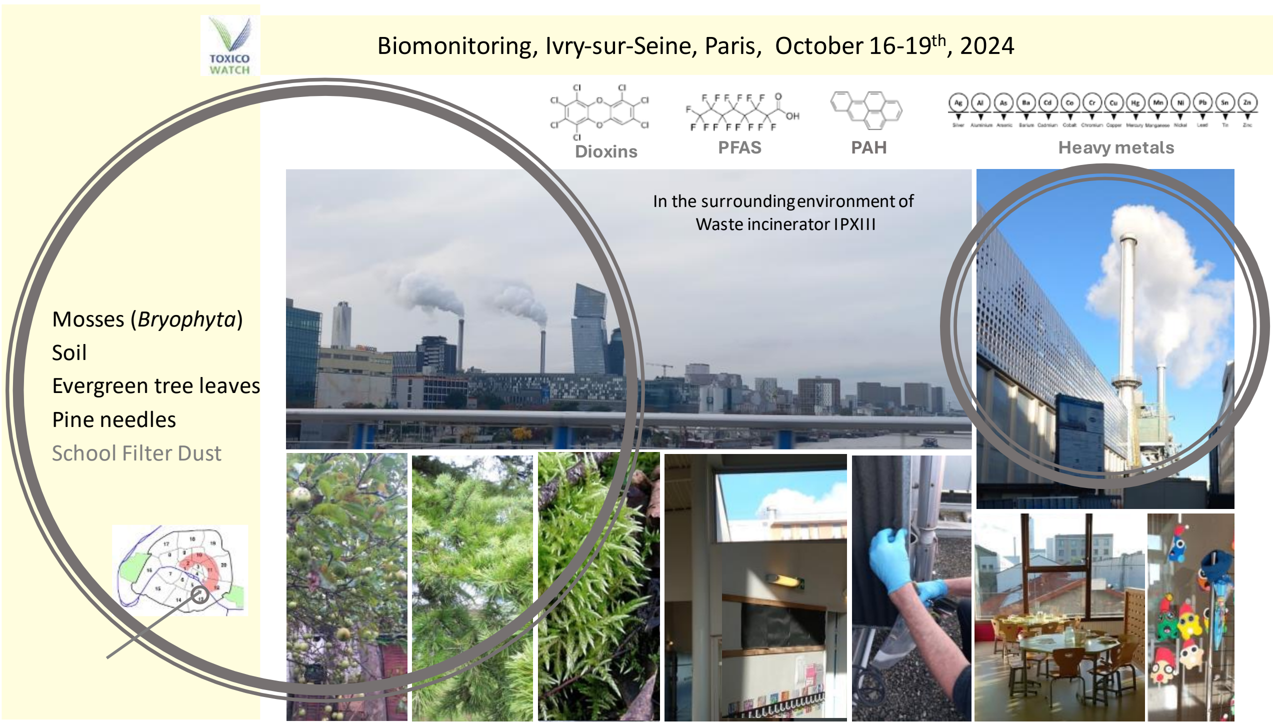
TW Biomonitoring Persistent Organic Pollutants, POPs
In the environment of the waste incinerator IPXIII
Ivry-sur-Seine, Paris 2025

Interim report



ToxicoWatch Foundation – April 1st, 2025

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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

All figures, graphs, and tables designed by ToxicoWatch, unless stated otherwise.
Photographs are made by Team ToxicoWatch and team members of Collectif 3R (*Réduire, Réutiliser, Recycler*).

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Abbreviations

BAT	Best Available Techniques
BEP	Best Environmental Practice
BEQ	Biological Equivalents
dl-PCB	Dioxin-Like Polychlorinated Biphenyls
DR CALUX®	Dioxin Responsive Chemical-Activated LUciferase gene eXpression
dw	Dry Weight
EFSA	European Food and Safety Authority
GC-MS	Gas Chromatography Mass Spectrometry GC-MS
LB	Lower Bound; results under detection limit are set to zero
LOD	Limit of Detection
LOQ	Limit of Quantification
MB	Middle Bound; values are set as half the detection limit values
MWI	Municipal Waste Incineration
ndl-PCB	Non-Dioxin-Like Polychlorinated Biphenyl (Non-Dioxin-Like PCB)
ng	Nanogram; 10^{-9} gram
OTNOC	Other Than Normal Operating Conditions
PAH	Polycyclic Aromatic Hydrocarbons
PCB	Polychlorinated Biphenyl
PCDD	Polychlorinated Dibenzodioxins
PCDF	Polychlorinated Dibenzofurans
PFAS	Per- and PolyFluoroAlkyl Substances
pg	Picogram; 10^{-12} gram
POP	Persistent Organic Pollutants
RPF	Relative Potency Factors
SVHC	Substances of Very High Concern
TCDD	2,3,7,8-tetrachloordibenzo-*p*-dioxine
TDI	Tolerable Daily Intake
TEF	Toxic Equivalency Factor
TEQ	Toxic Equivalents
TOF	Total Organic Fluorine
TW	ToxicoWatch
TWI	Tolerable Weekly Intake
UB	Upper Bound (ub), results under detection limit are set as detection limit values.
µg	Microgram 10^{-3} gram
WtE	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 interim 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, October 15th 2024

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 bio accumulation 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 (UPOPs). 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, ∑ 4 PFAS through food exposure (EFSA 2024).

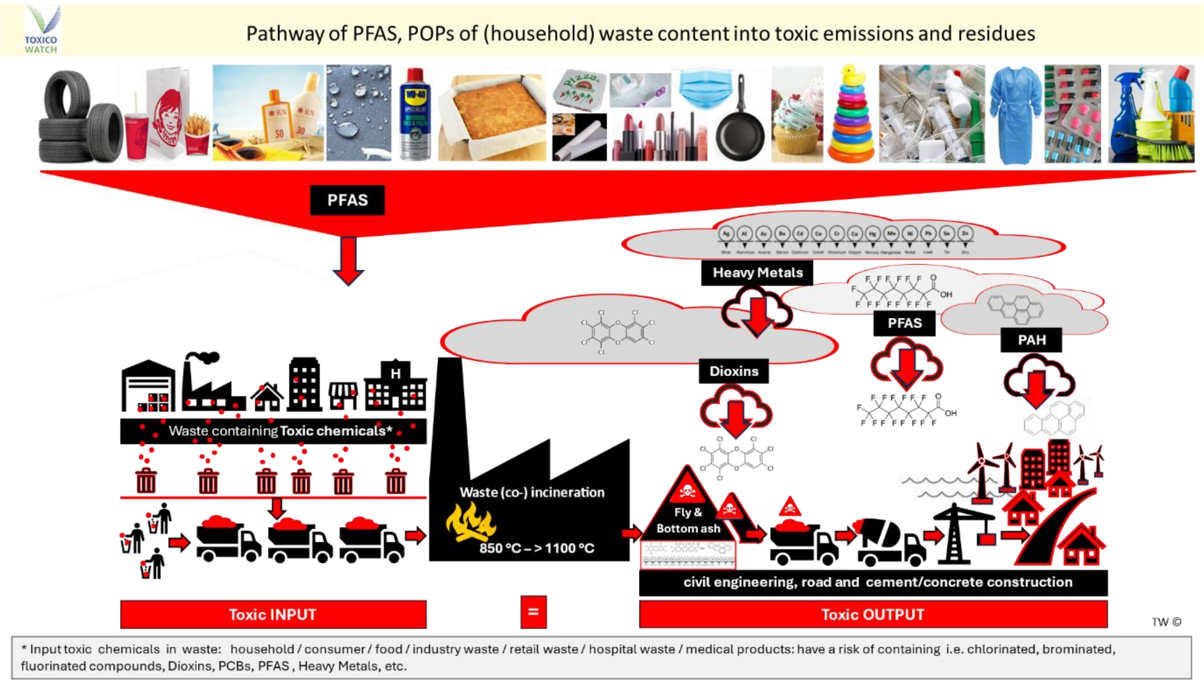


Figure 2: Pathway of PFAS, Persistent Organic Pollutants of household waste into toxic emissions

1.3. Heavy Metals

For TW Biomonitoring, 6 to 14 heavy metals [HM 6-14] 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.

2 Methods

Dioxins and PFAS analysis in this interim report were performed by BioDetection Systems (Amsterdam, the Netherlands), accredited under RvA L401.
Chemical analyses on ∑ 24 PFAS (LC-MS/MS) 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 13805and NEN-EN-ISO 17294-2 standards.

2.1Dioxin 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).

2.2PFAS 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% NH4OH; 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 NH4AC pH 4; 8 ml THF/MeOH (75:25)). PFAS were eluted from the WAX- SPE columns using 4 ml MeOH/0.1% NH4OH. The eluates were evaporated under nitrogen at 45 °C and reconstituted in 15 µg of DMSO.

2.3PFAS 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 the sum of ∑24 PFAS is used. For heavy metals, ICP-MS is 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, to interpret the results, 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).

3 Sampling

3.1. Sampling Mosses (*Bryophytes*)

For this interim TW biomonitoring research in Ivry-sur-Seine, Paris (Oct. 2024/Febr. 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 is 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 depending on species - 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).

3.2. 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 this Ivry-sur-Seine biomonitoring research on vegetation in October 2024. Tree species sampled included: Olive tree (*Olea Europea*), Atlas ceder (*Cedrus atlantica)*, Arizona cypress (*Cupressus arizonica)*, Fig (*Ficus carica)*, Scots pine (*Pinus silvestris)* and Bhutan pine (*Pinus Wallichiana)*.

3.3. 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.

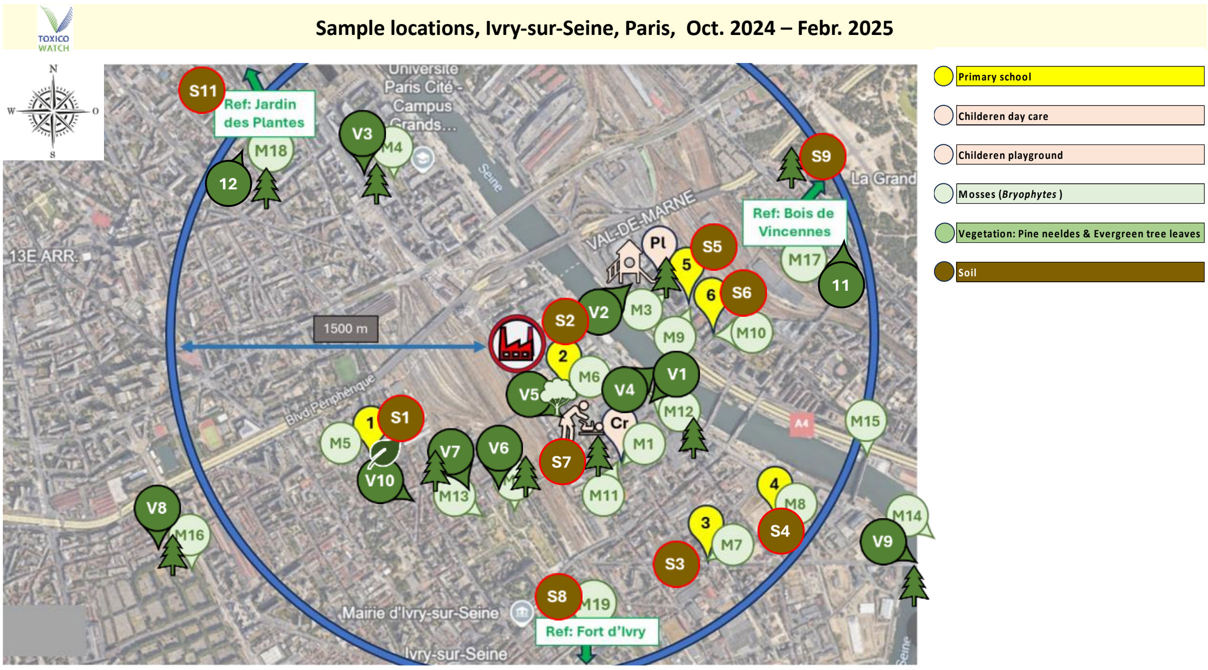


Figure 3: Sample locations, Ivry-sur-Seine, Paris, Oct. 2024 - Febr.2025

4 Results biomonitoring

4.1. Dioxins

4.1.1. 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 phytoremediation deserves further research and broader application (Alkorta, 2001).

Total overview Moss (*Bryophyta*) sampling – Ivry-Paris – Oct. 2024

	Date Sample	Total loc. / BioMat.	Samples Mosses: *Bryophyta*		Location Primary school	Wind direction	Distance Meter	TW-RF-NR October 2024
			Samples 2021:					
1	18-10-2024	M1	Mosses on the ground		M1 Jardin Elisabeth	South-East	620	24TWPA-JE-Mos-1
2	19-10-2024	M2a	Mosses on ground		M2 - Parc des Cormailles	South-West	603	24TWPA-PdC-Mos-2a
3		M2b	Mosses on ground					24TWPA-PdC-Mos-2b
4	18-10-2024	M3	Mosses on ground		M3 Jardin du Cardinal de Richelieu	East	720	24TWPA-CdR-Mos-3
5	18-10-2024	M4	Mosses on ground		M4 Jardin Abbé Pierre	North	920	24TWPA-JAP-Mos-4
			Primary Schools and Crèche:					
6	16-10-2024	M5a	Mosses on roof - near filter system		School 1: Guy Môquet	West	779	24TWPA-GM-S-1a-Mos-5
7		M5b	Mosses on roof					24TWPA-GM-S-1b-Mos-5
8	16-10-2024	M6	Mosses on roof school play yard		School 2: Dulcie September	South	200	24TWPA-DS-S-2-Mos-6
9	16-10-2024	M7	Mosses on roof		School 3: Orme au Chat	South-East	1070	24TWPA-OaC-S-3-Mos-7
10	16-10-2024	M8	Vegetation / Viburnem flowers		School 4: Anne Sylvestre	South-East	1180	24TWPA-AS-S-4-Mos-8
11	16-10-2024	M9	Mosses on plantcontainer		School 5: Robert Desnos	East	633	24TWPA-RD-S-5-Mos-9
12	16-10-2024	M10	Mosses on plantcontainer		School 6: Port au Lions	East	718	24TWPA-PaL-S-6-Mos-10
13	18-10-2024	M11a	Mosses on roof		Crèche Roof, Rue Elisabeth, Ivry- A	South	540	24TWPA-Ivr-CR-1a-Mos-11
14		M11b	Mosses in garden		Crèche Jardin Elisabeth, Ivry- B		487	24TWPA-Ivr-CR-1b-Mos-11
15		M11c	Mosses in Gutter		Crèche Gutter, Rue Elisabeth Ivry-C		540	24TWPA-Ivr-CR-1c-Moss-11
16		M11d	Mosses on ground		Crèche Jardin Elisabeth Ivry-D		487	24TWPA-Ivr-CR-1d-Moss-11
			Additional samples 2024:					
17	19-10-2024	M12a	Mosses on ground		Quai Jean Compagnon	East	395	24TWPA-QJC-Moss-12a
18		M12b	Mosses on ground					24TWPA-QJC-Moss-12b
19	19-10-2024	M13	Mosses on Roof		E Garden	South-West	707	24TWPA-EG-Moss-13
20	19-10-2024	M14	Mosses on ground		Marne - Graffiti	East	4000	24TWPA-TR-Moss-14
21	19-10-2024	M15	Mosses on ground		bycicle Traverse bridge Seine	East	1420	24TWPA-CM-Moss-15
22	19-10-2024	M16	Mosses on ground		Cimentiere	West	1700	24TWPA-GR-Moss-16


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 (ww) 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 (TDI) 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 (dw) These results are visualised using the TW indicative colour scale for mosses (*Bryophytes*), 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 Cardinale 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 1	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).

TW Indicative scale Vegetation (FEED)		
DR CALUX dry weight		
PCDD/F	dl-PCB	PCDD/F/dl-PCB
pg TEQ eq./g		
> 4.00	>2.67	> 6.67
> 2.00	> 1.33	> 3.33
> 1.00	> 0.67	> 1.67
> 0.50	> 0.33	> 0.83

TW Indicative scale Vegetation (FOOD)		
DR CALUX wet weight		
PCDD/F	dl-PCB	PCDD/F/dl-PCB
pg TEQ eq./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

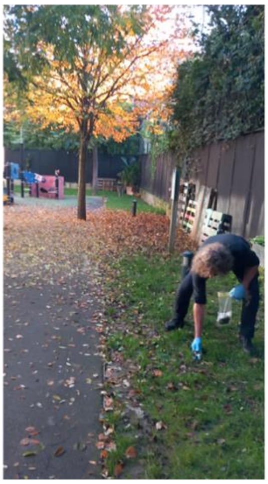
Figure 5: Moss (Bryophytes) sample locations – Ivry-sur-Seine, Paris, October, 2024 and February 2025

4.1.1 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.

Dioxins in Soil school children's playground, Ivry-sur-Seine, Paris – Oct. 2024



TW Indicative scale dioxins in SOIL		
DR CALUX		GC-MS
PCDD/F	dl-PCB	PCDD/F/dl-PCB
pg TEQ eq./g upperbound (ub)		
dry weight (dw)		
> 10,0	> 10,0	> 20,0
> 5,0	> 5,0	> 10,0
> 2,5	> 2,5	> 5,0
> 1,25	> 1,25	> 2,5
> 0,75	> 0,75	> 1,5
< 0,75	< 0,75	< 1,5

Dioxins (PCDD/F/dl-PCB) in soil (DR CALUX)									
Nr.	Soil Sample location	Wind	Distance (m)	DR CALUX (mb-dw)			DR CALUX (ub-dw)		
		direction	IPXIII	PCDD/PCDF	dl-PCBs	PCDD/F/dl-PCB	PCDD/PCDF	dl-PCBs	PCDD/F/dl-PCB
Soil-01	School Guy Môquet	West	779	0,20	0,20	0,40	0,20	0,20	0,40
Soil-02	School Dulcie September	South	200	3,70	0,25	3,95	3,70	0,25	3,95
Soil-03	School Orme au Chat	South-East	1070	5,00	1,80	6,80	5,00	1,80	6,80
Soil-04	School Anne Sylvestre	South-East	1180	0,68	0,38	1,06	0,68	0,38	1,06
Soil-05	School Robert Desnos	East	633	3,20	0,62	3,82	3,20	0,62	3,82
Soil-06	School Port au Lions	East	718	10,00	0,58	10,58	10,00	0,58	10,58
Soil-07	Childeren daycare Jardin Elisabeth	South-East	620	11,00	5,00	16,00	11,00	5,00	16,00
Soil-08	Ref. Fort d'Ivry	South	2050	11,00	6,20	17,20	11,00	6,20	17,20
Soil-09	Ref. Bois de Vincennes	North-East	4160	3,00	1,40	4,40	3,00	1,40	4,40
Soil-11	Ref. Jardin des plants	North-West	2050	3,80	0,86	4,66	3,80	0,86	4,66

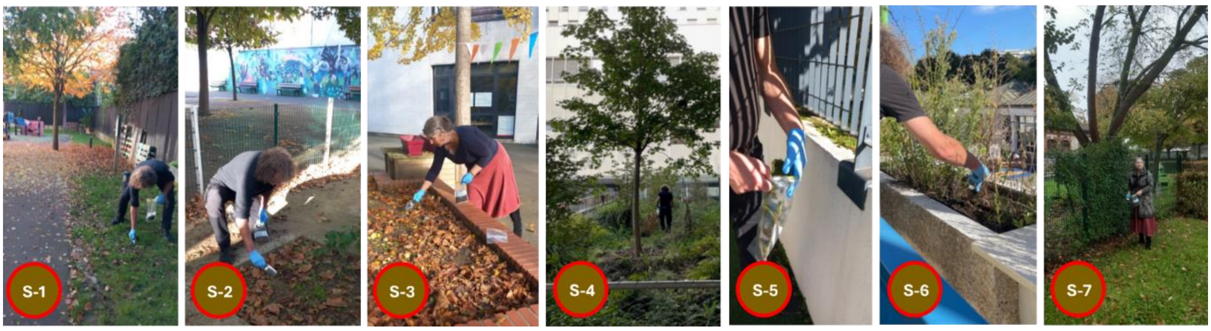


Figure 6: Dioxins in soil school children's playground, Ivry-sur-Seine, Paris 2024

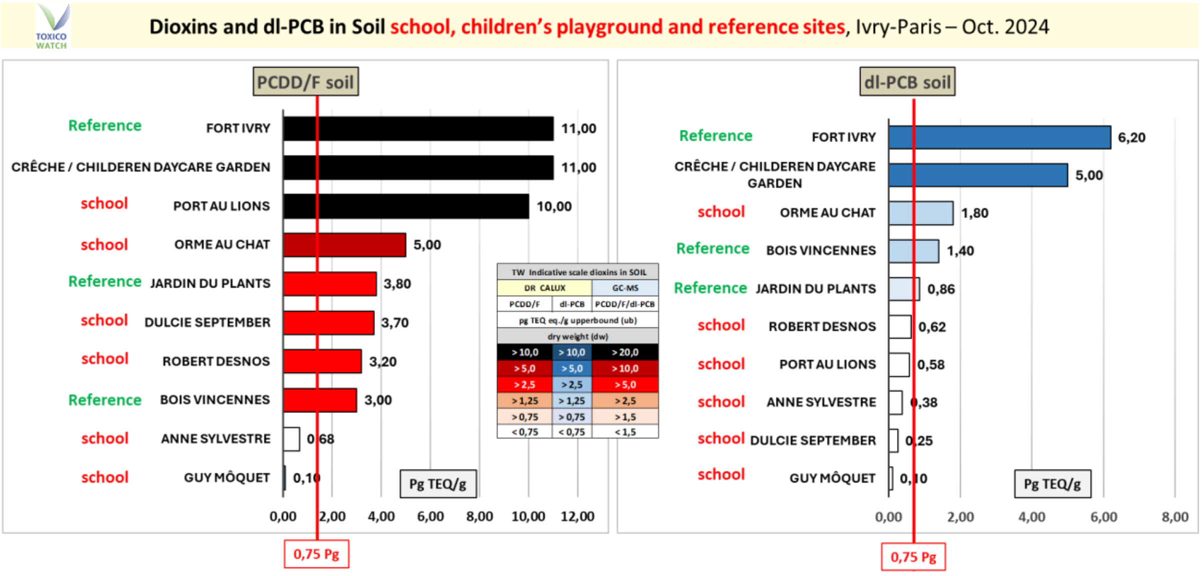


Figure 8: Dioxin and dl-PCB in soil, children's playground and reference sites, Ivry-sur Seine, Paris, 2024

A comparison of dioxin levels in soil and mosses (*Bryophytes*) at Fort d'Ivry reveals a striking contrast. While the soil sample from this location is heavily contaminated with dioxins (PCDD/F/dl-PCB), 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.

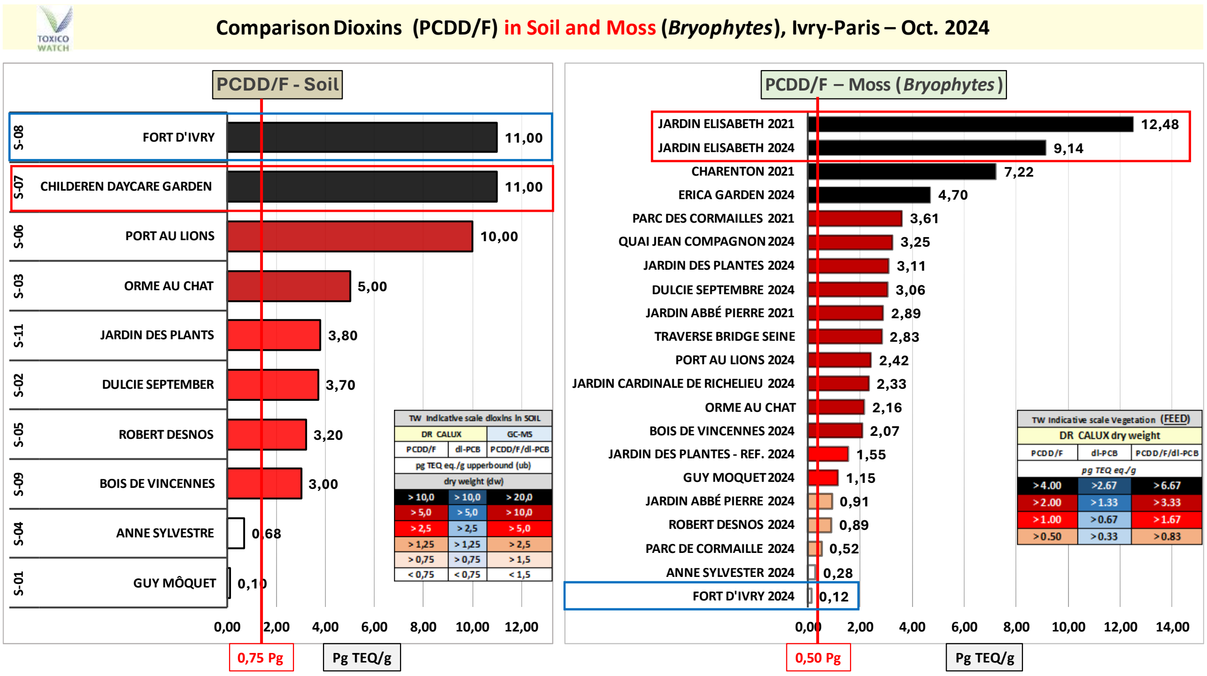


Figure 7: Comparison dioxins (PCDD/F) in soil and mosses - Ivry-sur-Seine, Paris, 2024

4.1.2. Dioxins in Vegetation, like pine needles and evergreen tree leaves

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 neeldles, evergreen tree leaves, Ivry-su-Seine, Oct 2024 / Febr. 2025									DR CALUX		
	Date Sample	Total BioMat.	Vegetation Samples Pine needles / leaves		Location Public Bvd/Garden/ School/Crèche	Wind direction	Distance (m) IP XIII	Paris, Oct. 2024 / Febr. 2025 TW-REF-NR	pg TEQ / g wet weight PCDD/F	dl-PCB	PCDD/F/dl-PCB
1	18-10-2024	V1	*Cedrus atlantica*		Jardin Elisabeth	South-East	487	24TWPA-JE-PNCeA-VEG-1	0,075	0,650	0,725
2	18-10-2024	V2a	*Cupressus arizonica*		Jardin du Cardinal de Richelieu	East	724	24TWPA-CdR-PNCuA-VEG-2a	0,880	0,360	1,240
3		V2b	*Cedrus atlantica*		Jardin du Cardinal de Richelieu			24TWPA-CdR-PNCeA-VEG-2b	0,320	0,320	0,640
4	18-10-2024	V3	*Pinus silvestris*		Jadrin Abbé Pierre	North	930	24TWPA-AP-PNPS-VEG-3	0,110	0,250	0,360
5	19-10-2024	V4a	*Pinus silvestris*		Quai Jean Compagnon	East	525	24TWPA-QJ-PNPS-VEG-4a	0,077	0,280	0,357
6		V4b	*Pinus silvestris*		Quai Jean Compagnon			24TWPA-QJ-PNPS-VEG-4b			
7	19-10-2024	V5	*Olea europaea*		Allée Chantedair	South	427	24TWPA-AC-LFOE-VEG-5	0,094	0,060	0,154
8	19-10-2024	V6	*Pinus sylvestris*		Parc des Cormailles	South-West	603	24TWPA-PC-PNPS-VEG-6	0,074	0,220	0,294
9	19-10-2024	V7	*Cedrus atlantica*		DH Garden	South-West	700	24TWPA-DH-PNCeA-VEG-7			
10	19-10-2024	V8	*Cedrus atlantica*		Cimentiere	West	1700	24TWPA-CE-PNCeA-VEG-8	0,110	0,390	0,500
11	19-10-2024	V9	*Cedrus atlantica*		Marne-Halfway_Traverse/Graffiti	East	3000	24TWPA-MA-PNCeA-VEG-9	0,230	0,240	0,470
12	19-10-2024	V10	*Fig - Ficus carica*		K Garden	West	850	24TWPA-KY-LFFI-VEG-10	0,076	0,094	0,170
13	Febr. 2025	V11	*Pinus Wallichiana*		Jardin des Plantes: Reference	North-West	3000	25TWPA-BJdP-PN-PPW-3A	0,730	0,350	1,080
14	Febr. 2025	V12	*Pinus silvestris*		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, October 2024, February 2025

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 (*Bryophytes*) samples collected in Oct. 2024/Febr. 2025. 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 Europea, Cedrus atlantica, Cupressus arizonica, Fig - Ficus carica, Pinus silvestris and Pinus Wallichiana.*

4.2. Heavy metals

4.2.1. Heavy metals in Mosses (B*ryophytes*)

A total of 14 heavy metals were analysed in moss samples (*Bryophytes*). The tables below presents the results in milligrams per kilogram of dry weight (mg/kg (dw)). 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 Ag Silver	2 Al Aluminium	3 As Arsenic	4 Ba Barium	5 Cd Cadmium	6 Co Cobalt	7 Cr Chromium	8 Cu Copper	9 Hg Mercury	10 Mn Manganese	11 Ni Nickel	12 Pb Lead	13 Sn Tin	14 Zn Zinc
24TWPA-GR-Moss-16	Reference: Cimentière	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 Cormailles	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-OaC-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: Cimentière	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_Mos-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	Schhool 1: Guy Môquet	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 Ag Silver	2 Al Aluminium	3 As Arsenic	4 Ba Barium	5 Cd Cadmium	6 Co Cobalt	7 Cr Chromium	8 Cu Copper	9 Hg Mercury	10 Mn Manganese	11 Ni Nickel	12 Pb Lead	13 Sn Tin	14 Zn Zinc
			< LOD		< LOD		< LOD	< LOD		< LOD	< LOD		< LOD			
24TWPA-GR-Moss-16	Reference: Cimentière	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 Cormailles	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-OaC-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: Cimentière	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_Mos-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	Schhool 1: Guy Môquet	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 Ag Silver	2 Al Aluminium	3 As Arsenic	4 Ba Barium	5 Cd Cadmium	6 Co Cobalt	7 Cr Chromium	8 Cu Copper	9 Hg Mercury	10 Mn Manganese	11 Ni Nickel	12 Pb Lead	13 Sn Tin	14 Zn 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 Cormailles	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
Exceeding	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
factor	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: Cimentière	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
> 100,0	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
50,0 - 100,0	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
10,0 - 50,0	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
5,0 - 10,0	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
2,0 - 5,0	Schhool 1: Guy Môquet	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
1,5 - 2,0	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 presents the results in milligrams per kilogram of dry weight (mg/kg dw)). The second table is a heatmap of heavy metals, based on reference data derived from literature.
Interestingly, the extreme elevated concentrations of heavy metals in the mosses (*Bryophytes*) on the same locations and at the same time collected, 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 above 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
Dulcie 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
Dulcie 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).

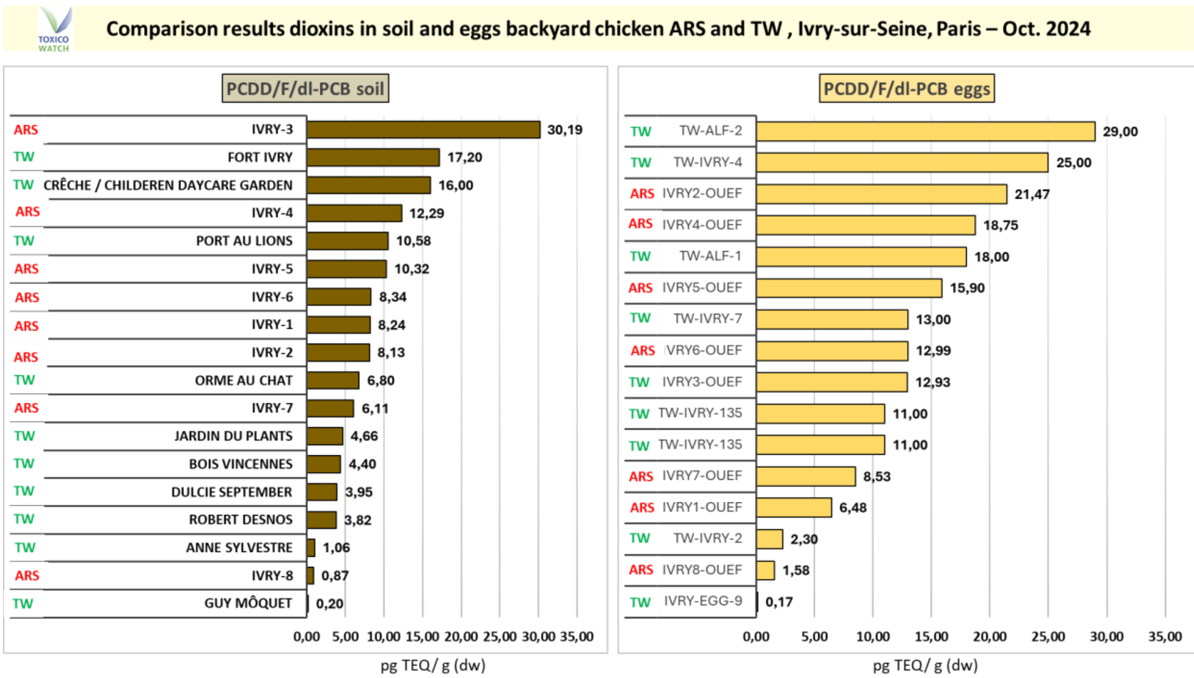


Figure 10: Comparison results dioxin in soil and eggs of backyard chicken ARS and TW, Ivry-sur-seine, Paris, 2024

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.

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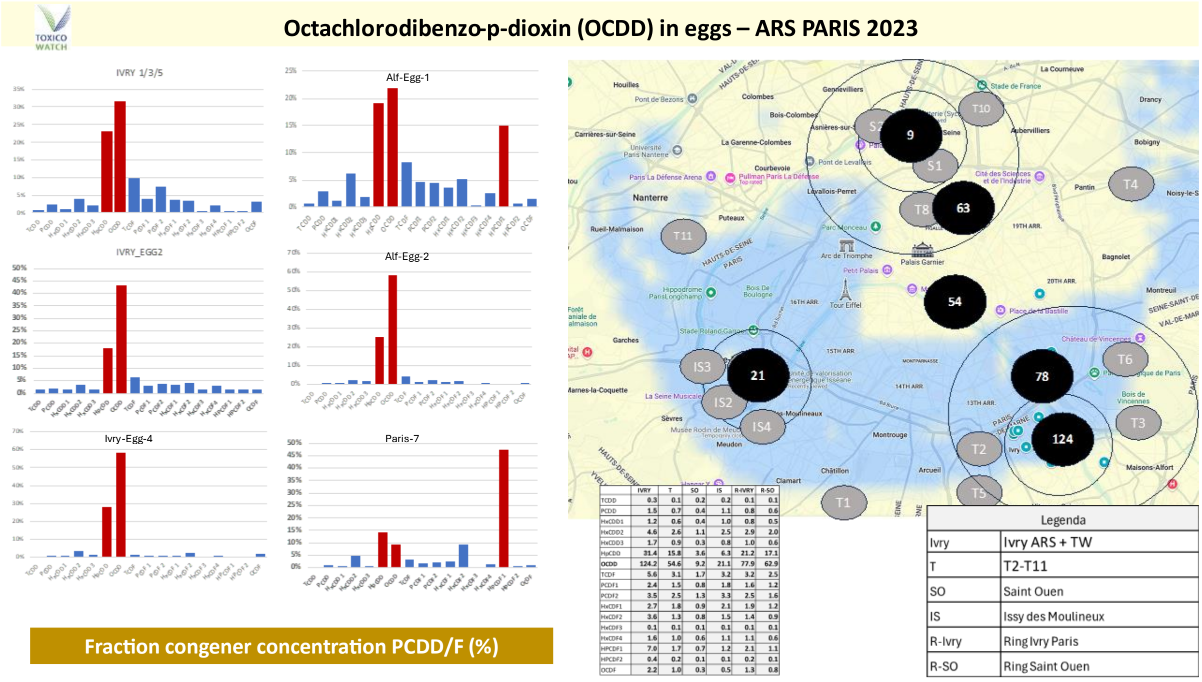

Figure 11: Octachloordibenzo-p-dioxin (OCDD) in eggs - ARS Paris 2023

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.

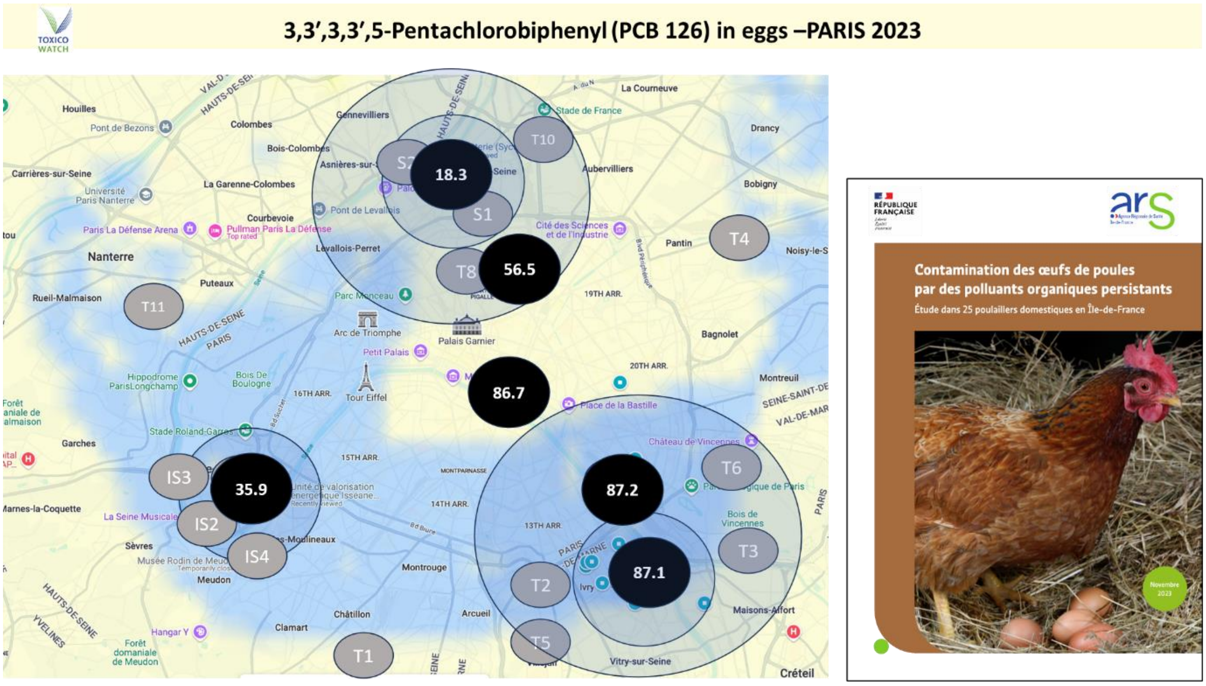

Figure 12: 3,3',3,3',5-Pentachlorobiphenyl (PCB 126) in eggs - Paris 2023

5. Conclusion

The first TW biomonitoring research in Paris initiated in 2021 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 October 2024 and February, 2025 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 North 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 (1) out of seven (7) schools could be classified as clean in terms of low dioxins analyse results in the moss and soil samples collected in Oct. 2024 and Febr. 2025. However, the presence of heavy metals in moss remains a significant concern, as it reflects airborne deposition of POPs.
All measured heavy metals [14] were elevated in the moss samples. 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.

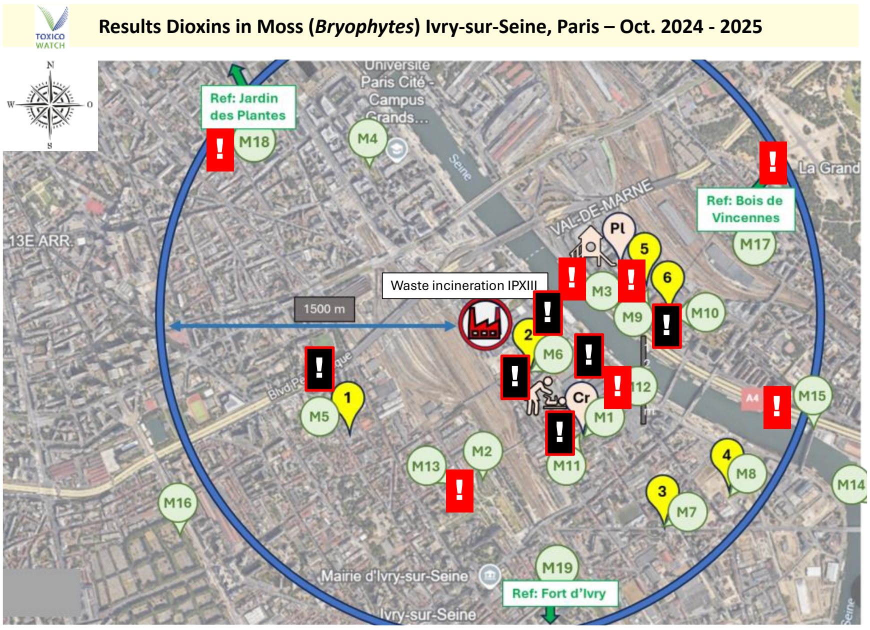

Figure 13: Results dioxins in moss, Ivry-sur-Seine, Paris 2024 - 2025

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