Effects of clay microstructure and compost quality on chlordecone retention in volcanic tropical soils: consequences on pesticide lability and plant contamination

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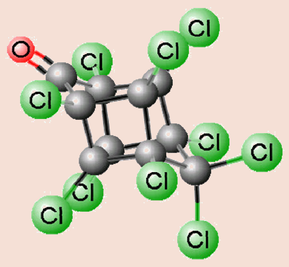
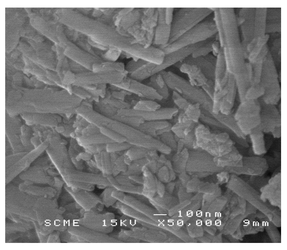
Abstract

The scientific and economic context of our study is related to the pollution of the soils, fresh and marine water by a persistent organochlorine pesticide (chlordecone) in a tropical context (French West Indies). The former application of chlordecone results today in a diffuse pollution in agricultural soils, which are sources of contamination for cultivated roots, tubers, vegetables and terrestrial and marine ecosystems. Chlordecone is a very though and stable molecule (considered as a POP), it is mainly present in solid phase and has a strong affinity with organic matters. To prevent consumers and ecosystems exposure, it is thus necessary for us to evaluate the factors that influence chlordecone migration in the environment. In our research, we studied the impacts of clay microstructure on the chlordecone retention, comparing allophanes (amorphous clays present in andosols) and halloysite clays (type 1/1). We showed that allophane aggregates had a greater ability to trap chlordecone mainly due to their fractal structure. We also measured the effects of added composts on soil microstructure and on chlordecone lability and transfer rate from soil to plant 3 and 6 months after incorporation. The intensity and persistence of these effects were related to the initial quality and richness of the added composts.

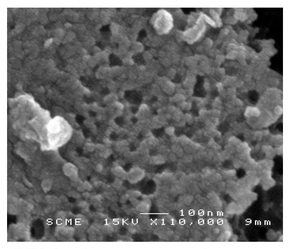


Molecule of chlordecone

Material and methods



SEM of a nitisol (Halloysite)



SEM of an andosol (Allophanes) with fractal structure

Treatments :

- Addition of 5% (w/w) of compost
  - Biogwa
  - Vegethumus
- control

Incubation conditions:

- 28-30°C
- 90% of maximal retention capacity

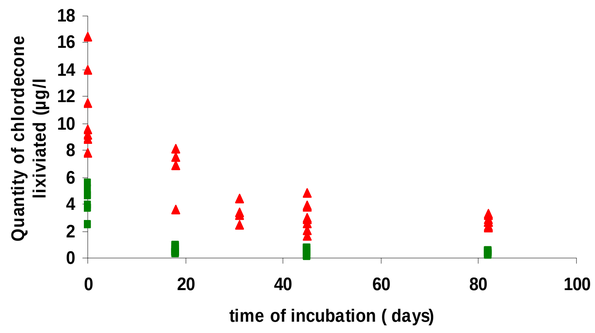
Measures :

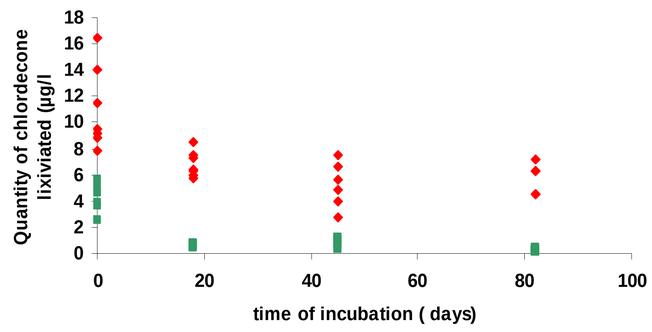
- Lixiviation of chlordecone from 0 to 90 days after compost addition by SPME on fibers PDMS/DVB 60µ
- Kinetic of mineralization of compost from 0 to 90 days after compost addition : production of mineral N measured by KCl 1M extraction
- Pore size distribution from 0 to 90 days after compost addition determined by adsorption desorption of N (Micromeritics) .
- Chlordecone content pf plant tissues
- measured after 90 and 180 days after
- compost addition

Composts characteristics	Biogwa	Vegethumus
Water content	47 %	24.8 %
Organic matter content	20.6 %	46.6 %
Humic yield (CBM)	49 kg C/t of fresh product	577 kg C/t of fresh product
Humic potential (K_1)	0.11	0.70

Results

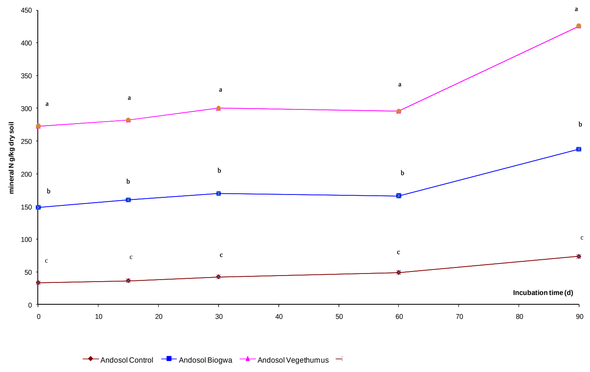
Quantity of lixiviated chlordecone (µg/l) for different incubation times from andosol (red dots) and nitisol (green dots) after compost addition (left: Vegethumus, right: Biogwa).

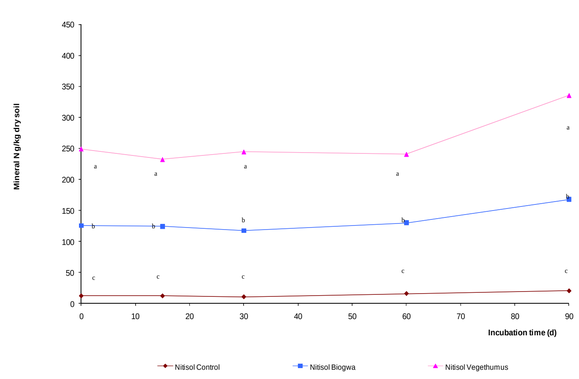




Vegethumus > Biogwa for reducing the lability of chlordecone in both soils

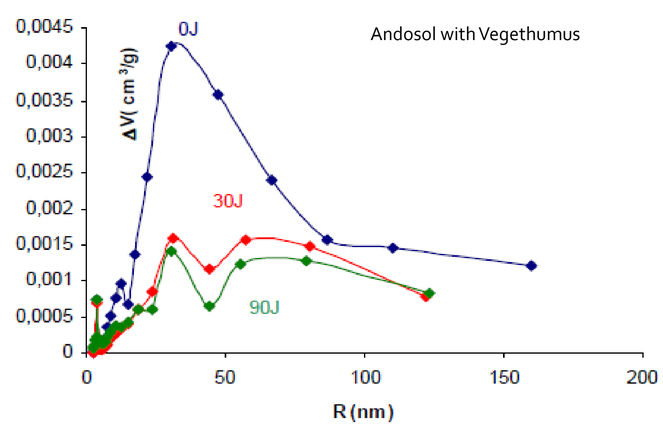
Effect of compost addition on production of total mineral N on andosol (left) and nitisol (right).

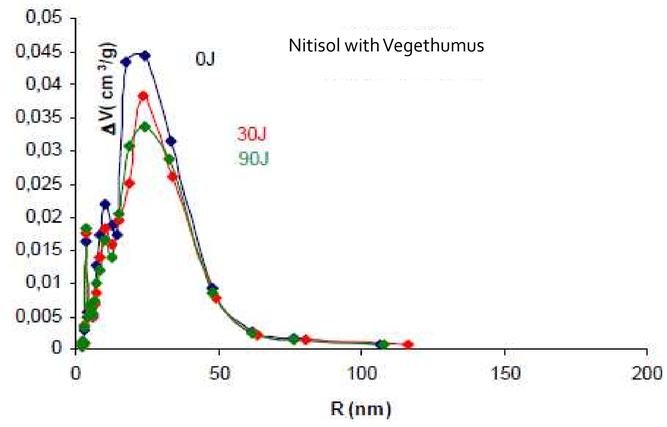




Elevated initial richness of Vegethumus leaded to a higher mineralization of N than with Biogwa . Andosol show a higher mineralization activity than Nitisol

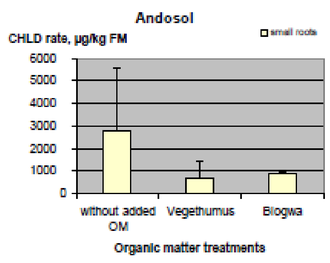
Evolution of the distribution of size pores according to the incubation time (0 day : blue ; red : 30 days ; green : 90 days) after addition of Vegethumus (left : andosol, right : nitisol)

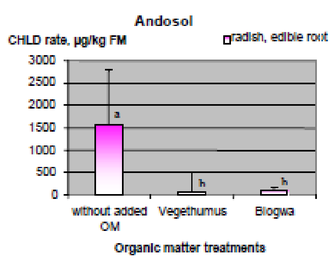


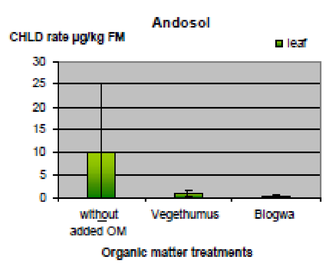


Dramatic reduction of porosity and specific area in the andosol by the addition of organic matter, more important in the case of Vegethumus. In nitisol, no compost effect

Chlordecone content (µg/kg of fresh material) of radish (in yellow : small roots ; in pink : main root ; in green : leaves) cultivated on contaminated andosol according to the different added composts. Means with different letters are significantly different (p < 0.05).

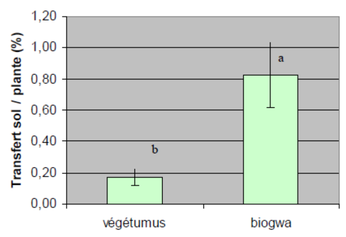






The addition of compost reduces noticeably, in both cases, the contamination of plant tissues, 3 months after compost

Effect of compost after 6 months of incubation on chlordecone transfert (%) from the andosol to the plant (lettuce). Means with different letters are significantly different (p < 0.05).



Contamination increased with Biogwa, compared to Vegethumus , 6 months after compost addition

CONCLUSION

Andosol and nitisol behave differently in the processes involved in chlordecone retention. The structural properties and the spatial arrangement of allophane aggregates constitute a trap for chlordecone molecule, thus mechanically retained. Compost addition modified the andosol porosity according to the compost quality and highly reduced chlordecone lability. In the case of nitisol, the retention of the molecule seems more directly affected by added organic matters such leading to a chemical retention of chlordecone. The intensity of the compost effects is driven by its initial richness while the persistence could depend of the complexity of its biochemical composition. Andosol is able to retain pesticides stronger than nitisol, combining physical trapping and chemical retention. Andosol could be highly polluted but less contaminant.

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