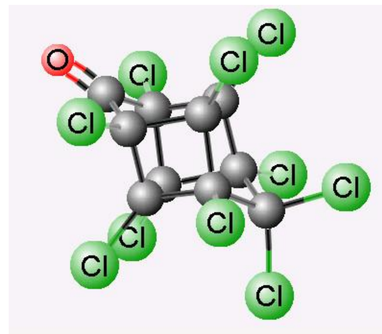
Pesticide transfer from soils to plants in tropical soils: influence of clay microstructure



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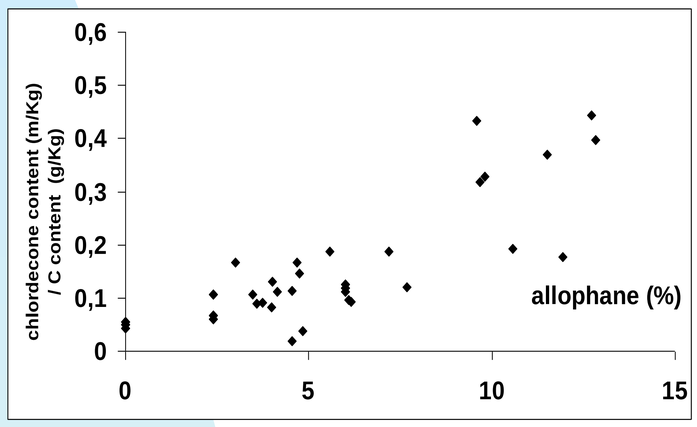
Introduction

Chlordecone is a very though pesticide which was used from 1971 to 1993 mainly for the control of the banana weevil in French West Indies (Guadeloupe and Martinique islands). Chlordecone pollution is now diffuse becoming new contamination source for crops and environment (water, trophic chain). Volcanic soils like andosols contain amorphous clays (allophanes), issued from the transformation of volcanic materials with very specific properties. Our hypothesis is that the clay microstructure characteristics could be a crucial physico-chemical factor governing the fate of the pesticide in the environment.

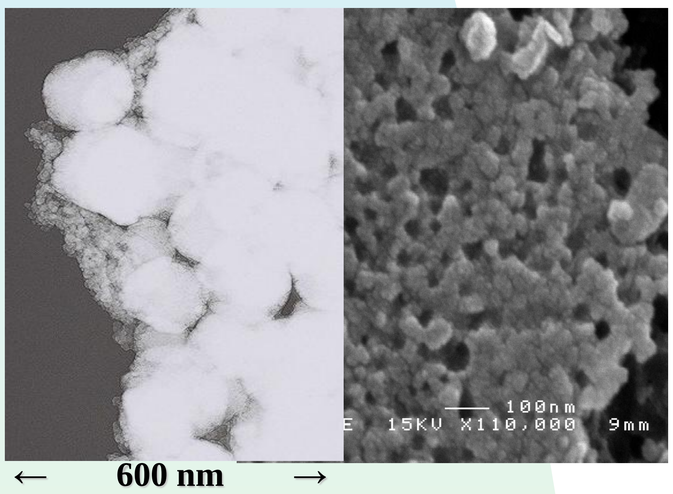


Soil pollutant content and properties vary with soil allophane content

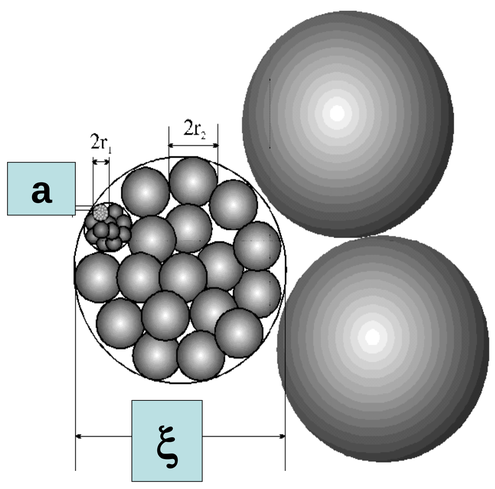
Chlordecone content doesn't depend only on high organic matter content in our volcanic soils. Allophane content is a key parameter.

Allophanes present drastically different structures and physical properties compared to usual clays: a very high poral volume (Vp) and an important pores surface too (specific surface S).

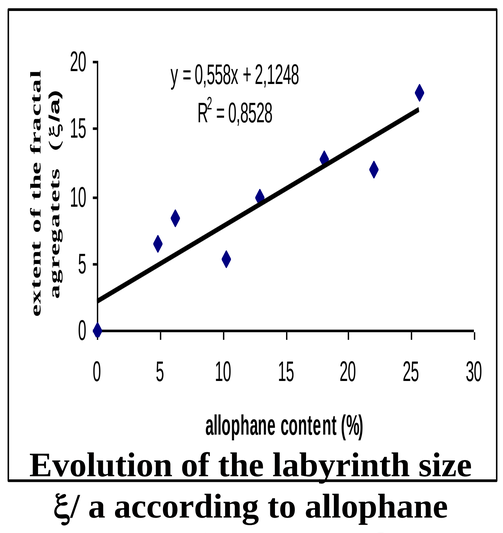
Fractal structure of allophane aggregates



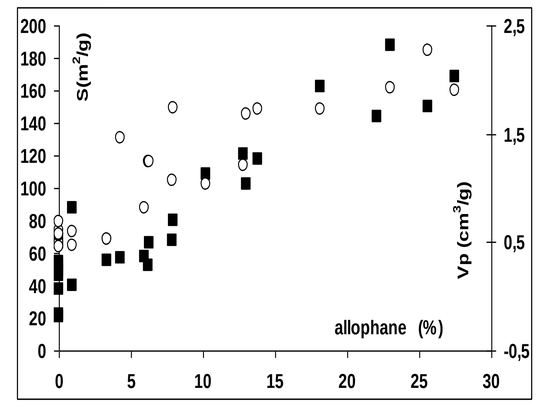
Electronic microscopy (TEM) of allophane aggregates



Fractal structure modelling for allophane aggregates



Evolution of the labyrinth size ξ/ a according to allophane content % (SAXS → Df= 2,7)



Evolution of the specific surface S and poral volume Vp, according to allophane content %

The fractal range increased with the allophane content.

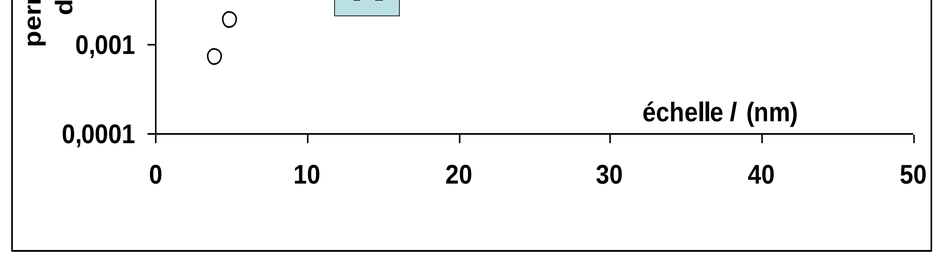
Modelling

Molecule transport in poral material depends on 2 parameters :
permeability K and diffusivity D.

- *K* depends on relative density ρ_r and on pores mean size *d* : $K \propto (1-\rho_r)\, d^2$
- D depends on P, the porosity and on t, the tortuosity: $D \propto P/t$

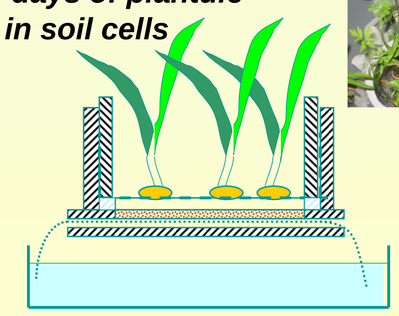
In the case of fractal aggregates, K(l) and D (l) decrease of several order ranges when the lenght scale decreases.

Thus, **chemical species inside the fractal aggregates are not accessible and are trapped by confinement.**



Crop transfer

Controlled conditions, after 20 days of plantule growth in soil cells



Extraction rate for carrot roots varied from:

- ***6,4 to 10,0% for andosol***
- ***31,1 to 32,1% for nitisol.***

At harvest, the mean transfer rate to sweet potatoes was ***proportional with the chlordecone soil content*** *and varied from* ***1,5% for andosol*** *to* ***3,1% for nitisol.***

Soil type had a great effect on the chlordecone availability in soil solution and its translocation into roots. We showed that allophane clay retained more pesticides than halloysite.

Conclusion

Allophane concentration in andosols favours chlordecone trapping. The trapping ability of this poral material (andosol) could explain the low chlordecone lability and thus accessibility and availability for crops and environment in these soils.

Transfer experimentations demonstrated that even if andosol chlordecone content was higher than nitisol, andosol were less contaminant for crops.

The knwoledge of this allophanic clay structure should help us to understand the environemental factors to take in account in the general question of pesticide trapping, transfer and remediation in these specific soils.