



HAL
open science

Dégradation naturelle de la chlordécone aux Antilles avec libération de nombreux produits chlorés

Oriane Della-Negra, Delphine Muselet, Sébastien Chaussonnerie, Charles Mottes, Marion L. Chevallier, Luc Rangon, Agnès Barbance, Stéphanie Fouteau, Stéphane Vuilleumier, Gwenaël Imfeld, et al.

► **To cite this version:**

Oriane Della-Negra, Delphine Muselet, Sébastien Chaussonnerie, Charles Mottes, Marion L. Chevallier, et al.. Dégradation naturelle de la chlordécone aux Antilles avec libération de nombreux produits chlorés. 4ème Rencontres nationales de la Recherche sur les sites et sols pollués, ADEME, Nov 2019, Montrouge, France. hal-04831952

HAL Id: hal-04831952

<https://hal.science/hal-04831952v1>

Submitted on 11 Dec 2024

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.



Dégradation naturelle de la chlordécone aux Antilles avec libération de nombreux produits chlorés

Natural chlordecone degradation in the French West Indies with the release of numerous chlorinated products

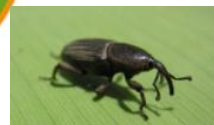
Oriane Della-Negra, Delphine Muselet, Sébastien Chaussonnerie, Charles Mottes, Marion Chevallier, Luc Rangon, Agnès Barbance, Stéphanie Fouteau, Stéphane Vuilleumier, Gwenaël Imfeld, Thierry Woignier, Pierre-Loïc Saaidi, Denis Le Paslier



Atelier 6

Impacts environnementaux et sanitaires

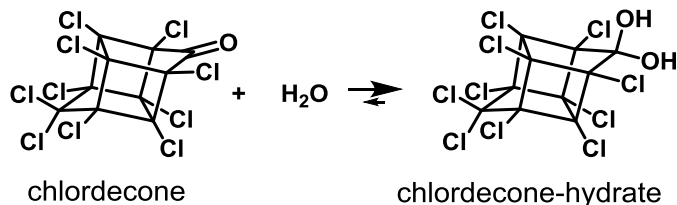
Oriane Della-Negra



www.cirad.fr

Chlordecone = Used as insecticide or fire retardants in

- United States: 1958-1976
- French West Indies (FWI): 1972-1993 (used against the banana black weevil)



- Mostly under its hydrate form
- 3 main impurities in its commercial formulations: Mirex, chlordecol & 8-monohydrochlordecone
- Persistent in the environment (soil, river water, mangrove...)
- Bioaccumulation in food chain (plants, animals, fishes...)
- Chronic toxicity (increase the risk of prostate cancer, neurobehavioral disorders in children)

POP

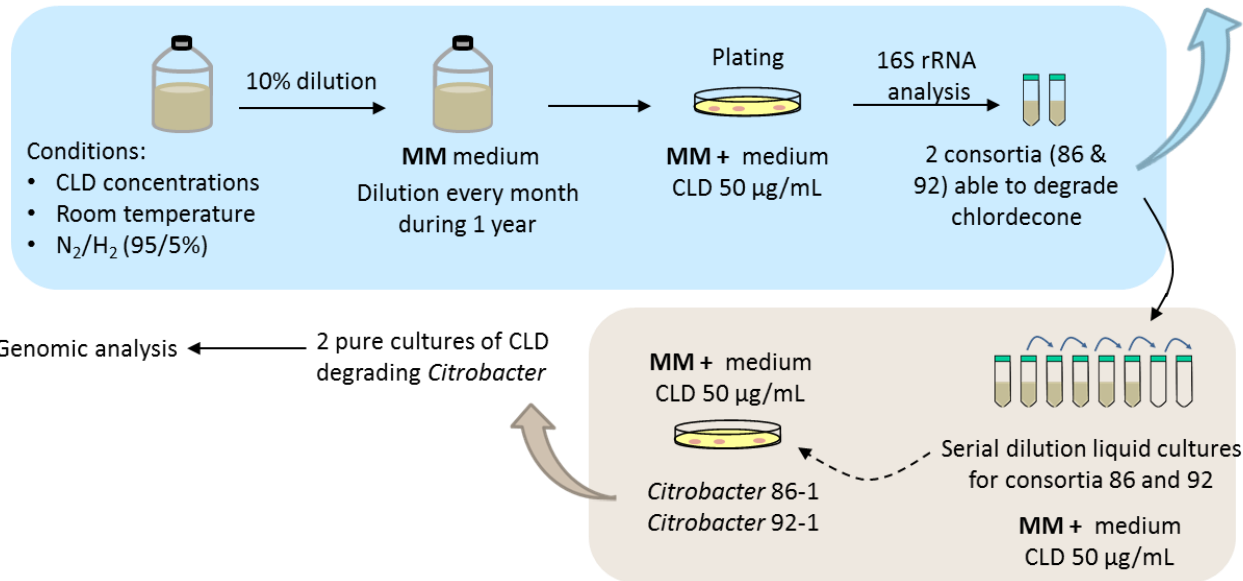
CHLORDECONE TRANSFORMATION IN LABORATORY



Identification and isolation of bacteria inducing chlordecone transformation

Metagenomic analysis

- Consortia 86 & 92
- *Citrobacter* 86-1 & 92-1

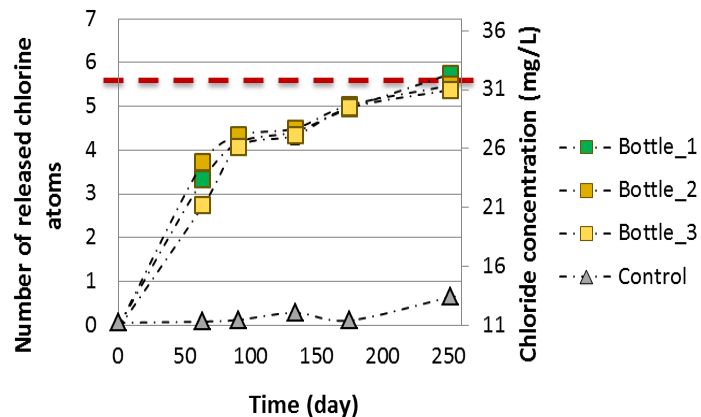


Facultative anaerobe	Anaerobe
<i>Citrobacter</i> _86-1	<i>Clostridiales</i> _86
<i>Citrobacter</i> _86-2	<i>Desulfovibrio</i> _86-1
<i>Dysgonomonas</i> _86-1	<i>δ-Proteobacteria</i> _86
<i>Dysgonomonas</i> _86-2	<i>Sporomusa</i> _86
<i>Pleomorphomonas</i> _86	
<i>α-Proteobacteria</i> _86	

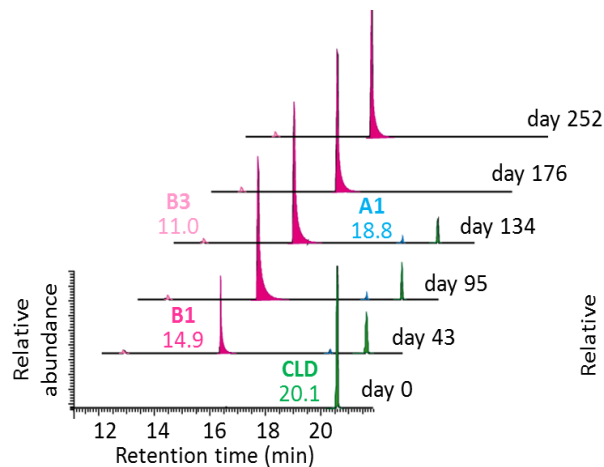
CHLORDECONE TRANSFORMATION IN LABORATORY



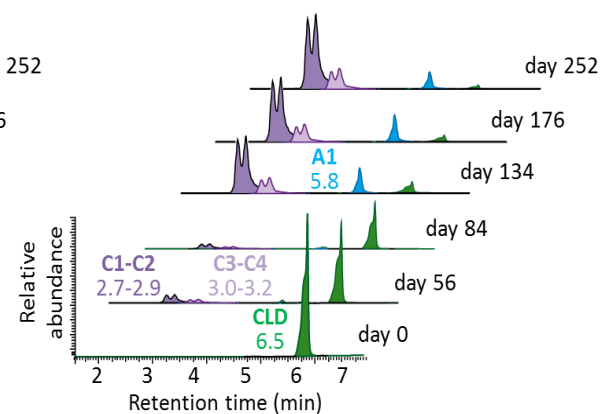
Detection & monitoring of chlordecone transformation products (TPs)



Chloride analysis



GC-MS analysis

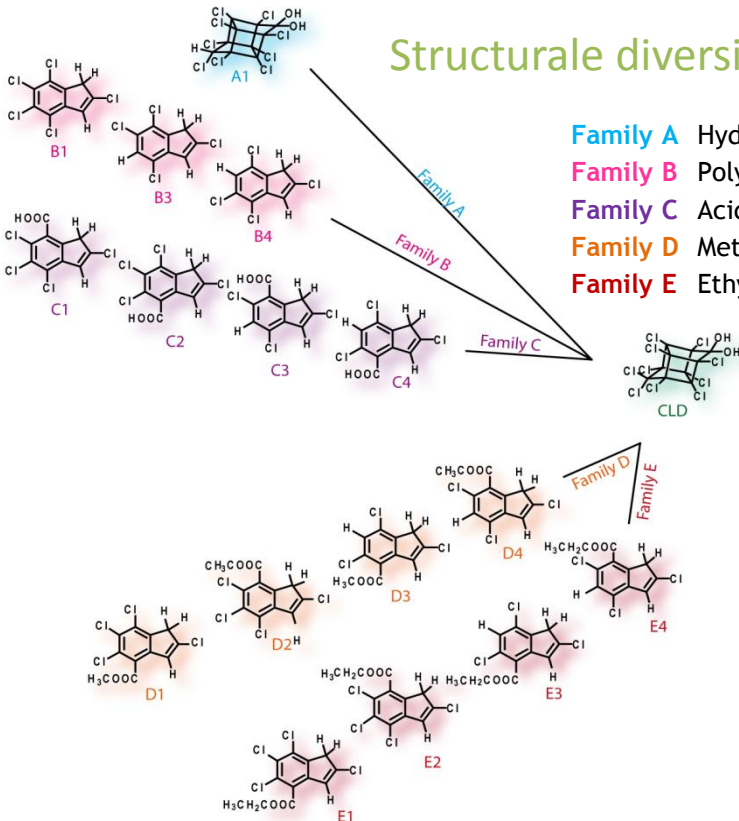


LC-MS analysis

CHLORDECONE TRANSFORMATION IN LABORATORY



Structurale diversity of chlordecone TPs



Identification of TPs in chlordecone bacterial transformation or microcosms by GC-MS and LC-MS

Interpretation of GC and LC mass spectra

Obtention of exact mass and raw formulae by LC-HRMS

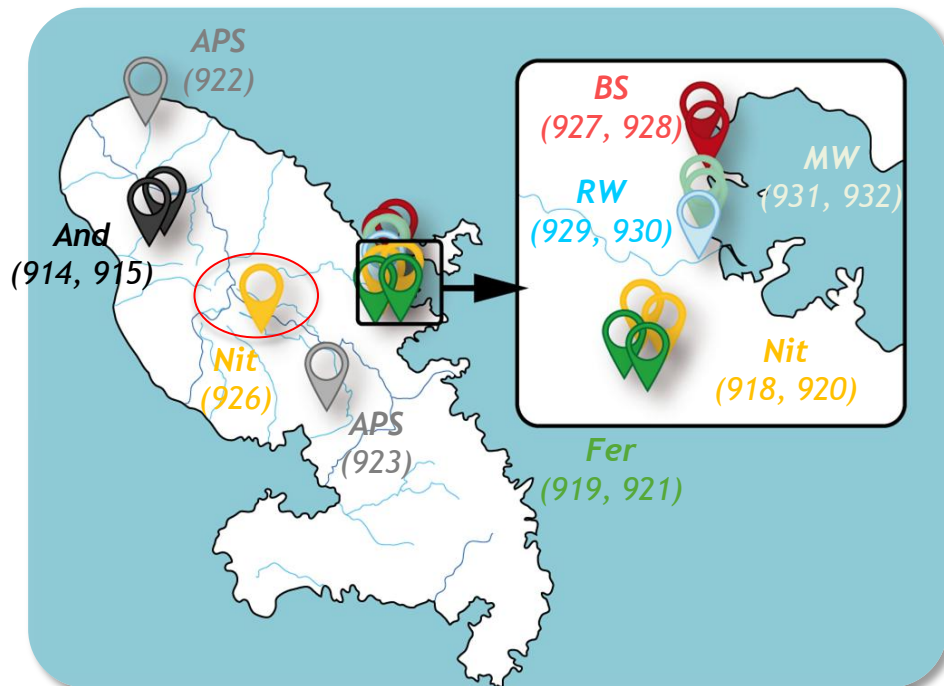
Chemical synthesis and purification of each TP

Structural elucidation by NMR experiments



Constitution of a chlordecone TPs database

Sampling and extraction strategy

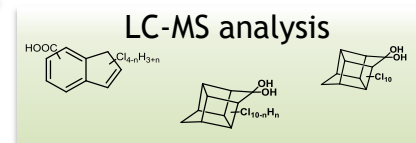
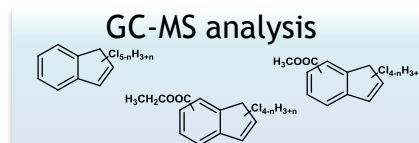
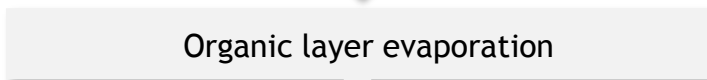
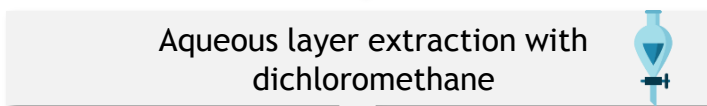
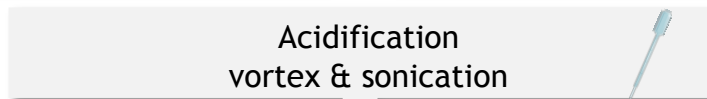
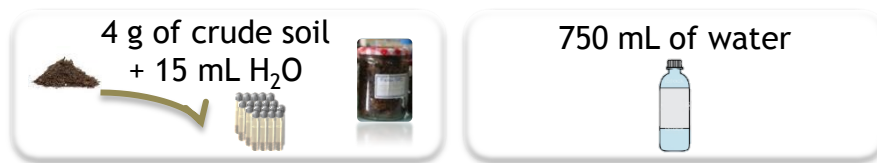


- 14 samples historically contaminated by chlordecone

- 6 soils
- 2 ashes & pumice stones
- 2 sediments
- 2 river water
- 2 mangrove water

- 1 negative control 

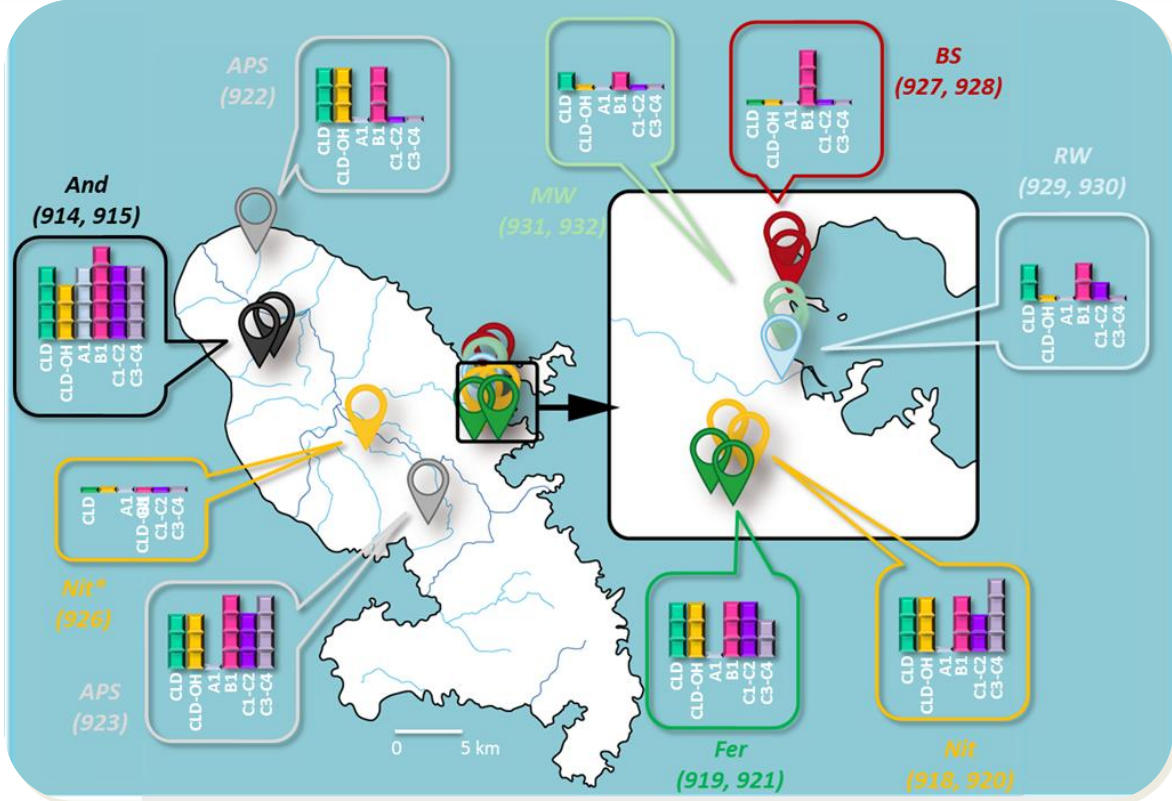
Sampling and extraction strategy



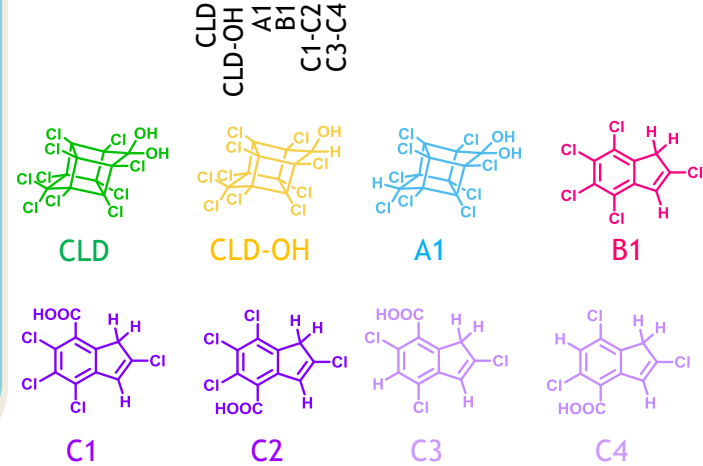
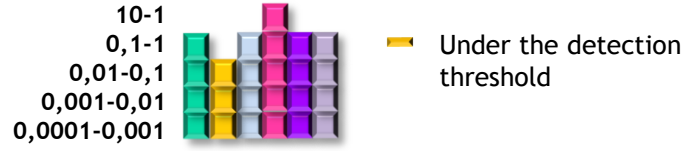
- 12 extraction for river water (6L/L of river water)
- 6-12 extractions for soils & sediments

No grinding
No drying steps

SEARCH FOR CHLORDECONE TPS IN THE ENVIRONMENT



Order of magnitude of chlordecone and TPS concentration (mg/kg wet soil or mg/L)



THE OBSERVED CONTAMINATION TPS PROFILE



Observations and questions



- **Chlordecone** found in every sample excepted negative control & bed sediments
-> Extraction protocol may not be appropriate for chlordecone in bed sediments



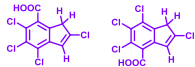
- **A1** only found in andosol
-> Such soils could have a specificity allowing A1 formation or retention (bacteria? physico-chemical properties?)



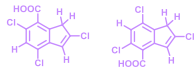
- **Chlordecyl** found in every soil samples
-> Does it come from chlordecone initial formulation (impurity) or from degradation/metabolisation?



- **B1** found in every sample (soil, water, sediments) with sometimes a concentration range similar to chlordecone



- **C1-2-3-4** presence is more variable compared to the others
-> It could be due to the carboxylic acid function generating a higher mobility in the environment



Natural chlordecone degradation occurs in Martinique Island

THE OBSERVED CONTAMINATION TPS PROFILE

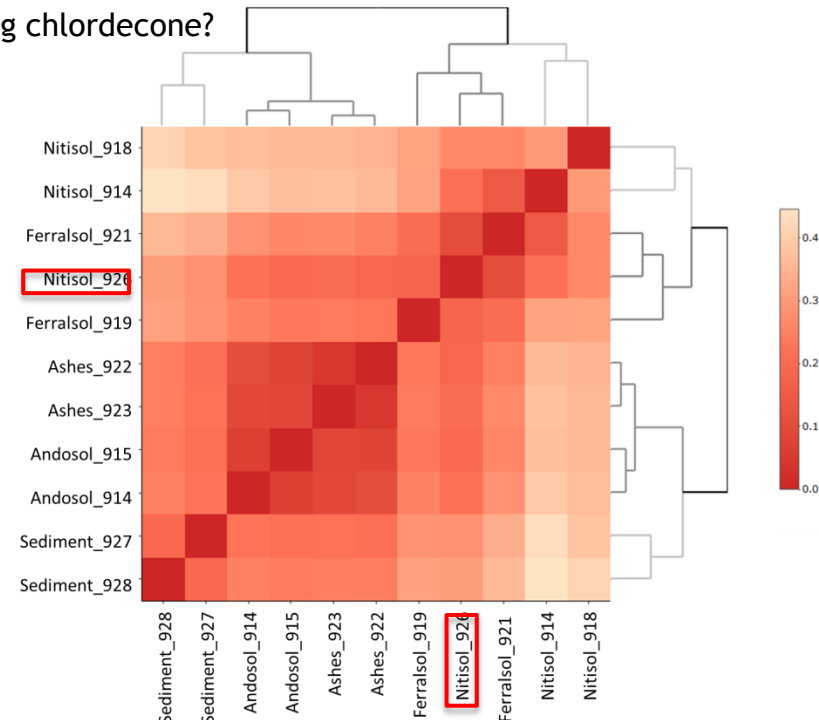


Biodiversity of the environmental samples

Do we find the previously identified bacteria degrading chlordecone?
Are there any differences with negative control?

- ❖ A few *Desulfovibrio* & *Citrobacter* bacteria genus < 1% diversity found in 918, 919, 920
- ❖ Similar soil type can be clustered according to their biodiversity
- ❖ No difference was observed between the negative control and other nitisols

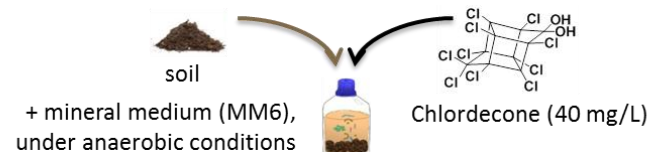
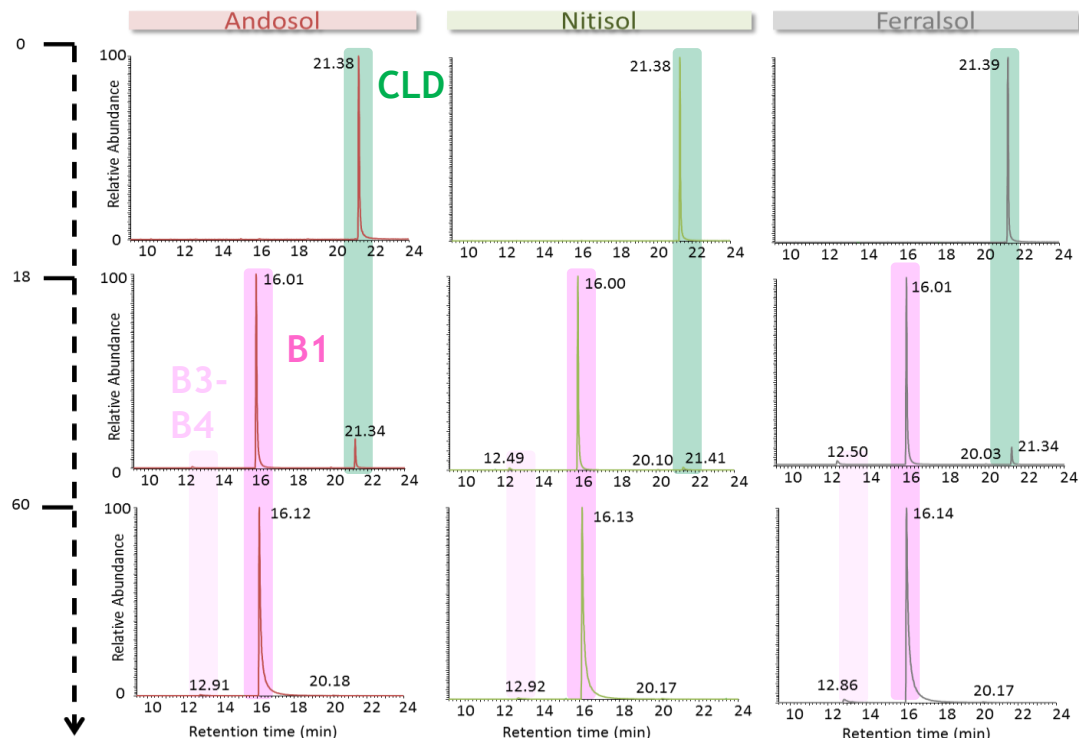
- Other bacteria probably induce chlordecone degradation
- Chlordecone TP diversity may depend on soil physico-chemical properties
- Chlordecone concentration does not seem to be high enough to disturb bacterial community



CONFIRMATION OF MARTINIQUE MICROFLORA CAPABILITY TO TRANSFORM CHLORDECONE



Strategy and results



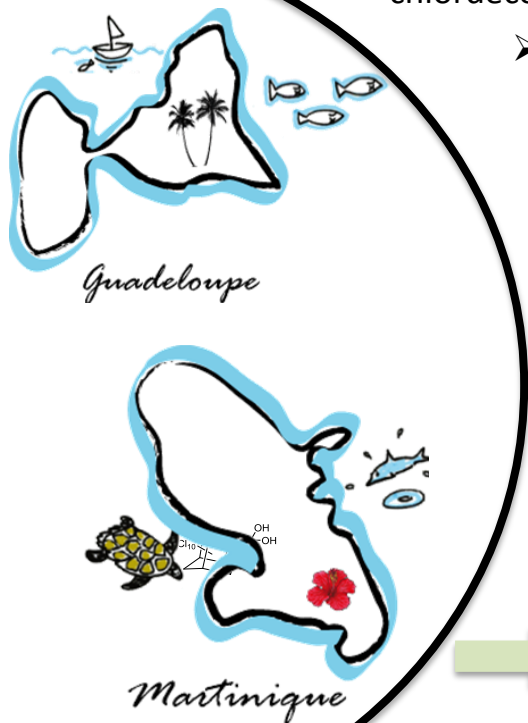
- 3 soils contain bacterial consortia able to transform chlordecone
- Indigenous bacteria are able to transform chlordecone in anaerobiosis

CONCLUSION



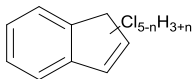
- Structural elucidation of 19 TPs & discovery of 5 new families of chlordecone TPs

- Detection of 17 TPs including in several environmental compartments (soils, river, mangrove, sediment)



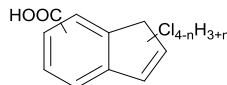
Hydrochlordecones
(n = 1, 2, 3)

A



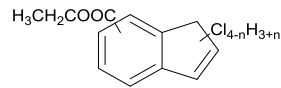
Polychloroindenes
(n = 0, 1)

B



**Polychloroindene
carboxylic acids**
(n = 0, 1, 2)

C

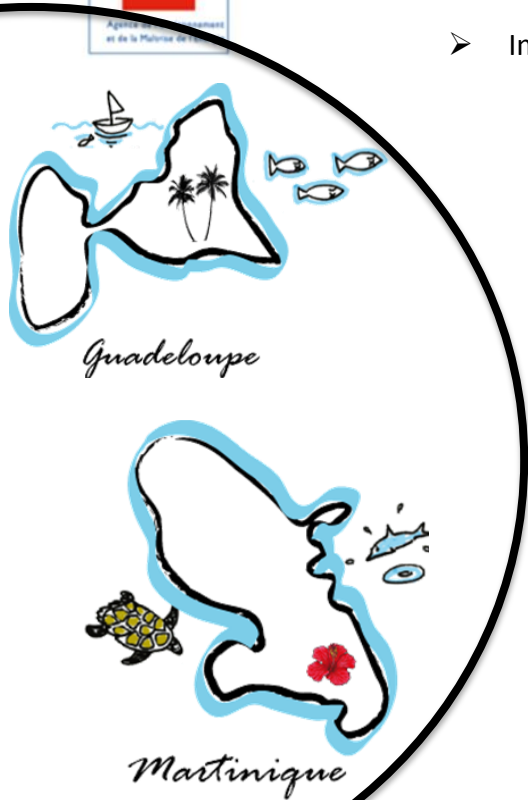


**Ethylpolychloroindene
carboxylates**
(n = 0, 1)

E

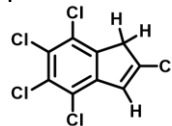
- Identification of TPs contamination levels of the same order of magnitude as chlordecone
- Highlighting the intrinsic capacity of Martinique soils to degrade chlordecone

Paradigm shift: natural degradation of chlordecone into soils and presence of an unsuspected pollution by its transformation products

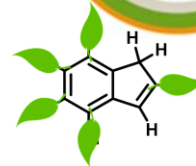


➤ Improve our knowledge about transformation products

- Toxicity
- Stability
- Biodegradability



?



➤ Quantification of these TP in environmental compartments

➤ What about human exposition to these TP?

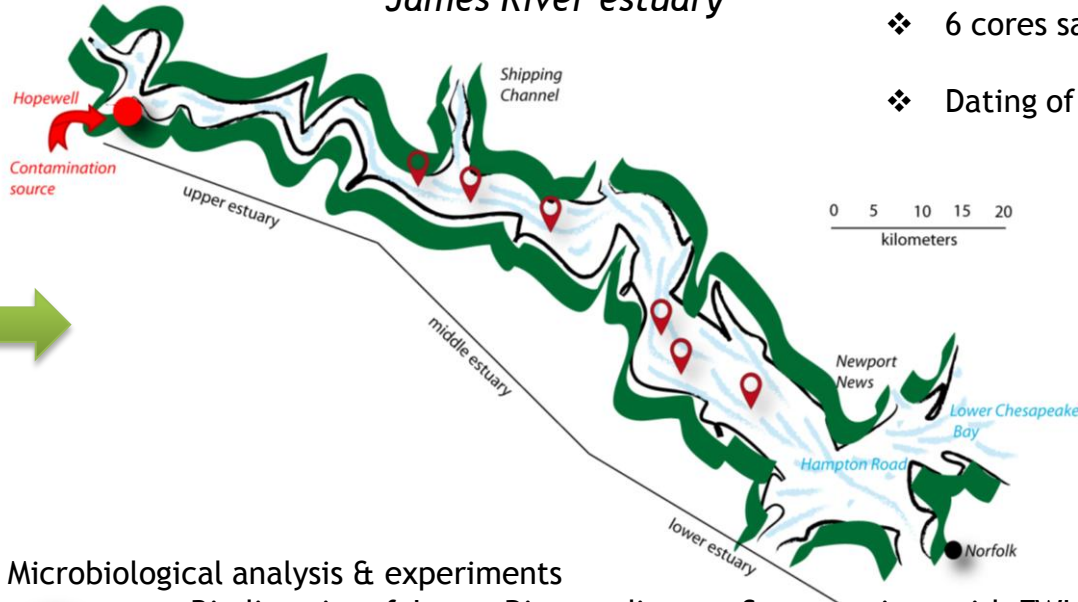


➤ Understand degradation mechanisms (microbiological?) and find methods to improve this degradation (soil types, physicochemical parameters, microbiota ...)

SEARCH FOR CHLORDECONE & TPS IN JAMES RIVER



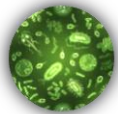
James River estuary



- ❖ 6 cores sampled alongside the river
- ❖ Dating of sediment stratum using ^{137}Cs & ^{210}Pb

- ❖ Chemical analysis of cores
 - Is there still any chlordecone?
 - Do we find the previously described chlordecone TPS?
 - Do we find some others?

- ❖ Microbiological analysis & experiments



- Biodiversity of James River sediments & comparison with FWI biodiversity
- Is there any bacteria able to fully biomineralize chlordecone (loss of the 10 chlorine atoms)?
- Is there any bacteria able to degrade B1?



AKNOWLEDGMENTS



THANK YOU FOR YOUR ATTENTION

