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Simulating the release of soil phosphorus in sulphidic sediments

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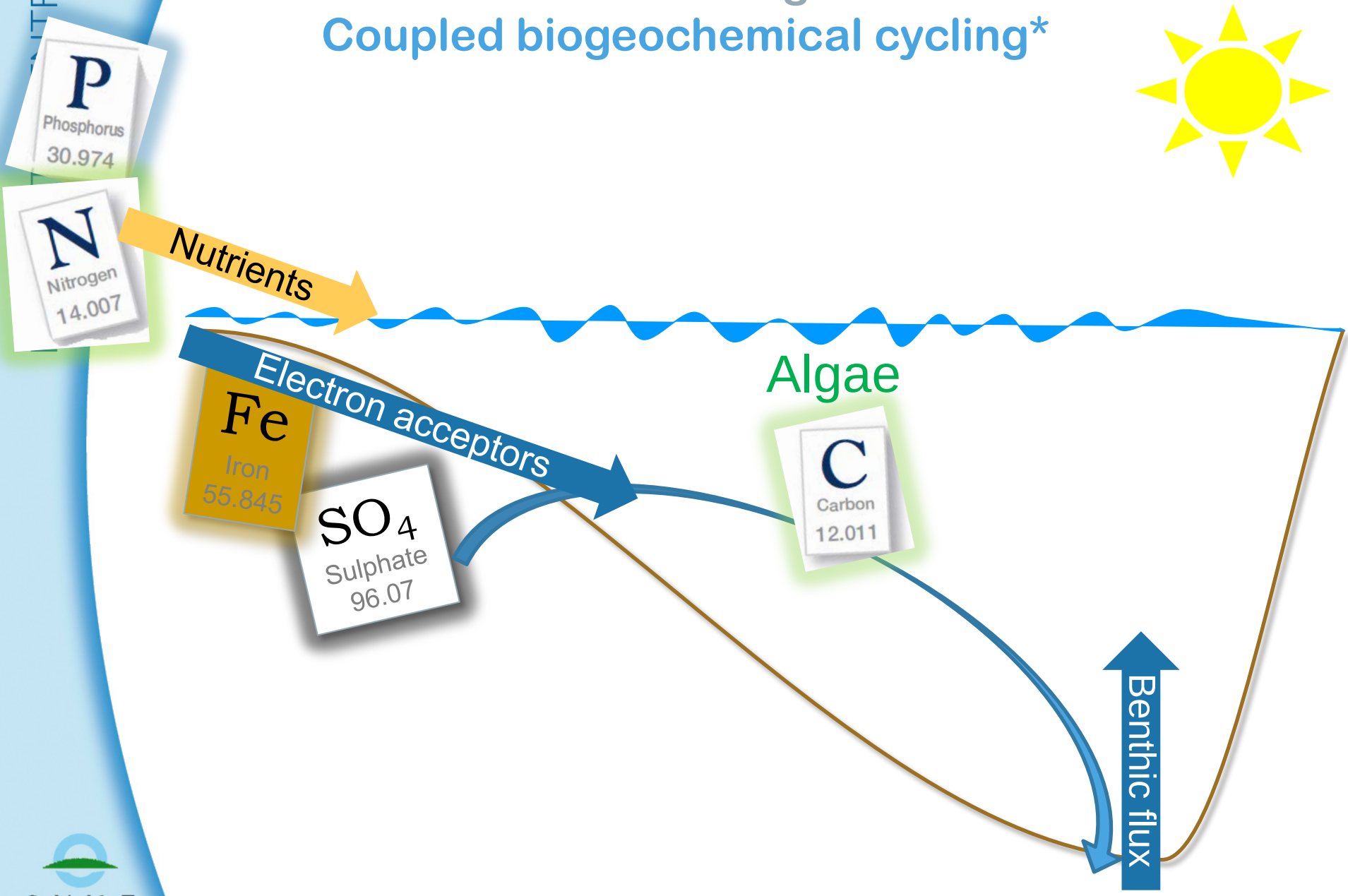
Theoretical background:
Coupled biogeochemical cycling*



*See: Frontiers in Ecology and the Environment 2011;9

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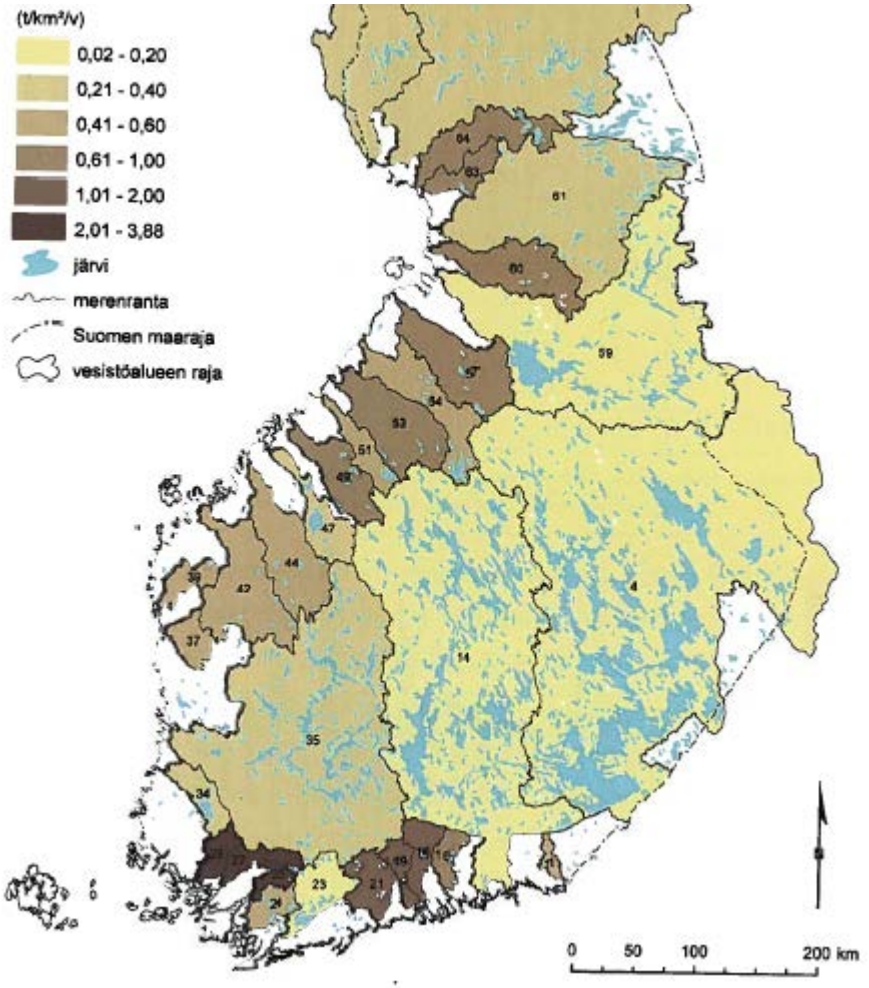
Agriculture is a major contributor to Fe losses



Agricultural rivers: 6.1–6.5% Fe in total suspended solids (Mäkiaho 2007)

Mäkiaho A. 2007. Transport of iron and suspended sediments by Finnish rivers into the Baltic Sea, University of Helsinki.

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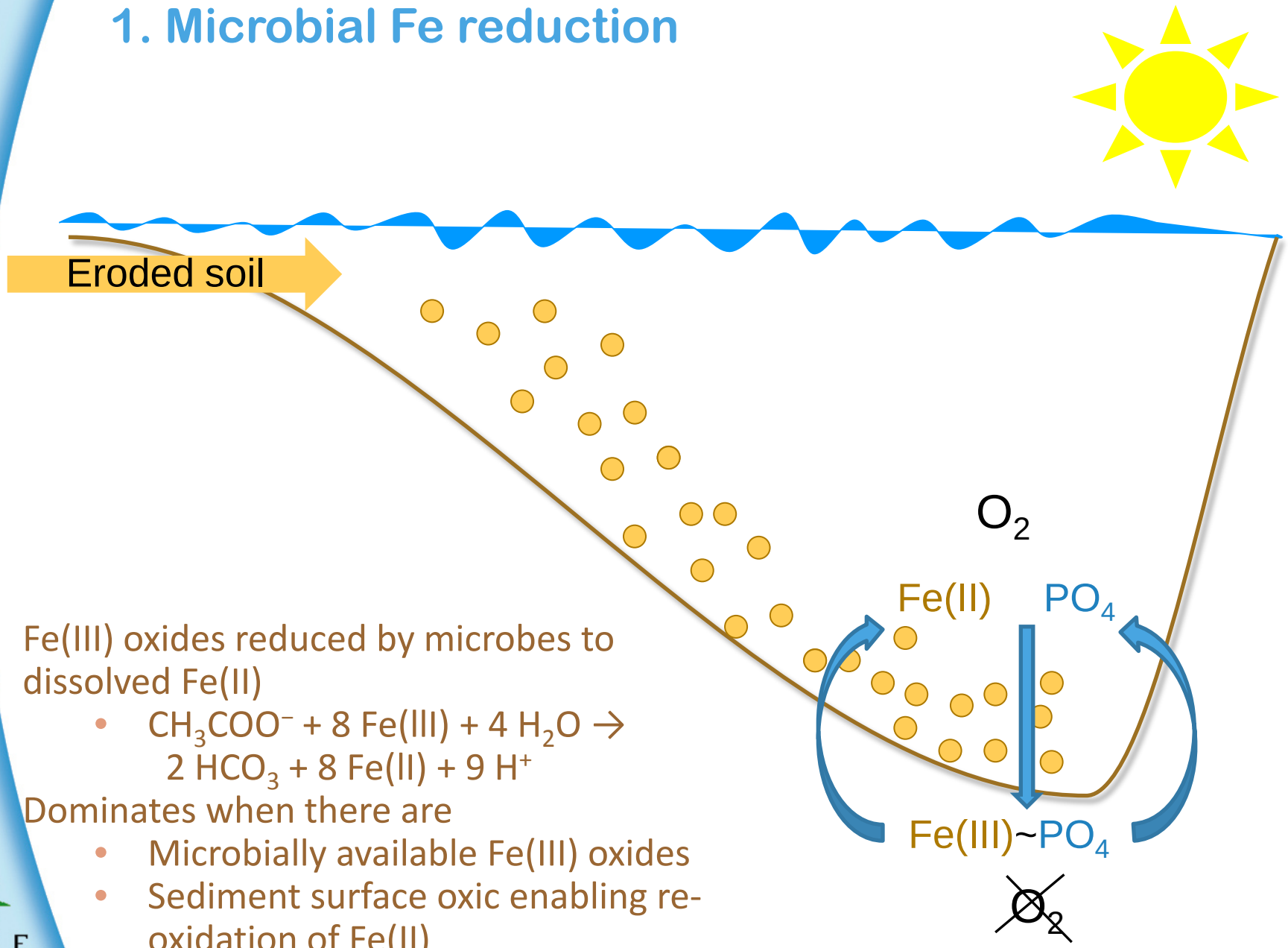
Phosphorus release from Fe oxides
1. Microbial Fe reduction



Fe(III) oxides reduced by microbes to dissolved Fe(II)

- $CH_3COO^- + 8\ Fe(III) + 4\ H_2O \rightarrow 2\ HCO_3 + 8\ Fe(II) + 9\ H^+$

Dominates when there are

- Microbially available Fe(III) oxides
- Sediment surface oxic enabling re-oxidation of Fe(II)

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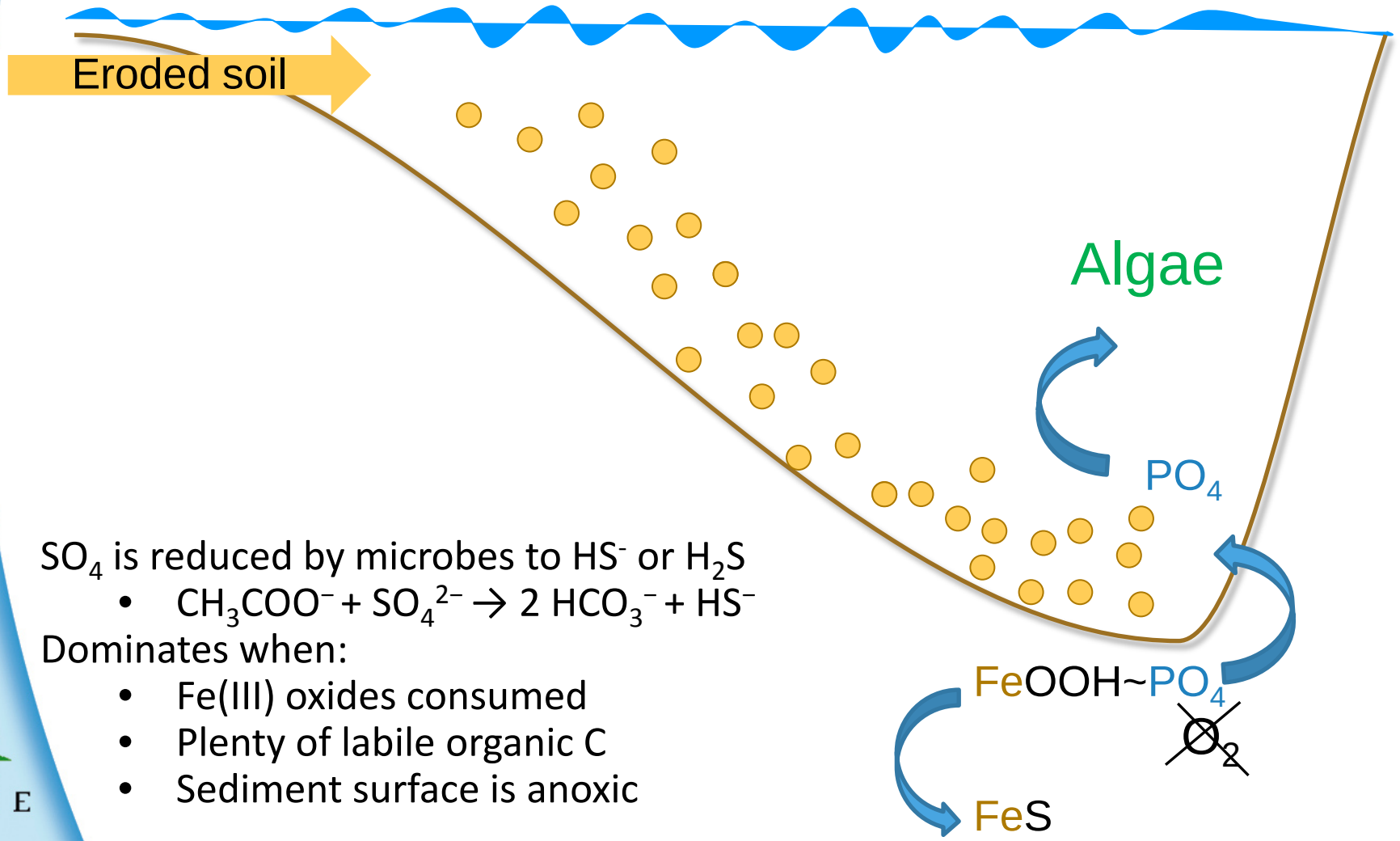
Phosphorus release from Fe oxides
2. Chemical Fe reduction
"Sulphate-mediated eutrophication"



SO_4 is reduced by microbes to HS^- or H_2S

- $CH_3COO^- + SO_4^{2-} \rightarrow 2\ HCO_3^- + HS^-$

Dominates when:

- Fe(III) oxides consumed
- Plenty of labile organic C
- Sediment surface is anoxic

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What is a sulphidic system?

Site	SO_4 (mg l^{-1})
Sea water	2400
The Baltic Sea (off Helsinki)	500
Lake Pyhäjärvi	9.6
Lake Pielinen	2.5

- SO_4 concentration in runoff increases with field percentage (Mattsson et al. 2007)

Mattsson T, Kortelainen P. Lepistö, Räike A. 2007. Organic and minerogenic acidity in Finnish rivers in relation to land use and deposition. Science of the Total Environment 383:183-192.

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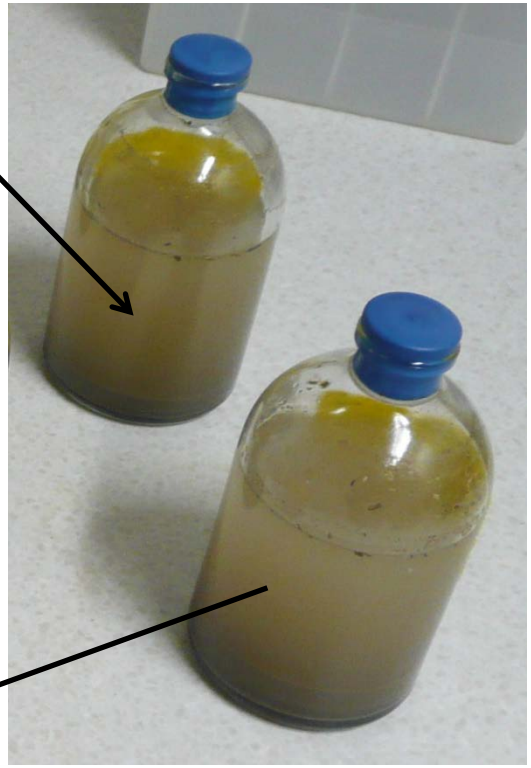
The experiment

Sandy clay soil (60–1000 mg)
(a) 80 ml brackish water medium (−P) + SO_4
(b) 80 ml filtered Baltic Sea water
+ acetate (0.375–24 mg C)
+ 10 µl sediment



Incubation on a shaking table
- At dark
- (a) +10 C, (b) +8 C
- (a) 308 d, (b) 745 d

Determinations
- Fe(II), Total Fe, DRP, TOC, SO_4, NH_4, pH

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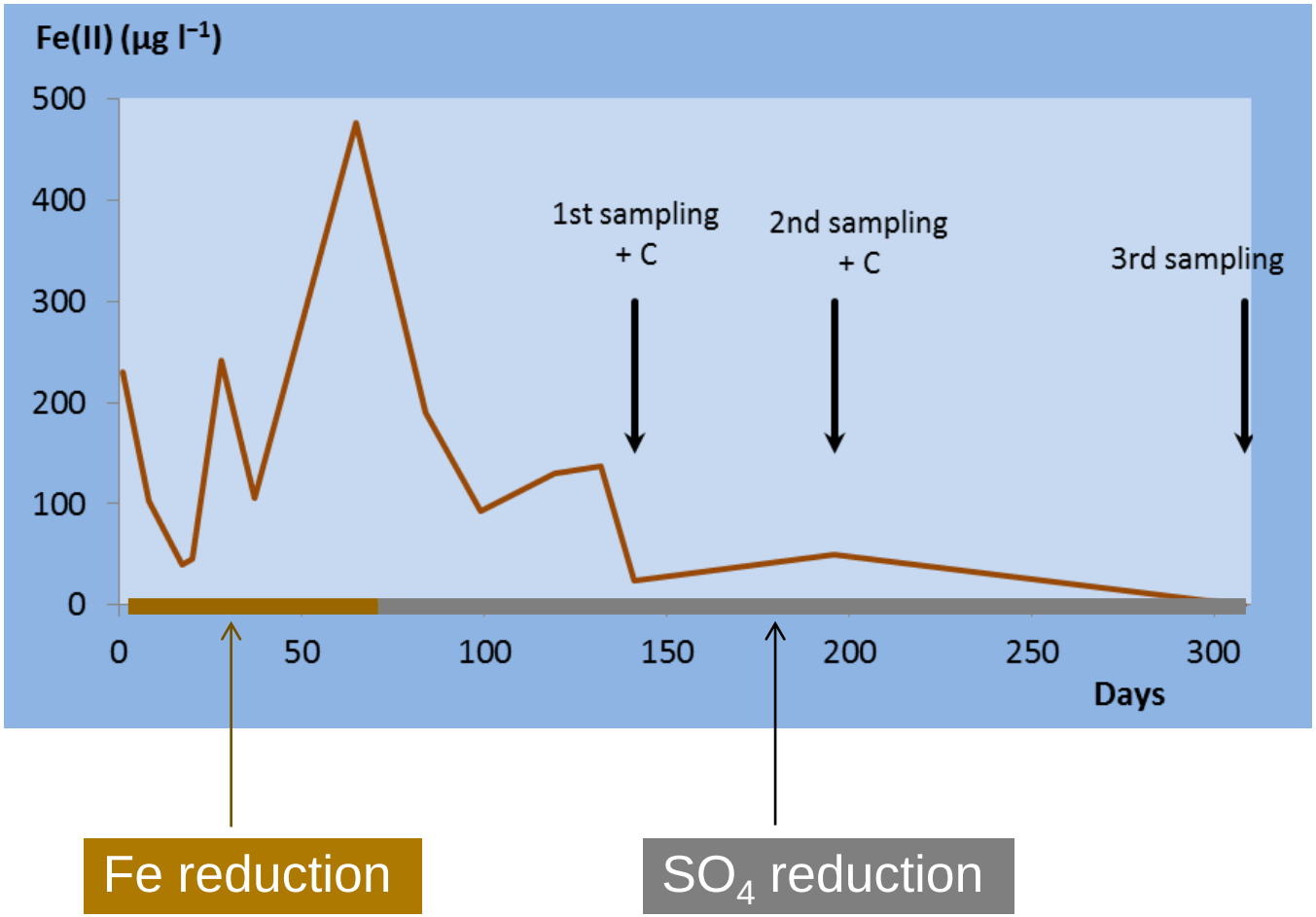
Mineralization processes in the experiment



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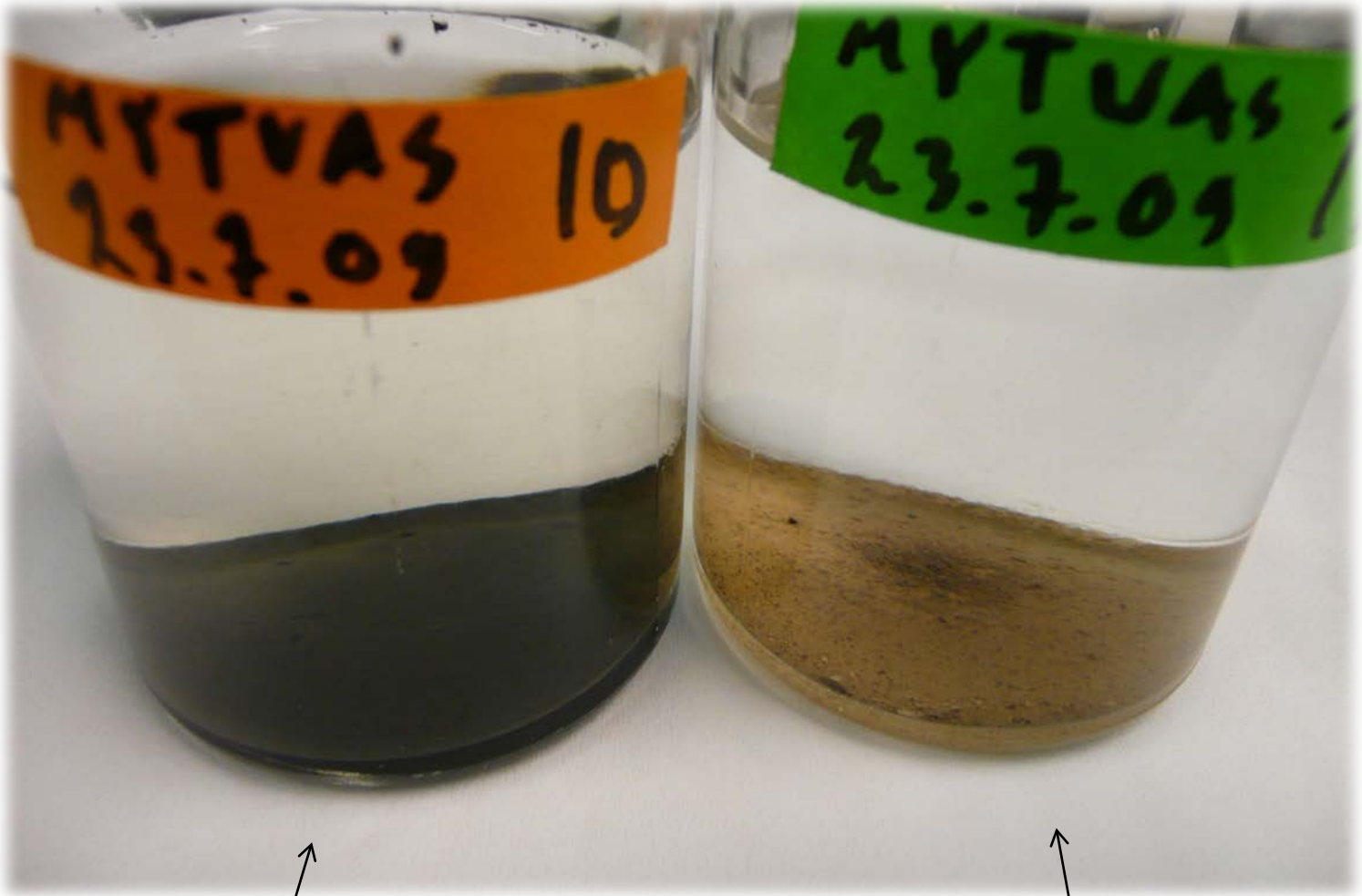

Carbon

No carbon

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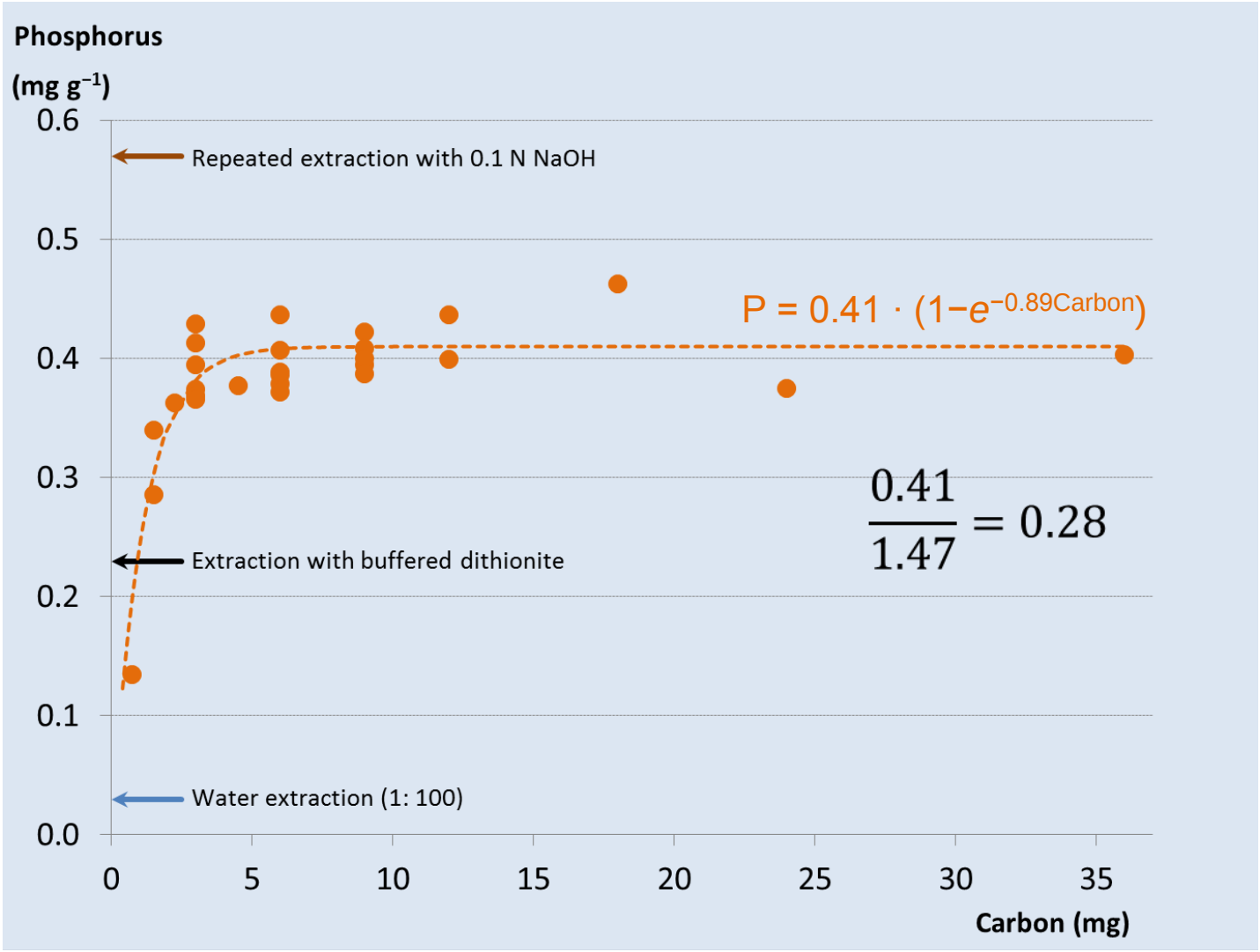
Phosphorus release as a function of carbon added



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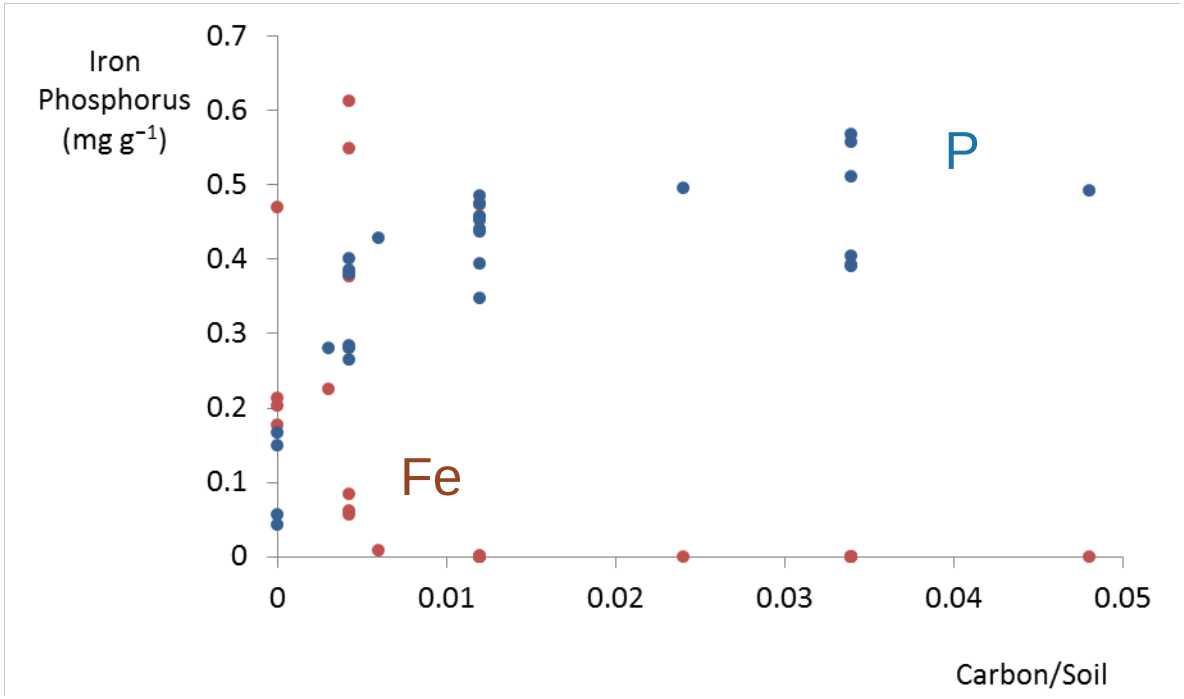

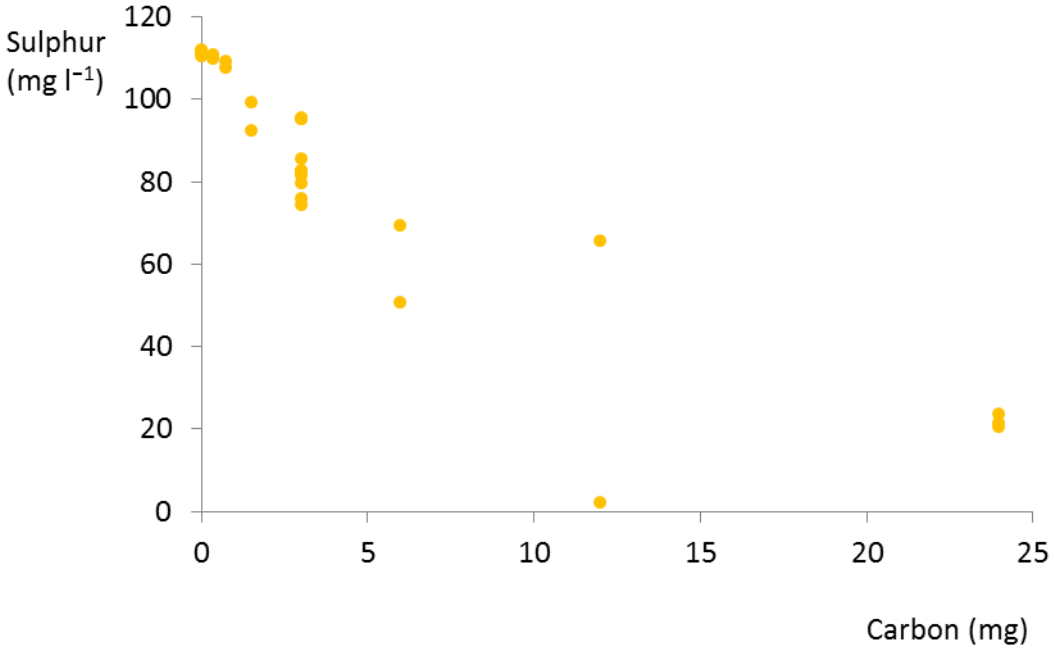

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Conclusions

- Release of P from soil can be enhanced by organic C and simulating a highly reducing environment
- The approach may serve as an alternative method for estimating the potentially mobile P
- Eroded soil is a major potential P source in sulphidic and eutrophic systems, such as the Baltic Sea or SO_4-rich lakes

→ The load of P, N (and in freshwaters SO_4) should be reduced

? BUT: to what extent does Fe in soil inhibit SO_4 reduction and P release?

? What P form (PP/DRP) should be reduced?

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How to manage that field plot?
Thank you!