

Chlordecone's Long-Term Contamination of Tropical Volcanic Soils

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Abstract

This led to the long-term poisoning of soils, waterways, aquatic biota, and crops. A leaching model based on first-order desorption kinetics called WISORCH was created and tested to evaluate the extent and duration of pollution according to soil type. Soil organic carbon content (SOC) and the SOC/water partitioning coefficient serve as its input parameters (Koc). It takes into account the concentrations of drainage water and chlordecone in the soil today. The fact that the model held true for andosol suggests that neither physico-chemical nor microbiological degradation took place. Soil scraping is unrealistic because of dilution from earlier deep tillages. The main method for reducing pollution seemed to be lixiviation. Along with an increase in SOC content and rainfall, Koc went from nitisol to ferralsol and then increased again.

Keywords: Volcanic soils • Chlordecone's • Policy • Soils

Introduction

In the French West Indies, chlordecone (CLD), an organochlorine insecticide, was applied from 1972 to 1978 under the brand name Kepone™ (5% CLD), produced by Life Science Products Co. (Hopewell, VA), and from 1982 to 1993 under the name Curlone™ (5% CLD), produced by Calliope S.A. (Port-la-Nouvelle, France). In 1972, Kepone was granted a temporary usage permit by the French Ministry of Agriculture. After being outlawed in the USA, its use came to an end in 1978. A French publication (Snegaroff, 1977) issued a cautionary note regarding the danger of CLD contamination of soil and water. A few years after Kepone began to be distributed, some banana farms' topsoil showed a CLD level of more than 9 mg kg⁻¹. There is no proof that microbial CLD degradation has occurred. Orndorff and Colwell (1980) achieved an apparent de-chlorination into mono- and di-hydro-chlordecone using *Pseudomonas aeruginosa* strain KO3 and a bacterial pool isolated from Hopewell plant sludge under aerobic circumstances. The initial mono- and di-hydro-chlordecone contents of the CLD were not described by those authors, however, and as a result, those values may have resulted from incomplete chlorination throughout the manufacture process. Later, three *Pseudomonas* spp. were examined by Georges and Claxton (1988) to see how CLD was degraded. Again, though, there were no details. Additionally, the HPLC chromatogram of the CLD solution that had simply been added yeast and glucose and wasn't inoculated revealed peaks that represented hydro- and dihydro-chlordecone. The authors emphasised that CLD is a poor carbon source for bacteria due to its highly chlorinated cage-like structure: after two weeks, the apparent [1].

Description

We made the decision to create a straightforward leaching model of

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CLD, WISORCH, based on first-order desorption kinetics, in order to take into consideration inter-annual chlordecone desorption and the current degree of soil contamination. Existing models of pesticide dissipation were not acceptable due to delayed decontamination and long-term soil pollution since they only take into account short-term sorption, leaching, and degradation, which would generate considerable inaccuracy when applied over years. In WISORCH, we made the assumption that neither degradation nor plant capture were effective ways to get rid of CLD from the different types of volcanic tropical soil found in the French West Indies. We utilised a "space for time" technique for validation because inter-annual CLD leaching tests were not practicable. We recreated the various CLD spreading schedules on fields and compared the simulated soil CLD levels to the actual CLD contents [2].

Three 8 cm diameter boreholes were sampled at 0, 1/4, and 1/2 of the distance between banana trees in the perennial banana cropping systems that are situated on steep slopes. Each borehole's sampling depths were 0–10 cm, 10–30 cm, and 50–70 cm. The first two layers of each topographic position were mixed (by volume, half) to produce composite samples ranging in thickness from 0 to 30 cm. On each parcel of the tilled banana cropping system, 20 samples of the 0–30 cm layer were taken to account for the impact of tillage on the spatial variability of soil contamination. The carbon (SOC) and CLD contents of each composite sample were calculated. Additionally, the bulk density of each soil type's profile was calculated. For each composite sample, the obtained relations were used to compute bulk density from SOC, allowing the conversion of gravimetric into volumetric contents for SOC and CLD. For two reasons, we concentrated our measurements on the 0–30 cm depth layer. This depth is most frequently employed to estimate carbon sequestration, and the crop protection service sampled the same depth at the same time period as part of its programme survey of soil pollution. We were able to determine through some repetitions that neither the CLD nor SOC contents significantly changed from one year to the next. A sampling of soils was done between 2001 and 2005 [3].

At a depth of 65 cm, drainage leachates were gathered using fibreglass wick lysimeters. Using the HYDRUS 1D or 2D models, we confirmed that the lysimeter cumulated flow matched the natural soil cumulated flow. On filters, there was no evidence of solids transfer. For a single-row banana crop NFC on andosol, lysimeters were buried beneath and between the plants. Three positions were used for the double-row banana field BRH5 on nitisol: underneath the banana tree, beneath the tiny 1.2 m interrow, and beneath the large 2.4 m interrow. Figure 7 provides dates for leachate sampling and measurement. The WISORCH model utilised the apparent Koc* to calculate the inter-annual development of [CLD] w for various soil types. For NFC andosol, the [CLD] w was accounted for by the application of the DD pattern to the water flow beneath banana feet and the MD pattern to bare soil. Figure 8

demonstrates that for BRH5 nitisol, applying DD or MD to the water flow below banana produced simulated [CLD] w values that were comparable to those recorded on the sample day. Experimental bias was not the cause of the varied K_{oc}^* . In comparison to andosol, which has a higher CLD sorption and a lower desorption capability, K_{oc}^* was lower for nitisol [4].

Some of our findings were anticipated. Notably, soil contamination only occurred where chlordecone had been applied, with the exception of where contaminated water tables first appeared (data not shown). Chlordecone's extremely low volatility makes it impossible for the atmosphere to transport any detectable pollution. Moreover, less than 3% of the CLD loads in drainage were contained in runoff flow. As a result, inter-parcel contamination remained uncommon. There were physical boundaries to the soil pollution. Only current chlordecone redistribution from top to lower levels and very sluggish leaching decontamination were detected. The primary transmission vector was drainage. Diffuse pollution has long-term effects on the water resources since drainage feeds water tables, downstream emergence areas, and rivers. Diminishing surface pollution could not be used to minimise this diffuse pollution [5].

Conclusion

Different types of soil have varying levels of chlordecone persistence. Nitisol has a lower K_{oc} than ferralsol or andosol. As a result, it will take a few decades for nitisol, several centuries for ferralsol, and more than half a millennium for andosol to decontaminate the soil. Accelerating SOC mineralization could speed up decontamination, but doing so would have negative effects on the environment and agronomy. Values from the model and the experiment supported the hypothesis that the concentration of chlordecone in water increases with decreasing K_{oc} . Because there is no clear correlation between soil pollution and its ability to contaminate plants and water, this

complicates the mapping of contamination hazards. To understand why the various organo-mineral matrixes behave in different ways during chlordecone sorption, more investigation is required.

Acknowledgement

None.

Conflict of Interest

None.

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