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Application of the Maximum Cumulative Ratio (MCR) as a screening tool for evaluating mixtures in residential indoor air

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Background

Humans are exposed to complex mixtures from multiple sources. Regulatory programs, such as US TSCA and EU REACH generally evaluate risks substance-by-substance. Yet, exposure to mixtures is of particular relevance in indoor air.

Aim

To test the applicability of the Maximum Cumulative Ratio (MCR), as screening tool for assessing the risks from European indoor air pollution mixtures.

Methods

Hazard quotient of an individual substance (HQi) is defined as concentration (Ci) divided by health based reference value (RVi).

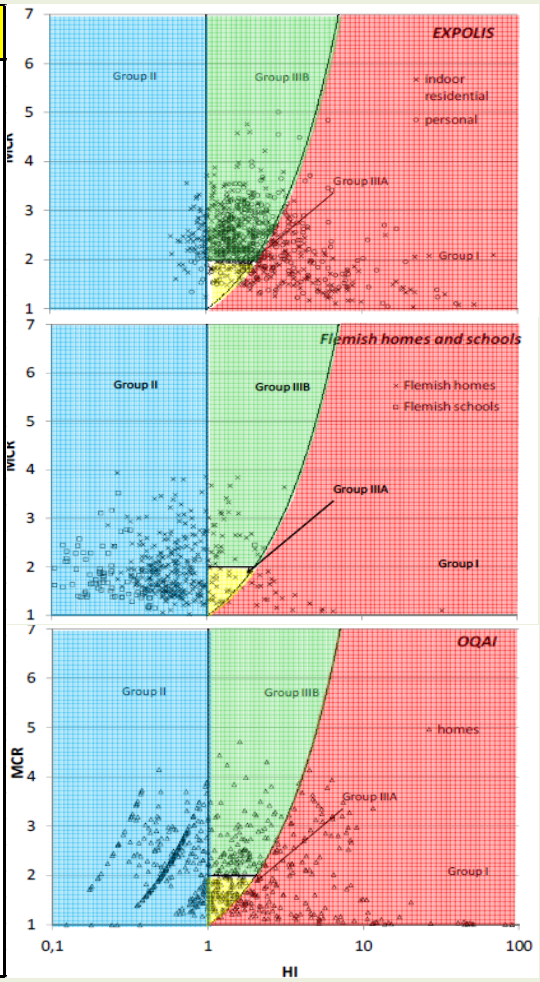
MCR is defined as the ratio of HI = Σ HQi of all analysed substances in the mixture divided by max HQi of any individual substance.

Indoor Ci data were compiled from the EXPOLIS, OQAI and Flemish IAQ surveys. In deriving the RVs, priority was given to international, recent, science-based, peer-reviewed and transparent assessments.

The reported indoor air pollution mixtures were divided into **four categories:**

- **I:** max HQi>1 → single substance of concern
- **II:** HI<1 → mixture of low concern
- **IIIa:** MCR<2, HI>1, max HQi<1 → mixture of concern dominated by one substance
- **IIIb:** MCR>2, HI>1, max HQi<1 → mixture of concern

Indoor air contaminant	EXPOLIS	Flemish IAQ	OQAI	Ref Value (µg/m³)	Source of chronic inhalation Ref Value
1,2 dichlorobenzene		X		60	US-EPA HEAST (1997)
1,4 dichlorobenzene		X	X	200	ATSDR (2006)
1-butanol	X			920	Ontario (2007)
1-octanol	X			1100	AgBB (2012)
2-butoxyethanol	X		X	1600	US-EPA IRIS (2010)
2-ethylhexanol	X			540	AgBB (2012)
2-methyl-1-propanol	X			550	AFSSET (2009)
2-propenal (acrolein)			X	0,35	OEHHA (2008)
3-carene	X	X		5500	Kasanen et al. (1999)
α-pinene	X	X		450	JRC (2005)
acetaldehyde		X	X	140	OEHHA (2008)
benzaldehyde	X			90	AgBB (2012), AFSSET (2009)
benzene	X	X	X	10	ATSDR (2007)
cyclohexane	X	X		6000	US-EPA IRIS (2003)
decane	X		X	6000	AgBB (2012), AFSSET (2009)
d-limonene	X	X		450	JRC (2005)
ethylbenzene	X	X	X	260	ATSDR (2010)
formaldehyde		X	X	100	WHO (2010)
heptane		X		10000	AFSSET (2009)
hexaldehyde	X		X	650	AFSSET (2009)
hexane	X	X		700	US-EPA IRIS (2005)
methyl tert butyl ether (MTBE)		X		2500	ATSDR (1996)
naphthalene	X			10	WHO (2010)
nitrogen dioxide (NO2)	X	X		40	WHO (2010)
nonane	X			200	US-EPA ORD (2009)
n-propylbenzene	X			1000	US-EPA ORD (2009)
octanal	X			650	AFSSET (2009)
phenol	X			20	OEHHA (2008)
styrene	X	X	X	850	ATSDR (2010)
tetrachloroethene	X			250	WHO (2010)
toluene	X	X	X	260	WHO (2000)
trichloroethene		X	X	2	US-EPA IRIS (2011)
trimethylbenzene	X	X	X	250	Ontario (2007)
undecane	X		X	6000	AgBB (2012), AFSSET (2009)
xylenes	X	X	X	200	ATSDR (2007)



Results

Ci data suffers from differences in the included substances and RV data from differences in health criteria. Only 6 compounds – aromatics – were analysed in all of the three surveys, 15 in two and 14 in only one.

To assess the impacts of these inconsistencies, sensitivity analyses were made using different substance lists and different RV selection criteria. In general the findings of the four categories were robust to the identified sources of uncertainty.

In the three residential indoor air datasets, 3-25% of the individual samples belonged to group I, 53-89% to II, 3-13% to IIIa and 6-13% to IIIb.

Conclusions

- MCR is applicable for screening indoor air risks. Comparability across the surveys, however, is limited.
- **Most of the monitored indoor air mixtures were of low concern, up to 1/4 of single substance concern. Less than 1/3 were of concern for mixture but not for any single compound.**

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