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Dynamics in Phosphorus Pools in Soils and Sediments along the Land-Freshwater Continuum of Agricultural Catchments

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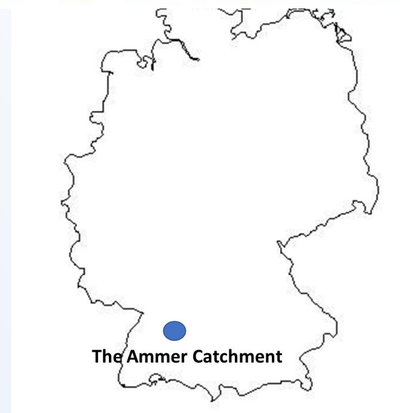


Motivation

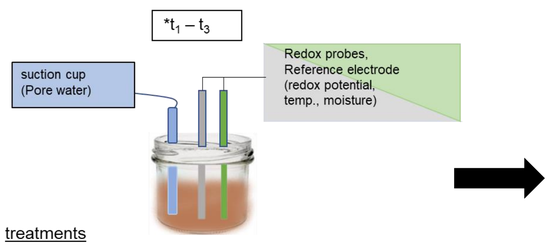
- To recommend effective management measures and model future scenarios of phosphate (PO_4^{3-}) inputs into surface waters, it is mandatory to understand the dynamics that affect the storage of PO_4^{3-} in our cultural landscapes
- The diffuse input of PO_4^{3-} from farmland represents a key factor regarding the eutrophication of aquatic ecosystems in agricultural catchments
- Prolonged fertiliser application leads to legacy PO_4^{3-} that exceed crop requirements

Overarching Aim

- Unravel biogeochemical processes that change PO_4^{3-} storage pools and therefore the mobility of PO_4^{3-} in soils and sediments over time
- Advance our mechanistic understanding of PO_4^{3-} pool transformations under dynamic redox conditions

Material and Methods

- Laboratory labeling and incubation experiment using stream bed sediment from an agricultural catchment (Ammer valley)
- Application of ^{18}O-enriched PO_4^{3-} as label
- Simulation of contrasting hydrological conditions („static reduction“ vs. „drying-rewetting“)
- Regular treatments at 20°C and variant with reduced microbial activity at 5°C
- Monitoring short-term changes (i.e., six weeks)
- Assessing biogeochemical dynamics in sedimentary P pools by combining sequential extraction methods with $\delta^{18}O_{PO43-}$ analysis



treatments

(i) 'static reduction' (permanently water-logged conditions)

(ii) 'short pulsed drying-rewetting' (3 alternating cycles of one week-long saturation, draining and a one week drought interval)

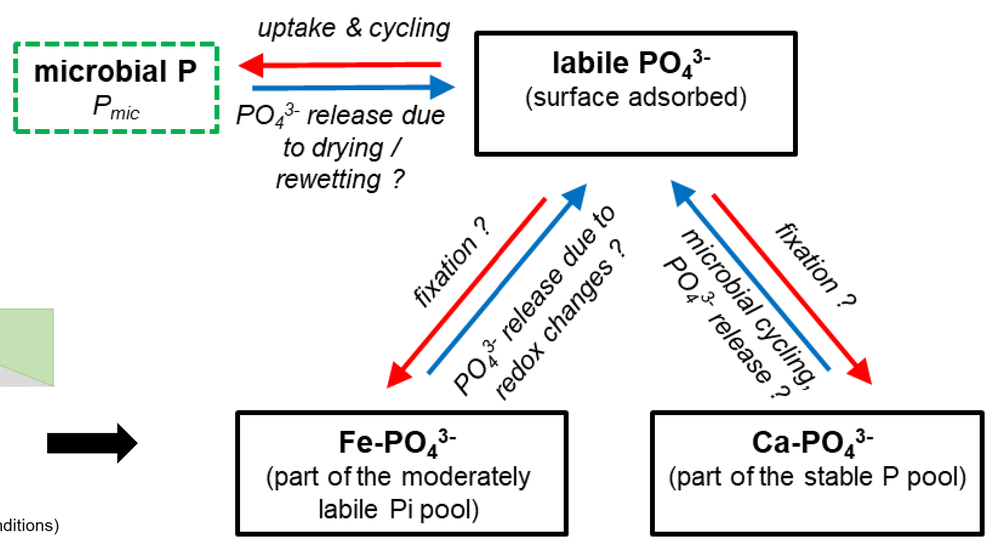


Figure 1: Schematic concept of transport and storage dynamics of PO_4^{3-} in soils and sediments. Storage dynamics mainly depend on the Fe- and Ca-PO_4^{3-} pools and microbial cycling, but details regarding the release and transfer of PO_4^{3-} between these pools remain unclear.

Results

1. Pronounced impact of hydrological conditions on PO_4^{3-} pools
2. Static reduction increased the labile (i.e., exchangeable PO_4^{3-}) and moderately labile PO_4^{3-} pool (i.e., Fe- and Al-oxides bound PO_4^{3-})
3. After 3 drying-rewetting cycles shift from moderately labile towards the labile PO_4^{3-} and the stable Ca-PO_4^{3-} pool
4. Decrease of $\delta^{18}O_{PO43-}$ signal after 14 days under static reduction

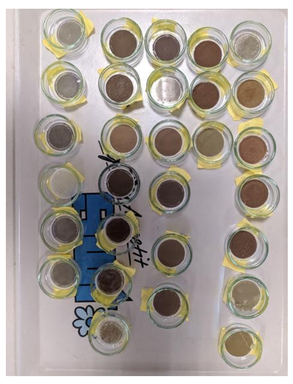


Figure 1: Precipitated $Ag_3PO_4^{3-}$ of the sequential extractions of the soil samples.

P pools under Static reduction

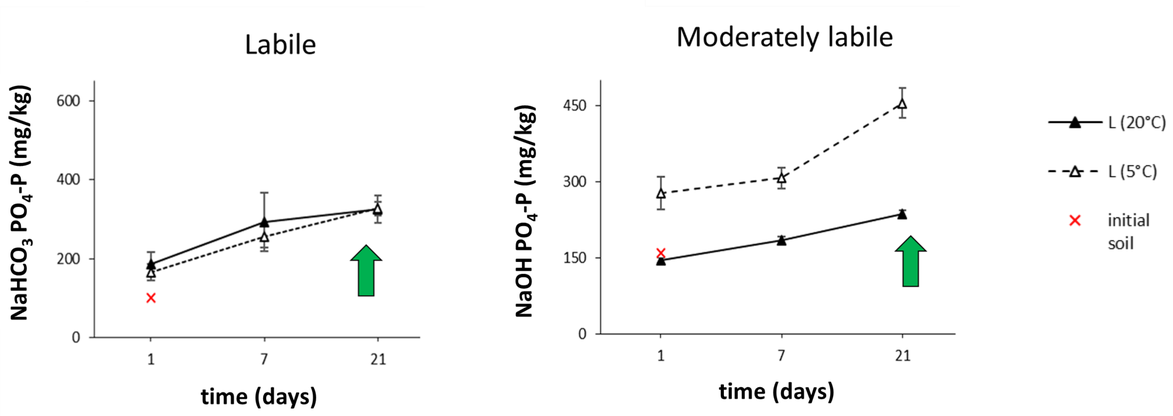


Figure 3: P_i and P concentrations (mg kg^{-1}) in the soil samples logged under statically reduced conditions. Y-error bars indicate standard deviation of the mean values of P.

$\delta^{18}O$-PO_4^{3-} under static reduction

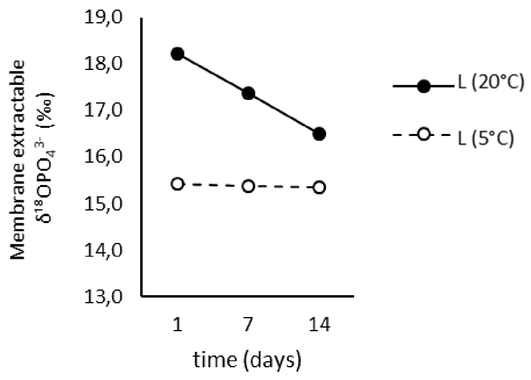


Figure 2: Membrane extractable $\delta^{18}O$ (‰) in the soil samples under statically reduced conditions.

P pools under Short pulsed drying-rewetting

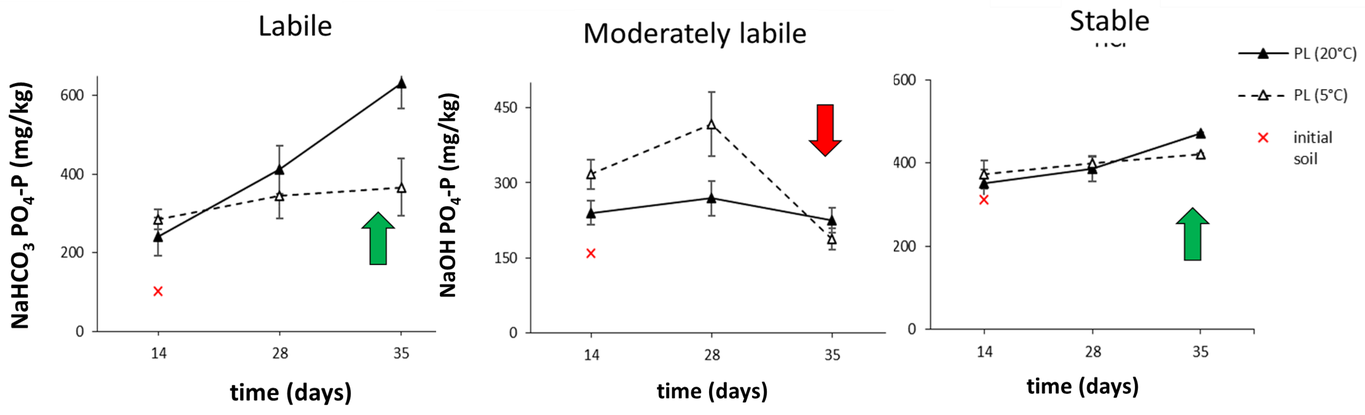


Figure 4: P_i and P concentrations (mg kg^{-1}) in the soil samples under drying - rewetting conditions. Y-error bars indicate standard deviation of the mean values of P.

Conclusion

- The results corroborated assumed changes in the P pool composition of soils and sediments that we previously observed in the field.
- Such dynamic changes in P pools, especially with varying redox conditions, are relevant with regard to the transfer of PO_4^{3-} from interim storage pools to surface water.
- Outlook: extension of the incubation experiment from short- to long-term (i.e., six months)

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