What about transfers and effects of edaphic pollutants, on the restoration of peatlands ?

G. CHIAPUSIO, P. BINET, B. DAVID

Symposium on may 15-16 th, 2017, "Retours d'expériences de restauration et de valorisation de tourbières de plaine".

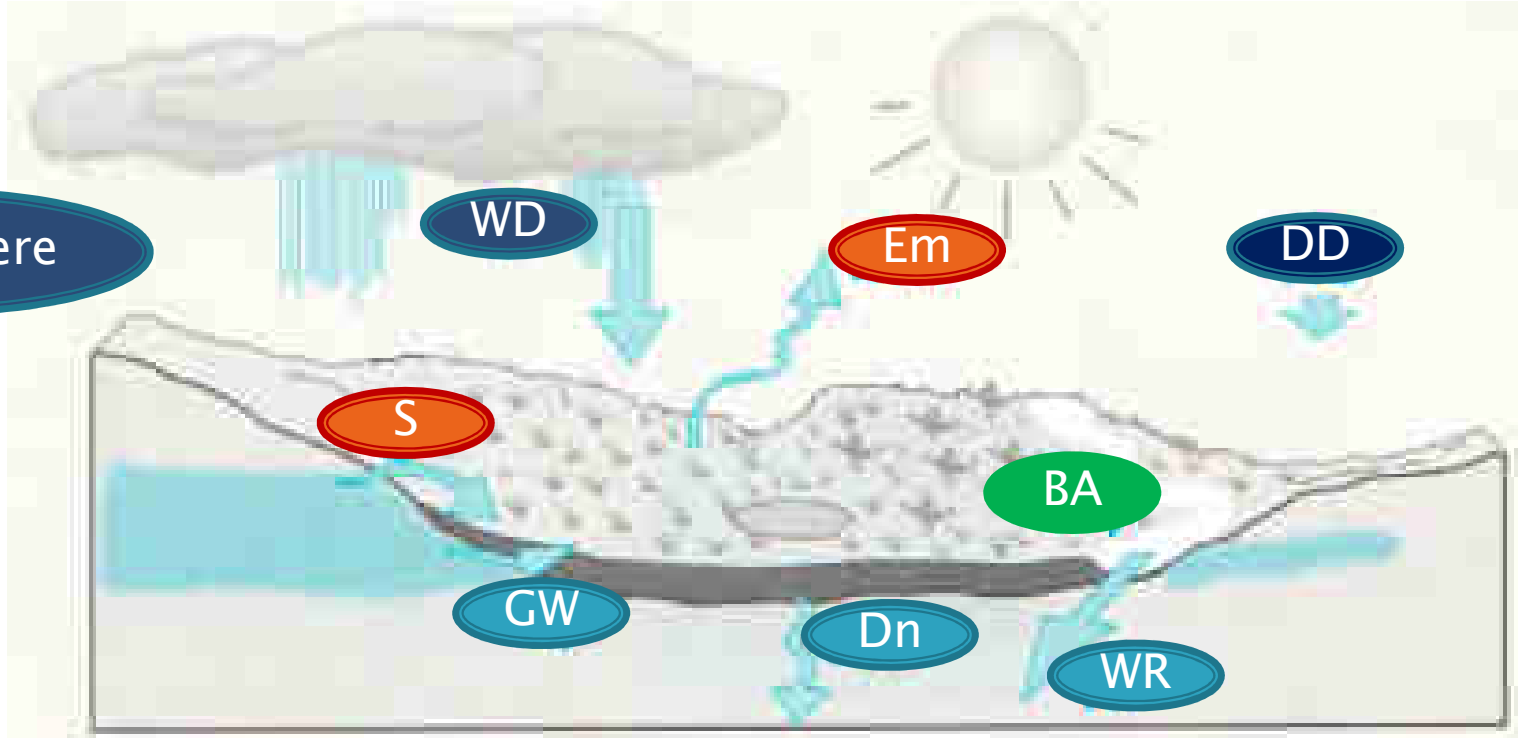
Current data on pesticides

- **France** is presently the first European consumer of plants protection products, with 100 000 T/year used = 33 % of herbicides + 56 % of fongicides.

- **Consequences** : health risk for farmers, risks on terrestrial and aquatic ecosystems and on the development of resistant organisms.

- **Key role of soil**: main sink for pesticides, before any transfer in water for hydrosoluble compounds or in vegetation .

Which transfers from edaphic pollutants ?



WD : Wet Deposition (rainfalls)

DD : Dry Deposition

GW : Ground Water
Dn : Drainage,

WR : Water Runoff

Em :Emission from soil

BA : BioAccumulation, phytoremedialtion

Aadapted from J.Durfort (2007) Bilan hydrique des tourbières.

Preliminary study of pesticides in the peatland of Chautagne

- 11 molecules recovered in the water of drains (CEN, Savoie) :

- Triazines → **atrazine, terbuthylazine** (*forbidden sale*)
- Chloroacétamides → **acetochlor, metolachlor** (*forbidden sale*)
- Benzoxazines → **benoxacor**
- Diazines → **bentazone**
- Acides benzoïques → **dicamba**
- Dérivés d'acides aminés → **glyphosate**
- Tricétones → **mesotrione, sulcotrione**
- Chloroacétamides → (*forbidden sale*),
- Sulfonylurées → **nicosulfuron**

Goal of the preliminary study

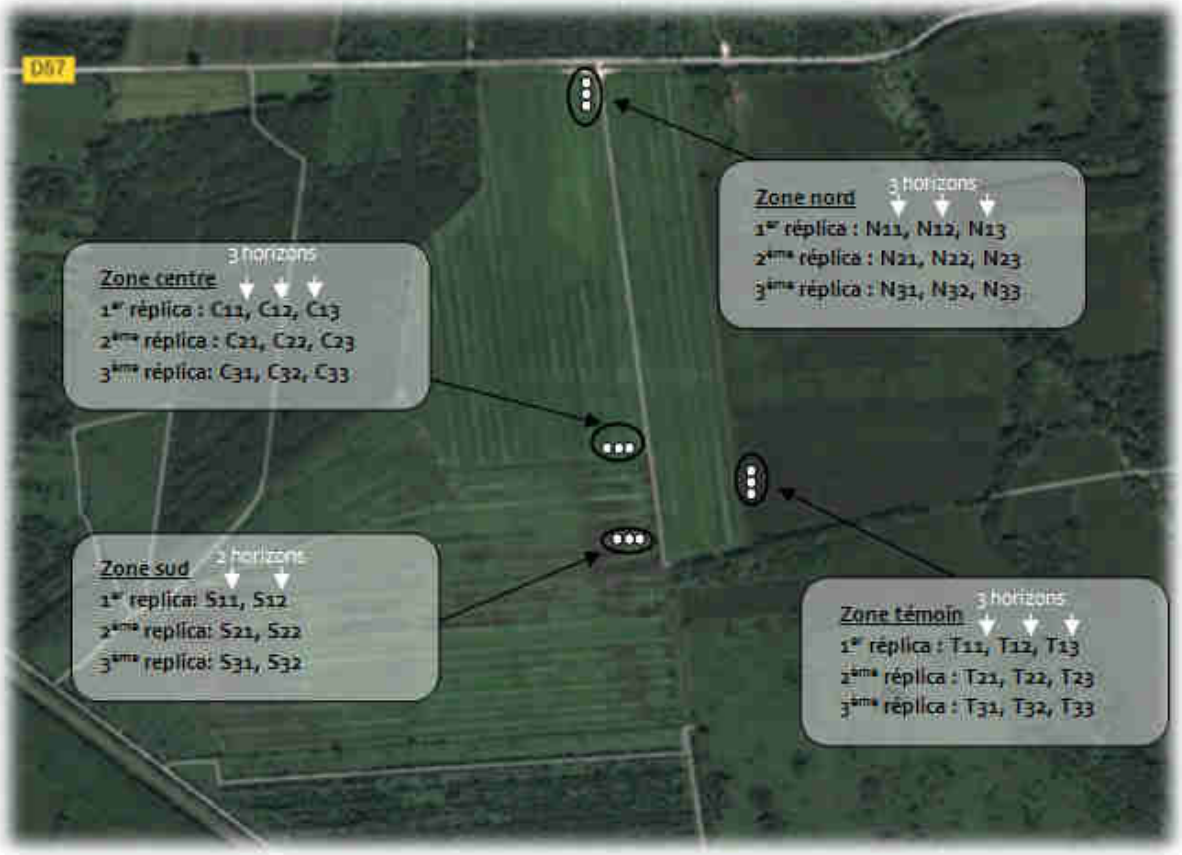
- Work done by MSc Students at UFC, Montbéliard (Supervisors G Chiapusio, P Binet) : Aline Grosclaude, Mathieu Petitjean, Laura Schmitt

1- synthesis of the physicochemical properties of the 11 recovered pesticides in water,

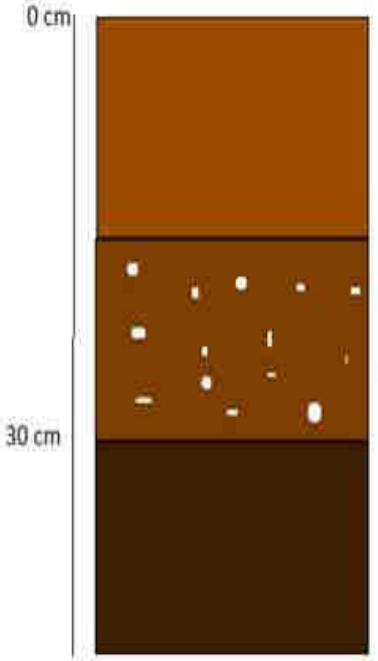
2- preliminary results of soil contamination by pesticides, with one sampling date (march 2016).

Focus on Atrazine and Metolachlor

Soil and sediments sampling



6<pH<7,6



LO (organic)
OM: 30-40%

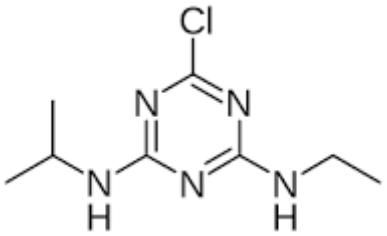
LS (clay + with calcareous fragments)
OM: 30-40%

Hs (peat)
OM: 60-70%

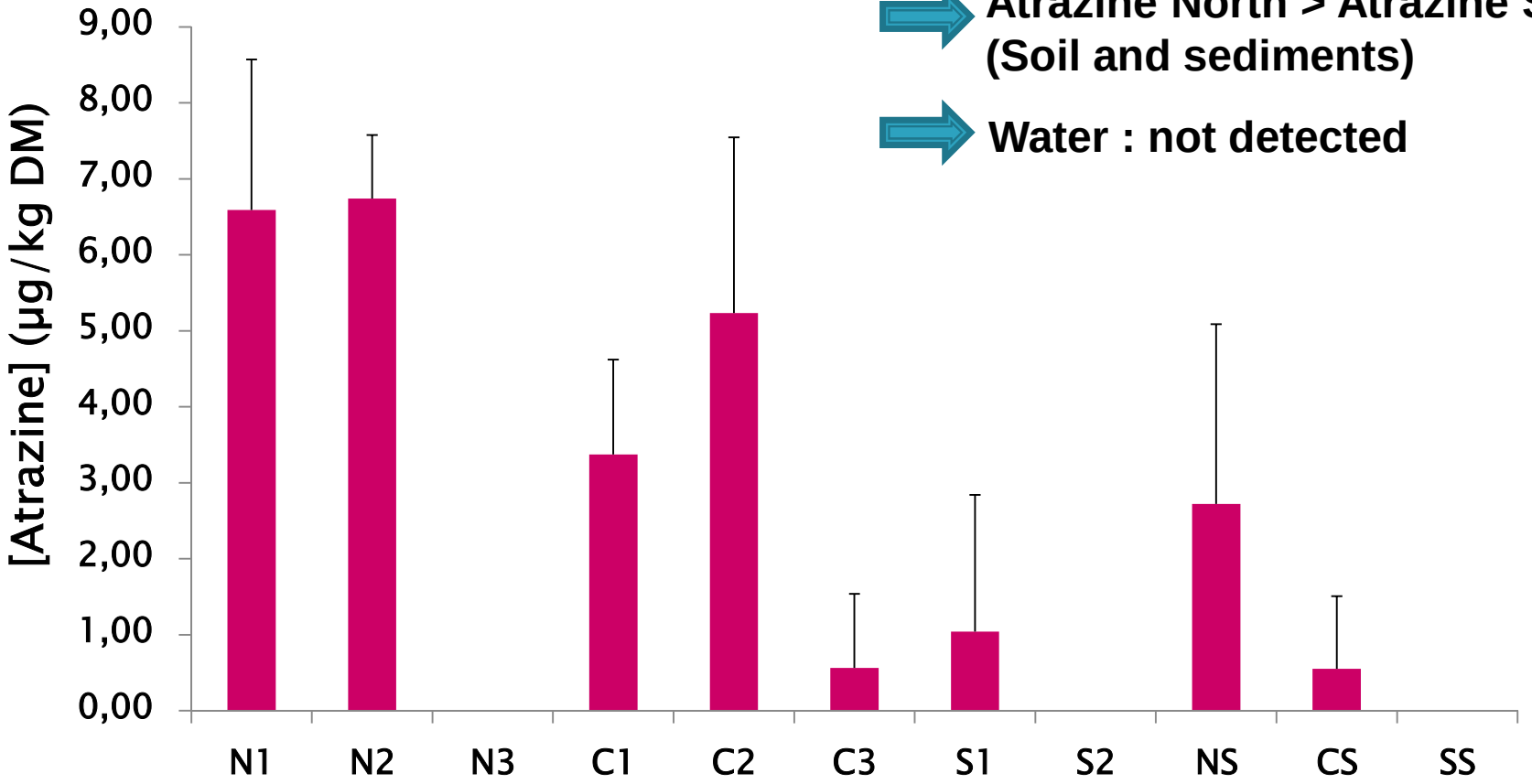
Sampling : march 2016

- ✓ ASE extraction (hexane/acetone)
- ✓ GC/MS quantification

Atrazine

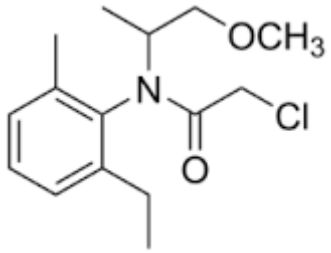


- Only trace in the control
- No difference between horizons
- Atrazine North > Atrazine South (Soil and sediments)
- Water : not detected

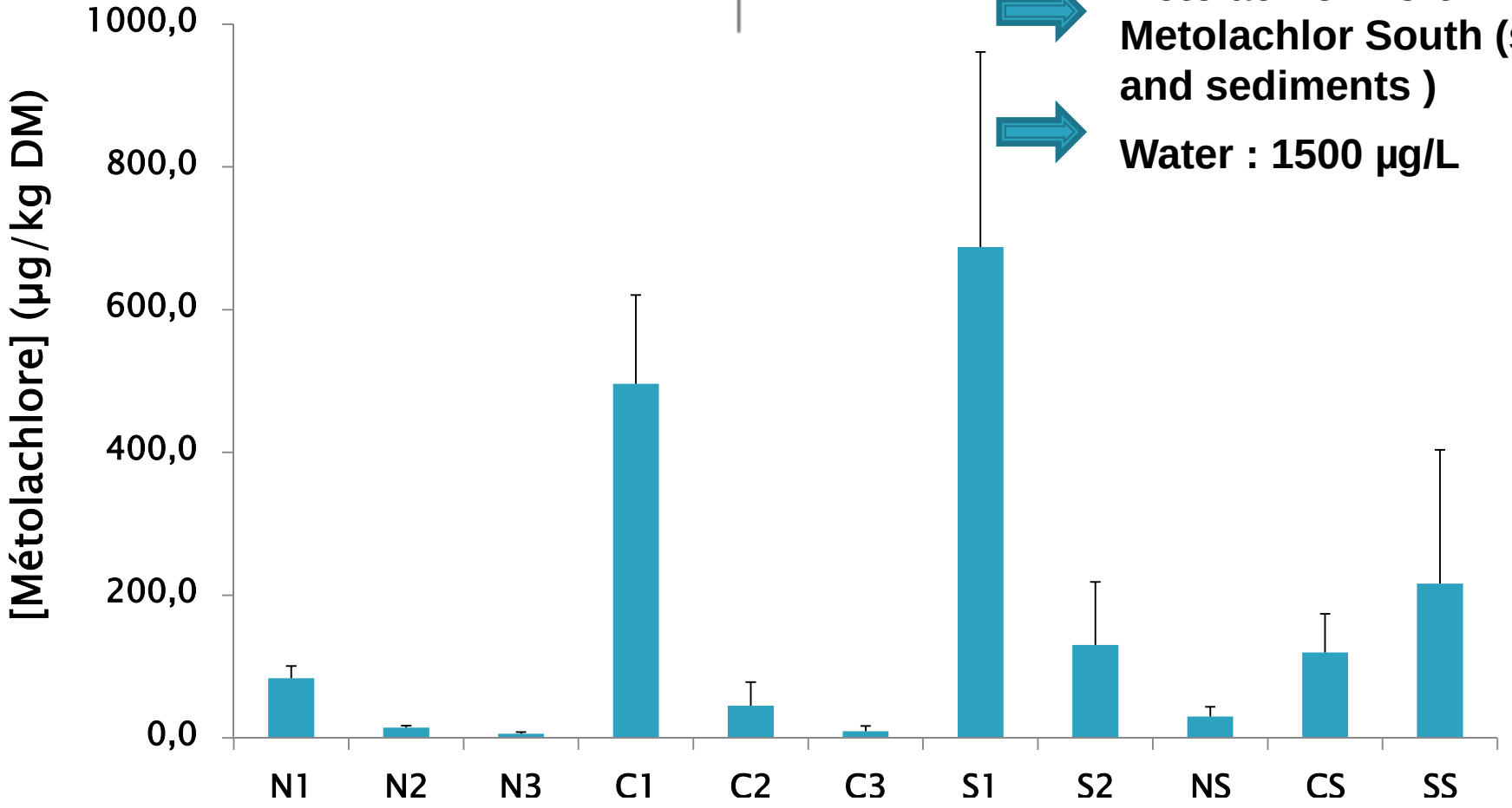


Preliminary results

Metolachlor



- Only trace in the control
- Difference between horizons (max. at 10cm)
- Metolachlor North < Metolachlor South (soil and sediments)
- Water : 1500 µg/L



Preliminary results

Discussion

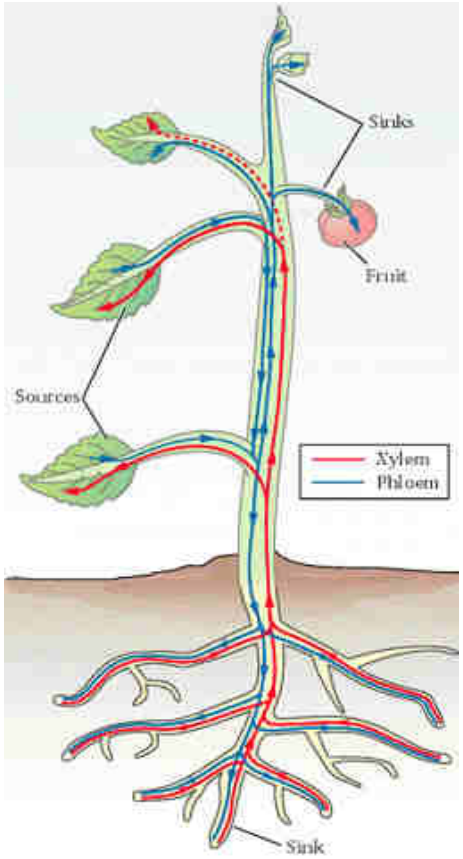
- Atrazine (6µg/kg) : metabolites (products of Atrazine degradation) ?

- Metolachlor : maximum recovered at 10 cm (700 µg/kg) showing a slow adsorption in soils, transfer into water.

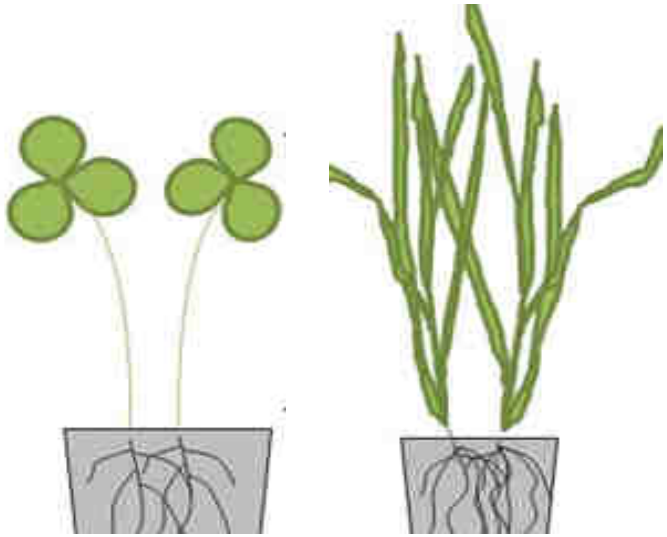
- Observed gradient North / South : which differences ? acidification ? organic matter ? clay ? water ?

In soils, pesticides are linked to organic matter and clay. They are transformed/detoxified by microorganisms or found as bound residues (non extractable residues).

Transfer into the Vegetation



Aerial organs (+%)



Bound residues also found in plants !

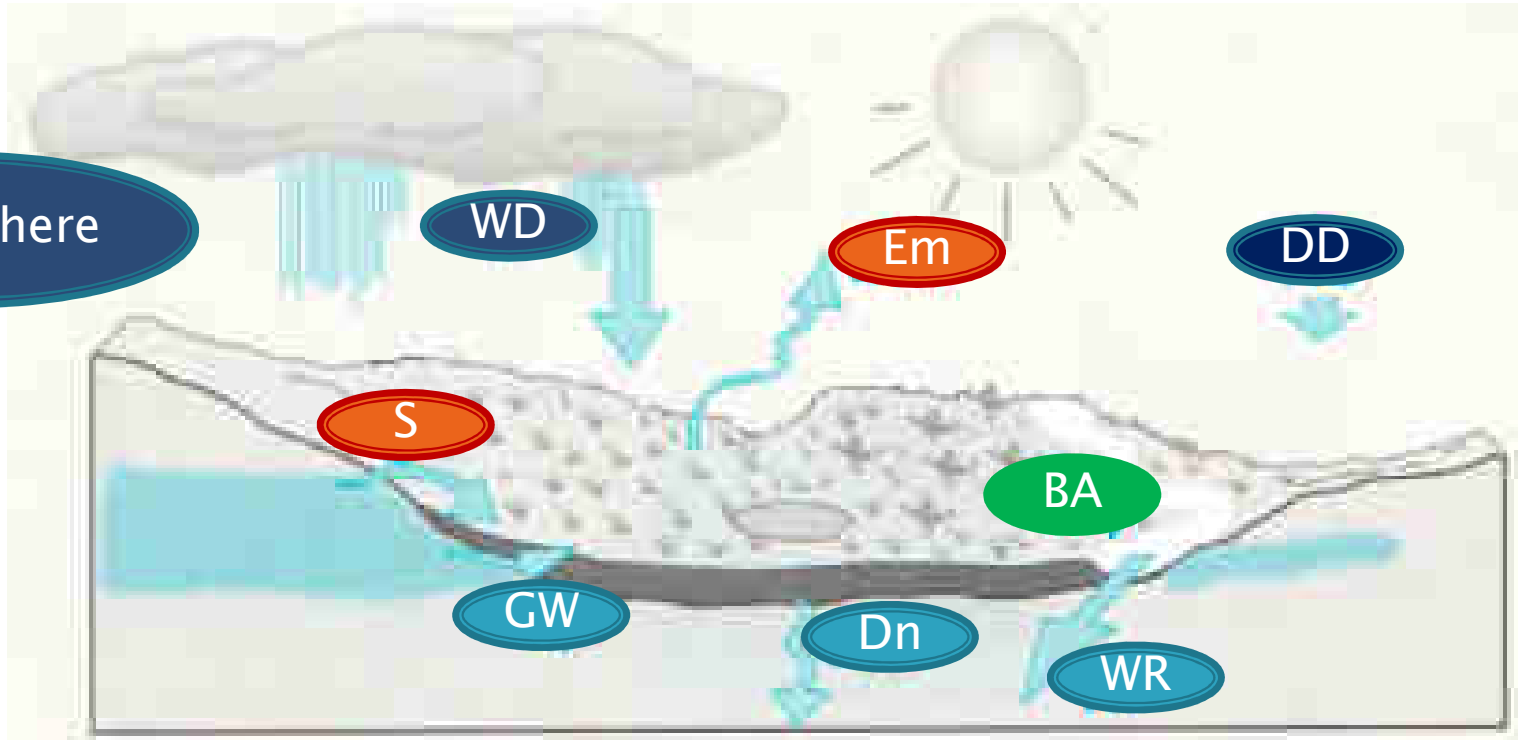
Differences between A. monocotyledons and A. dicotyledons

Underground organs : sink organs (+++%)

depend on soil characteristics

- ✓ **Different physiological impacts on the natural vegetation**
- ✓ **Natural grassland can increase microbial pesticide degradation**

Which transfers from edaphic pollutants ?



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Soil

Em :Emission from soil

Water

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Vegetation

BA : BioAccumulation, phytoremedialtion

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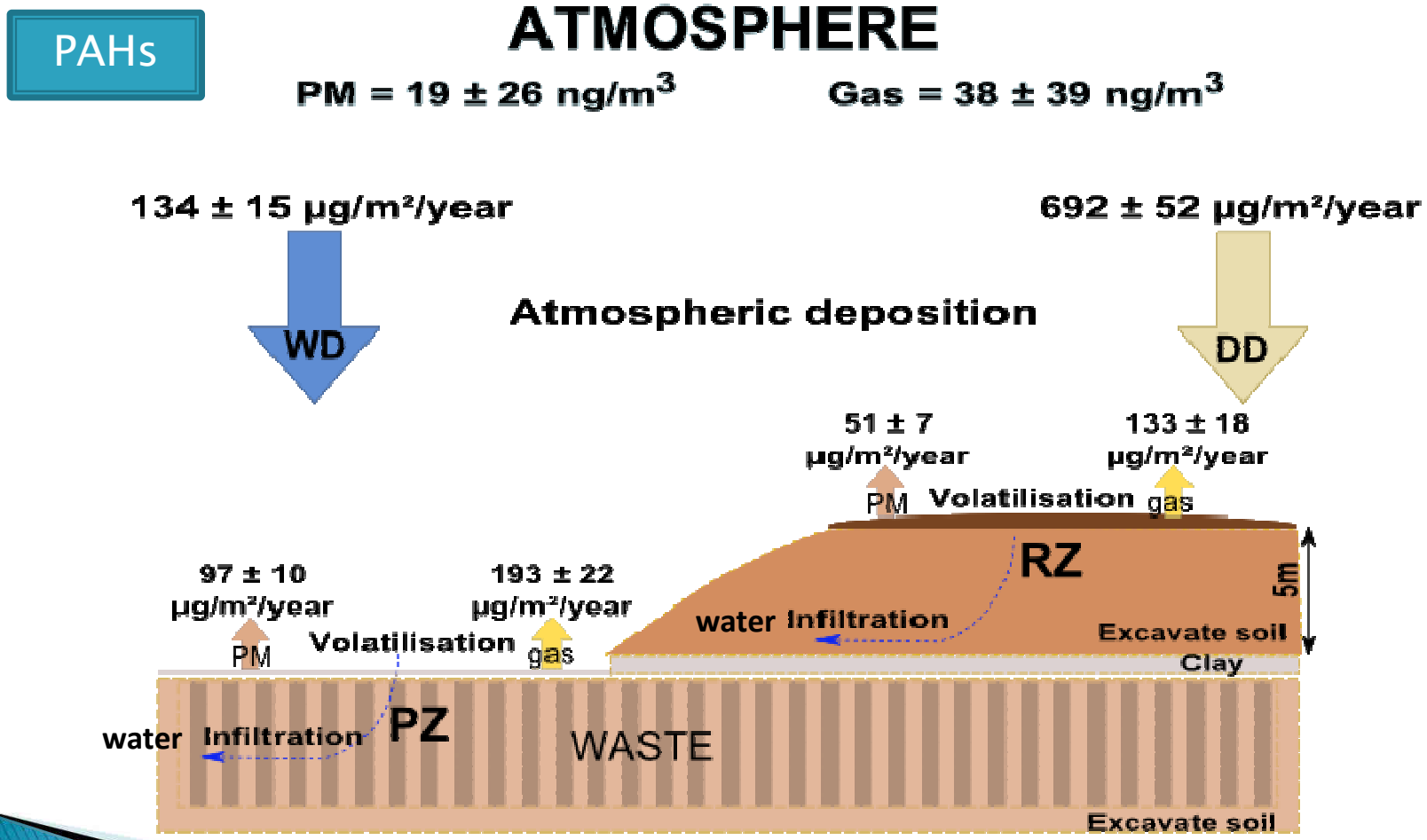
How ?

Methodology for estimation of pesticides flows, transfered from soil to the atmosphere, on different sites (Savoie – France).

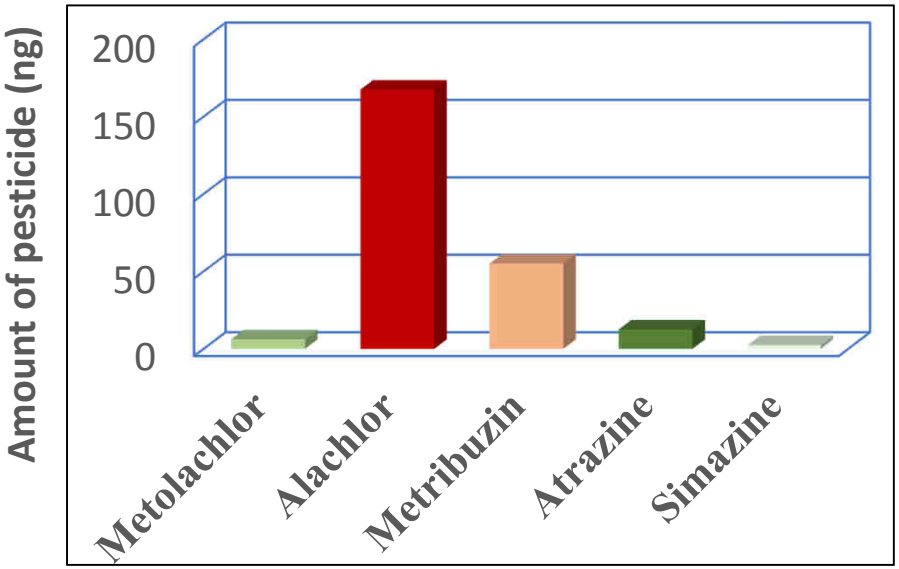
Mass balance of pollutants: PAH, PCB, dioxines, furanes, metals and pesticides.



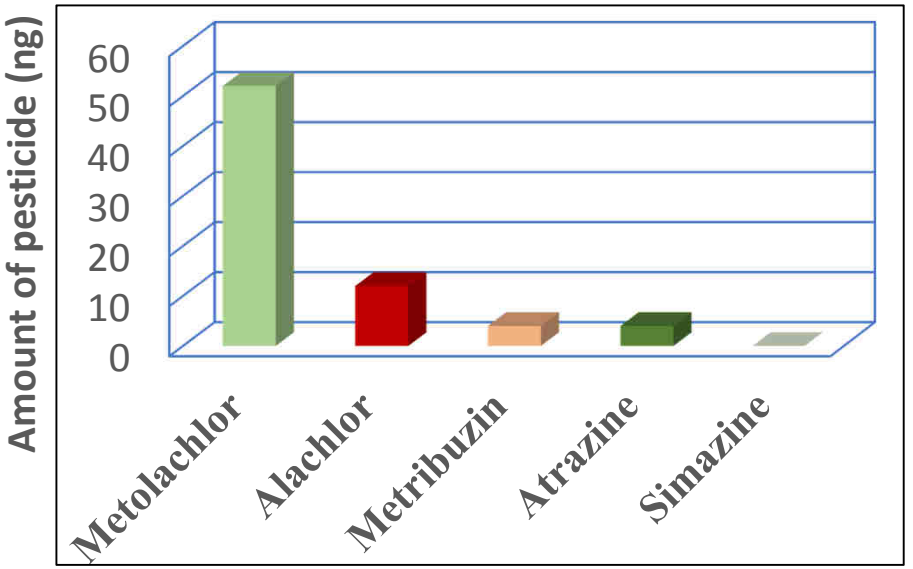
Example of a former landfill

At the soil-air interface : case of pesticides

Presence of pesticides in the atmosphere (rural & urban) => Are soils a secondary source of such persistants polluants? Is there a long range atmospheric transport, namely «Grasshopper» effect ?



Gas phase



Particulate phase

Σ 5 Pesticides in soil = 25 µg/kg dry soil

- **Total (gas + particles) pesticides flows :**
  - Alachlore = 2,2 ng/m²/h — 0,5 year
  - Métribuzine = 0,7 ng/m²/h — 1,1 year
  - Métolachlore = 0,1 ng/m²/h — 7,8 years

Duration time :
complete volatilization
by emission…only !

How to study these processes?

- Very few results on peatlands in the literature.

- Models used :
  - Partition coefficients :
    - $K_{soil/water} = C_{soil}/C_{water}$
    - $K_{soil}/_{vegetation} = C_{soil}/C_{vegetation}$
    - $K_{soil/air} = C_{soil}/C_{air}$

    vs K_{ow}, f_{oc}, K_H, K_{OA}…

  - Fugacity (f) : trend of a chemical to leave its original medium (Lewis 1901, MacKay 2001).

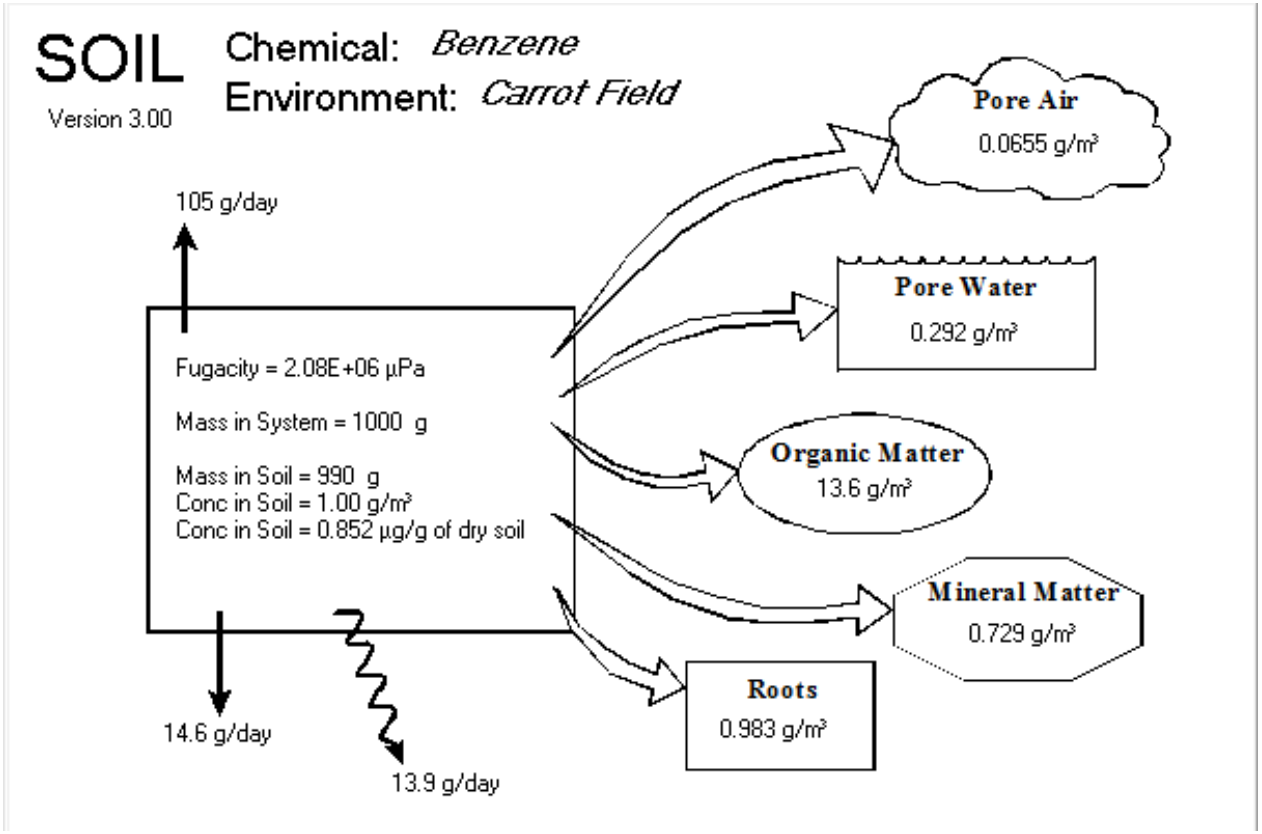
At low concentration : $C_i = Z_i . f_i$

Cte, whatever the medium

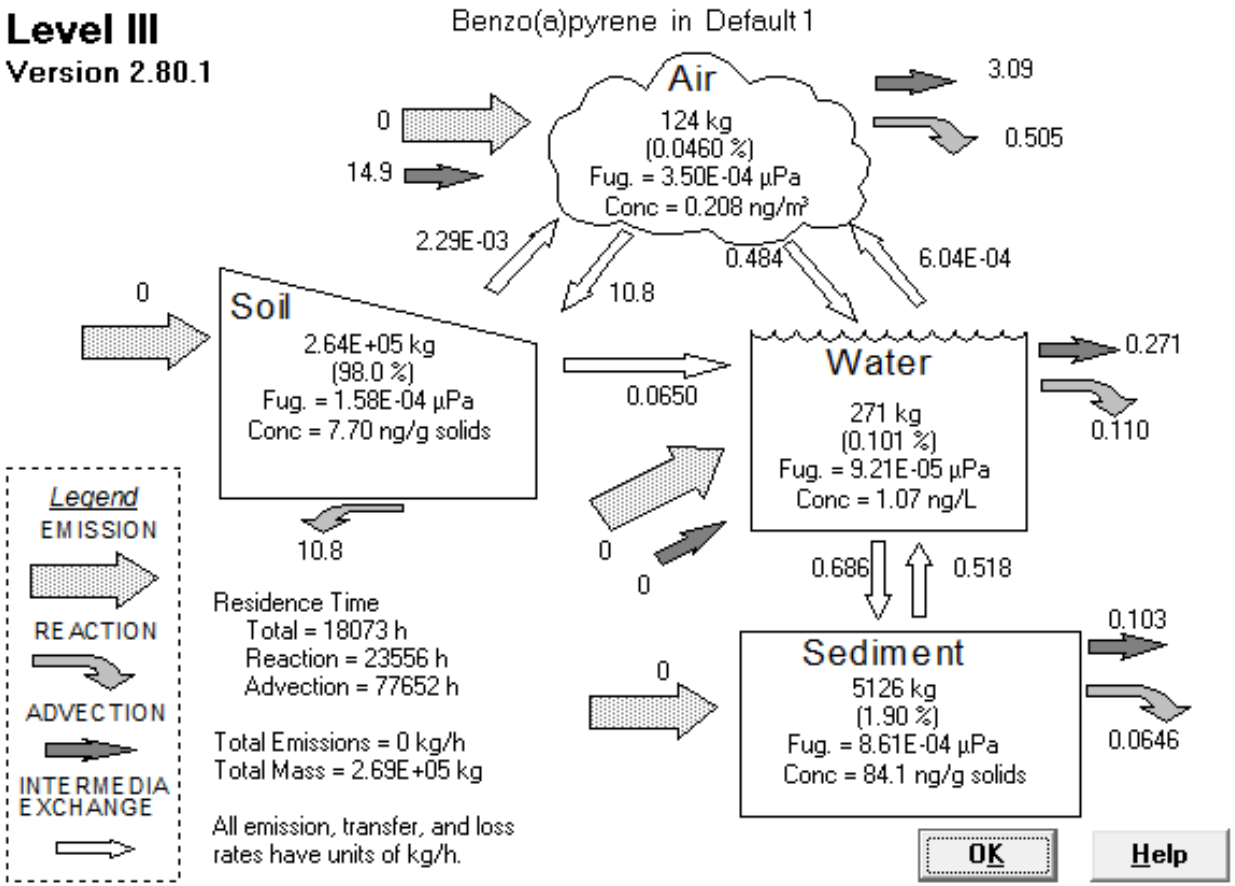
experimental

known expression

Model SOIL


SOIL
Version 3.00
Chemical: Benzene
Environment: Carrot Field
105 g/day
Fugacity = 2.08E+06 µPa
Mass in System = 1000 g
Mass in Soil = 990 g
Conc in Soil = 1.00 g/m³
Conc in Soil = 0.852 µg/g of dry soil
14.6 g/day
13.9 g/day
Pore Air
0.0655 g/m³
Pore Water
0.292 g/m³
Organic Matter
13.6 g/m³
Mineral Matter
0.729 g/m³
Roots
0.983 g/m³

Model LEVEL


Level III
Version 2.80.1
Benzo(a)pyrene in Default 1
Air
124 kg
(0.0460 %)
Fug. = 3.50E-04 µPa
Conc = 0.208 ng/m³
0
14.9
3.09
0.505
2.29E-03
10.8
0.484
6.04E-04
Soil
2.64E+05 kg
(98.0 %)
Fug. = 1.58E-04 µPa
Conc = 7.70 ng/g solids
0
0.0650
Water
271 kg
(0.101 %)
Fug. = 9.21E-05 µPa
Conc = 1.07 ng/L
0.271
0.110
10.8
0
0
0.686
0.518
Sediment
5126 kg
(1.90 %)
Fug. = 8.61E-04 µPa
Conc = 84.1 ng/g solids
0
0.103
0.0646
Legend
EMISSION
REACTION
ADVECTION
INTERMEDIA EXCHANGE
Residence Time
Total = 18073 h
Reaction = 23556 h
Advection = 77652 h
Total Emissions = 0 kg/h
Total Mass = 2.69E+05 kg
All emission, transfer, and loss rates have units of kg/h.
OK
Help

Scientific issues

- Alcaline peatlands : high amount of organic matter where pollutants are expected to be highly sequestered. In which amount ? what is the turn over/remobilisation ?
- With time, is the peatland a source or a sink for pollutants?
- Restoration : What will be the biogeochemical consequences of a rise of water on the peatland ?
  - Mechanisms of transfer and transport of pesticides: solubilisation, adsorption, volatilization ?
  - Mechanisms of bioaccumulation by natural vegetation and responses of microbial communities ?
- Scientific studies in collaboration with local managers are necessary in order to propose fundamental and practical useful indicators.
- Chautagne is a unique model site !