 25    | 50    | 75    | 95    |       |
| Antimony            | Urine  | µg/g cr.  | 1,991 | 0.075       | [0.072; 0.078] | 0.033 | 0.048 | 0.072 | 0.120 | 0.250 |
| Total arsenic       | Urine  | µg/g cr.  | 1,515 | 11.96       | [11.41; 12.53] | 4.29  | 6.42  | 10.72 | 21.69 | 61.29 |
| Inorganic arsenic** | Urine  | µg/g cr.  | 1,500 | 3.34        | [3.23; 3.45]   | 1.44  | 2.28  | 3.53  | 5.07  | 8.90  |
| Cadmium             | Urine  | µg/g cr.  | 1,930 | 0.29        | [0.28; 0.31]   | 0.13  | 0.18  | 0.29  | 0.45  | 0.91  |
| Chromium            | Urine  | µg/g cr.  | 1,991 | 0.17        | [0.16; 0.18]   | 0.08  | 0.12  | 0.17  | 0.26  | 0.54  |
| Cobalt              | Urine  | µg/g cr.  | 1,991 | 0.21        | [0.20; 0.22]   | 0.09  | 0.13  | 0.19  | 0.32  | 1.13  |
| Lead                | Blood  | µg/L      | 1,949 | 25.7        | [24.9; 26.5]   | 12    | 17    | 25    | 39    | 73    |
| Mercury in adults   | Hair   | µg/g hair | 365   | 0.59        | [0.54; 0.64]   | 0.26  | 0.41  | 0.46  | 0.85  | 1.8   |
| Mercury in children | Hair   | µg/g hair | 1,364 | 0.37        | [0.35; 0.38]   | 0.13  | 0.24  | 0.38  | 0.61  | 1.2   |
| Nickel              | Urine  | µg/g cr.  | 1,991 | 1.23        | [1.17; 1.28]   | 0.57  | 0.88  | 1.30  | 1.93  | 3.77  |
| Tin                 | Urine  | µg/g cr.  | 1,991 | 0.51        | [0.49; 0.53]   | 0.17  | 0.30  | 0.53  | 0.93  | 2.28  |
| Uranium             | Urine  | ng/g cr.  | 1,991 | 4.4         | [4.2; 4.6]     | 1     | 3     | 5     | 8     | 21    |
| Vanadium            | Urine  | µg/g cr.  | 1,991 | 0.85        | [0.82; 0.89]   | 0.32  | 0.51  | 0.87  | 1.42  | 2.80  |

n: number of measurements performed in ENNS.

µg/g cr.: microgram per gram of creatinine; µg/g hair: microgram per gram of hair.

\* Mean level: geometric mean and its confidence interval to 95%.

\*\* Inorganic arsenic: amount of inorganic arsenic and its methylated metabolites (Asi+MMA+DMA).

MMA: monomethylarsonic acid; DMA: dimethylarsinic acid.

Percentile: value for the concentration of the biomarker below which 10% (P10), 25% (P25), 50% (P50, median), 75% (P75), 95% (P95) of the population falls.



## Pesticides

The originality of this work lies on the study of pesticides, as illustrated by the distribution in the population of serum pesticides concentrations or urinary metabolites of the three chemical families: organochlorines, organophosphorus and pyrethroid compounds.

### 1 – THEIR USE

#### ORGANOCHLORINE PESTICIDES

**Organochlorine pesticides**, including DDT, are effective against a number of insects. Some organochlorines, including hexachlorobenzene and pentachlorophenol, have been used principally as fungicides and antimicrobial agents. All the chlorophenols have been used as biocides and some have been used in the manufacture of phytosanitary products. These chemical products were introduced in the 1940s and many of their uses have been restricted due to their persistence in the environment. With the exception of the chlorophenols, these chemical products are rarely or no longer used in France.

Some organochlorine pesticides or their metabolites, known for their persistence in the environment, have been measured:

- in serum:
  - lindane (still known as  $\gamma$ -HCH) and  $\alpha$ - and  $\beta$ -HCH;
  - DDT and its metabolite, DDE;
  - hexachlorobenzene (HCB)
- or in urine:
  - 4-monochlorophenol (4-MCP);
  - 2,4-dichlorophenol (2,4-DCP);
  - 2,5-dichlorophenol (2,5-DCP), metabolite of 1,4-dichlorobenzene, used extensively as moth killer;
  - 2,4,5- and 2,4,6-trichlorophenol (2,4,5- and 2,4,6-TCP);
  - and pentachlorophenol (PCP) which has been used in the treatment of wood.

#### ORGANOPHOSPHORUS PESTICIDES

The development of **organophosphorus compounds** as pesticides dates from the beginning of the 1970s as an alternative to the organochlorine compounds such as DDT, which are persistent in the environment and in the human body. Organophosphorus compounds very quickly became popular due to their effectiveness, particularly against insects.

Their exposure has been estimated by the measurement in urine of six dialkyl phosphates, metabolites that are common to many different organophosphorus insecticides (3 ethyl-type phosphates (DE) and 3 methyl-type phosphates (DM)).

#### PYRETHROID PESTICIDES

In the 1970s, **pyrethroid compounds** represented an alternative to the previously used molecules (organochlorines, organophosphorus compounds, carbamates, etc.), as their ecotoxicity was acknowledged. Pyrethroid pesticides such as organophosphorus compounds are today among the most widely used insecticides.

Pyrethroid pesticides are used against a wide variety of insects in agriculture, horticulture, forestry, public health (in hospitals), commercial and public sector construction projects, animal facilities, warehouses, greenhouses and for domestic use. Thus, at home, pyrethroids such as permethrin are not only used against insects, on plants, but also to protect textiles, such as carpets. Some pyrethroid insecticides (such as permethrin, resmethrin and sumithrin) are also used against mosquitoes and parasites.

There are five pyrethroid metabolites measured in the study:

- Br<sub>2</sub>CA: cis-3-(2,2-dibromo-vinyl)-2,2-dimethylcyclopropanecarboxylic acid;
- cis-Cl<sub>2</sub>CA and trans-Cl<sub>2</sub>CA: cis- and trans-3-(2,2-dichlorovinyl)-2,2-dimethylcyclopropanecarboxylic acid;
- F-BPA: 4-fluoro-3-phenoxybenzoic acid, metabolite of cyfluthrin;
- and 3-BPA: 3-phenoxybenzoic acid, metabolite of permethrin, cypermethrin, deltamethrin and other pyrethroids.



## 2 – RESULTS OF THE STUDY

It was possible to **quantify** organochlorine pesticides and their metabolites in **nearly all individuals, with the exception of lindane**, which could be quantified in only **around 7% of individuals**.

### ORGANOCHLORINE PESTICIDES: LEVELS RELATIVELY LOW EXCEPT FOR 2,5-DCP

Mean serum concentrations of organochlorine pesticides are **24 ng/g** of lipids for HCB, **0.6 and 0.30 ng/g** for  $\alpha$ - and  $\beta$ -HCH, **4 ng/g** and **120 ng/g** of lipids for DDT and its metabolite, DDE.

Mean urinary concentrations of organochlorine pesticides are **5.42  $\mu\text{g/g}$  of creatinine** for 4-MCP, **1.07  $\mu\text{g/g}$  cr.** for 2,4-DCP, **10.30  $\mu\text{g/g}$  cr.** for 2,5-DCP, **0.14 and 0.36  $\mu\text{g/g}$  cr.** for 2,4,5- and 2,4,6-TCP and **0.88  $\mu\text{g/g}$  cr.** for PCP. Depending on the pesticide, levels in comparison with those observed in other countries are either higher or lower.

On average, levels of HCBs in France are between those observed in American and German populations and are generally lower than those observed in other European countries. Mean serum concentrations of DDT and DDE in France are low; they are lower than those indicated in other countries and the low DDT/DDE ratio confirms that there has been no exposure to DDT in France for a long time, as a result of the ban of these products.

Overall, the French data relating to chlorophenols is similar to that reported in the United States [CDC, 2009] and in Germany (10 years ago; Becker, 2002), except for 2,5-DCP; its mean level in France is approximately 10 times higher than in Germany. This biomarker is a metabolite of para-dichlorobenzene, which is used as a moth-killer, air-freshener and disinfectant. This observation needs further research to identify specific features in the exposure to this substance in France.

Dialkyl phosphate metabolites (DAP), which are common to many organophosphorus insecticides, have been found in more than 90% of urine samples. The majority of these samples contained both ethyl-type phosphates (DE) and methyl-type phosphates (DM) metabolites. The highest mean levels among the six DAP metabolites were observed for dimethyl phosphate (DMP) and dimethyl thiophosphate (DMTP).

Mean concentrations in urine are **7.10  $\mu\text{g/g}$  cr.** for DMP, **6.57  $\mu\text{g/g}$  cr.** for DMTP and **0.75  $\mu\text{g/g}$  cr.** for DMDTP (dimethyl dithiophosphate).

For the three diethyl phosphates (diethyl phosphate (DEP), diethyl thiophosphate (DETP) and diethyl dithiophosphate (DEDTP)), they are **3.89  $\mu\text{g/g}$  cr.**, **1.05  $\mu\text{g/g}$  cr.** and **0.018  $\mu\text{g/g}$  cr.** respectively.

Overall, the levels of urinary dialkyl phosphates in the French population aged between 18 and 74 years are similar to those observed in Germany [Heudorf, 2006] and higher than those observed in America [CDC, 2009].

### PYRETHROID PESTICIDES: LEVELS HIGHER THAN THOSE OBSERVED IN AMERICA AND GERMANY

Metabolites of pyrethroid pesticides were **found in more than 80% of samples, with the exception of F-BPA (30%) and cis-Cl<sub>2</sub>CA (55%)**.

The highest levels of pyrethroid metabolites were found for 3-BPAs, which is a metabolite of many pyrethroid insecticides, including cypermethrin, deltamethrin and permethrin. These levels are twice higher than those found for trans-Cl<sub>2</sub>CA and Br<sub>2</sub>CA (metabolite of deltamethrin), which are themselves twice higher than those found for cis-Cl<sub>2</sub>CA (present in 55% of samples). F-BPA, a specific metabolite of cyfluthrin, could only be quantified in 30% of individuals. The relationship between trans-Cl<sub>2</sub>CA and cis-Cl<sub>2</sub>CA is approximately 2/1, indicating an exposure that is principally oral or respiratory rather than cutaneous.

Mean concentrations in urine were **0.72  $\mu\text{g/g}$  cr.** for 3-BPA, **0.36  $\mu\text{g/g}$  cr.** for Br<sub>2</sub>CA, **0.16  $\mu\text{g/g}$  cr.** and **0.36  $\mu\text{g/g}$  cr.** for cis-Cl<sub>2</sub>CA and trans-Cl<sub>2</sub>CA respectively.

Mean levels of pyrethroid metabolites observed in France seem to be approximately three times higher than those observed in the United States [CDC, 2009] and even higher than levels observed in Germany [Heudorf, 2006]. It is probable that uses in France differ from those in these other countries.

### ORGANOPHOSPHORUS PESTICIDES: LEVELS HIGHER THAN THOSE OBSERVED IN AMERICA AND SIMILAR TO THOSE IN GERMANY

## Distribution of biomarkers of pesticides in the population studied

| Biomarkers                 | Matrix | Unit      | n   | Mean level* | Percentiles    |       |       |       |       |        |
|----------------------------|--------|-----------|-----|-------------|----------------|-------|-------|-------|-------|--------|
|                            |        |           |     |             | 10             | 25    | 50    | 75    | 95    |        |
| Organochlorines            |        |           |     |             |                |       |       |       |       |        |
| HCB                        | Serum  | ng/g lip. | 386 | 24          | [23; 26]       | 12    | 16    | 23    | 33    | 73     |
| α-HCH                      | Serum  | ng/g lip. | 386 | 0.6         | [0.5; 0.7]     | 0.13  | 0.4   | 0.7   | 1.1   | 1.8    |
| β-HCH                      | Serum  | ng/g lip. | 386 | 30          | [28; 38]       | 8.4   | 14    | 27    | 71    | 190    |
| γ-HCH                      | Serum  | ng/g lip. | 386 | <LOD        | -              | <LOD  | <LOD  | <LOD  | <LOD  | <LOD   |
| DDT                        | Serum  | ng/g lip. | 386 | 4           | [3; 5]         | 1.2   | 2.2   | 3.8   | 6.9   | 33     |
| DDE                        | Serum  | ng/g lip  | 386 | 120         | [100; 140]     | 38    | 61    | 100   | 210   | 730    |
| 4-MCP                      | Urine  | µg/g cr.  | 393 | 5.42        | [4.7; 6.3]     | 2.22  | 2.59  | 4.35  | 7.94  | 35.11  |
| 2,4-DCP                    | Urine  | µg/g cr.  | 393 | 1.07        | [1.0; 1.2]     | 0.34  | 0.53  | 0.97  | 1.86  | 7.92   |
| 2,5-DCP                    | Urine  | µg/g cr.  | 393 | 10.30       | [8.4; 12.7]    | 1.25  | 2.50  | 7.99  | 31.87 | 221.48 |
| 2,4,5-TCP                  | Urine  | µg/g cr.  | 393 | 0.14        | [0.13; 0.16]   | 0.05  | 0.08  | 0.14  | 0.24  | 0.53   |
| 2,4,6-TCP                  | Urine  | µg/g cr.  | 393 | 0.36        | [0.34; 0.39]   | 0.18  | 0.25  | 0.35  | 0.52  | 0.96   |
| PCP                        | Urine  | µg/g cr.  | 393 | 0.88        | [0.78; 0.98]   | 0.29  | 0.48  | 0.90  | 1.56  | 3.29   |
| Organophosphorus compounds |        |           |     |             |                |       |       |       |       |        |
| DMP                        | Urine  | µg/g cr.  | 392 | 7.10        | [6.10; 8.26]   | 1.82  | 3.94  | 8.04  | 14.15 | 59.46  |
| DMTP                       | Urine  | µg/g cr.  | 392 | 6.57        | [5.6; 7.7]     | 1.66  | 3.01  | 5.95  | 13.54 | 48.74  |
| DMDTP                      | Urine  | µg/g cr.  | 392 | 0.75        | [0.6; 0.9]     | 0.21  | 0.35  | 0.54  | 1.74  | 7.31   |
| DEP                        | Urine  | µg/g cr.  | 392 | 3.89        | [3.40; 4.40]   | 1.17  | 2.30  | 3.66  | 6.57  | 15.91  |
| DETP                       | Urine  | µg/g cr.  | 392 | 1.05        | [0.9; 1.2]     | 0.2   | 0.44  | 1.12  | 2.53  | 6.53   |
| DEDTP                      | Urine  | µg/g cr.  | 392 | 0.018       | [0.015; 0.022] | 0.005 | 0.008 | 0.015 | 0.03  | 0.26   |
| Pyrethroids                |        |           |     |             |                |       |       |       |       |        |
| 3-PBA                      | Urine  | µg/g cr.  | 396 | 0.72        | [0.64; 0.81]   | 0.24  | 0.38  | 0.63  | 1.40  | 3.48   |
| F-BPA                      | Urine  | µg/g cr.  | 396 | <LOD        | -              | <LOD  | <LOD  | <LOD  | 0.11  | 0.98   |
| Br <sub>2</sub> CA         | Urine  | µg/g cr.  | 396 | 0.36        | [0.31; 0.41]   | 0.096 | 0.17  | 0.35  | 0.67  | 2.18   |
| cis-Cl <sub>2</sub> CA     | Urine  | µg/g cr.  | 396 | 0.16        | [0.14; 0.19]   | 0.048 | 0.077 | 0.14  | 0.29  | 1.24   |
| trans-Cl <sub>2</sub> CA   | Urine  | µg/g cr.  | 396 | 0.38        | [0.32; 0.45]   | 0.10  | 0.18  | 0.31  | 0.69  | 2.64   |

n: number of measurements performed in ENNS.

µg/g cr.: microgram per gram of creatinine; ng/g lip.: nanogram per gram of lipids.

<LOD: below the limit for detection: 0.1 µg/L for F-BPA, 10 ng/L for γ-HCH.

\* Mean level: geometric mean and its confidence interval to 95%.

## Polychlorinated biphenyls

Also known, in France, as "pyralènes".

Six polychlorinated biphenyls (PCB) indicators were measured: PCBs 28, 52, 101, 138, 153 and 180.

### 1 – THEIR USE

PCBs were used in industry, as a mixture, for their insulating properties (electrical transformers) as well as for their chemical and physical stability (inks, paints). Their production peaked at the beginning of the 1970s. Thereafter, their production and their use were progressively reduced during the 1970s and they were finally banned in 1987.

The PCBs measured in the study are the non-dioxin-like PCBs (NDL-PCBs), which have a different mechanism of action to dioxins. Some of them were particularly present in the environment and in food (accounting for 50% of the amount of PCBs); these are also known as PCB indicators.

### 2 – RESULTS OF THE STUDY

The substances present in the highest quantities are the NDL-PCBs 138, 153 and 180.

Mean concentrations in serum are **2.2, 1 and 1.1 ng/g** of lipids for **PCBs 28, 53 and 101** respectively and **70 ng/g** of lipids for **PCB 138, 110 ng/g** for **PCB 153** and **90 ng/g** for **PCB 180**, the mean of the sum of the 6 PCBs equals **290 ng/g** of lipids.

These levels are similar to those observed in the study carried out by InVS in 2005 in areas surrounding incinerators. They are a little higher than those reported in the German population 10 years ago [Becker, 2002]; these levels observed in Germany have probably decreased since then. The levels observed in France are also four to five times higher than those observed in the American population [CDC, 2009] or in the New Zealand population [Bates, 2004]. However, they are lower than those observed in the Czech Republic [NIPH, 2005]. This observation needs an analysis of the specific features of each country to better understand the origin of the observed differences in exposure.

Using health thresholds proposed by the French Food Safety Agency (Afssa - Agence française de sécurité sanitaire des aliments) (5 March 2010), 3.6% of women of childbearing age (18-45 years) have a concentration of total PCBs that is higher than the threshold of 700 ng/g of lipids and 0.4% of other adults have a concentration higher than the threshold of 1800 ng/g of lipids.

As for other organochlorine chemicals measured in serum, concentrations of PCBs are influenced by age, sex and body mass index.

| TABLE 4 |

#### Distribution of biomarkers of NDL-PCBs in the studied population

| Biomarkers      | Matrix | Unit      | n   | Mean level*    | Percentiles |      |      |     |       |
|-----------------|--------|-----------|-----|----------------|-------------|------|------|-----|-------|
|                 |        |           |     |                | 10          | 25   | 50   | 75  | 95    |
| PCB 28          | Serum  | ng/g lip. | 386 | 2.2 [1.9; 2.5] | 0.5         | 1.6  | 2.7  | 3.9 | 5.7   |
| PCB 52          | Serum  | ng/g lip. | 386 | 1 [0.2; 3.1]   | 0.33        | 0.58 | 0.89 | 1.4 | 2.2   |
| PCB 101         | Serum  | ng/g lip. | 386 | 1.1 [0.9; 1.3] | 0.23        | 0.62 | 1.3  | 2   | 3.7   |
| PCB 138         | Serum  | ng/g lip. | 386 | 70 [60; 80]    | 29          | 48   | 73   | 120 | 190   |
| PCB 153         | Serum  | ng/g lip. | 386 | 110 [100; 130] | 40          | 80   | 130  | 190 | 290   |
| PCB 180         | Serum  | ng/g lip. | 386 | 90 [80; 110]   | 34          | 64   | 110  | 150 | 270   |
| Sum of all PCBs | Serum  | ng/g lip. | 386 | 290 [260; 320] | 110         | 210  | 320  | 470 | 720   |
| Total PCBs**    | Serum  | ng/g lip. | 386 | 480 [430; 530] | 180         | 340  | 540  | 790 | 1,210 |

n: number of measurements performed in ENNS.

ng/g lip.: nanogram per gram of lipids.

\* Mean level: geometric mean and its confidence interval to 95%.

\*\* Sum of the 3 NDL-PDBs (138, 153, 180)x1.7.

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