

# MODULE 1

## Tox-free, circular, and climate-friendly buildings

**Interreg**  
Baltic Sea Region



Co-funded by  
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SUSTAINABLE WATERS

NonHazCity 3

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# **1.1. IMPACT OF BUILDINGS ON HEALTH AND ENVIRONMENT**



## Climate

Buildings account for roughly 40 % of EU greenhouse gas emissions across their life cycle.

1/3 coming from energy use and an additional 5-12 % resulting from material production and construction.



## Resources

Buildings store hundreds of millions of tonnes of construction materials.

Construction & demolition waste is the largest EU waste stream – ~450-500 million tonnes annually (1/3 of all waste).



## Soil / Water

Chemical substances are washed out of building products with rainwater.



# Buildings and their influence beyond skylines

- **VOC emissions** from paints and coatings contribute to **outdoor air pollution**.
- **Formaldehyde** from composite wood products harms **indoor air quality** and contaminates soil and water.
- Extraction and processing of toxic raw materials **deplete natural resources**.
- Production processes often involve **environmentally destructive** practices.



# Impact lasting decades

- Toxic chemicals in insulation, coatings, and materials **remain in buildings for decades**, continuously exposing people and nature.
- After demolition, these **substances can leak into soil**, water, and air, causing long-lasting environmental harm.
- **VOCs evaporate** from materials **for years**, reducing indoor air quality and affecting human health.
- Heavy metals and persistent pollutants in plastics hinder safe recycling and **contaminate material streams**.



# Human health implications (1)

- **Respiratory irritation and chronic lung diseases** caused by VOCs, dust, fibres, and chemical off-gassing.
- **Endocrine disruption** from substances such as phthalates and flame retardants found in plastics, flooring, and insulation.
- **Carcinogenic risks** linked to materials containing formaldehyde, silica dust, or certain composite wood resins.



# Human health implications (2)

- **Skin and eye irritation** from adhesives, sealants, paints, and solvents.
- **Neurological effects** due to exposure to heavy metals (e.g., lead in old paints, mercury in certain products).
- **Allergic reactions and asthma** triggers from mould-prone materials, VOCs, and chemical additives.



# Why are hazardous substances prevalent in construction materials?

- Chemical additives are **essential** for modern buildings **to be comfortable**, durable, easy to maintain, and energy-efficient.
- **Increased expectations** demand additives that keep facades clean, surfaces dirt-repellent, and materials fire-safe.
- Manufacturers add biocides, PFAS, bisphenols, and flame retardants **to achieve these properties.**



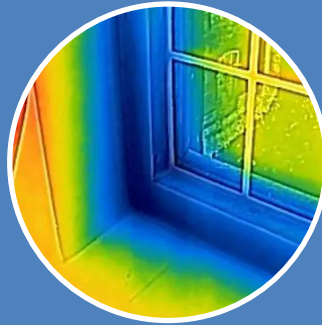
Photo by Pixabay



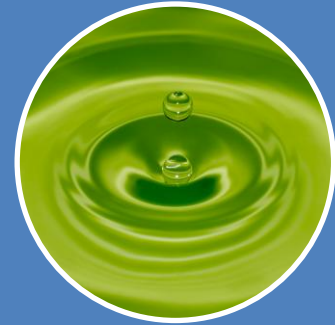
# Hotspots in buildings



Toxicity hotspots



Embodied  
emission and  
heat loss  
hotspots



Circularity  
hotspots



# Hotspots for hazardous substances

- **Paints, varnishes, and PVC flooring release VOCs** Choose low-VOC or VOC-free products to minimize harmful emissions.
- **Adhesives and sealants emit harmful chemicals** Select low-emission or non-toxic options.
- **Stain-resistant carpets often contain PFAS** Avoid these "forever chemicals" by skipping stain-treated carpets.
- **Good ventilation is critical** Ensure adequate air exchange and replace filters regularly.



Photo by La Miko



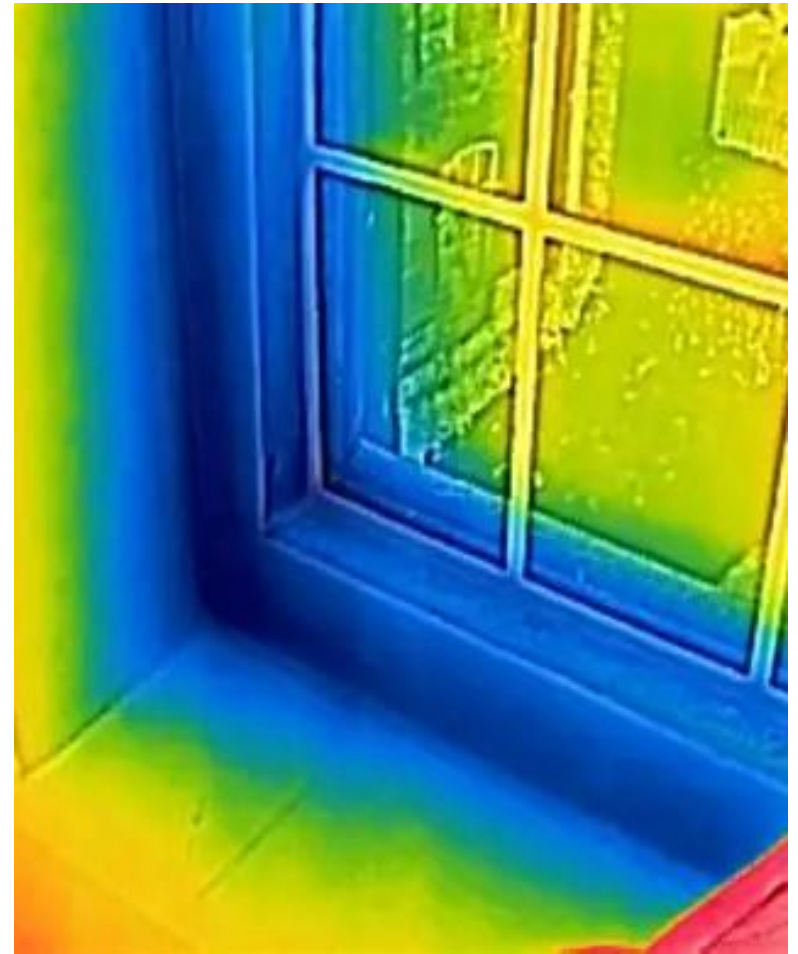
# Chemical cocktail effect

- We are exposed to a mixture of different chemicals.
- We do not precisely understand the mixture effects.
- There is no threshold limit with regards to hormone mimicking chemical substances (Sheehan et al, 1999).
- Threshold assumption has still not been abandoned by regulators.
- Additive effects can and should be the basis for restriction (precautionary principle).



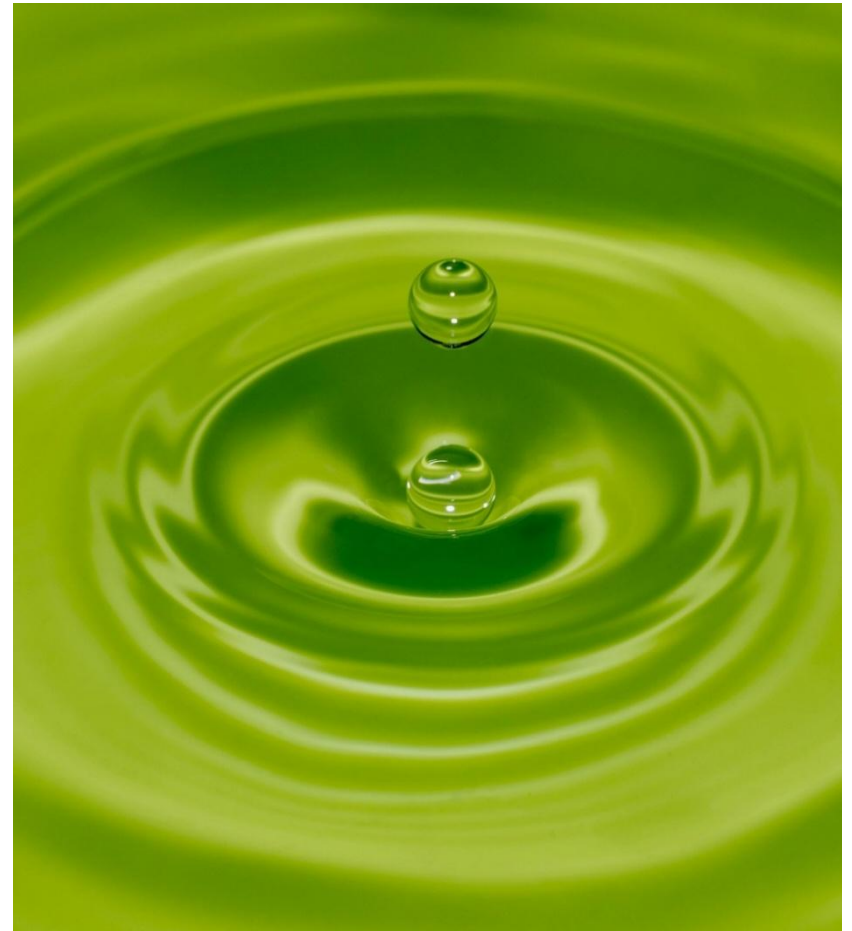
# Embodied emission and heat loss hotspots

- The primary hotspot of embodied emissions is the load-bearing structure of a building.
- Avoid unnecessary treatments of materials and finishes.
- Poorly planned building envelope can be responsible for large heat losses: insulation, airtightness, windows and doors.



# Circularity hotspots

- Circularity is intricately tied to material selection and assembly methods.
- Locating hotspots based on the largest material volume and/or weight.



# Typical hazardous substances in construction materials

- **PFAS** - Per- and polyfluoroalkyl substances
- **BFRs** - Brominated flame retardants
- **ORFRs** - Organophosphate flame retardants
- **Biocides**
- **VOCs** - Volatile Organic Compounds



# PFAS - forever chemicals

## Overview

- Composition: over 10 000 compounds
- Properties: heat, radiation, weather resistant, chemically inert, stain repellent

## Applications

- Surface treatments, textiles, wood products, linoleum, plastic piping, insulation, paints, coatings, sealants

## Health and Environment

- Persistence: extremely resistant to degradation
- Mobility: can reach groundwater, globally transported
- Bioaccumulation: build up in organisms, contaminate food chains
- Toxicity: some are endocrine disruptors, reproductive toxins, carcinogens



# BFRs - Brominated flame retardants

## Overview

- Composition: Organic compounds with at least one bromine atom
- Purpose: Reduce flammability and slow fire spread

## Applications

- Treated materials: Polystyrene, foams, insulation, linoleum, laminate, wood, sealants, paints

## Health and Environment

- Properties: Persistent, mobile, bioaccumulate, toxic
- Health risks: Carcinogenic, mutagenic, endocrine disruptors
- Exposure: Dust and inhalation
- Environmental impact: found globally, including remote areas



# ORFRs - Organophosphate flame retardants

## Overview

- Properties: Flame retardants and plasticisers
- Purpose: Substitutes for restricted brominated flame

## Applications

- Treated materials: PVC plastics, polyurethane, PIR materials, polyurethane foams

## Health and Environment

- Health risks: Neurotoxicity, developmental toxicity, reproductive damage, endocrine disruption, carcinogenicity, bioaccumulation, persistence
- Exposure: Skin contact: ingestion, inhalation
- Environmental impact: found in air, water, dust, sediments, soil and biological matrices



# Biocides

## Overview

- Function: prevent microbiological degradation and protect materials from microorganisms like mosses, fungi, bacteria, algae, and lichens.
- Usage: commonly applied in construction to enhance durability and longevity

## Applications

- Treated materials: paints, coatings, sealants, adhesives, wood, natural fibre insulation, other biodegradable materials

## Health and Environment

- Toxicity: Designed to affect biota, thus hazardous to humans and the environment
- Environmental impact: Hazardous to aquatic life
- Regulations: often restricted due to their toxic properties



# Volatile Organic Compounds (VOCs)

## Overview

- Properties: not a unified chemical group but share volatility at room temperature
- Usage: commonly found in construction materials

## Applications

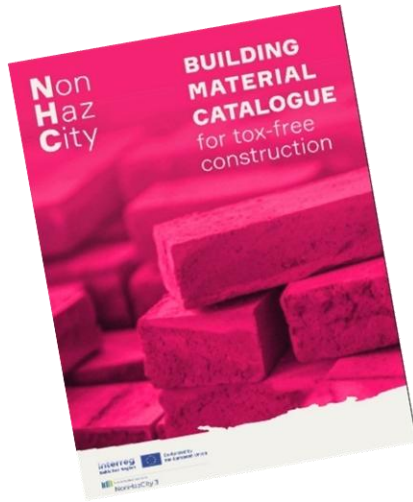
- Treated materials: Various construction materials as coatings, adhesives, sealants, wood, stains, insulation and boards

## Health and Environment

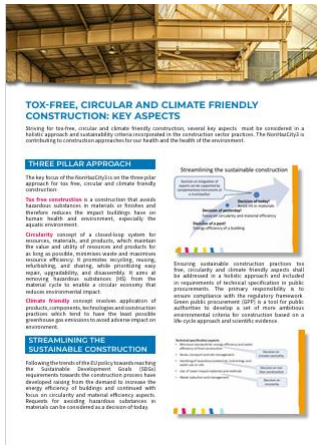
- Adverse effects: Respiratory issues, sensitization, cardiovascular and nervous system damage, and even cardiogenic effects
- Environmental impact: continuous contamination of air, water, dust, sediments, soil and biological matrices
- Exposure: Skin contact, ingestion, inhalation



# Where to look further?



The [Building material catalogue](#) offers a collection of building materials and their hazardous components to help planners and builders with product selection.



The [NHC3 fact sheets](#) serve to increase knowledge of chemical aspects and relate them to the circular economy of materials and the energy efficiency of buildings.

# Thank you!

Explore further:  
[NonHazCity 3 - Interreg Baltic Sea Region](#)



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