Indoor Monitoring

Results & examples from the IAQ routine survey program

in Luxembourg homes & offices

LE GOUVERNEMENT
DU GRAND-DUCHÉ DE LUXEMBOURG
Ministère de la Santé

Direction de la Santé - Division de la Santé au Travail
Department for Occupational Health

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DSAT – ralph baden 2/12/011

Chemicals
- Aldehydes including formaldehyde (15 substances)
- VOC inc. BTX, terpens, glycolethers, halogens (>29 substances)
- biocides (17)
- pyrethroids (8)
- PAH (16)
- Organo-phosphorous flame retardants (8)
- Brominated flame retardants (7)
- DEHP & phthalates (6)
- PCB ()
- Heavy metals (31)
- Asbestos & Man made mineral fibres
- CO & CO2

Mycological pollutants
- Mould spores (air & contact)
- Mycotoxins
- Humidity & surface temperatures

Physics
- Low frequency electric & magnetic fields
- High frequency electromagnetic fields
- Radioactivity & radon
- Noise & light
- PM10, PM2,5, PM1,0

Analyzes & measurements

Black = standard
Blue = optional if indication

air
dust

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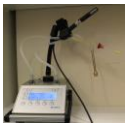
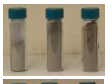
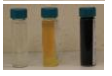
sampling

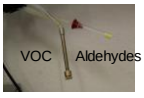
air



Materials & products







VOC Aldehydes

dust

analyzing

COV : TD-GC/MS (SOP-B-25)

Aldehydes : HPLC (SOP-B-32)

SVOC - GC/MS (SOP-B-29)

heavy metals - ICP/MS

µ-chamber

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Contents lists available at ScienceDirect

Journal of the Neurological Sciences

journal homepage: www.elsevier.com/locate/jns

Short communication

2004: French Patient – female - 29 years-old :

Double-blind non-controlled chemical challenge with environmental toxicological assessment in a Multiple Chemical Sensitivity case

periode	symptômes	condition
2004/07	Recurrent atypical opthalmic migraines (Severe headache attacks with visual troubles)	home1

Living room

Permethrine 5,5 mg/kg
Propiconazol 1,1 mg/kg
PCP 1,6 mg/kg

kitchen

Permethrin 4,7 mg/kg
Propiconazol 2,5 mg/kg
TBEP 27 mg/kg
TCPP 29 mg/kg

bedroom

Permethrin 10 mg/kg

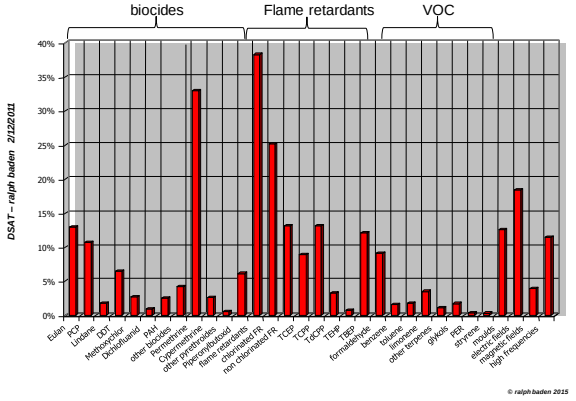
august 2007	Progressive improvement of condition	Moved to parents home
end 2007	Nausea, vomitments, ...at night	New home

Mattress

Permethrin 30 mg/kg

since 2008	Progressive improvement of condition	New mattress

Indoor pollutants in residential buildings in Luxembourg 2004-2007 (n = 2186)



Google.com may2015

Substance health	number of hits
PCB	131 mm
moulds	67,5 mm
Benzene	40,3 mm
Benzene	20,6 mm
Pentachlorphenol PCP	18 mm
Formaldehyde	17,8 mm
Toluene	12,8 mm
DDT	8,5 mm
PAH	5,1 mm
low frequency electric fields	3 mm
high frequencies	2,8 mm
Mineral fibres	2,6 mm
low frequency magnetic fields	1,6 mm
Styrene	1,3 mm
Glycol ethers	1,3 mm
Terpens	540.000
Limonene	538.000
Permethrin	485.000
Lindane	414.000
Hexa-BDE	406.000
Pyrethroids	396.000
Tetrachloro	385.000
Butoxyethanol	374.000
DEHP	373.000
Benzene	331.000
brominated fire/flame retardants	287.000
Cypermethrin	259.000
Perchlorethylene	188.000
Methanol/Alk	147.000
TCPP	137.000
Chlorthalonil	129.000
Piperonylbutoxyde	129.000
Deca-BDE	123.000
Propiconazole	102.000
TCEP	101.000
Tetrachlorvinphos	94.900
Dichlofluanid	88.200
oragnophosphorus flame/fire retardants	86.000
TdCPP	56.600
TBEP	48.100
Eulan	18.000

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change of windows (double glass) as origin of nevrodermitis

evolution 10 days after moving out

	living	bedroom	*Orient. val*	
formaldehyde	59	28	*25-60*	µg/m3
	0,047	0,022	*0,02-0,05*	ppm
hexanal	23	24	*19*	µg/m3
pinenes	**243**	74	*105*	µg/m3
d3-carene	**97**	30	*35*	µg/m3
		chambres		
Bisphenol A	1	**15**	-	mg/kg
DDT	**3,3**	<	*1-5*	mg/kg
PAH	**165,9**	6,3	*10-50*	mg/kg
lead	**1510**	81	*150*	µg/g
nickel	11	43	*30*	µg/g

Living room : wooden floor – tar glue

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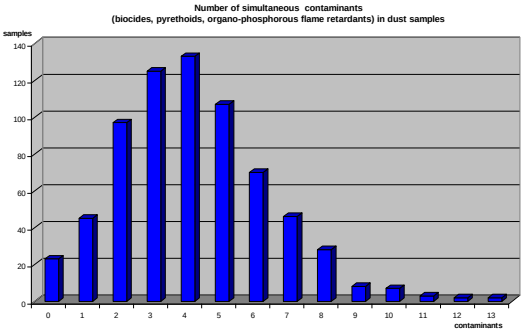

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Secretary, female, born in 1973: ***Asthma, cutaneous exzema (2009)***

since renovation of workplace (removal of vitrification of wooden floor)

• Positive activation of lymphocytes (LAT) for glycol ethers (butoxyethanol, butoxypropanol, butoxyethoxyethanol,, butoxyethylacetate), flame retardants (TPP, TBEP) and DDT

•Genetic predisposition having effect on detoxification phases

(Phase 1 Cyp1A1*2F wt/vt; Phase 2 GSTP 1 vt/vt, NAT2(*5A) wt/vt)

Office	home (Bed room)	Home (Living room)
Indoor air:	**Indoor air:**	**Indoor air:**
Butoxyethanol 31 µg/m³	Buthoxyethylacetate 57 µg/m³	Benzene 9 µg/m³
Butoxyethoxyethanol 74 µg/m³	Aldehydes (C6-C9) qualitative	Toluene 108 µg/m³
Butoxypropanol 16 µg/m³	**Dust:**	Aldehydes (C6-C9) qual.
Dust:	TBEP < 1 mg/kg	**Dust:**
TBEP 3700 mg/kg	TPP < 1 mg/kg	TBEP 1.6 mg/kg
	DDT < 1 mg/kg	TPP 1.2 mg/kg
		DDT < 1 mg/kg

Sources: 3 detergents & 1 paint stripper for wooden floor
Glycol ether as conservative agents, TBEP for brilliant effect of product

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Similar exposure at different locations

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Special school

Symptoms:

- Skin irritation
- Stinging eyes
- dizziness
- Headaches
- Improvement outside rooms

Dust analysis

Permethrin	1.8 mg/kg
Cypermethrin	252 mg/kg
TBEP	2874 mg/kg

Material analysis of wooden floor

Depth	Cypermethrin	TBEP
Surface	24 mg/kg	2699 mg/kg
0-1 mm	10 mg/kg	88 mg/kg
1-2 mm	4 mg/kg	<
2-3 mm	<	<
3-4 mm	<	<
4-5 mm	<	<

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patient: policeman, 30 years old, respiratory trouble at work only

HVAC

Mould spores – negative, no contamination

Substance	Unit	Ref value	Conc.	Cause	Health effect
Endotoxins	(EU)/g OS	> 10000	357,8	Bacteria	???
Aflatoxins	µg/kg OS	> 5	8	Aspergillus flavus	hepatotoxic, carcinogenic
T2-Toxins (Trichothecen)	µg/kg OS	> 50	87,5	Trichothecium spp., Fusarium spp.	immunosuppressive, pot.carcinogenic
Ochratoxin A	µg/kg OS	> 20	19,2		
Zearalenone	µg/kg OS	> 0,1	7,6	Fusarium spp.	mimics oestrogen
Fumosin	µg/kg OS	> 0,1	<25		
Deoxynivalenol DON	µg/kg OS	> 0,1	54	Fusarium spp.	carcinogenic?
Citrinin	µg/kg OS	> 100	150	Penicillum citrinum	pot. carcinogenic

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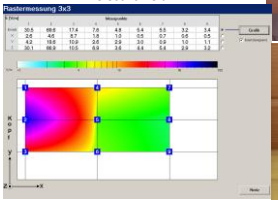
Patient – female – 32 years old

- After moving (2 years before):
  - insomnia
  - chronic fatigue
  - Sleeping pills

LF electric field



LF magn field

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Young man, 29 years old, single

- tinnitus

Measurements

- Office 0,80 V/m (2,4 GHz)
- Home 0,62 V/m (1,9 GHz)

After removal

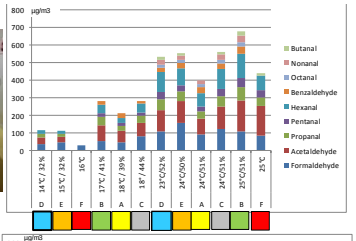
- both places < 0,02 V/m

WiFi hidden in false ceiling above head

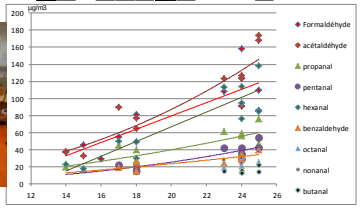
Neighbour´s cordless phone (DECT)

ICNIRP	**41-62 V/m**
Luxembourg GSM antennae	**3 V/m**
Bioinitiative	**0,6 V/m**

„emissions" from linoleum floors …



… dependent on temperature (oxydation of unsaturated fatty acids)



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High school secretary

- 4 employees
dizziness,
headaches,
allergies,
cutaneous exzema
40 000 -70 000 copies/week
26.000 in sampling period

Indoor dust contamination

Parameter	*Sample*	*Unit*	Concentration	O.v.	Factor
PM 10	*air*	*µg/m³*	51	40	1,3x
Nickel	*Dust*	*µg/g*	68	30	2,3x
Manganese	*dust*	*µg/g*	49500	940	53x

After separation wall	Factor
14 µg/g	5x
580 µg/g	85x

Comparison between dust and printer toner

spatial division by a partition wall

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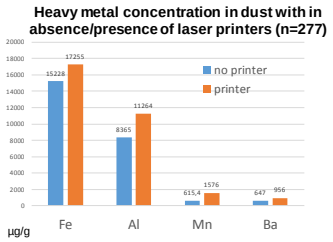
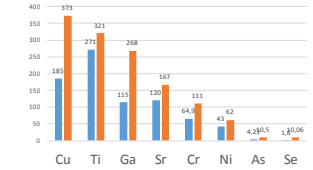
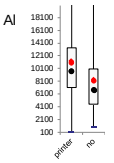


	increase	µg/g
Fe	13%	**17255**
Al	35%	**11264**
Ba	48%	**956**
Ti	18%	**321**
Sr	39%	**167**
Cr	70%	**111**
Ni	44%	**62**

Mn	x 2,56	**1576**
Cu	x 2	**373**
Ga	x 2,3	**268**





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Boy, 2 years old (2011/12)

- Respiratory troubles, coughing
- Nevrodermitis
- only at home, not in holydays

Dust analyzes at home

- TBEP 6,1 mg/kg (o.v. 40-100 mg/kg)
- **TCPP 33 mg/kg (o.v. 5-10 mg/kg)**

2015 during holydays

- Severe coughing in bed at night
- Vomiting
- Improved after changing bed

Mattress analyze at holidays

- **TCPP 8,9 mg/kg foam**

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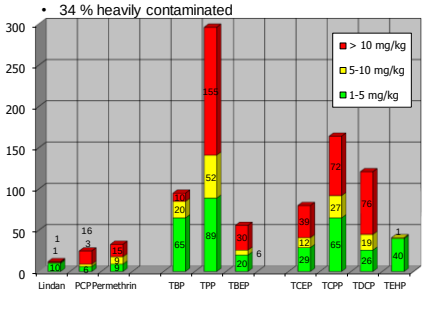
Contamination of mattresses & pillows (foam)

2004-2007 (n=905)

- 62 % of analysed mattresses & pillow contaminated (biocides, pyrethroids, flame retardants)
- 34 % heavily contaminated



Substance	Max. concentration
TBP	122 mg/kg
TPP	997 mg/kg
TBEP	6992 mg/kg
TCEP	7636 mg/kg
TCPP	29778 mg/kg
TDCP	41335 mg/kg
TEHP	7.7 mg/kg

Substance	Max. concentration
Chlorpyrifos	1.4 mg/kg
DDT	1.8 mg/kg
Dichlofluanide	3.8 mg/kg
Methoxychlor	1.3 mg/kg
Lindane	12 mg/kg
PCP	92 mg/kg
Chlorphenylid	332 mg/kg
Cyfluthrin	1.7 mg/kg
Cypermethrin	1.1 mg/kg
Tetramethrin	4.3 mg/kg
Permethrin	173 mg/kg
Piperonylbutoxide	541 mg/kg

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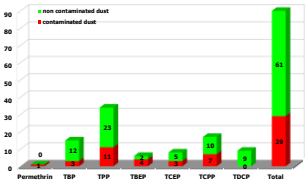
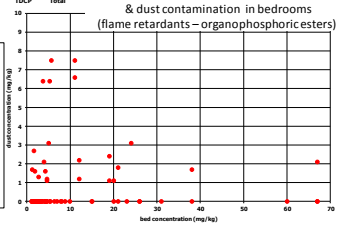
Dust contamination in bed chambers containing a contaminated mattress



Correlation between mattress contamination & dust contamination in bedrooms (flame retardants – organophosphoric esters)



LAT

FR & Bio in dust (n=147)

O.R: 5,08 (2,05-12,75)

FR & Bio in beddings & dust (n=54)

O.R: 12,8 (1,3-30,8)

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Cleaning products

- Eye irritation of teacher & children
- Teacher suffering from asthma (home clean)

Dust analysis

TBEP 4862 mg/kg

Material anlysis-TBEP

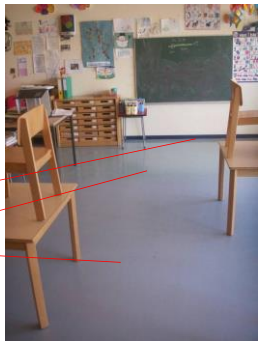
Linoleum behind baseboard 12 mg/kg

Linoleum shiny 663 mg/kg

Linoleum not shiny 79 mg/kg

Linoleum after stripping 85 mg/kg

Product analysis: TBEP-containing paint stripper



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building	room	symptoms	substance	conc.	unit	source
school	secrétary	asthma, exzema	TBEP	600	mg/kg dust	Wooden floor paint stripper
			glycolethers	186	µg/m3 air	Cleaning product
hospital	secrétary	Respiratory troubles, headaches	glycolethers	88	µg/m3 air	Cleaning product
			TBEP	144	mg/kg dust	?
administration	office	Repsiratory and nervous troubles	butoxyethanol	19	µg/m3 air	Cleaning product
			limonène	47	µg/m3 air	Cleaning product
			TBEP	1413	mg/kg dust	Cleaning product
school	classroom	different	glycolethers	110	µg/m3 air	Cleaning product
maison relais	office	asthma	limonène	52	µg/m3 air	Cleaning product
			TBEP	90	mg/kg dust	Cleaning product
administration	office	Respiratory troubles	TBEP	1406	mg/kg dust	Paint stripper lino
			glycolethers	440	µg/m3 air	Cleaning product
school	secrétary	exzema, respiratory troubles	glycolethers	28	µg/m3 air	Cleaning product
			lead		µg/g dust	painting
administration	office	different	TBEP	3577	mg/kg dust	Cleaning product
			limonène	26	µg/m3 air	Cleaning product
			glycolethers	26	µg/m3 air	Cleaning product
			acétaldéhyde	21	µg/m3 air	Cleaning product
finance	office	irritation of mucosa	glycolethers	64	µg/m3 air	Cleaning product
			limonène	6	µg/m3 air	Cleaning product
administration	office	odors, no symptoms	glycolethers	17	µg/m3 air	Cleaning product
			limonène	12	µg/m3 air	other

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	Total	Ground level	Roof truss
Affected people	10	6	4
Having symptoms	8	4	4

Mucous membrane irritation 8, headaches 4, respiratory problems 2

Office	TBEP	TCPP	HAP
"état civil"	170 mg/kg	<	73.2 mg/kg
"recette"	120 mg/kg	4.4 mg/kg	1.0 mg/kg
"population" & corridor	335 mg/kg	8.8 mg/kg	6.9 mg/kg

	Dust	before	after	*Orient. value*
Ground level	TBEP	170 mg/kg	28 mg/kg	*100 mg/kg*
Ground level	TCPP	8.8 mg/kg	2 mg/kg	*10 mg/kg*
Ground level	PAH	73 mg/kg	40 mg/kg	*50 mg/kg*
Roof truss	Dichlofluanide	-	< 1 mg/kg	*5 mg/kg*

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Reconstruction
Wood sealed with shielding foil
Additional heat insulation
Plasterboard & mineral painting
Visible wooden beams painted with special varnish « shelllack »
Costs: 69 830 €

Reconstruction

- Removal of parquett & floor screed
- Covering with PE foil
- Oiling of new solid parquett
- Internal wooden walls replaced by plasterboards
- Mineral painting
- Costs: 110 0000 €

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Dust samples
(7 day old dust)

Substance	DDT	TBEP	TCEP	Pb	Hg
dust	mg/g	mg/kg	mg/kg	µg/g	µg/g
Orient. value	*1*	*100*	*10*	*150*	*1*
Office 1	14	222	21	2257	3.4
Office 1	9,5	179	25	2530	1.8
Secretar. 1	7.3	537	27	1010	2.8
Office 2	1.7	567	4.6	428	2
Secretar. 2	3.9	89	33	957	2
Office 3	3,8	387	2.7	445	3
Office 4	2.4	353	4.1	474	2
Office 5	1.4	461	4.7	470	1
Office 6	3.2	29	< 1	719	6
Office 7	2.7	22	26	1450	1

aile 2		
cellar	7 µg/l	
ground floor	12 µg/l	kitchen
ground floor	27 µg/l	coffee machine
1st floor	15 µg/l	
2nd floor	39µg/l	kitchen
2nd floor	7 µg/l	
3rd floor	37 µg/l	
4th floor	31 µg/l	

Lead in drinking water analysis (stagnatic

external laboratory: air samples; all negative

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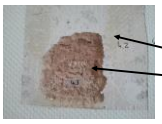

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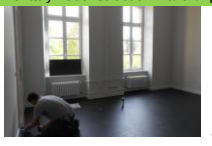
Reconstruction (Jan 2013)

Supplementary reconstruction March/April 2014



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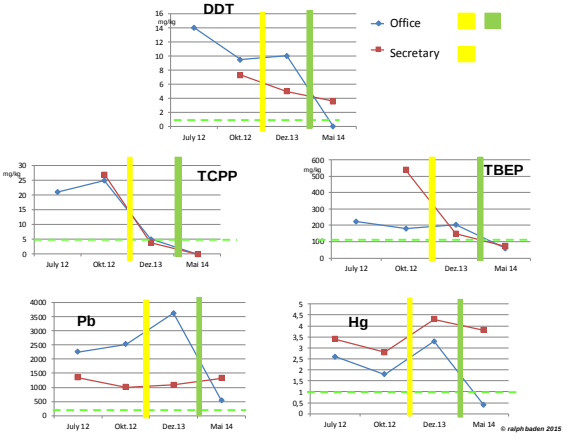

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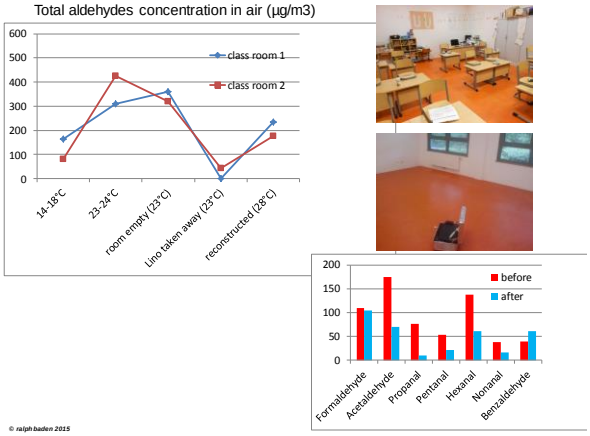

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Substance	Cen. téléphonique	Orientation value
Unit	µg/m³	µg/m³
benzene	26	5
toluene	434	100
ethylbenzene	21	5
xylenes	106	55
limonene	70	35
butoxyethanol	39	18
butoxypropanol	11	3
formaldehyde	88	25-60
acetaldehyde	47	70

Substance	Cen. télép.	Orientation value
Unit	mg/kg	mg/kg
TCEP	1,3	10
Benzylbutylphtalate	3,5	150
DEHP	111	1000
PAH	25,5	10-50

Substance	Centrale téléphonique	Orientation values
Unit	µg/g	µg/g
arsenic As	2,80	3 µg/g
lead Pb	19,1	150 µg/g
cadmium Cd	0,20	5 µg/g
chrome Cr	33,6	200 µg/g
nickel Ni	36,2	30 µg/g
mercury Hg	<0,2	1 µg/g
cobalt Co	2,80	5 µg/g
antimon Sb	0,70	3 µg/g

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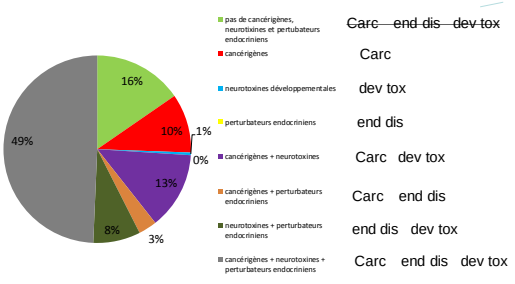
IARC: Class 1 human carcinogen; 2A probably carcinogenic; 2B potentially carcinogenic; unknown

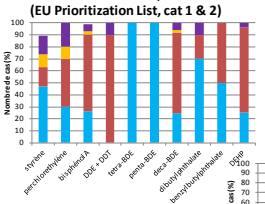
For 441 investigated workplaces (2009-2014)

- 18% without carcinogens (58% Class1 carcinogens – WHO/IARC list)
- 37% without endocrine disruptors (55% evident disruptors – EU priority list)
- 29% without developmental neurotoxins (63% substantial evidence – Mundy list (EPA)

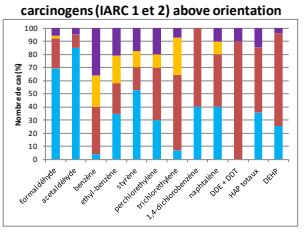


Concentrations above O.V. (n=441) at working places

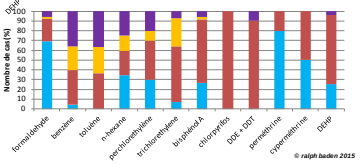
Endocrine disruptors (EU Prioritization List, cat 1 & 2)



carcinogens (IARC 1 et 2) above orientation



Developmental neurotoxins (Mundy-list, EPA, subst & min evidence)



Workshops
Shops,
Offices
Sensitive persons (schools, hospitals…)

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If you do not measure
you do not see a problem,
if you do not see a problem
you cannot take action
Sir Michael Marmott, english professor

Certified project ié

Substance	Typ	Probe	DSAT 1	A1	Richtwert Zert	Richtwert DSAT
Aromates	COV	Luft	7 µg/m³	5 µg/m³	*	**
Aliphates	COV	Luft	<	<	*	**
Terpenes	COV	Luft	<	2 µg/m³	*	**
Éthers de glycol	COV	Luft	traces	2 µg/m³	*	**
Hydroc. Halogenés	COV	Luft	<	<	*	**
Autres	COV	Luft	<	<	*	**
Formaldéhyde	Ald	Luft	13 µg/m³	5 µg/m³	60	25-60
autres Aldéhydes	Ald	Luft	<	3 µg/m³		**
HAP (16)		Staub	<	-	-	10
Bisphenol A	Bio	Staub	1,5 mg/kg	-	-	-
Propiconazol	Bio	Staub	8,0 mg/kg	-	-	1
TBEP	RF	Pouss	8,5 mg/kg	-	-	40
TCPP	RF	Pouss	1,9 mg/kg	-	-	5
BDE 209	RF	Pouss	48 mg/kg	-	-	1
Dibutylphtalate	Plas	Pouss	5,4 mg/kg	-	-	200
Benzylbutylphtalate	Plas	Pouss	9,3 mg/kg	-	-	150
DEHP	plas	pouss	19251 mg/kg	-	-	1000

* TVOC < 500 µg/m3

** limite pour chaque substance individuellement

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	orient val	Indoor air 15/02/2011	Indoor air 05/05/2011	Indoor air 15/02/2012	caoutch back	Concrete slab
styrene	12	23	12	<	20	**75**
trichlorethylene	1	201	8	15	3	**20**
formaldehyde	30	35	40	39	33	21
pentanal	7	17	<	<	32	**138**
hexanal	20	38	<	<	50	**567**
benzaldehyde	10	18	<	<	**73**	62

Trichlorethylene: degreasing the slab (concrete)

Pentanal: accelerating vulcanisation

Hexanal: oxydation process of insaturated oils (ecological glue)

Benzaldehyde: oxydation of toluene

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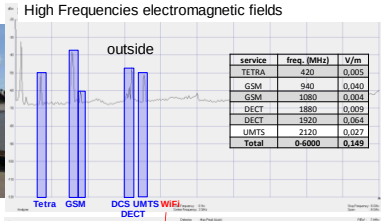
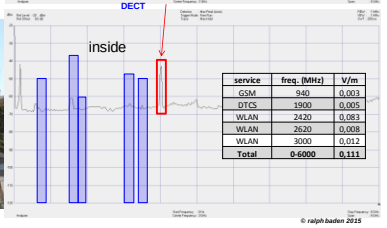
High Frequencies electromagnetic fields



service	freq. (MHz)	V/m
TETRA	420	0,005
GSM	940	0,040
GSM	1080	0,004
DECT	1880	0,009
DECT	1920	0,064
UMTS	2120	0,027
Total	**0-6000**	**0,149**



service	freq. (MHz)	V/m
GSM	940	0,003
DTCS	1900	0,005
WLAN	2420	0,083
WLAN	2620	0,008
WLAN	3000	0,012
Total	**0-6000**	**0,111**

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Wireless communication devices

Stdby 1,0 V/m
call 1,3 V/m

Stdby 2,2 V/m
call 2,2 V/m

Stdby 0,28 V/m
call 0,28 V/m

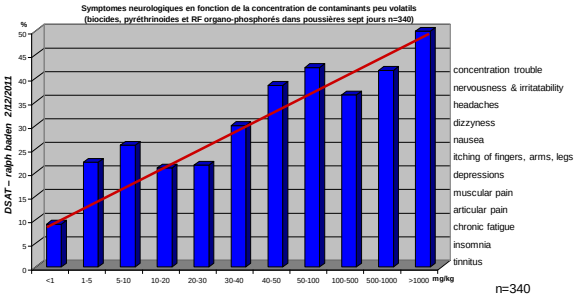
Stdby 4,2 V/m
call 9,0 V/m

Stdby 0,05 V/m
call 1,5 V/m

Stdby 0,09 V/m
call 0,16 V/m

ICNIRP	**41-62 V/m**
Luxembourg GSM antennae	**3 V/m**
Bioinitiative	**0,6 V/m**

Incidence of neurological symptoms related to growing concentrations of dust contamination (biocides, pyrethroids and organo-phosphorous flame retardants)



n=340

→ non specific health effects

at concentrations far under limits or guide values

multiple exposures

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