

Survey of organic flame retardants and plasticizers in building materials on the Swedish market and their occurrence in indoor environments

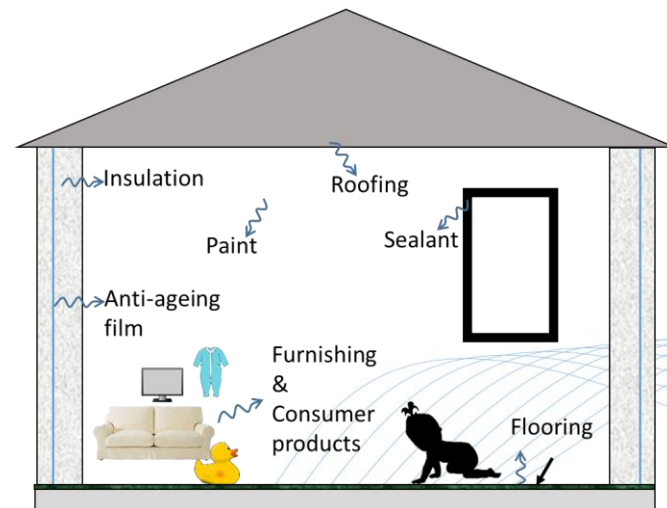


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Occupational and Environmental Medicine, Örebro University Hospital**

Background:

- Humans spend up to 90% or more of our time in indoor settings.
- Building products contain significant amounts of industrial chemicals that can be residuals during production or intentionally added to improve functionality.
- Additives: flame retardants, plasticizers, antioxidants and UV stabilizers, impact modifiers, antimicrobials, colorants,..
 - Reactively or additively added to building products:
 - ppm levels to >50% by weight
- Release from building materials can be a significant human exposure source to these substance (near-field).
- Release to outdoor environment (far-field).



- Exposure is a critical component of risk evaluations and provides real-world context to hazard (i.e., toxicity data).
- Knowing the chemical contents is important for assessing exposure risks from building material and consumer products.
- Efforts to find which chemical substances are present in categorized consumer products:
 - Sweden: KEMI
 - Nordic countries: SPIN
 - EU: CLP, REACH
 - US EPA: CPCat, CPCPdb, CPDat
 - ...

Data collection:

- CAS numbers
- Information available to regulators
- Publically available information on chemical contents in chemical products and consumer products from Material Safety Data Sheets (MSDS)

Building product assessment systems

- Concerns from the public and stakeholders about hazardous substances in building material.
- Public and regulatory initiatives to choose safer building products.
- Commercial market for building product assessment systems:
 - Voluntarily registered by building product suppliers/vendors.
 - Environmental assessment for e.g. chemical content, life cycle perspectives,..
 - Assessment based on certain criteria

Building material assessment systems in Sweden

General chemical content criteria:

Usually 0.1 or 0.3% of CMR, EDCs,.. for pass (acceptable).

Stricter requirement (e.g. 0.01%) for pass with distinction (recommended).

Assessment system	Registered items	Assessments grade (Best to worst)
Byggvarubedömningen (BvB)	21 000 products	Recommended, Accepted, To be avoided
SundaHus	41 000 products 147 000 articles	A, B, C+, C, C-, D
BASTA	150 000 articles	BASTA, BETA, RISK EVALUATED

Databases in the building product assessment allows a systematic investigation of the substance in different products and across different categories.

Note about products and articles: One product can have several articles (such as different colors, shape patterns, etc..)

Current survey:

- **Funded by the Swedish EPA**
- **Building products**
- **Organic flame retardants and plasticizers**

Global plastic additives are expected to reach 17 000 ktonnes and worth \$60 billion by 2020.

Global demand for FRs: 2 800 ktonnes and worth \$7 billion by 2018.

Most FRs and plasticizers are physically added to products -> high potential for migration to the surface and release to the indoor environment and subsequent exposure.

Environmental and human health concern for some/many of these.

Key steps in the survey process

Search literatures, reports and online resources



Set up a database of known organic flame retardants and plasticizers



Curate: verify CAS numbers (if available), single/multi component, main usage, physical chemical properties..

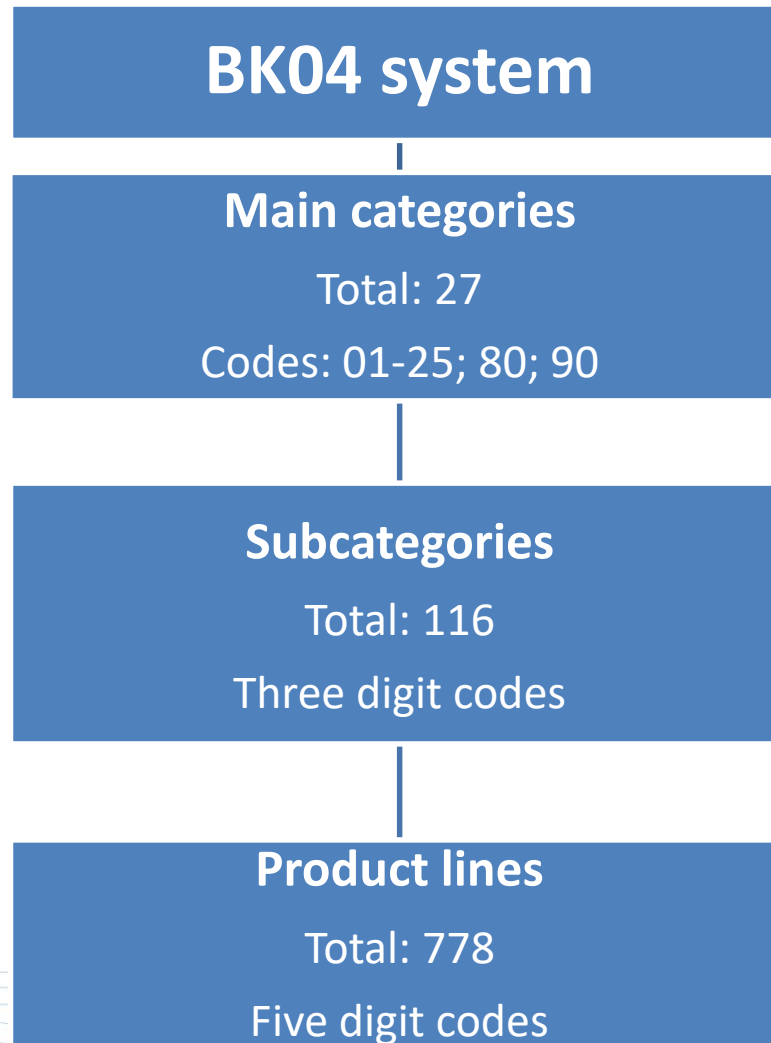


Use CAS numbers to search in building product assessment databases (BvB and SundaHus).



Link CAS with hits for individual products and classify these by building material categories

Classification of building products

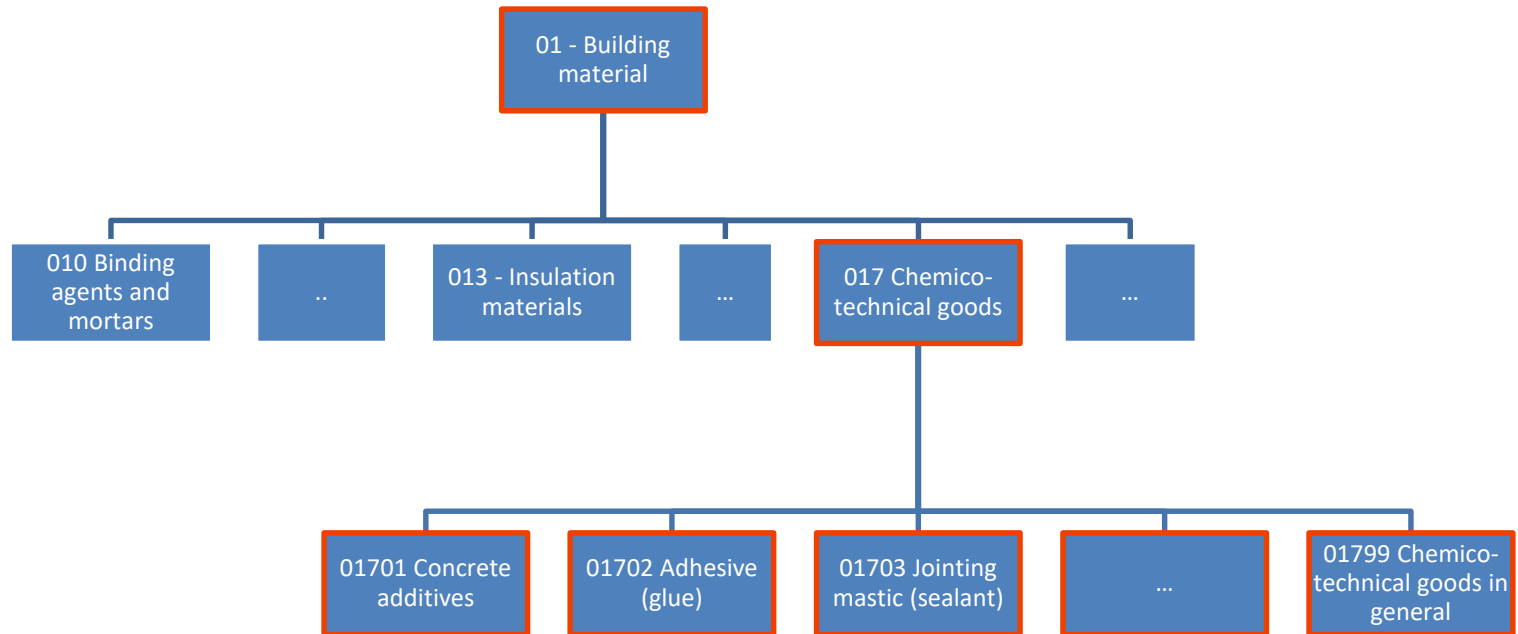


Example of BK04 structure

Main category

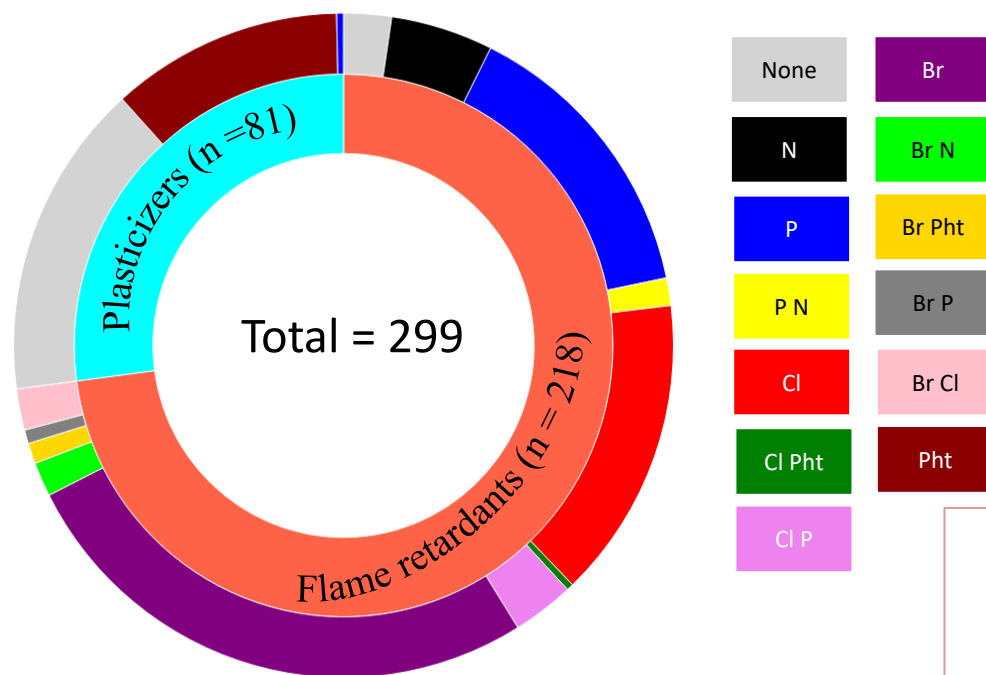
Subcategory
(n = 10)

Product line
(n = 8)



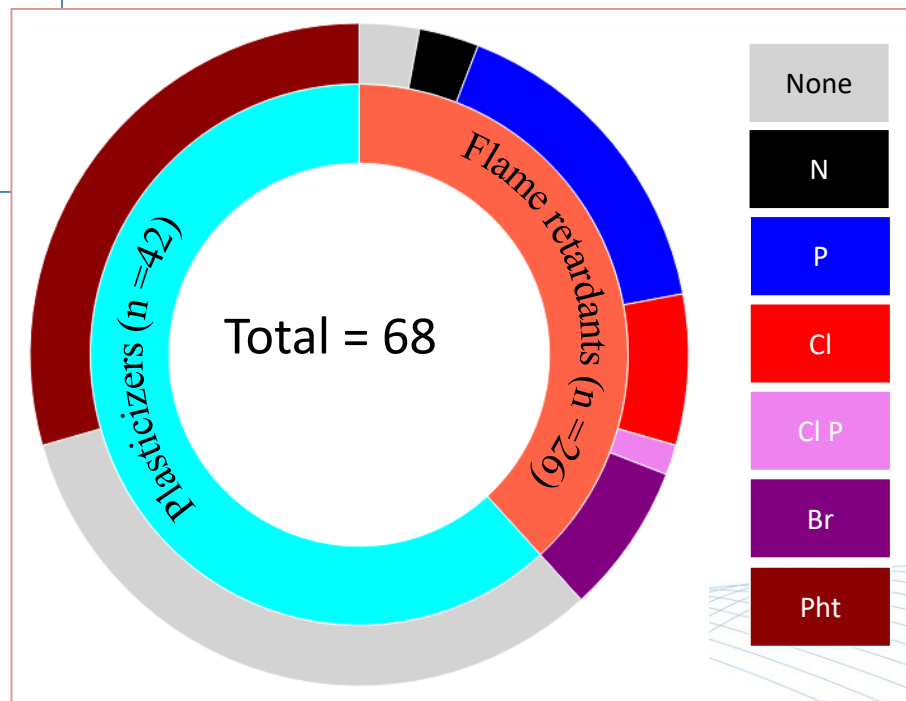
Results

“Elemental” composition of FRs and plasticizers



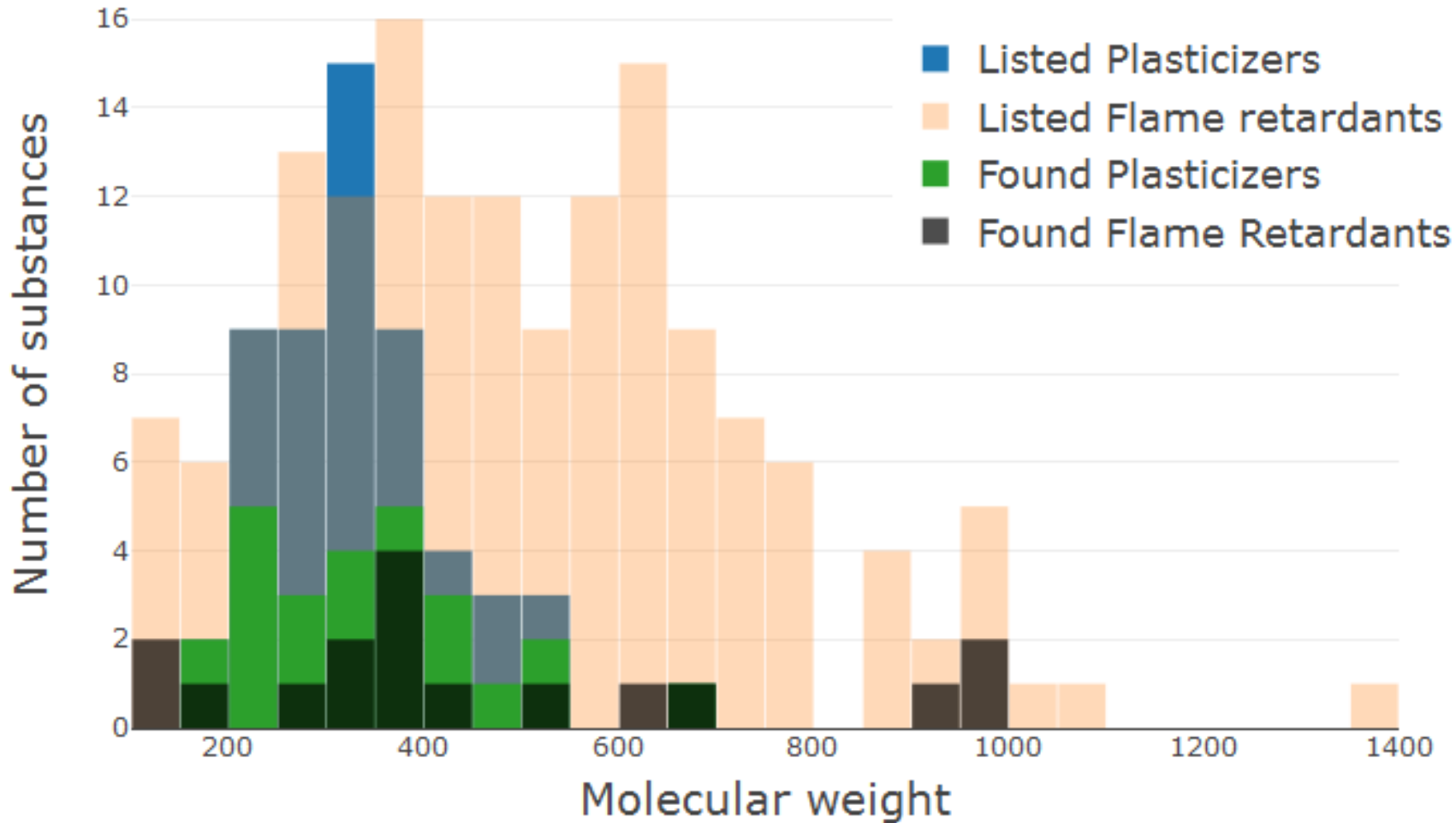
All listed FR and plasticizer additives

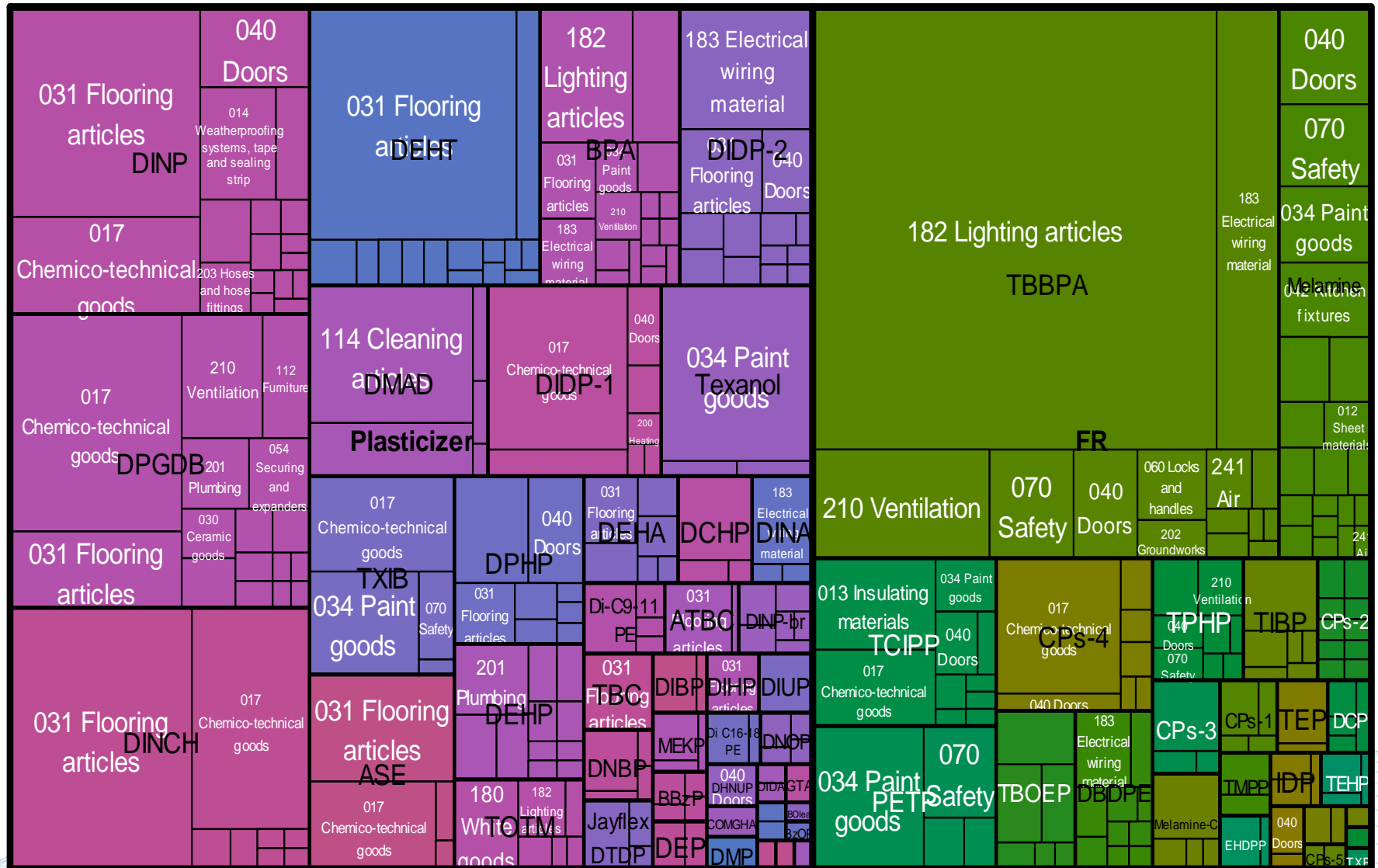
Found in at least one products from building material assessment databases



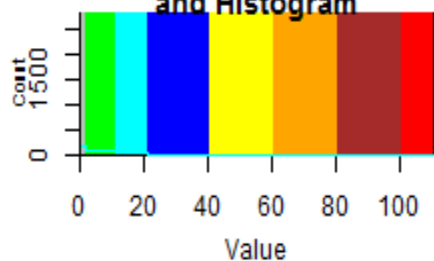
Listed substances: median MW: FR 486 g/mol, Plasticizers 322

Found substances: median MW : FR 390, Plasticizers 340





Color Key
and Histogram



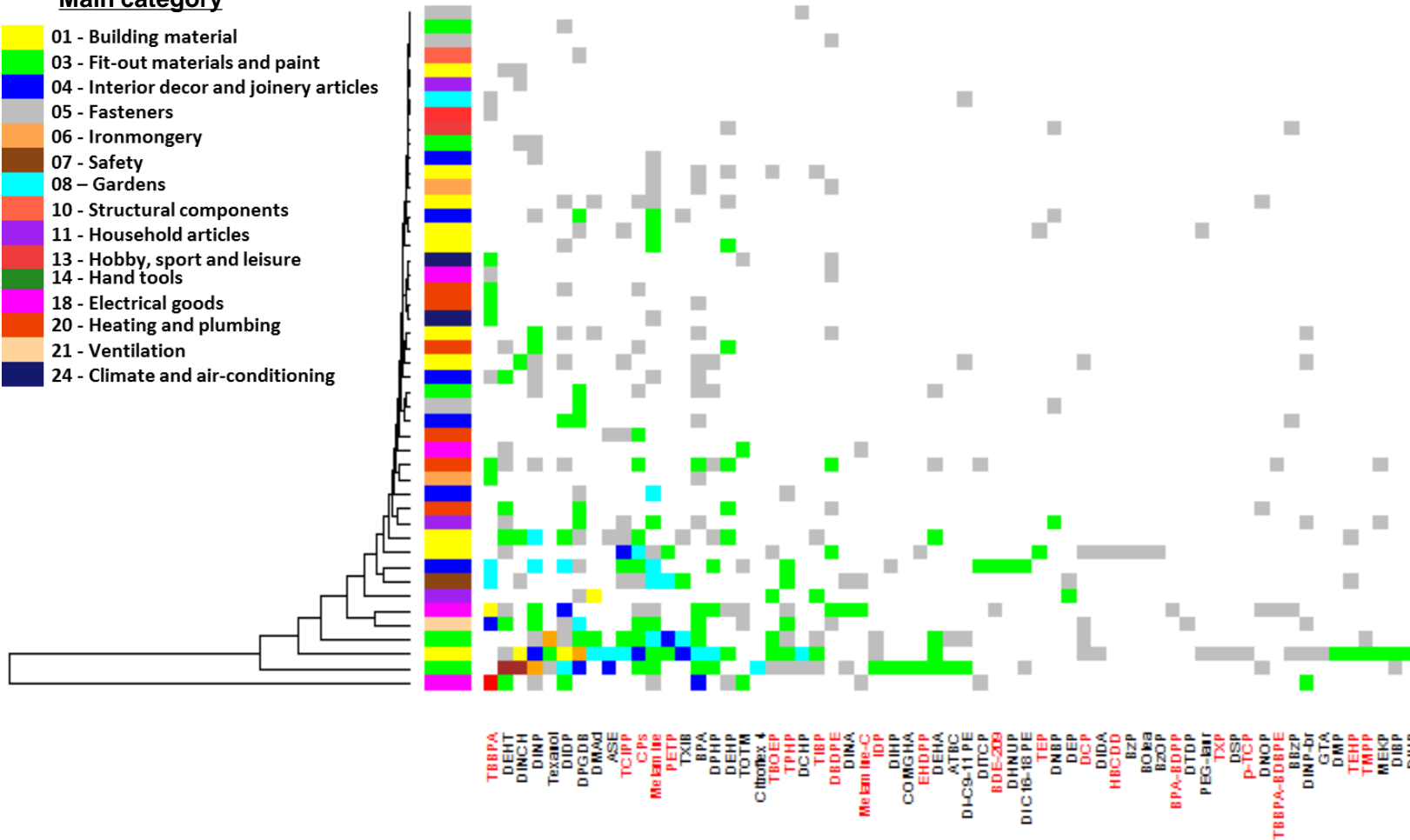
$N_{\text{tot}}: 2500$

Main category

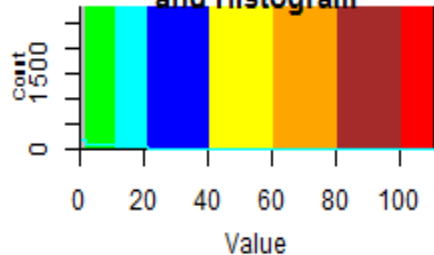
- 01 - Building material
- 03 - Fit-out materials and paint
- 04 - Interior decor and joinery articles
- 05 - Fasteners
- 06 - Ironmongery
- 07 - Safety
- 08 - Gardens
- 10 - Structural components
- 11 - Household articles
- 13 - Hobby, sport and leisure
- 14 - Hand tools
- 18 - Electrical goods
- 20 - Heating and plumbing
- 21 - Ventilation
- 24 - Climate and air-conditioning

Subcategory

- 051 Screws
- 033 Ceiling and wall systems
- 052 Bolt articles, nuts and washers
- 100 Structural components
- 018 Soffit system
- 110 Kitchen equipment
- 082 Tools and implements
- 145 Instruments
- 130 Games and play
- 032 Wallpapers
- 045 Storage
- 010 Binding agents and mortars
- 061 Ironmongery
- 015 Reinforcement, steel and meta
- 044 Room fitting-out
- 012 Sheet materials
- 011 Building blocks and aggregate
- 240 Heating
- 181 Electrical appliances
- 200 Heating
- 207 Fittings
- 241 Air
- 019 Home remodelling
- 203 Hoses and hose fittings
- 016 Roof and wall cladding
- 043 Bathroom fixtures
- 030 Ceramic goods
- 054 Securing and expanders
- 041 Windows and glass goods
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- 180 White goods
- 202 Groundworks
- 060 Locks and handles
- 042 Kitchen fixtures
- 201 Plumbing
- 112 Furniture
- 014 Weatherproofing systems, tap
- 013 Insulating materials
- 040 Doors
- 070 Safety
- 114 Cleaning articles
- 183 Electrical wiring material
- 210 Ventilation
- 034 Paint goods
- 017 Chemfoo-technical goods
- 031 Flooring articles
- 182 Lighting articles



Color Key
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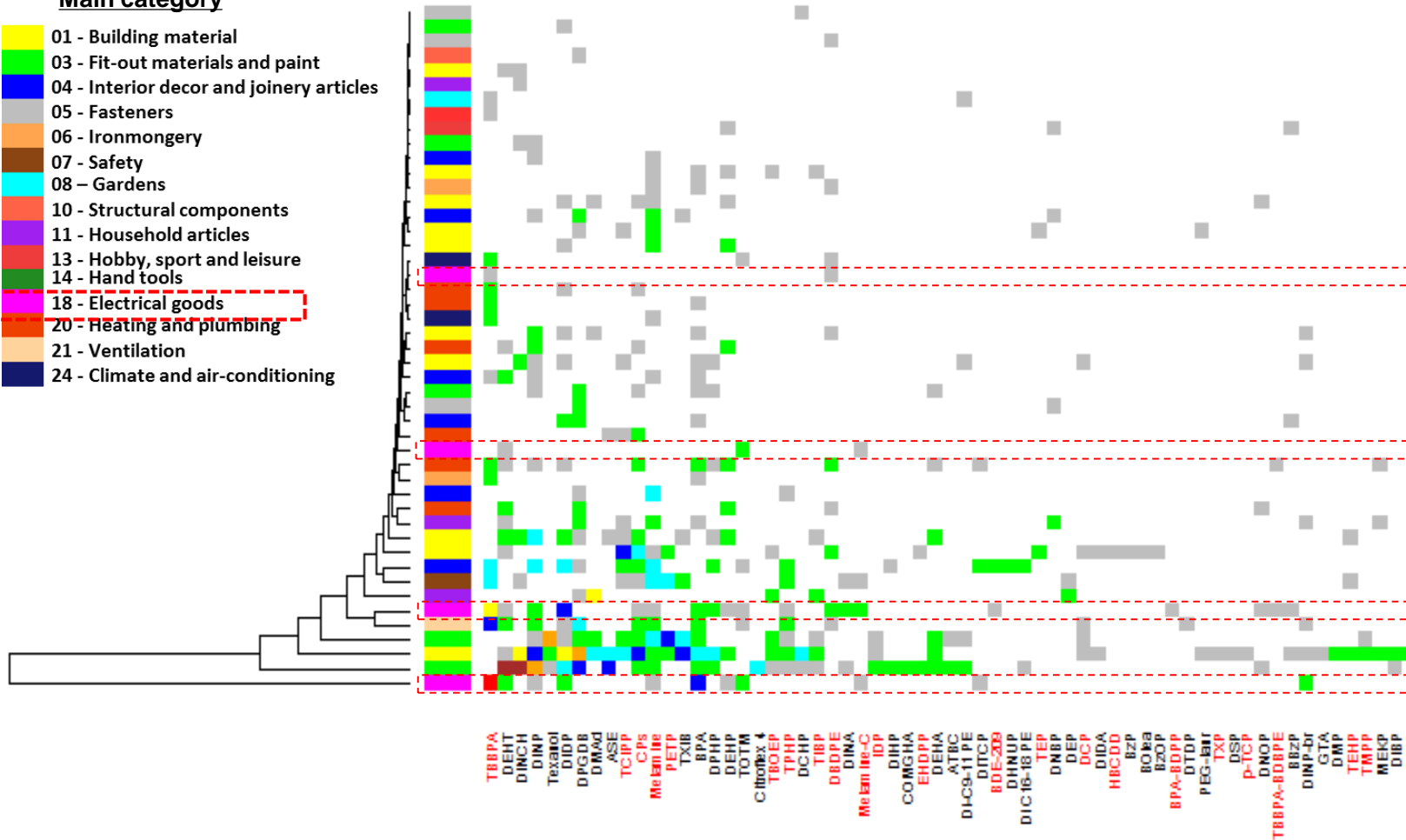
18 - Electrical goods

Main category

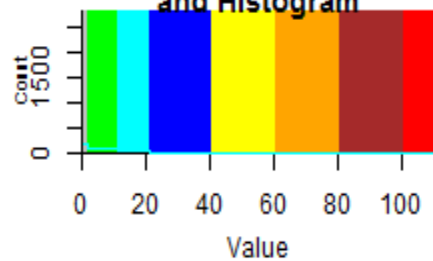
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- 014
- 013
- 040
- 070
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Color Key
and Histogram



01 – Building material

Main category

01 - Building material

03 - Fit-out materials and paint

04 - Interior decor and joinery articles

05 - Fasteners

06 - Ironmongery

07 - Safety

08 - Gardens

10 - Structural components

11 - Household articles

13 - Hobby, sport and leisure

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21 - Ventilation

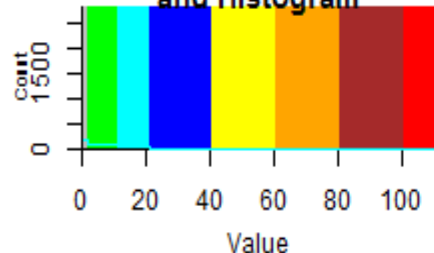
24 - Climate and air-conditioning

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TBPA DEHT DINCH DINP Texanol DPGDB DMAD ASE TCIPP C-PS PETP TXB BPA DPHP DEHP TOTM C1000x4 TBDEP TPHP DCHP TBEP DBDPE DINA Me lan line-C IDP DIHP COMGHA EHDPP DEHA ATBC DIC9-11 PE DUTCP BDE-300 DHRUP DIC 16-16 PE TEP DNBP DEP DCP DIDA HBCDD BZP BOKA BZOP BPA-BDPP DTDP PEG-EMT TXP DSP P-ICP DNOP BZBP DINP-br GTA DMP TEHP TMPP MEKP DIBP DIUP

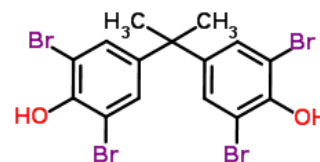
Color Key
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Main category

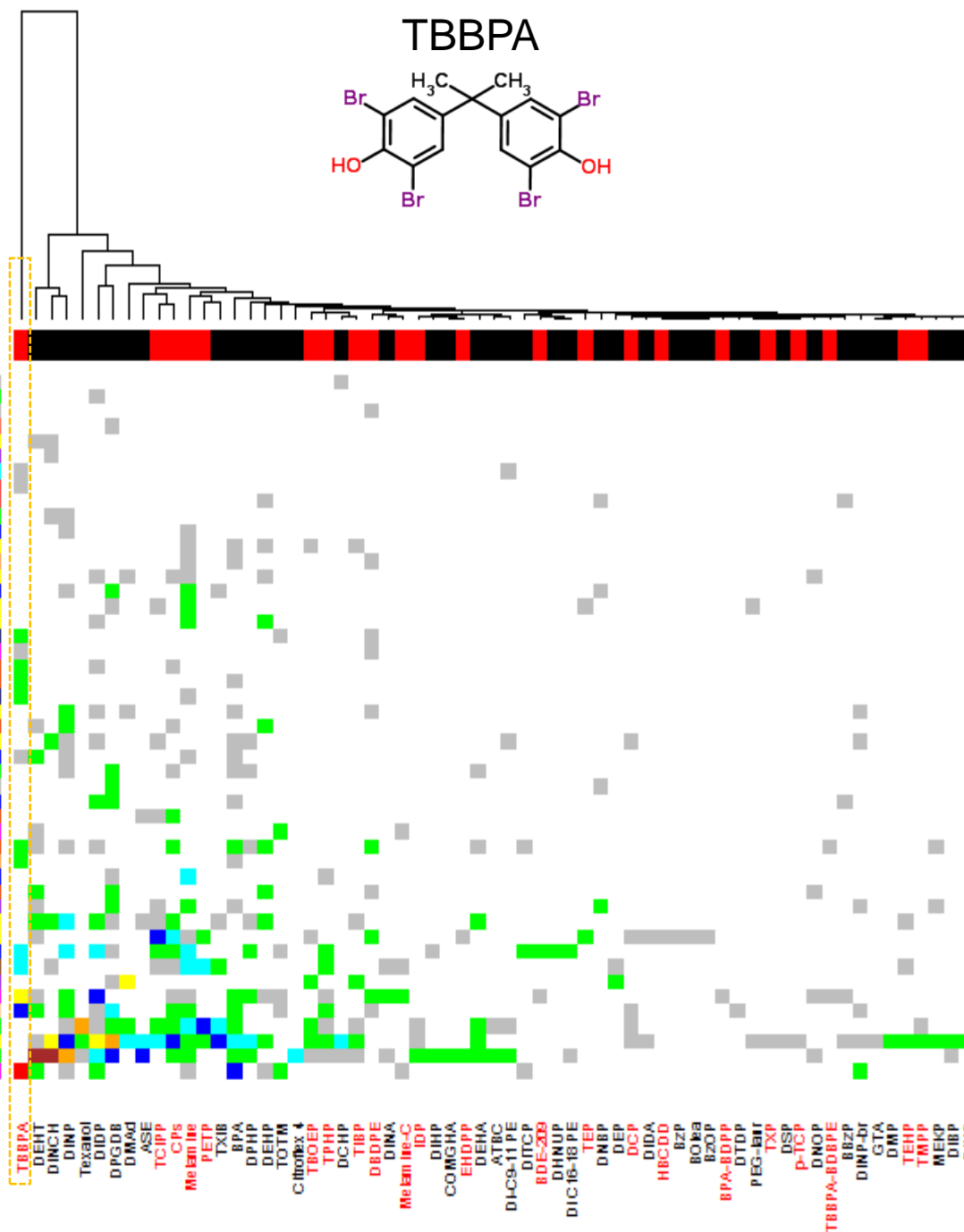
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TBBPA



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CLASSIFIED PLASTICISERS

Included in
REACH Candidate List
or pending
Authorisation

ORTHOPHTHALATES Low Molecular weight 3-6C

DEHP DBP
DIBP BBP

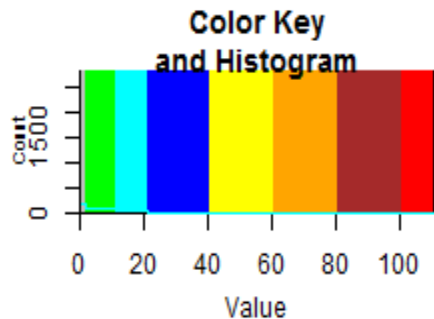
DCHP

NON-CLASSIFIED PLASTICISERS

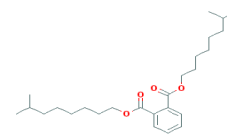
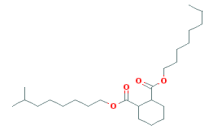
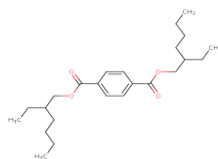
ORTHOPHTHALATES High Molecular weight $\geq 7C$ DINP DIDP DPHP			Sebacates DMS DBS
			Azelates DIDAz
Cyclo- hexanoates	Terephthalates DOTP DBT	Adipates DEHA DINA DIDA DTDA	Alkyl sulfonates ASE
		Phosphate TPP	Citrates ATBC
Dibenzoates ODEB OXPDB	Trimellitates TOTM	Acetates	Butyrates
Benzoates INB IDB	Vegetable Oil based Expoxidized, hydrogenated and acetylated vegetable oil		Valerates

This table is for illustration purposes only. The list of plasticisers is non-exhaustive and box sizes do not accurately represent market volumes.

Color Key
and Histogram



DEHT, DINCH, DINP

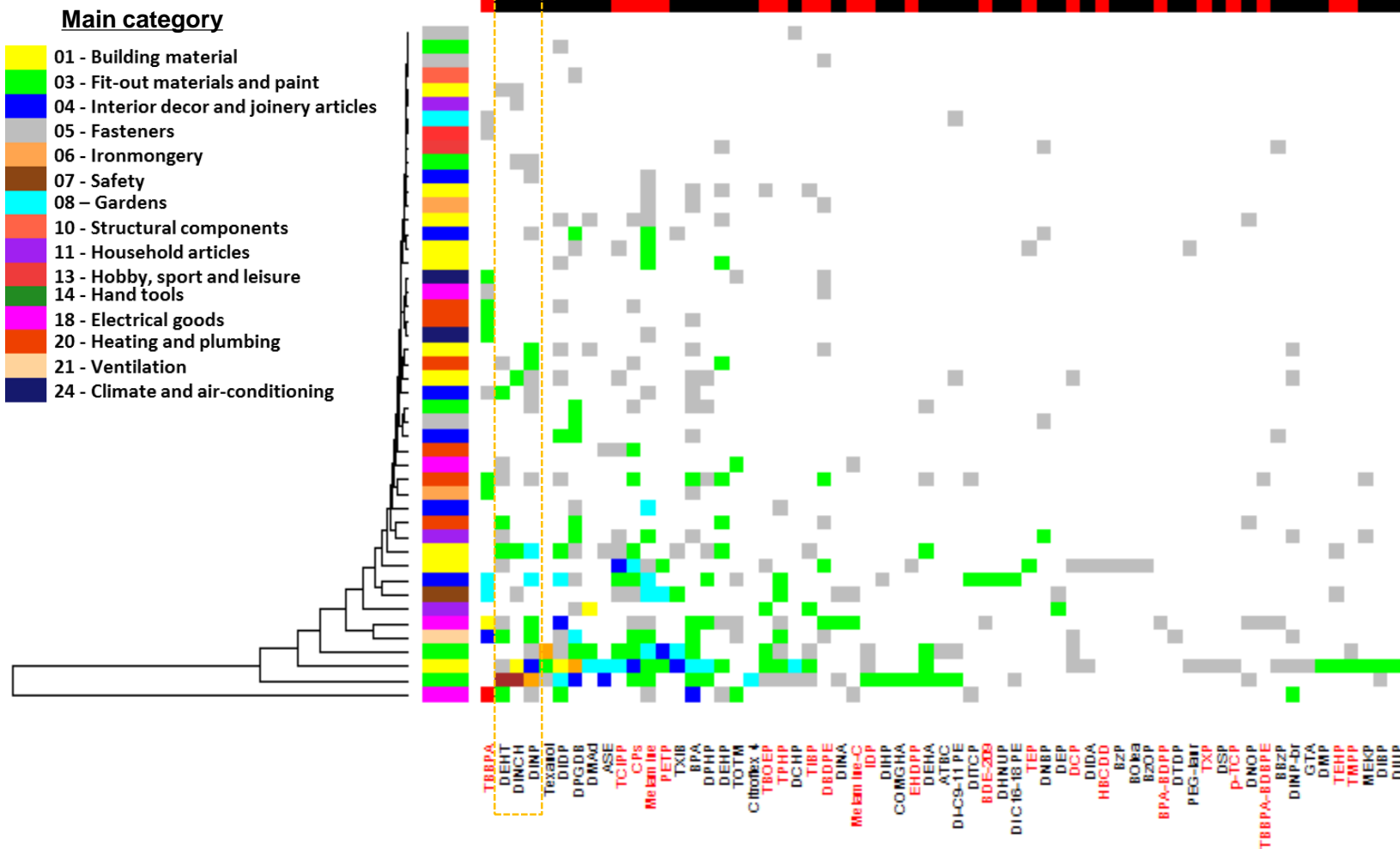


Main category

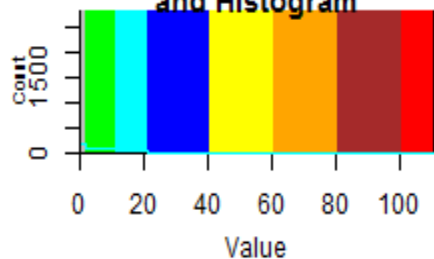
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Color Key
and Histogram



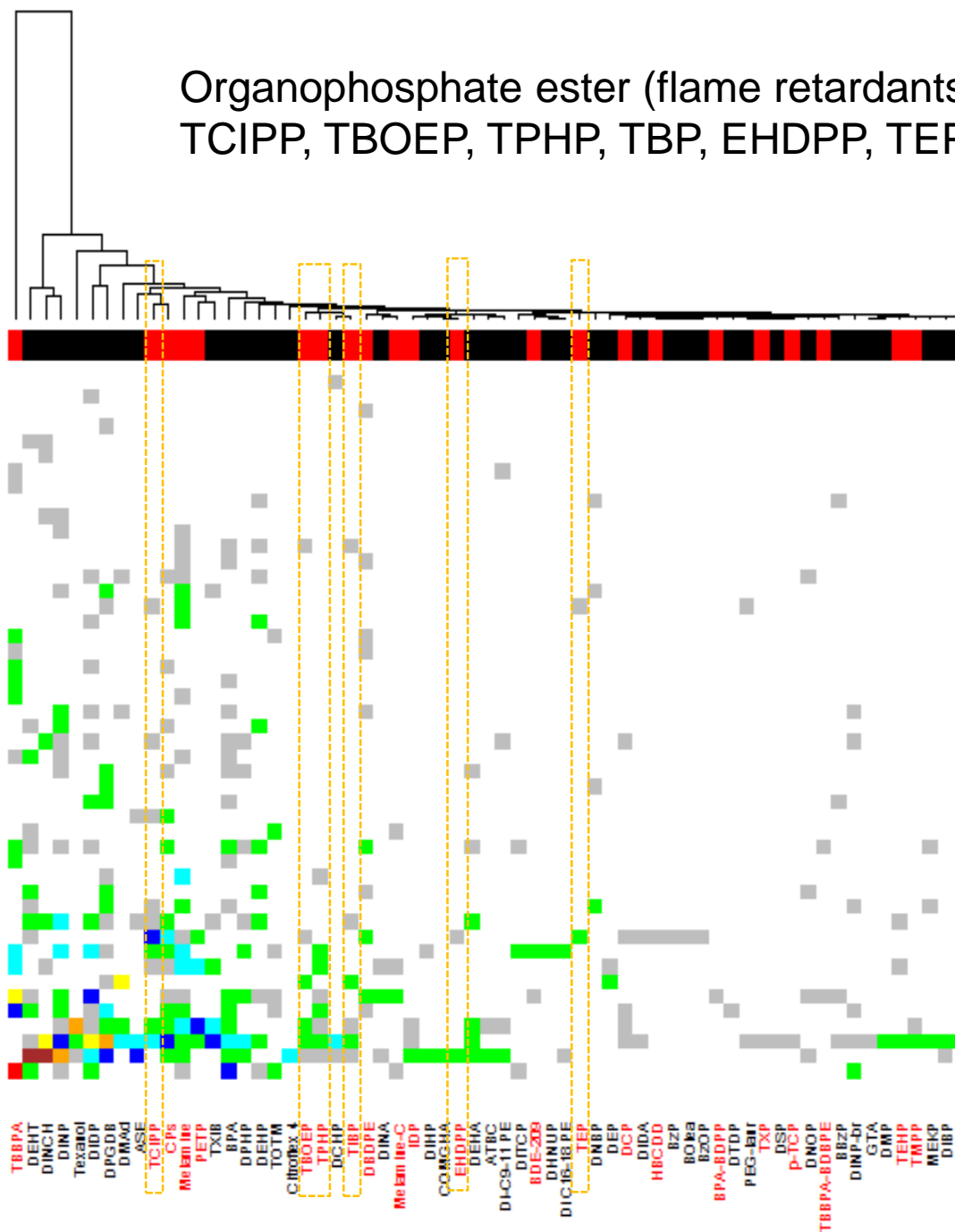
Organophosphate ester (flame retardants)
TCIPP, TBOEP, TPHP, TBP, EHDPP, TEP, ..

Main category

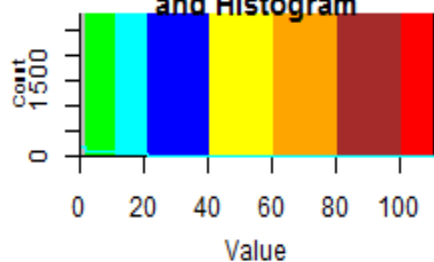
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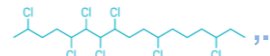
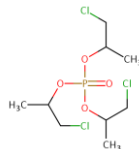
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Color Key
and Histogram



TCIPP & CPs

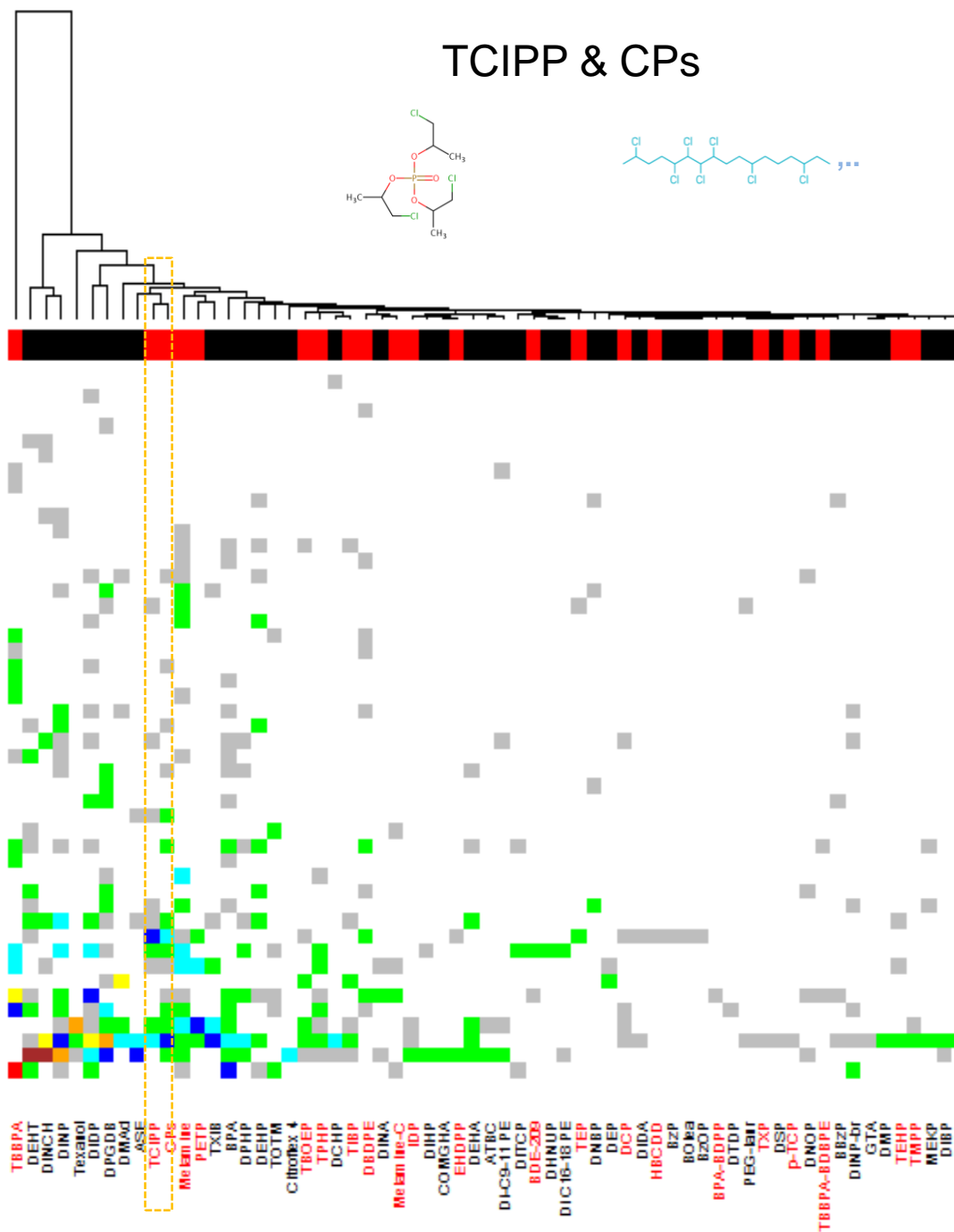


Main category

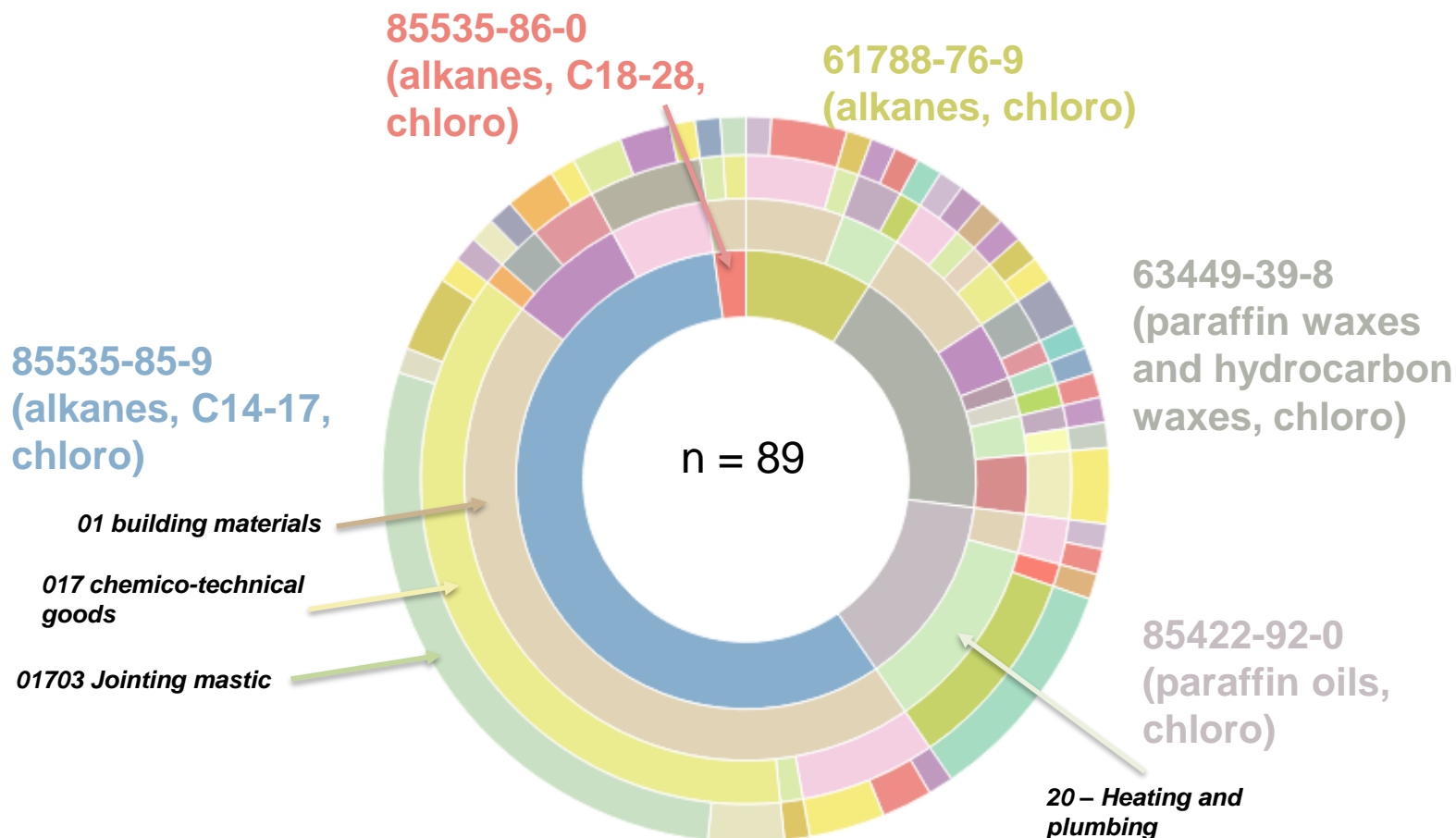
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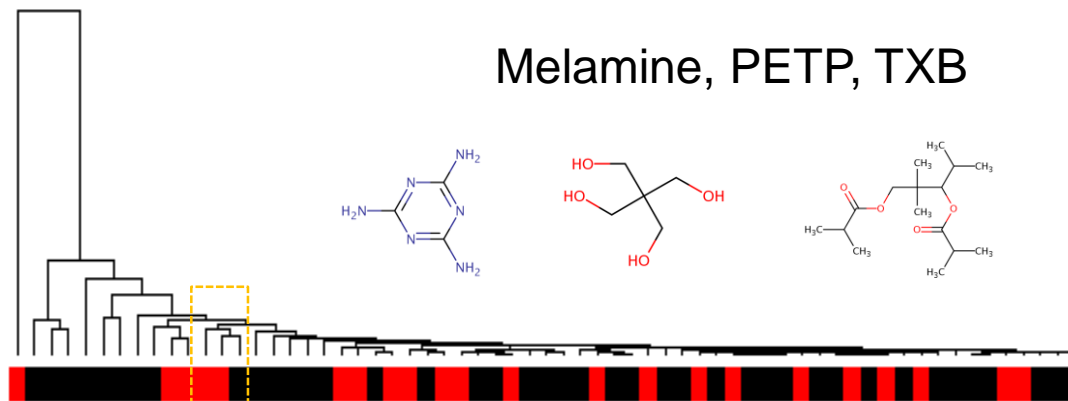
Subcategory

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Chlorinated Paraffins (five technical products by separate CAS numbers)

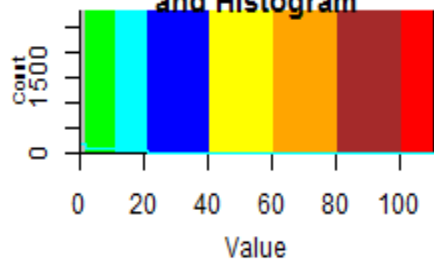




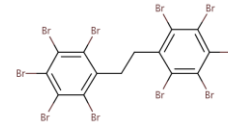
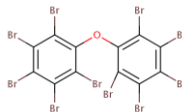
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Color Key
and Histogram



BDE-209 and DPDBE

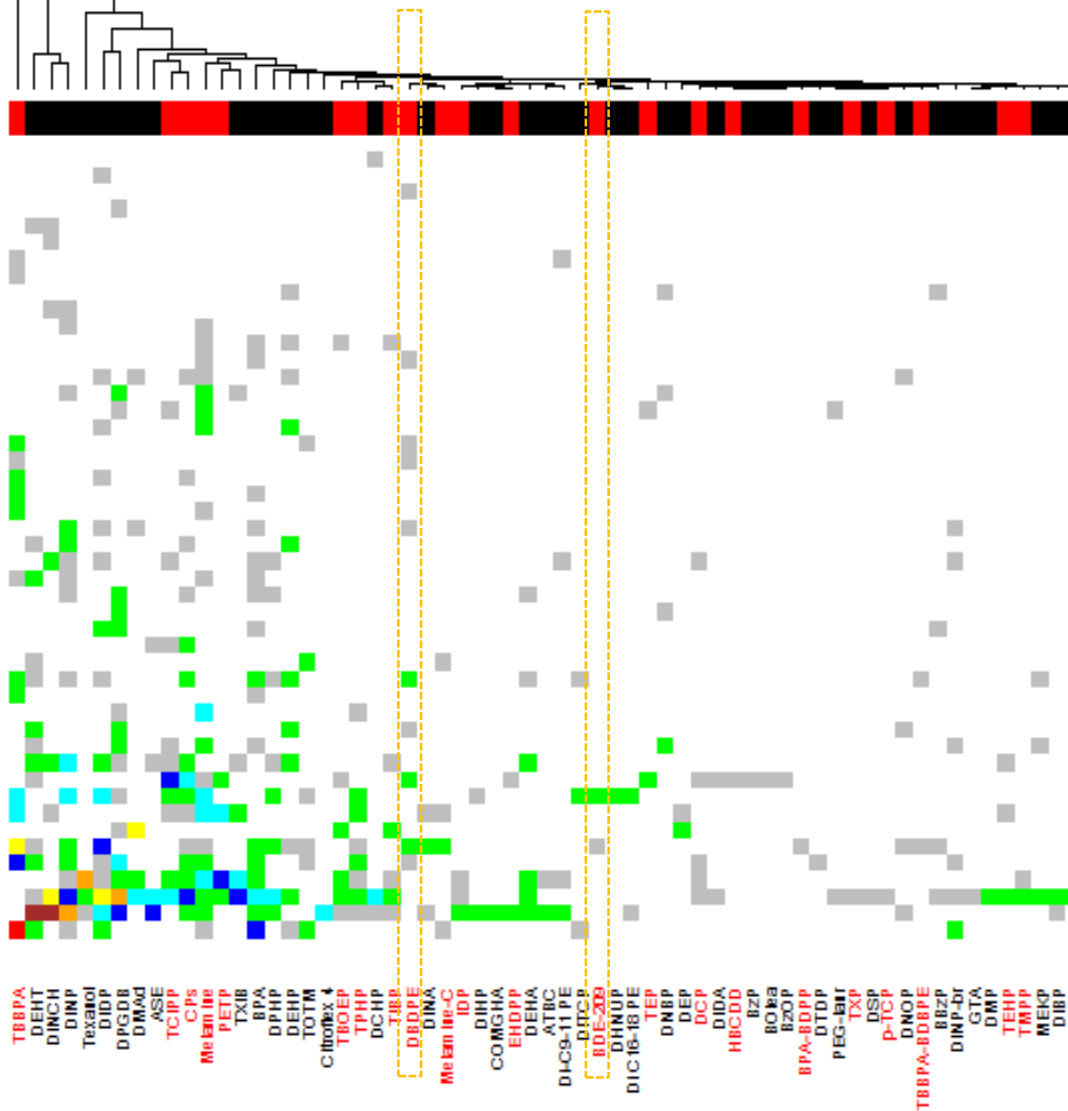


Main category

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- 200 Heating
- 207 Fittings
- 241 Air
- 019 Home remodelling
- 203 Hoses and hose fittings
- 016 Roof and wall cladding
- 043 Bathroom fixtures
- 030 Ceramic goods
- 054 Securing and expanders
- 041 Windows and glass goods
- 205 Installation systems
- 180 White goods
- 202 Groundworks
- 060 Locks and handles
- 042 Kitchen fixtures
- 201 Plumbing
- 112 Furniture
- 014 Weatherproofing systems, tap
- 013 Insulating materials
- 040 Doors
- 070 Safety
- 114 Cleaning articles
- 183 Electrical wiring material
- 210 Ventilation
- 034 Paint goods
- 017 Chemfoo-technical goods
- 031 Flooring articles
- 182 Lighting articles

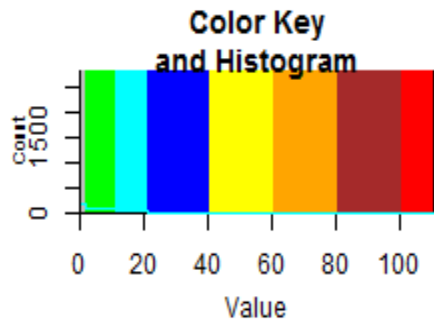


What useful information can we convey from this survey?

- Substances more prevalent in building materials with high surface coverage
-> higher potential to be released to the indoors
- Exposure through various indoor pathways (dust ingestion, inhalation, dermal)
- Health risks associated with indoor exposure
- In order to reduce exposure: need to track sources of exposure
- Use in suspect list for screening projects

Which substances and building materials should we focus on to assess the exposure risks of FRs and plasticizers?

Color Key
and Histogram



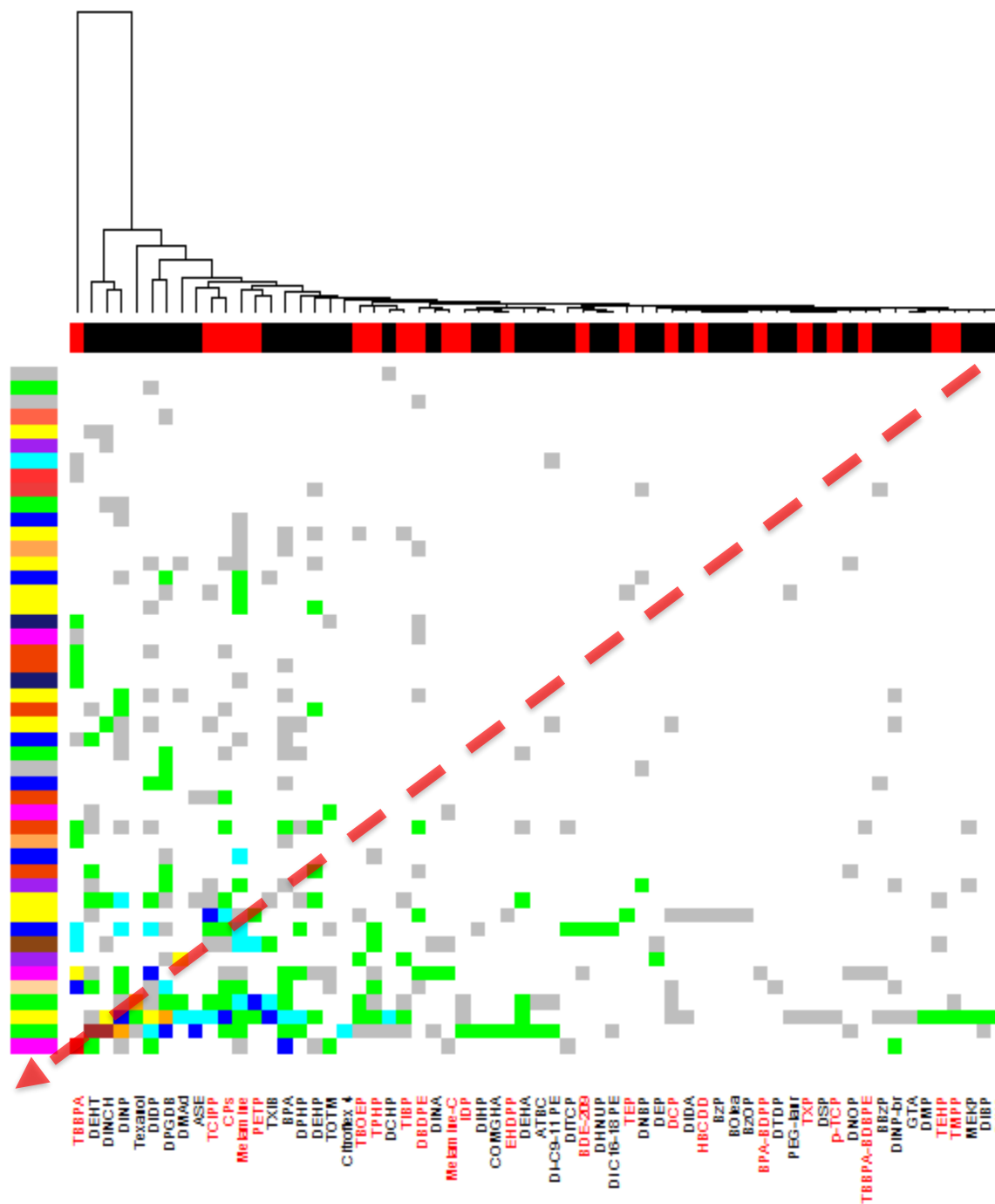
Main category

- 01 - Building material
- 03 - Fit-out materials and paint
- 04 - Interior decor and joinery articles
- 05 - Fasteners
- 06 - Ironmongery
- 07 - Safety
- 08 - Gardens
- 10 - Structural components
- 11 - Household articles
- 13 - Hobby, sport and leisure
- 14 - Hand tools
- 18 - Electrical goods
- 20 - Heating and plumbing
- 21 - Ventilation
- 24 - Climate and air-conditioning

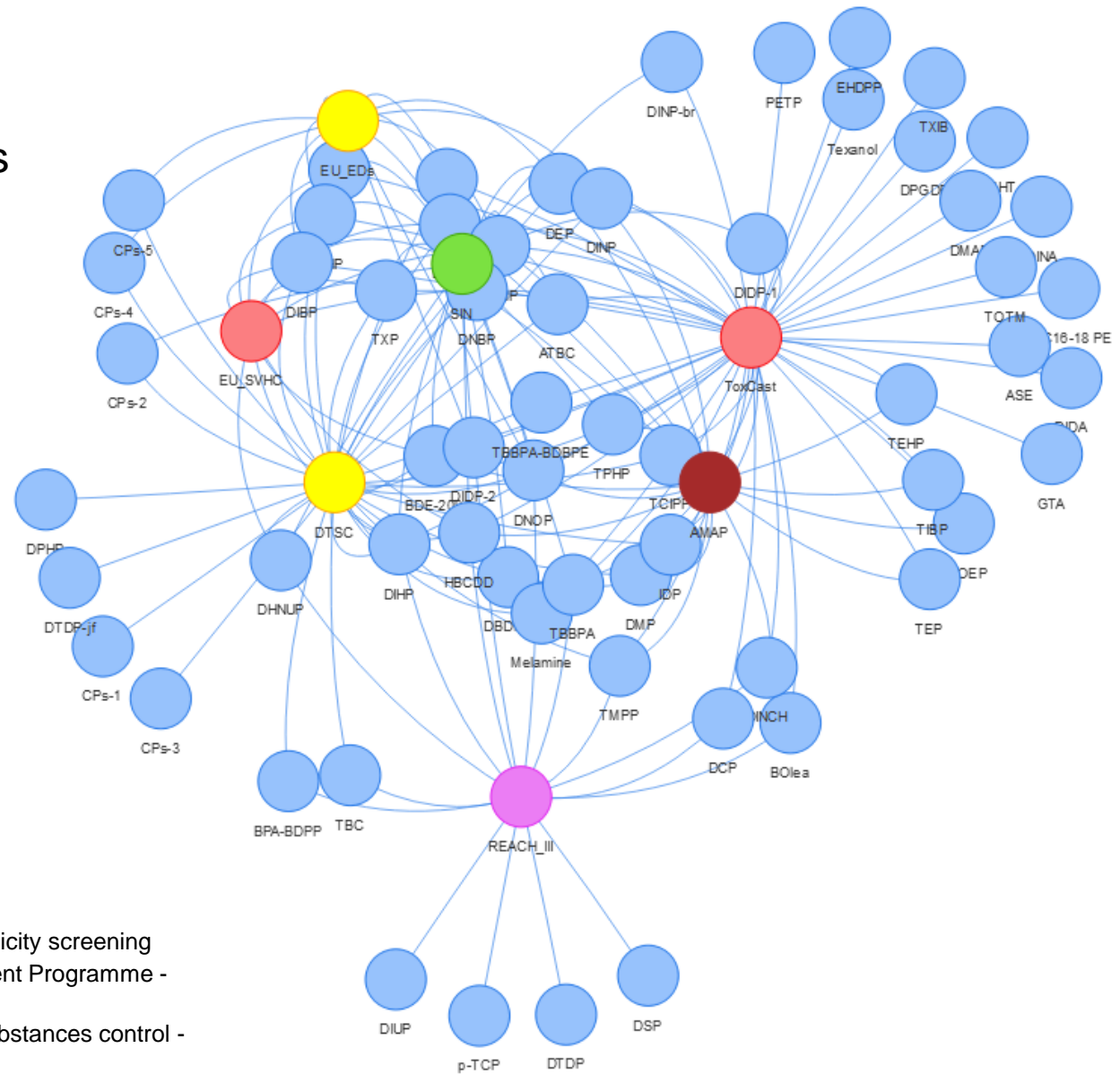
Subcategory

- 051 Screws
- 033 Ceiling and wall systems
- 052 Bolt articles, nuts and washers
- 100 Structural components
- 018 Soffit system
- 110 Kitchen equipment
- 082 Tools and implements
- 145 Instruments
- 130 Games and play
- 032 Wallpapers
- 045 Storage
- 010 Binding agents and mortars
- 061 Ironmongery
- 015 Reinforcement, steel and meta
- 044 Room fitting-out
- 012 Sheet materials
- 011 Building blocks and aggregate
- 240 Heating
- 181 Electrical appliances
- 200 Heating
- 207 Fittings
- 241 Air
- 019 Home remodelling
- 203 Hoses and hose fittings
- 016 Roof and wall cladding
- 043 Bathroom fixtures
- 030 Ceramic goods
- 054 Securing and expanders
- 041 Windows and glass goods
- 205 Installation systems
- 180 White goods
- 202 Groundworks
- 060 Locks and handles
- 042 Kitchen fixtures
- 201 Plumbing
- 112 Furniture
- 014 Weatherproofing systems, tap
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- 183 Electrical wiring material
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- 182 Lighting articles

Higher emission and
exposure potential?



Additives found in the building material assessment databases and listed in selected authoritative lists



ToxCast (US EPA): high throughput toxicity screening

AMAP: Arctic Monitoring and Assessment Programme - Chemicals of emerging concern

DTSC: California department of toxic substances control - Candidate chemicals

REACH_III: Annex III of REACH

EU_EDS: EU priority list of endocrine disruptors

SIN: Chemsec list

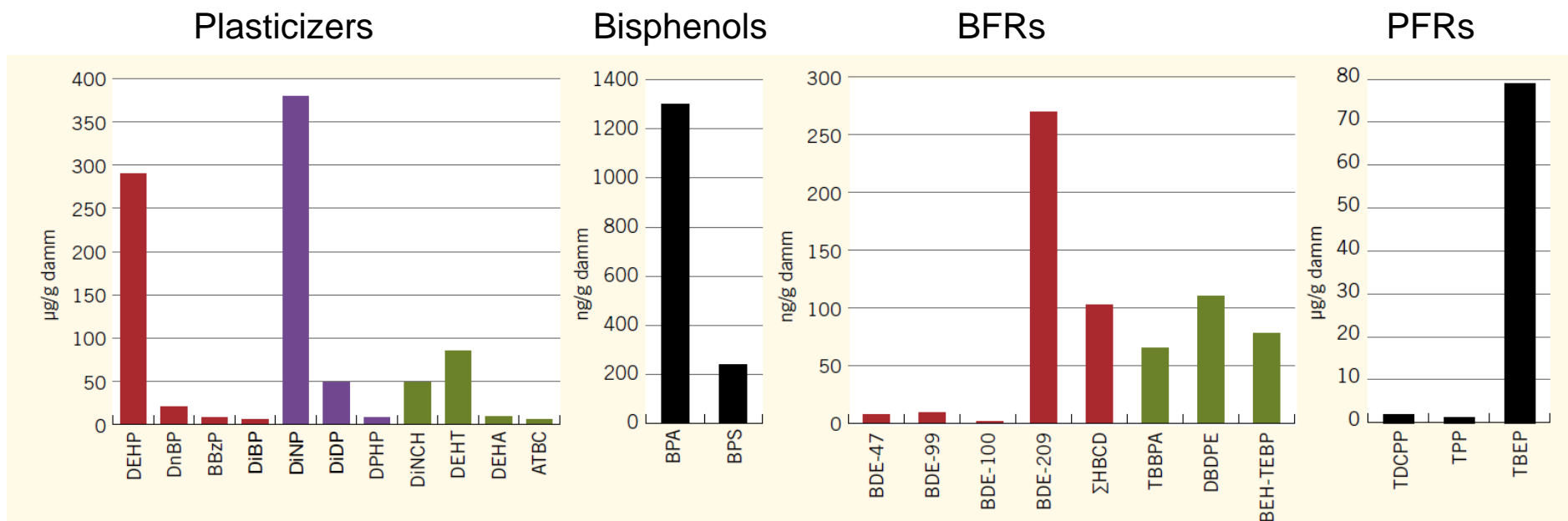
EU SVHC: REACH SVHC - Candidate list & Authorisation list

Current limitations of this study:

- Not all additives included.
- Polymeric additives not included.
- Multiple CAS numbers for same substance (branched, mixtures,..).
- Multiple uses or other functionalities for some substances.
- Residual from manufacturing processes,..
- Not considering production volumes, amounts in product, indoor surface area coverage,..
- Building product assessment systems:
 - Mostly self-reported BK04 codes -> not always correctly assigned.
 - Some products were registered in both systems.
 - Representativeness of the two systems for building products in Sweden and in general?
 - Higher usage of recommended products than those failing the criteria?
 - Dynamic systems that constantly changes and updates.
 - New articles are added and outdated are removed.

Can these additives be found in the indoor environment?

Median levels of FRs and plasticizers in dust of 100 preschools in Stockholm



Healthy building forum project



- Healthy Building Forum (HBF)
 - Constructors, building owners, consultants around Örebro region.
- MTM Research Centre, Örebro University
- Occupational and Environmental Medicine, Örebro University

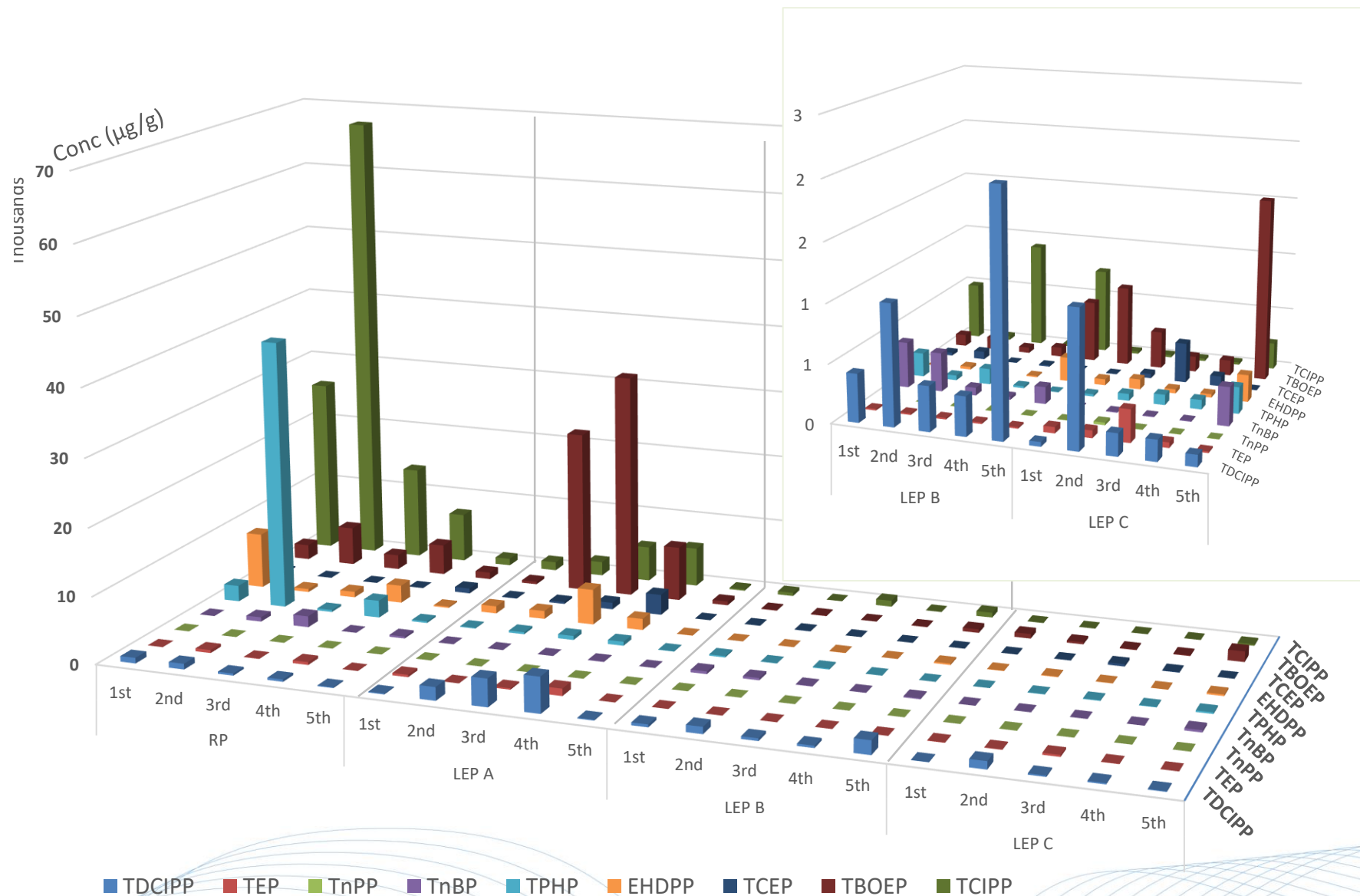
Pilot project:

- Study chemical emissions from building material in low energy buildings with focus on preschools
- Study the temporal trends of indoor air quality and chemical contamination in newly built low-energy preschools.

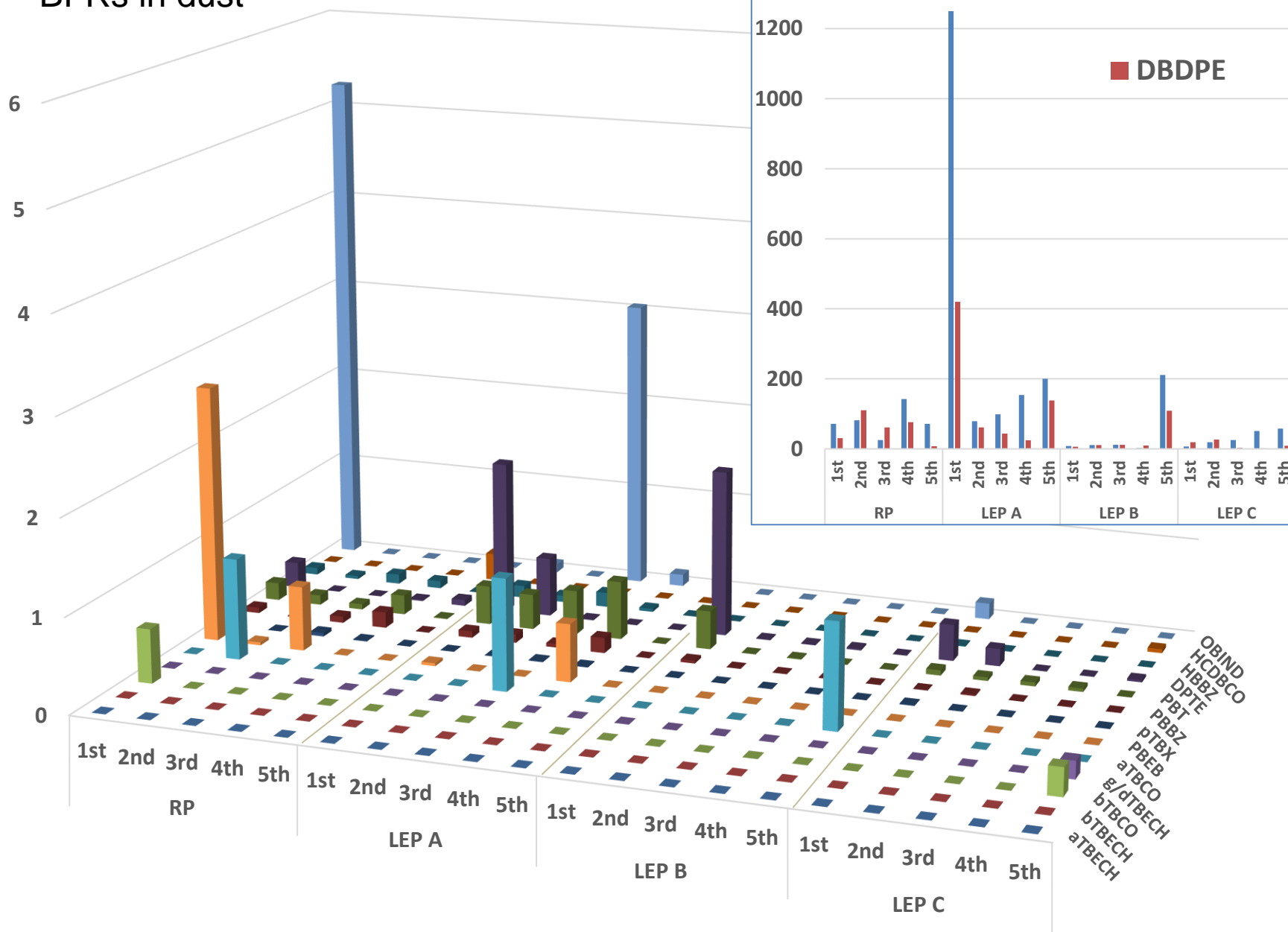
Sampling design

- **Preschools:**
 - **One reference building: RP**
 - **Three low-energy buildings:**
 - LEP A**
 - LEP B: Swan ecolabel**
 - LEP C: Environmental building Silver**
- **Sampling every 3 months during the first year:**
 - SP1: Newly built. Unoccupied.**
 - SP2: Preschool activity started.**
 - SP3-4: Preschool activity.**
 - SP5: follow-up sampling after 1-2 years.**
- **Matrices and analyses:**
 - **Indoor temperature, humidity, CO₂, NO₂, VOCs, aldehydes, suspended particles**
 - **Dust, air, surface wipes: Organophosphate and brominated flame retardants**
 - **Emission testing of collected building materials**

OPFR in dust



BFRs in dust



Conclusions

- Wide variety of FRs and plasticizers found in a wide variety of building products.
- Many of these found in the indoor environments
- Elucidating sources still difficult
- “Product-chemical” databases could help elucidate sources for detected substances at indoor environments.

More works needed:

Include all substances in found within the databases: UV stabilizers, biocides, colorants, fillers,...

Include information on chemical contents (%) in the products.

More concerted efforts and combine with other databases: BASTA,
US EPA databases,

...

Environmental informatics:

Manual work tedious -> automatize information collection steps

Build up a suspect list for suspect screening analysis (SSA) and nontarget analysis (NTA)

Exhaustive extraction and high throughput emission tests of relevant building materials (verify MSDS and find other substances)

Josefin Persson (MTM, Örebro University)

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Health Building Forum (HBF)



 **SundaHus**

BYGGVARUBEDÖMNINGEN™

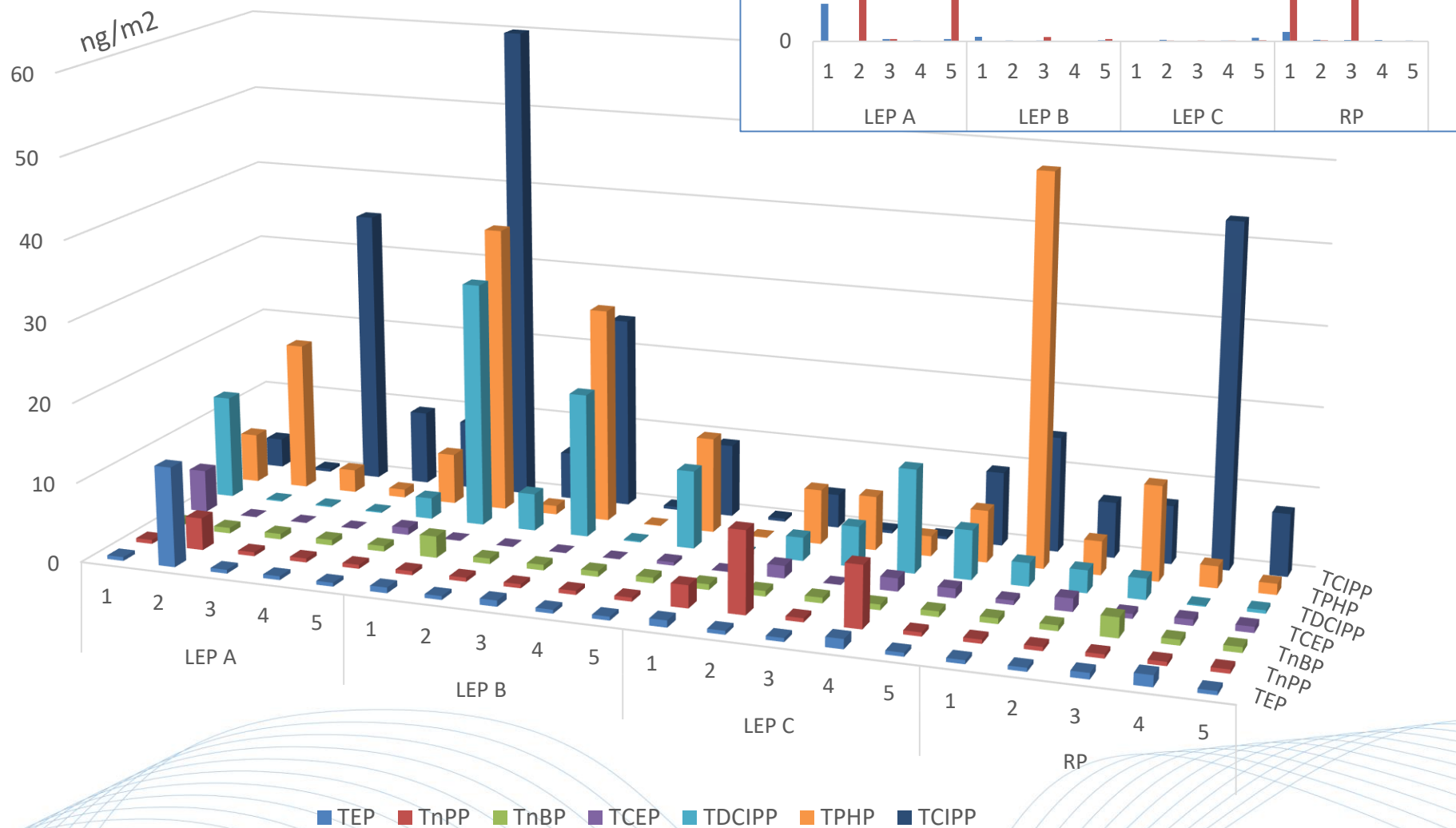


Region Örebro län

Universitetssjukhuset Örebro

Thank you!

OPFRs in surface wipes



OPFRs in indoor air

