





## TW Biomonitoring research on persistent organic pollutants (POPs) in the surrounding environment of the waste incinerator IPXIII Ivry-sur-Seine, Paris 2025

### Interim report

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Thanks to Zero Waste Europe for support of this research on persistent organic pollutants (POPs).



Special thanks to Collectif 3R (réduire, réutiliser, recycler) for supporting of this research and by assistance collecting samples and organising public and ARS TW presentations



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HARLINGEN, THE NETHERLANDS, TOXICOWATCH FOUNDATION, March 2025  
PUBLICATION NUMBER: 2025-TWS-PA-01

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## Abbreviations

|                  |  |
|------------------|--|
| <b>BAT</b>       | Best Available Techniques  |
| <b>BEP</b>       | Best Environmental Practice  |
| <b>BEQ</b>       | Biological Equivalents   |
| <b>dl-PCB</b>    | Dioxin-Like Polychlorinated Biphenyls  |
| <b>DR CALUX®</b> | Dioxin Responsive Chemical-Activated LUCiferase gene eXpression                    |
| <b>dw</b>        | Dry Weight   |
| <b>EFSA</b>      | European Food and Safety Authority   |
| <b>GC-MS</b>     | Gas Chromatography Mass Spectrometry GC-MS   |
| <b>LB</b>        | Lower Bound; results under detection limit are set to zero                         |
| <b>LOD</b>       | Limit of Detection   |
| <b>LOQ</b>       | Limit of Quantification  |
| <b>MB</b>        | Middle Bound; values are set as half the detection limit values                    |
| <b>MWI</b>       | Municipal Waste Incineration   |
| <b>ndl-PCB</b>   | Non-Dioxin-Like Polychlorinated Biphenyl (Non-Dioxin-Like PCB)                     |
| <b>ng</b>        | Nanogram; 10 <sup>-9</sup> gram  |
| <b>OTNOC</b>     | Other Than Normal Operating Conditions   |
| <b>PAH</b>       | Polycyclic Aromatic Hydrocarbons   |
| <b>PCB</b>       | Polychlorinated Biphenyl   |
| <b>PCDD</b>      | Polychlorinated Dibenzodioxins   |
| <b>PCDF</b>      | Polychlorinated Dibenzofurans  |
| <b>PFAS</b>      | Per- and PolyFluoroAlkyl Substances  |
| <b>pg</b>        | Picogram; 10 <sup>-12</sup> gram   |
| <b>POP</b>       | Persistent Organic Pollutants  |
| <b>RPF</b>       | Relative Potency Factors   |
| <b>SVHC</b>      | Substances of Very High Concern  |
| <b>TCDD</b>      | 2,3,7,8-tetrachloordibenzo- <i>p</i> -dioxine                                      |
| <b>TDI</b>       | Tolerable Daily Intake   |
| <b>TEF</b>       | Toxic Equivalency Factor   |
| <b>TEQ</b>       | Toxic Equivalents  |
| <b>TOF</b>       | Total Organic Fluorine   |
| <b>TW</b>        | ToxicoWatch  |
| <b>TWI</b>       | Tolerable Weekly Intake  |
| <b>UB</b>        | Upper Bound (ub), results under detection limit are set as detection limit values. |
| <b>µg</b>        | Microgram 10 <sup>-3</sup> gram  |
| <b>WtE</b>       | Waste to Energy (waste incinerator)  |

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## Introduction

This report presents the analysis results of the vegetation and soil in the surrounding environment of the IVRY-PARIS XIII waste incinerator, located in Ivry-sur-Seine. The samples were collected in October 2024 by the team of TW and in February by the C3R team, which was commissioned to carry out complementary sampling.

This interim report focuses on the analysis of the vegetation and soil in the surrounding area of the IVRY-PARIS XIII waste incinerator. For comprehensive background information on persistent organic pollutants (POPs), EU regulations, and methodologies, please refer to previous TW reports: TW Biomonitoring Research Paris (2021) and Hidden Emissions Waste Incinerator IVRY-PARIS XIII (2023)—both listed in the reference section at the end of this report.

The initial biomonitoring research undertaken by ToxicoWatch in 2021 focused on dioxin and used backyard chicken eggs from private chicken coop owners living near the waste incinerator. Although, the government validated the findings of the biomonitoring, it concluded that similar contamination occurred in other parts of Paris, not just near the incinerator. As a result, public willingness to raise chickens or participate in a follow-up studies significantly declined due to the negative attention associated with backyard chicken eggs. Therefore, the 2024/2025 TW biomonitoring strategy in Ivry-sur-Seine prioritises mosses (Bryophytes), vegetation (pine needles and evergreen tree leaves), and soil as key matrices for analysis.

As with previous TW research, chemical analyses are complemented by innovative bioassays to detect a broader range of POPs, including dioxin-like PCBs, mixed halogenated dioxins, and PFAS. In addition, this study includes the analyses of heavy metals in mosses (Bryophytes).



*Figure 1: View of the incinerator Ivry-Paris XIII*

# 1. Persistent Organic Pollutants (POPs)

## 1.1. Dioxins

Dioxins are ubiquitous and persistent environmental contaminants that pose a serious public health concern. These highly toxic chemicals are linked to cancer, diabetes, neurotoxicity, immunotoxicity, chloracne and even suspected – when exposure occurs during critical developmental-windows – of causing epigenetic alterations across multiple generations (Viluksela & Pohjanvirta, 2019).

Dioxins have no intentional industrial use and are formed unintentionally during industrial and thermal processes, including those involving waste incinerators, secondary aluminium smelters, sinter plants, small-scale municipal solid waste incinerators (MSWI), medical waste incinerators (MWI), electric-arc furnaces (EAF), industrial waste incinerators, cement kilns, and crematoria.

Dioxins and dioxin-like PCBs (dl-PCB) are highly persistent substances and degrade very slowly, leading to bioaccumulation in the food chain. Under the Stockholm Convention in 2004, 184 nations committed to minimising emissions of dioxins and other unintentionally produced persistent organic pollutants. Since then, PFOS (added in 2009) and PFOA (added in 2019) have also been listed under the convention, with brominated dioxins nominated for inclusion (BRS Convention, 2025).

## 1.2. PFAS

Per- and PolyFluoroAlkyl substances (PFAS) are a large group of synthetic chemicals used in a wide range of industrial and consumer products. Their widespread use has led to ubiquitous environmental contamination.

PFAS are valued for their thermal, chemical, and biological stability, non-flammability, and surface-active properties. However, this same stability has led to persistent environmental accumulation. PFAS have been detected in numerous environmental matrices, including air, sewage, rivers, and dust, as well as in food products, food packaging, drinking water, and in human biological samples such as breast milk and blood.

Exposure to PFAS is associated with adverse health effects, including disruptions to thyroid function, metabolism (e.g. obesity, diabetes, insulin resistance, high cholesterol), foetal development, and immune function (Young, 2021). The risk of immunotoxicity in both humans and wildlife is now widely recognised (Corsini, 2014).

PFAS enter the environment through various routes and are now found in soil, dredging sludge, surface water and- critically- in the waste stream, contributing to emissions through air, ash, and other incinerator residues RIVM, (2025).

The European Food and Safety Authority (EFSA) has concluded that parts of the European population exceed the tolerable weekly intake (TWI) for the sum of four PFAS,  $\sum 4$  PFAS through food exposure (EFSA 2024).

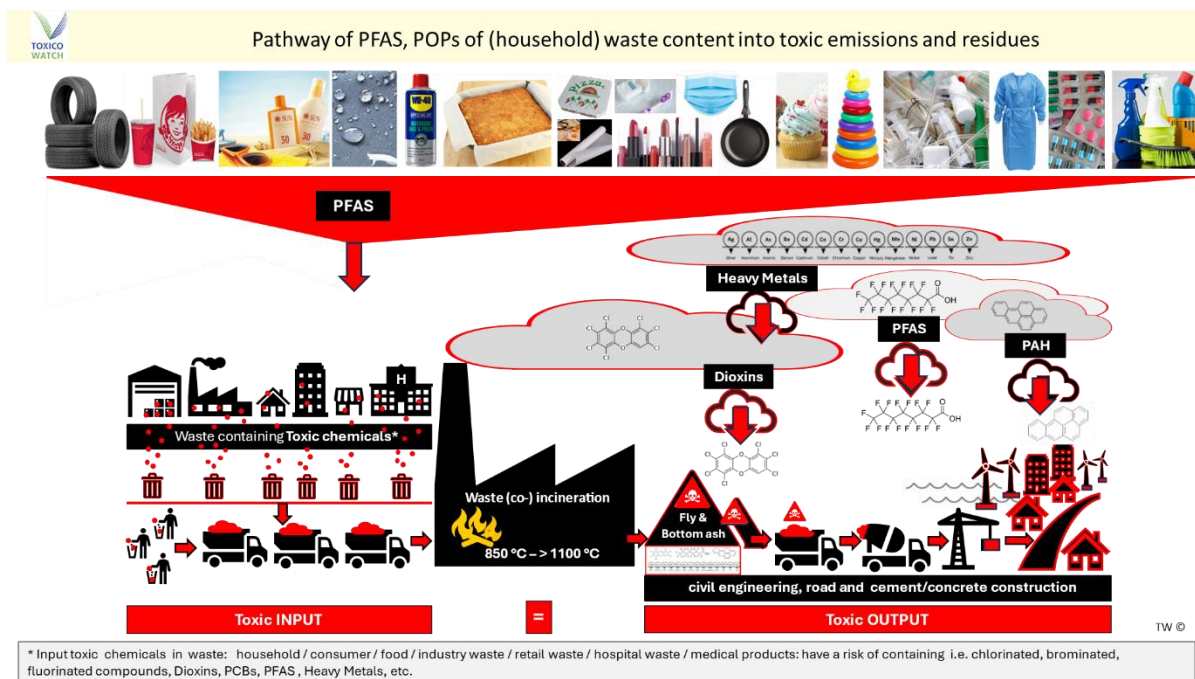


Figure 2: Pathway of PFAS, Persistent Organic Pollutants of household waste into toxic emissions

### 1.3. Heavy Metals

For TW Biomonitoring, 6 to 14 heavy metals were analysed, including: Silver (Ag), Aluminium (Al), Arsenic (As), Barium (Ba), Cadmium (Cd), Cobalt (Co), Chromium (Cr), Copper (Cu), Mercury (Hg), Manganese (Mn), Nickel (Ni), Lead (Pb), Tin (Sn), and Zinc (Zn). The analysis is conducted by the accredited laboratory Normec Groen Agro Control using ICP-MS according to methods A068 +A095 (Normec method), compliant with NEN-EN 13805, and measured according to NEN-EN-ISO 17294-2.

## 1. Methods

Dioxins and PFAS analysis in this interim report were performed by BioDetection Systems (Amsterdam, the Netherlands), accredited under RvA L401.

Chemical analyses on  $\Sigma$  24 PFAS and Heavy Metals were carried out by Normec Groen Agro Control, using the ICP-MS method for heavy metals (A068 +A095), in line with NEN-EN 13805 and NEN-EN-ISO 17294-2 standards.

### 1.1. Dioxin Analysis - DR CALUX

The DR CALUX® (Dioxin Responsive Chemical Activated LUciferase gene eXpression) bioassay is used for quantification of dioxins/furans (PCDD/F) and dioxin-like PCBs (dl-PCBs). For a detailed explanation of the method, refer to first TW Biomonitoring Report Ivry-Sur-Seine (2021).

### 1.2. PFAS Analysis - PFAS CALUX

The PFAS CALUX bioassay uses human bone marrow cell lines (U2OS), containing firefly luciferase gene linked to Thyroid Hormone Responsive Elements (TREs). This reporter system detects thyroid hormone-disrupting compounds, specifically measuring TTR-binding competition by PFAS.

The assay benchmarks PFAS activity against the reference compound Perfluorooctanoic acid (PFOA), assigning it a relative potency value of 1, analogous to the use of TCDD in TEQ calculations (Behnisch, 2021). The results are expressed in µg PFOA equivalent/g product.

PFAS were extracted using weak anion exchange (WAX) SPE cartridge. Approximately 500 ml surface water or 1 litre of WWTP influent/effluent was filtered on glass-fibre filters. WAX-SPE columns (Oasis WAX, Waters 186002493) were conditioned with the following sequence (4 ml MeOH/0.1% NH<sub>4</sub>OH; 4 ml MeOH; 4 ml super-demi water). After conditioning, the specified sample volumes were loaded onto the columns. The columns were then washed with (4 ml 25 mM NH<sub>4</sub>AC pH 4; 8 ml THF/MeOH (75:25)). PFAS were eluted from the WAX- SPE columns using 4 ml MeOH/0.1% NH<sub>4</sub>OH. The eluates were evaporated under nitrogen at 45 °C and reconstituted in 15 µg of DMSO.

### 1.3. PFAS Chemical Analysis (LC-MS/MS)

The chemical analysis of PFAS and heavy metals were performed by the accredited laboratory Normec, Groen Agro Control, located in Delft, the Netherlands.

For PFAS, chemical analyses LC-MS/MS was used for the sum of  $\Sigma$ 24 PFAS. For heavy metals, ICP-MS was applied, following methods A068 +A095 (Normec method), in accordance with NEN-EN 13805, and measured according to NEN-EN-ISO 17294-2.

The TW-indicative colour scale used for mosses and vegetation is based on COMMISSION REGULATION (EU) 2023/915 and the EFSA report: *Risk for animal and human health related to the presence of dioxins and dioxin-like PCBs in feed and food* (Knutsen, 2018).

## 2. Sampling

### 2.1. Sampling Mosses (*Bryophytes*)

In the TW biomonitoring research in Paris (2024/2025), only mosses (*Bryophytes*) from the Class *Bryidae* -which contain the majority of moss species globally (over 9500)- were selected for analysis to monitor the load of persistent organic pollutants (POPs).

In October 2024, a minimum of 100 grams of moss were collected per location, primarily consisting of the species *Hylocomium splendens* and *Pleurozium schreberi*. The cuticle is a fatty/wax 'skin' layer covering plant leaves. The waxy cuticle, along with stomata (pores on the leaf surface that facilitate gas exchange), plays a key role in the transport of xenobiotics, making plants effective biomarkers for environmental monitoring (Matos et al., 2022).

Although bryophytes generally have a poorly developed cuticle, the degree of cuticle development varies among species, which can influence their ability to absorb pollutants. The lipid content of the cuticle- also species dependent- is particularly important for xenobiotic transport. Despite interspecies differences in the uptake of POPs, mosses (*Bryophytes*) - as well as lichens (not used in this TW research)- are considered valuable bioindicators for monitoring environmental POP pollution. They can reflect both the levels and types of pollutants present in their habitats. Effective biomonitoring relies on accurate species identification and the use of composite samples, which combine well-balanced material increments. This ensures reliable comparisons of analytical results between polluted and reference sites. The application of mosses in biomonitoring research has been extensively documented in the scientific literature (Jovan et al., 2024; Musilova et al., 2024; Qarri et al., 2019).



## 2.2. Sampling Evergreen Tree Leaves and Pine Needles

Evergreen tree leaves, foliage and pine needles (100 gram per sample) from various evergreen and pine tree species were collected for the Ivry-sur-Seine biomonitoring research on vegetation in 2024. Tree species sampled included: Olive tree (*Olea Europea*), Atlas cedar (*Cedrus atlantica*), Arizona cypress (*Cupressus arizonica*), Fig (*Ficus carica*), Scots pine (*Pinus silvestris*) and Bhutan pine (*Pinus Wallichiana*).

## 2.3. Sampling Soil

Soil samples were collected using hand shovels, focusing on the topsoil layers (0-5 cm). Samples were taken from multiple points within a few several square meters at each location to ensure representativeness. A minimum of 150 grams of soil was collected per site and immediately stored in an HDPE lab bag or a glass jar.

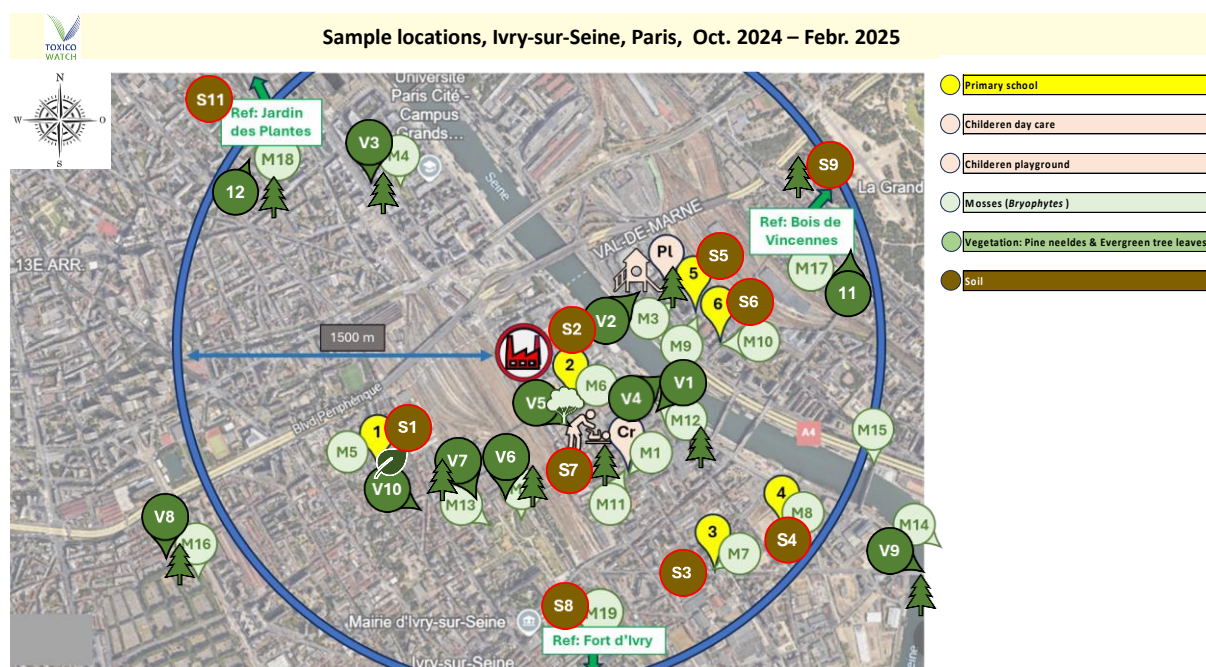


Figure 3: Sample locations, Ivry-sur-Seine, Paris, Oct. 2024 - Febr.2025

## 3. Results biomonitoring

### 3.1. Dioxins

#### 3.1.1. Dioxins in Mosses

Mosses are widely recognised as bioindicators of pollution. However, much like the public resistance to bans on consuming chicken eggs, a ban on the use or presence of moss would be undesirable and counterproductive in efforts to reduce POPs in the environment. Such a measure would represent a short-sighted approach that ignores the root causes of pollution.

Vegetation acts as a natural buffer, capturing atmospheric deposition of pollutants. Without this buffer, pollutants are more likely to enter the human environment as outdoor or indoor dust, increasing exposure through inhalation, skin contact and ingestion. Phytoremediation - the use of plants to remove or neutralise pollutants - is increasingly accepted by both local communities and regulatory agencies as a visually appealing and sustainable solution (Ensley, 1997). The potential of

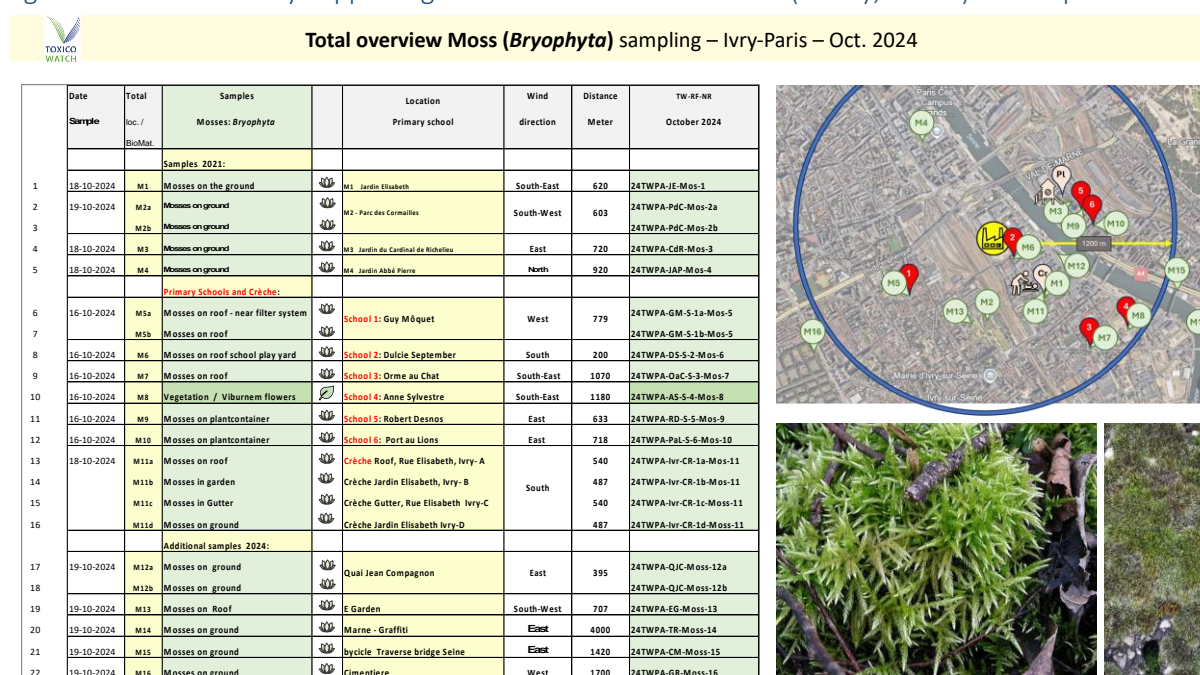


Figure 4: Total overview moss sampling - 2024

There are two main approaches to interpreting the dioxins analysis results from moss samples collected in October 2024.:

- Using moss as an indicator species, comparing its pollutant load to that of vegetation.
- Assessing moss as if were feed for animals, to evaluate potential health risks through the food chain.

For comparison, the average dioxin levels in vegetables are 0.21 pg TEQ/g wet weight as measured by DR CALUX.

The table below presents dioxins results in wet weight/whole product, aligned with EU Action limits for dioxins in vegetation (EFSA, 2018). It is important to emphasise that all relevant directives should be updated to reflect the revised Tolerable Weekly Intake for dioxins, which is currently set at of 2 pg TEQ/kg bw/week (EFSA, 2018). The dioxin analysis results are also expressed in 88% dry weight. These results are visualised using the TW indicative colour scale for mosses, based on comparison with the EU maximum limit for dioxins in animal feed of 1.25 pg TEQ/g, as established in Directive 2002/32/EC on undesirable substances in animal feed. The indication table also shows a conversion factor of 66.6 %, used to derive an indicative limit DR CALUX limit of 0.83 pg TEQ/ g, following the same approach applied in egg regulation analogies.

**Results Dioxins Total overview Moss (Bryophytes) & sample locations, Ivry-sur-Seine, Paris – Oct. 2024 - 2025**

| Dioxin analysis Vegetation: Mosses (Bryophytes) - DR CALUX |        |               |             |                                  |         |               |              |                                   |         |               |       |
|--|--------|---------------|-------------|----------------------------------|---------|---------------|--------------|-----------------------------------|---------|---------------|-------|
| Year   | Sample | Moss Location | Graph code  | Results wet weight , ww (FOOD)   |         |               | Moisture (%) | Results 88% dry weight, dw (FEED) |         |               |       |
|  |        |               |             | PCDD/PCDF                        | dl-PCBs | PCDD/F/dl-PCB |              | PCDD/PCDF                         | dl-PCBs | PCDD/F/dl-PCB |       |
| 1  | 2024   | Moss          | School M 8  | Anne Sylvester                   | 0,10    | 0,05          | 0,15         | 68,3                              | 0,28    | 0,14          | 0,42  |
| 2  | 2024   | Moss          | M 4         | Jardin Abbé Pierre 2024          | 0,31    | 0,10          | 0,41         | 70,1                              | 0,91    | 0,29          | 1,21  |
| 3  | 2024   | Moss          | M 2         | Parc De Cormaille 2024           | 0,26    | 0,22          | 0,48         | 55,6                              | 0,52    | 0,44          | 0,95  |
| 4  | 2024   | Moss          | School M 7  | Orme Au Chat                     | 0,29    | 0,31          | 0,60         | 88,2                              | 2,16    | 2,31          | 4,48  |
| 5  | 2025   | Moss          | Ref. M 18 B | Jardin Des Plantes               | 0,86    | 0,05          | 0,91         | 51,1                              | 1,55    | 0,09          | 1,64  |
| 6  | 2025   | Moss          | Ref. M 17   | Bois De Vincennes                | 0,95    | 0,05          | 1,00         | 59,7                              | 2,07    | 0,11          | 2,18  |
|  | 2021   | Moss          | M 4         | Jardin Abbé Pierre 2021          | 0,88    | 0,29          | 1,17         | 73,2                              | 2,89    | 0,95          | 3,84  |
| 7  | 2024   | Moss          | M 3         | Jardin De Cardinate De Richelieu | 0,86    | 0,32          | 1,18         | 67,6                              | 2,33    | 0,87          | 3,20  |
| 8  | 2024   | Moss          | M 15        | Traverse Bridge Seine            | 0,79    | 0,40          | 1,19         | 75,4                              | 2,83    | 1,43          | 4,26  |
| 9  | 2024   | Moss          | School M 9  | Robert Desnos                    | 0,79    | 0,60          | 1,39         | 21,9                              | 0,89    | 0,68          | 1,57  |
|  | 2021   | Moss          | M 2         | Parc Des Cormailles 2021         | 1,10    | 0,31          | 1,41         | 73,2                              | 3,61    | 1,02          | 4,63  |
| 10   | 2025   | Moss          | Ref. M 18 A | Jardin Des Plantes               | 1,20    | 0,30          | 1,50         | 66,0                              | 3,11    | 0,78          | 3,88  |
| 11   | 2024   | Moss          | M 13        | Erica garden                     | 0,77    | 0,76          | 1,53         | 85,6                              | 4,70    | 4,64          | 9,34  |
| 12   | 2024   | Moss          | School M 6  | Dulcie Septembre                 | 1,20    | 0,41          | 1,61         | 65,5                              | 3,06    | 1,05          | 4,11  |
|  | 2021   | Moss          | M 3         | Cardinal de Richelieu 2021       | 2,20    | 0,61          | 2,81         | 73,2                              | 7,22    | 2,00          | 9,23  |
| 13   | 2025   | Moss          | Ref. M19    | Fort d'Ivry                      | 0,05    | 3,10          | 3,15         | 62,6                              | 0,12    | 7,29          | 7,41  |
| 14   | 2024   | Moss          | M 12        | Quai Jean Compagnon              | 1,50    | 2,00          | 3,50         | 59,3                              | 3,25    | 4,33          | 7,57  |
| 15   | 2024   | Moss          | M 11        | Jardin Elisabeth 2024            | 1,60    | 2,20          | 3,80         | 84,6                              | 9,14    | 12,57         | 21,70 |
|  | 2021   | Moss          | M 11        | Jardin Elisabeth 2021            | 3,80    | 1,10          | 4,90         | 73,2                              | 12,48   | 3,61          | 16,09 |
| 16   | 2024   | Moss          | School M 10 | Port Au Lions                    | 1,10    | 6,40          | 7,50         | 60,0                              | 2,42    | 14,09         | 16,51 |
| 17   | 2024   | Moss          | School M 5  | Guy Moquet                       | 0,76    | 7,60          | 8,36         | 41,7                              | 1,15    | 11,47         | 12,61 |

Table 1: Results dioxins in moss expressed in wet weight and 88% dry weight (DR CALUX).



Figure 5: Moss sample locations – Ivry-sur-Seine, Paris, 2024

### 3.1.2. Dioxins in Soil

Exposure to soil can occur either through direct ingestion – particularly relevant for young children - or through soil particles adhered to fruits and vegetables. The extent of human intake from soil depends on the surrounding environmental (e.g. rural vs urban) and the presence of dioxins (PCDD/F) emission sources (EFSA 2018).

Assuming soil concentrations between 5 and 50 pg TEQ/g and a daily ingestion of 0.1 g, the potential intake from soil would range from 0.5–5.0 pg TEQ per person per day (Fürst, 1992). These findings should be taken into account when considering outdoor school activities, such as school vegetable gardening, to minimise potential exposure risks.

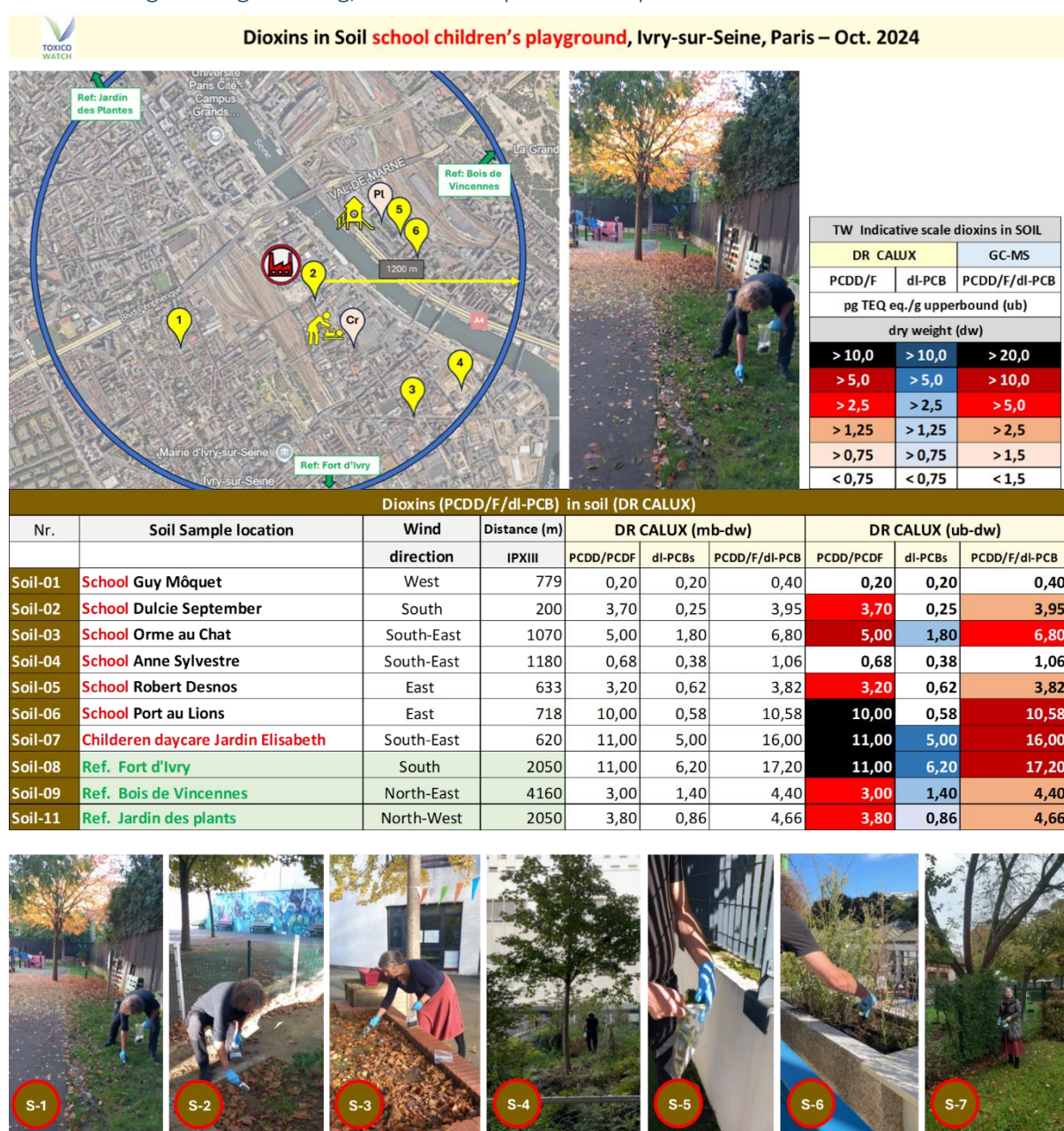


Figure 6: Dioxins in soil school children's playground, Ivry-sur-Seine, Paris 2024

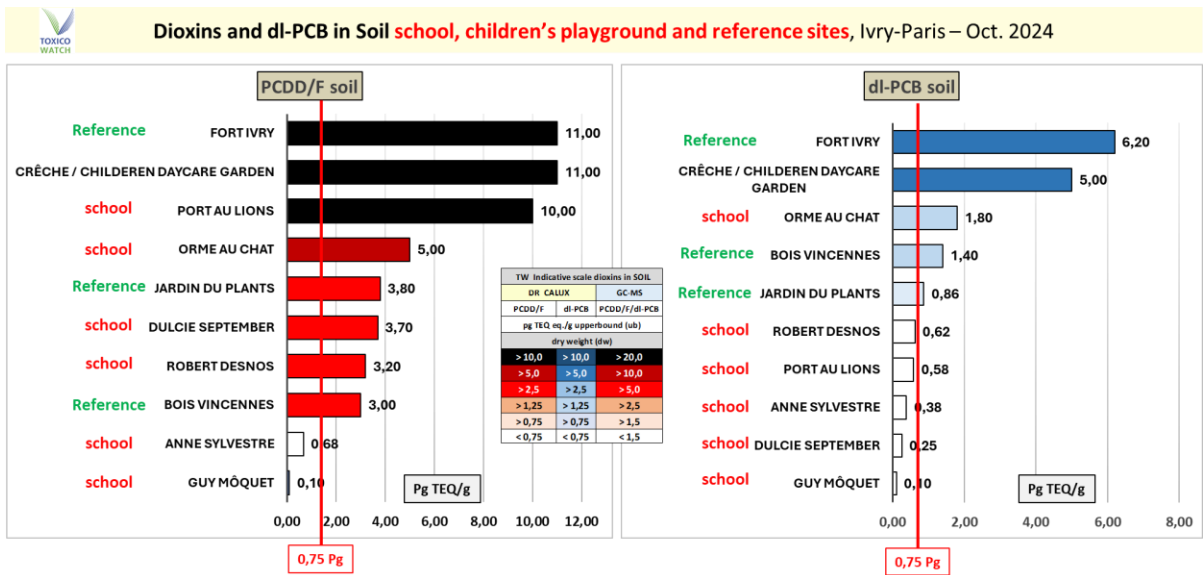


Figure 8: Dioxin and dl-PCB in soil, children's playground and reference sites, Ivry-sur Seine, Paris, 2024

A comparison of dioxin levels in soil and mosses at Fort d'Ivry reveals a striking contrast. While the soil sample from this location is heavily contaminated with dioxins, the moss samples collected at the same location and time are amongst the 'cleanest' in this biomonitoring study. In contrast, both soil and moss samples collected from Jardin Elisabeth, located near a children's daycare centre, exhibited elevated levels of dioxins. It is well established that mosses (Bryophytes) do not absorb POPs from the soil, but instead accumulate them from the atmosphere. Unlike vascular plants, mosses lack a root (xylem) for water and nutrient uptake. Instead, they anchor to surfaces using rhizoids, a rootlike structure that does not facilitate absorption from the substrate. Therefore, the high dioxin values in mosses collected near the children's daycare at Jardin Elisabeth are attributed to atmospheric deposition, not soil contamination. Regarding POPs in soil, it is important to consider the possible influence of other) confounding factors, which may contribute to the observed contamination and variability in results.

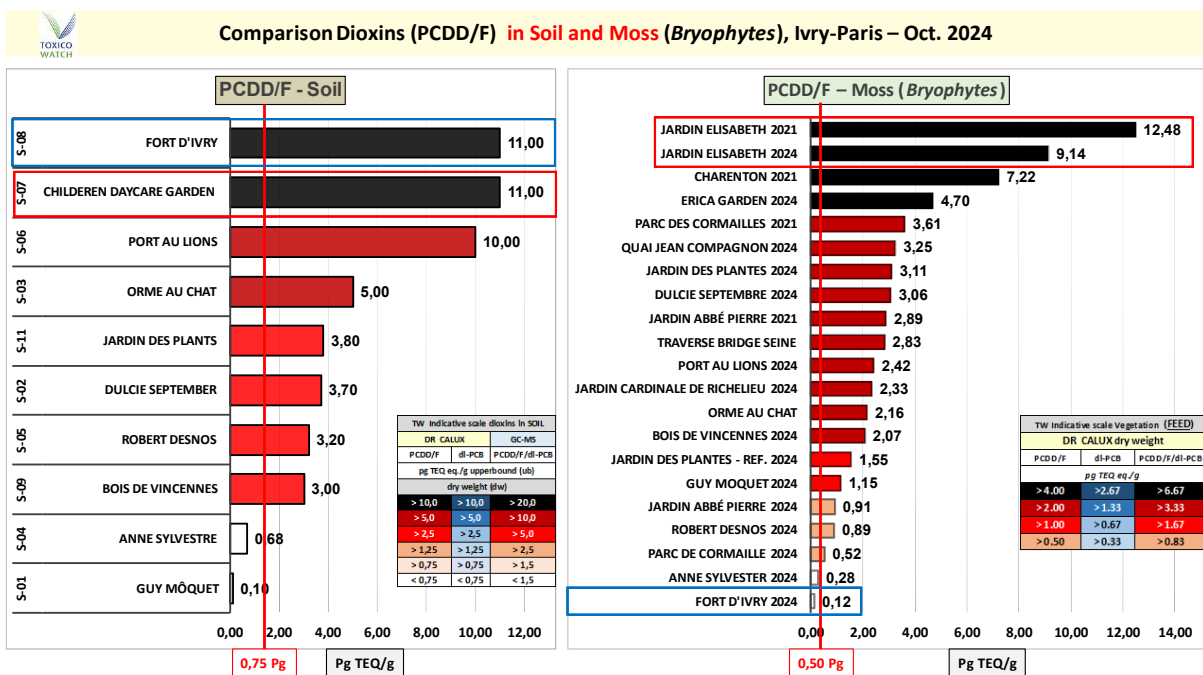
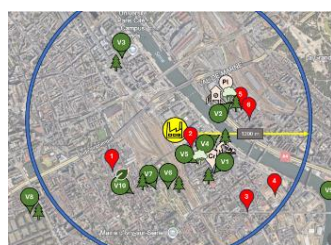


Figure 7: Comparison dioxins (PCDD/F) in soil and mosses - Ivry-sur-Seine, Paris, 2024

### 3.1.3. Dioxins in Pine Needles and Evergreen Tree Vegetation

At 10 vegetation sampling locations, pine needles and evergreen tree leaves were collected and analysed for dioxins (PCDD/F/dl-PCB) using the DR CALUX method. These sample locations are located within 400 to 1,700 metres of the IPXIII waste incinerator, covering all wind directions, with a focus on the south and east quadrant beyond the *Périphérique* ring road. The dioxin results are presented in the table below and in Annex-C: Dioxins in Vegetation. Notably, there is consistent exceedance of dioxin-like PCB (dl-PCB) levels, which significantly contribute to the total dioxins (PCDD/F/dl-PCB) load, if assessed under animal feed regulations, these results would exceed EU limits and are visualised using the TW indicative colour scale. The highest dioxin concentration was found in the evergreen foliage of Arizona cypress (*Cupressus arizonica*), sampled from Jardin du Cardinal de Richelieu, measuring **0.88 pg TEQ/g**. The second highest value was recorded in pine needles from Buthan pine (*Pinus Wallichiana*), at the reference location *Jardin des Plantes*, with **0.73 pg TEQ/g**.

| Dioxins (PCDD/F) in pine needles and evergreen tree leaves, Ivry-sur-Seine, Paris – Oct. 2024 / Febr. 2025 |               |                            |                                   |                |              |                               |                       |        |               |  |  |  |  |
|--|---------------|----------------------------|-----------------------------------|----------------|--------------|-------------------------------|-----------------------|--------|---------------|--|--|--|--|
| Dioxins (PCDD/F) in Pine needles, evergreen tree leaves, Ivry-su-Seine, Oct 2024 / Febr. 2025              |               |                            |                                   |                |              |                               |                       |        |               |  |  |  |  |
| Date   | Total BioMat. | Vegetation Samples         | Location                          | Wind direction | Distance (m) | Paris, Oct. 2024 / Febr. 2025 | DR CALUX              |        |               |  |  |  |  |
|  |               |                            |                                   |                |              |                               | pg TEQ / g wet weight |        |               |  |  |  |  |
| Sample   |               | Pine needles / leaves      | Public Bvd/Garden/ School/ Crèche |                | IP XIII      | TW-REF-NR                     | PCDD/F                | dl-PCB | PCDD/F/dl-PCB |  |  |  |  |
| 18-10-2024   | V1            | <i>Cedrus atlantica</i>    | Jardin Elisabeth                  | South-East     | 487          | 24TWPA-JE-PNCeA-VEG-1         | 0,075                 | 0,650  | 0,725         |  |  |  |  |
| 18-10-2024   | V2a           | <i>Cupressus arizonica</i> | Jardin du Cardinal de Richelieu   | East           | 724          | 24TWPA-CdR-PNCuA-VEG-2a       | 0,880                 | 0,360  | 1,240         |  |  |  |  |
|  | V2b           | <i>Cedrus atlantica</i>    | Jardin du Cardinal de Richelieu   |                |              | 24TWPA-CdR-PNCeA-VEG-2b       | 0,320                 | 0,320  | 0,640         |  |  |  |  |
| 18-10-2024   | V3            | <i>Pinus silvestris</i>    | Jadrin Abbé Pierre                | North          | 930          | 24TWPA-AP-PNPS-VEG-3          | 0,110                 | 0,250  | 0,360         |  |  |  |  |
| 19-10-2024   | V4a           | <i>Pinus silvestris</i>    | Quai Jean Compagnon               | East           | 525          | 24TWPA-AP-PNPS-VEG-4a         | 0,077                 | 0,280  | 0,357         |  |  |  |  |
|  | V4b           | <i>Pinus silvestris</i>    | Quai Jean Compagnon               |                |              | 24TWPA-QJ-PNPS-VEG-4b         |                       |        |               |  |  |  |  |
| 19-10-2024   | V5            | <i>Olea europaea</i>       | Allée Chantedair                  | South          | 427          | 24TWPA-AC-LFOE-VEG-5          | 0,094                 | 0,060  | 0,154         |  |  |  |  |
| 19-10-2024   | V6            | <i>Pinus sylvestris</i>    | Parc des Cormailles               | South-West     | 603          | 24TWPA-PC-PNPS-VEG-6          | 0,074                 | 0,220  | 0,294         |  |  |  |  |
| 19-10-2024   | V7            | <i>Cedrus atlantica</i>    | DH Garden                         | South-West     | 700          | 24TWPA-DH-PNCeA-VEG-7         |                       |        |               |  |  |  |  |
| 19-10-2024   | V8            | <i>Cedrus atlantica</i>    | Cimentiere                        | West           | 1700         | 24TWPA-CE-PNCeA-VEG-8         | 0,110                 | 0,390  | 0,500         |  |  |  |  |
| 19-10-2024   | V9            | <i>Cedrus atlantica</i>    | Marne-Halfway_Traverse/Graffiti   | East           | 3000         | 24TWPA-MA-PNCeA-VEG-9         | 0,230                 | 0,240  | 0,470         |  |  |  |  |
| 19-10-2024   | V10           | <i>Fig - Ficus carica</i>  | K Garden                          | West           | 850          | 24TWPA-KY-LFFI-VEG-10         | 0,076                 | 0,094  | 0,170         |  |  |  |  |
| Febr. 2025   | V11           | <i>Pinus Wallichiana</i>   | Jardin des Plantes: Reference     | North-West     | 3000         | 25TWPA-BJdP-PN-PPW-3A         | 0,730                 | 0,350  | 1,080         |  |  |  |  |
| Febr. 2025   | V12           | <i>Pinus silvestris</i>    | Bois de Vincennes: Reference      | East           | 2700         | 25TWPA-BV-PS-PN-1B            | 0,270                 | 0,230  | 0,500         |  |  |  |  |



| TW Indicative scale Vegetation (Food) |        |               |
|---------------------------------------|--------|---------------|
| DR CALUX - wet weight (ww) ub         |        |               |
| PCDD/F                                | dl-PCB | PCDD/F/dl-PCB |
| pg TEQ/g                              |        |               |
| > 1.60                                | > 0.53 | > 2.13        |
| > 0.80                                | > 0.27 | > 1.07        |
| > 0.40                                | > 0.13 | > 0.53        |
| > 0.20                                | > 0.07 | > 0.27        |
| < 0.20                                | < 0.07 | < 0.27        |



Figure 9: Dioxins (PCDD/F) in pine needles and evergreen tree leaves, Ivry-sur-Seine, Paris, 2024

The analysis results from the ten (10) vegetation samples collected in 2024 show lower dioxin levels compared to those measured at four (4) locations in 2021. These findings contrast with the elevated dioxin concentrations observed in the moss (*Bryophyte*) samples collected in 2024.

Unlike the moss samples, the distribution of dioxins and dl-PCBs is vegetation samples – such as not as evergreen leaves and pine needles – is less clearly defined. This may be due to the heterogeneous nature of the sampled tree species; *Olea Europa*, *Cedrus atlantica*, *Cupressus arizonica*, *Fig - Ficus carica*, *Pinus silvestris* and *Pinus Wallichiana*.

## 3.2. Heavy metals

### 3.2.1. Heavy metals in Mosses (Bryophytes)

A total of 14 heavy metals were analysed in moss samples (Bryophytes). The tables below present the results in milligrams per kilogram of dry weight. The second table includes a heatmap comparing heavy metals concentrations with those measured in moss samples from the Ivry-sur-Seine cemetery (*Cimetière d'Ivry*) – a reference location situated 1700 metres west from IPXIII waste incineration. This reference site shows slightly elevated concentrations of certain heavy metals. Notably, 7 out of the 14 heavy metals are below the limit of detection (< LOD). However, the heavy metals values at this location differ significantly from those measured in moss samples collected closer to the IPXIII waste incinerator. Key findings include Zinc (Zn) levels are notably elevated, ranging from 481 to 23,427. Arsenic (As), cobalt (Co), copper (Cu) and nickel (Ni) have increased by more than a factor of 100. Cadmium (Cd) levels are elevated by 10-50 times, while mercury (Hg) levels exceed the reference by a factor of 2.8 to 5.3.

| Results Heavy Metals [14] in Mosses (Bryophytes), mg/kg, (dw), Upper Bound (UB) - Paris, October 2024                |                            |       |              |                 |               |              |               |              |                |              |               |                 |              |            |           |            |
|--|----------------------------|-------|--------------|-----------------|---------------|--------------|---------------|--------------|----------------|--------------|---------------|-----------------|--------------|------------|-----------|------------|
| TW-REF-NR  | Location                   | Moss  | 1            | 2               | 3             | 4            | 5             | 6            | 7              | 8            | 9             | 10              | 11           | 12         | 13        | 14         |
|  |                            |       | Ag<br>Silver | Al<br>Aluminium | As<br>Arsenic | Ba<br>Barium | Cd<br>Cadmium | Co<br>Cobalt | Cr<br>Chromium | Cu<br>Copper | Hg<br>Mercury | Mn<br>Manganese | Ni<br>Nickel | Pb<br>Lead | Sn<br>Tin | Zn<br>Zinc |
| 24TWPA-GR-Moss-16  | Reference: Cimetière       | M 16  | 0,01         | 3522,00         | 0,02          | 46,00        | 0,01          | 0,05         | 11,00          | 0,02         | 0,01          |                 | 0,05         | 28,00      | 18,00     | 0,11       |
| 24TWPA-PdC-Mos-2b  | Parc des Cormaille         | M 2 b | 0,10         | 6523,00         | 4,90          | 85,00        | 0,20          | 3,30         | 31,00          | 23,00        | 0,12          |                 | 10,00        | 64,00      | 6,40      | 84,00      |
| 24TWPA-PaL-S-6-Mos-10  | School 6: Port au Lions    | M 10  | 0,78         | 13590,00        | 6,00          | 202,00       | 1,50          | 9,60         | 86,00          | 347,00       | 0,28          |                 | 40,00        | 330,00     | 71,00     | 2577,00    |
| 24TWPA-QaC-S-3-Mos-7   | School 3: Orme au chat     | M 7   | 0,36         | 13513,00        | 3,10          | 96,00        | 0,44          | 7,90         | 32,00          | 73,00        | 0,09          | 414,00          | 29,00        | 113,00     | 13,00     | 551,00     |
| 24TWPA-DS-S-2-Mos-6  | School 2: Dulcie Septembre | M 8   | 0,71         | 8376,00         | 3,30          | 126,00       | 1,20          | 5,70         | 46,00          | 158,00       | 0,22          |                 | 21,00        | 132,00     | 31,00     | 2523,00    |
| 24TWPA-GR-Moss-16  | Reference: Cimetière       | M 16  | 0,01         | 3522,00         | 0,02          | 46,00        | 0,01          | 0,05         | 11,00          | 0,02         | 0,01          |                 | 0,05         | 28,00      | 18,00     | 0,11       |
| 24TWPA-EG-Moss-13  | E garden                   | M 13  | 1,10         | 12382,00        | 6,50          | 378,00       | 3,40          | 6,90         | 56,00          | 116,00       | 0,13          |                 | 39,00        | 1304,00    | 30,00     | 1527,00    |
| 24TWPA-QJC-Moss-12a  | Quai Jean Compagnon        | M 12a | 0,35         | 8513,00         | 20,00         | 264,00       | 0,65          | 13,00        | 55,00          | 361,00       | 0,10          |                 | 27,00        | 125,00     | 26,00     | 919,00     |
| 24TWPA-Ivr-CR-1d_Moss-11   | Crèche Ivry ground         | M11d  | 0,11         | 13667,00        | 2,60          | 122,00       | 0,24          | 1,80         | 28,00          | 25,00        | 0,19          |                 | 16,00        | 77,00      | 2,90      | 167,00     |
| 24TWPA-Ivr-CR-1a_Moss-11   | Crèche Ivry roof           | M 11a | 0,67         | 11748,00        | 4,90          | 104,00       | 0,69          | 8,20         | 40,00          | 103,00       | 0,11          |                 | 30,00        | 157,00     | 8,30      | 1577,00    |
| 24TWPA-GM-S-1a-Mos-5   | School 1: Guy Moquet       | M 5a  | 0,08         | 2309,00         | 2,50          | 47,00        | 0,22          | 1,60         | 8,30           | 57,00        | 0,06          |                 | 6,80         | 16,00      | 7,20      | 135,00     |
| 24TWPA-JAP-Mos-4   | Jardin Abbé Pierre         | M4    | 0,05         | 15145,00        | 7,40          | 83,00        | 0,23          | 5,50         | 33,00          | 16,00        | 0,05          |                 | 15,00        | 17,00      | 1,70      | 53,00      |
| Heat map of Heavy Metals [14] of mosses (Bryophytes) vs reference location M16, Ivry-sur-Seine - Paris, October 2024 |                            |       |              |                 |               |              |               |              |                |              |               |                 |              |            |           |            |
| TW-REF-NR  | Location                   | Moss  | 1            | 2               | 3             | 4            | 5             | 6            | 7              | 8            | 9             | 10              | 11           | 12         | 13        | 14         |
|  |                            |       | Ag<br>Silver | Al<br>Aluminium | As<br>Arsenic | Ba<br>Barium | Cd<br>Cadmium | Co<br>Cobalt | Cr<br>Chromium | Cu<br>Copper | Hg<br>Mercury | Mn<br>Manganese | Ni<br>Nickel | Pb<br>Lead | Sn<br>Tin | Zn<br>Zinc |
| 24TWPA-GR-Moss-16  | Reference: Cimetière       | M 16  | 0,01         | 3522,00         | 0,02          | 46,00        | 0,01          | 0,05         | 11,00          | 0,02         | 0,01          |                 | 0,05         | 28,00      | 18,00     | 0,11       |
| 24TWPA-PdC-Mos-2b  | Parc des Cormaille         | M 2 b | 10,0         | 1,9             | 245,0         | 1,8          | 20,0          | 66,0         | 2,8            | 1150,0       | 12,0          |                 | 200,0        | 2,3        | 0,4       | 763,6      |
| 24TWPA-PaL-S-6-Mos-10  | School 6: Port au Lions    | M 10  | 78,0         | 3,9             | 300,0         | 4,4          | 150,0         | 192,0        | 7,8            | 17350,0      | 28,0          |                 | 800,0        | 11,8       | 3,9       | 23427,3    |
| 24TWPA-QaC-S-3-Mos-7   | School 3: Orme au chat     | M 7   | 36,0         | 3,8             | 155,0         | 2,1          | 44,0          | 158,0        | 2,9            | 3650,0       | 8,9           |                 | 580,0        | 4,0        | 0,7       | 5009,1     |
| 24TWPA-DS-S-2-Mos-6  | School 2: Dulcie Septembre | M 8   | 71,0         | 2,4             | 165,0         | 2,7          | 120,0         | 114,0        | 4,2            | 7900,0       | 22,0          |                 | 420,0        | 4,7        | 1,7       | 22936,4    |
| 24TWPA-GR-Moss-16  | Reference: Cimetière       | M 16  | 1,0          | 1,0             | 1,0           | 1,0          | 1,0           | 1,0          | 1,0            | 1,0          | 1,0           |                 | 1,0          | 1,0        | 1,0       | 1,0        |
| 24TWPA-EG-Moss-13  | E garden                   | M 13  | 110,0        | 3,5             | 325,0         | 8,2          | 340,0         | 138,0        | 5,1            | 5800,0       | 13,0          |                 | 780,0        | 46,6       | 1,7       | 13881,8    |
| 24TWPA-QJC-Moss-12a  | Quai Jean Compagnon        | M 12a | 35,0         | 2,4             | 1000,0        | 5,7          | 65,0          | 260,0        | 5,0            | 18050,0      | 10,0          |                 | 540,0        | 4,5        | 1,4       | 8354,5     |
| 24TWPA-Ivr-CR-1d_Moss-11   | Crèche Ivry ground         | M11d  | 11,0         | 3,9             | 130,0         | 2,7          | 24,0          | 36,0         | 2,5            | 1250,0       | 19,0          |                 | 320,0        | 2,8        | 0,2       | 1518,2     |
| 24TWPA-Ivr-CR-1a_Moss-11   | Crèche Ivry roof           | M 11a | 67,0         | 3,3             | 245,0         | 2,3          | 69,0          | 164,0        | 3,6            | 5150,0       | 11,0          |                 | 600,0        | 5,6        | 0,5       | 14336,4    |
| 24TWPA-GM-S-1a-Mos-5   | School 1: Guy Moquet       | M 5a  | 8,3          | 0,7             | 125,0         | 1,0          | 22,0          | 32,0         | 0,8            | 2850,0       | 6,0           |                 | 136,0        | 0,6        | 0,4       | 1227,3     |
| 24TWPA-JAP-Mos-4   | Jardin Abbé Pierre         | M4    | 4,7          | 4,3             | 370,0         | 1,8          | 23,0          | 110,0        | 3,0            | 800,0        | 5,3           |                 | 300,0        | 0,6        | 0,1       | 481,8      |
| Heatmap Heavy Metal [14] in moss (Bryophytes) - Paris, October 2024 vs reference data HM in vegetables               |                            |       |              |                 |               |              |               |              |                |              |               |                 |              |            |           |            |
| TW-REF-NR  | Location                   | Moss  | 1            | 2               | 3             | 4            | 5             | 6            | 7              | 8            | 9             | 10              | 11           | 12         | 13        | 14         |
|  |                            |       | Ag<br>Silver | Al<br>Aluminium | As<br>Arsenic | Ba<br>Barium | Cd<br>Cadmium | Co<br>Cobalt | Cr<br>Chromium | Cu<br>Copper | Hg<br>Mercury | Mn<br>Manganese | Ni<br>Nickel | Pb<br>Lead | Sn<br>Tin | Zn<br>Zinc |
|  | TW reference Vegetable     |       | 0,03         | 27,50           | 0,05          | 45,70        | 0,20          | 0,05         | 1,30           | 1,22         | 0,03          | 70,00           | 0,33         | 0,10       | 0,05      | 6,10       |
|  | Parc des Cormaille         | M 2 b | 3,3          | 237,2           | 98,0          | 1,9          | 1,0           | 66,0         | 23,8           | 18,9         | 4,0           | 0,0             | 30,3         | 640,0      | 120,8     | 13,8       |
|  | School 6: Port au Lions    | M 10  | 26,0         | 494,2           | 120,0         | 4,4          | 7,5           | 192,0        | 66,2           | 284,4        | 9,3           | 0,0             | 121,2        | 3300,0     | 1339,6    | 422,5      |
|  | School 3: Orme au chat     | M 7   | 12,0         | 491,4           | 62,0          | 2,1          | 2,2           | 158,0        | 24,6           | 59,8         | 3,0           | 5,9             | 87,9         | 1130,0     | 245,3     | 90,3       |
|  | School 2: Dulcie Septembre | M 8   | 23,7         | 304,6           | 66,0          | 2,8          | 6,0           | 114,0        | 35,4           | 129,5        | 7,3           | 0,0             | 63,6         | 1320,0     | 584,9     | 413,6      |
|  | Reference: Cimetière       | M 16  | 0,3          | 128,1           | 0,4           | 1,0          | 0,1           | 1,0          | 8,5            | 0,0          | 0,3           | 0,0             | 0,2          | 280,0      | 339,6     | 0,0        |
|  | E garden                   | M 13  | 36,7         | 450,3           | 130,0         | 8,3          | 17,0          | 138,0        | 43,1           | 95,1         | 4,3           | 0,0             | 118,2        | 13040,0    | 566,0     | 250,3      |
|  | Quai Jean Compagnon        | M 12a | 11,7         | 309,6           | 400,0         | 5,8          | 3,3           | 260,0        | 42,3           | 295,9        | 3,3           | 0,0             | 81,8         | 1250,0     | 490,6     | 150,7      |
|  | Crèche Ivry ground         | M11d  | 3,7          | 497,0           | 52,0          | 2,7          | 1,2           | 36,0         | 21,5           | 20,5         | 6,3           | 0,0             | 48,5         | 770,0      | 54,7      | 27,4       |
|  | Crèche Ivry roof           | M 11a | 22,3         | 427,2           | 98,0          | 2,3          | 3,5           | 164,0        | 30,8           | 84,4         | 3,7           | 0,0             | 90,9         | 1570,0     | 156,6     | 258,5      |
|  | School 1: Guy Moquet       | M 5a  | 2,8          | 84,0            | 50,0          | 1,0          | 1,1           | 32,0         | 6,4            | 46,7         | 2,0           | 0,0             | 20,6         | 160,0      | 135,8     | 22,1       |
|  | Jardin Abbé Pierre         | M4    | 1,6          | 550,7           | 148,0         | 1,8          | 1,2           | 110,0        | 25,4           | 13,1         | 1,8           | 0,0             | 45,5         | 170,0      | 32,1      | 8,7        |

Table 2: Results heavy metals in moss, concentrations and heat maps - Ivry-sur-Seine - Paris 2024

When comparing the results with safe and average limit values for vegetables, levels of aluminium (Al), lead (Pb) and tin (Sn) are found to be elevated. The findings from these biomonitoring moss-locations show that even in a densely populated urban area like Paris, there is a significant contamination pressure from the 14 analysed heavy metals.

Notably, even at the reference site, the *Cimetière d'Ivry*, elevated levels of lead (Pb) and tin (Sn) were observed. This raised the question: To what extent are the emissions from the incinerator responsible for these elevated levels?

It is important to note that heavy metal emissions from incinerators are only required to be measured for a limited number of hours per year. Furthermore, emissions that occur during non-routine operational periods- referred to as Other Than Normal Operating Conditions (OTNOC) are not included in the standard heavy metal monitoring programme.

### 3.2.2. Heavy Metals in Soil

Analyses of 14 heavy metals were conducted on soil samples. The tables below present the results in milligrams per kilogram of dry weight. The second table is a heatmap of heavy metals, based on reference data derived from literature.

Interestingly, the extreme elevated concentrations of heavy metals were not observed in the soil samples. The exception were two school locations, which exhibited elevated levels of aluminium (Al) and silver (Ag). The difference factors from the other heavy metals ranged from 0.6 to 9.4, but still quite an increase over the reference values.

Heavy metals in soil concentrations and heatmap TW reference, Ivry-Paris – Oct. 2024

| Heavy metals soil mg/kg dw ub dw |    |        |           |         |        |         |        |          |        |         |           |        |        |       |        |
|----------------------------------|----|--------|-----------|---------|--------|---------|--------|----------|--------|---------|-----------|--------|--------|-------|--------|
|                                  |    | Ag     | Al        | As      | Ba     | Cd      | Co     | Cr       | Cu     | Hg      | Mn        | Ni     | Pb     | Sn    | Zn     |
|                                  |    | Silver | Aluminium | Arsenic | Barium | Cadmium | Cobalt | Chromium | Copper | Mercury | Manganese | Nickel | Lead   | Tin   | Zinc   |
| Guy Moquet                       | S1 | 0.09   | 114772.00 | 7.70    | 111.00 | 0.28    | 6.60   | 32.00    | 23.00  | 0.18    | 417.00    | 21.00  | 32.00  | 3.20  | 90.00  |
| Dutcie Septembre                 | S2 | 0.10   | 14980.00  | 8.60    | 91.00  | 0.21    | 6.90   | 33.00    | 26.00  | 0.10    | 411.00    | 21.00  | 32.00  | 3.20  | 77.00  |
| Orme au chat                     | S3 | 0.72   | 13390.00  | 9.80    | 192.00 | 0.71    | 6.80   | 34.00    | 68.00  | 0.29    | 435.00    | 35.00  | 106.00 | 11.00 | 273.00 |
| Anne Sylvestre                   | S4 | 0.07   | 13687.00  | 8.10    | 84.00  | 0.35    | 7.00   | 29.00    | 18.00  | 0.09    | 458.00    | 17.00  | 30.00  | 1.90  | 53.00  |
| Robert Desnos                    | S5 | 0.11   | 8009.00   | 4.00    | 49.00  | 0.22    | 3.80   | 18.00    | 23.00  | 0.06    | 207.00    | 32.00  | 20.00  | 3.10  | 82.00  |
| Port au Lyon                     | S6 | 0.23   | 13895.00  | 7.40    | 120.00 | 0.53    | 6.50   | 34.00    | 86.00  | 0.22    | 385.00    | 17.00  | 68.00  | 14.00 | 213.00 |
| Children Daycare                 | S7 | 0.57   | 9551.00   | 9.30    | 159.00 | 1.10    | 5.50   | 25.00    | 85.00  | 0.31    | 286.00    | 21.00  | 143.00 | 14.00 | 330.00 |

| Heatmap heavy metals soil Paris |    |      |         |      |       |      |      |       |      |      |        |      |       |      |       |
|---------------------------------|----|------|---------|------|-------|------|------|-------|------|------|--------|------|-------|------|-------|
|                                 |    | 1    | 2       | 3    | 4     | 5    | 6    | 7     | 8    | 9    | 10     | 11   | 12    | 13   | 14    |
|                                 |    | Ag   | Al      | As   | Ba    | Cd   | Co   | Cr    | Cu   | Hg   | Mn     | Ni   | Pb    | Sn   | Zn    |
| 24TWS-reference                 |    | 0.03 | 4000.00 | 5.00 | 22.00 | 0.31 | 8.00 | 13.00 | 9.00 | 0.03 | 500.00 | 9.80 | 29.00 | 2.83 | 47.00 |
| Guy Moquet                      | S1 | 3.1  | 28.7    | 1.5  | 5.0   | 0.9  | 0.8  | 2.5   | 2.6  | 5.5  | 0.8    | 2.1  | 1.1   | 1.1  | 1.9   |
| Dutcie Septembre                | S2 | 3.2  | 3.7     | 1.7  | 4.1   | 0.7  | 0.9  | 2.5   | 2.9  | 2.9  | 0.8    | 2.1  | 1.1   | 1.1  | 1.6   |
| Orme au chat                    | S3 | 24.0 | 3.3     | 2.0  | 8.7   | 2.3  | 0.9  | 2.6   | 7.6  | 8.8  | 0.9    | 3.6  | 3.7   | 3.9  | 5.8   |
| Anne Sylvestre                  | S4 | 2.5  | 3.4     | 1.6  | 3.8   | 1.1  | 0.9  | 2.2   | 2.0  | 2.8  | 0.9    | 1.7  | 1.0   | 0.7  | 1.1   |
| Robert Desnos                   | S5 | 3.7  | 2.0     | 0.8  | 2.2   | 0.7  | 0.5  | 1.4   | 2.6  | 1.8  | 0.4    | 3.3  | 0.7   | 1.1  | 1.7   |
| Port au Lyon                    | S6 | 7.7  | 3.5     | 1.5  | 5.5   | 1.7  | 0.8  | 2.6   | 9.6  | 6.7  | 0.8    | 1.7  | 2.3   | 4.9  | 4.5   |
| Children Daycare                | S7 | 19.0 | 2.4     | 1.9  | 7.2   | 3.5  | 0.7  | 1.9   | 9.4  | 9.4  | 0.6    | 2.1  | 4.9   | 4.9  | 7.0   |

| Exceeding Factors |  |
|-------------------|--|
| 1.5 - 2.0         |  |
| 2.0 - 5.0         |  |
| 5.0 - 10.0        |  |
| 10.0 - 50.0       |  |
| 50.0 - 100.0      |  |
| > 100.0           |  |

Table 3: Heavy metals in soil, concentrations and heat maps - Ivry-sur-Seine, Paris, 2024



## 4. Counter-Research ARS 2023 –Backyard Chicken Eggs

Following TW Biomonitoring’s 2021 research on dioxins in backyard chicken eggs in Ivry-sur-Seine (Arkenbout A. & Bouman KJAM, 2021), the *Agence Régionale de Santé Île-de-France* (ARS) conducted a follow-up-study (ARS, 2024). The ARS confirmed ToxicoWatch findings and recommended that eggs from domestic hen houses in the 410 communities of the Paris metropolitan area should not be consumed. On 15 October 2024, TW had the opportunity to review the ARS research and present its own findings at the ARS office.

The following graphs illustrate the results from both TW and ARS studies on dioxin concentrations in soil and backyard chicken eggs. TW’s soil biomonitoring dioxins was conducted in 2024-2025. Findings from both studies indicate a significant dioxin burden in Ivry-sur-Seine, Paris. Consequently, it is recommended that further research be conducted to identify the sources of contamination; and that effective monitoring measures be implemented to address pollution caused by substances of very high concern (SVHC).

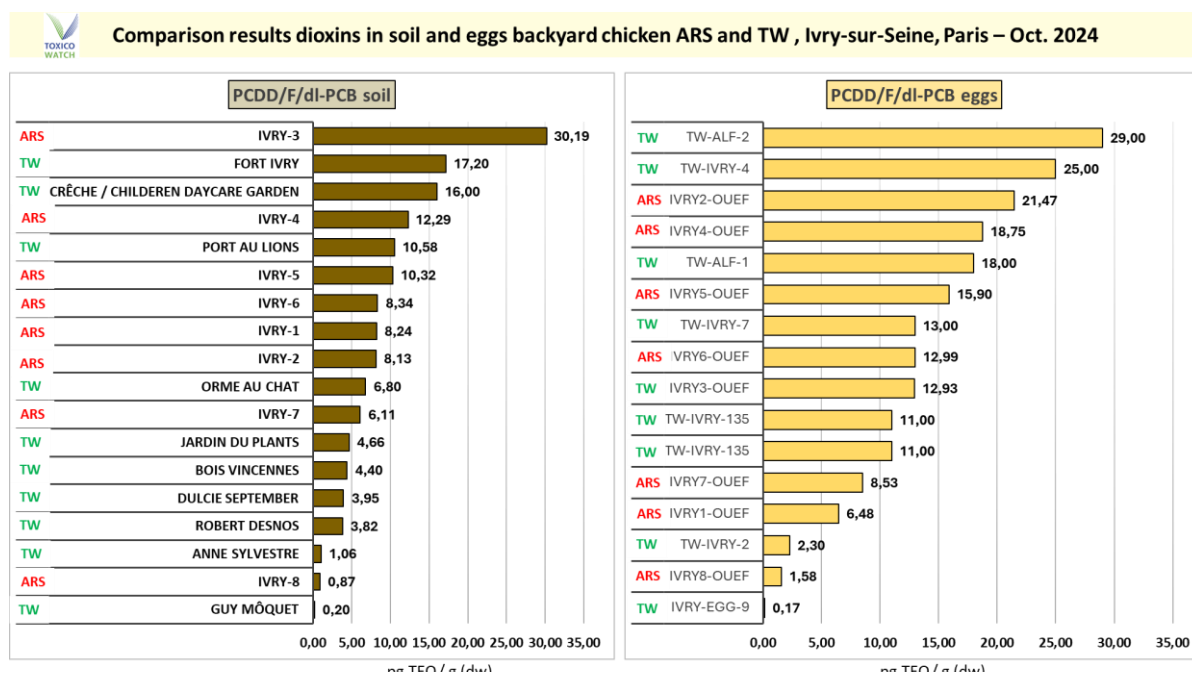


Figure 10: Comparison results dioxin in soil and eggs of backyard chicken ARS and TW, Ivry-sur-seine, Paris, 2024

Analysis of waste incineration emissions has shown elevated levels of specific dioxin congeners of concern, including: Octachlorodibenzo-p-dioxin (OCDD), 1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin (HpCDD), 1,2,3,7,8-Pentachlorodibenzo-p-dioxin (PCDD), and 3,3',4,4',5-Pentachlorobiphenyl (PCB 126). When the chemical analysis data from backyard chicken eggs is plotted on a map of Paris, a clear pattern emerge, showing a higher burden in Ivry-sur-Seine. This aligns with finding from the AMESA semi-continuous measurement research (ToxicoWatch, 2023), which revealed numerous operational incidents and calamities at the IPXIII waste incineration, likely resulting in high dioxin emissions. The results for dioxin congeners OCCD and PCB 126 are shown in the figures below.

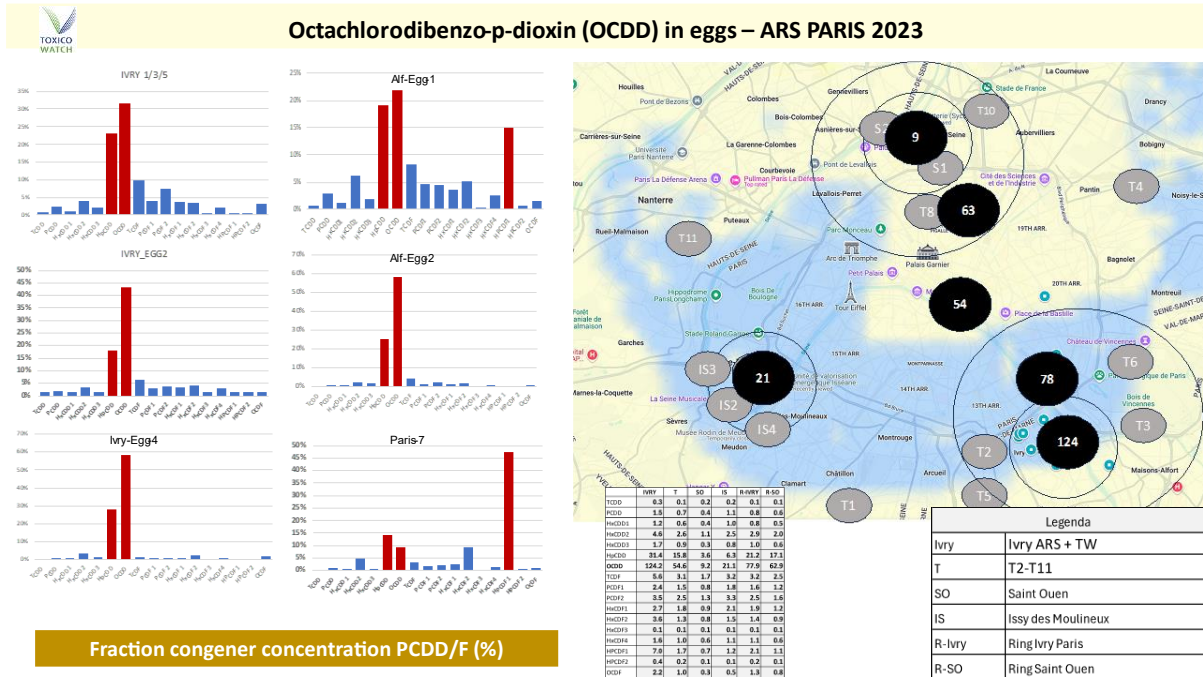


Figure 11: Octachlorodibenzo-p-dioxin (OCDD) in eggs - ARS Paris 2023

A key congener associated with combustion processes is dl-PCB 126. When mapped, high concentrations of dl-PCB 126 are visible in Ivry-Paris, while significantly lower levels are observed in areas north and east of Ivry-sur-Seine. The ARS study showed an extremely high outlier value of **128 pg TEQ/g** for dioxin-like PCBs, which is excluded from the visual comparisons in the figures below due to its disproportionate impact on the scale.

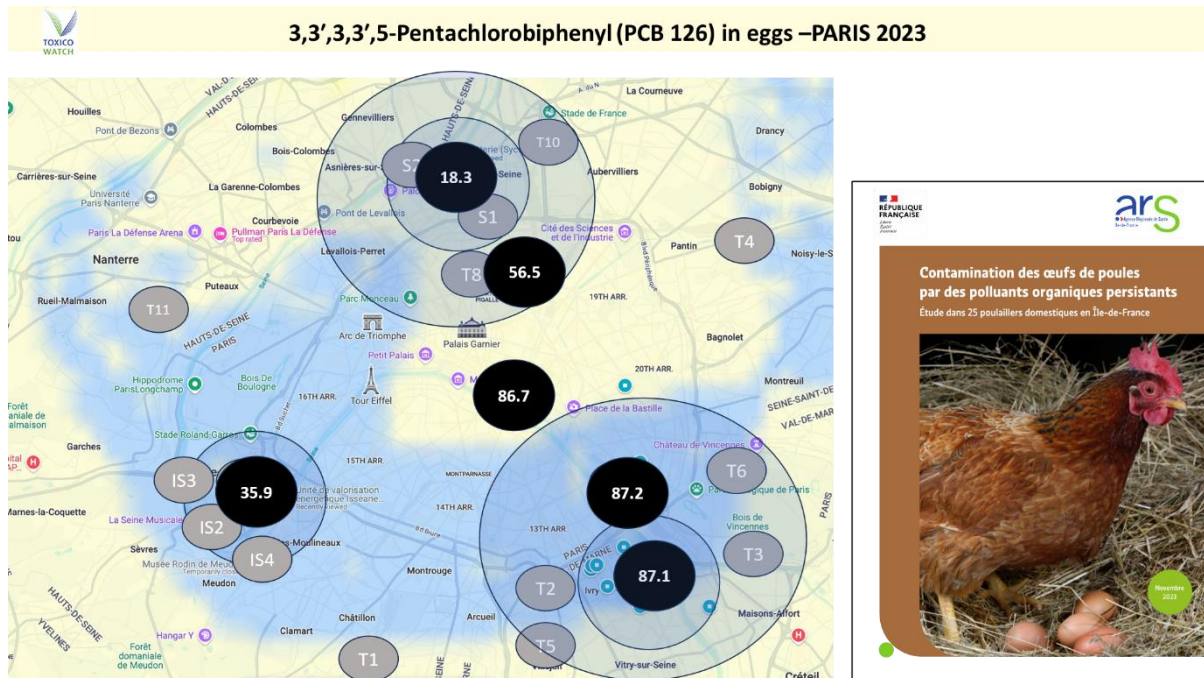


Figure 12: 3,3',3,3',5-Pentachlorobiphenyl (PCB 126) in eggs - Paris 2023

## 5. Conclusion

The first biomonitoring research in Paris initiated in Ivry-sur-Seine, focused on dioxins in eggs from backyard chickens. The excessive dioxin levels detected in these samples raised public and governmental concern. In response, the French public health authority (ARS) conducted a broader study across the Paris region, identifying elevated levels of dioxins and PFAS in eggs.

Based on ARS findings, a spatial distribution pattern of dioxins and dioxin-like substances can be derived from the study area. Waste incineration emissions are typically associated with elevated levels of the following combustion-related dioxin congeners: octachlorodibenzo-p-dioxin (OCDD), 1,2,3,4,6,7,8-heptachlorodibenzo-p-dioxin (HpCDD), 1,2,3,7,8-pentachlorodibenzo-p-dioxin (PCDD) and 3,3',4,4',5-pentachlorobiphenyl (PCB 126). These congeners were found to be most elevated in Ivry-sur-seine. The findings are consistent with the semi-continuous measurement study of IPXIII incinerator (TW 2023), which reported up to 7,000 hours of exceedances over a two-year period. These events are linked to Other Than Normal Operating Condition (OTNOC) which toxic emissions, including dioxins, heavy metals and PFAS are more likely to be emitted.

The second phase of biomonitoring research in 2024 shifted focus to mosses (*bryophytes*), evergreen vegetation, and soil samples collected from primary schools in Ivry-sur-Seine and Charenton. The results indicate widespread dioxin contamination across parts of Paris.

Notably, even the *Jardin des Plantes* botanical garden, located 2.5 km from the IPXIII incinerator, was found to be contaminated with dioxins and heavy metals in moss and vegetation. The highest dioxin concentration in moss was recorded in a primary school 780 metres west of the incinerator – despite low dioxin levels in the soil. Conversely, a primary school 200 metres south of the incinerator showed low moss contamination but high dioxin levels in soil. Most schools demonstrated high levels of dioxins in both moss and soil. Only one out of 7 schools could be classified as clean in terms of dioxins in moss and soil. However, the presence of heavy metals in moss remains a significant concern, as it reflects airborne deposition of POPs.

All measured heavy metals were elevated in moss sample. A comparison with established food safety limits revealed a clear pattern of exceedance. The presence of both dioxins and heavy metals in moss underscores the urgent need for further research and monitoring.

The biomonitoring data clearly show that Ivry-sur-Seine is seriously contaminated with dioxins and heavy metals, with schools identified as particularly vulnerable sites.



Figure 13: Results dioxins in moss, Ivry-sur-Seine, Paris 2024 - 2025

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Annex 1: Lab results

Annex 2: Maximum and action levels European legislation

Annex 3: Vegetation and results