Sequestering a persistent organochlorine with organic fertilizer and organic amendment to increase food safety in Martinique

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Chlordecone is an environmentally persistent insecticide that was intensively used in banana cropping systems. Although its use was restricted 20 years ago, chlordecone permanently pollutes soils and consequently continues to contaminate crops, water resources, and food chains. This pesticide was recently suspected of being implicated in the increasing incidence of prostate cancer and in the impaired development of young children. Given the proven risks to human health, the release of chlordecone from polluted soil needs to be controlled to reduce contamination of the different food chains.
Natural decontamination of the soil through lixiviation will take decades to centuries. The persistence of chlordecone in soils is explained by i) its physicochemical properties: low solubility in water, hydrophobicity, which gives it a high affinity for organic matter and ii) its poor biodegradability related to its peculiar chemical structure with high steric hindrance. Chlordecone pollution concerns a large area, meaning chlordecone-polluted sites require efficient cost-effective in situ treatments. To date, phytoextraction and microbial degradation have not really been efficient in the case of diffuse pollution of chlordecone in the soil. Thus, sequestering chlordecone in the soil could be an alternative way to reduce its availability for crops and water resources. We then chose to study the ability of two different organic matters to sequestrate this molecule in the two main contaminated soil types presenting different characteristics: andosols, with amorphous clays (allophane), and nitisols, with crystalline 1/1 clays. We tested two types of organic matter: an organic fertilizer and an organic amendment. For each experiment (in microcosm, in pots and at field scale), the same quantities (5% w/w) of organic fertilizer or organic amendment were incorporated into both contaminated soils. During these experiments, we measured during three months the effects of organic fertilizer and organic amendment incorporation into soil on (i) chlordecone leaching by water, (ii) chlordecone bioavailability for susceptible crops (radish, cucumber, lettuce) and contamination of their different organs (roots, tuber, fruits, leaves) (iii) chlordecone distribution in different soil fractions (0-50µm, 50-200µm, 200-2000µm), (iv) soil microstructure (pore size distribution, specific surface area, mesopore volume and nanoscale structure).
A quick decrease in water extractable chlordecone was observed in amended soils and then its transfer from soils to plants. Depending on the soil and the crop, the soil-plant transfer was also reduced by a factor of 1.9 to 15 when organic matter was incorporated. Chlordecone distribution was modified by the incorporation of both organic materials leading to a transfer of the molecule from the finest to the coarser fractions according to the organic matter size distribution, thus raising a "sponge" effect, mainly observed on the nitisol, of the added organic matter on the chlordecone probably due to the high affinity to organic matter and hydrophobicity of this molecule. For the andosol, the results showed that the changes in chlordecone distribution in the different soil fractions were not as dramatic as those in the nitisol. This raises the question of the specific physical and structural properties of the allophanic clays. Considering the impact of organic matter on soil microstructure seen though the pore size distribution, after the addition of organic matter, the mesopore structure was not really affected in the nitisol, even after 3 months. These results clearly differed from those observed on andosol where the addition of compost led to a marked reduction in mesoporosity. After 90 days, the pore size distribution was still strongly affected by both composts (loss of 80% of the mesopores). Results also show a clear decrease in the specific surface area and specific mesopore volume of the andosol after addition of organic matter. This phenomenon was not observed on the nitisol. The reduction in the size of the aggregates demonstrated the collapse of the microstructure at a scale of 10 to 100 nm. The main structural result of the addition of compost was the progressive collapse of the allophane aggregates, associated with closure of the mesopores.

We demonstrated that it is possible to increase the sequestration of pesticide in soils by adding an organic fertilizer or an organic amendment. The combination of the high pesticide affinity for organic matter observed in both soils, plus the tortuosity of the pore network of andosol may be a key feature in chlordecone availability.

Keywords : *organochlorine, organic matter, pesticide sequestration, soil porosity, crop contamination*

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