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Occurrence and fate of xenobiotics in sewage sludge and in sludge-amended soils

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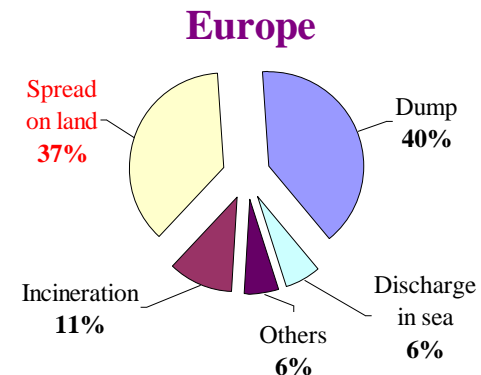
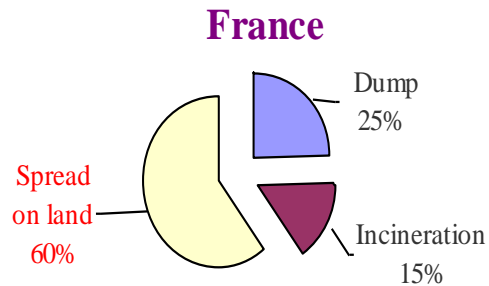
www.biowaste.dk

Wastewater treatment and sewage sludge production...



- over 50.000 ww treatment plants
- ~ 7.9 millions tons of dry solids (2000)
- Amount will increase

... and sewage sludge disposal



Are there Xenobiotics in wastewater ????

Yellow and brown water



Industrial water

Storm water



Grey water



WWTP

Rivers, sediments



Soils, groundwaters



Effluents

Sludges

...and where do they accumulate ???

because of low water solubility
of high affinity for organic matter

Goals of the project

Xenobiotics



Sewage sludge spreading
on agricultural land



Environmental and human risks, public concern

- Contamination of ecosystems and natural resources (soil, water, air)?
> *Ecotoxicological risk assessment*
- Drinking polluted waters and eating polluted foods?
> *Sanitary risk assessment*



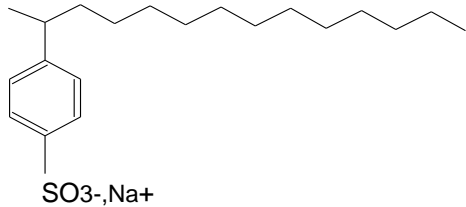
Occurrence of xenobiotics in SS

Litterature survey and analysis of european SS

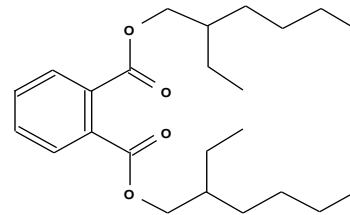
Fate of xenobiotics in sludge amended soils

From Lab-scale to field experiment

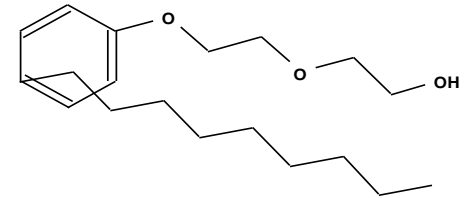
Xenobiotics assessed in the project



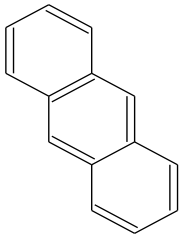
Linear alkylbenzene sulfonate (LAS)



Phthalates



Nonylphenol ethoxylate (NPE)



Polycyclic aromatic hydrocarbon (PAH)

- Listed in EU legislation
- Level of concentration
- High toxicity (ED)
- Low biodegradation
- Persistence

Litterature survey and analysis

Measurement in water, soil and sediment

Less information in sludge

Various level of concentrations

diverse analytical methodologies (no std)

industrial wastewater

rain runoff collection

population size

type of WW treatment (AS, filters)

type of SS (primary, secondary)

type of SS treatment (AD, composting)

time (date, season, day)

Occurrence of xenobiotics in SS

Typically found concentration in EU SS	3rd draft of the SS EU Directive
LAS : 100 - 15000 mg/kg DW	2600
NPE : 25 - 500 mg/kg DW	50
Phthalates : 10 - 600 mg/kg DW	100
PAH (16) : 0.1 - 10 mg/kg DW	6
for other : less than 1 mg/kg to µg/kg	

Fate of xenobiotics in sludge amended soils

Lab-scale experiments : microcosms and radiolabelled molecules



Unpolluted soil as control
Soil spiked with labelled ^{14}C -xenobiotic
Soil amended with a diverse spiked SS
 non-transformed SS
 anaerobically treated SS
 anaerobically and composted SS

Adsorption - bound residus ?

Volatilization ?

Degradation - metabolites ?

Transfer to water or plant (radish) ?

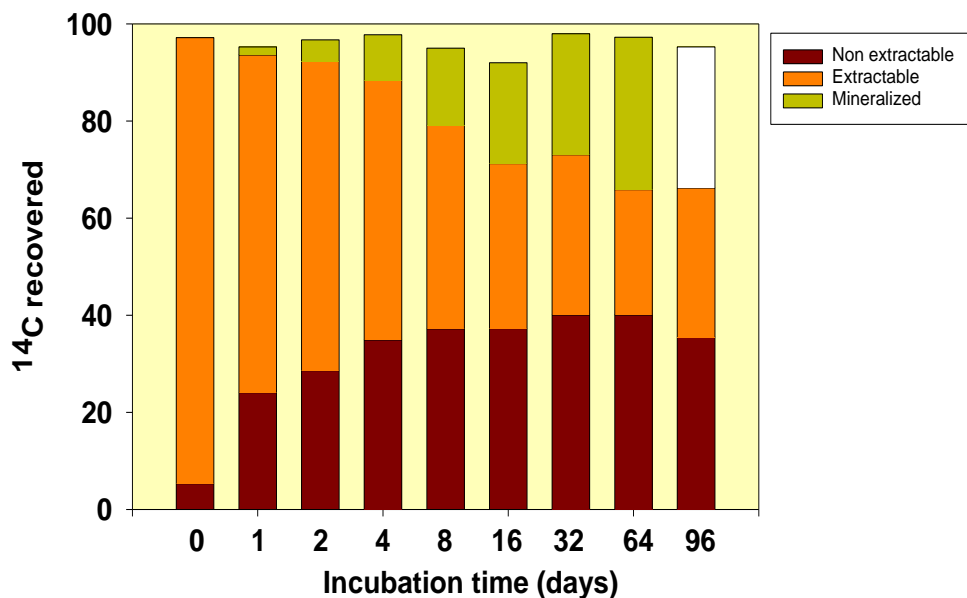
Impact on bacterial and fungal communities ?

Fate of xenobiotics in sludge amended soils

Lab-scale experiments : microcosms and radiolabelled molecules

NP spiking on soil

27 g dry silt loam sieved at 2 mm
 40 mg/kg t-NP*, 80 % MHC, 25°C, darkness



¹⁴C-balance +
 HPLC analysis:

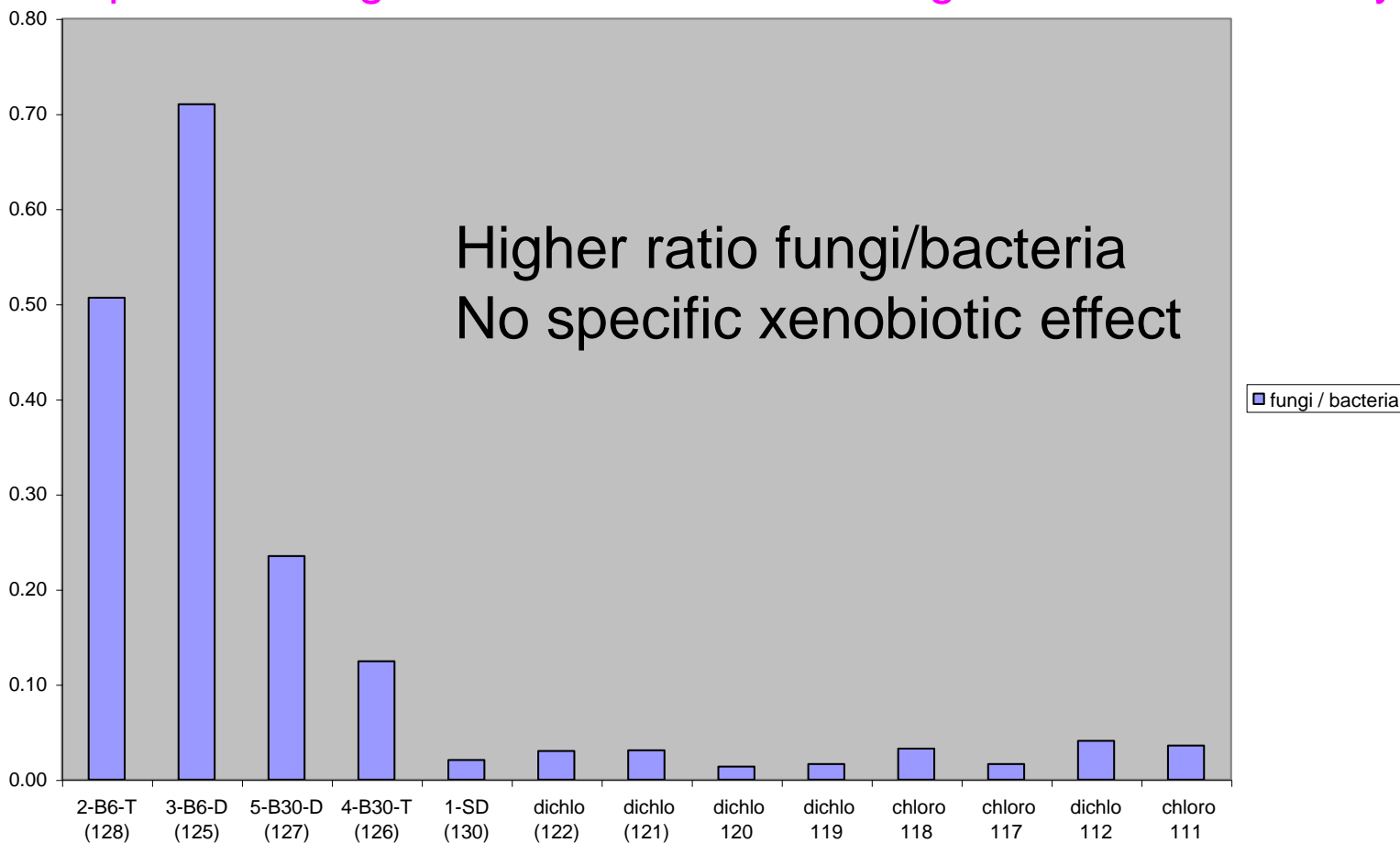
T_{1/2} ≈ 4 days

- Fast dissipation
 mineralization
 formation of bound residus
- Strong impact of the SS
 delay of degradation
 higher adsorption
 half life of 16 d and more
- Low transfer to the plant
 less than 9% radioactivity
 metabolites ?
- Impact on microorganisms
 higher PLFA concentration
 higher ratio fungi/bacteria

Fate of xenobiotics in sludge amended soils

Lab-scale experiments : microcosms and radiolabelled molecules

Impact of sludge amendment on microorganisms : PLFA analysis



Fate of xenobiotics in sludge amended soils

Field experiment

Experimental maize crops, Bordeaux, France

Sludges addition **100 tons sludges/ha/2yr** (total 1000 tons)

← Sampling →

← →

1974

1993

2004



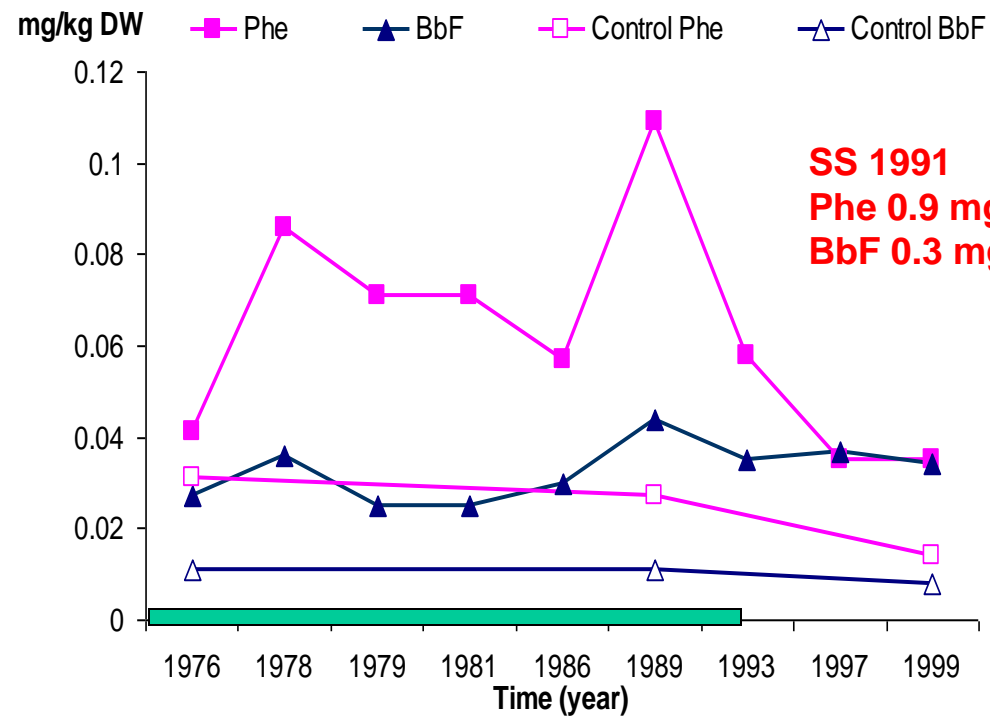
Analysis of LAS, NPE,
Phthalates and PAH



Fate of xenobiotics in sludge amended soils

Field experiment

Results on PAH



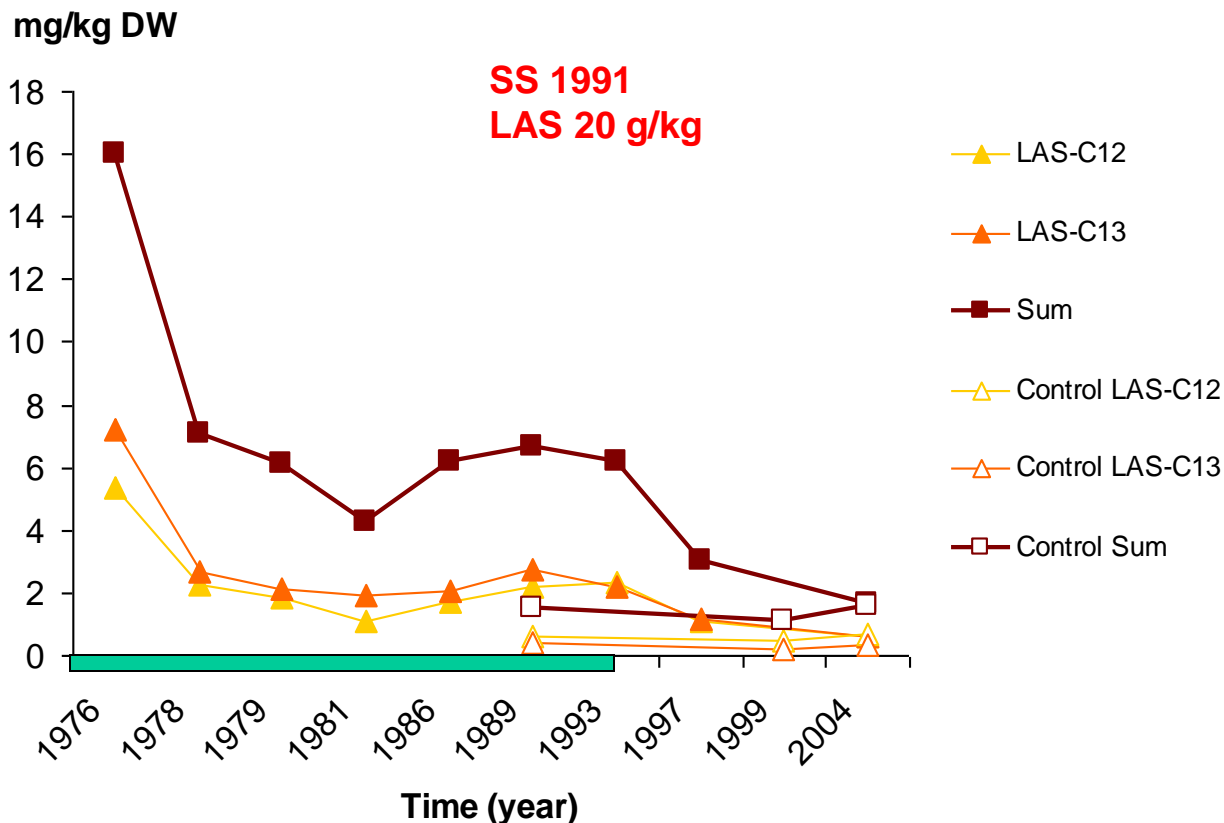
- PAH concentration 2-5 x higher in sludges-amended soils.
- Levels increase during sludges addition.
- Levels still high 7 years after end of sludges addition.
- Different behaviour towards molecular weight

Long term impact of high molecular weight PAH

Fate of xenobiotics in sludge amended soils

Field experiment

Results on LAS



- Higher LAS concentration in SS
- Decrease and stabilization
Adaptation - degradation - mobility?
- Decrease to background level after 10 years

Higher degradability (or mobility?)...
....less residual concentration in soil

- **Development of new methods for Xenobiotics analysis**
 Overview of occurrence and level of xenobiotics in EU SS

- **Fate in soil**
 Fate of X in sludge-amended soil is adsorption-degradation dependant
 Low transfer to plant and water
 Long term soil accumulation of xenobiotics after sludge spreading for the less degradable and most hydrophobic compounds

- **Impact**
 Be careful to the mixed effect : sludge and xenobiotics in sludge
 Measured effect at even high load of SS. What about at normal load?

Thank you for your attention



» Men walked on the moon, now it's time they learn how to walk on earth... «
[Henri de la Bretèche]