

The effect of Fe - amendment of peaty freshwater systems depends on amount and form of added Fe

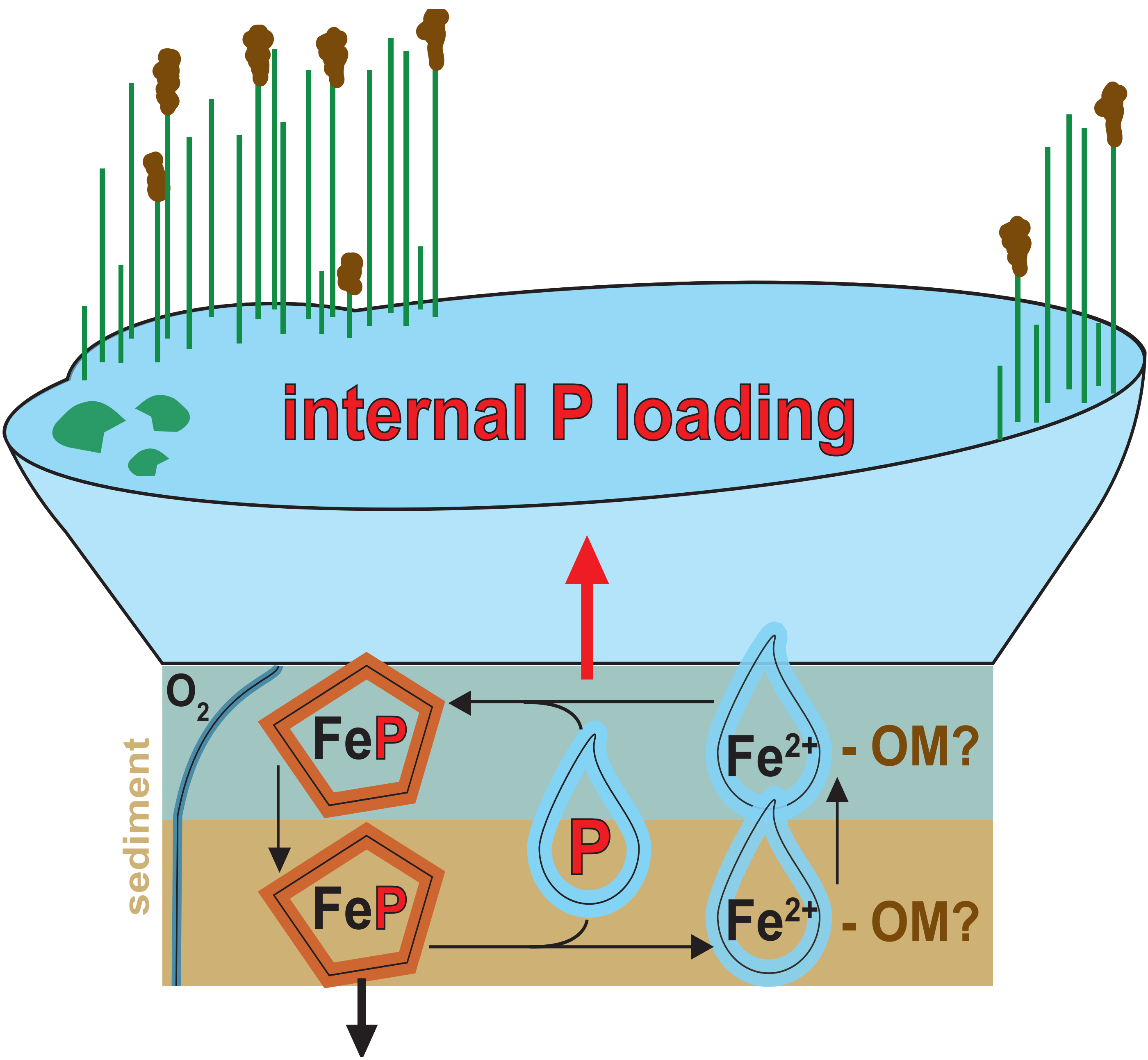
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What and Why?

Fe-amendment has been used for the mitigation of internal P loading in lakes. Its success varies for not fully understood reasons.¹⁻⁷ Because of the high affinity of P to Fe, fate of P in the sediment is coupled to the Fe-redox-cycle.^{4,8} Thus, the properties and amounts of added Fe are expected to be crucial to the success of Fe-amendment.

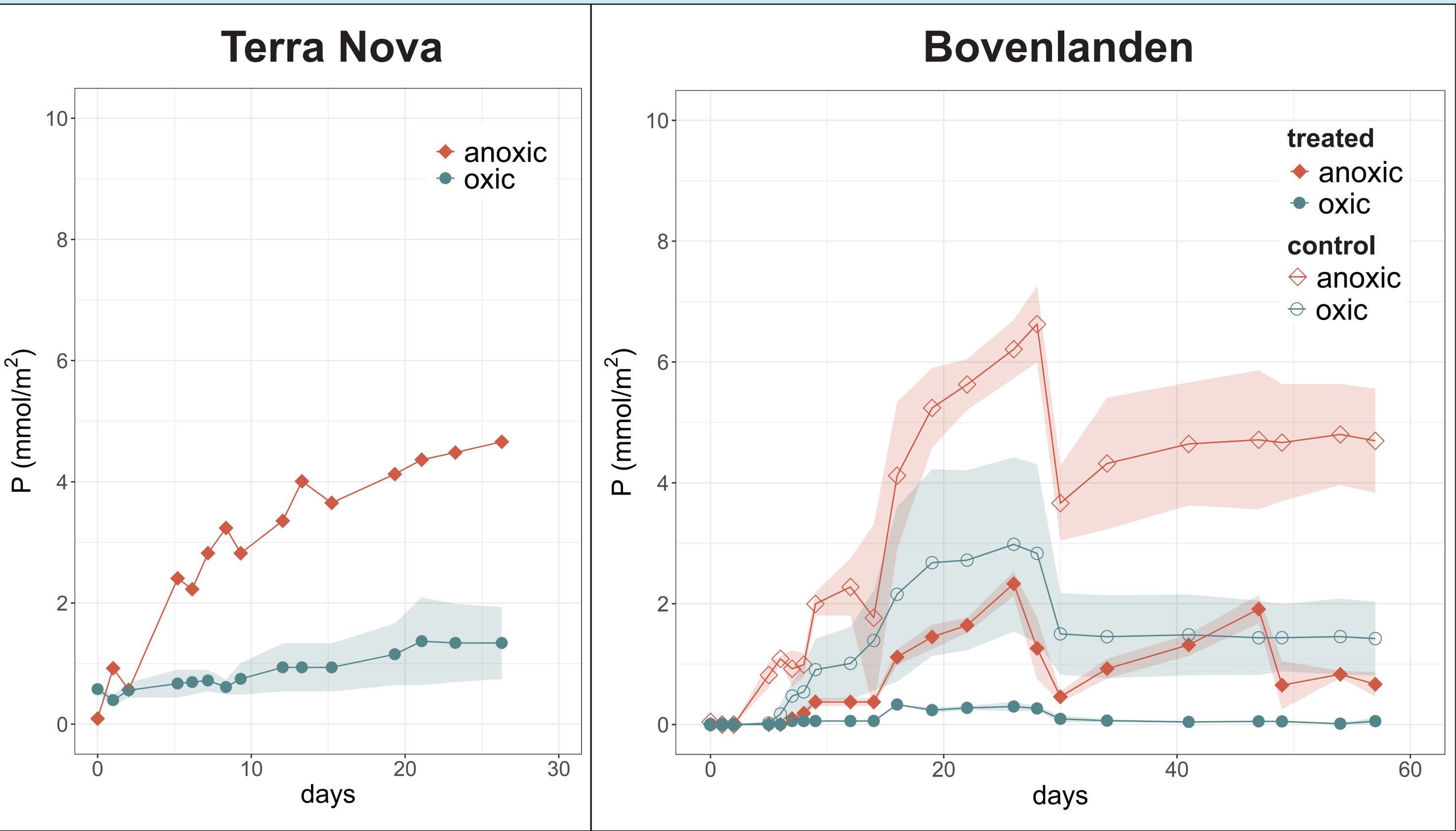
FeCl₃ vs. Fe - WTR

Fe-containing by-products from drinking water production (Fe-WTR) are a promising alternative to Fe-salts (e.g. FeCl₃). Fe-WTR allows for higher dosage because it does not cause acidification of the surface water and represents a circular economy solution.



Sediment incubation experiments

Benthic P flux under oxic and anoxic conditions



- At Bovenlanden the Fe-treatment reduced the benthic flux of P from the sediment to the water column by two third both under oxic and anoxic conditions with respect to the control.
- When comparing Fe treated sediments, the P release in Terra Nova is about twice as high as in Bovenlanden.



Terra Nova

Peat lake, polymictic, mean depth 1.5 m
Treatment : **dissolved FeCl₃**,
ca. 56 g Fe / m²,
2010

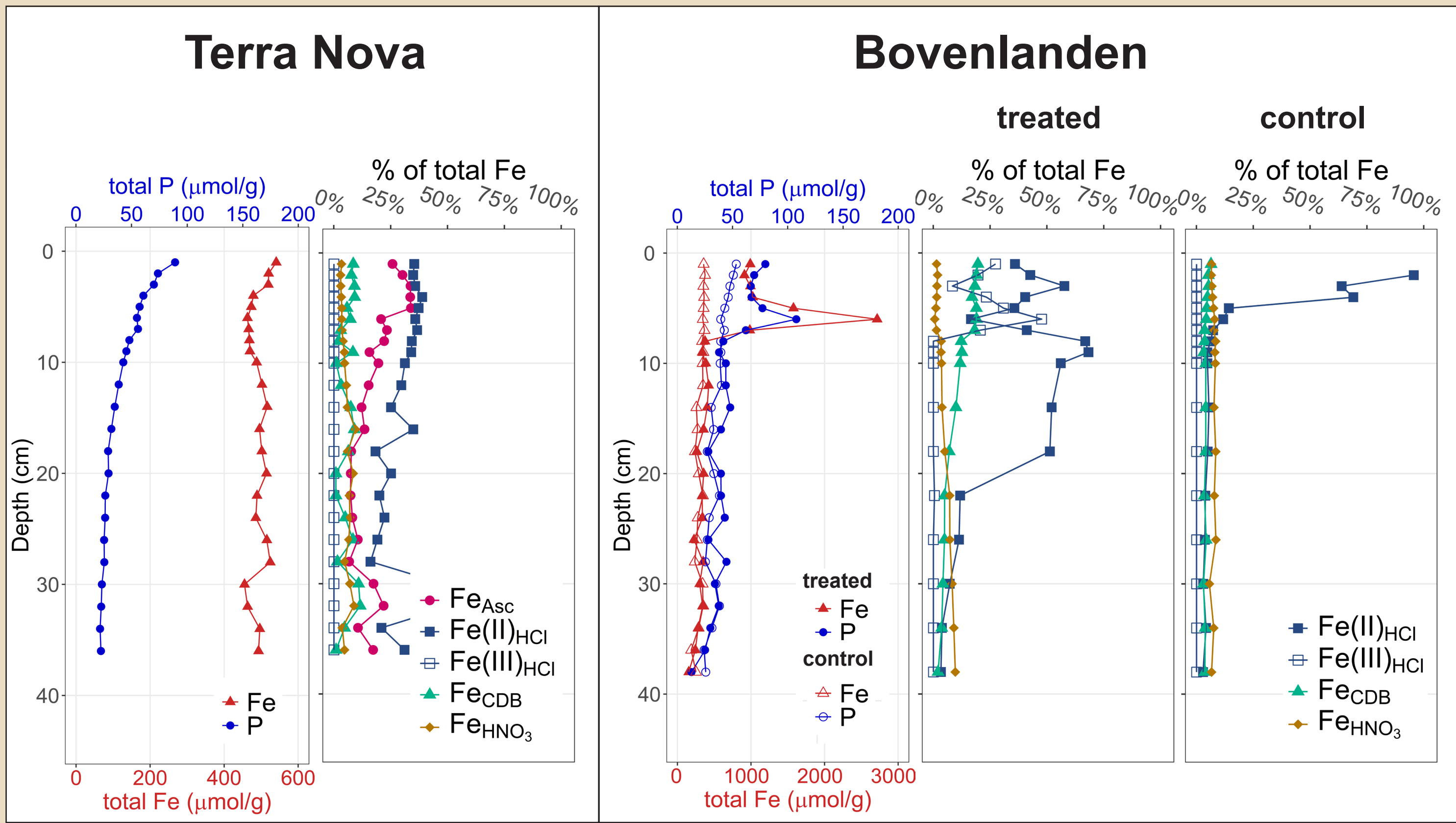
Sampling : June 2020

Bovenlanden

Peat ditch system, mean depth 0.3 m
Treatment : **solid Fe-WTR** (Fe₂O₃·3H₂O),
ca. 2 kg Fe / m²,
December 2019

Sampling : November 2021

Sediment sequential extraction



- At Terra Nova the addition of FeCl₃ introduced a highly redox active Fe-pool (Fe_{Asc}), which 10 years after treatment is still cycling in the top 5 cm of sediment. The Fe-cycling seems to take place within this Fe_{Asc}-pool with minor formation of more crystalline Fe-oxides (Fe_{CDB}) and FeS (Fe(II)_{HCl}). The Fe_{Asc} is suspected to not only represent amorphous ferrihydrite, but also highly redox active Fe complexed by organic ligands.¹²
- At Bovenlanden, the addition of Fe-WTR substantially increased the Fe-content of the sediment, shifting the relevance from FeS (Fe(II)_{HCl}) to poorly crystalline Fe-oxides (Fe(III)_{HCl}) and crystalline Fe-oxides (Fe_{CDB}) in the top layers of sediment. The majority of the added Fe has moved to a depth of 6 cm after only one year but influences the entire top core. The poorly crystalline Fe-oxides of the Fe-WTR seem to age into crystalline Fe-oxides (Fe_{CDB}) and transform into FeS (Fe(II)_{HCl}). Below the treatment derived Fe-front, FeS formation dominates Fe diagenesis similar to the control location.
- P contents in treated sediments from Bovenlande and Terra Nova are comparable. However, at Bovenlanden the Fe-treatment increased the P-pool of the top layers of sediment.

CONCLUSION

At both sites the Fe – amendment introduced reactive Fe – pools to the surface sediment. **While the addition of FeCl₃ lead to the expansion of mainly one highly redox active Fe – pool (Fe_{Asc}), Fe – WTR introduced a large pool of reactive Fe – oxides and was more effective in retaining P in the sediment.** This is probably also due to the higher dose creating a much larger pool of reactive Fe, which is also less redox sensitive and affects a bigger portion of the top sediment. The comparison is further limited as Terra Nova has been treated 10 years before sampling while at Bovenlanden sampling was performed one year after treatment. At Bovenlanden the progress of Fe oxide burial and its transformation into FeS is already visible. Therefore, it is questionable, if the addition of Fe – WTR effectively reduces internal P loading on the long – term. **Nevertheless, Fe - WTR qualifies as a viable alternative to Fe – salts for Fe – amendment as it can be applied in high doses and leads to more stable reactive Fe – phases in the sediment.**



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References

