Leibniz-Institute of
Freshwater Ecology and Inland Fisheries

How top soil removal may influence the mobilisation of phosphorus and greenhouse gases in rewetted fens

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drained →

rewetted
— = →
restored
?

Research
for the future
of our freshwaters

Gützkow 22.06.2012

What is meant by side effects?

Methane emission (1-50 kg C/ha y)

Net P mobilisation (~ 1 kg/ha y)

Natural growing peatland in NW-Polen

Methane emission (~ 2 t C/ha y)

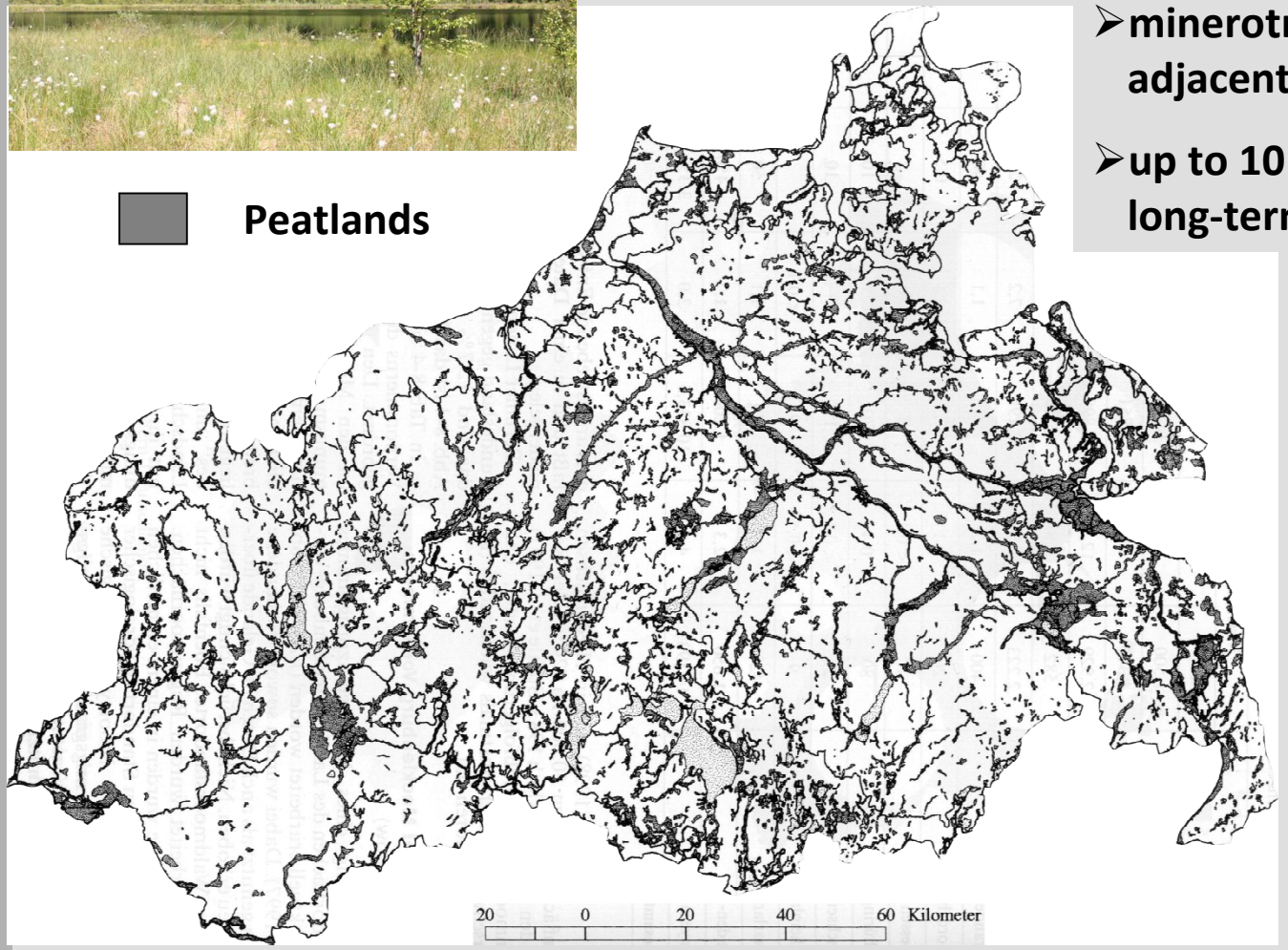
Net P mobilisation (~ 22 kg/ha y)

Polder Zarnekow in NE Germany (1 year rewetted)

(Gelbrecht, Zak & Augustin 2008)

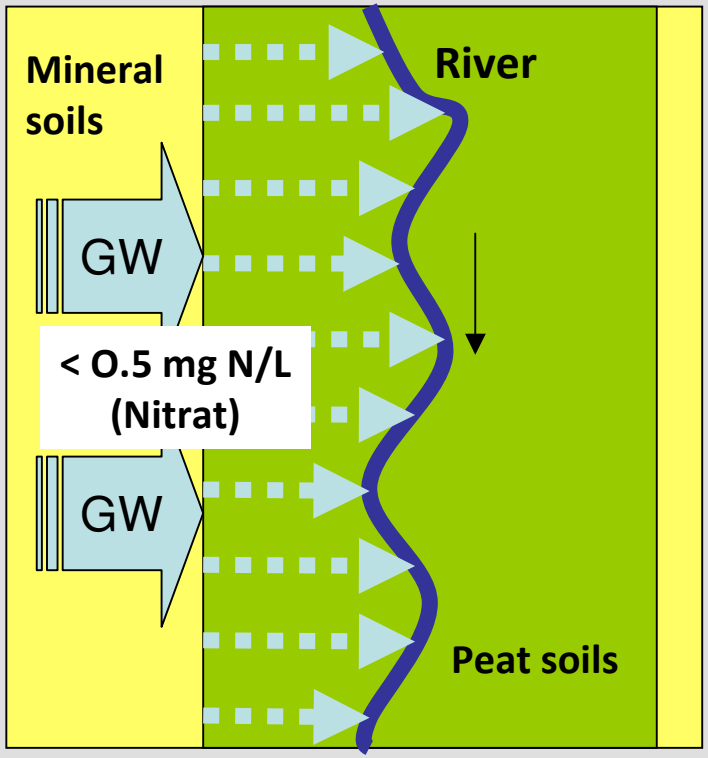
Let us go back 300 years ago in NE Germany….

- covered about 10 % of land surface
- minerotrophic and adjacent to waters
- up to 10 m thick; long-term C sinks

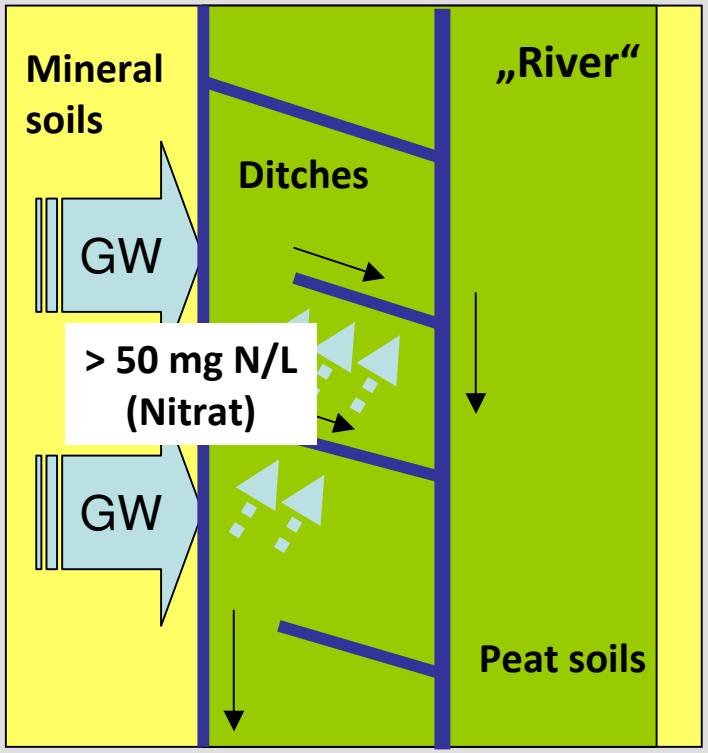


INTRO
METHODS
RESULTS
RESUME

Large scale drainage and the change of ground water quality!



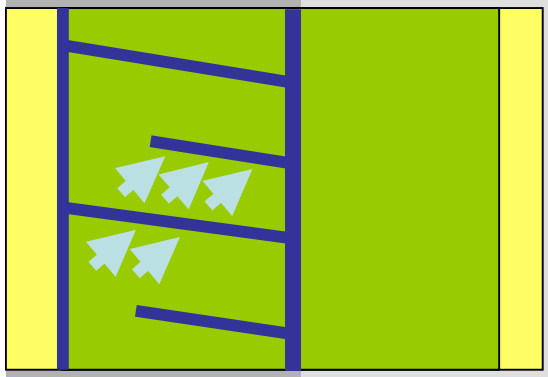
Natural Peatlands as perolated filters for ground water (GW) (covered 10% of land surface In NE Germany)



The loss of the filter function by complex drainage systems (> 95% are drained in NE Germany)

Our three main research restoration questions

1. What physico-chemical changes occur under drained conditions?



2. Do drained peatlands still retain nutrients?

3. Which are the „rewetting problems“ and how to optimize the restoration success in rewetted fens?

Our sampling site – „The BIG 5“

Rewetted inundated peatland in the River Peene Valley (M-V)

Rewetted inundated peatlands (12)

Our sampling site – „The BIG 5“

Natural growing peatland in northeastern Poland

Rewetted inundated peatlands (12)

Natural growing peatlands (10)

Our sampling site – „The BIG 5“

Peat hole Guetzkow 25: „inundated fen with top soil removal“

Rewetted inundated peatlands (12)

Natural growing peatlands (10)

Peat hole „inundated fens“ (6)

Our sampling site – „The BIG 5“

Drained intensively used peatland in River Tollense Valley (M-V)

Rewetted inundated fens (12)

Natural growing fens (10)

Peat hole „inundated fens“ (6)

Drained used fens (2)

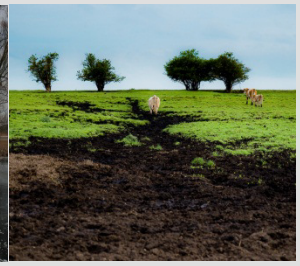
Our sampling site – „The BIG 5“

Rewetted fen with top soil removal (non-inundated) in Brandenburg

Rewetted inundated fens (12)

Natural growing fens (10)

Peat hole „inundated fens“ (6)



Drained used fens (2)

Rewetted non-inundated fen (1)

Our sampling techniques and investigation scales

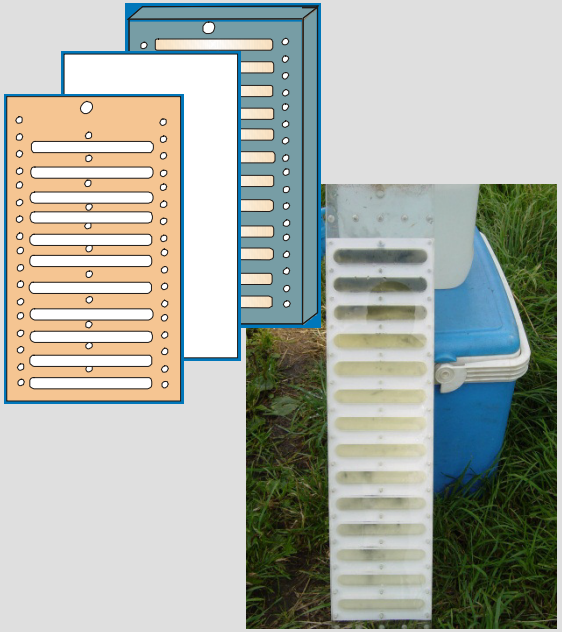
Measurement of water discharge and water chemistry for mass balance calculations

Sampling of new formed mud for the determination of mobile P, N and C pools as well as for assessment of accumulation rates

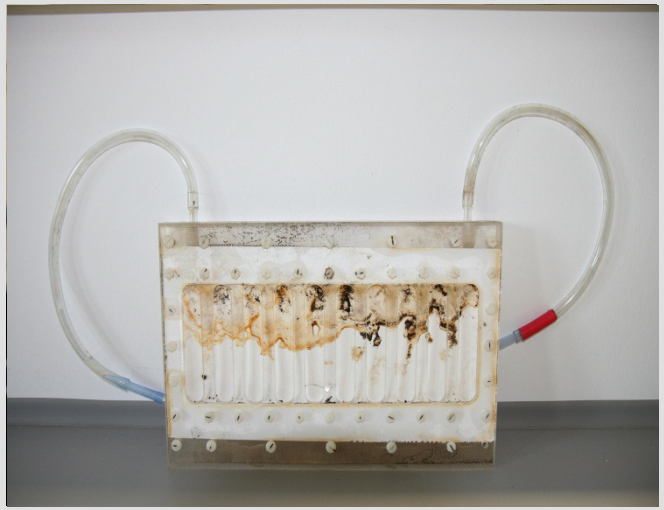
Lab experiments for the determination of mobilisation rates and controlling factors

How we can optimize the restoration of peatlands?

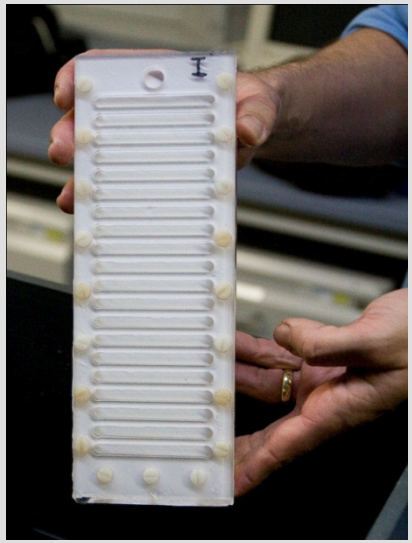
Our three mostly used anoxic soil water samplers ...



Dialysis sampler for passive in-situ sampling; sampling depth up to 70 cm (Zak et al. 2004)



Rechargeable sampler for lab and field experiments to monitor temporal concentration changes (Zak & Gelbrecht 2007)



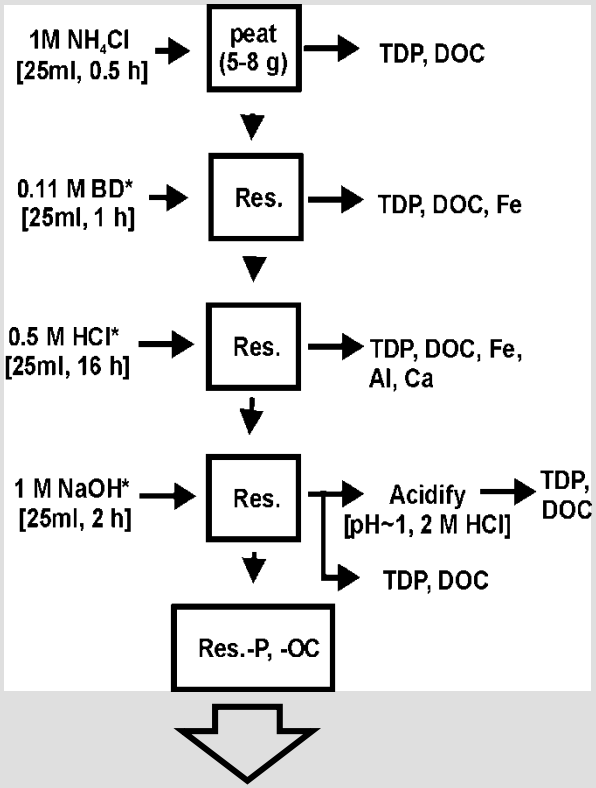
„Fine scale profile sampler“ (1 cm resolution) for the calculation of diffusive P fluxes in the lab (Zak et al. 2010)

Few of our analytical methods

CN Analyser
(DOC, DIC, DN)

Shaker for
peat extraction

Chemical
sequential
extraction procedure
(Zak et al. 2008)



P, N und C mobilisation
potential

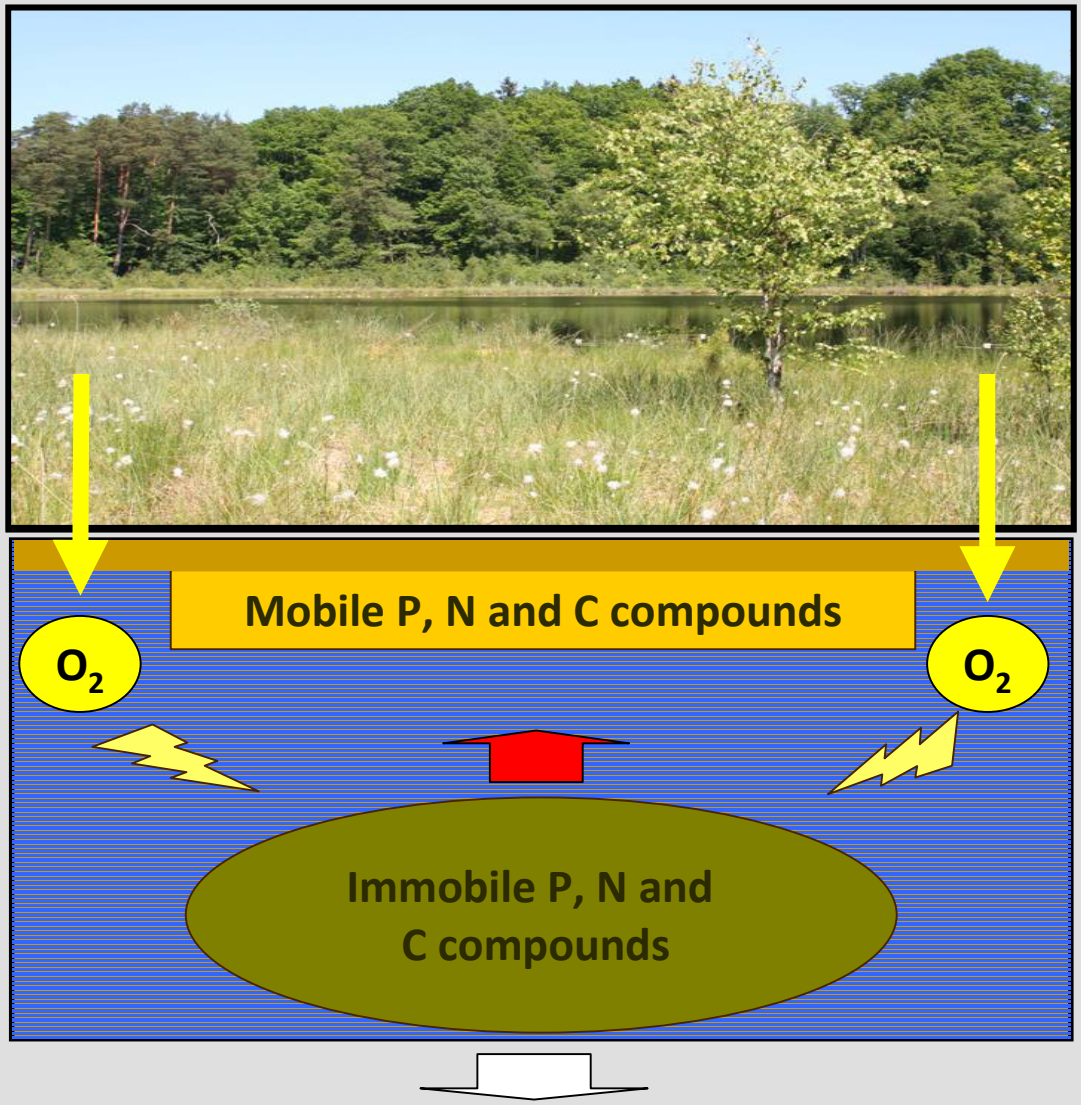
LC-OCD/OND
(DOC/N finger print)

Just established

FTIR Analytics

Fluoreszence
spectroskopie

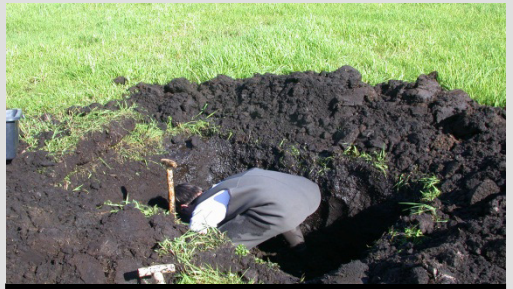
1) Which physico-chemical changes due to drainage?



Peat loss + shrinkage (up tp 2 cm/y)
(damage of the oscillation capability)

The soil changes from the grand mother perspective

The change from slightly decomposed peat to ‚muck soils‘ (highly decomposed) due to peat mineralization

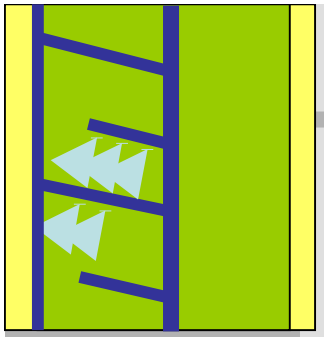


Highly decomposed peat or muck soils (0-0.3 m)

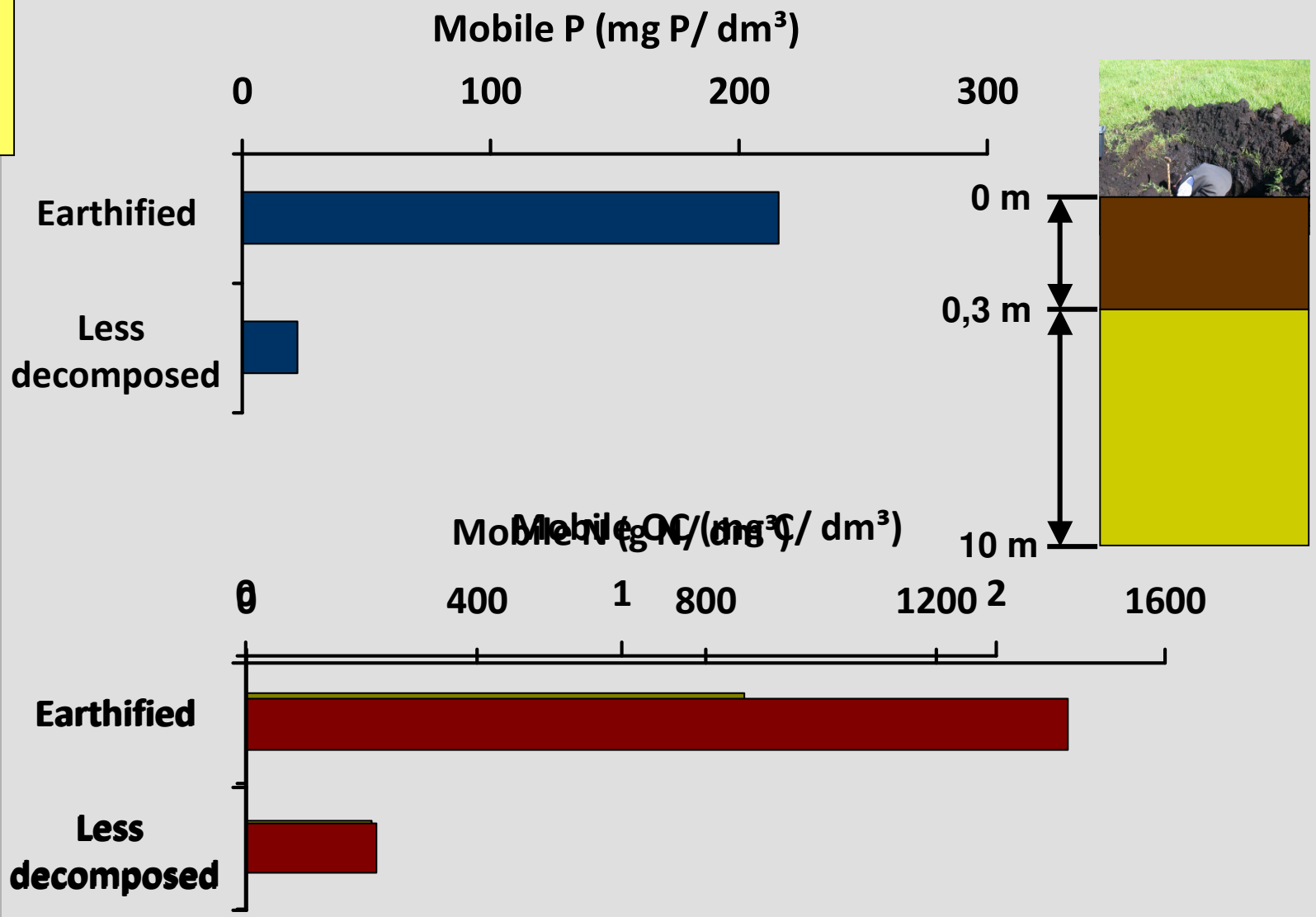
Moderately decomposed peat (0.3-1 m)

Slightly decomposed peat (1-10 m)

Drained polder Zarnekow before rewetting

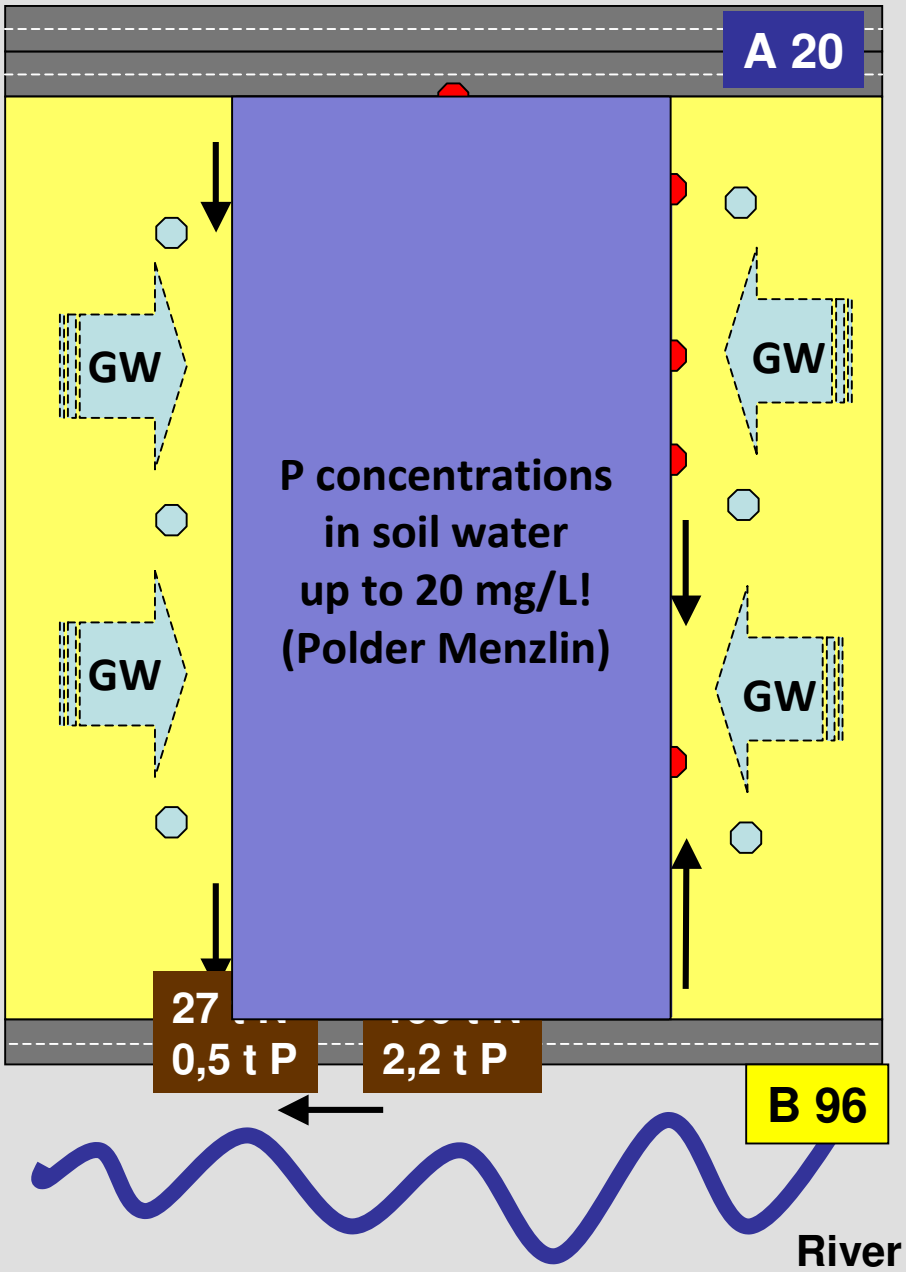


How much P and N is transformed in mobile forms?



Mobile P, N and C in different decomposed peat determined by a chemical sequential extraction procedure (Zak et al. 2008; Cabezas et al. 2012)

2) Do drained peatlands still retain (dissolved) nutrients?



Kleiner Landgraben 2011

- Input via surface water
- Input via ground water

120 t N (nitrate)
2,5 t P (dissolved P_i)

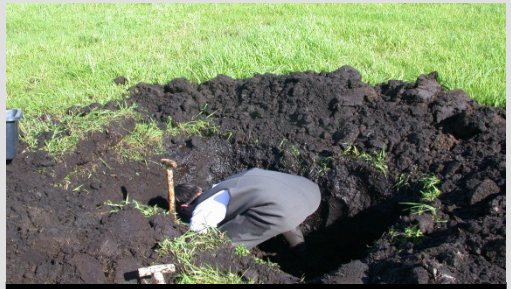
- Output (only surface water)

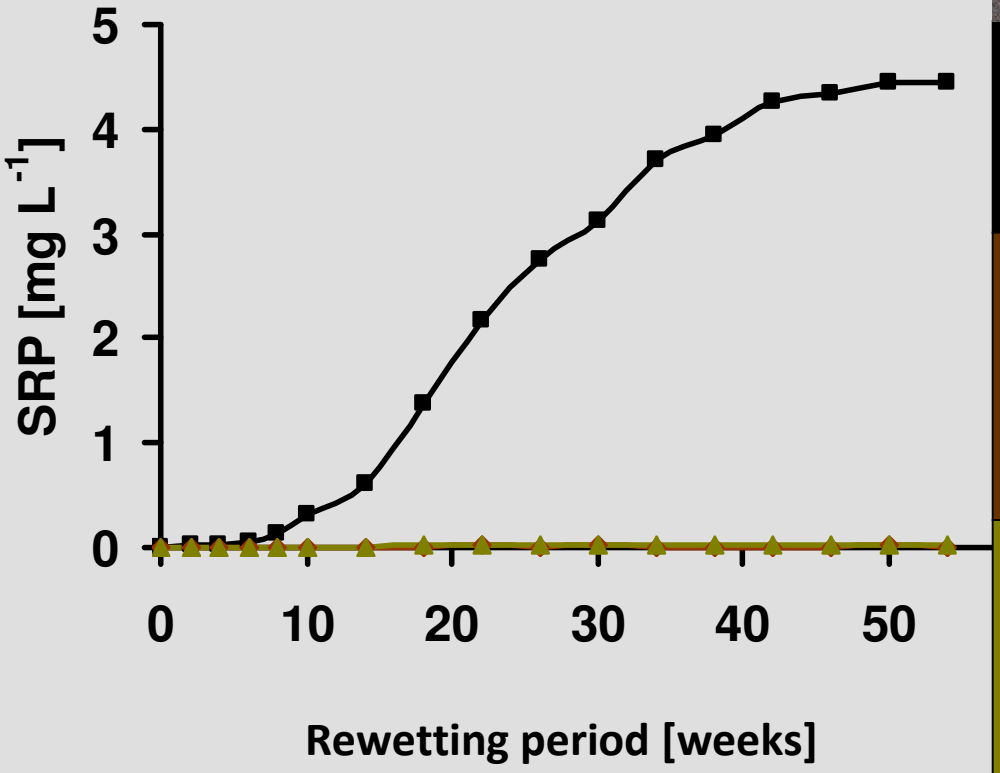
100 t N
2,2 t P

First mass balance

- 20 t N
- 0,3 t P

3) Problems: High amount labil P = high P mobilisation?





Highly decomposed peat or muck soils (0-0.3 m)

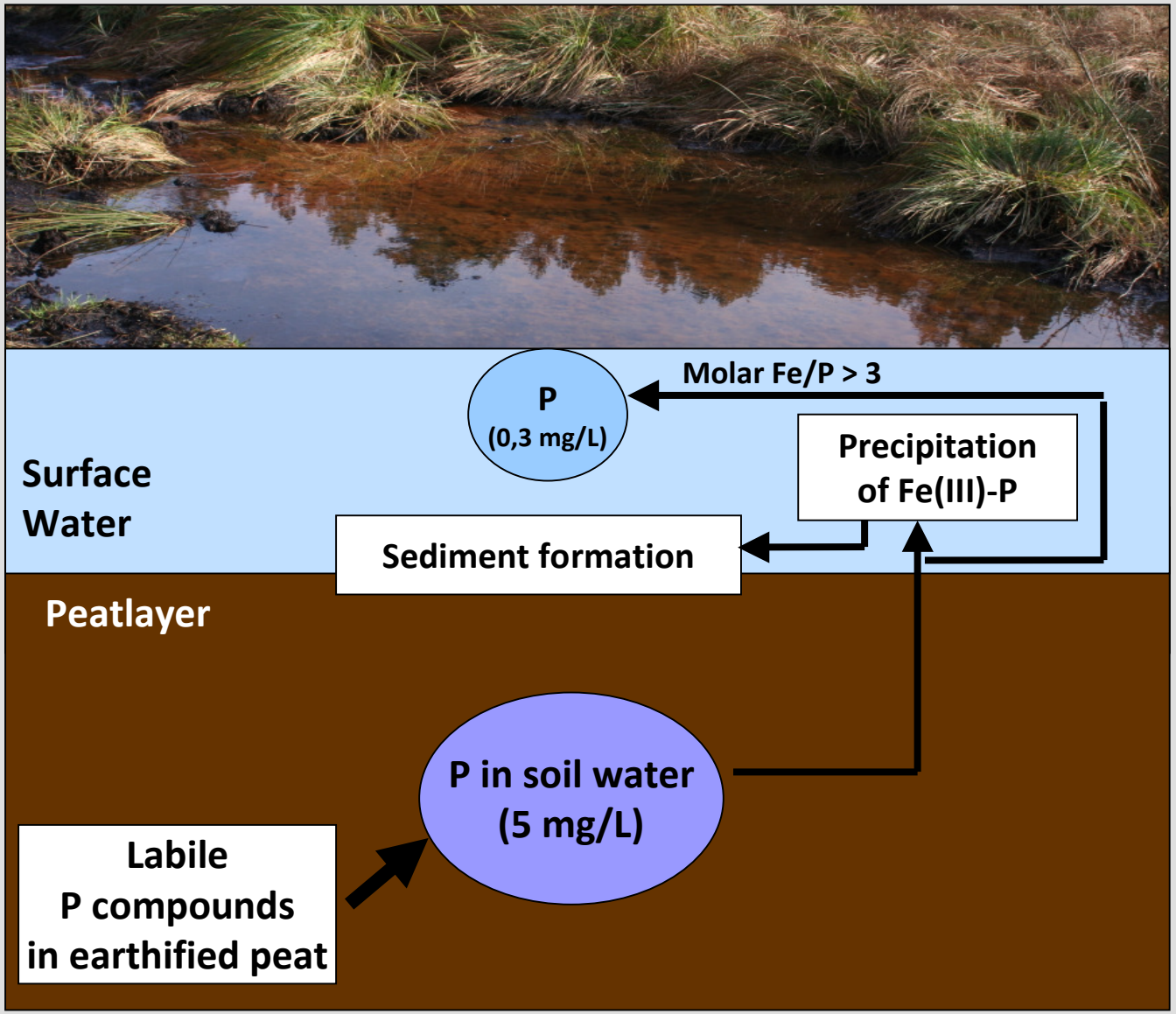
Moderately decomposed peat (0.3-1 m)

Slightly decomposed peat (1-10 m)

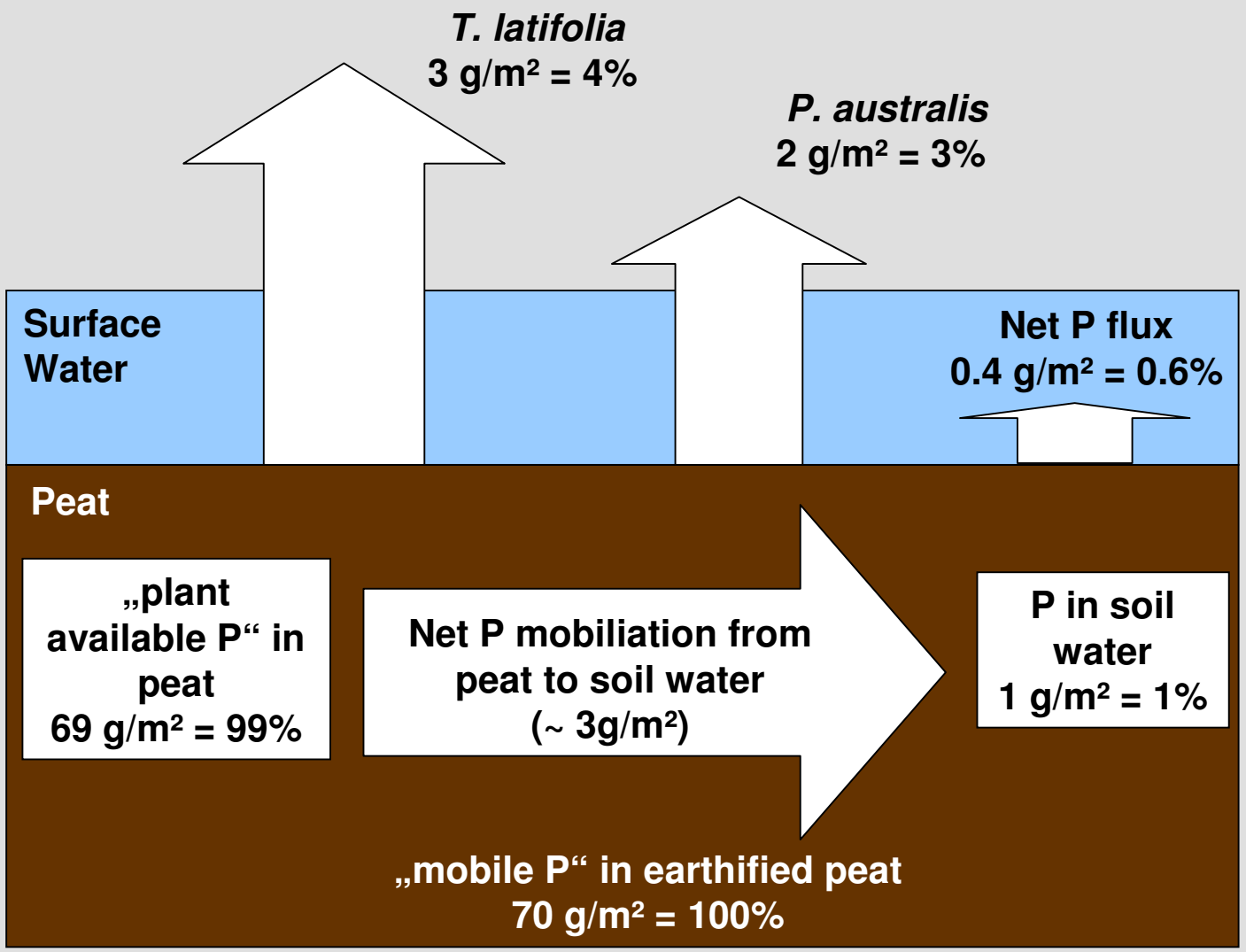
Course of P in soil water of re-wetted mesocosms with different decomposed peat from polder Zarnekow (mean ± SD, n =3).

(Zak & Gelbrecht 2007)

High P mobilisation = P export to adjacent surface water?



Do plants compensate high P mobilisation in peat?



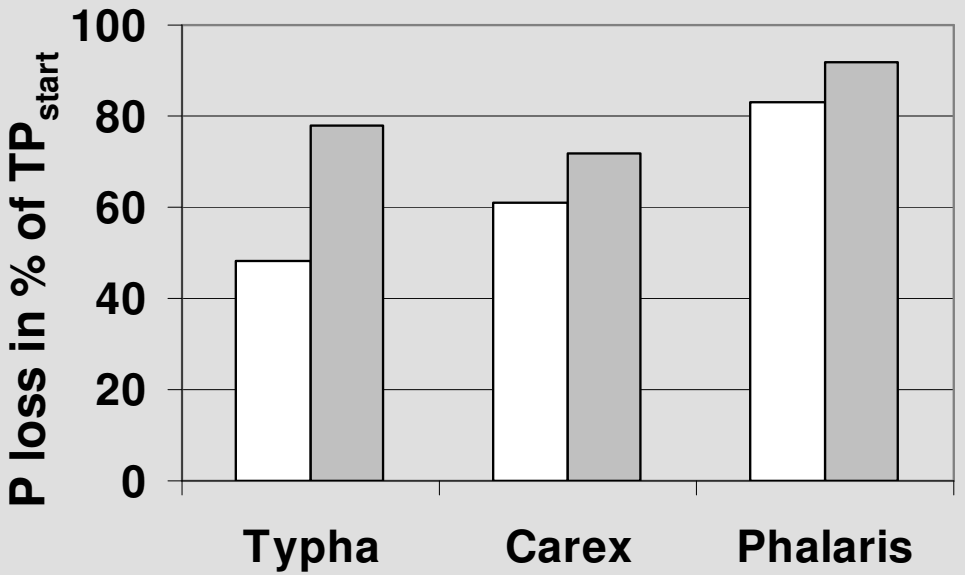
Average P fluxes in rewetted peatlands of River Peene valley. (values are related to the vegetation period of 150 d)

Kooperation with Uni Greifswald

But plants are only a temporal sink!!! (solution harvesting)


Menzlin (July)


Menzlin (November)

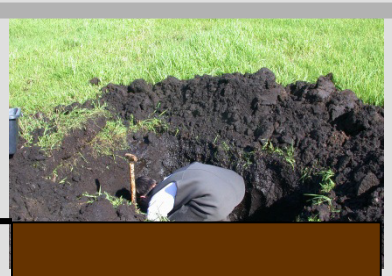


□ Leaching (1 d)

□ Decomposition (150 d)

P loss of plant litter due to leaching and subsequent anaerobic decomposition (MW, n = 3)
(Zak et al. in prep.)

3) How we can optimize the restoration success?



up to 1 m

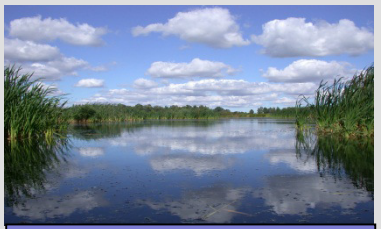
ground water level

heavily drained peatland

earthified peat

less decomposed peat

surface water



inundated peatland

How top soil removal influence matter retention/release?

Inundated peatland with top soil removal

Impact of top soil removal on P mobilisation from the peat

P in surface water ~ 0,7 mg/L

P in soil water ~ 5 mg/L

70 years

Mobile P 500 kg P/ha

Inundated peatland

Polder Zarnekow

> 100x

> 100x

P in surface water ~ 0,007 mg/L

P in soil water ~ 0,05 mg/L

Inundated peatland with top soil removal

Guetzkow

The mud formation as a new substantial retention process!

TC: 190, TN: 16 and TP 1.7

Inundated peatland

TC: 17, TN: 0.6 and TP: 0.02
(data from Succow 2001)

Inundated peatland
with top soil removal

P, C, N sequestration (g/m² year)

Impact of top soil removal on P mobilisation from the mud

50 mg P/m² d

Phosphor

5 mg P/m² d

Inundated peatland

> 100 x

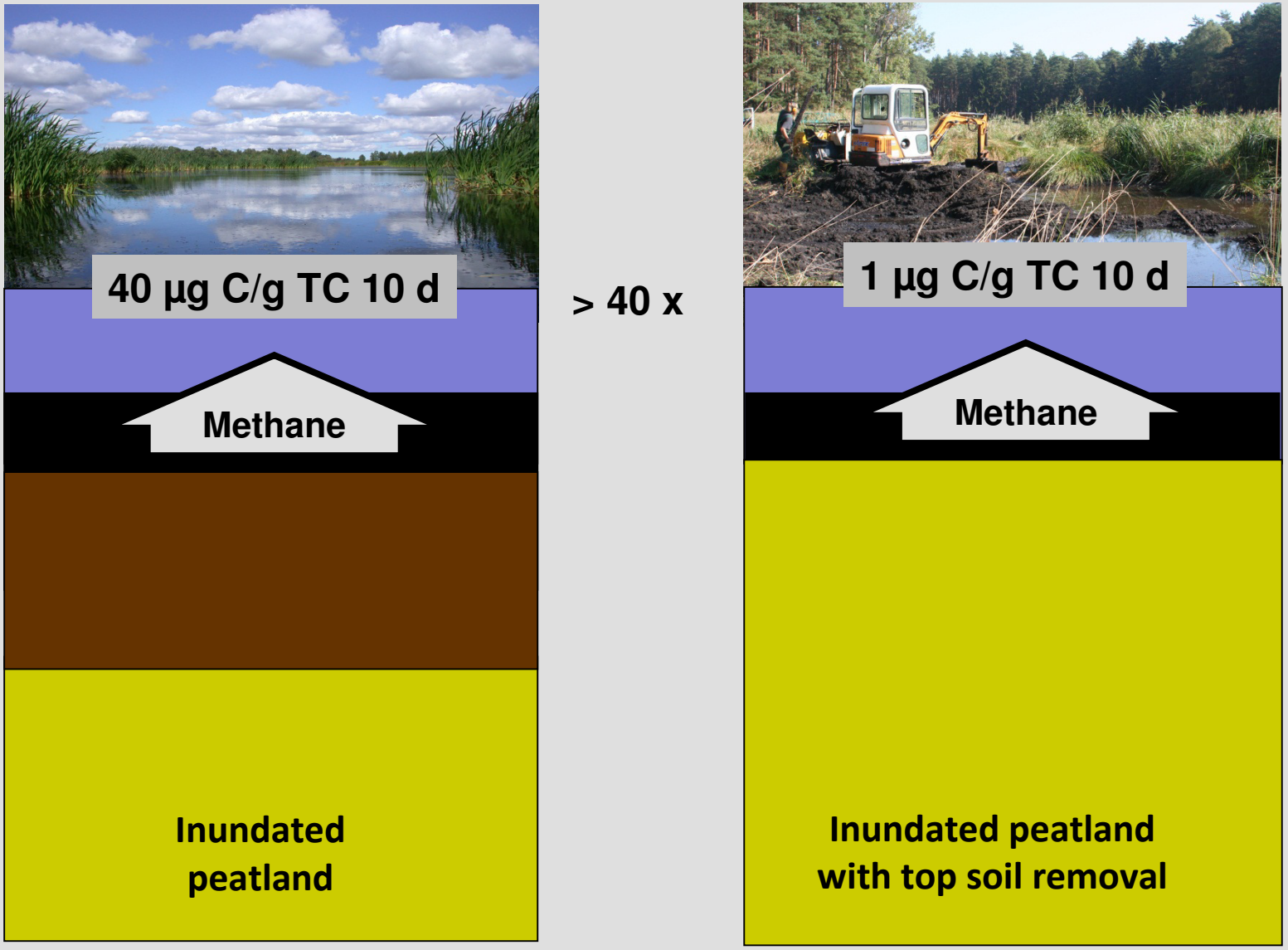
0.5 mg P/m² d

Phosphor

0.1 mg P/m² d

Inundated peatland with top soil removal

Impact of top soil removal on methane release from the mud



Methane release potential at 15 °C

Impact of top soil removal on nitrate removal

20 mg Nitrat-N/m² d

> 2x

10 mg Nitrat-N/m² d

Inundated peatland

Inundated peatland with top soil removal

Nitrate removal at 5 ℃ and nitrate load of 140 kg/N ha y

Top soil removal and no inundation: A story of success

Lehtsseeniederung in Brandenburg

Area without soil removal
(earthified peat)

SRP in soil water
1.1 mg L^{-1}

P mobilisation
2.1 mg P m^{-2} d^{-1}

after
6 years
rewetting

> ca. 30x

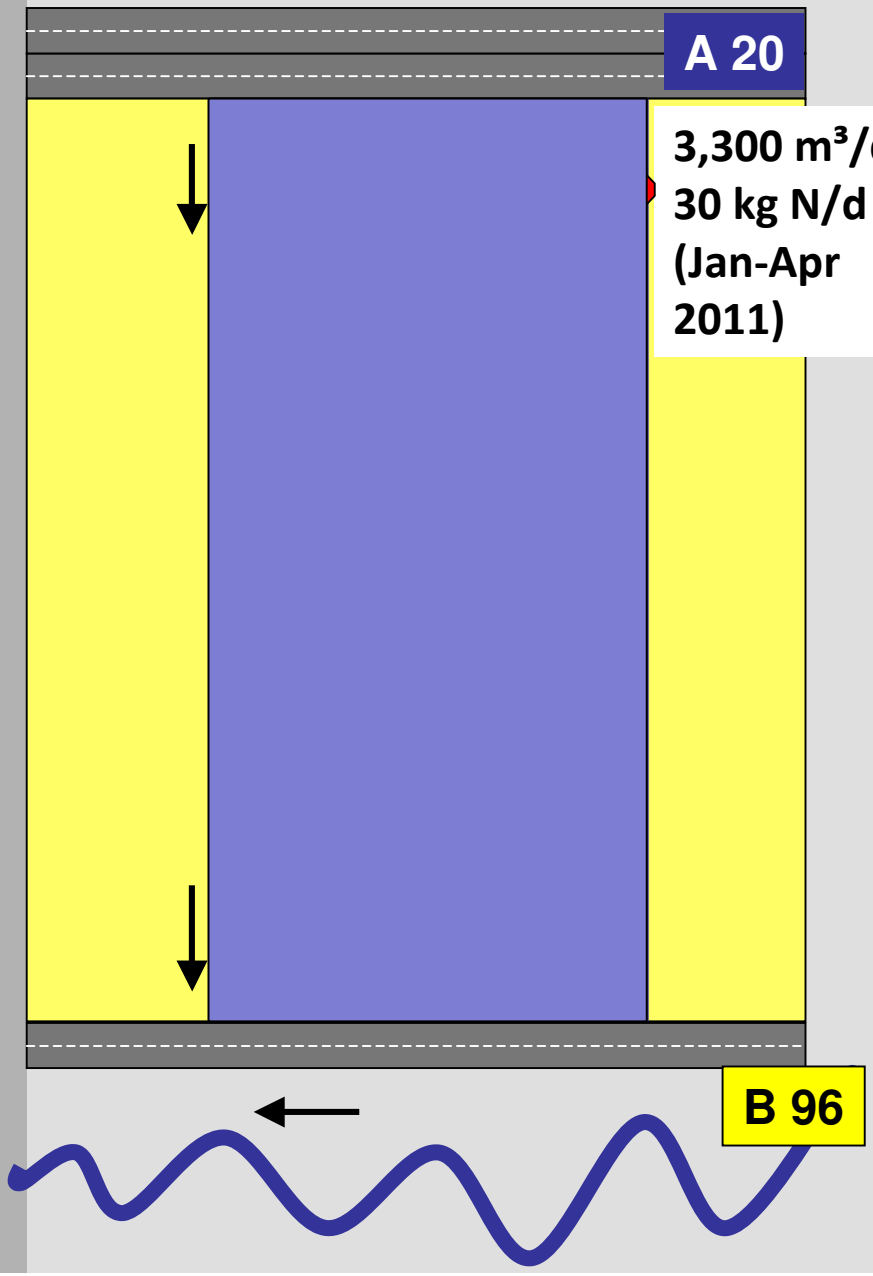
> ca. 70x

Area with soil removal
(less decomposed peat)

SRP in soil water
0.04 mg L^{-1}

P mobilisation
0.03 mg P m^{-2} d^{-1}

An alternative for large scale rewetting: ponds



Pond depth 1 m

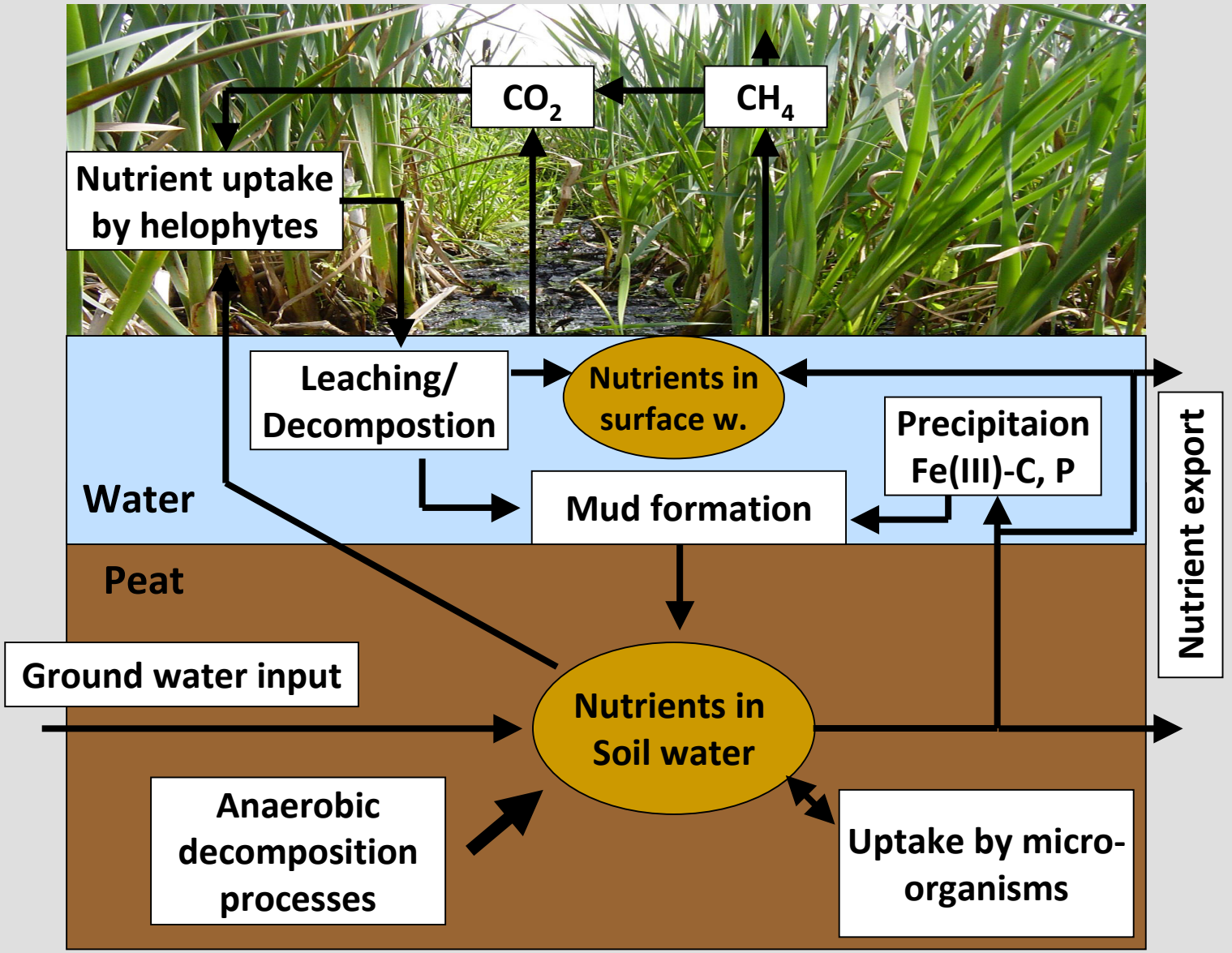
Removal 90% /50%

Pond wide 300 m /260 m

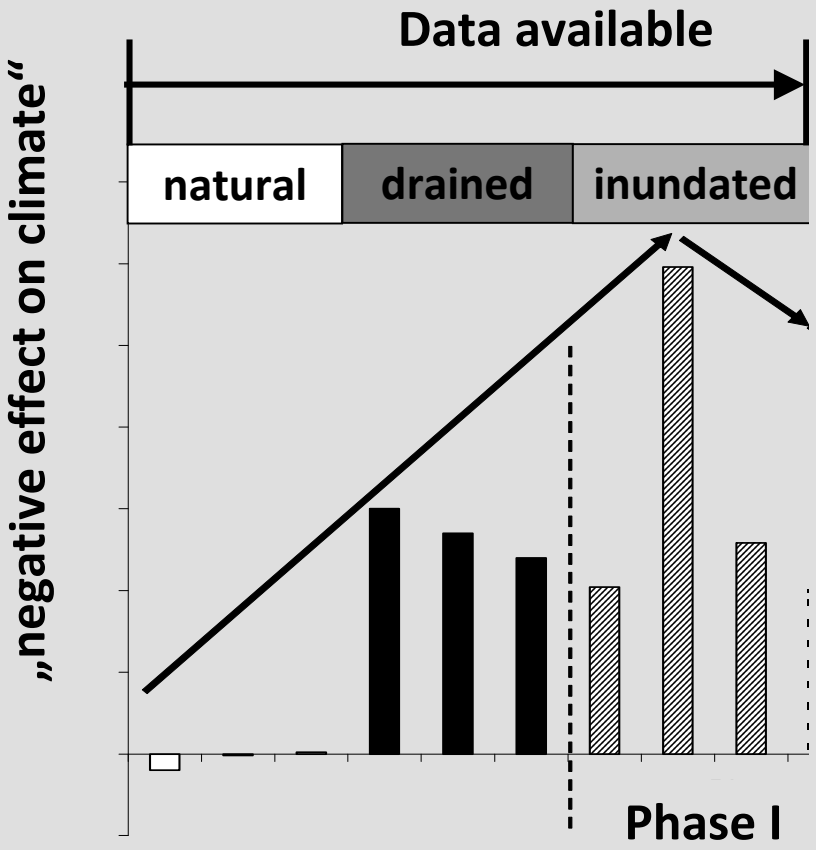
Removal: 10 mg N/m²d
(at 5 °C and high N load)

„nitrate removal pond“ with
Less decomposed peat

Taking all together at the example of an inundated fen



Open question: GHG emissions trend in inundated peatlands?



Take home messages for peatland restoration

1. **Despite all uncertainities a rewetting of peatlands is necessary to stop to stop soil subsidence, conserve peat and rehablilitate ecosystem functioning!**
2. **We have to accept that a full restoration of lost functions is not feasible within a human time perspective – top soil removal may shorten the time to legislative periods!**
3. **Can we compensate the high costs of top soil removal by using the peat for something valuable?**

Thank you

Colleagues of our Central Chemical Lab

Government of Mecklenburg-Vorpommern

Land users on site

„Show me you feeds and I tell you if the restoration is completed!“