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Fertilizer P changes the surface area of aluminium and iron (hydr)oxides in soil - Evidence from NOM-CD modelling

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In surface complexation models, the specific surface area (SSA) parameter is often fixed at a constant value and assumed not to change over time. However, NOM-CD modelling results from a Dutch soil fertility experiment suggested that SSA may change dynamically as a function of phosphorus load (Bai, 2023). In the current study, phosphate adsorption data from five Swedish long-term soil fertility experiments, along with several additional soils, were re-analyzed using the NOM-CD model. The sum of oxalate-extractable Al and Fe was assumed to exhibit surface characteristics similar to ferrihydrite. In the model, total P and SSA were optimized. Across all five fertility experiments, the modelled SSA increased consistently with PK fertilizer load (see Fig. 1 for one example). A linear model using dissolved P and $f(Al_{ox})$ (the fraction of oxalate-extractable Al relative to the sum of oxalate-extractable Al and Fe) as predictors explained SSA well (adjusted r^2 = 0.82). These results suggest that the phosphate ion itself may act as an agent increasing SSA, although the exact mechanism remains unclear. Possible mechanisms include recrystallization following temporary $AlPO_4$ formation and/or a long-term reduction in (hydr)oxide aggregate size due to suppression of crystal growth; these mechanisms are not mutually exclusive. At first glance, these conclusions may appear to contradict the widely accepted view that P sorption reactions in soils are strongly governed by slow diffusion processes. However, rather than contradicting this view, the findings may provide new insights into how the importance of slow diffusion processes could vary depending on soil conditions.

Reference:

Bai, Y. (2023) Interactions of phosphate and mineral-associated organic carbon in soils in relation to long-term phosphorus fertilization. PhD thesis, Wageningen University, Netherlands.

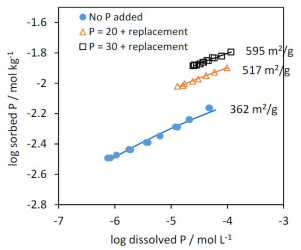


Fig. 1. Phosphate adsorption isotherms for the Ekebo long-term fertility experiment. Points are observations, lines are fits with the NOM-CD model. Optimized SSA:s are shown on the right. The quantity of P is expressed as kg ha^{-1} yr^{-1}.