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Fate of adsorbable micropollutants through sludge drying and composting processes

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Introduction

- Recycling of sludge to land for agriculture : > 50% sludge disposal routes in Europe and USA
- New legislations on reduction of micro-pollutants emissions to the environment :
 - EU Water Framework Directive (2000): 33 + 8 substances
 - Sewage Sludge Directive (Update of 86/278/EEC, expected)
- Good global performance of biological processes, only 20% priority substances remain in treated wastewater but most of them (60%) expected to accumulate in sludge
- Presence of micro-pollutants in sludge confirmed => **Importance to address fate of priority substances in sludge line and identify efficient treatments**

Material and methods

• Micropollutants selection and analytical methods

Family of substances	Substances	Preparation/Extraction	Analytical techniques
Hormones (5)	17β-estradiol, 17α-ethinylestradiol, estriol, 17α-estradiol, estrone	ASE-SPE	HPLC/MS/MS
PCB (8)	CB 50+28, CB 52, CB 101, CB 118, CB 153, CB 138, CB 180	Microwave assisted extraction	GC/ED-GC/MS
Metals (14)	Aluminium, titane, chromium, manganese, iron, nickel, copper, zinc, arsenic, selenium, silver, cadmium, lead, mercury	-	ICP-MS
PDBe (20)	BDE 7, BDE 15, BDE 17, BDE 28, BDE 47, BDE 49, BDE 66, BDE 71, BDE 77, BDE 85, BDE 99, BDE 100, BDE 119, BDE 153, BDE 154, BDE 183, BDE 206, BDE 207, BDE 208, BDE 209	Microwave assisted extraction	GC/ED-GC/MS
Alkylphenols (6)	4-nonylphenol monoethoxylate, 4-nonylphenol diethoxylate, 4-nonylphenol, 4-ter octylphenol, 4-nonylphenoxyacetic acid, 4-ter butylphenol	SPE and SPME	LC/MS/MS and GC/MS
Polycyclic Aromatic Hydrocarbons (19)	Naphtalene, dibenzothiophene, phenanthrene, anthracene, acenaphthylene, acenaphthene, fluorene, fluoranthene, pyrene, benzo(a)anthracene, chrysene + triphenylene, 2,1 benzo-naphtothiophene, benzo(b+j+k)fluoranthene, benzo(e)pyrene, benzo(a)pyrene, perylene	SPME	GC/MS
Others (10)	Lindane, benzothiazole, tertbutylphenol, galaxolide, tonalide, di-butylphthalate, pentachlorophenol, triclosan, DEHP, bisphenol A	ASE-SPE	GC/MS

• Sampling methodology

- Difficulty : sample a representative quantity of the batch to follow

Definition of an audit protocol for drying processes

- Number of elementary samples and sampling frequency calculated with formulas given in the European standard NF EN ISO 5667-13:1998
- With V the "batch" volume
- With Q the volume of the batch, G the maximal flow in the dryer and n_{sp} the number of samples

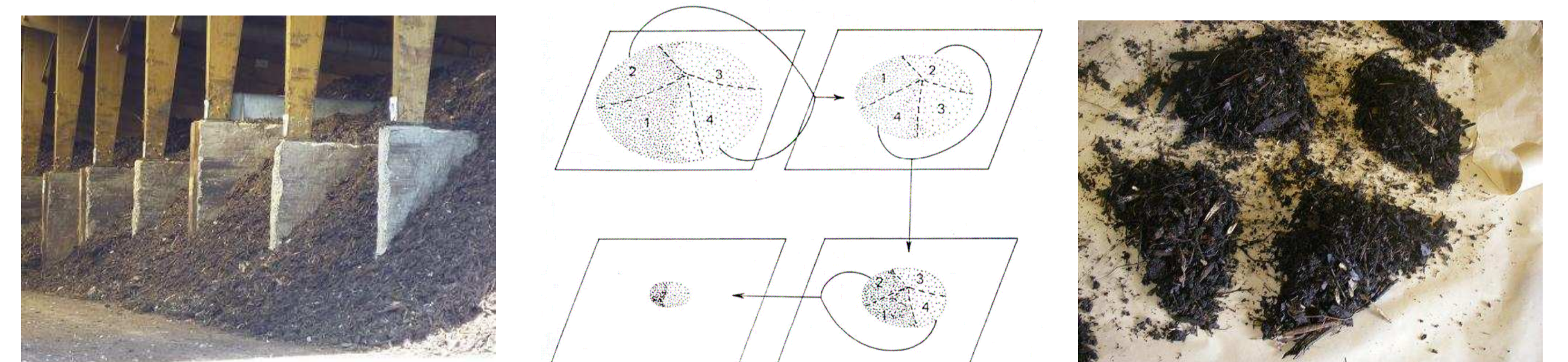
$$n_{sp} = \frac{\sqrt{V}}{2} \quad t = \frac{60Q}{Gn}$$



Definition of an audit protocol for composting processes

- Number of elementary samples and sampling frequency calculated with formulas given in the European standard NF EN ISO 5667-13:1998
- Coning and quartering method (ISO 5667-13:1998)

$$n_{sp} = \frac{\sqrt{V}}{2}$$



• Sludge treatment facilities

Four sludge treatment facilities were selected: two thermal drying facilities, and two composting facilities

Type of dryer	Type of sludge	Temperature (°C)	SRT (h)	Inlet sludge load (m3/d)	Inlet sludge load (kg DM/d)	Condensates (m3/d)
High temperature indirect palette dryer	Mixed sludge	120	5	76	27840	48
Low temperature direct belt dryer	Single activated sludge	72	1,8	144	45072	90

Type of composting	Type of sludge	Aeration	Mecanical turnover	Duration (months)	Compost production (T/year)
Confined compartment	Mixed sludge	Hot air recirculation	Yes	1	3150
Tunnel	Mixed sludge	Forced aspiration	Yes	2	15000

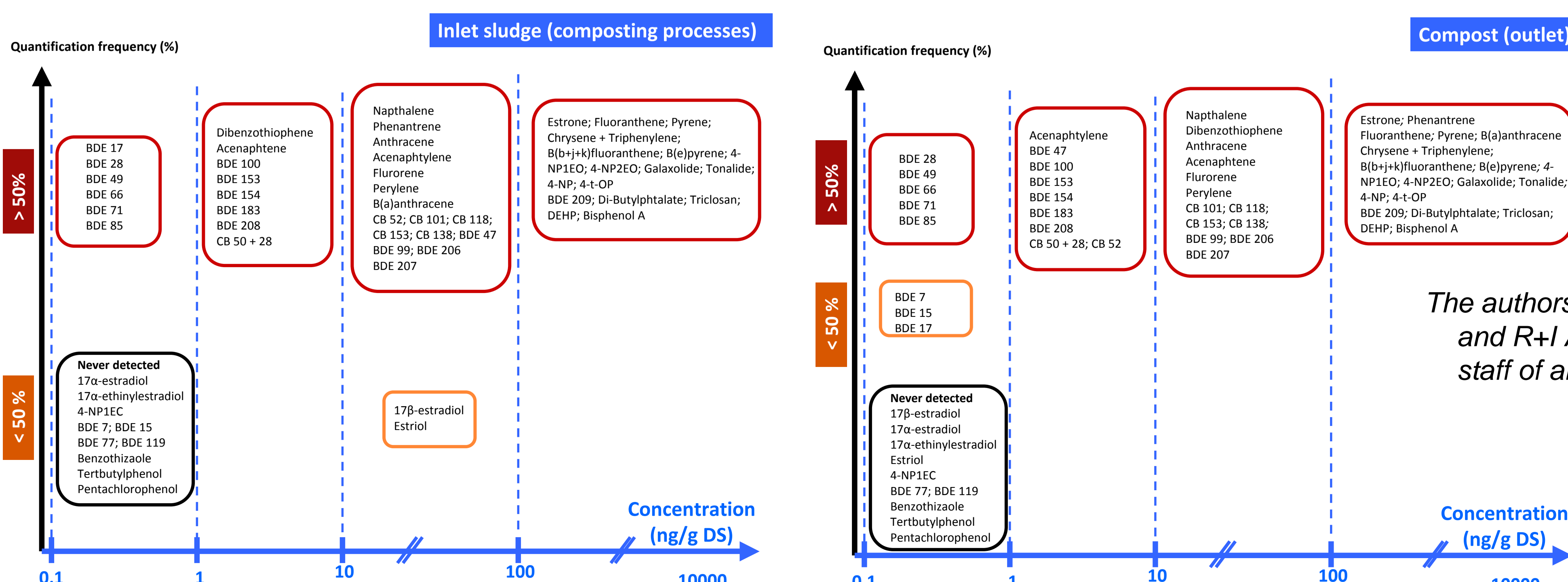
Results and conclusions

Drying : High temperature dryers tend to reduce the concentration in sludge of a higher amount of compounds, but complex phenomena : temperature and sludge retention time (Henry's constant), type of drying (adsorption and adhesion forces), type of sludge, history of dryer

Composting : Most of the analysed substances were detected in the raw sludge (inlet of the composting), hormones (except estrone) are never detected in the compost, some PCBs and PBDEs have lower concentrations in compost than in raw sludge, HAPs have a variable behaviour

Families of substances	High temperature indirect dryer	Low temperature direct dryer
PCBs	CB101, CB138, CB153, B180	-
PBDEs	-	BDE99
PAHs	Naphtalene	
	Acenaphthylene, Acenaphthene	Acenaphthylene, Acenaphthene
	Fluorene	-
Other PAHs : variable behaviour		
Alkylphenols and derivatives	NP1EO	NP1EO
	-	NP2EO
Musks	Galaxolide, tonalide	Galaxolide, tonalide
Other organics	DEHP, triclosan	
Metals	Al, Ti, Cr, Mn, Fe, Ni, Cu, Zn, As, Se, Ag, Cd, Pb	-
	Hg	Hg

"R > 30%"	Concentration significantly reduced in sludge
"- 50% < R < 30%"	No significant change
"R < -50 %"	Potential accumulation in sludge



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