Information Needs in Green Chemistry & Chemicals Policy





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CENTER FOR OCCUPATIONAL 8 ENVIRONMENTAL HEALTH

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U.S. Chemical Production & Importation

74 billion lbs/day

206

- 80,000+ chemical substances, millions of products
- 3,000 High Production Volume chemicals
- ~1,000 new chemicals/year

TSCA Inventory Update Rule, 2005

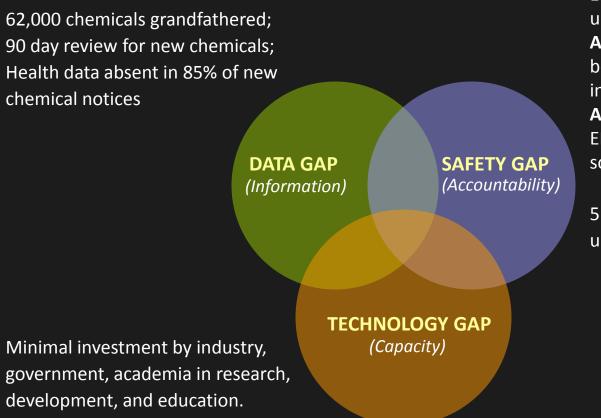
Federal Policy Governing Chemicals & Pollutants

•	Toxic Substances Control Act	83,000
-		
•	Clean Water Act (CWA)	148
•	Resource Conservation and Recovery Act	502
•	Clean Air Act (CAA)	189
•	Occupational Safety and Health Act	453
•	Emergency Planning and Community Right-to-Know (EPCRA): — Toxics Release Inventory (TRI)	600
	Total 1,134 (wit	th overlap

Durnbach. 1997. Harvard Law Review 21(1):1-57.



The Toxic Substances Control Act (TSCA) A Legacy of Three Policy Gaps



EPA must provide "substantial evidence" of unreasonable risk to health/environment, **AND**

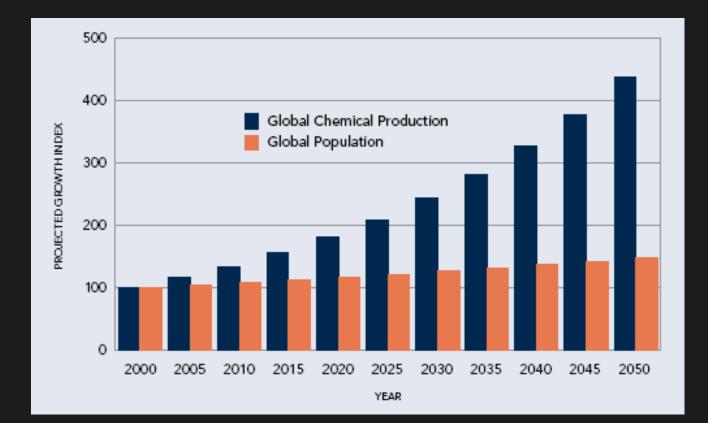
benefits of regulation outweigh cost to industry or lost social value of a product, **AND**

EPA has chosen the least burdensome solution.

5 chemicals/classes formally regulated under TSCA since 1976

Wilson and Schwarzman, Environmental Health Perspectives, 117:8, August, 2009.

Global Chemical Production Growing 3% per year Doubling every 25 years

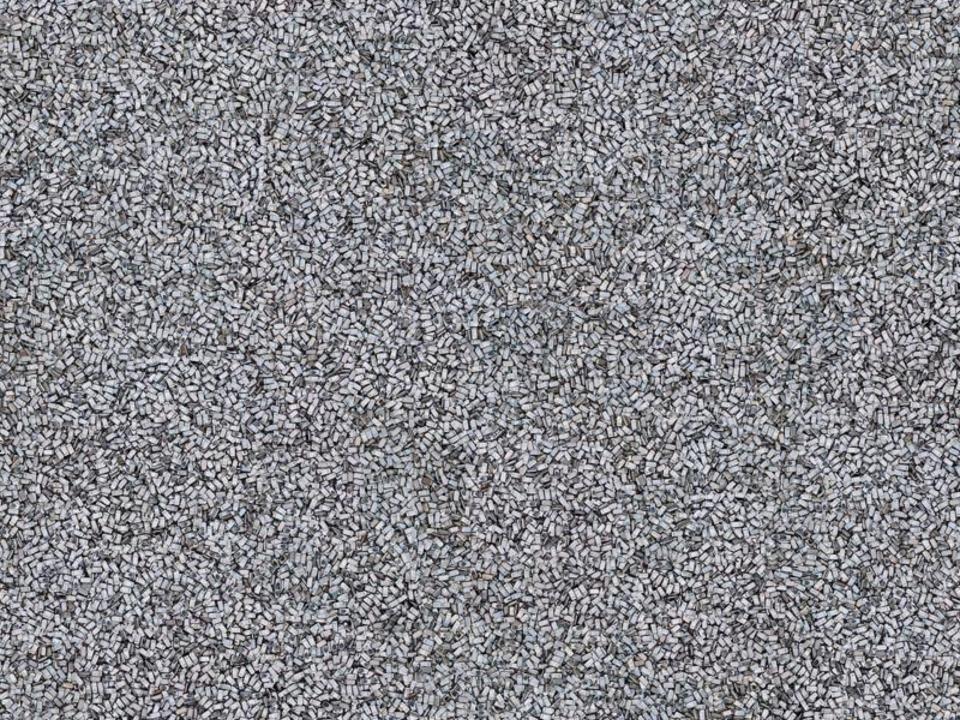


Hazardous waste



50% of substances at hazardous waste sites are carcinogens and/or teratogens 61 of 85 of CA largest hazardous waste sites leaking into groundwater. 94% of those pose "a major threat to human health or the environment." Cleaning up existing sites in California: 400 years at current rate. 600 new sites will be needed in the U.S. each month (US EPA)

it is the





426,000 cell phones retired each day in the U.S.



E-waste Recycling and Disposal: Africa and China





2009

Fourth National Report on Human Exposure to Environmental Chemicals



Acrylamide hemoglobin adducts * Glycidamide hemoglobin adducts

tal Ph one-3 (2-Hydroxy-4-methoxybenzophe phenol A (2,2-bis [4-Hydroxyphenyl] propane) * 4-tert-Octviphenol (4-[1,1,3,3-Tetramethylbutvi] phenol) * Triclosan (2,4,4'-Trichloro-2'-hydroxyphenyl ether) * Fungicides Pentachlorophenol ortho -Phenylphenol Herbicides Acetochlor mercapturat Alachior mercapturate Atrazine mercapturate 2,4-Dichlorophenoxyacetic acid Metolachlor mercapturate 2.4.5-Trichlorophenoxyacetic acid Carbofuranphenol sopropoxyphen Dieldrin indrin o,p'-Dichlorodiphenyltrichloroethane p,p'-Dichlorodiphenyldichloroethene (DDE) p,p'-Dichlorodiphenyltrichloroethane (DDT) Heptachlor epoxide Hexachlorobenzene beta -Hexachlorocyclohexane gamma -Hexachlorocyclohexane (Lindane) Mirex trans -Nonachlor Oxychlordane 2,4,5-Trichlorophenol 2,4,6-Trichlorophenol Organophosphorus Ins s: Dialkyl Phosphate Metabolites Diethyldithiophosphate (DEDTP) Diethylphosphate (DEP) Diethylthiophosphate (DETP) Dimethyldithiophosphate (DMDTP) Dimethylphosphate (DMP) nethylthiophosphate (DMTP) ganophosphorous Insecti -Chloro-7-hydroxy-4-methyl-2H-chromen-2-one/ol 2-(Diethylamino)-6-methylpyrimidin-4-ol/one 2-Isopropyl-4-methyl-6-hydroxypyrimidine Malathion dicarboxylic acid para -Nitrophenol

3.5,6-Tristietor-2-pyrdiad Pyrshinoid Pasticides dis-12,2-20Enrownyh-2,2-dimethylcyclopropane carboxylic acid dis-12,2-20Enrownyh-2,2-dimethylcyclopropane carboxylic acid trans-1-2,2-20Enrownyh-2,2-dimethylcyclopropane carboxylic acid 4-Fluoro-3-phenoxyhenzic acid 3-Phenoxyhenzic acid

Biomonitoring of Chemicals

CDC measured 212 substances in the 2003-04 NHANES cohort

Metals Antimony					
Antimony					
Arsenic, Total *					
Arsenic (V) acid *					
Arsenobetaine *					
Arsenocholine *					
Arsenous (III) acid	1*				
Dimethylarsinic ac	id *				
Monomethylarsoni					
Trimethylarsine ox					
Barium					
		Non-Dioxin-Like Polychlorinated Biphe	vis	Polycyclic Aromatic Hydrocarbons (PAHs)	
Beryllium		2,4,4'-Trichlorobiphenyl (PCB 28)		2-Hydroxyfluorene	
Cadmium					
Cesium		2,2',3,5'-Tetrachlorobiphenyl (PCB 44) *		3-Hydroxyfluorene	
Cobalt		2,2',4,5'-Tetrachlorobiphenyl (PCB 49) *		9-Hydroxyfluorene	
Lead		2,2',5,5'-Tetrachlorobiphenyl (PCB 52)		1-Hydroxynaphthalene (1-Naphthol)	
Mercury		2,3',4,4'-Tetrachlorobiphenyl (PCB 66)		2-Hydroxynaphthalene (2-Naphthol)	
Molybdenum		2,4,4',5-Tetrachlorobiphenyl (PCB 74)		1-Hydroxyphenanthrene	
Platinum		2,2',3,4,5'-Pentachlorobiphenyl (PCB 87)		2-Hydroxyphenanthrene	
Thallium		2,2',4,4',5-Pentachlorobiphenyl (PCB 99)		3-Hydroxyphenanthrene	
Tungsten		2,2',4,5,5'-Pentachlorobiphenyl (PCB 101)		4-Hydroxyphenanthrene	
Uranium		2,3,3',4',6-Pentachlorobiphenyl (PCB 110)	1	1-Hydroxypyrene	
		2,2',3,3',4,4'-Hexachlorobiphenyl (PCB 128)	1		
Perfluorochemicals			hand (DCD 100 0 100)	Distatestics Bu Bandusts (Telbalamathanas)	_
Perfluorobutane sulfo		2,2',3,4,4',5' and 2,3,3',4,4',6-Hexachlorobi	nenyi (PCB 138 & 158)	Disinfection By-Products (Trihalomethanes)	
		2,2',3,4',5,5'-Hexachlorobiphenyl (PCB 146)		Bromodichloromethane *	
Perfluorodecanoic acid		2,2',3,4',5',6-Hexachlorobiphenyl (PCB 149)	1	Dibromochloromethane (Chlorodibromomethane) *	
Perfluorododecanoic a		2,2',3,5,5',6-Hexachlorobiphenyl (PCB 151)	1	Tribromomethane (Bromoform) *	
Perfluoroheptanoic ac	id (PFHpA) *				
Perfluorohexane sulfo	onic acid (PFHxS) *	2,2',4,4',5,5',-Hexachlorobiphenyl (PCB 153		Trichloromethane (Chloroform) *	
Perfluorononanoic aci		2,2',3,3',4,4',5-Heptachlorobiphenyl (PCB 1			
Perfluorooctane sulfor		2,2',3,3',4,5,5'-Heptachlorobiphenyl (PCB 1	2)	Volatile Organic Compounds (VOCs)	
Perfluorooctane sulfor		2,2',3,3',4,5',6'-Heptachlorobiphenyl (PCB 1	77)	Benzene *	
		2,2',3,3',5,5',6-Heptachlorobiphenyl (PCB 1		Chlorobenzene (Monochlorobenzene) *	
	ctane sulfonamido) acetic acid (Et-PFO				
2-(N-Methyl-perfluoro	ooctane sulfonamido) acetic acid (Me-PI	2,2',3,4,4',5,5'-Heptachlorobiphenyl (PCB 1	0)	1,2-Dibromo-3-chloropropane (DBCP) *	
Perfluorooctanoic acid	1 (PFOA) *	2,2',3,4,4',5',6-Heptachlorobiphenyl (PCB 1	3)	Dibromomethane *	
Perfluoroundecanoic a	acid (PFUA) *	2,2',3,4',5,5',6-Heptachlorobiphenyl (PCB 1	7)	1,2-Dichlorobenzene (ortho-Dichlorobenzene) *	
		2,2',3,3',4,4',5,5'-Octachlorobiphenyl (PCB		1,3-Dichlorobenzene (meta -Dichlorobenzene) *	
Phthalates					
	()	2,2',3,3',4,4',5,6-Octachlorobiphenyl (PCB 1		1,4-Dichlorobenzene (para -Dichlorobenzene) *	
Mono-benzyl phthalat		2,2',3,3',4,4',5,6' and 2,2',3,4,4',5,5',6-Oct	chlorobiphenyl (PCB 196 & 203)	1,1-Dichloroethane *	
Mono-n-butyl phthala	te (MnBP)	2,2',3,3',4,5,5',6-Octachlorobiphenyl (PCB 1	99)	1,2-Dichloroethane (Ethylene dichloride) *	
Mono-(3-carboxyprop	oyl) phthalate (MCPP)	2,2',3,3',4,4',5,5',6-Nonachlorobiphenyl (PC	206)	1,1-Dichloroethene (Vinylidene chloride) *	
Mono-cyclohexyl phth		2,2',3,3',4,4',5,5',6,6'-Decachlorobiphenyl (cis -1,2-Dichloroethene *	
Mono-ethyl phthalate		2,2,3,3,4,4,5,3,0,0 *Decachiorobiphenyi (CB 209) -		
	ooxypentyl) phthalate (MECPP) *			trans -1,2-Dichloroethene *	
	roxyhexyl) phthalate (MEHHP)	Dioxin-Like Chemicals		Dichloromethane (Methylene chloride) *	
		Polychlorinated Dibenzo-p-dioxins		1,2-Dichloropropane *	
Mono-(2-ethyl-5-oxor	hexyl) phthalate (MEOHP)	1,2,3,4,6,7,8-Heptachlorodibenzo-p -dioxin	HoCDD)	2,5-Dimethylfuran (DMF) *	
Mono-2-ethylhexyl ph		1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin (Ho		Ethylbenzene *	
Mono-isobutyl phthala	ate (MiBP)				
Mono-isononyl phthal	late (MINP)	1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin (Ht		Hexachloroethane *	
Mono-methyl phthalal		1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin (H:		Methyl tert-butyl ether (MTBE) *	
Mono-n-octyl phthalat		1,2,3,4,6,7,8,9-Octachlorodibenzo-p -dioxin	(OCDD)	Nitrobenze *	
				Styrene *	
mono-in-occyr pritriala		1,2,3,7,8-Pentachlorodibenzo-p-dioxin (Pet			
		1,2,3,7,8-Pentachlorodibenzo-p-dioxin (Peo 2,3,7,8,-Tetrachlorodibenzo-p-dioxin (TCD)			
Phytoestrogens		2,3,7,8,-Tetrachlorodibenzo-p-dioxin (TCDI		1,1,2,2-Tetrachloroethane *	
Phytoestrogens Daidzein		2,3,7,8,-Tetrachlorodibenzo-p-dioxin (TCDI Polychlorinated Dibenzofurans)	1,1,2,2-Tetrachloroethane * Tetrachloroethene (Perchloroethylene) *	
Phytoestrogens Daidzein Enterodiol		2,3,7,8,-Tetrachlorodibenzo-p-dioxin (TCDI Polychlorinated Dibenzofurans 1,2,3,4,6,7,8-Heptachlorodibenzofuran (Hpi) DF)	1,1,2,2-Tetrachloroethane * Tetrachloroethene (Perchloroethylene) * Tetrachloromethane (Carbon tetrachloride) *	
Phytoestrogens Daidzein		2,3,7,8,-Tetrachlorodibenzo-p-dioxin (TCDI Polychlorinated Dibenzofurans) DF)	1,1,2,2-Tetrachloroethane * Tetrachloroethane (Perchloroethylene) * Tetrachloromethane (Carbon tetrachloride) * Toluene *	
Phytoestrogens Daidzein Enterodiol		2,3,7,8,-Tetrachlorodibenzo-p-dioxin (TCDI Polychlorinated Dibenzofurans 1,2,3,4,6,7,8-Heptachlorodibenzofuran (Hpi 1,2,3,4,7,8,9-Heptachlorodibenzofuran (Hpi) DF) DF)	1,1,2,2-Tetrachloroethane * Tetrachloroethane (Perchloroethylene) * Tetrachloromethane (Carbon tetrachloride) * Toluene *	
Phytoestrogens Daidzein Enterodiol Enterolactone Equol		2,3,7,8,-Tetrachlorodibenzo-p-dioxin (TCDU Polychlorinated Dibenzofurans 1,2,3,4,6,7,8-Heptachlorodibenzofuran (Hp 1,2,3,4,7,8,9-Heptachlorodibenzofuran (HxCDI 1,2,3,4,7,8-Hexachlorodibenzofuran (HxCDI) DF) DF))	1, 1, 2, 2-7 etrachicorethane * Tetrachicorethane (Perchicorethylene) * Tetrachicorethane (Carton tetrachioride) * Toluene * .1, 1, 1-7 richicorethane (Methyl chicorform) *	
Phytoestrogens Daidzein Enterodiol Enterolactone Equol Genistein		2,3,7,8,-Tetrachlorodibenzo-p-dioxin (TCDI Polychlorinated Dibenzofurans 1,2,3,4,6,7,8-Heptachlorodibenzofuran (Hpi 1,2,3,4,7,8,9-Heptachlorodibenzofuran (HxCDI 1,2,3,4,7,8-Hexachlorodibenzofuran (HxCDI 1,2,3,6,7,8-Hexachlorodibenzofuran (HxCDI) DF) DF))	1,1,2,3-7etrachlorotthane * Tetrachlorottene (Perchlorotthylee) * Tetrachloromethane (Carton tetrachloride) * Toluere * 1,1,1-7richloroethane (Methyl chloroform) * 1,1,2-7richlorothane *	
Phytoestrogens Daidzein Enterodiol Enterolactone Equol		2,3,7,8,-Tetrachlorodibenzo-p-dioxin (TCDI Polychlorinated Dibenzofurans 1,2,3,4,6,7,8-Heptachlorodibenzofuran (Hpi 1,2,3,4,7,8,9-Heptachlorodibenzofuran (HxCDI 1,2,3,6,7,8-Hexachlorodibenzofuran (HxCDI 1,2,3,6,7,8-Hexachlorodibenzofuran (HxCDI) DF) DF)))	1,1,2,2-retrachloroethane * Tetrachloroethane (Parchloroethylene) * Tetrachloromethane (Carbon tetrachloride) * Toluere * 1,1,1-rinkloroethane (Methyl chloroform) * 1,2,2-rinkloroethane (Trichloroethylene, TCE) *	
Phytoestrogens Daldzeln Enterodiol Enterolactone Equol Genistein O-Desmethylangolens	sin	2.3,7,8,7-tetrachlorodiltenzop-adoxin (TCDI Polychlorinated Dibenzofuran 1,2,3,4,6,7,9-Heptachlorodiltenzofuran (Hpi 1,2,3,4,7,9,9-Heptachlorodiltenzofuran (Hsi 1,2,3,4,7,8-Heachlorodiltenzofuran (Hsi 1,2,3,4,7,8-Heachlorodiltenzofuran (Hsi 1,2,3,4,5,7-8-Heachlorodiltenzofuran (Hsi 2,3,4,6,7-8-Heachlorodiltenzofuran (Hsi 1,2,3,4,6,7-8-Heachlorodiltenzofuran (Hsi 1,2,3,4,7,7-8-Heachlorodiltenzofuran (Hsi 1,2,3,4,7,7-8-Heachlorodiltenzofuran (Hsi 1,2,3,4,7,7-8-Heachlorodiltenzofuran (Hsi 1,2,3,4,7,7-8-Heachlorodiltenzofuran (Hsi 1,2,3,4,7,7-8-Heachlorodiltenzofuran (Hsi 1,2,3,4,7,7-8-Heachlorodiltenzofuran (Hsi 1,2,3,4,7,7-8-Heachlorodiltenzofuran (Hsi 1,2,3,4,7,7-8-Heachlorodiltenzofuran (Hsi 1) DF) DF))))	1,1,2,3-7etrachlorocthume * Tetrachlorocethume (Perchlorocethylene) * Tobures * 1,1,1-Trichloroethame (Vethyl dhord/orm) * 1,1,2-Trichloroethame (Trichlorocthylene, TCE) * meta - and para -Xylene *	
Phytoestrogens Daidzein Enterodiol Enterolactone Equol Genistein O-Desmethylangolens Brominated Fire Re	sin stardants	2,3,7,8,-Tetrachlorodibenzo-p-dioxin (TCDI Polychlorinated Dibenzofurans 1,2,3,4,6,7,8-Heptachlorodibenzofuran (Hpi 1,2,3,4,7,8,9-Heptachlorodibenzofuran (HxCDI 1,2,3,6,7,8-Hexachlorodibenzofuran (HxCDI 1,2,3,6,7,8-Hexachlorodibenzofuran (HxCDI) DF) DF))))	1,1,2,2-retrachloroethane * Tetrachloroethane (Parchloroethylene) * Tetrachloromethane (Carbon tetrachloride) * Toluere * 1,1,1-rinkloroethane (Methyl chloroform) * 1,2,2-rinkloroethane (Trichloroethylene, TCE) *	
Phytoestrogens Daidzein Enterodiol Enterodiol Equol Genistein O-Desmethylangolenr Brominated Fire Re 2,2;4-Tribromodipher	sin tardants ny ether (BDE 17) *	2,3,7,8,7-tetrachlorodiltenzo-p-dioxin (TCD) Polychol raised a Dilbenzofurans 12,3,4,6,7,8-Hegtachlorodiltenzofuran (Hs 1,2,3,4,7,8-Hestachlorodiltenzofuran (HsCD) 1,2,3,6,7,8-Hestachlorodiltenzofuran (HsCD) 1,2,3,6,7,8-Hestachlorodiltenzofuran (HsCD) 2,3,4,6,7,8-Hestachlorodiltenzofuran (HsCD) 2,3,4,6,7,8-Hestachlorodiltenzofuran (HsCD)) DF) DF))))	1,1,2,3-7etrachlorocthume * Tetrachlorocethume (Perchlorocethylene) * Tobures * 1,1,1-Trichloroethame (Vethyl dhord/orm) * 1,1,2-Trichloroethame (Trichlorocthylene, TCE) * meta - and para -Xylene *	
Phytoestrogens Daidzein Enterodiol Enterodiol Genistein O-Desmethylangolenr Brominated Fire Re 2,2',4-Tribromoliphe 2,4,4'-Tribromoliphe	sin tardants ný ether (DDE 17) * ný ether (DDE 28) *	2,3,7,8,-retrachlorodilbenzo-p-dioxin (TCD) Polychlorinated Dibenzofuran (Hp) 1,2,3,4,6,7,8)-Heptachlorodibenzofuran (Hp) 1,2,3,4,7,8)-Heptachlorodibenzofuran (Hz) 1,2,3,5,7,8-Hexachlorodibenzofuran (HxCD) 1,2,3,5,7,8-Hexachlorodibenzofuran (HxCD) 2,3,4,6,7,8-Hexachlorodibenzofuran (HxCD) 1,2,3,7,8-9-Hexachlorodibenzofuran (HxCD) 1,2,3,7,8-9-Hexachlorodibenzofuran (HxCD) 1,2,3,7,8-9-Hexachlorodibenzofuran (HxCD) 1,2,3,7,8-9-Hexachlorodibenzofuran (HxCD)) DF) DF))))	1,1,2,3-7etrachlorocthume * Tetrachlorocethume (Perchlorocethylene) * Tobures * 1,1,1-Trichloroethame (Vethyl dhord/orm) * 1,1,2-Trichloroethame (Trichlorocthylene, TCE) * meta - and para -Xylene *	
Phytoestrogens Daidzein Enterodiol Enterodiol Genistein O-Desmethylangolenr Brominated Fire Re 2,2',4-Tribromoliphe 2,4,4'-Tribromoliphe	sin tardants ny ether (BDE 17) *	2,3,7,8,7-Efrashteröllerszoy-elisini (TC) Phytholinitade Ditenzofurani C 12,3,4,6,7,8-Herachleroditerszofuran (Hig 1,2,3,4,7,8,9-Herachleroditerszofuran (His 1,2,3,4,7,8,9-Herachleroditerszofuran (His 1,2,3,4,7,8,9-Herachleroditerszofuran (His 2,3,4,7,8,9-Herachleroditerszofuran (His 2,3,4,7,8,9-Herachleroditerszofuran (His 1,2,3,4,7,8,9-Herachleroditerszofuran (His 1,2,3,4,7,8,9-Herachleroditerszofuran (His 2,3,4,7,8,9-Herachleroditerszofuran (His 2,3,4,7,8,9-His 2,3,4,7,8,9,7,8,9,7,8,9,7,8,9,7,8,9,7,8,9,7,8,9,7,8,9,7,8,9,7,8,9,7,8,9,7,8,9,7) DF) DF))))	1,1,2,3-7etrachlorocthume * Tetrachlorocethume (Perchlorocethylene) * Tobures * 1,1,1-Trichloroethame (Vethyl dhord/orm) * 1,1,2-Trichloroethame (Trichlorocthylene, TCE) * meta - and para -Xylene *	
Phytoestrogens Daidzein Enterodol Enterolactone Eguol Genistein O-Desmethylangolens Brominated Fire Re 2,2;4-Tribromodiphe 2,2;4-Tribromodiphe 2,2;4-Tribromodiphe	sin tardants ný ether (DDE 17) * ný ether (DDE 28) *	2,3,7,8,7-Ertrachlorodilenzoy – clickin (TCD) Polychol fratade Dibensofurna (12,3,4,6,7,8-Heigrachlorodibenzofurna (Hp) 1,3,3,4,7,8-Heigrachlorodibenzofurna (Hz) 1,3,3,4,7,8-Heigrachlorodibenzofurna (Hz) 1,3,3,4,6,7,8-Heidenzofurna (HzCD) 1,3,3,4,6,7,8-Heidenzofurna (HzCD) 1,3,3,4,6,7,8-Heidenzofurna (HzCD) 1,3,3,4,6,7,8-Polachlorodibenzofurna (HzCD) 1,3,3,7,8-Pertachlorodibenzofurna (HzCD) 2,3,4,7,8-Pertachlorodibenzofurna (HZD)) DF) DF))))	1,1,2,3-7etrachlorocthume * Tetrachlorocethume (Perchlorocethylene) * Tobures * 1,1,1-Trichloroethame (Vethyl dhord/orm) * 1,1,2-Trichloroethame (Trichlorocthylene, TCE) * meta - and para -Xylene *	
Phytoestrogens Datdzein Enterodiol Enterolactone Equol Genistein O-Desmethylangolen: 2,2:,4-Tribromodiphe 2,4:4-Tribromodiphe 2,2:,4:-Terbaromou	sin tardants ný ether (BDE 27) * ný ether (BDE 28) * Sjöhený dhere (BDE 66) *	2,3,7,8,7-Efrachtordiberzopdiskin (TCB) Phycholaritads Dibenzofuran (E 1),2,3,4,6,7,8-Herzachtordiberzofuran (His 1,2,3,4,7,8,8-Herzachtordiberzofuran (His 1,2,3,4,7,8-Herzachtordiberzofuran (His 1,2,3,4,7,8-Herzachtordiberzofuran (His 2,3,4,6,7,8-Herzachtordiberzofuran (His 1,2,3,7,8-Herzachtordiberzofuran (His 2,3,4,6,7,8-Herzachtordiberzofuran (His 1,2,3,7,8-Herzachtordiberzofuran (His 2,3,7,4,7,8-Herzachtordiberzofuran (His 2,3,7,8,7,8-Herzachtordiberzofuran (His 2,3,7,8,7,8-Herzachtordiberzofuran (His 2,3,7,8,7,8,7,8,7,8,7,8,7,8,7,8,7,8,7,8,7) DF) DF))))	1,1,2,3-7etrachlorocthume * Tetrachlorocethume (Perchlorocethylene) * Tobures * 1,1,1-Trichloroethame (Vethyl dhord/orm) * 1,1,2-Trichloroethame (Trichlorocthylene, TCE) * meta - and para -Xylene *	
Phytoestrogens Daidzein Exteroloio Exteroloio Genistein O-Desmethydangotem 2,2,4,4-Trithomodipie 2,3,4,4-Trithomodipie 2,3,4,4-Yentahormo 2,2,3,4,4-Pentahormo 2,2,3,4,4-Pentahormo 2,2,3,4,4-Pentahormo 2,2,3,4,4-Pentahormo	sin Handdante My ether (BDE 23) * My ether (BDE 23) * Sigheny ether (BDE 47) * Sigheny ether (BDE 66) * Modpheny ether (BDE 65) *	2,3,7,8,7-Ertrachlorodilenzoy – clickin (TCD) Polychol fratade Dibensofurna (12,3,4,6,7,8-Heigrachlorodibenzofurna (Hp) 1,3,3,4,7,8-Heigrachlorodibenzofurna (Hz) 1,3,3,4,7,8-Heigrachlorodibenzofurna (Hz) 1,3,3,4,6,7,8-Heidenzofurna (HzCD) 1,3,3,4,6,7,8-Heidenzofurna (HzCD) 1,3,3,4,6,7,8-Heidenzofurna (HzCD) 1,3,3,4,6,7,8-Polachlorodibenzofurna (HzCD) 1,3,3,7,8-Pertachlorodibenzofurna (HzCD) 2,3,4,7,8-Pertachlorodibenzofurna (HZD)) DF) DF))))	1,1,2,3-7etrachlorocthume * Tetrachlorocethume (Perchlorocethylene) * Tobures * 1,1,1-Trichloroethame (Vethyl dhord/orm) * 1,1,2-Trichloroethame (Trichlorocthylene, TCE) * meta - and para -Xylene *	
Phytoestrogens Daldzein Enterolial Enterolial Enterolial Genistein D-Desmethylangdein 2, 4, 4, 47 Fernahomo 2, 7, 4, 4, 47 Fernahomo 2, 7, 4, 4, 47 Fernahomo 2, 7, 4, 4, 5 Fernahomo	sin ný elber (BOE 17) * ný elber (BOE 28) * ný elber (BOE 28) * nódpheny elber (BOE 66) * nódpheny elber (BOE 69) *	2,3,7,8,7-Ertrachlorodilenzoy – dison (TCD) Polychol fratade Dibensofurna (1,2,3,4,6,7,8-Heigrachlorodibenzofurna (Hp) 1,2,3,4,7,8,7-Heigrachlorodibenzofurna (Hz) 1,2,3,4,7,8,7-Heigrachlorodibenzofurna (HzO) 1,2,3,7,8,7-Heidrachlorodibenzofurna (HzO) 1,2,3,4,6,7,8-Hockachlorodibenzofurna (HzO) 1,2,3,4,6,7,8-Polachlorodibenzofurna (HzO) 1,2,3,4,6,7,8-Polachlorodibenzofurna (HzO) 2,3,4,7,8-Pentachlorodibenzofurna (HZO) 2,3,4,4,7-Setachlorodibenzofurna (HZO) 2,3,4,4,7-Setachlorodibenzofurna (HZO) 2,3,4,4,7-Setachlorodibenzofurna (HZO) 2,3,4,4,7-Setachlorodibenzofurna (HZO) 2,3,4,4,7-Setachlorodibenzofurna (HZO) 2,3,4,4,7-Setachlorodibenzofurna (HZO) 2,3,4,4,5-Setachlorodibenzofurna (HZO) 2,3,4,5-Setachlorodibenzofurna (HZO) 2,3,4,5-Setachlorodi) DF) DF))))	1,1,2,3-7etrachlorocthume * Tetrachlorocethume (Perchlorocethylene) * Tobures * 1,1,1-Trichloroethame (Vethyl dhord/orm) * 1,1,2-Trichloroethame (Trichlorocthylene, TCE) * meta - and para -Xylene *	
Phytoestrogens Dadzein Enterolai Enterolai Genistein O-Deamstrukagioen 2,2,4,4-7 Tritemondiphe 2,2,4,4-4 Fentakromo 2,2,3,4,4 -4 Fentakromo 2,2,3,4,4 -4 Fentakromo 2,2,3,4,4 -6 Fentakromo 2,2,3,4,4 -6 Fentakromo 2,2,3,4,4 -6 Fentakromo 2,2,3,4,4 -6 Fentakromo 2,2,3,4,4 -6 Fentakromo 2,2,3,4,4 -6 Fentakromo	sin Atardanter m/ ether (EDE 17) * m/ ether (EDE 73) * Sigheny ether (EDE 47) * Sigheny ether (EDE 66) * nodpheny ether (EDE 65) * nodpheny ether (EDE 50) *	2,3,7,6,7-Ertexhordbetxop-dison 7CO 2,9,7,6,7-Ertexhordbetxop-dison 7CO 2,3,4,6,7,8-Hetpschlorodbetxofurn (Hp 1,2,3,4,7,8)-Hetpschlorodbetxofurn (Hz 1,2,3,4,7,8)-Hetpschlorodbetxofurn (Hz 1,2,3,4,7,8)-Hetpschlorodbetxofurn (Hz 1,2,3,4,7,8)-Hetpschlorodbetxofurn (Hz 1,2,3,4,7,8)-Hetpschlorodbetxofurn (Hz 1,2,3,4,7,8)-Pettschlorodbetxofurn (Hz 1,2,3,4,7,8)-Pettschlorodbetxofurn (Hz 2,3,4,7,8)-Pettschlorodbetxofurn (Hz 2,3,4,7,8)-Pettschlorodbetxofurn (Hz 3,4,4,7)-Fettschlorodbetxofurn (HZ 3,4,4,7)-Fetts) DF) DF))))	1,1,2,3-7etrachlorocthume * Tetrachlorocethume (Perchlorocethylene) * Tobures * 1,1,1-Trichloroethame (Vethyl dhord/orm) * 1,1,2-Trichloroethame (Trichlorocthylene, TCE) * meta - and para -Xylene *	
Phytoestrogens Daldzein Enterolal Enterolal Enterolad Genistein O-Desmeth/angelen 2,4,4-Thermodiphe 2,4,4-Thermodiphe 2,4,4-Therharmono 2,7,4,4-Fentahormo 2,7,4,4-Fentahormo 2,7,4,4-Fentahormo 2,7,4,4-Fentahormo 2,7,4,4-Fentahormo 2,7,4,4-Fentahormo 2,7,4,4-Fentahormo 2,7,4,4-Fentahormo 2,7,4,4-Fentahormo 2,7,4,4-Fentahormo	sin my ether (BDE 17) * my ether (BDE 17) * my ether (BDE 17) * modpheny ether (BDE 19) * modpheny ether (BDE 19) * modpheny ether (BDE 153) *	2,3,7,8,7-Ertrachlorodilexcop-elicin (TCD) Polychol frastadc Dibensofurnas 1,2,3,4,6,7,8-Heigrachlorodibenzofurna (Hp) 1,2,3,4,7,8,7-Heigrachlorodibenzofurna (Hp) 1,2,3,4,7,8,7-Heigrachlorodibenzofurna (HcD) 1,2,3,4,6,7,8-Heidenklorodibenzofurna (HcD) 1,2,3,4,6,7,8-Heidenklorodibenzofurna (HcD) 1,2,3,4,6,7,8-Polachlorodibenzofurna (HcD) 2,3,4,6,7,8-Polachlorodibenzofurna (HcD) 2,3,4,7,8-Pentachlorodibenzofurna (HcD) 2,3,4,4,7-Settachlorodibenzofurna (HcD) 2,3,4,4,7-Settachlorodibenzofurna (HcD) 3,4,4,7-Settachlorodibenzofurna (HcD) 3,3,4,4,5-Settachlorobipheny (HcB 81) 3,3,4,4,5-Settachlorobipheny (HcB 16)) DF))))))))))))))	1,1,2,3-7etrachlorocthume * Tetrachlorocethume (Perchlorocethylene) * Tobures * 1,1,1-Trichloroethame (Vethyl dhord/orm) * 1,1,2-Trichloroethame (Trichlorocthylene, TCE) * meta - and para -Xylene *	
Phytosetrogens Daldzein Enterolal Enterolal Estudio Genistein D-Demethylangolen D-Demethylangolen D-Demethylangolen D-Zr, 44, 4-Fenathorno 2, 27, 44, 4-Fenathorno 2, 27, 44, 4-Fenathorno 2, 27, 44, 5-Fenathorno 2, 27, 44, 5-Fenathorno 2, 27, 44, 5-Fenathorno 2, 27, 44, 5-Fenathorno 2, 27, 44, 5-Fenathorno	tin tandmitti ing ether (BDE 20) * ing ether (BDE 20) * Sigheny ether (BDE 60) * sigheny ether (BDE 60) * modpheny ether (BDE 50) * modpheny ether (BDE 100) * smodpheny ether (BDE 154) *	2,3,7,6,7-Effectiveloidiescop-elicini (TCC) Phylichiofrated Dilenzofurani 1,2,3,4,6,7,8-Heigachiordibescofuran (Hp 2,3,4,7,8,7,8-Heigachiordibescofuran (Hp 2,3,4,7,8,7,8-Heigachiordibescofurani (Hc 2,3,7,8,7,8-Heigachiordibescofurani (Hc 2,3,7,8,7,8,7,8))) (H) (H) (H) (H) (H) (H) (H) (H) (H)) DF))))))))))))))	1,1,2,3-7etrachlorocthume * Tetrachlorocethume (Perchlorocethylene) * Tobures * 1,1,1-Trichloroethame (Vethyl dhord/orm) * 1,1,2-Trichloroethame (Trichlorocthylene, TCE) * meta - and para -Xylene *	
Phytosetrogens Daldzein Enterolal Enterolal Estudio Genistein D-Demethylangolen D-Demethylangolen D-Demethylangolen D-Zr, 44, 4-Fenathorno 2, 27, 44, 4-Fenathorno 2, 27, 44, 4-Fenathorno 2, 27, 44, 5-Fenathorno 2, 27, 44, 5-Fenathorno 2, 27, 44, 5-Fenathorno 2, 27, 44, 5-Fenathorno 2, 27, 44, 5-Fenathorno	tin tandmitti ing ether (BDE 20) * ing ether (BDE 20) * Sigheny ether (BDE 60) * sigheny ether (BDE 60) * modpheny ether (BDE 50) * modpheny ether (BDE 100) * smodpheny ether (BDE 154) *	2,3,7,8,7-Ertrachlorodilexcop-action (TCO) Polychol frastadc Dibensofurna (1,2,3,4,6,7,8-Heigrachlorodibenzofurna (Hp 1,2,3,4,7,8,7-Heigrachlorodibenzofurna (Hz 1,2,3,4,7,8,7-Heigrachlorodibenzofurna (Hz 1,2,3,4,6,7,8-Heidenklorodibenzofurna (Hz 1,2,3,4,6,7,8-Heidenklorodibenzofurna (Hz 1,2,3,4,6,7,8-Polachlorodibenzofurna (Hz 1,2,3,7,8-Frastachlorodibenzofurna (Hz 2,3,4,6,7,8-Polachlorodibenzofurna (Hz 2,3,4,6,7,8-Polachlorodibenzofurna (Hz 2,3,4,7,8-Pentachlorodibenzofurna (Hz 2,3,4,4,7-Sertachlorodibenzofurna (Hz 2,3,4,4,7-Sertachlorodibenzofurna (Hz 3),3,4,4,5-Fertachlorobipheny (Hz B 13) 3,3,4,4,5-Fertachlorobipheny (Hz B 13)) DF))))))))))))))	1,1,2,3-7etrachlorocthume * Tetrachlorocethume (Perchlorocethylene) * Tobures * 1,1,1-Trichloroethame (Vethyl dhord/orm) * 1,1,2-Trichloroethame (Trichlorocthylene, TCE) * meta - and para -Xylene *	
Phytosetrogens Daldzein Enterolat Enterolat Growinski (1996) Growinski (1997) Commission (1997) Commis	sin tandants my ether (BDE 27) * my ether (BDE 28) * Sighewi dher (IDE 47) * Sighewi dher (IDE 46) * sindphery ether (IDE 53) * modphery ether (IDE 153) * sindphery ether (IDE 153) * sindphery ether (IDE 153) * sindphery ether (IDE 153) *	2,3,7,6,7-Effectiveloidiescop-elicini (TCC) Phylichiofrated Dilenzofurani 1,2,3,4,6,7,8-Heigachiordibescofuran (Hp 2,3,4,7,8,7,8-Heigachiordibescofuran (Hp 2,3,4,7,8,7,8-Heigachiordibescofurani (Hc 2,3,7,8,7,8-Heigachiordibescofurani (Hc 2,3,7,8,7,8,7,8))) (H) (H) (H) (H) (H) (H) (H) (H) (H)) DF))))))))))))))	1,1,2,3-7etrachlorocthume * Tetrachlorocethume (Perchlorocethylene) * Tobures * 1,1,1-Trichloroethame (Vethyl dhord/orm) * 1,1,2-Trichloroethame (Trichlorocthylene, TCE) * meta - and para -Xylene *	
Phytosetrogens Daldzein Enterolat Enterolat Growinski (1996) Growinski (1997) Commission (1997) Commis	tin tandmitti ing ether (BDE 20) * ing ether (BDE 20) * Sigheny ether (BDE 60) * sigheny ether (BDE 60) * modpheny ether (BDE 50) * modpheny ether (BDE 100) * smodpheny ether (BDE 154) *	2,3,7,6,7-EffectiveNordBetwarp-wickin (TCS) Phylochortastac Dilenzordrinan 1,2,3,4,6,7,8-Heigachiorodbetwarburn (Hp 1,2,3,4,7,8)-Heigachiorodbetwarburn (Hc 1,2,3,4,7,8)-Heigachiorodbetwarburn (Hc 1,2,3,4,6,7,8)-Heigachiorodbetwarburn (Hc 1,2,3,4,6,7,8)-Heigachiorodbetwarburn (Hc 1,2,3,4,6,7,8)-Heigachiorodbetwarburn (Hc 1,2,3,4,6,7,8)-Heigachiorodbetwarburn (Hc 1,2,3,4,6,7,8)-Heigachiorodbetwarburn (Hc 1,2,3,4,6,7,8)-Heigachiorodbetwarburn (Hc 1,2,3,4,6,7,8)-Heigachiorodbetwarburn (Hc 2,3,4,6,7,8)-Fortachiorodbetwarburn (Hc 2,3,4,7,8)-Fortachiorodbetwarburn (Hc 2,3,4,4,7)-Fortachiorodbetwarburn (Hc 2,3,4,4,4)-Fortachiorobjetwary (Hc 1,2,3,4,4)-Fortachiorobjetwary (Hc 1,2,3,4)-Fortachiorobjetwary (Hc 1,2,3,4)-Fortachiorobjetwarbarbarbarbarbarbarbarbarbarbarbarbarba) DF))))))))))))))	1,1,2,3-7etrachlorocthume * Tetrachlorocethume (Perchlorocethylene) * Tobures * 1,1,1-Trichloroethame (Vethyl dhord/orm) * 1,1,2-Trichloroethame (Trichlorocthylene, TCE) * meta - and para -Xylene *	
Phytosetrogens Daldzein Enterolat Enterolat Growinski (1996) Growinski (1997) Commission (1997) Commis	sin tandants my ether (BDE 27) * my ether (BDE 28) * Sighewi dher (IDE 47) * Sighewi dher (IDE 46) * sindphery ether (IDE 53) * modphery ether (IDE 153) * sindphery ether (IDE 153) * sindphery ether (IDE 153) * sindphery ether (IDE 153) *	2,3,7,4,7-Ertrachtoroliteruozy-action (TCC) Polychol frastadz Olitenzofurana 1,2,3,4,6,7,8-Heiszahloroditeruofuran (Hp 1,2,3,4,7,8,7-Heiszahloroditeruofuran (Hz 1,2,3,4,7,8,7-Heiszahloroditeruofuran (Hz 1,2,3,4,6,7,8-Heiszahloroditeruofuran (Hz 1,2,3,4,6,7,8,8-Hostahloroditeruofuran (Hz 1,2,3,7,8,7-Bentachtoroditeruofuran (Hz 2,3,4,6,7,8-Pentachtoroditeruofuran (Hz 2,3,4,6,7,8-Pentachtoroditeruofuran (Hz 2,3,4,7,8-Pentachtoroditeruofuran (Hz 2,3,4,4,7-Sertachtoroditeruofuran (HZ 2,3,4,4,7-Sertachtoroditeruofuran (HZ 1,3,3,4,4,7-Sertachtorobiteruof (HZ 1,3,3,4,4,7-Sertachtorobiteruof (HZ 1,3),4,4,5-Fertachtorobiteruof (HZ 1,5),5,4,4,5-Fertachtorobiteruof (HZ 1,5),5,4,5,5,4,5,4,5,4,5,4,5,4,5,4,5,4,5,) DF))))))))))))))	1,1,2,3-7etrachlorocthume * Tetrachlorocethume (Perchlorocethylene) * Tobures * 1,1,1-Trichloroethame (Vethyl dhord/orm) * 1,1,2-Trichloroethame (Trichlorocthylene, TCE) * meta - and para -Xylene *	
Phytosetrogens Daldzein Enterolat Enterolat Growinski (1996) Growinski (1997) Commission (1997) Commis	sin tandants my ether (BDE 27) * my ether (BDE 28) * Sighewi dher (IDE 47) * Sighewi dher (IDE 46) * sindphery ether (IDE 53) * modphery ether (IDE 153) * sindphery ether (IDE 153) * sindphery ether (IDE 153) * sindphery ether (IDE 153) *	2,3,7,6,7-Ertexholodiexxop-elixin (TCD) Phylokofratade Olibenzofurani 1,2,3,4,6,7,8-Heigachiorodiexxofurani (Hp. 2,3,4,7,8,7-8-Heigachiorodiexxofurani (Hp. 2,3,4,7,8,7-8-Heigachiorodiexxofurani (HcD) 2,3,7,4,6,7,8-Heigachiorodiexxofurani (HcD) 2,3,7,4,6,7,8-Heigachiorodiexxofurani (HcD) 2,3,7,4,6,7,8-Heigachiorodiexxofurani (HcD) 2,3,7,4,6,7,8-Heigachiorodiexxofurani (HcD) 2,3,7,4,6,7,8-Heigachiorodiexxofurani (HcD) 2,3,7,4,6,7,8-Heigachiorodiexxofurani (HcD) 2,3,7,4,6,7,8-Heigachiorodiexxofurani (HcD) 2,3,7,4,6,7,8-Heigachiorodiexxofurani (HcD) 2,3,7,4,7,5-Heigachiorodiexxofurani (HcD) 2,3,7,4,4,7,5-Heigachiorodiexxofurani (HcD) 2,3,7,4,4,7,5-Heigachiorodiexxofurani (HcD) 2,3,7,4,4,7-5-Heigachiorodiexy04104 2,3,7,4,4,7-Heigachiorodiexy04104 2,3,7,4,7-Heigachiorodiexy04104 2,3,7,4,7-Heigachiorodiexy04104 2,3,7,4,7-Heigachiorodiexy04104 2,3,7,4,7-Heigachiorodiexy04104 2,3,7,4,7-Heigachiorodiexy04104 2,3,7,4,7-Heigachiorodiexy04104 2,3,7,4,7-Heigachiorodiexy04104 2,3,7,4,7-Heigachiorodiexy04104 2,3,7,4,7-Heigachiorodiexy04104 2,3,7,4,7-Heigachiorodiexy04104 2,3,7,4,7-Heigachiorodiexy04104 2,3,7,4,7-Heigachiorodiexy04104 2,3,7,4,7-Heigachiorodiexy04104 2,3,7,4,7-Heigachiorodiexy04104 2,3,7,4,7-Heigachiorodiexy04104 2,3,7,4,7-Heigachiorodiexy04104 2,3,7,4,7-Heigachiorodiexy04104 2,) DF))))))))))))))	1,1,2,3-7etrachlorocthume * Tetrachlorocethume (Perchlorocethylene) * Tobures * 1,1,1-Trichloroethame (Vethyl dhord/orm) * 1,1,2-Trichloroethame (Trichlorocthylene, TCE) * meta - and para -Xylene *	
Phytosetrogens Daldzein Enterolat Enterolat Growinski (1996) Growinski (1997) Commission (1997) Commis	sin tandants my ether (BDE 27) * my ether (BDE 28) * Sighewi dher (IDE 47) * Sighewi dher (IDE 46) * sindphery ether (IDE 53) * modphery ether (IDE 153) * sindphery ether (IDE 153) * sindphery ether (IDE 153) * sindphery ether (IDE 153) *	2,3,7,4,7-Ertrachtoroliteruozy-action (TCC) Polychol frastadz Olitenzofurana 1,2,3,4,6,7,8-Heiszahloroditeruofuran (Hp 1,2,3,4,7,8,7-Heiszahloroditeruofuran (Hz 1,2,3,4,7,8,7-Heiszahloroditeruofuran (Hz 1,2,3,4,6,7,8-Heiszahloroditeruofuran (Hz 1,2,3,4,6,7,8,8-Hostahloroditeruofuran (Hz 1,2,3,7,8,7-Bentachtoroditeruofuran (Hz 2,3,4,6,7,8-Pentachtoroditeruofuran (Hz 2,3,4,6,7,8-Pentachtoroditeruofuran (Hz 2,3,4,7,8-Pentachtoroditeruofuran (Hz 2,3,4,4,7-Sertachtoroditeruofuran (HZ 2,3,4,4,7-Sertachtoroditeruofuran (HZ 1,3,3,4,4,7-Sertachtorobiteruof (HZ 1,3,3,4,4,7-Sertachtorobiteruof (HZ 1,3),4,4,5-Fertachtorobiteruof (HZ 1,5),5,4,4,5-Fertachtorobiteruof (HZ 1,5),5,4,5,5,4,5,4,5,4,5,4,5,4,5,4,5,4,5,) DF))))))))))))))))))	1,1,2,3-7etrachlorocthume * Tetrachlorocethume (Perchlorocethylene) * Tobures * 1,1,1-Trichloroethame (Vethyl dhord/orm) * 1,1,2-Trichloroethame (Trichlorocthylene, TCE) * meta - and para -Xylene *	

CDC, Fourth National Report on Human Exposure to Environmental Chemicals, 2009

Biomonitoring of Chemicals & Pollutants: Umbilical Cord Blood and Breast Milk

BodyBurden The Pollution in Newborns

A benchmark investigation of industrial chemicals, pollutants, and pesticides in human umbilical cord blood

> Mercury PCBs Flame retardants Solvents Stain repellants Dioxins and furans Organochlorine pesticides...



JANE HOULIHAN TIMOTHY KROPP, PH.D. RICHARD WILES SEAN GRAY CHRIS CAMPBELL

JULY 14, 2005

PBDE Levels in Breast Milk, Sweden

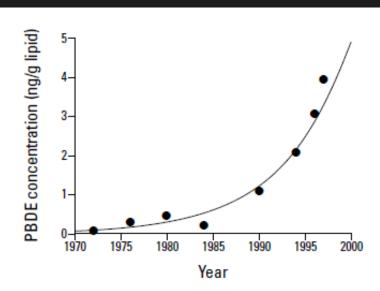


Figure 5. Time trend of the sum concentrations of 8 PBDE congeners in pooled mother's milk samples from Swedish mothers living in the Stockholm region. Data from Norén and Meironyté (*51*).

Darnerud et al. Environ Health Persp, 107 (supp1), March, 2001.

Prevention Through Green Chemistry?



The design of chemical products and processes that are safer for health and ecosystems.

- 1. Make safer products
- 2. Use less-toxic feedstocks and processes
- 3. Design for cradle-to-cradle use
- 4. Account for energy efficiency



Anastas, P.T. and J. Warner. 1999. Green Chemistry Theory and Practice

European Union Affecting Global Change

- **REACH:** Registration, Evaluation, Authorization, and Restriction of Chemicals (2007)
- Requires registration of all chemicals sold in EU > 1 ton/yr/producer
- Increasing data requirements based on volume in commerce
- Designates some chemicals as Substances of Very High Concern (SVHCs)
- Can require use-by use authorization for a subset of SVHCs
- Establishes "no data, no market" paradigm
- Shifts burden of proof of safety to manufacturers for chemicals of highest concern

35 Chemicals Bills in California, 2005-2006

AB 121 (Vargas) **AB 263 (Chan) AB 289 (Chan) AB 319 (Chan) AB 342 (Baca)** AB 597 (Montanez) AB 623 (Aanistad) AB 639 (Aghazarian) AB 752 (Karnette) AB 815 (Lieber) AB 816 (Lieber) AB 848 (Berg)

AB 908 (Chu) AB 912 (Ridley-Thomas) AB 966 (Saldana) **AB 985 (Dunn)** AB 990 (Lieber) AB 1125 (Pavley) AB 1337 (Ruskin) AB 1342 (Assem ESTM) AB 1344 (Assem ESTM) AB 1354 (Baca) AB 1415 (Pavley) AB 1681 (Pavley)

SB 419 (Simitian) SB 432 (Simitian) SB 432 (Migden) SB 490 (Lowenthal) SB 600 (Ortiz) SB 838 (Escutia) SB 849 (Escutia) SB 982 (Sen EQ comm) SB 989 (Sen EQ comm.) SB 1067 (Kehoe) SB 1070 (Kehoe)

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New Chemicals Policy in the U.S.



Federal Toxic Substances Control Act reform

- House and Senate versions, 2010
- Will require chemical testing



California EPA Green Chemistry Initiative

- Ingredient Disclosure (SB 928 pending)
- Create an Online Toxics Clearinghouse (SB 509)
- Accelerate the Quest for Safer Products (AB 1879)



New Chemicals Policy in California

Accelerate the Quest for Safer alternatives

Systematic process for:

- Evaluating chemicals of concern in consumer products
- Identifying safer alternatives
- Stimulating investment in CA's product development sector
- 1. Generate list of Chemicals of Concern (CoC)
- 2. Identify products containing CoCs
- 3. Create a list of Priority Products based on exposure potential
- 4. Perform an alternatives analysis (AA) using a lifecycle approach
- 5. Complete requirements of a regulatory response



Breast Cancer & Chemicals Policy Project



Science Policy Identify decision-making tools and data needs to inform implementation of new chemicals policy.



Toxicity Testing

Identify currently available testing methods for detecting chemicals that may raise the risk of breast cancer; identify emerging test methods that could be adapted for rapid chemical screens.

Breast Cancer **Policy Project**

Cancer Biology Identify known and suspected events in biological pathways that may raise the risk of breast cancer.





Breast Cancer & Chemicals Policy Project



Core Question

As new chemicals policies develop toxicity testing requirements, what body of toxicity data obtained using *existing methods*— could best identify chemicals that may increase the risk of breast cancer?



Breast Cancer & Chemicals Policy Project Goals



- **1. Develop an approach for identifying chemicals** that may contribute to the development or progression of breast cancer;
- 2. Identify research needs and recommend improvements to existing test methods; and
- **3. Pilot a model process** that can be applied to other disease endpoints, enabling the ultimate aim of producing a comprehensive approach for identifying hazardous chemicals.



Expert Panel



- Susan Braun, MA Commonweal
- Vincent James Cogliano, PhD WHO International Agency for Research on Cancer
- Shanaz Dairkee *, PhD California Pacific Medical Center Research Institute
- Suzanne Fenton, PhD National Institute of Environmental Health Sciences
- William H. Goodson III, MD California Pacific Medical Center Research Institute
- Joe Guth *, PhD, JD Science and Environmental Health Network
- Dale Johnson, PharmD, PhD University California Berkeley & Emiliem
- Jean Latimer, PhD School of Medicine University of Pittsburgh
- Ron Melnick, PhD National Institute of Environmental Health Sciences
- Rachel Morello-Frosch, PhD, MPH University of California Berkeley
- Ruthann A. Rudel, MS Silent Spring Institute
- Gina Solomon*, MD, MPH University of California San Francisco & Natural Resources Defense Council
- Carlos Sonnenschein, MD Tufts University School of Medicine
- Lauren Zeise*, PhD Cal/EPA Office of Environmental Health Hazard Assessment

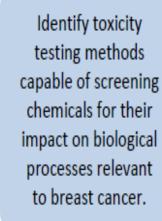


Steps of the Breast Cancer and Chemicals Policy Project

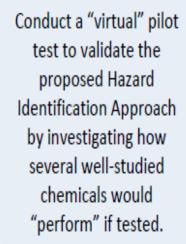


An interdisciplinary panel with expertise in breast cancer biology, toxicology, epidemiology, risk assessment, chemicals policy, community advocacy met to:

Identify toxicity "endpoints": alterations to biological processes resulting in an increased risk of breast cancer.



Propose a "Hazard Identification Approach," consisting of prioritization and testing for altered mammary gland development, endocrine disruption, and carcinogenesis in general.



Step 1. Events in Biological Processes Associated with Breast Cancer

Cellular & Molecular Events

Alterations in hormone levels, metabolism or receptors Changes in gene transcription & translation Cell cycle changes Peptide hormones (growth hormones) Genotoxicity Oxidative stress Immune modulation Limitless replication potential Evasion of apoptosis Self-sufficiency in growth

Tissue Changes

Breast density Tissue invasion Sustained angiogenesis TEB proliferation Altered mammary gland development Ductal hyperplasia Atypical hyperplasia

Susceptibility Factors

Obesity Early onset of breast development Alterations in cyclicity Genetic polymorphisms in metabolizing enzymes

Duration of lifetime estrogen exposure

Step 2: Identify test methods (Sample 1)

	Detectable Events Affecting Breast Cancer Risk					
	Molecular Mechanisms			Phenotypic Indicators		
Model System	Gene Expression	Genotoxicity	Steroid Hormones	Pathological Markers	TEB Proliferation	Carcinoma
In Silico						
In Vitro						
In Vivo						
Epidemiological						

http://coeh.berkeley.edu/greenchemistry/cbcrpdocs/matrix.pdf

Step 2: Identify Test Methods (Sample 2)

	Detectable Events Affecting Breast Cancer Risk					
	Susceptibility Factors			Biological Programs		
Model System	Altered Cyclicity	Metabolic Factors	Estrogen Exposure	Immune Modulation	Oxidative Stress	Apoptosis Evasion
In Silico						
In Vitro						
In Vivo						
Epidemiological						etc

http://coeh.berkeley.edu/greenchemistry/cbcrpdocs/matrix.pdf

Step 3. Hazard Identification Approach: Chemical Prioritization

Chemical Prioritization

Chemicals, their metabolites and degradation products, should be prioritized for testing based on the following parameters:

Hazard indicators

including structural similarities to other mammary gland carcinogens, or indicators that a chemical or its possible metabolite have endocrine activity, alter breast development or gene expression, or create genetic mutations.

Exposure potential

predicted by physical-chemical properties that indicate potential for bioaccumulation, persistence in the environment, or result in exposure to breast tissue. Also those identified by biomonitoring, environmental monitoring, or other proxy measures such as high production volume or dispersive use in consumer products or workplaces. Exposure potential should be assessed across the entire human life-cycle, and the product lifecycle from manufacturing through disposal.

Step 3. Hazard Identification Approach: Rapid Screening Methods

Hazard Identification Approach

Rapid (in vitro) screening

Genotoxicity

Mutagenicity (e.g., Ames or equivalent) Chromosome aberrations (e.g., OECD TG 473) Micronuclei formation (e.g., OECD TG 487) DNA strand breaks (e.g., COMET assay)

Cell cycle changes

Cell division (e.g., ³H thymidine proliferation assay) Altered apoptosis (e.g., TUNNEL assay)

Endocrine disruption

Activation or inhibition of:

Estrogen-mediated transcription (e.g., E-screen)

Androgen-mediated transcription (e.g., A-screen)

Enzymes specific to synthesis or metabolism of estrogen, androgen or progesterone (e.g., aromatase activity assay)

Step 3. Hazard Identification Approach: in vivo studies

Hazard Identification Approach

Animal studies (in vivo): development and maturation

Genotoxicity in breast epithelial cells

Mutagenicity Chromosome aberrations Micronuclei formation DNA strand breaks

Precursor changes, biomarkers and induction of mammary gland tumors

Modification of existing long-term cancer bioassays* redesigned to evaluate mammary gland endpoints, and:

include whole mounts of mammary tissue

include in utero exposures

assess effects over the whole lifespan

use an animal strain appropriate to the exposure and the endpoint Cell cycle changes in breast epithelial cells Cell proliferation Decreased apoptosis

Endocrine disruption

Estrogenic activity (e.g., Uterotrophic assay)

Androgenic activity (e.g., Hershberger assay)

Developmental changes in female and male mammary gland tissue (e.g. TEB formation, ductal branching, ER and AR levels)

Reproductive changes in males and females (e.g., AGD, nipple retention, altered cyclicity, pubertal timing)

Altered circulating hormone levels (e.g. steroid or peptide hormones)



Breast Cancer & Chemicals Policy Recommendations



Chemical toxicity testing—and the public policies that require it—can inform breast cancer prevention efforts by identifying chemicals that may raise the risk of breast cancer.

- 1. Chemical testing relevant to breast cancer should include the following endpoints:
 - Genotoxicity
 - Cell cycle changes
 - Endocrine disruption (e.g., estrogenicity)
 - Altered mammary gland development
- 2. Design and conduct toxicity tests to consider:
 - Timing of exposure
 - Underlying susceptibility factors



Breast Cancer & Chemicals Policy Recommendations



- 3. Research needs:
- Further elucidate biological pathways
- Adapt current methods to increase relevance for breast cancer
- Develop and validate new toxicity tests HTS screening methods

4. Apply a similar process to other disease endpoints to develop a comprehensive approach to identifying chemicals of concern.



Breast Cancer & Chemicals Policy Recommendations



Panel recommended an approach, not specific tests

- The field of toxicity testing is rapidly evolving
- Best practices can evolve with emerging tests

High throughput screens are under development

- Promise of testing thousands of chemicals
- Potential to evaluate many possible metabolites

Medium throughput screens using human breast tissue

 Research methods could be adapted for toxicity testing to replace some animal studies (e.g., for mammary gland development effects)



PATHWAYS TO BREAST CANCER:

A CASE STUDY FOR INNOVATION IN CHEMICAL SAFETY EVALUATION







Final report: http://coeh.berkeley.edu/greenchemistry/cbcrp.htm

