Inquinanti Organici Persistenti

Contaminanti organici persistenti di interesse emergente per la salute umana

G. Scortichini, T. Tavoloni, A. Stramenga, T. Stecconi, M. Giannotti, A. Piersanti

Istituto Zooprofilattico Sperimentale dell'Umbria e delle Marche

Polychlorinated- dioxins/furans/biphenyls

EU strategy for PCDD/Fs and PCBs

Reduction of PCDD/Fs and PCBs in the environment

a) Hazard identification, risk assessment, risk management, research communication to the public, communication with third countries (short- to medium-term)

b) Data collection, monitoring and surveillance, identification of measures (long-term)

Reduction of PCDD/Fs and PCBs in feed an food

a) Maximum levels (strict but feasible): if exceeded, feed or food not to be placed on the market

b) Action levels (early warning of higher than desirable levels): if exceeded, take measures to identify and eliminate the source

Polychlorinated- dioxins/furans/biphenyls

Maximum/Action Levels

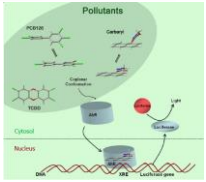
Regulation (EC) 1881/2006	Recommendation 2014/663/EU	Directive 2002/32/EC
↓	↓	↓
Maximum levels in food	Action levels in food	Maximum/Threshold levels in feed

Methods of sampling and analysis

Regulation (EU) 2017/644 - food

Screening methods

- Bioassays
- GC-MS/MS; GC-HRMS



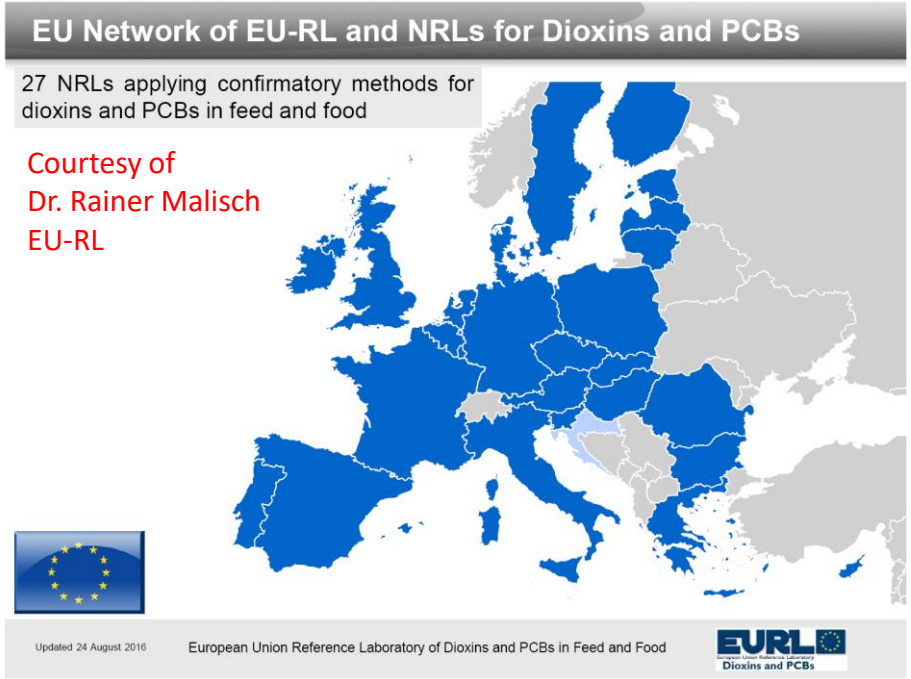
Regulation (EU) 2017/771 - feed

Confirmatory methods

- GC-MS/MS
- GC-HRMS

Polychlorinated- dioxins/furans/biphenyls

EU Laboratory Network



EU-RL tasks

Technical support to EC

Workshops with NRLs

Proficiency tests programme

Core working groups

- *Revision of EU legislation*
- *Analytical criteria definition*
- *Measurement uncertainty estimation*
- *Congener profiles database*

Polychlorinated- dioxins/furans/biphenyls

Data collection 2013-2016 in Italy

Origin	Fruit and vegetables	Olive Oil	Eggs	Meat	Milk	Sheep Liver	Farmed Fish	Wild Fish	Total
North-East		2	169	514	129	11	98		923
North-West		3	123	308	193	7	11		645
Centre		17	47	63	62		46		235
South and Islands	224	58	50	102	196		66		696
Mediterranean Sea								160	160
Total	**224**	**80**	**389**	**987**	**580**	**18**	**221**	**160**	**2659**

SOURCE: Official controls (National Residue Plan, Regional Control Plans) – Research (Marine Fish Project)

Polychlorinated- dioxins/furans/biphenyls

Contamination levels (1)

Upper-bound values, pg WHO-TEQ/g (fat basis for eggs, meat and milk, wet weight for fish, liver, vegetables and fruits)

Food category	PCDD/Fs		DL-PCBs		PCDD/Fs + DL-PCBs	
	Mean	Median	Mean	Median	Mean	Median
Eggs (n=389)	0.282	0.190	0.465	0.150	0.747	0.360
Fish (n=381)	0.104	0.050	0.577	0.217	0.682	0.307
Vegetables and Fruits (n=224)	0.009	0.005	0.012	0.005	0.021	0.011
Meat (n=800)	0.199	0.170	0.373	0.239	0.572	0.410
Milk (n=579)	0.249	0.210	0.687	0.420	0.936	0.640
Olive Oil (n=80)	0.047	0.040	0.053	0.040	0.100	0.081
Sheep Liver (n=18)	0.481	0.465	0.402	0.335	0.883	0.845

Polychlorinated- dioxins/furans/biphenyls

Contamination levels (2)

Comparison with data from EFSA 2012 (upper-bound values, pg WHO-TEQ/g fat for eggs, meat and milk, wet weight for fish).

PCDD/Fs + DL-PCBs							
Food category		Italy 2013-2016			EFSA 2012 (1999-2010)		
		Mean	Median	P95	Mean	Median	P95
Eggs	---	0.75	0.36	2.07	1.62	0.61	5.16
Meat	Bovine	0.79	0.64	1.85	2.34	1.68	5.97
	Poultry	0.51	0.37	1.13	0.99	0.56	2.79
	Swine	0.33	0.32	0.54	0.31	0.11	0.79
	Sheep	0.73	0.53	2.06	1.24	0.84	3.18
Milk	Bovine	1.04	0.77	2.66	1.91*	0.77*	4.36*
	Sheep	0.93	0.46	2.56			
	Buffalo	0.54	0.45	1.11			
	Goat	1.53	0.64	3.90			
Fish	Trout	0.22	0.17	0.55	1.05	0.94	2.01

* Milk and milk products

Polychlorinated- dioxins/furans/biphenyls

Dietary exposure estimation

Based on Food Consumption Database INRAN (2006), pg WHO-TEQ/kg b.w. per day

Health Reference Levels

EFSA, 2018: tolerable weekly intake (TWI) 2 pg WHO-TEQ/kg b.w. for PCDD/Fs + DL-PCBs

US EPA, 2012: oral reference dose (RfD) 0.7 pg WHO-TEQ/kg b.w. per day for PCDD/Fs

JECFA, 2001: provisional tolerable monthly intake (PTMI) 70 pg WHO-TEQ/kg b.w. for PCDD/Fs + DL-PCBs

SCF, 2001: tolerable weekly intake (TWI) 14 pg WHO-TEQ/kg b.w. for PCDD/Fs + DL-PCBs

EFSA. Journal 13(5) 2015, 16(11) 2018

Population group	Mean	Median	P75	P95
PCDD/Fs + DL-PCBs				
Children	1.98	1.40	2.33	4.98
Adolescents	1.16	0.82	1.36	2.90
Adults	0.90	0.64	1.05	2.24
PCDD/Fs				
Children	0.62	0.44	0.62	1.66
Adolescents	0.37	0.26	0.37	0.98
Adults	0.28	0.20	0.28	0.75
DL-PCBs				
Children	1.36	0.96	1.71	3.32
Adolescents	0.79	0.56	0.99	1.92
Adults	0.62	0.44	0.77	1.49

Polychlorinated- dioxins/furans/biphenyls

Dietary intake in Italy

For more details

Science of the Total Environment 627 (2018) 11–19

Contents lists available at ScienceDirect

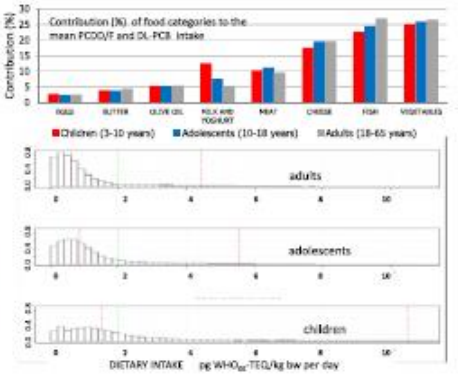
Science of the Total Environment

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

Intake estimates of dioxins and dioxin-like polychlorobiphenyls in the Italian general population from the 2013-2016 results of official monitoring plans in food

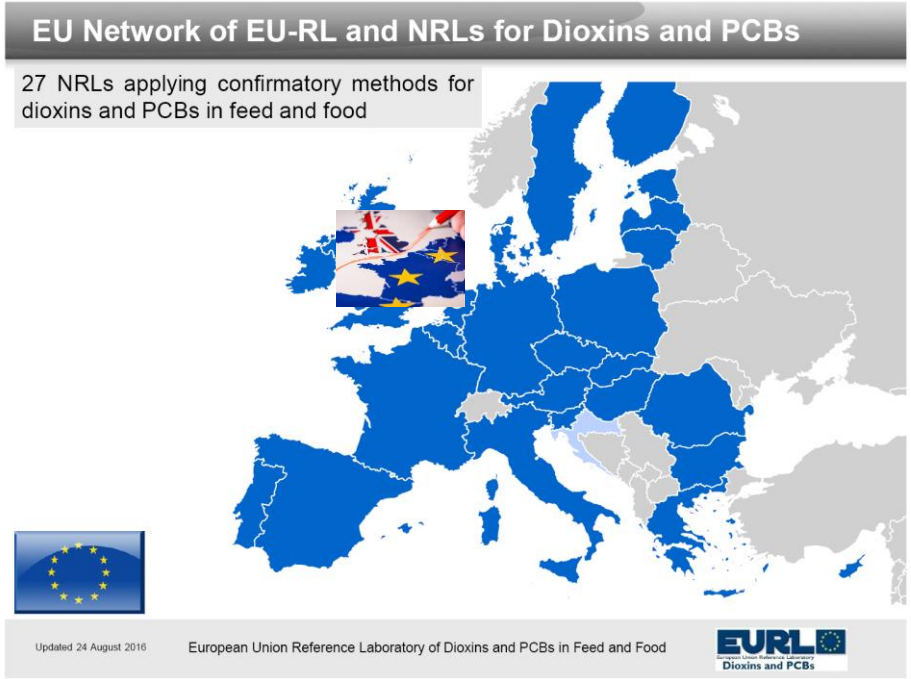
Gianfranco Diletti [a], Giampiero Scortichini [b], Maria Cesarina Abete [c], Giovanni Binato [d], Luca Candeloro [a], Roberta Ceci [a], Giannina Chessa [e], Annamaria Conte [a], Alessandra Di Sandro [f], Mauro Esposito [g], Giorgio Fedrizzi [h], Vincenzo Ferrantelli [i], Enrica Ferretti [j], Simonetta Menotta [h], Valeria Nardelli [k], Bruno Neri [l], Arianna Piersanti [m], Francesca Roberti [f], Alessandro Ubaldi [i], Gianfranco Brambilla [n,*]

[a] Istituto Zooprofilattico Sperimentale dell'Abruzzo e del Molise, Campo Boario, 64100 Teramo, Italy
[b] Istituto Zooprofilattico Sperimentale dell'Umbria e delle Marche, Via Gaetano Salvemini 1, 06126 Perugia, Italy
[c] Istituto Zooprofilattico Sperimentale del Piemonte, Liguria e Valle d'Aosta, Via Bologna 148, 10154 Torino, Italy
[d] Istituto Zooprofilattico Sperimentale delle Venezie, Viale dell'Università 10, 35020 Legnaro, Italy
[e] Istituto Zooprofilattico Sperimentale della Sardegna, Via Duca degli Abruzzi 8, 07100 Sassari, Italy
[f] Ministero della Salute, Viale Giorgio Ribotta 5, 00144 Roma, Italy
[g] Istituto Zooprofilattico Sperimentale del Mezzogiorno, Via della Salute 2, 80055 Portici, Italy
[h] Istituto Zooprofilattico Sperimentale della Lombardia e dell'Emilia Romagna, Via Pietro Fiorini, 5, 40127 Bologna, Italy
[i] Istituto Zooprofilattico Sperimentale della Sicilia, Via Gino Marinuzzi 3, 90129 Palermo, Italy
[j] Istituto Zooprofilattico Sperimentale della Lombardia e dell'Emilia Romagna, Via Antonio Bianchi 9, 25124 Brescia, Italy
[k] Istituto Zooprofilattico Sperimentale della Puglia e della Basilicata, Via Manfredonia, 20, 71121 Foggia, Italy
[l] Istituto Zooprofilattico Sperimentale delle Regioni Lazio e Toscana, Via Appia Nuova, 1411, 00178 Roma, Italy
[m] Istituto Zooprofilattico Sperimentale dell'Umbria e delle Marche, Via Cupa di Posatora, 3, 60131 Ancona, Italy
[n] Istituto Superiore di sanità, Food Safety, Nutrition, and Veterinary Public Health Dept.,Viale Regina Elena 299, 00161 Roma, Italy



Polychlorinated- dioxins/furans/biphenyls

EU Laboratory Network



Since 2018
EU-RL for halogenated POPs in feed and food

Regulation (EU) 2018/192

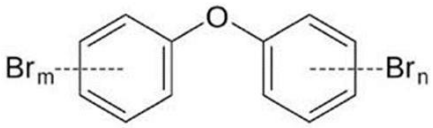
EU-RL additional tasks

New substances

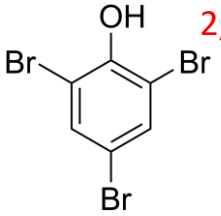
- *Brominated Flame Retardants (BFRs)*
- *Per- Polyfluorinated Alkyl Substances (PFASs)*
- *Chlorinated Paraffins (CPs)*

Brominated Flame Retardants

Class of substances

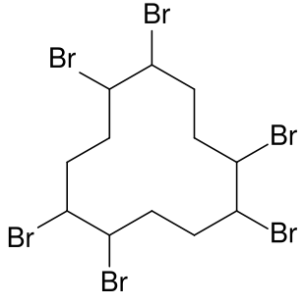


Polybrominated Diphenyl Ethers (PBDEs)



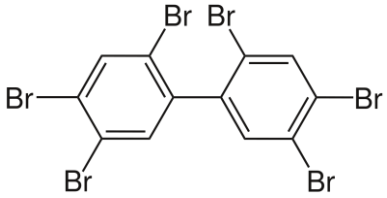
2,4,6-TBP

Brominated Phenols (BPs)

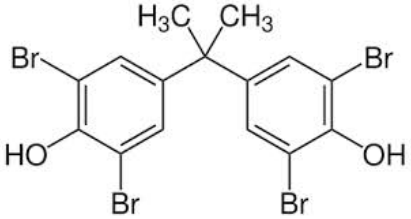


Hexabromoyclododecanes (HBCDDs)

2,2',4,4',5,5'-HxBB

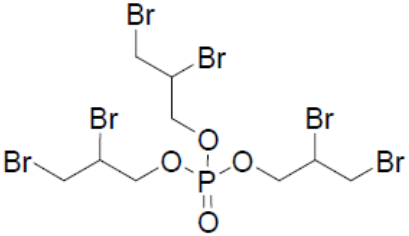


Polybrominated Biphenyls (PBBs)

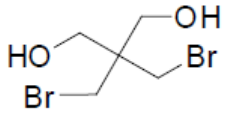


Tetrabromobisphenol A (TBBPA)

TDBPP



DBNPG



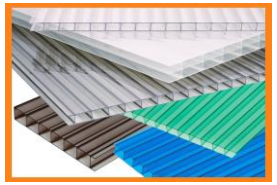
Emerging and novel BFRs

Brominated Flame Retardants

Main uses

Approximately 311,000 tons used worldwide in 2005 (21% of FRs total consumption)

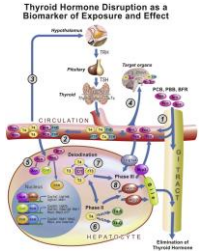
- Electronic devices (computers, TVs)
- Upholstery
- Carpets
- Textiles
- Epoxy resins
- Polystyrene foams



Health effects

Toxicological data mainly available for PBDEs and HBCDDs with following critical endpoints

- Liver toxicity
- Endocrine system disruption
- Reproductive effects
- Developmental effects
- Neurobehavioural effects
- DNA damage (induction of reactive oxygen species)



EFSA. Journal 9(5) 2011, 9(7) 2011

Brominated Flame Retardants

Human exposure

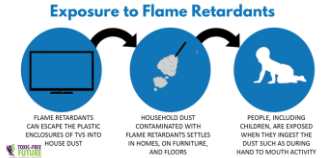
- Dietary exposure (main route)
  - ✓ Fish and fish products
  - ✓ Meat and meat products
  - ✓ Fat of animal and vegetable origin
  - ✓ Milk and milk products
  - ✓ Eggs and egg products
- Air (indoor and outdoor)
- Dust

Fromme et al. Int J Hyg Environ Health. 2016

Health reference levels

US EPA: Reference Dose (RfD) at which no appreciable health risk expected during lifetime

- 100 ng/kg b.w. per day for BDE-47 and BDE-99
- 200 ng/kg b.w. per day for BDE-153
- 3000 ng/kg b.w. per day for octaBDEs
- 7000 ng/kg b.w. per day for BDE-209



US EPA. Technical Fact Sheet. 2017

Brominated Flame Retardants

Analytical methods

PBDE: 28, 47, 49, 66, 77, 85, 99, 100, 138, 153, 154, 183, 197, 206, 209

15 PBDEs + 3 HBCDDs

α-HBCDD, β-HBCDD γ-HBCDD

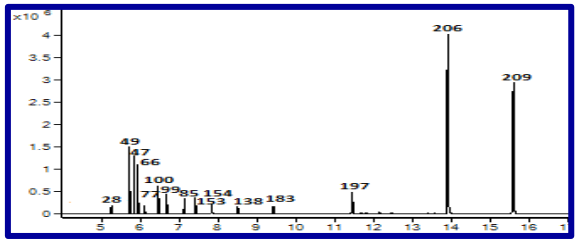
Piersanti et al. Food Anal Meth. 2018

Piersanti et al. Anal Bioanal Chem. 2020

QuEChERS
($MgSO_4$+NaCl+EtAc)

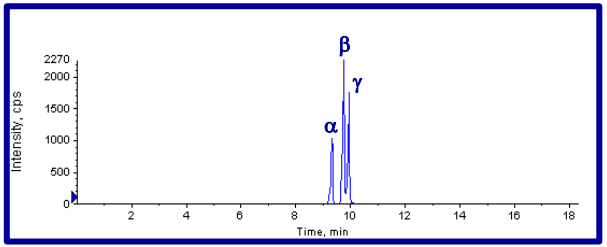
SPE
(Solid Phase Extraction)
Extrelut NT-3 + Silica
1g/6mL

GPC
(Gel Permeation
Chromatography)



GC-MS/MS

LC-MS/MS



Brominated Flame Retardants

EU monitoring programme

Recommendation 2014/118/EU on the monitoring of the presence of BFRs in food.

Monitoring of BFRs in a wide range of food products reflecting consumers' habits with the aim of estimate human exposure (2014-2015).

PBDEs and HBCDDs in food samples

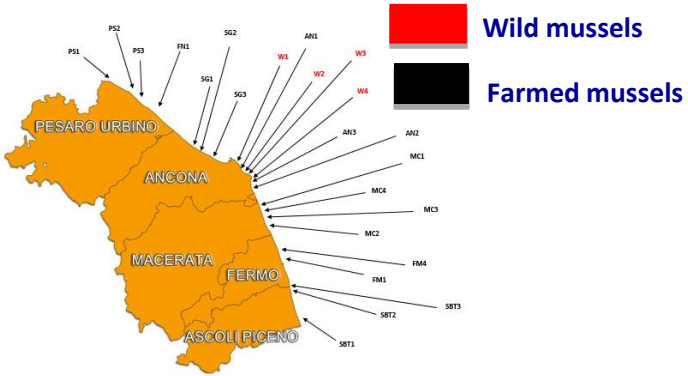
Samples tested in the period 2013-2019

Type of sample	N. of samples	Programme
Mussels	134	Research
Eggs	8	Regional control plan
Milk	10	Regional control plan
Cheese	21	Regional control plan
Meat and meat products	5	Regional control plan Research
Fish (marine)	44	Regional control plan Research
Fish/crustaceans (fresh water)	58	Research

Brominated Flame Retardants

PBDEs in mussels (1)

Monitoring of *Mytilus galloprovincialis* 23 sampling points along Marche region coastline (April-November 2013).



Piersanti et al. Mar. Poll. Bull. 2015

PBDE levels (pg/g, fresh weight)

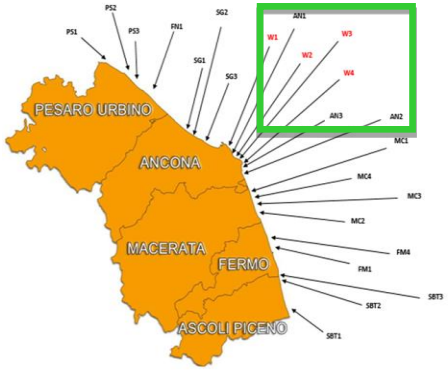
Type	Congener	49[a]	47	100	99
Farmed (n=106)	Mean	19	68	16	28
	Median	19	68	17	26
	SD	7	27	7	14
	Min	<10	16	<10	<10
	Max	37	146	49	91
Wild (n=28)	Mean	39	92	24	40
	Median	39	96	24	40
	SD	5	32	11	16
	Min	36	32	<10	15
	Max	42	186	68	89
Total (n=134)	Mean	19	73	18	30
	Median	20	71	17	28
	SD	8	30	8	15
	Min	<10	16	<10	<10
	Max	42	186	68	91

[a] For PBDE-49 the number of considered results was 95 (93 farmed and 2 wild)

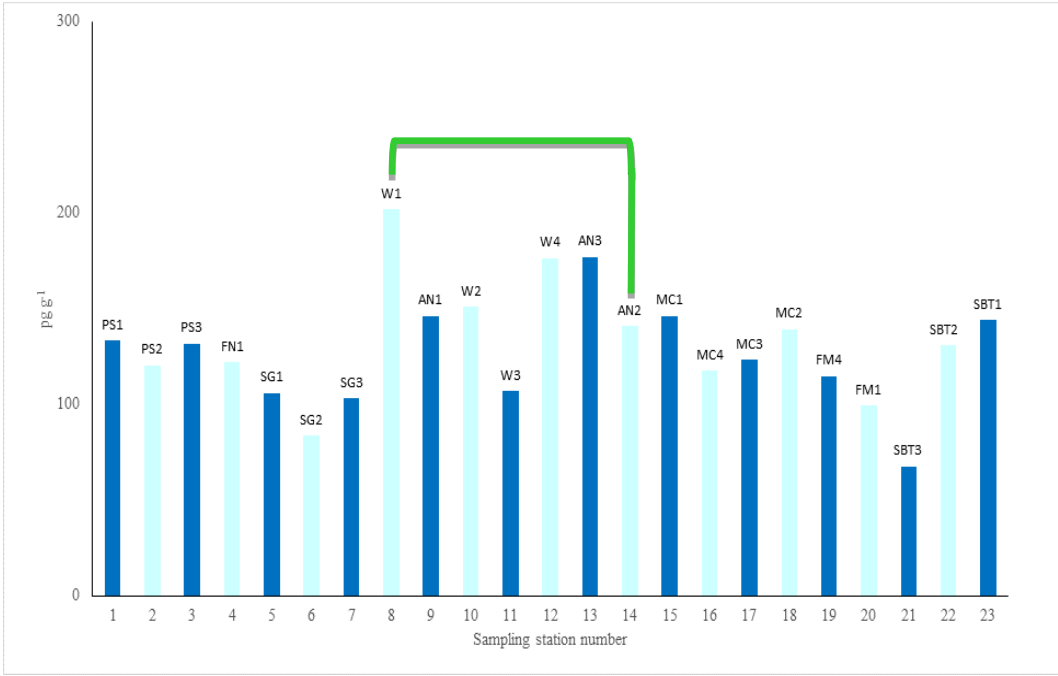
Brominated Flame Retardants

PBDEs in mussels (2)

PBDE levels recorded at the sampling points near the city of Ancona were higher than in the rest of coastline.



ΣPBDEs (pg/g, fresh weight), mean lower bound values

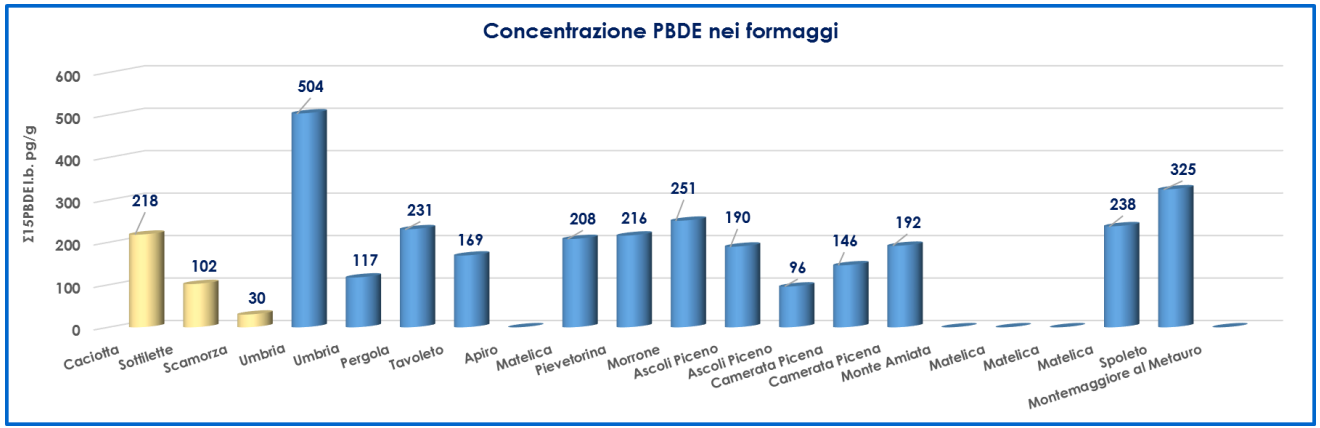


Brominated Flame Retardants

PBDEs in cheese

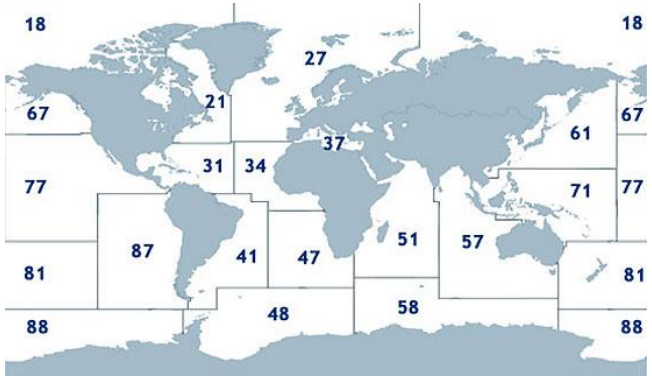
PBDE levels in ovine milk cheese tended to be higher than that in bovine milk cheese.

ΣPBDEs (pg/g, fresh weight), mean lower bound values



Brominated Flame Retardants

PBDEs and HBCDDs in marine fish (1)



Species		N. of samples	Trophic level[a]	FAO fishing area	Lipid content (%)
Tuna	*Thunnus alalunga*	1	4.3	37	7.8 [b]
	Thunnus albacares	2	4.4	27	0.5 [d]
Sole	*Solea solea*	2	3.2	37	1.6 [b]
Grey mullet	*Mugil cephalus*	3	2.5	37	2.2 [b]
Spiny dogfish	*Squalus acanthias*	2	4.4	21	13.4 [b]
Smooth-hound	*Mustelus mustelus*	4	3.8	27	1.2 [c]
Mackerel	*Scomber scombrus*	5	3.6	27	4.1 [b]
Swordfish	*Xiphias gladius*	2	4.5	51	12.4 [b]
Atlantic horse mackerel	*Trachurus trachurus*	3	3.7	37	9.1 [b]
Cod	*Merluccius merluccius*	3	4.4	27	0.6 [b]
Anchovie	*Engraulis encrasicolus*	3	3.1	37	4.8 [b]
Red mullet	*Mullus barbatus*	4	3.1	37	3.5 [b]
Mussel	*Mytilus galloprovincialis*	10		37	2.6 [b]

[a] http://www.fishbase.se

[b] FAO/INFOODS Databases (AnFooD2.0) - http://www.fao.org/infoods/infoods/tables-and-databases/faoinfoods-databases/it/

[c] CREA food composition database - http://nut.entecra.it/646/tabelle_di_composizione_degli_alimenti.html

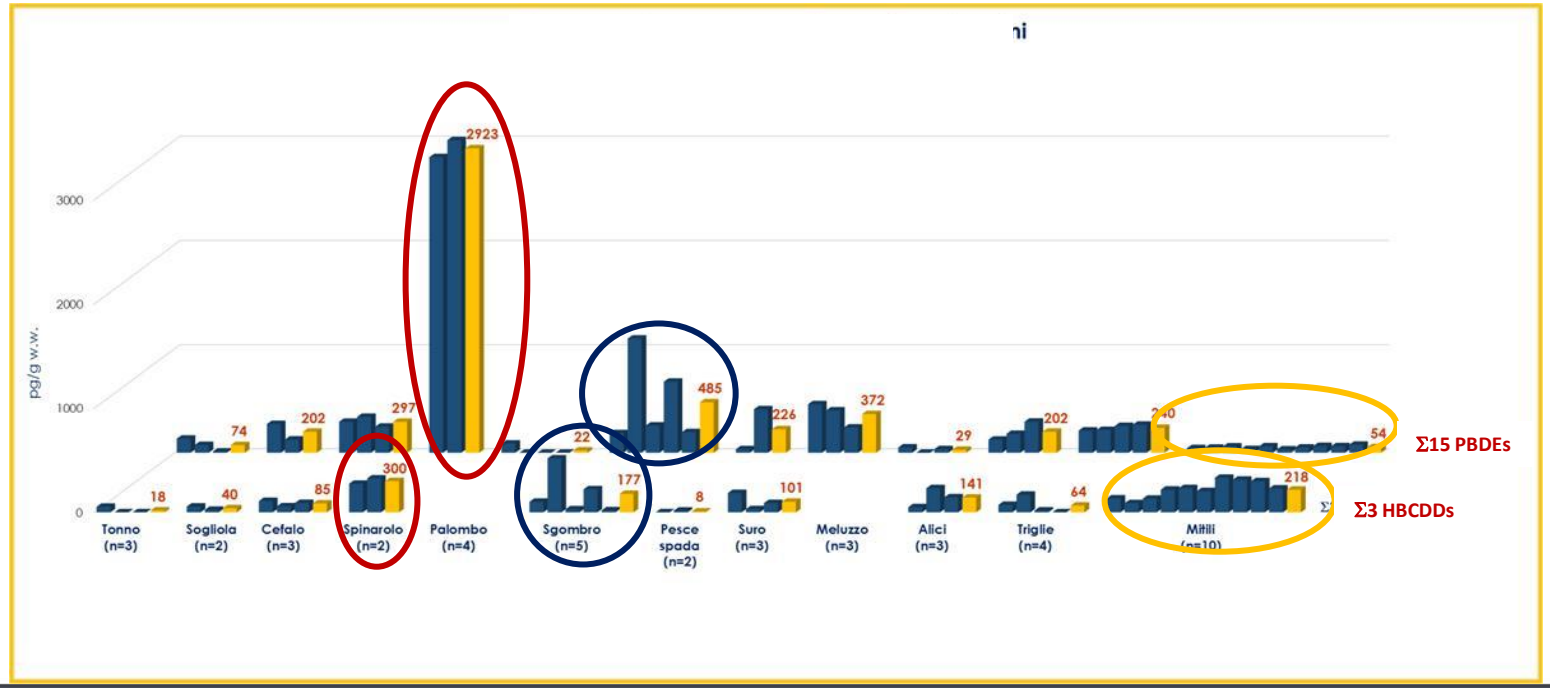
[d] USDA food composition database - https://ndb.nal.usda.gov/ndb/search/list

Piersanti et al. Anal Bioanal Chem. 2020

Brominated Flame Retardants

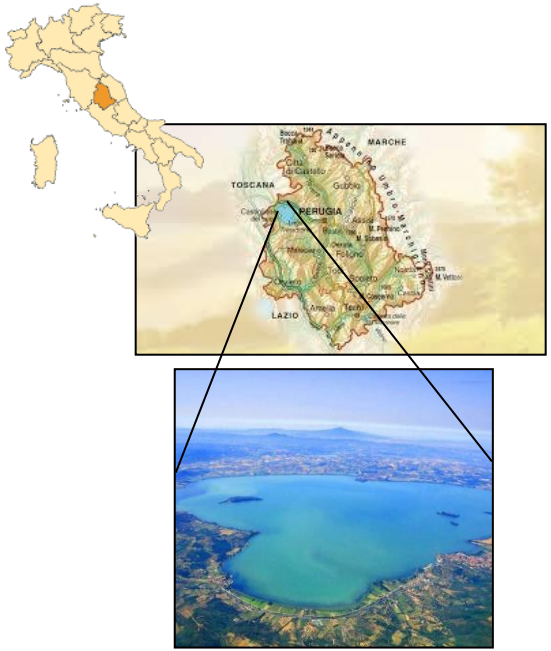
PBDEs and HBCDDs in marine fish (2)

ΣPBDEs and ΣHBCDDs (pg/g, fresh weight), lower bound values



Brominated Flame Retardants

PBDEs and HBCDDs in freshwater fish and crustaceans (1)



SAMPLING AREA	SPECIES	SAMPLES (N°)		LABORATORY SAMPLES (N°)
Trasimeno Lake (Central Italy)	*Carassius carassius* (Crucian Carps)	14	Female	14
	Perca fluviatilis (European perches)	18	8 Male 10 Female	18
	Tinca tinca (Tenches)	14	11 Male 3 Female	14
	Anguilla anguilla (Eels)	10	Female	10
	Procambarus clarkii (Red Swamp Crayfishes)	20	10 Male 10 Female	2

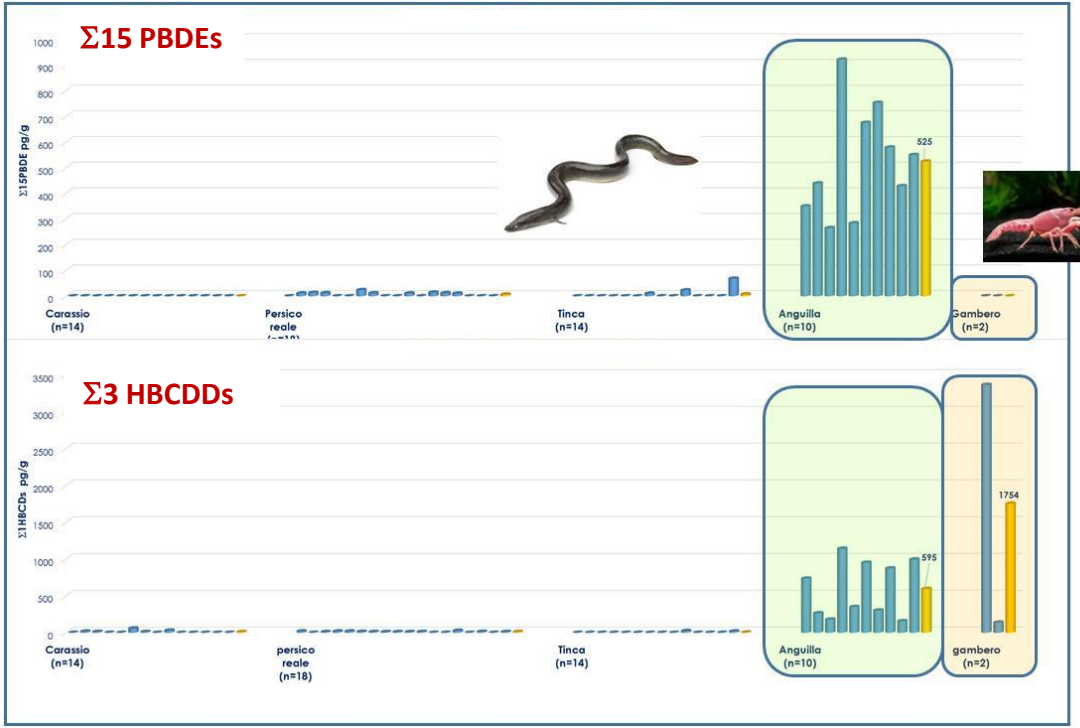
Brominated Flame Retardants

PBDEs and HBCDDs in freshwater fish and crustaceans (2)

PBDEs and HBCDDs were more abundant in eels.

HBCDDs were higher than PBDEs in crayfish.

ΣPBDEs and ΣHBCDDs (pg/g, fresh weight), lower bound values



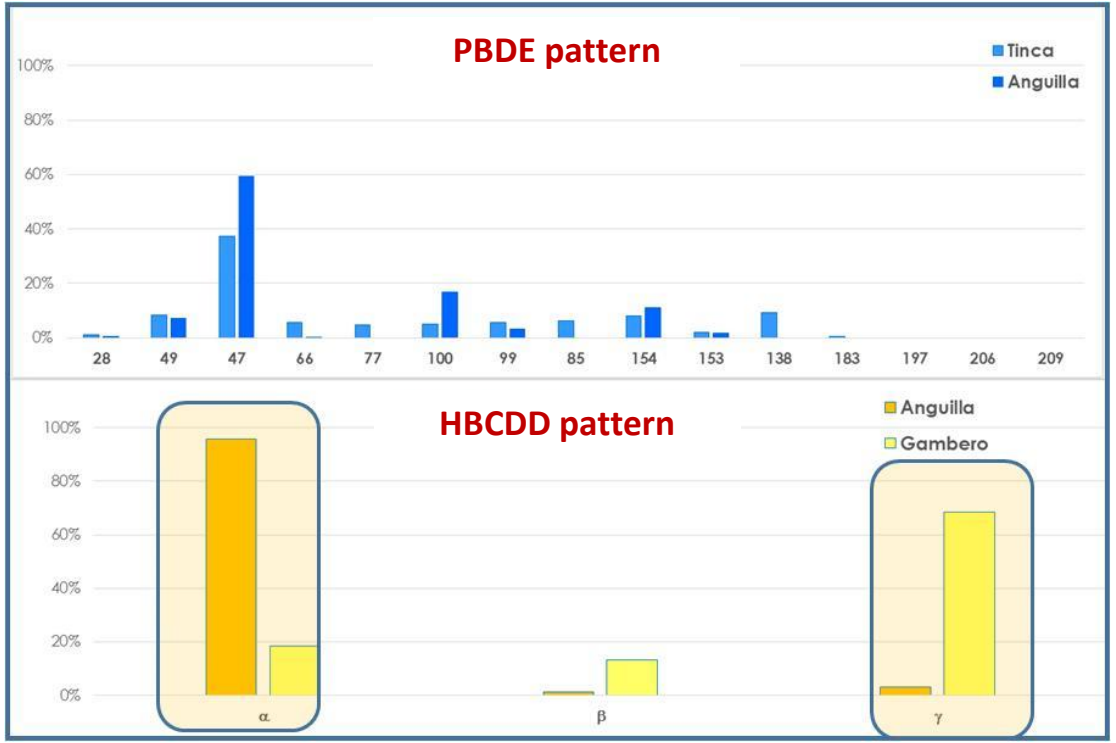
Brominated Flame Retardants

PBDEs and HBCDDs in freshwater fish and crustaceans (3)

PBDE contamination pattern in eels: **47 > 100 > 154 > 49 > 99.**

α-HBCDD was always the most abundant congener.

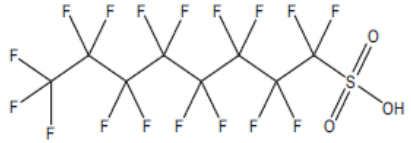
Only in red swamp crayfish γ- HBCDD was dominant.



Per- polyfluoroalkyl substances

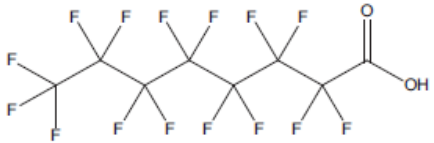
Class of substances (1)

Pefluorooctane sulfonic acid (PFOS)

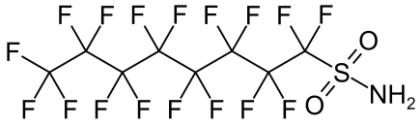


Perfluoroalkyl sulfonic acids (PFSAs)	
PFBS	Perfluorobutane sulfonic acid
PFPS	Perfluoropentane sulfonic acid
PFHxS	Perfluorohexane sulfonic acid
PFHpS	Perfluoroheptane sulfonic acid
PFOS	Perfluorooctane sulfonic acid
PFNS	Perfluorononane sulfonic acid
PFDS	Perfluorodecane sulfonic acid
PFDoS	Perfluorododecane sulfonic acid

Pefluorooctanoic acid (PFOA)



Pefluorooctane sulfonamide (PFOSA)



Perfluoroalkyl carboxylic acids (PFCAs)	
PFBA	Perfluorobutanoic acid
PFPA	Perfluoropentanoic acid
PFHxA	Perfluorohexanoic acid
PFHpA	Perfluoroheptanoic acid
PFOA	Perfluorooctanoic acid
PFNA	Perfluorononanoic acid
PFDA	Perfluorodecanoic acid
PFUnDA	Perfluoroundecanoic acid
PFDoDA	Perfluorododecanoic acid
PFTrDA	Perfluorotridecanoic acid
PFTeDA	Perfluorotetradecanoic acid
PFHxDA	Perfluorohexadecanoic acid
PFODA	Perfluorooctadecanoic acid

Per- polyfluoroalkyl substances

Class of substances (2)

Figure 1.
Family Tree of perfluoroalkyl and polyfluoroalkyl Substances

Photo: Agency for Toxic Substances and Disease Registry

Per- and polyfluoroalkyl substances (PFASs)

- **PFASs**
  - **Non-polymers**
    - **Perfluoroalkyl acids (PFAAs)** $C_nF_{2n+1}R$
      - Perfluoroalkyl carboxylic acids (PFCAs)
      - Perfluoroalkane sulfonic acids (PFSAs)
      - Perfluoroalkyl phosphonic acids (PFPAs)
      - Perfluoroalkyl phosphinic acids (PFPIAs)
    - **Perfluoroalkane sulfonyl fluoride (PASF)** $C_nF_{2n+1}SO_2F$ → **PASF-based derivatives** $C_nF_{2n+1}SO_2$-R, R = NH, $NHCH_2CH_2OH$, etc.
    - **Perfluoroalkyl iodides (PFAIs)** $C_nF_{2n+1}I$ → **Fluorotelomer iodoes (FTIs)** $C_nF_{2n+1}CH_2CH_2I$ → **FT-based derivatives** $C_nF_{2n+1}CH_2CH_2$-R, R = NH, $NHCH_2CH_2OH$, etc.
    - **Per- and polyfluoroalkyl ethers (PFPEs)-based derivatives** – Polyfluoroalkyl ether carboxylic acids
  - **Polymers**
    - **Fluoropolymers** — Polytetrafluoroethylene (PTFE), Polyvinylidene fluoride (PVDF), Fluorinated ethylene propylene (FEP), Perfluoroalkoxyl polymer (PFA), etc.
    - **Side-chain fluorinated polymers** — Fluorinated (meth)acrylate polymers, Fluorinated urethane polymers, Fluorinated oxetane polymers
    - **Perfluoropolyethers**

OECD. Synthesis paper on Per- and Polyfluorinated Chemicals (PFCs). 2013

Per- polyfluoroalkyl substances

Main uses

Used in industrial and consumer products due to their dielectric properties, thermal and chemical stability, and low surface energy

- Protective coatings for textiles and carpets
- Paper coatings
- Paints
- Cosmetics
- Insecticide formulations
- Wax, polishing agents
- Fire fighting foams

Health effects

Adverse effects derived from animal studies and human epidemiological studies

- Reproductive and developmental toxicity
- Neurobehavioral toxicity
- Immunotoxicity
- Kidney, liver and lung toxicity
- Thyroid hormone disruption
- Hypercholesterolemia
- Carcinogenic effects

Kan et al. Environ Int. 2017

EFSA. Journal 10(6) 2012

Per- polyfluoroalkyl substances

Human exposure

- ❑ Dietary exposure (main route)
  - ✓ Fish and other seafood
  - ✓ Food grown in PFAS contaminated soil or water
  - ✓ Contamination by food contact materials
  - ✓ Contamination during food processing
  - ✓ Drinking water
- ❑ Indoor and outdoor air/aerosols and dust
- ❑ Consumer products treated with PFAS

US EPA. https://www.epa.gov/pfas, 2018

Health reference levels

- ❑ Tolerable daily intake (TDI), EFSA 2008
  - ✓ 150 ng/kg b.w. per day for PFOS
  - ✓ 1500 ng/kg b.w. per day for PFOA
- ❑ Oral reference doses (RfDs), U.S. EPA 2016
  - ✓ 20 ng/kg b.w. per day for PFOS and PFOA
- ❑ Tolerable weekly intake (TWI), EFSA 2018
  - ✓ 13 ng/kg b.w. per week for PFOS
  - ✓ 6 ng/kg b.w. per week for PFOA

EFSA. Journal 653 2008, 10(6) 2012, 16(12) 2018

Per- polyfluoroalkyl substances

Analytical methods (1)

21 PFASs

PFBA
PFPA
PFHxA
PFHpA
PFOA
PFNA
PFDA
PFUnDA
PFDoDA
PFTrDA
PFTeDA
PFHxDA
PFODA

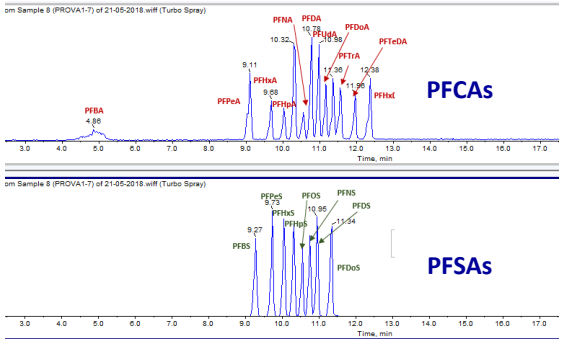
PFBS
PFPS
PFHxS
PFHpS
PFOS
PFNS
PFDS
PFDoS

QuEChERS ($MgSO_4$ + NaCl + Formic acid + ACN)

SPE
(Solid Phase Extraction)
WAX 150mg/6mL

SPE
(Solid Phase Extraction)
ENVICARB 500mg/6mL

LC-MS/MS



Per- polyfluoroalkyl substances

Analytical methods (2)

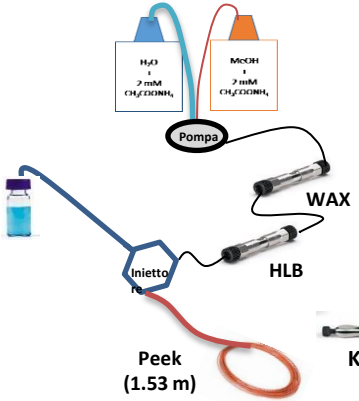
33 PFASs

PFBA
PFPA
PFHxA
PFHpA
PFOA
PFNA
PFDA
PFUnDA
PFDoDA
PFTrDA
PFTeDA
PFHxDA
PFODA
FHpPA
FOEA
FOUEA
HFPO-DA
NaDONA
N-EtFOSAA
N-MeFOSAA
L-PFBS
L-PFPS
L-PFHxS
L-PFHpS
L-PFOS
L-PFNS
L-PFDS
L-PFDoS
9Cl-PF3ONS
11Cl-PF3OUdS
6:2FTS
8:2FTS
PFECHS

ACN

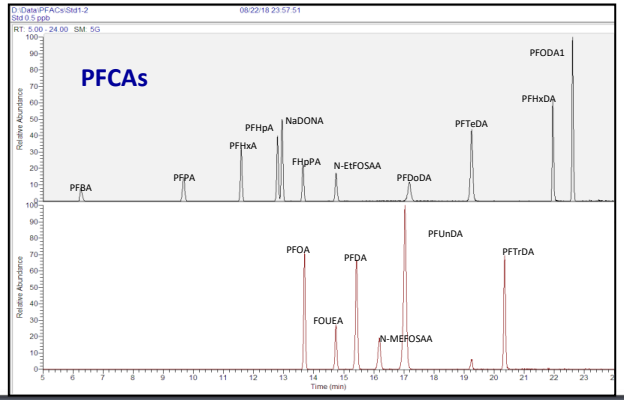
SPE
WAX
150mg/6mL

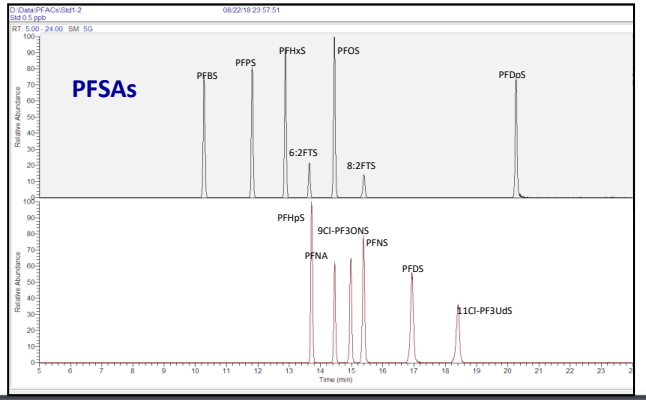
d-SPE
ENVICARB
80 mg



LC-Q-HRMS

Kinetex XB C18





Per- polyfluoroalkyl substances

EU monitoring programme (1)

Recommendation 2010/161/EU on the monitoring of PFAS in food.

Focus on PFOA in game animals

Meat (mainly wild boar): 0.28 – 76 μg/kg

Edible offal (mainly wild boar liver): 20 – 789 μg/kg

min – max, ub values

Occurrence of **PFCAs** (mean values, μg/kg)

Food group	PFPA		PFHxA		PFHpA		PFOA		PFNA	
	lb	ub	lb	ub	lb	ub	lb	ub	lb	ub
Meat and meat products	0.018	0.17	0.0087	0.19	0.0003	0.13	0.78	1.6	0.24	0.38
Fish and other seafood	0.0051	0.60	0.045	0.60	0.010	0.80	0.082	0.69	0.015	0.64
Vegetables and veg products	--	--	0.0016	0.10	0.0014	0.075	0.039	0.13	0.0007	0.088
Eggs and egg products	--	--	0.0020	0.54	0.0025	0.51	0.066	0.58	--	--
Drinking water	0.0004	0.0022	0.001	0.0034	0.0035	0.0038	0.001	0.0027	0.000008	0.0017

Food group	PFDA		PFUnDA		PFDoDA		PFTrDA		PFTeDA	
	lb	ub	lb	ub	lb	ub	lb	ub	lb	ub
Meat and meat products	0.1496	0.28	0.0019	0.29	0.085	0.24	0.0004	0.21	0.00004	0.33
Fish and other seafood	0.059	0.57	0.078	0.63	0.041	0.67	0.078	0.46	0.04	0.74
Vegetables and veg products	0.0002	0.088	--	--	0.0038	0.082	--	--	--	--
Eggs and egg products	--	--	0.0004	0.59	--	--	0.0012	0.12	--	--
Drinking water	--	--	--	--	--	--	--	--	--	--

lb: lower bound values; ub: upper bound values

EFSA. Journal 10(6) 2012

Per- polyfluoroalkyl substances

EU monitoring programme (2)

Recommendation 2010/161/EU on the monitoring of PFAS in food.

Occurrence of **PFSAs** and **PFOSA** (mean values, μg/kg)

Food group	PFBS		PFHxS		PFHpS		PFOS		PFDS		PFOSA	
	lb	ub	lb	ub	lb	ub	lb	ub	lb	ub	lb	ub
Meat and meat products	0.0008	0.27	0.0010	0.21	0.00001	0.0098	29.5	30	––	––	0	0.72
Fish and other seafood	0.0024	1.1	0.0096	0.49	––	––	1.99	2.4	0.0052	0.23	0.37	1.8
Vegetables and veg products	0.0002	0.11	0.0001	0.090	––	––	0.020	0.12	0.0004	0.0079	––	––
Eggs and egg products	––	––	0.0001	0.52	––	––	0.034	0.74	––	––	––	––
Drinking water	0.0016	0.032	0.0007	0.21	––	––	0.0005	0.025	––	––	––	––

lb: lower bound values; ub: upper bound values

Focus on PFOS in game animals and fish

Meat (wild boar):
1.5 μg/kg (1.1 – 29 μg/kg)

Edible offal (mainly wild boar liver):
215 μg/kg (0.002 – 3480 μg/kg)

Fish meat: 2.5 μg/kg
(0.004 – 211 μg/kg)

Mean (min – max), ub values

EFSA. Journal 10(6) 2012

Per- polyfluoroalkyl substances

EU monitoring programme (3)

Updated evaluation on the risks to human health related to the presence of PFOS and PFOA in food: based on 10,191 results for PFOS and 9,828 results for PFOA, collected in the period 2007-2015.

- PFOS (mean value, lower-bound)
  - ✓ Meat and meat products: 28.6 μg/kg
  - ✓ Fish and fish products : 2.08 μg/kg
  - ✓ Liver of game mammals: 215 μg/kg
- PFOA (mean value, lower-bound)
  - ✓ Meat and meat products : 0.10 μg/kg (offals excluded)
  - ✓ Fish and fish products : 0.22 μg/kg
  - ✓ Liver of game mammals: 5.46 μg/kg

EFSA. Journal 216 (12) 2018

Per- polyfluoroalkyl substances

Drinking water

EU: proposal for a Directive on the quality of water intended for human consumption.

Parameter	Parametric value (µg/L)	Notes
PFASs	0.10	Each individual per- and polyfluoroalkyl substance (C_nF_{2n+1}–R)
PFASs - Total	0.50	Sum of per- and polyfluoroalkyl substances (C_nF_{2n+1}–R)

EU COM (2017) 753 final

USA: health advisory levels in drinking water.

Parameter	Parametric value (ng/L)	Notes
PFOA	70	Individual or combined
PFOS	70	

US EPA. Fact Sheet PFOA & PFOS Drinking Water Health Advisories, 2016

Per- polyfluoroalkyl substances

PFAS contamination in Veneto region

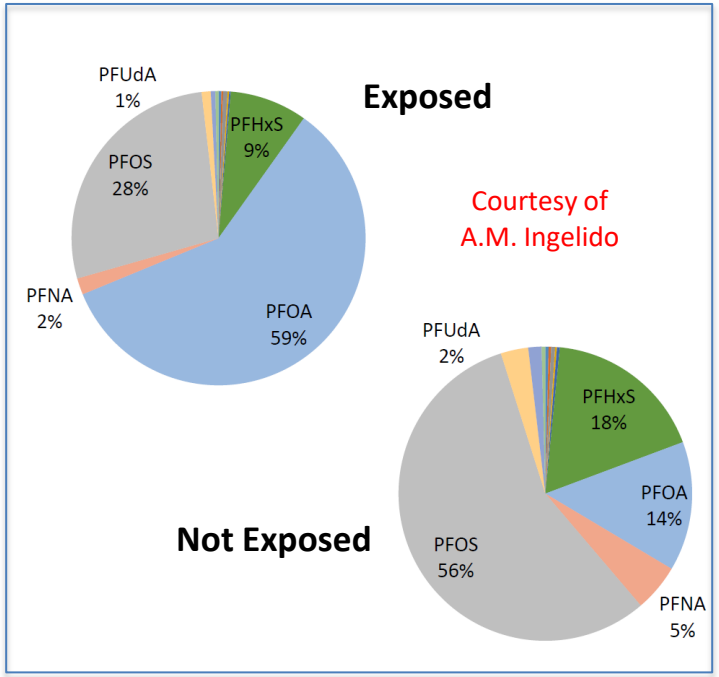
PFASs in drinking water, contamination originated mainly from industrial emissions (chemical plant that has produced PFASs since 1968).
The study involved 507 subjects, 257 in areas under impact (E), 250 in areas at presumed background exposure (NE), sampling July 2015 – April 2016.

PFOA levels in human serum

- E (total): median 13.77 ng/g
- E (ULSS 5 sub-area): median 74.21 ng/g
- NE: median 1.64 ng/g

PFOA health-related guidance value 2 ng/mL in blood plasma (German Human Biomonitoring Commission)

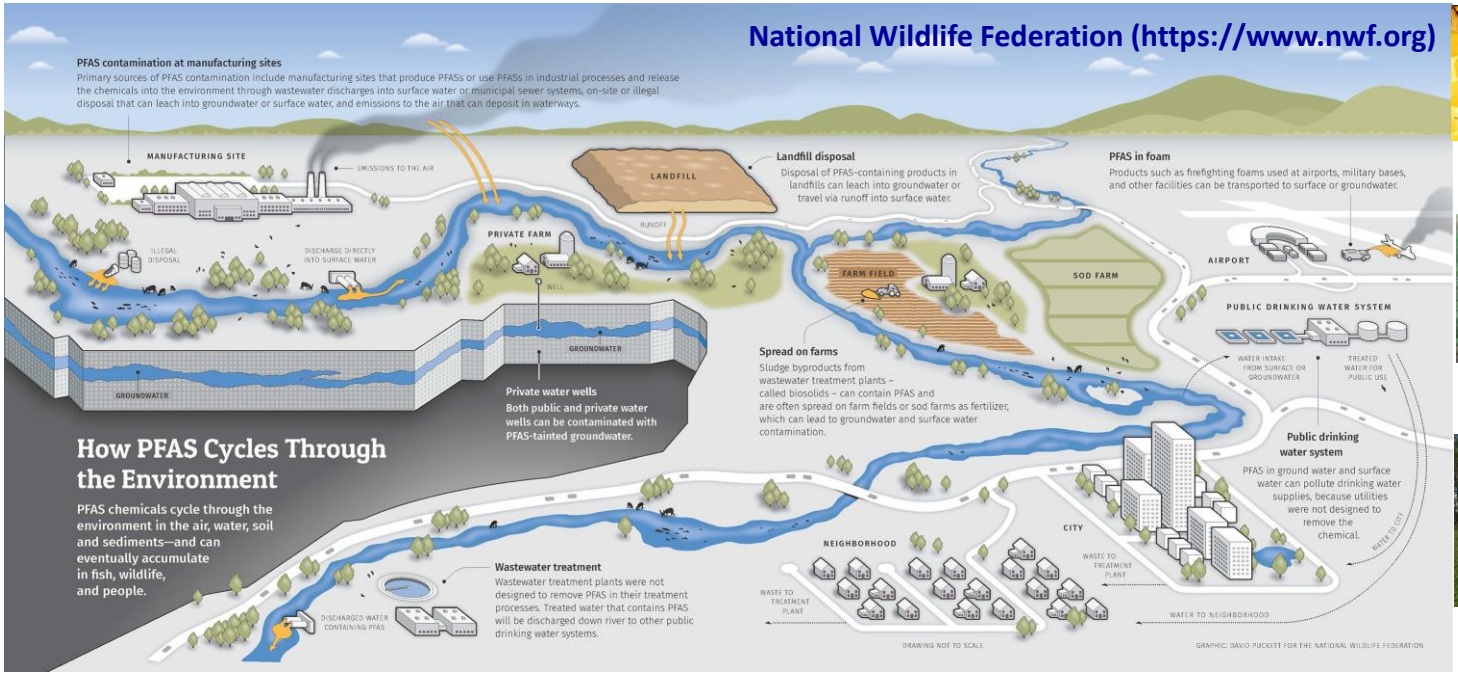
PFAS distribution in human serum



Ingelido et al. Environ Int. 2018

Per- polyfluoroalkyl substances

Cycles through the environment



Air and Deposition
=> Bee, Honey

Soil => Forages,
Vegetables, Game

Fresh/Marine
Waters => Fish

Persistent Organic Pollutants

UN 2030 Agenda for Sustainable Development

The impact of POPs

1) Reduced income for farmers
2) Reduced production of safe food
3) Human exposure higher than HBGVs
6) Compromising water resource
8) Reduced economy growth
12) Soil consumption
14) Compromising fish resource
15) Environmental damage in agricultural areas

Conclusions

- Monitoring programmes of POPs in food and feed is crucial to:
  - evaluate time trends and effectiveness of measures taken to reduce or eliminate their release into the environment;
  - establish new maximum levels for certain substances and re-evaluate the limits in force;
  - discover new contamination incidents.
- Need for analytical methods with high sensitivity in order to quantify POPs at the lowest possible levels.
- Evaluation of dietary exposure of new substances and its relevance to human health based on updated toxicological data.
- Definition of priority substances for future monitoring programmes.
- Re-evaluation and harmonisation of health-based guidance values.

Grazie per l'attenzione

Acknowledgements

Gianfranco Brambilla, ISS, Roma, Gianfranco Diletti, IZSAM, Teramo
Anna Maria Ingelido, ISS, Roma, Roberta Galarini, IZSUM, Perugia
Rainer Malisch, EURL, Freiburg

ISTITUTO ZOOPROFILATTICO SPERIMENTALE
DELL'UMBRIA E DELLE MARCHE "TOGO ROSATI"

Contacts: g.scortichini@izsum.it