

Variation of chlordecone sorption properties over a transect of volcanic soils in Basse Terre Island (FWI)

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Introduction

The organochlorine insecticide chlordecone (CLD), formerly used in the French West- indies up to 1990 to control banana weevil, has led to a permanent contamination of soil and water resources in the French West Indies given its persistence in soils and gradual release to water (Voltz *et al.*, 2023). The aim of this study is to identify the variability of chlordecone sorption and relate it to the range of physico-chemical properties of the volcanic soils (Andosols and Nitisols) concerned by chlordecone spraying.

Material and Methods

Soil samples

- 13 soil samples of Basse-Terre Island representing 7 soil sub-classes of Andosols and Nitisols (Colmet Daage, 1969)
- Range of main soil properties : organic carbon, minerals and pH

Soil sample properties

Soil type	OC (%)	Allophane/Clay fraction	water pH
Andosols	0,21 - 7,12	0,20 - 3,59	4,40 - 7,00
Nitisols	0,42 - 3,10	0,00 - 0,01	4,60 - 7,60

Kinetic sorption experiments :

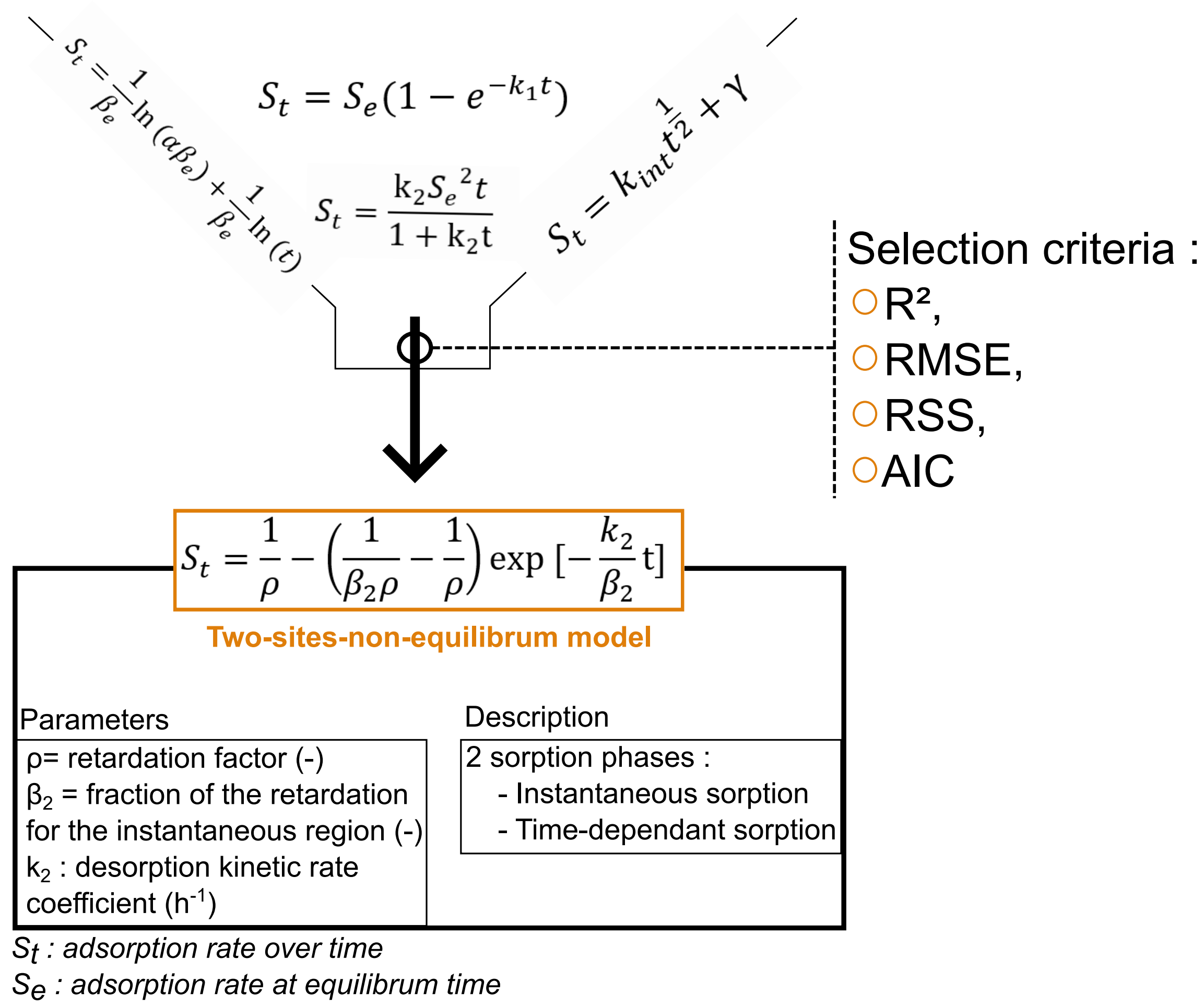
- Chlordecone solution :
 - 50% of radio-labeled and 50% of unlabeled
 - Concentration : 210 µg/L
 - Analysis by liquid scintillation counting

Sorption kinetics

- stirring times from 2h to 72h
- 3 repetitions per time
- soil/solution ratio of 1/5

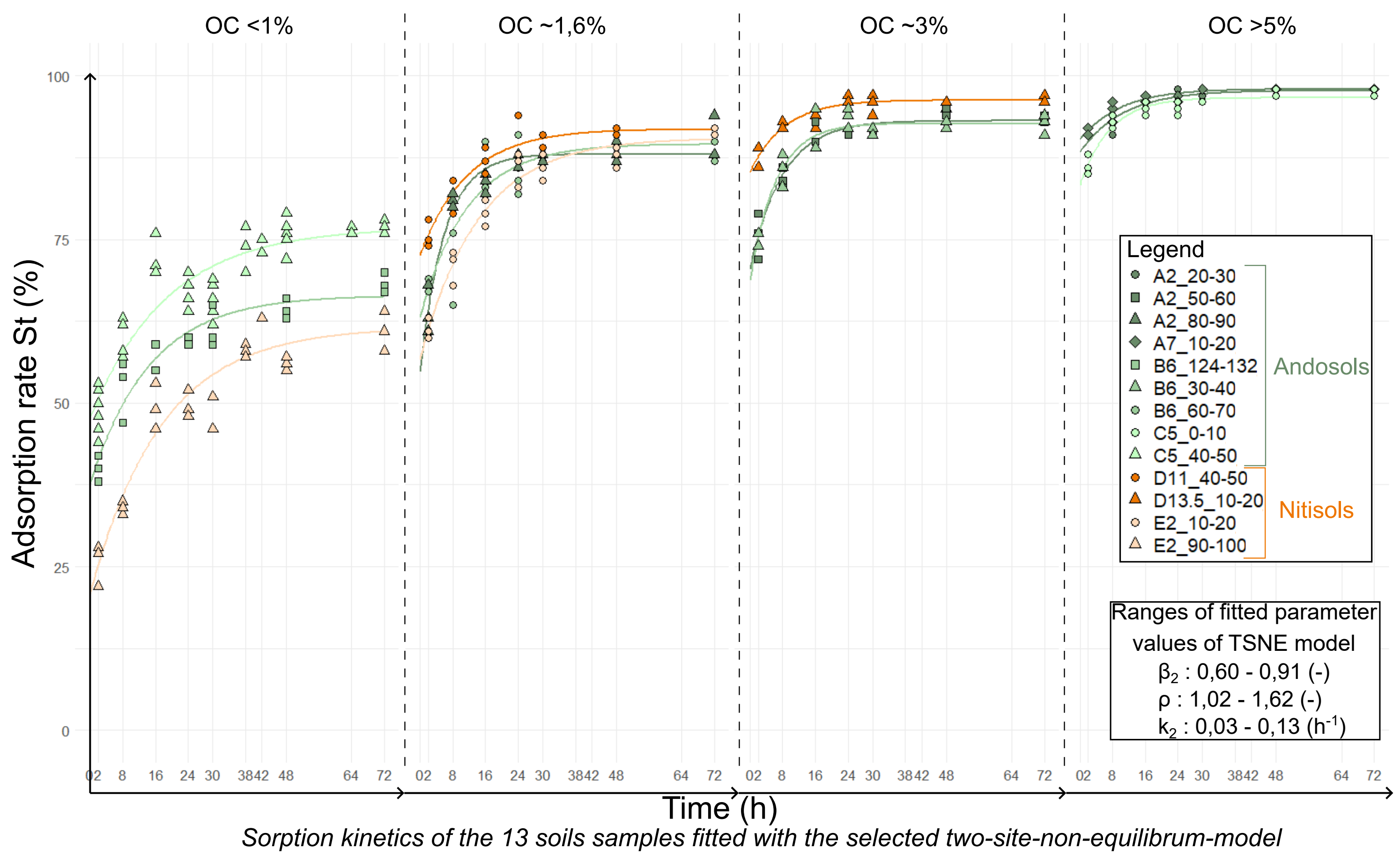
Sorption kinetics models

5 models tested : pseudo-first-order, pseudo-second-order, Weber-Morris, Elovich, two-sites-non-equilibrium (Cáceres *et al.*, 2010)



Results & Discussions

Sorption kinetics



The optimum equilibrium time identified is 48 h.

OC content is the main driver of sorption. An increase in OC induces an increase in the equilibrium sorption rate and in the proportion of instantaneous sorption. The latest is predominant above 3% OC. Below 1% OC, a positive effect of allophane/clay ratio on sorption kinetics is visible. At OC ~1,6% and 3%, a positive effect of pH on sorption appears to be evident for two samples with pH>7.

Evaluation of kinetic models

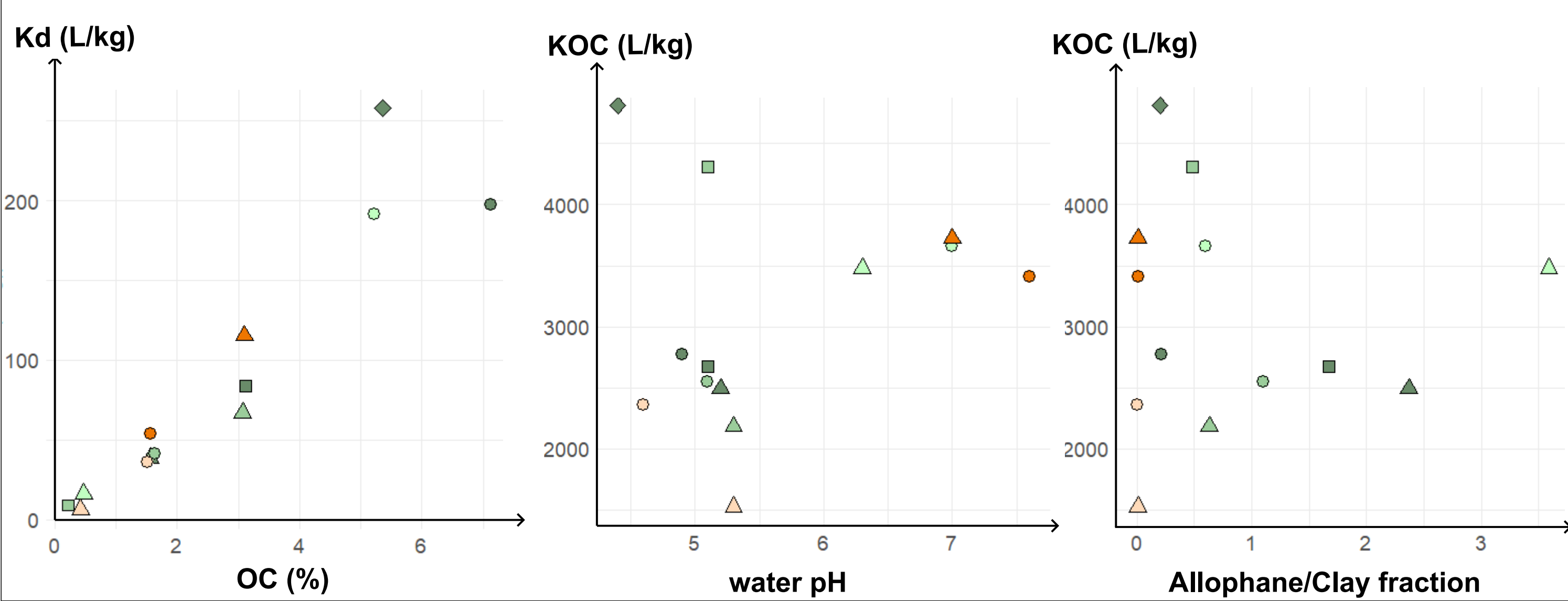
Based on the selection criteria, the two site kinetic model provided the best fit to the data, describing a two phases sorption mecanism that may reflect heteorgeneity in the nature and location of sorption sites.

Ranking of the tested models based on the 1st order selection criteria : R², Root Mean Squared Error (RMSE), Residual Sum of Squares (RSS), Akaike Information Criterion (AIC)

	R ²	RMSE	RSS	AIC
1st order	5 5 5 5 4 5 5 5 5 5 5 5	5 4 4 5 5 4 5 4 5 5 4 5	5 4 4 5 5 4 5 4 5 5 4 5	5 4 4 5 5 4 5 4 5 5 4 5
2nd order	3 2 1 3 4 2 3 3 4 3 3 4 4	3 2 1 3 3 2 3 2 4 3 2 4 3	3 2 1 3 3 2 3 2 4 3 2 4 3	3 2 1 3 3 2 3 1 4 3 2 4 3
Weber-Morris	4 4 4 4 3 5 4 4 3 4 4 3 3	4 5 4 4 5 4 5 3 4 5 3 4 5	4 5 4 4 5 4 5 3 4 5 3 4 5	4 5 5 4 4 5 4 5 3 4 5 3 4
Elovich	2 3 3 2 1 3 2 2 1 2 2 2 2	2 3 3 2 1 3 2 3 1 2 3 2 2	2 3 3 2 1 3 2 3 1 2 3 2 2	2 3 3 2 1 3 2 3 1 2 3 2 2
Two-sites-non-equilibrium	1 1 2 1 2 1 1 1 2 1 1 1 1	1 1 2 1 2 1 1 1 2 1 1 1 1	1 1 2 1 2 1 1 1 2 1 1 1 1	1 1 2 1 2 1 1 1 2 1 1 1 1

best fitted model second best fitted model selected model soil samples

Correlation of sorption at equilibrium time with soil properties



The strong correlation between OC and Kd is confirmed in accordance with the literature (Fernández-Bayo *et al.* 2013). A part of Kd variability also seems to be associated with water pH and the allophane/clay fraction ratio. However, these parameters cannot be treated separately from the OC value because they are correlated.

Conclusions

CLD sorption in these tropical volcanic ash soils follows a 2 phases sorption mecanism. Equilibrium times longer than 24h were observed in some soils. Variations in pedological properties induce changes in the duration of instantaneous and slow phases and in the adsorption rate. OC content was as expected the first driver of sorption with a threshold effect. OC content masks the effects of other pedological properties but at OC content <1%, the effect of the allophane/clay fraction ratio becomes apparent and <3%, a pH>7 seems to induce a faster and greater sorption. Further investigations with more samples in this pH range are needed. This study highlights the reciprocal influence of OC and mineralogical composition on the sorption of a legacy organochlorine pesticide.

References

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