

## CARTHAGE Project

The Contribution of Air to Risks and Transfers  
associated with PAH in Urban Agriculture: calculation of new  
bioconcentration factors in edible plants

Karen PERRONNET, Etienne CATRY, Roseline BONNARD – Health Risk Assessment Unit,  
[karen.perronnet@ineris.fr](mailto:karen.perronnet@ineris.fr), [etienne.catry@ineris.fr](mailto:etienne.catry@ineris.fr)

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# Introduction

## Growing practice of urban agriculture in France



**Lack of data** about pollutants (i.e. Polycyclic Aromatic Hydrocarbons - **PAH**) in edible vegetables, soil and air in urban areas

**On-site experiments** conducted on 3 urban community farms around Paris Area to obtain Bioconcentration Factors (soil-plant and air-plant)

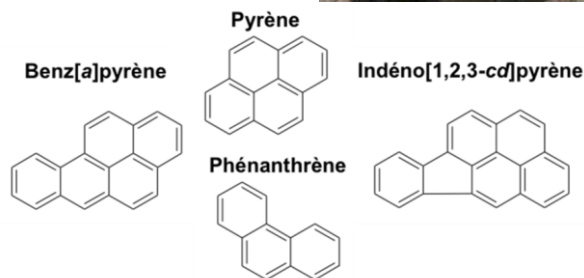
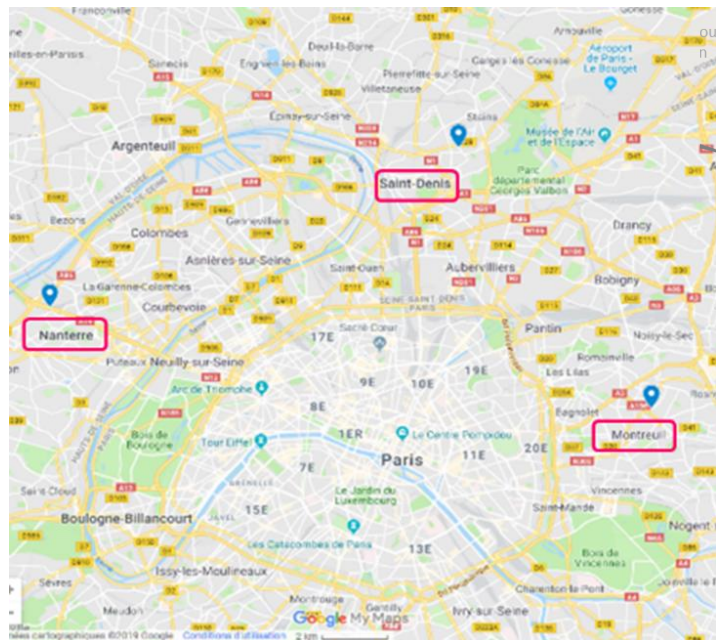


**Pathway model** : use equations given by the French software **Modul'ERS** to compare field and modeled data

**Give operational recommendations regarding the management of urban agriculture when PAHs are quantified in soil and air.**

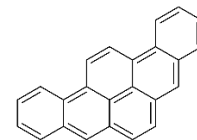


# French farms locations and PAHs origin

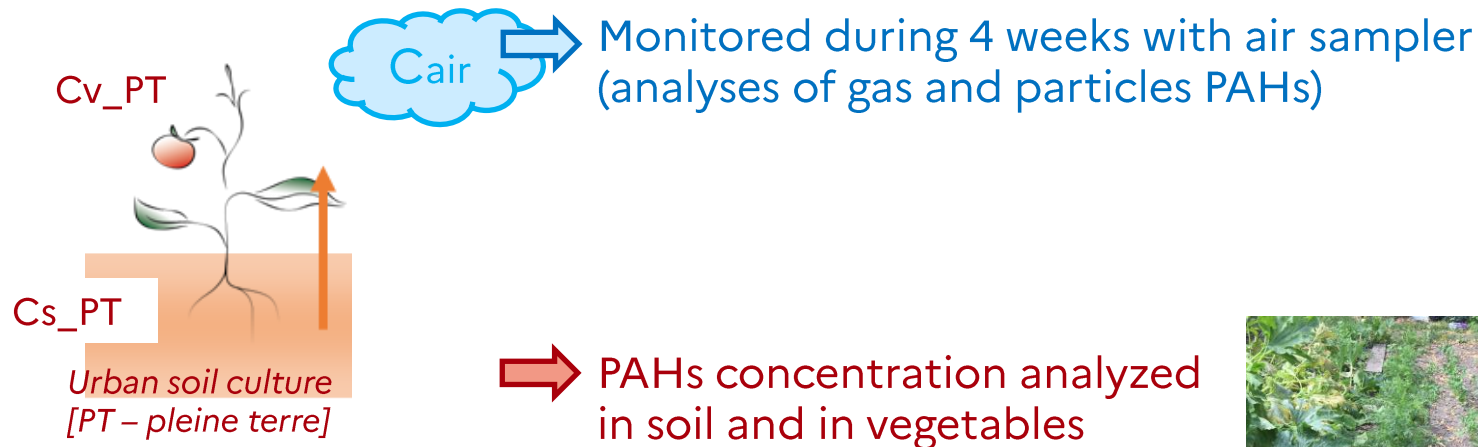


→ 18 to 24 PAHs analysed in exposure media:  
soil, air, irrigation water, vegetables

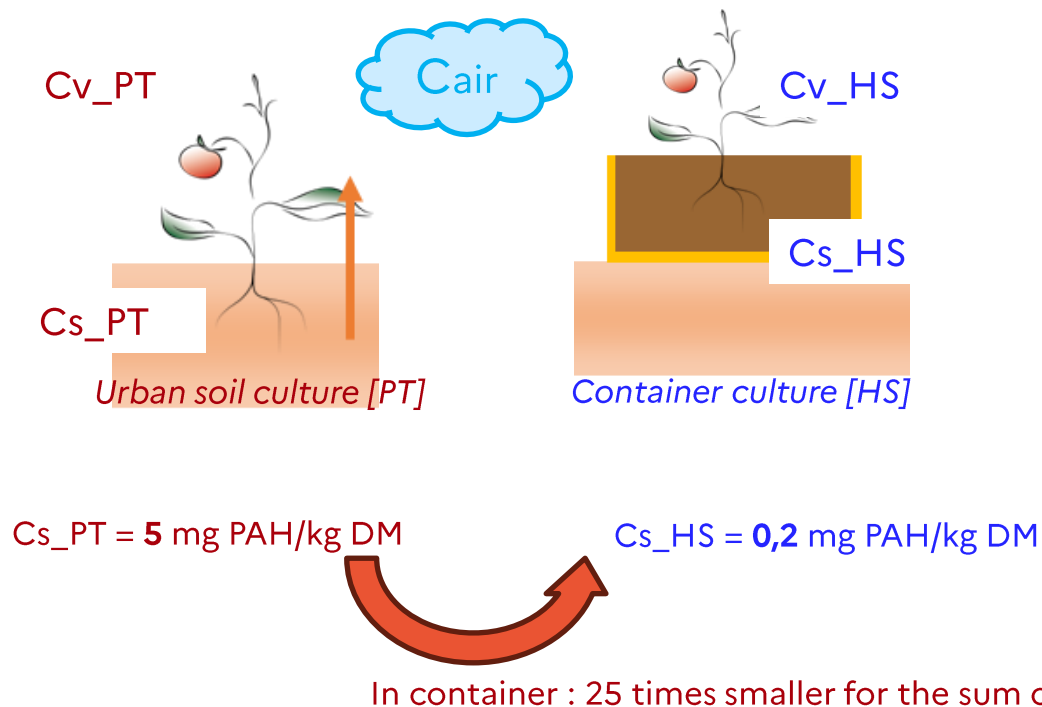
enclosed also 4 unusual PAH (6 rings):  
Dibenzopyrenes (a,l) (a,e) (a,i) (a,h)



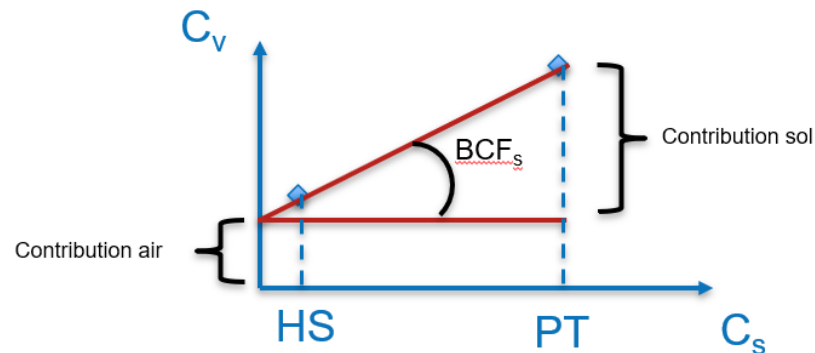
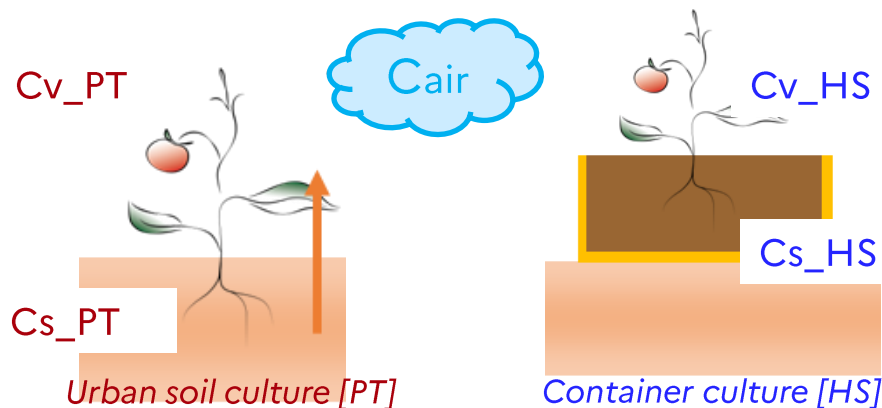
# Air and soil Bioconcentration factors (BCF)



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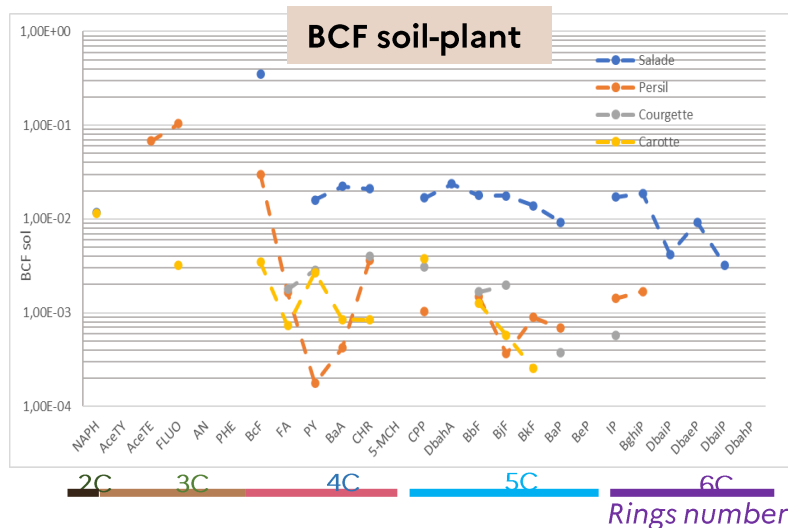
$$BCF_{sol} = \frac{(C_{v\_PT} - C_{v\_HS})}{(C_{s\_PT} - C_{s\_HS})}$$

$$BCF_{air} = \frac{(C_{v\_PT} - BCF_{sol} \times C_{s\_PT})}{C_{air}}$$

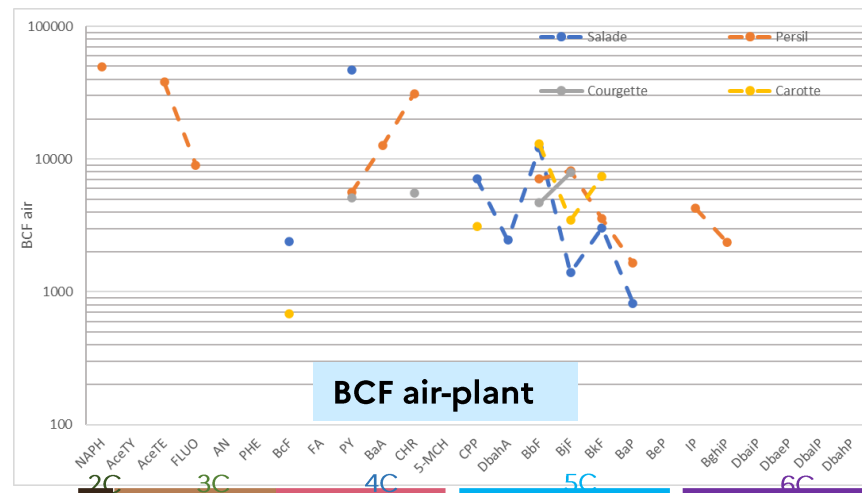
$C_{air}$  = gas and particles PAHs

# PAHs BCF

Mean values for the 3 farms (washed vegetables), log scale



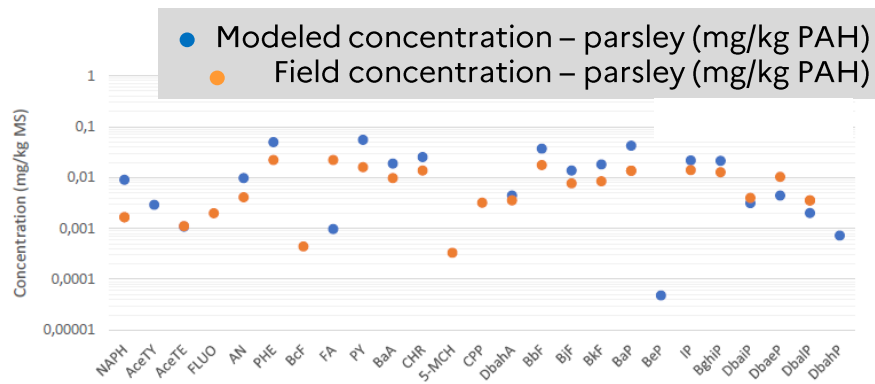
- ✓ **49** BCF soil-plant
- ✓ Higher values for **salads**
- ✓ Light decrease of values with increasing rings number



- ✓ **29** BCF air-plant
- ✓ Few values for light PAHs. No difference between vegetables
- ✓ Light decrease of values with increasing rings number
- ✓ Two BCF values for PAH with high number of rings (>5)

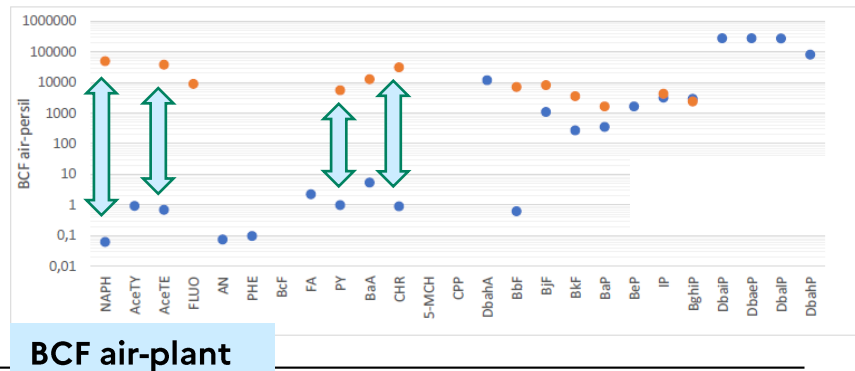
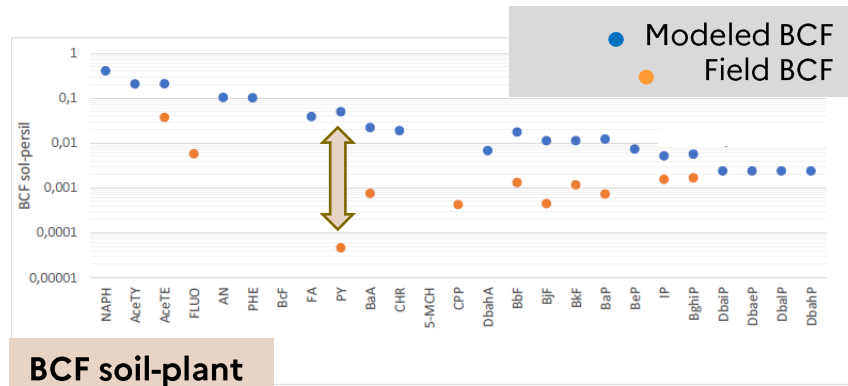
# PAH concentration in parsley

## Modeled concentrations versus field ones

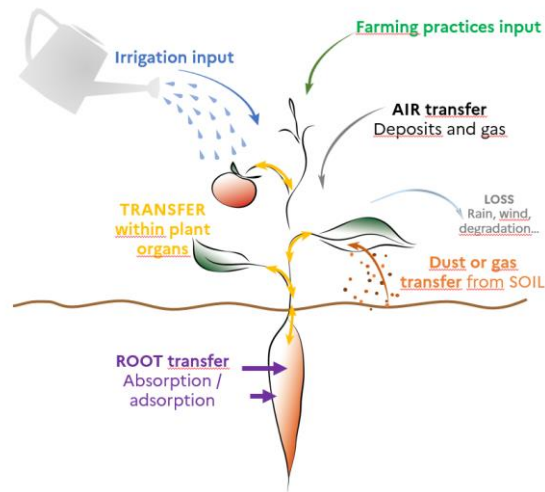


Transfers involved into the **modeled approach Modul'ERS**:

- root transfer (soil → plant)
- rainsplash (soil → plant)
- gaseous absorption (air → plant)
- airborne deposits (air → plant)



## Parsley



## Materials and methods | Results and discussion | Conclusion

- Modeled soil-plant BCF with Ineris tool MODUL'ERS

$$\log BCF_{soil\_leaf} = 1,588 - 0,578 \log(Kow) \text{ (Travis C. , 1988)}$$

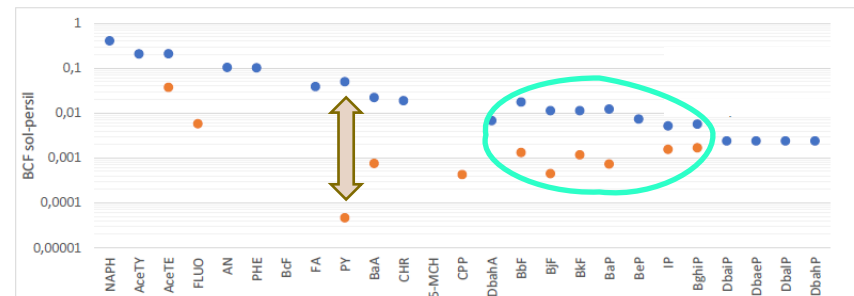
- Modeled air-plant BCF with Ineris tool MODUL'ERS

$$\log B_{vol} = 1,065 \log Kow - \log \frac{H}{R \times T} - 1,654 \text{ (Bacci, 1992)} \quad \text{and} \quad BCF_{air} = \frac{B_{vol}}{\rho_v}$$

Two Transfer equations used for PAHs' **concentrations** calculations but not involved in ModulErs **BCF** calculations :

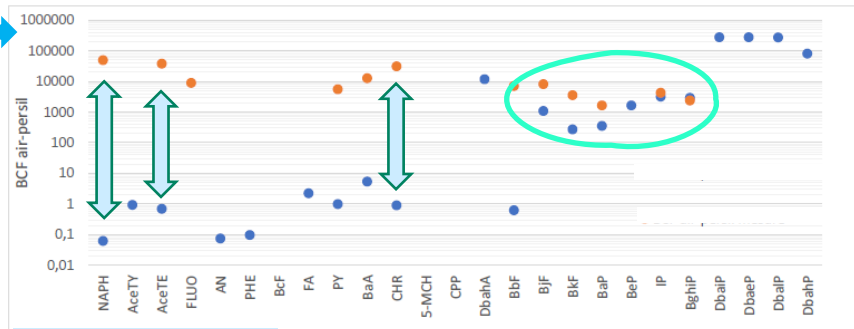
$$D_{pp} = D_{psp} + F_h \times D_{php} \quad (\text{particles deposits})$$

$$D_{p\_sol\_p} = C_{ap\_sol} \times v_{d\_psol} \quad (\text{Rain splash, ERMYN, US DOE, 2003})$$



BCF soil-plant

● Modeled BCF  
● Field BCF



BCF air-plant

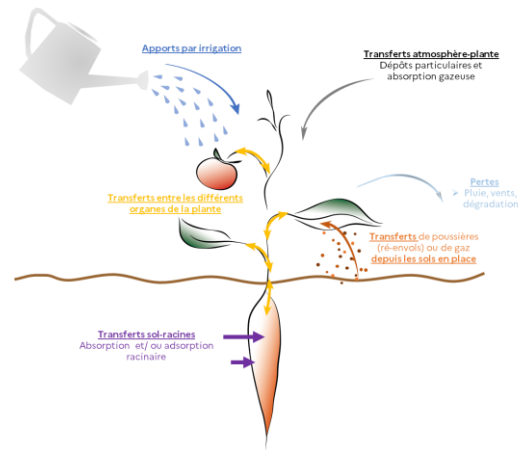
# Conclusions and recommendations (1/2)

## ➤ Transfers modeling for PAHs in edible plants :

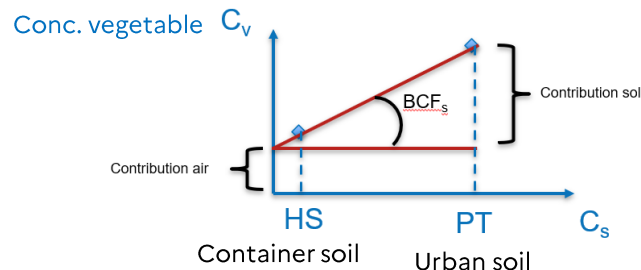
**Modeled concentrations** with empirical equations based on physico-chemical properties ( $K_{ow}$ , H) and **measured concentrations** in field were within the **same order of magnitude**, indicating consistency between results.

## ➤ Comparison of modeled and field BCF (soil-plant and air-plant) is not relevant as field BCF involve more transfer pathways (global indicator)

## ➤ Simultaneous experimentations performed with a light greenhouse **A** and protective covering **B** on soil didn't allow to specify contribution of each pathway of contamination (rainsplash / deposit)



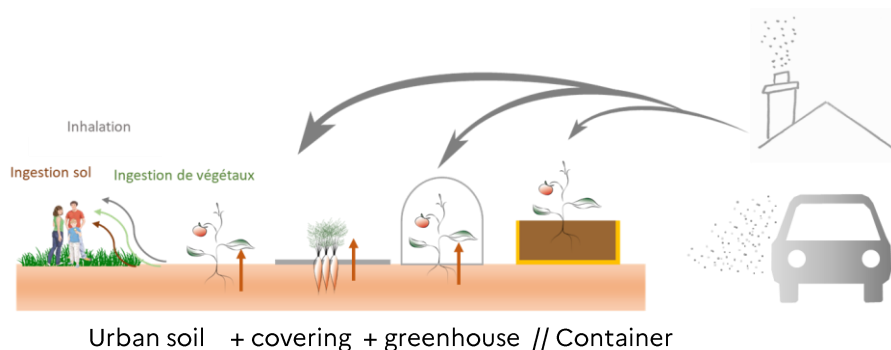
# Conclusions and recommendations (2/2)



## ➤ Current limits about BCF values:

Used approach suggests that BCF is constant with concentration levels in soil.

Remind that BCF values are valid for tested range of air/soil concentrations and may be over/underestimated for other soil and air values.



## Other project results:

Health risk assessment was conducted for workers and users, demonstrating low health risks when agricultural production and edible plants consumption occur in urban area

Generated BCF soil-plant and air-plant are integrated in French national database **BAPPOP (2024)**, collecting organic pollutants in exposure media from various papers and studies (soil, air, water, edible plants when known)



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FRANÇAISE**

*Liberté  
Égalité  
Fraternité*



*maîtriser le risque  
pour un développement durable*

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**Thank you for your attention**