

Health impact assessment of indoor quality

relation to limiting VOC emissions

29/04/2021

OUTDOOR POLLUTION

- ▲ Outdoor pollution is the biggest environmental health risk in Europe (EEA)

INDOOR POLLUTION

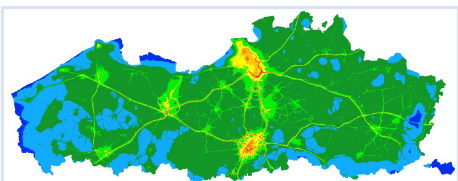
- ▲ People spend > 90 % time indoors
- ▲ Indoor air quality often worse than outdoor air quality
- ▲ Diversity of (indoor) sources and pollutants indoors
- ▲ Construction materials as important indoor sources for VOCs



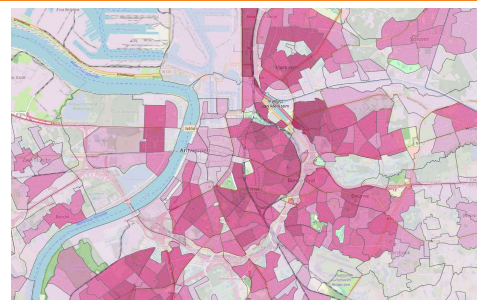
HEALTH IMPACT ?

HEALTH IMPACT ASSESSMENT - METHODOLOGY

Air quality maps



Population maps



Exposure

Attributive fraction
of disease(s) /
deaths caused by
air pollution

Economical costs
Mortality and
morbidity

Health outcomes :

- Exposure effect relationships
- Disease statistics

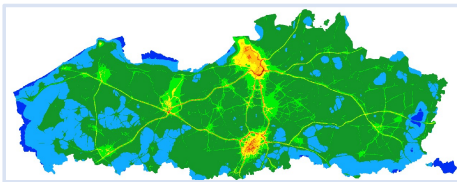
Health effects/diseases :
Economical costs

29/04/2021

HEALTH IMPACT ASSESSMENT

AMBIENT AIR POLLUTION

- ▲ Population representative data (using modelling ambient AQ); scenario analysis



- ▲ Exposure response (E-R) relationships

e.g. $PM_{2.5}$ RR (all cause mortality) = 1.062 per $10 \mu g/m^3$

**Health impact assessment
ambient air quality**

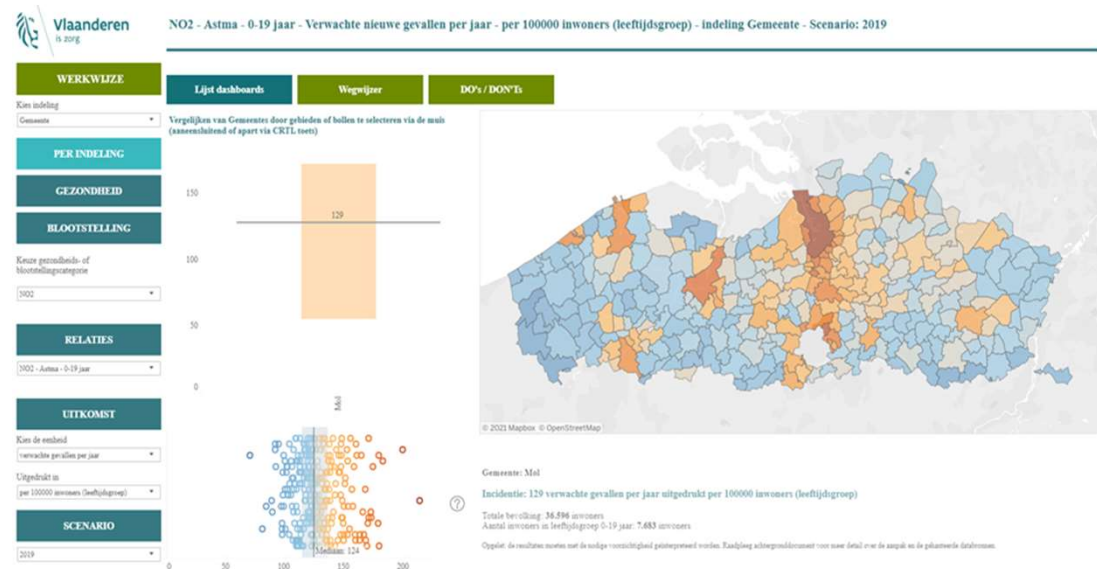
→ well advanced, outcome
triggers policy makers to
reduce burden of disease

Examples

Source: EAA report; data for 2018

	Population (x 1000)	$PM_{2.5}$	NO_2	O_3
		Attributable premature death		
Belgium	11.399	7.400	1.200	350
EU -28	507.558	379.000	54.000	4970

Interactive dashboards at local scale (e.g. Flanders)



HEALTH IMPACT ASSESSMENT

INDOOR AIR POLLUTION

- ▲ Population representative indoor pollution data: ?
~ IAQ monitoring data
- ▲ Exposure response (E-R) functions limited to subset of indoor air chemicals (e.g. formaldehyde, benzene, trichlorethylene, radon, CO)
- ▲ **for majority of VOCs present in indoor air/emitted from construction materials: no E -R available**

Examples

Health impact due to 6 indoor pollutants in France (Boulanger et al. 2017)

Ebode study (Hänninen et al., 2014)

→ Burden of disease due to indoor air pollution is likely underestimated by lack of adequate E -R relations for VOCs and lack of representative VOC (monitoring) data

INDOOR AIR POLLUTION

HEALTH IMPACT ASSESSMENT

- ▲ expected morbidity/mortality due to exposure

Health impact assessment indoor air quality
→ more methodological constraints compared to HIA outdoor air
→ Improvements HIA indoor air: work in progress!

- ▲ Construction materials as important indoor sources for VOCs

**HEALTH IMPACT :
UNDER DEVELOPMENT**

RISK ASSESSMENT

- ▲ Comparison of exposure (indoor levels) with health based indoor air quality guidelines (IAQG) or limit values for emissions (EU-LCI)
- ▲ Health based guidance values for a large set of VOCs available: e.g.
 - ▼ WHO IAQG,
 - ▼ EU-LCI values, for > 170 VOCs
- ▲ impact of exceeding IAQG or EU-LCI value

INDOOR AIR POLLUTION

RISK ASSESSMENT

Wide range of effects caused by indoor air pollution (VOCs)

<https://wwwn.cdc.gov/TSP/substances/ToxOrganSystems.aspx>

from mild to severe effects

RESPIRATORY /IRRITATION

Aldehydes
Terpenes
Aromatic
hydrocarbons
...

DEVELOPMENTAL

Ethylbenzene,
ethylene glycol
Xylenes,
trichloroethylene,
....

CARDIOVASCULAR

Dinitrotoluenes
Vinyl chloride
Acrolein
Chloroform
trichloroethylene
...

NEUROLOGICAL

Styrene
Xylene
Toluene
Trichloroethane
...

RENAL

Trichloroethylene
...

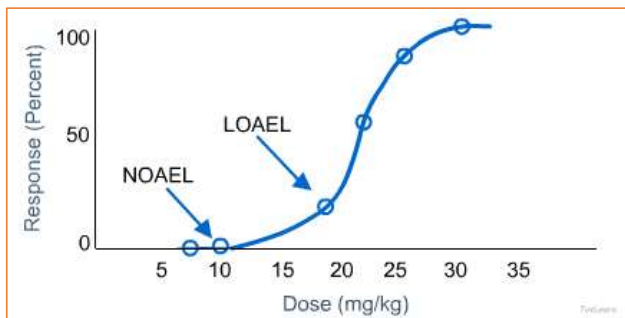


INDOOR AIR POLLUTION

RISK ASSESSMENT

For most critical health effect: derivation of a safe level for human health (long term exposure) 'health based guidance value'

Example: styrene



Health based guidance value =
NOAEL (or BMD) $\times$ $AF_1 \times AF_2 \times \dots \times AF_N$

AF: Assessment Factor 1 $\rightarrow$ n:
Exposure duration, study length,
intraspecies, interspecies, quality of data,....

POD: LOAEL 107 mg/m³ (neurological effects, colour vision, reaction time) occupational study

AF	Value
AF Adjustment for exposure duration	4.2 (worker exposure $\rightarrow$ continuous)
AF Adjustment factor for study length	- (Not relevant)
AF reliability of dose-response	10 (LOAEL $\rightarrow$ NOAEL)
AF interspecies (kinetic & dynamic)	- (Not relevant)
AF intraspecies (kinetic & dynamic)	10
AF sensitive populations	-
Other adjustment factors	-
Total assessment factor (TAF)	420

Π

Health based guidance value = 260 μ g/m³

RISK ASSESSMENT

Application of this principle in several indoor fields:

Indoor air monitoring evaluation

WHO IAQG [WHO/Europe | Publications - WHO guidelines for indoor air quality: selected pollutants](#)



Flemish IAQG <https://doi.org/10.1016/j.ijheh.2020.113579>

Health based evaluation of VOC emissions from construction materials

EU LCI – list of VOCs (> 170 VOCs) [EU-LCI Values | Internal Market, Industry, Entrepreneurship and SMEs \(europa.eu\)](#)

RISK ASSESSMENT: APPLICATION FIELDS

INDOOR AIR QUALITY MONITORING

Parameter	target value	intervention value	IAQ in 'baseline' dwellings						IAQ in dwellings with IAQ related health complaints				
			450 dwellings in Flanders						75 dwellings in Flanders				
			min	median	mean	P75	P95	max	min	median	mean	P75	max
formaldehyde		100 µg/m³	0,2	22,7	26,1	31,0	59,0	180					
acetaldehyde	160 µg/m³	480 µg/m³	0,7	6,2	8,5	9,3	18	264					
C4-C11 aldehydes	650 µg/m³	1600 µg/m³	DL	12	14	17	29	120					
benzeen		0.4 µg/m³	0,1	1,0	1,7	1,7	5	29	0	1,2	1,7	2	8
tolueen	5000 µg/m³	14000 µg/m³	0,9	5,1	31,0	11,1	56,0	7704	2,0	3,8	9,5	15,8	100,0
tetrachloorethyleen	4 µg/m³	38 µg/m³	0,1	0,1	1,2	0,2	2,5	195	0,2	0,3	0,3	0,3	0,3
trichloorethyleen	0,25 µg/m³	2,5 µg/m³	0,1	0,1	0,3	0,1	0,7	12,0					
C ₉ -C ₁₄ alkanen	250 µg/m³	490 µg/m³							2461		5245		13445
2-ethylhexanol	100 µg/m³	810 µg/m³							14,0		21,0		35,0
Styreen	260 µg/m³	2500 µg/m³	0,1	0,1	0,2	0,1	0,4	28,0					
benzo(a)pyreen (als ind)	0.012 ng/m³	0.1 ng/m³											
naftaleen	3 µg/m³	31 µg/m³											
TVOC (totaal)	300 µg/m³	1000 µg/m³	0,1	337	437	462	925	7517	75,0	455,0	2719	4907	14584
PM _{2.5}	10 µg/m³												
ozon	40 µg/m³ 8h	78 µg/m³ 8h											
stikstofdioxide	20 µg/m³	40 µg/m³	0,1	14	16	19	33	93					
koolstofmonoxide		8 mg/m³											
Hg	0.05 µg/m³	0.6 µg/m³							0,1	1,7	3,9	4,2	49

Risk assessment informs on priorities to reduce exposure

RISK ASSESSMENT: APPLICATION FIELDS

HEALTH BASED EVALUATION OF VOCs FROM CONSTRUCTION MATERIALS

IMPLEMENTATION IN POLICY

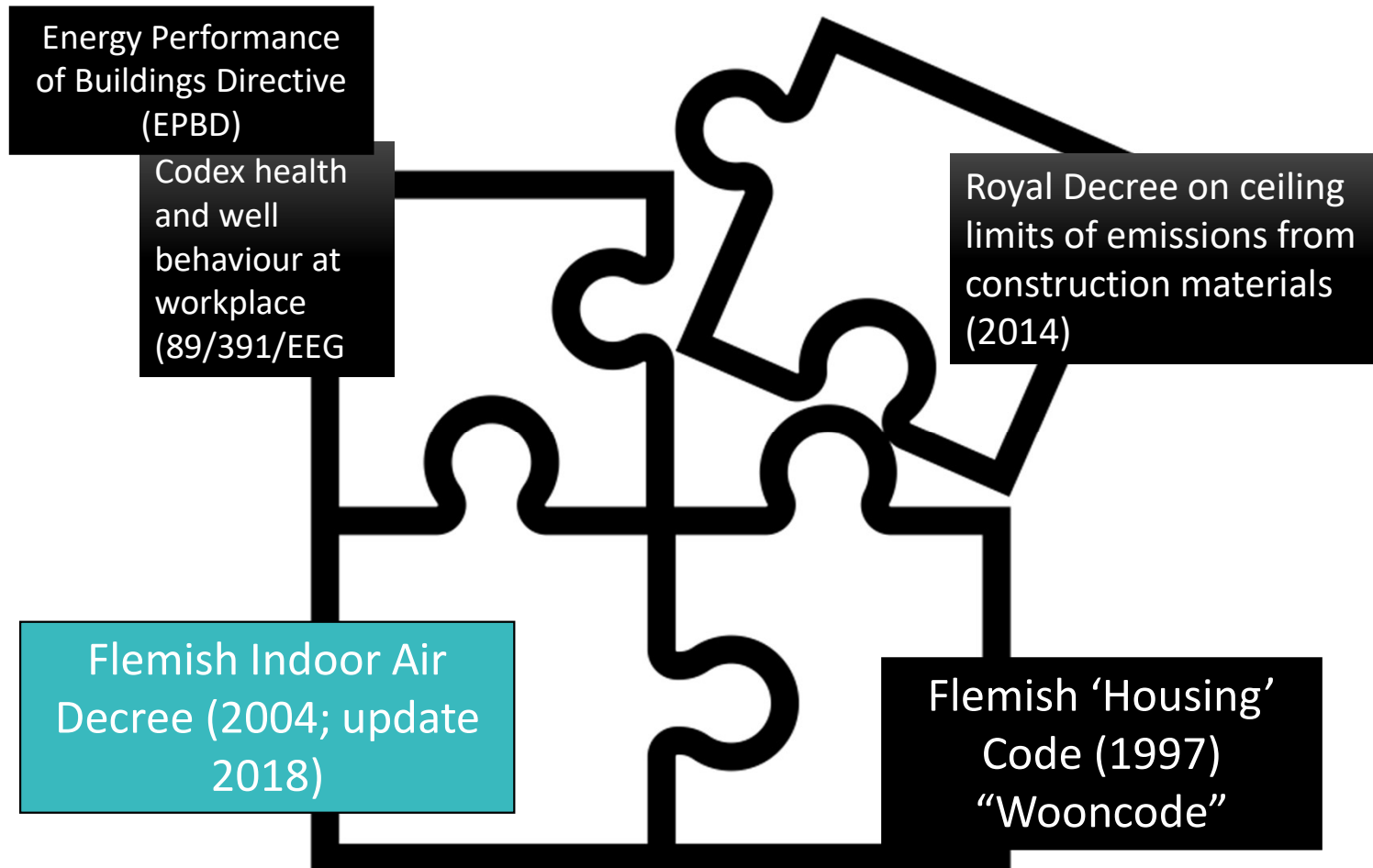
Belgium: [KB May 8, 2014](#) Royal Decree establishing the threshold levels of emissions into the indoor environment of building products for specific intended use (floor covering products, glues for floor covering products and finishing products for wooden floor coverings);

Substance/limit after 28 Days	Belgian VOC decree
TVOC	$\leq 1000 \mu\text{g}/\text{m}^3$
TSVOC	$\leq 100 \mu\text{g}/\text{m}^3$
Toluene	$\leq 300 \mu\text{g}/\text{m}^3$
Formaldehyde	$\leq 100 \mu\text{g}/\text{m}^3$
Acetaldehyde	$\leq 200 \mu\text{g}/\text{m}^3$
CMR 1A & B	$\leq 1 \mu\text{g}/\text{m}^3$
R value	≤ 1

R value: $\sum_i Ri$; $Ri : \frac{C}{EU-LCI}$ (i: > 170 VOCs)

Cfr CEN/TS 16515 construction products

POLICY MEASURES IN BELGIUM TO MINIMIZE HEALTH IMPACT OF VOC EMISSIONS



FLEMISH INDOOR AIR DECREE (2004; UPDATE 2018)

**1: awareness
sensibilisation**



**2: dwelling
Examination**



**3: indoor air
quality
guidelines**



FLEMISH INDOOR AIR DECREE (2004; UPDATE 2018)

1: awareness sensibilisation



- General public:
campaigns in media
Via local actors
- environmental services
of municipalities, (para)
medici, lodging agencies,
social workers



Woon gezond, geef lucht aan je huis!



FLEMISH INDOOR AIR DECREE (2004; UPDATE 2018)

~ health complaints

2: dwelling Examination



Citizens

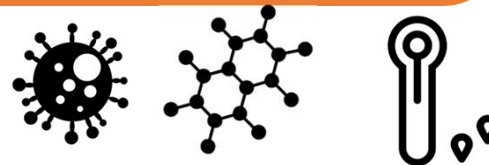
Doctors, home care workers, social housing agencies, environmental



Local medical environmental team:

- 1) Home visits, visual examination
- 2) [Measurements IAQ]

~ remediation



TAKE HOME MESSAGE

- ▲ Importance of indoor air quality for human health !
- ▲ Health impact assessment:
 - ▼ powerful tool inform policy makers
 - ▼ HIA for indoor air pollution: methodological constraints → probably underestimate health impact
 - ▼ Health impact assessment indoor air : in progress
- ▲ Risk assessment complementary to health impact assessment
- ▲ Risk assessment based policies
 - ▼ Examples EU LCI for evaluation of emissions VOCs
 - ▼ IAQG

Thank you for your attention !

Questions are welcome

Katleen.debrouwere@vito.be