Comparison of case studies from natural formed and constructed wetlands in passive treatment of mine waters

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The mechanisms of metal removal and retention in passive treatment systems are varied, and work out with self-acting reactions (see www.gardguide.com):

- Oxidation
- Precipitation as hydroxides and carbonates under aerobic conditions
- Precipitation as sulphides and hydroxy-sulphate (aluminum special case) under anaerobic conditions
- Complexation and adsorption onto organic matter
- Ion exchange with organic matter
- Uptake by plants (phyto-remediation)

No active addition of chemicals or remove adsorbents and add new ones

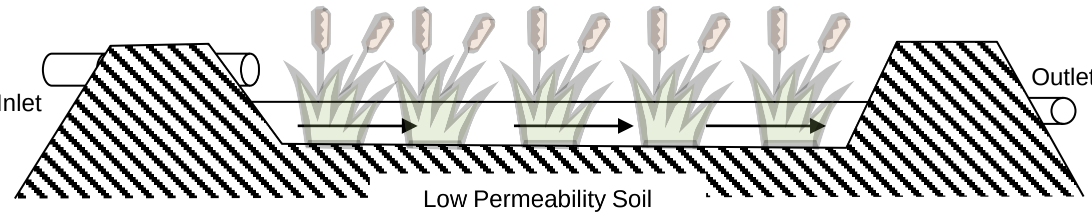
Waste water treatment with passive water treatment structures benefits:

- the low cost of their construction, operation and maintenance
- low on-going energy requirements
- overall decreased environmental and human health risk from discharge of contaminated wastewater

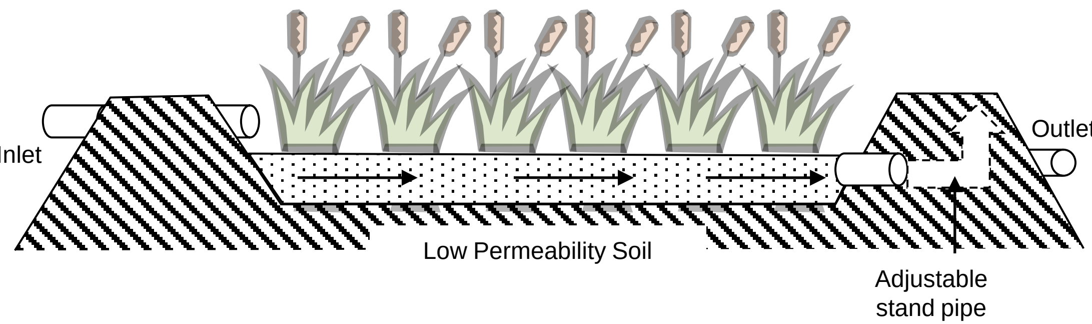

Constructed wetland pools, Luikonlahti©M. L. Räisänen

Constructed wetlands generally have impervious clay or synthetic liners and include engineered structures to control flow direction, hydraulic retention time and water level

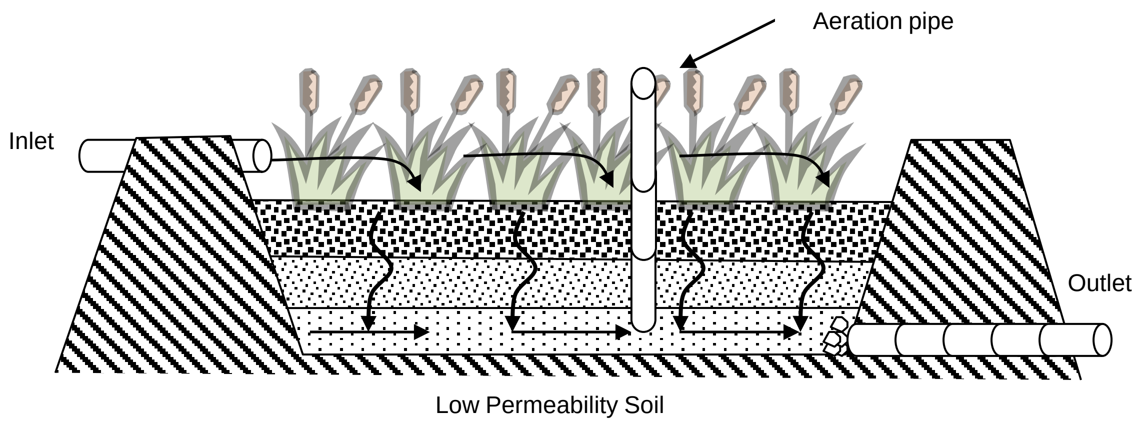
(adapted Wendling & Mroueh 2013, unpublished VTT-report)



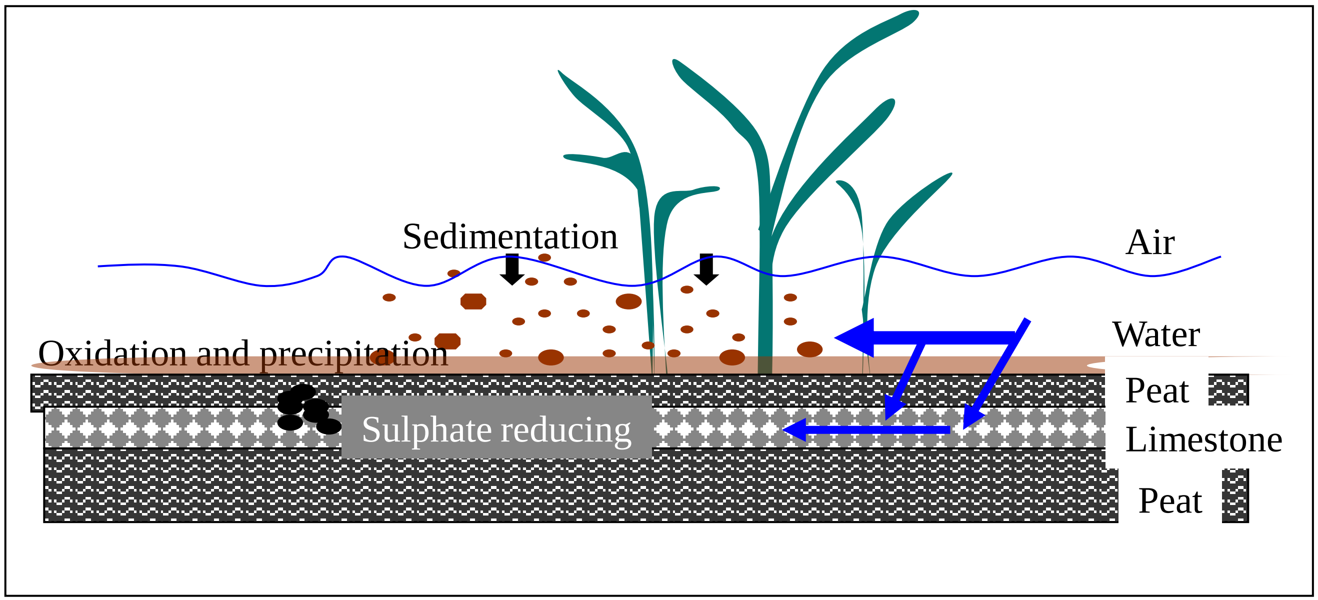
Schematic representation of a free water surface (FWS) flow wetland.



Schematic representation of a subsurface horizontal flow (HF) wetland



Schematic representation of a subsurface vertical flow (VF) wetland (adapted Wendling & Mroueh 2013)



Cross section
-Mixture of aerobic and anaerobic pool

Mine waste water types in Finland

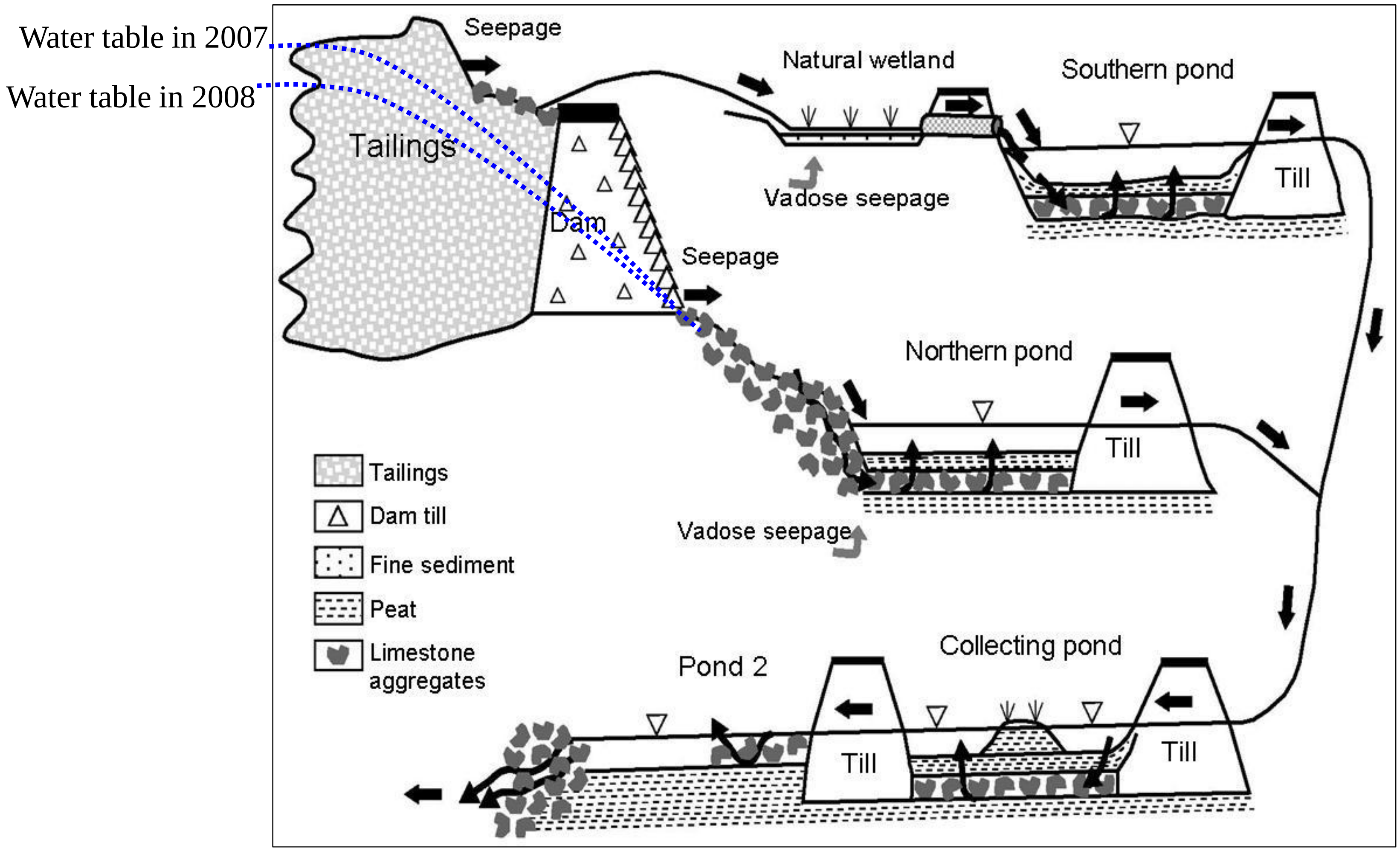
- Acidic, metal and sulphate bearing waters derived from oxidation and dissolution of sulphide minerals (e.g. Fe sulphides)
- Neutral or alkaline, hydrogen sulphide-rich waters with low metal content arising from buffering reactions and/or sulphate reduction
- Saline formation waters (e.g. process water)

Use of passive treatments:

- constructed wetland pools
- former settling pond transformed into flooded mire or meadow
- treatment peatland (infiltration bog)
- naturally formed wetland (mire)

In summer 2007, four wetland ponds (aerobic-anaerobic) were constructed in the Suursuo bog, west of the Luikonlahti tailings facility

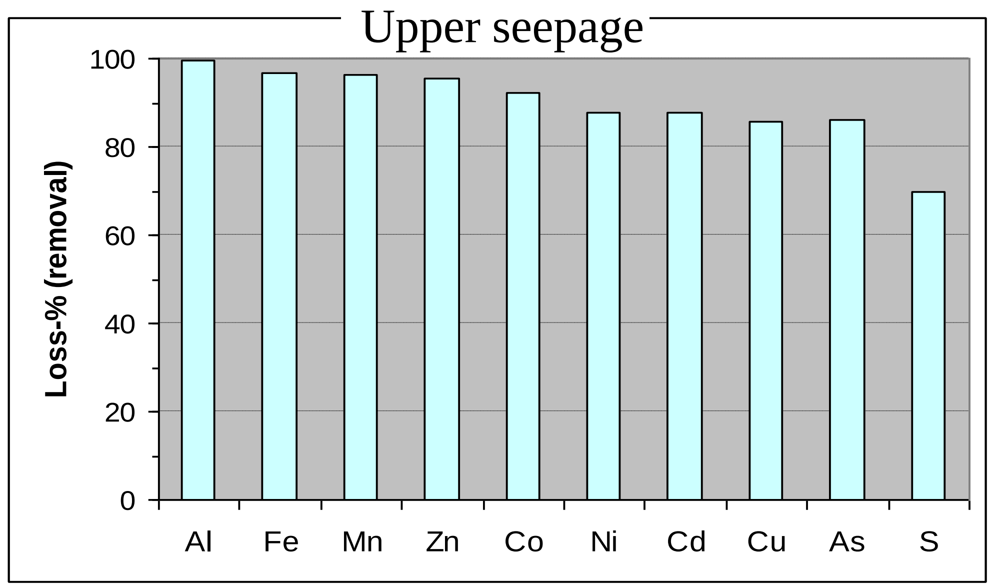
– a peat-limestone-based wetland-type passive system



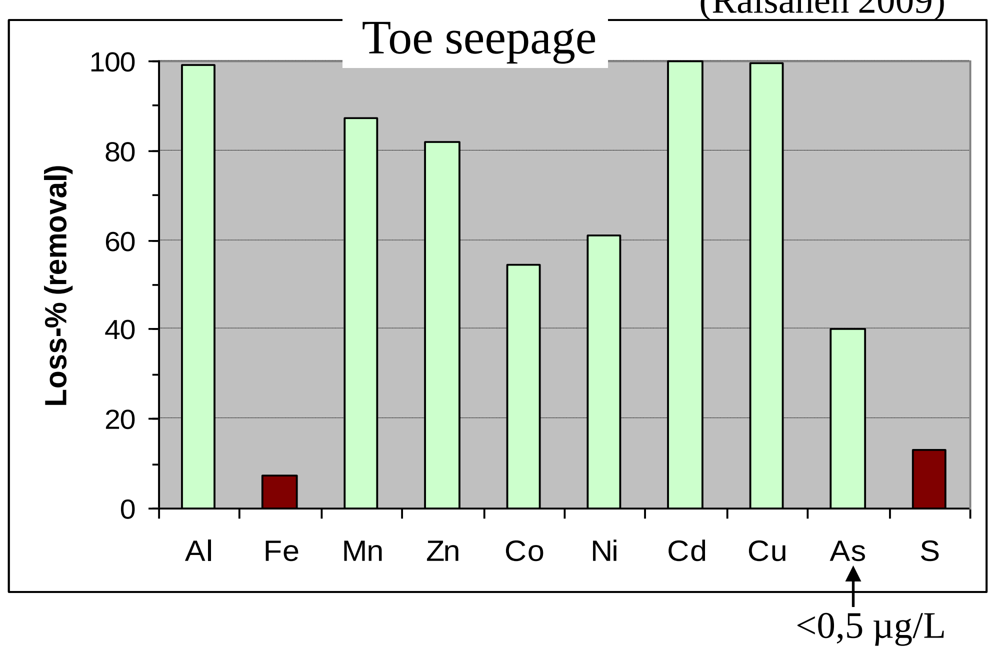
Case 1:
constructed wetland pools

- Recovering acid generating tailings with basic, carbonate bearing material changed markedly the seepage water quality

⇒ acidic, metal bearing seepage water transformed into neutral (less acidic), Fe and SO_4 bearing seepage water with minor trace metal content



(Räisänen 2009)



<u>Additional removal in wetland pools</u>

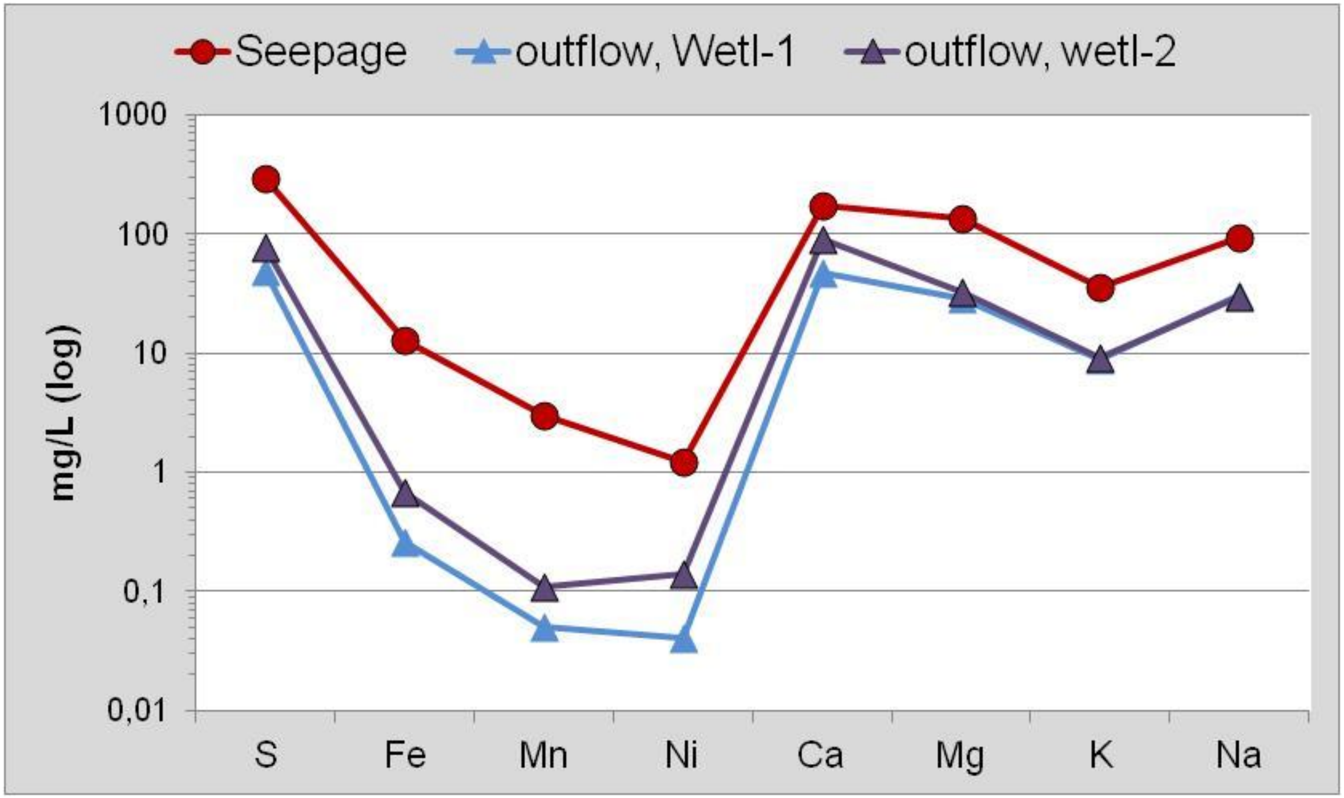
- 96 % for Fe and 30 % for S and

~10-30 % for trace metals

⇒ Limited reducing of sulphate due to high ratio of sulphur to Fe and other metals and As (S/Fe>3)

⥣ Additions of Fe-oxides would intensify Fe-sulphide precipitation!

Case 2
Former settling ponds were let to transform into flooded meadow

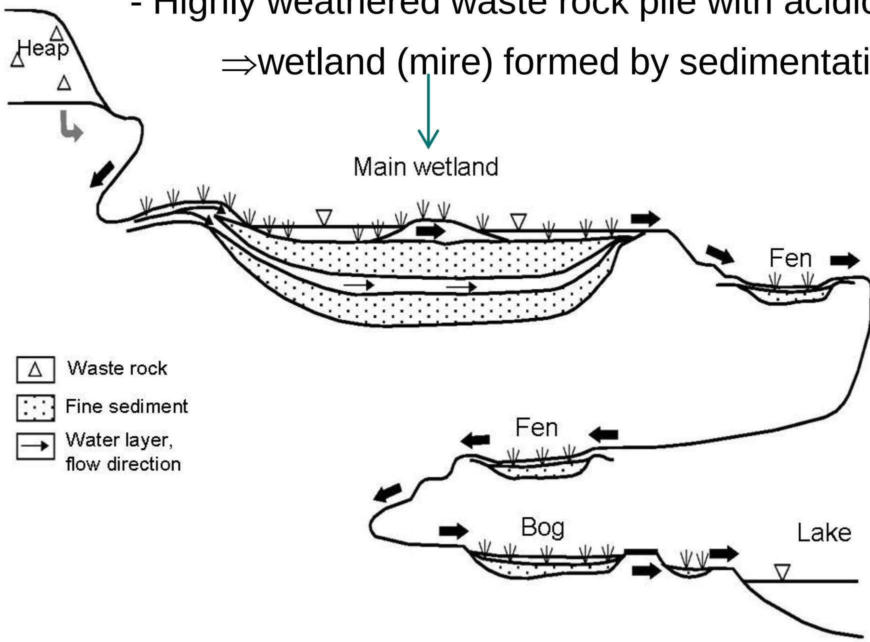


Removal % 47-96 %; Ni pretty good (88%)

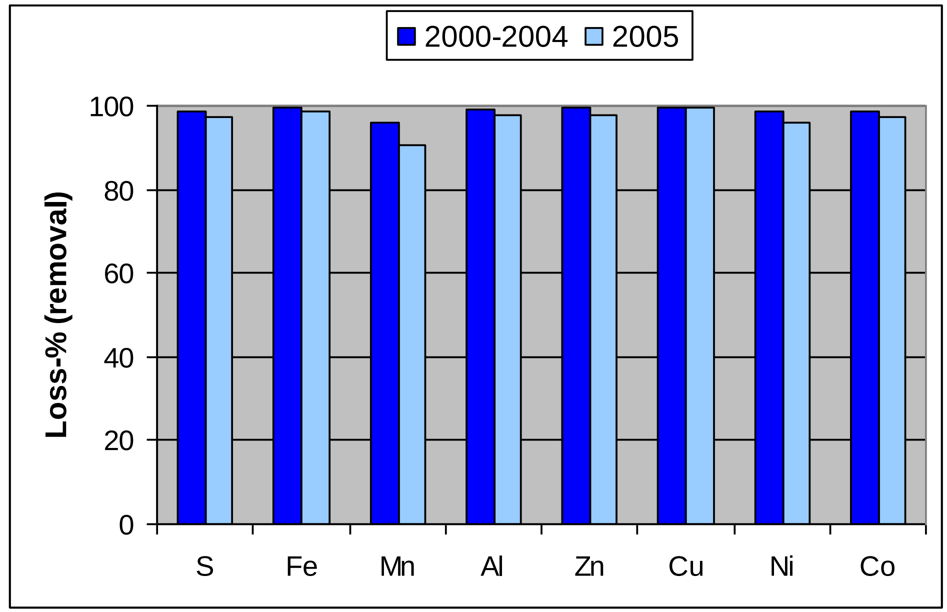
Case 3: naturally formed wetland (mire)

- Highly weathered waste rock pile with acidic effluent (pH≤2.5)

⇒wetland (mire) formed by sedimentation of organo-Fe precipitates in the creek plateau

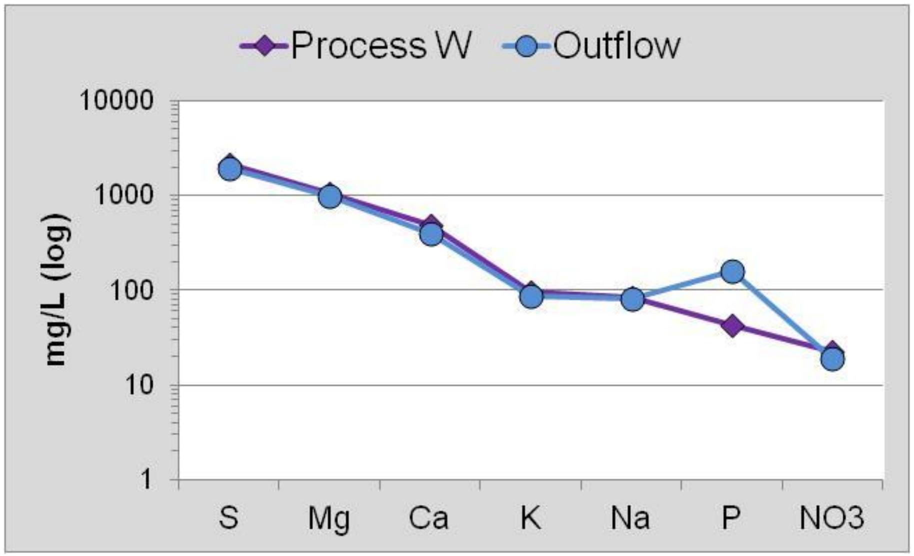


- Alkalinity is mainly produced by sulphate reducing, but not enough
  - pH of outflow ~3.5 (pH of sediments ~4.5)
  - Metal retention excellent!

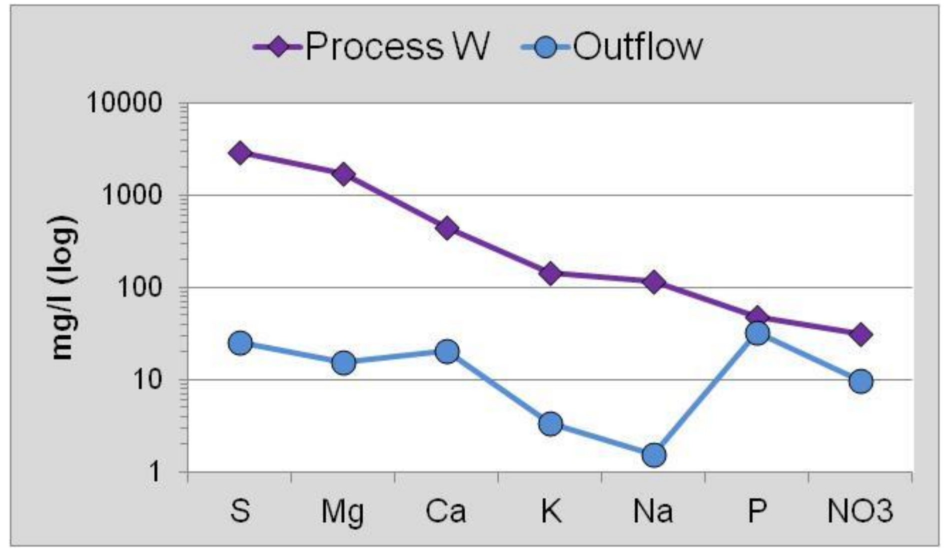


Case 3
Treatment peatland

Early summer:
low removal of process water remains

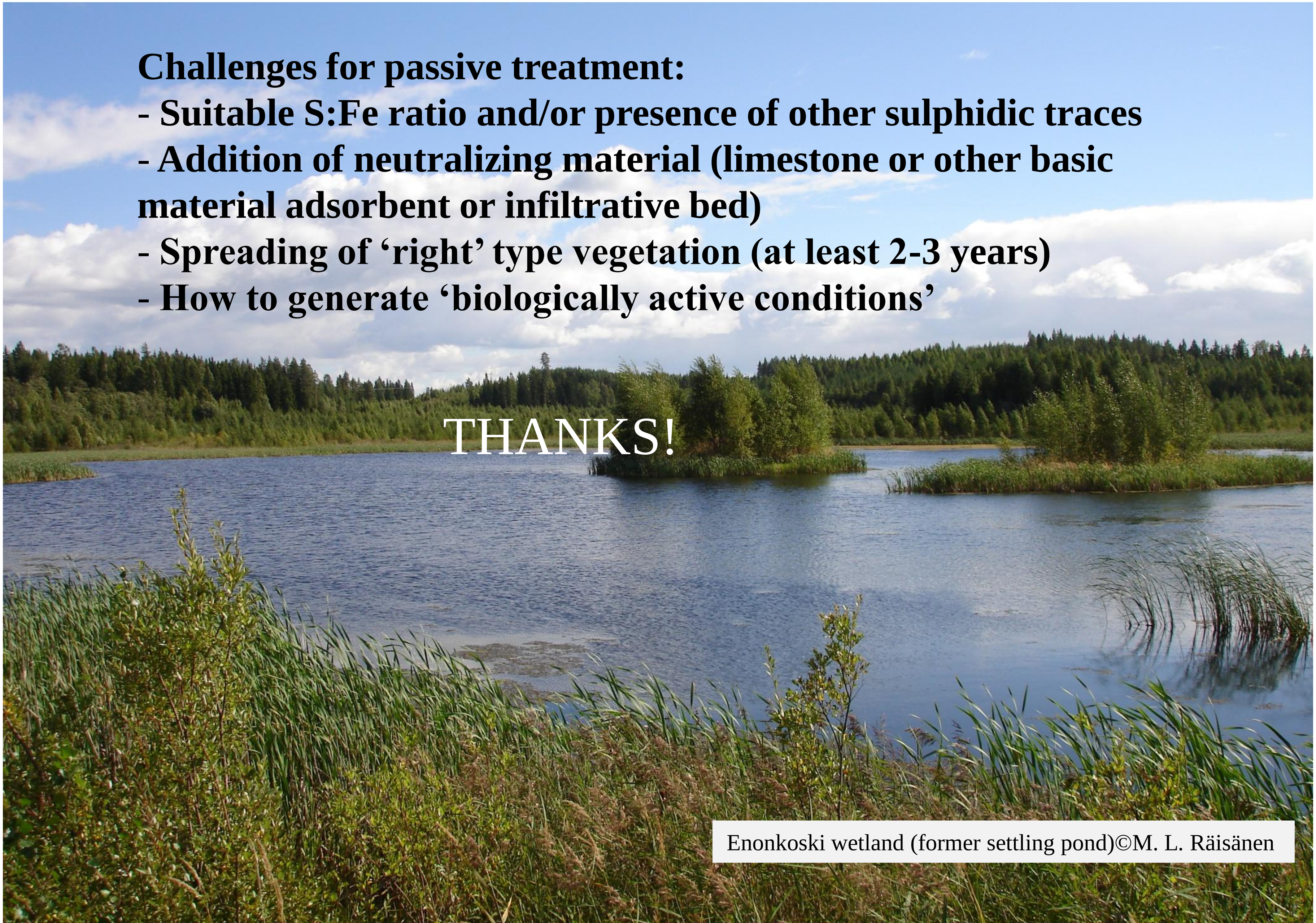


In summer (end of July):
high removal of process water remains



Challenges for passive treatment:

- **Suitable S:Fe ratio and/or presence of other sulphidic traces**
- **Addition of neutralizing material (limestone or other basic material adsorbent or infiltrative bed)**
- **Spreading of ‘right’ type vegetation (at least 2-3 years)**
- **How to generate ‘biologically active conditions’**



Enonkoski wetland (former settling pond)©M. L. Räisänen