

HOW THEY FORM AND ENTER THE ENVIRONMENT

Dioxins, furans and polychlorinated biphenyls (PCBs) can occur in the environment far from the places where they were produced or released. Understanding their presence in food requires starting with their origins: these substances do not all arise in the same way, and not all emission sources are equally important today.

UNWANTED BY-PRODUCTS AND INTENTIONALLY MANUFACTURED COMPOUNDS

Polychlorinated dibenzo-p-dioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs) are not normally manufactured for commercial use. They form unintentionally during certain thermal and chemical processes. PCBs, by contrast, were synthesised and marketed for decades because of their chemical stability and insulating properties. This distinction matters: for dioxins and furans, the primary issue is preventing their formation and release; for PCBs, the legacy of equipment, materials and waste containing them is also significant.

The distinction is not absolute: some PCBs may also form unintentionally in industrial and thermal processes, while commercial PCB mixtures sometimes contained furans as impurities. Environmental sources can therefore overlap despite their different industrial histories.

COMBUSTION: WHY DIOXINS AND FURANS MAY FORM

PCDDs and PCDFs can form when organic materials and chlorine-containing compounds undergo high-temperature reactions. The mere presence of chlorine, however, is not enough to predict the quantity of dioxins produced: material composition, combustion conditions, oxygen availability, residence times, metal catalysts and flue-gas cooling all matter.

Some formation may occur through reactions involving chemical precursors; further formation may occur on particle and ash surfaces as the gases cool, through mechanisms often termed 'de novo synthesis'. This leads to an important point: the maximum furnace temperature alone does not describe actual emissions to the environment. The entire process, flue-gas treatment and operating practices are relevant.

Uncontrolled waste burning and combustion in unsuitable equipment or conditions may be emission sources. Modern incinerators, when properly designed, operated and monitored, use systems to limit pollutant formation and remove contaminants. It is not scientifically sound to equate them automatically with uncontrolled burning.

OTHER INDUSTRIAL ACTIVITIES

Metallurgy, certain processes for manufacturing and treating chlorinated compounds and, historically, particular methods of pulp bleaching are among the activities considered in international assessments of PCDD and PCDF sources. The importance of individual sources varies over time and between regions, depending partly on technology and environmental requirements.

Industrial thermal processes may produce not only air emissions but also solid residues and dust requiring appropriate management. Assessing a plant's impact requires measurements and up-to-date inventories, not merely its classification within an industrial sector.

PCBs: A LEGACY OF DECADES OF USE

PCBs were widely used in transformers, capacitors and other electrical equipment, as well as heat-transfer fluids and certain industrial applications. The very properties that made them useful — stability, resistance to degradation and dielectric performance — also contribute to their environmental persistence.

Although manufacture and uses have progressively been banned or severely restricted, sources may remain in obsolete equipment, buildings, storage sites, contaminated land and inadequately managed waste. Leaks, material handling and improper disposal can release pollutants that have been present for decades. The Stockholm Convention addresses PCB elimination and the management of materials and waste containing them.

SOURCES AND ENVIRONMENTAL PERSISTENCE

The formation of PCDD/F and the legacy of PCBs are two distinct issues

PCDD / PCDF

Unintentionally formed as by-products of specific thermal and industrial processes



PCB

Produced industrially in the past
Possible residues in equipment, materials and contaminated sites

AIR • SOIL • WATER • SEDIMENTS

Transport, deposition and historical contamination

FIRES, ACCIDENTS AND NATURAL SOURCES

Fires involving chlorine-containing materials and industrial accidents can produce episodic emissions of PCDDs, PCDFs and, depending on the materials involved, PCBs. Interpreting their environmental consequences requires specific information about the fire, the materials burnt, dispersion and deposition: the presence of smoke alone cannot quantify a food-related risk.

Wildfires and natural events, such as volcanic eruptions, may also contribute to environmental PCDD and PCDF levels. They should not, however, be invoked as a generic explanation for a particular contamination event: natural, historical and human-made contributions must be distinguished in each case.



FROM SOURCE TO ENVIRONMENT: AIR, SOIL AND SEDIMENTS

Once released, these substances may bind to airborne particles, be transported and settle on land or water surfaces. Deposition may affect areas close to sources, but atmospheric transport can also spread contamination over greater distances.

Partitioning between the gaseous and particulate phases depends on the compound and environmental conditions.

In soils and sediments, the low water solubility of many congeners and their affinity for organic matter favour retention. Degradation can be slow and variable. Reduced emissions today therefore do not necessarily mean that contamination accumulated over past decades will disappear immediately.

Finding a substance in soil or sediment is not, by itself, enough to attribute it to a specific source. Congener patterns, spatial distributions, historical data and environmental analyses can sometimes support source-attribution hypotheses, which still require critical assessment.

CURRENT EMISSIONS AND HISTORICAL CONTAMINATION

Two concepts should be kept separate: the flow of new emissions and the quantity already present in the environment. A region may now have low emissions yet retain contaminated deposits formed in the past. Conversely, a new emission source does not automatically demonstrate significant contamination of local food.

This distinction is essential when interpreting monitoring results. Emission measurements describe what leaves a source under certain conditions; air, soil and sediment measurements describe environmental concentrations; food analyses examine a further stage. These datasets are not interchangeable.

REDUCING CONTAMINATION AT SOURCE

The Stockholm Convention on Persistent Organic Pollutants provides for action on unintentionally produced substances, including PCDDs, PCDFs and PCBs, through source identification, best available techniques (BAT) and best environmental practices (BEP). For historically used PCBs, identifying materials that contain them and managing them safely until elimination are also particularly important.

In practice, prevention requires well-designed facilities, controlled management of processes and residues, emission testing and remediation where necessary. Effectiveness is measured not by technological slogans, but by verifiable monitoring results and progressive improvements in environmental conditions.

FROM THE ENVIRONMENT TO FOOD: THE NEXT STAGE

Environmental contamination creates the possibility of transfer to living organisms, but does not itself determine the concentration in a food or the health risk to its consumer.

Movement through vegetation, animal feed, terrestrial animals and aquatic ecosystems involves different mechanisms, examined in Chapter 3.

SCIENTIFIC AND REGULATORY REFERENCES

[World Health Organization \(2026\). Dioxins — updated fact sheet.](#)

[WHO \(2019\). Dioxins and dioxin-like substances — technical information sheet.](#)

[Stockholm Convention. Convention text, Annex C: Unintentional production.](#)

[Secretariat of the Stockholm Convention. Unintentional POPs: overview, BAT and BEP.](#)

[Stockholm Convention. The 12 Initial POPs — fact sheets on PCDD and PCDF families.](#)

[European Union. Council Decision 2006/507/EC concerning the conclusion of the Stockholm Convention.](#)