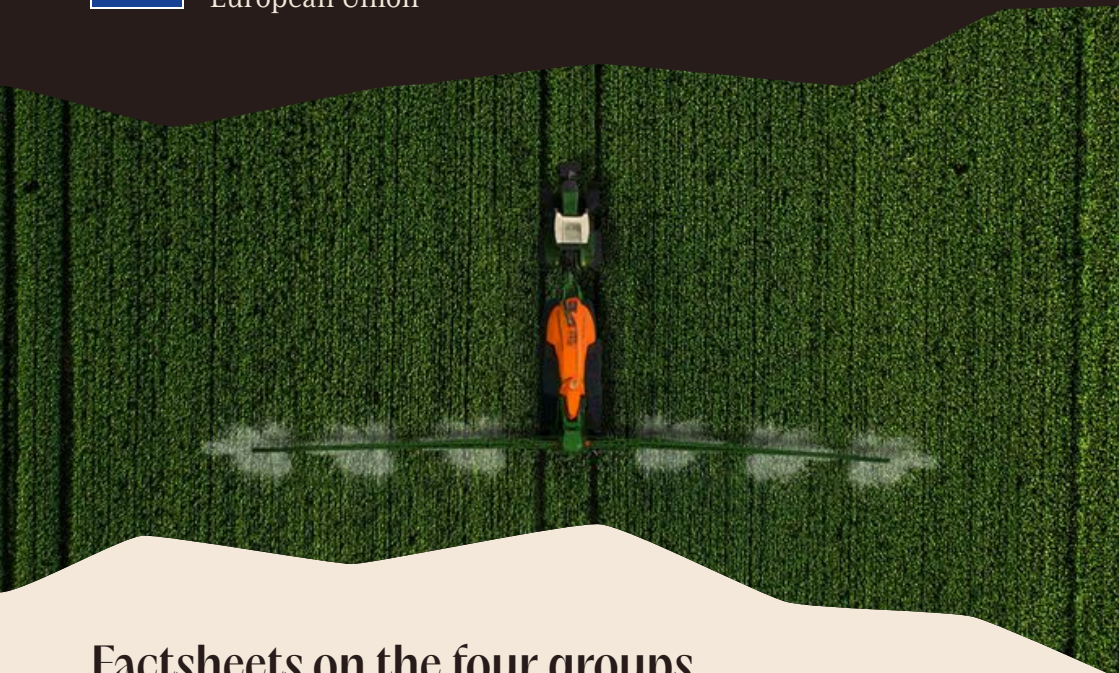


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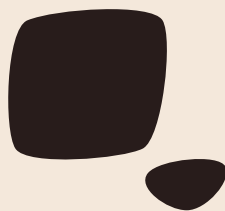
Funded by the
European Union



Factsheets on the four groups
of persistent pollutants:

Metals	←	OCBs	→	PETCO	PFAS
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Organochlorine and bromine compounds



This factsheet is designed to help anyone interested in learning about the most persistent pollutants affecting local land and water.

It explains what these contaminants are, why they matter, and how landowners and other stakeholders can learn how to assess and manage them responsibly.



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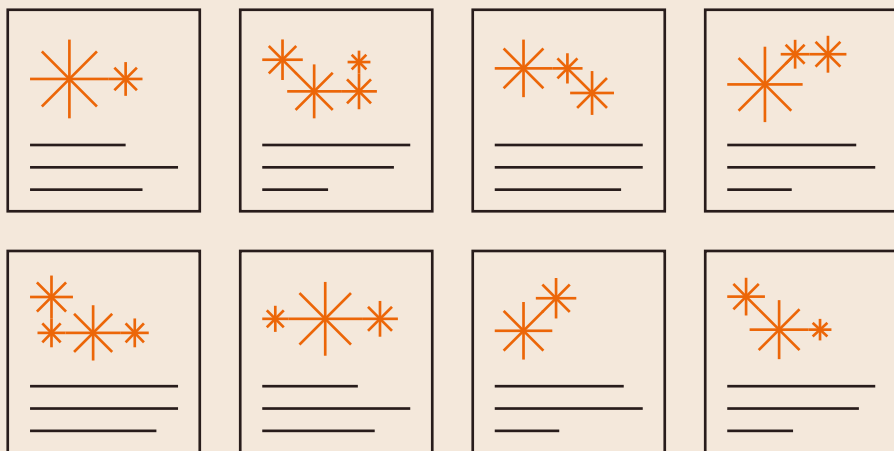
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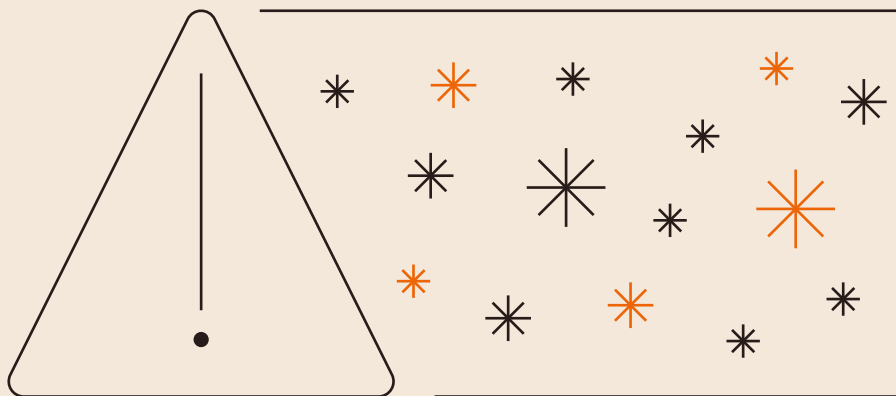


What are these contaminants and what are they used for?

Organochlorines and organobromines (OCBs) are synthetic hydrocarbons containing one or more chlorine or bromine atoms that replace hydrogen atoms in structures ranging from simple chains to complex rings. Key examples of OCBs include **polychlorinated biphenyls (PCBs)**, **polychlorinated dibenzo-p-dioxins and furans (PCDD/Fs)**, **chlorinated pesticides and solvents**, **chlorobenzenes**, **chlorophenols**, **chlorinated paraffins**, as well as **brominated aromatics** used as flame retardants (incl. polybrominated diphenyl ethers – PBDEs and brominated biphenyls - PBBs), **brominated ethylenes**, and **bromophenols**.

OCBs have been widely used in industrial and agricultural contexts, largely due to their chemical stability, fat-loving nature, and resistance to biological degradation. Their stability under heat and light makes them ideal for use in lubricants, dielectric fluids, flame retardants, and plastic additives. PCBs, for example, were widely used in capacitors, transformers, light ballasts, switches, and voltage regulators, as well as in hydraulic oils, cable insulation, adhesives,

paints, caulking, and older appliances. PBDEs have been extensively used as additive flame retardants in a variety of products including electronic devices, polyurethane foam in furniture, textiles, plastics, building insulation, and automotive parts. Chlorinated solvents, on the other hand, have been widely used in applications such as degreasing metals, dry cleaning fabrics, chemical manufacturing, paint stripping, and as intermediates in the production of pharmaceuticals and agrochemicals. **In agriculture, several OCBs** (e.g., dichlorodiphenyltrichloroethane – DDT, chlordane, heptachlor, lindane) **were once widely employed as effective pesticides** because of their ability to persist on crops and resist microbial breakdown. Their fat-loving nature enables them to penetrate the lipid membranes of pests, enhancing toxicity by accumulating in tissues. However, **the same chemical properties that make OCBs functionally valuable also contribute to their environmental persistence, mobility, and bioaccumulation.** Their resistance to degradation because of their strong carbon-halogen bonds, allows OCBs to accumulate in soil, sediments, and fatty tissues of organisms. Some OCBs, like chlorinated solvents and paraffins, are denser than water and can form dense non-aqueous phase liquids (DNAPLs) that sink and pollute groundwater. Many OCBs are semi-volatile enabling long-range atmospheric transport, reaching remote areas like the Arctic, far from their original sources. **These risks have led to strict regulations or bans on many OCBs worldwide.**



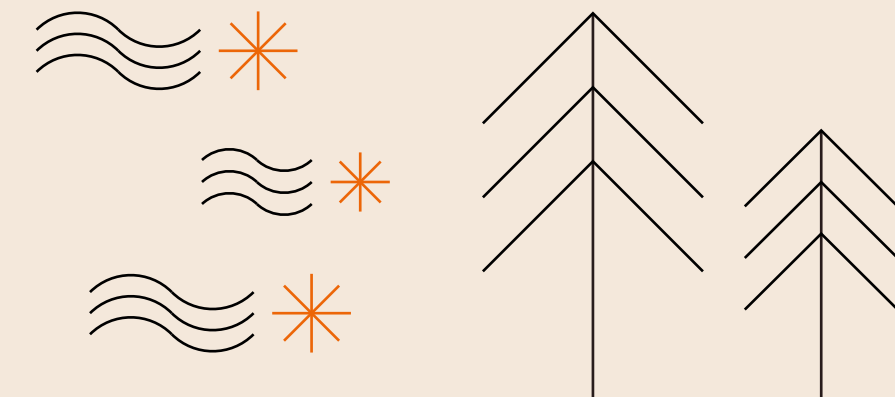
Why are we concerned?

OCBs are linked to endocrine disruption, neurotoxicity, immunotoxicity, and reproductive harm in both humans and animals. Many are probable or possible carcinogens and are associated with obesity, diabetes, and cardiovascular disease. Their persistence and fat-loving nature cause them to accumulate in tissues and magnify through food chains, **leading to long-term, cumulative exposure and unpredictable health effects.**

Many legacy pollution sites worldwide contain OCBs as either the primary or secondary pollutant group. These sites mainly originated from industrial, agricultural, and waste management activities during the mid and late 20th century, including the production and formulation of pesticides, solvents, paints and varnishes, pharmaceuticals, refrigerants, and polyvinyl chloride (PVC). Due to limited understanding of their toxicity at the time, **these compounds were often irresponsibly disposed of through uncontained waste dumps, landfills, and outdated storage facilities.**

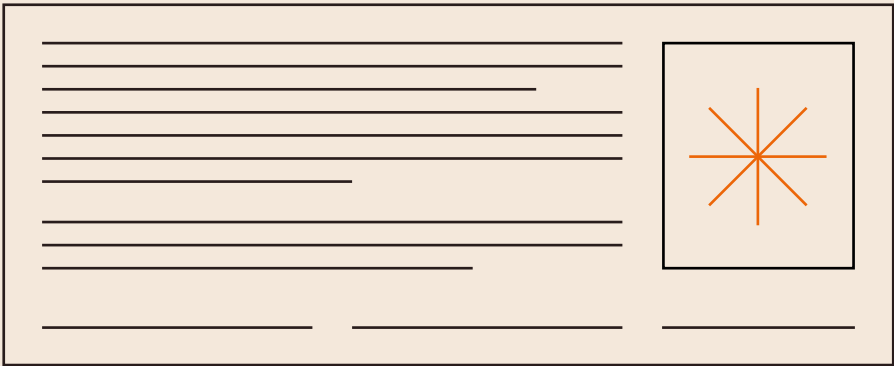
Additionally, OCBs are also found at aging industrial sites with leaking transformers, electronic waste shredding and storage, metal recycling operations, and renovation of anti-corrosion coatings.

OCBs are still used in various applications today, **making careful handling and management crucial to minimizing their environmental and health impacts**. Modern industries continue to unintentionally release chemicals like hexachlorobutadiene (HCBD) and short-chain chlorinated paraffins (SCCPs) during petrochemical processes, while the production, use, and transport of vinyl chloride (VC) for PVC manufacturing also contributes to environmental contamination and increased health risks. Brominated flame retardants (BFRs) generate toxic by-products, especially during improper recycling and e-waste incineration. **Poor waste disposal and inadequate treatment further worsen contamination**, making these compounds persistent threats to ecosystems and human health.



Environmental fate, transport, effects

OCB behaviour in soil depends on the size and structure of these hydrocarbons and halogen content, which influence properties like fat affinity, water solubility, density and boiling point. Some chlorinated solvents and pesticides (e.g., TCE, HCH, HCBd) are mobile and can leach into groundwater, while highly lipophilic pollutants like PCBs and dioxins strongly bind to soil organic matter. **OCBs degrade into various by-products**, some more toxic or mobile, **and many persist in the environment for years**. They enter water through leaching and runoff, volatilize into the air for long-range transport, and bioaccumulate in food chains, posing risks to ecosystems and humans. **Human exposure mainly comes from contaminated food** but also indoor air, dust, occupational contact, water, and products. Their fate and impact are shaped by their chemistry, industrial uses, and waste management.



Regulation and guidelines

European framework for soil legislation

The European Union introduced legislation on soil health in the **Soil Monitoring and Resilience Directive (SMRD)** that mandates the monitoring and assessment of soil quality. However, most threshold limit values and procedural rules are set and enforced by Member States and often at regional/local level. EU sets frameworks, principles and reporting/monitoring obligations, and **Member States translate these into national laws** (setting site-identification, screening values, risk assessment methods and mandatory remediation duties); local authorities typically implement, inspect and require remediation on the ground.

There are two common approaches used by Member States:

- ☀ **Generic screening/threshold values** (soil screening values, intervention values) that trigger further action when exceeded.
- ☀ **Risk-based site assessment** where exposure pathways and site-specific conditions determine whether remediation is required and what measures are appropriate.

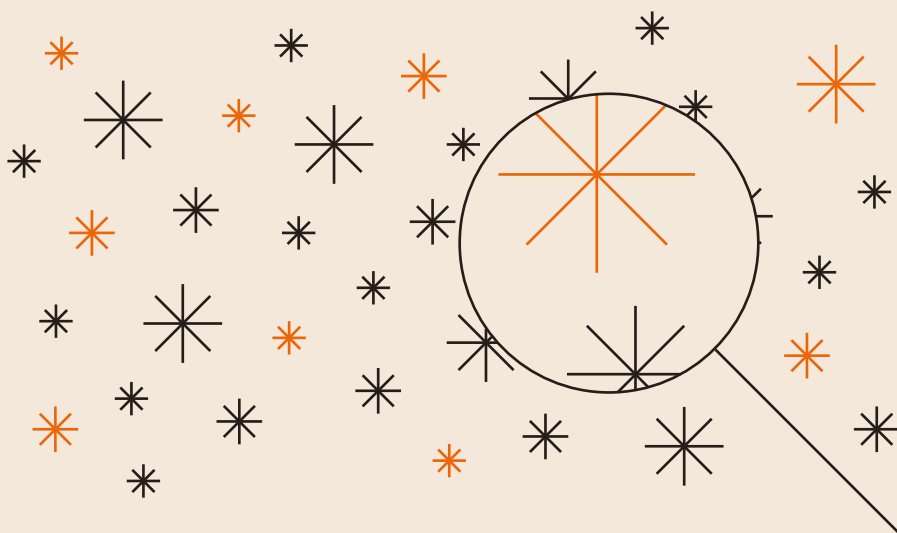
For specific Member States approaches, the specific **Member State's environment ministry** or **national environmental agency** (e.g., UK: Environment Agency; Germany: Länder Umweltämter; Sweden: Naturvårdsverket) may contain information on national soil law, contaminated-land guidance, national screening values or risk assessment protocols.

Links to other European regulations

Soil rules may be affected and can affect other EU rules such as groundwater/surface-water protection under the Water Framework Directive and dangerous substances rules, waste and landfill legislation (affecting historical waste-derived contamination), and permitting under the Industrial Emissions Directive. These links mean that **EU law can impose soil-protective outcomes** through water protection, waste rules or pollution permitting.

International frameworks and conventions

While EU and national laws provide binding rules within specific jurisdictions, **international treaties and organizations provide global standards**, obligations, and guidance that influence national regulations, enable cross-border cooperation, and address chemicals that persist and move beyond one country's borders. Examples are the Stockholm Convention on Persistent Organic Pollutants (POPs), Minamata Convention on Mercury, and the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes (including contaminated soils).



Soil testing and analysis

There are standardized methods for environmental characterization of soil and related matrices, for example the European Committee for Standardization CEN/TC 444, with the goal of **harmonizing how environmental data are collected and reported across Europe**.

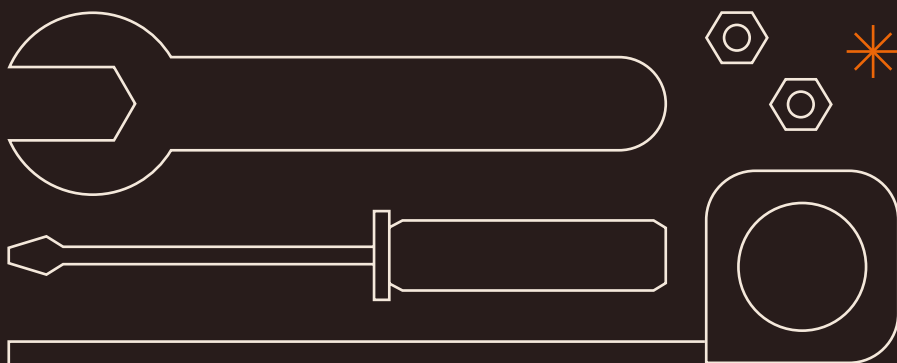
Also, national or regional guidance might specify how and when soil or groundwater should be tested, and what analytical standards to use. Sampling protocols therefore often need to be conducted or supervised by accredited laboratories.

Several OCBs are volatile and best sampled using undisturbed soil cores with rapid transfer to airtight, preferably glass sampling jars with secure seals to prevent volatilization. Furthermore, **OCBs can be significantly denser than water and settle at aquifer bottoms**, thus collected water samples should capture both surface and bottom layers. For water, glass vials with Teflon® septa, filled without headspace and optionally preserved with hydrochloric acid, are recommended, with samples stored at 4°C to maintain quality.

In soil samples, OCBs are extracted using solvent mixtures such as hexane–acetone or methylene chloride–acetone, combined with techniques that apply heat, pressure, or ultrasound to release the compounds from the soil matrix. The resulting extracts are cleaned by sequential treatment with sulfuric acid and potassium permanganate to remove interfering substances.

In water samples, OCBs are extracted from water using either liquid-liquid extraction with methylene chloride or solid-phase extraction, where the compounds are first retained on a solid material and then eluted with a suitable solvent. Finally, the purified extracts are analyzed by gas chromatography, with detection carried out using electron capture detectors or mass spectrometers.

Sites impacted by chemical production, industrial activities, or landfills often **contain complex mixtures of multiple pollutant groups**, not just OCBs. As a result, soil sampling and analysis methods need to be carefully adapted to preserve sample integrity and ensure the safety of personnel during sampling and laboratory work. It is also important to **be aware of potential interferences from other contaminants**, which may affect analytical accuracy and require specialized procedures or additional testing to properly identify and quantify the pollutants present.



Remediation options

If your land is contaminated, **remediation means cleaning it up or managing the pollution**, to sufficiently reduce the risk to people, water, or the ecosystem animals and plants. Remediation does not always mean physically removing all the contaminated soil, it can also involve isolating the pollution or treating it on site. **Costs can vary widely depending on the contamination and chosen method.** The table below provides an overview of the different remediation principles together with specific methods and their advantages and limitations.





Physical removal or isolation of contaminants

Excavation:

Remove contaminated soil or sediment for off-site treatment.

Pump-and-treat:

Extract groundwater for treatment and reinjection/discharge

Soil vapor extraction (thermal and non-thermal methods):

Remove volatile contaminants

Advantages:

- Immediate removal
- Suitable for many contaminants types and high concentrations (source)
- Scalable and controllable

Limitations:

- High costs & high energy input
- Invasive & destructive
- Non-destructive
- Volatility dependent



Chemical agents transform contaminants into less harmful substances

In-situ Chemical Oxidation:

Inject oxidizers like permanganate or persulfate

In-situ Chemical Reduction:

Inject reducing agents (e.g., zero-valent iron)

Advantages:

- Treat contaminants in place
- Potential for full contaminant destruction
- Fast reaction time

Limitations:

- High reagent demand
- Costly if multiple injection and monitoring is required
- Selectivity & potential hazardous by-products
- Inaccessible contamination



Biological processes remove, degrade, or contain contaminants

Bioremediation:

Use or stimulate microorganisms

Phytoremediation:

Plant growth

Monitored natural attenuation:

non-intervention, monitoring of the contamination content and spreading

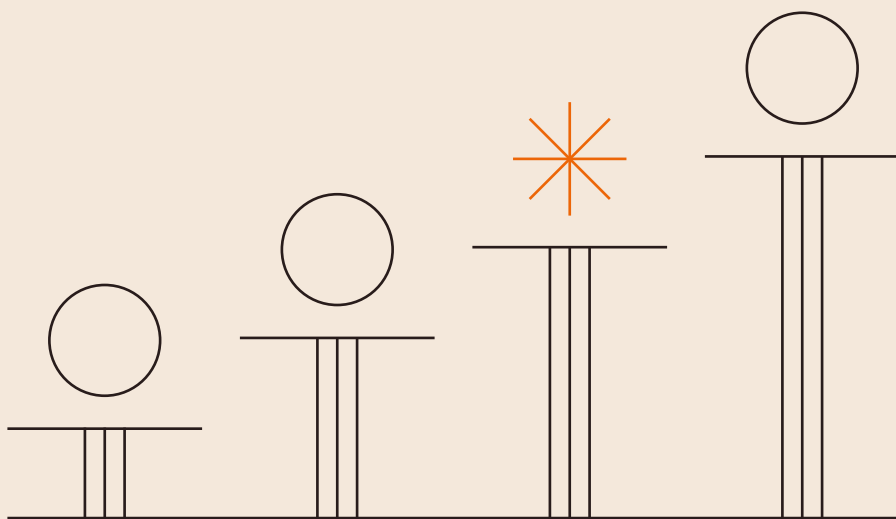
➤ **Advantages:**

Low-cost, sustainable, and non-invasive
Potential for complete destruction
Environmentally friendly

➤ **Limitations:**

Slow degradation/uptake thus long treatment time
Inhibitory intermediates
Strongly dependent on soil conditions





Initial steps to assess a potentially contaminated site

Gather information about the site

Before any work or decisions can begin it's important to build a complete picture of the site. This means gathering different kinds of information about the land itself, its history, and its surroundings. Each piece helps us understand how pollution might spread and who or what could be affected.

- ☀ **Collect site history**, such as uses, know sources of pollution, old maps, news on special events, environmental permits, as past uses often helps explain what types of pollution might be present.
- ☀ **Topographical data**, including shape of the land and location of buildings, helps predict pathways of pollution via water and air including spreading of dust.

- ☀ **Geological data** on type of soil or rock and how deep the layers are, matters since some solids trap pollution while others let it spread quickly.
- ☀ **Hydrogeology**, such as depth of water and direction of groundwater flow is important since contamination can move with groundwater and reach wells, rivers, or lakes, creating health and environmental risks.
- ☀ **Meteorological data** (climate and weather) can wash pollutants deeper into the soil or spread them to water bodies. Wind can carry dust or vapours to nearby areas.
- ☀ **Contamination data** (what is in the soil and water) show how serious the problem is and whether it poses a direct risk.
- ☀ **Surrounding exposure pathways** (how people or nature could come into contact) determines the risks. Even if pollution is present, it only becomes dangerous if it has a “pathway” to reach people, animals, or ecosystems.

Gathering of the background information should be followed by field verification – sampling of soil, groundwater, surface water, as well as on-site screening using portable instruments. This data will be the basis for the risk assessment.

Assess the economic and logistic factors



Budget:

Cost of treatment, monitoring, and long-term management.



Infrastructure:

Availability of equipment and skilled personnel.



Timeframe:

Urgency of remediation (e.g., emergency vs. long-term project).

Set the remediation goals



Containment vs. destruction:

Whether the goal is to immobilize or eliminate the contamination.



Reuse potential:

Whether the soil needs to be reused (e.g., agriculture, construction).



Risk reduction:

Immediate vs. long-term health and environmental risk mitigation.

Understand the rules and responsibilities

It is of importance to clarify **who is legally responsible for the contamination** (landowner, business provider, etc.), **who caused the contamination** and **when it may create different obligations**. Check whether the site or soil use falls under any EU directive obligations (water, industrial emissions, waste), as these also can bring binding obligations.

Most often it is the Member State's contaminated-land regime: national law, agency guidance, and any regional technical guidance on soil use and contamination, that are the most important rules to be aware of.

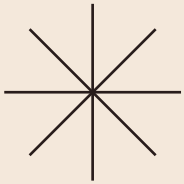
Some regions or municipalities have additional rules for construction, excavation, or soil movement even if national or EU rules do not explicitly require action. Certain contamination incidents may require **mandatory reporting to environmental authorities and potential restrictions on land use**.

Consult experts and find information

Remediation and restoration depend on the risk level and intended use of the land. Therefore, it is advisable to consult experts to perform risk assessments and recommend actions in line with the current legislation. Seeking expert advice early can also be cost saving, as early misguided actions can become expensive over time. Environmental consultants can help with performing basic screening for initial assessment, doing legal compliance check, and develop remediation plans. They should also be very familiar with local and national regulations and able to translate them into practical guidance for landowners.

There are many useful resources for anyone seeking more information on pollutants and soil remediation. Because knowledge in this field is constantly evolving, it is recommended to consult both national and regional knowledge hubs as well as European sources. For example, the **Common Forum** (commonforum.eu) brings together expertise and facilitates information exchange on contaminated land and groundwater management. The **EU Soil Observatory (EUSO)** (joint-research-centre.ec.europa.eu) provides soil data, supports research and innovation, and raises awareness of the importance of soils. The **European Food Safety Authority (EFSA)** (efsa.europa.eu) offers scientific advice to risk managers, especially on risks linked to the food chain.

The **European Chemical Agency (ECHA)** manages the implementation of the EU's chemicals legislation and promotes the safe use of chemicals to protect human health and the environment (echa.europa.eu).







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