Bioremediation for Water Quality Enhancement

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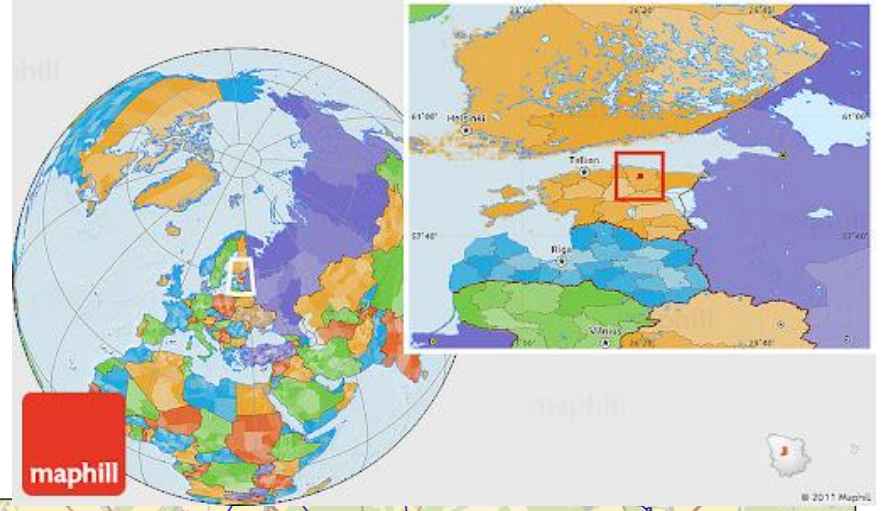
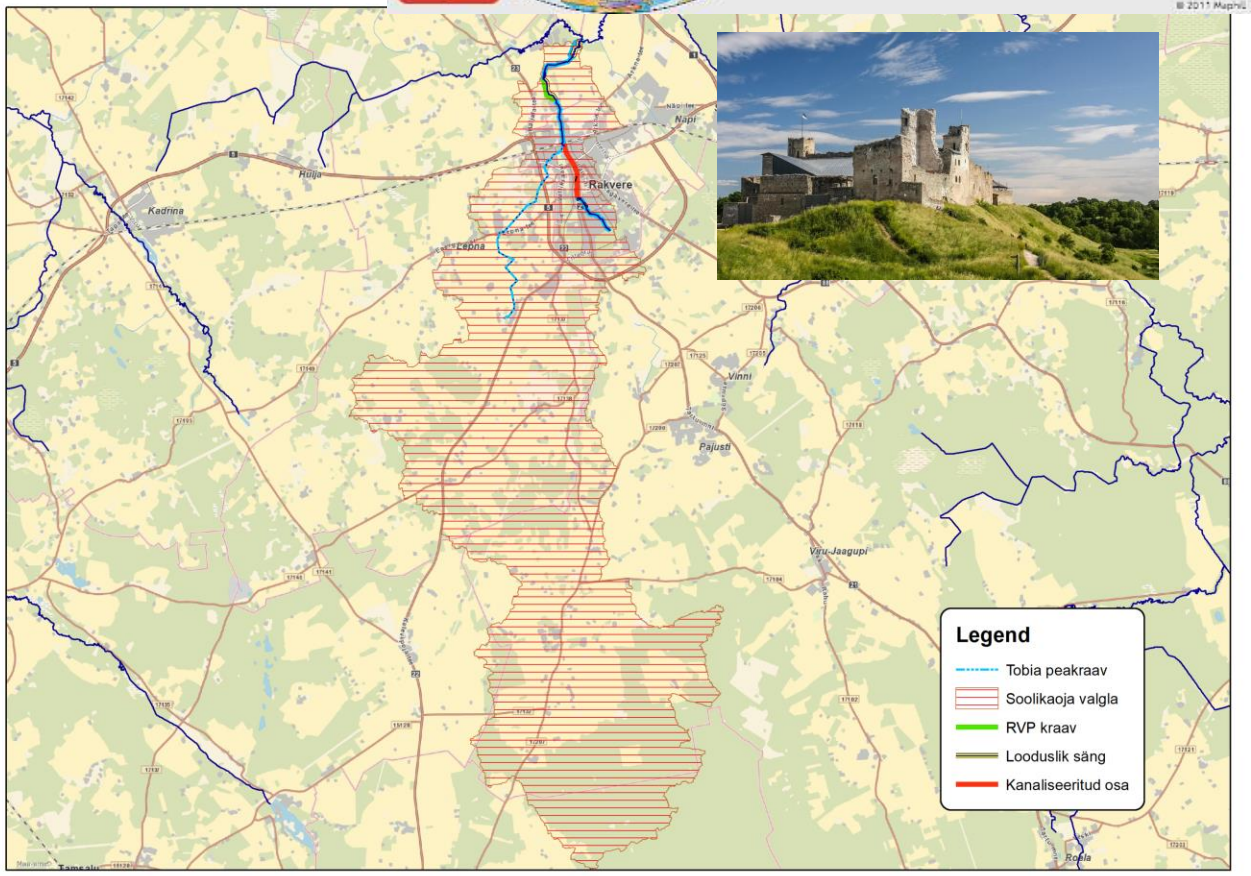
What is bioremediation?

- Bioremediation is a process where biological organisms are used to remove or neutralize an environmental pollutant by metabolic process.
- The “biological” organisms include microscopic organisms, such as fungi, algae and bacteria, and the “remediation”—treating the situation.
- It is most often used for removing hazardous substances

Case study - Soolikaoja

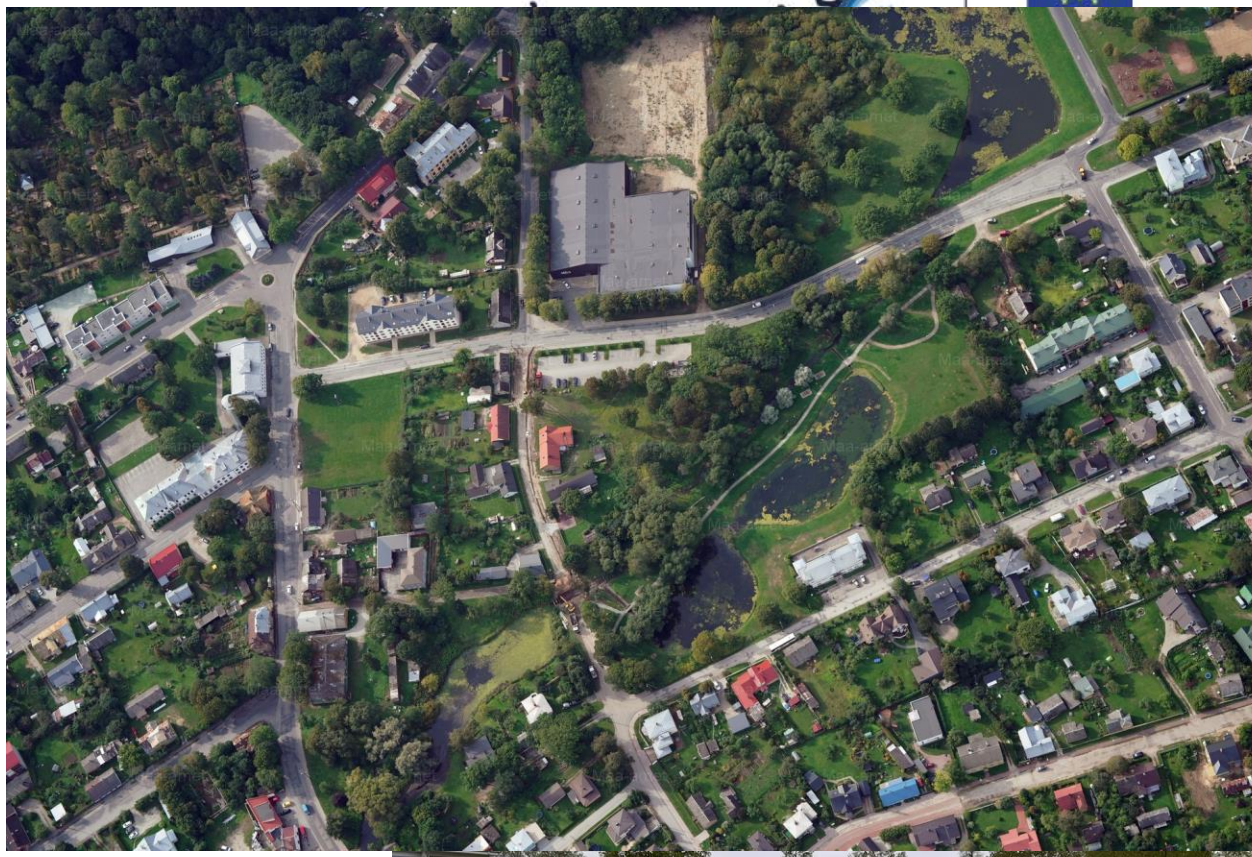
- Soolikaoja (Linnaoja) is located in Lääne-Virumaa and it flows through the town of Rakvere.
- Soolikaoja is a 7.5 km long heavily modified waterbody with catchment area 122.1 km^2.
- The baseflow component in the stream is in the range of 30-95 %
- The creek is located in Nitrate Vulnerable Zone
- The ecological status of Soolikaoja is bad





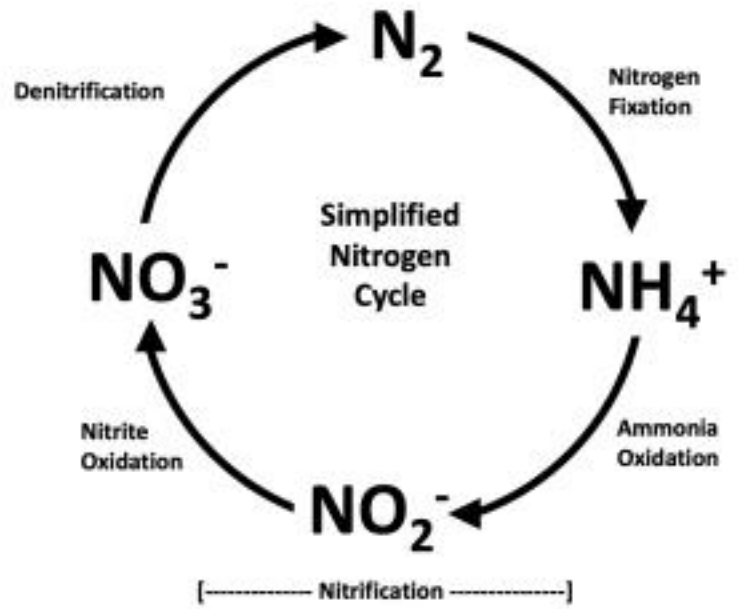
Hydromorphology

- There are several dams within the city creating extensive network of small lakes that are eutrophic due to the high content of nitrates (8.6 ± 1.9 mgN/L).
- The middle part is canalized and flows through pipes.
- The lower part is an open water channel.



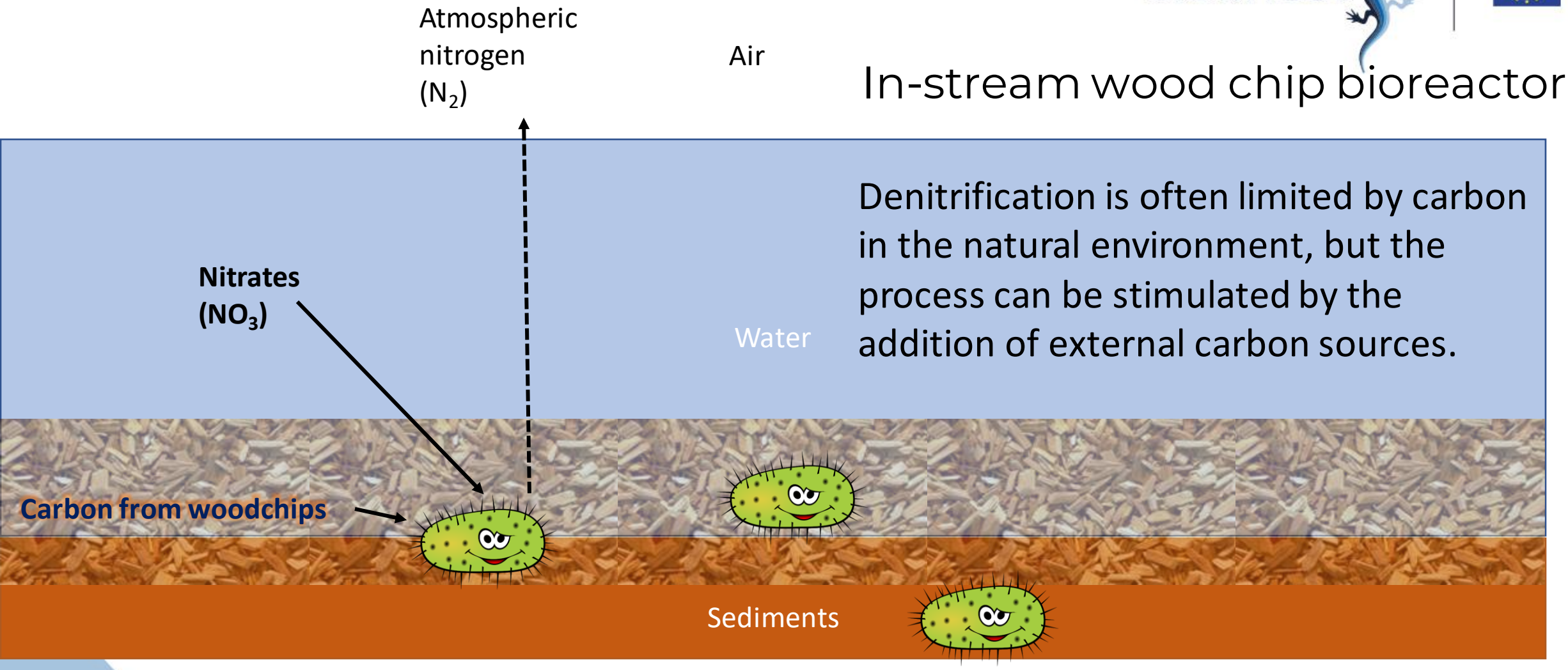
Diffuse pollution is a wicked problem

- *Wicked problem could be defined as a complex problem that has no single solution and every attempt can matter, because it affects the things people depend upon* (Rittel and Webber, 1973).
- Our solution for diffuse pollution – wood chip reactor for denitrification



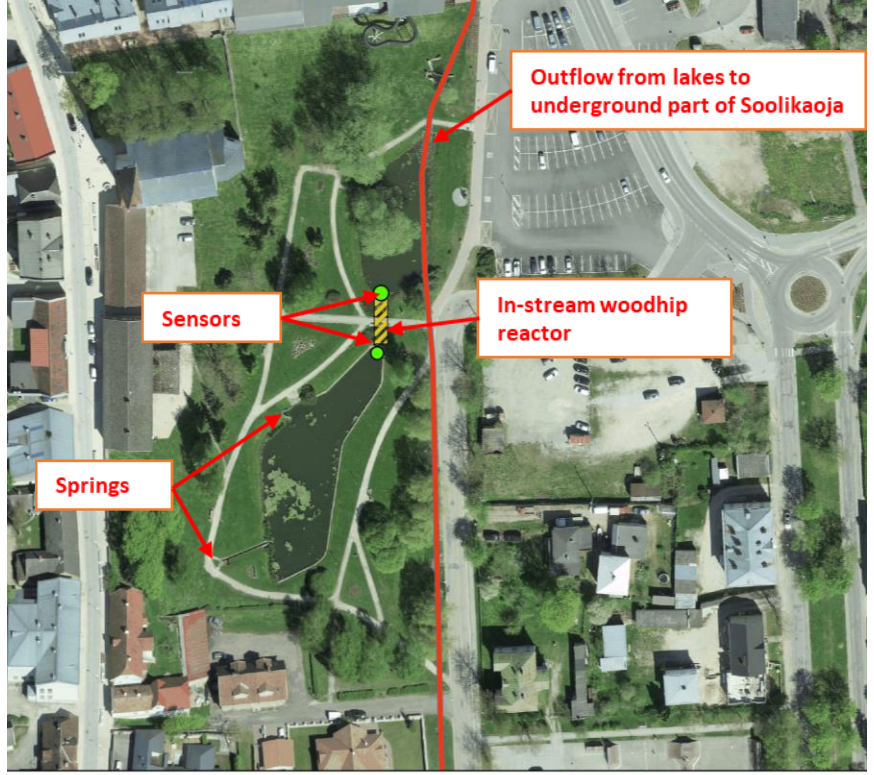
Biostimulation – adding food for native bacteria

In-stream wood chip bioreactor



Denitrification is often limited by carbon in the natural environment, but the process can be stimulated by the addition of external carbon sources.

In-stream wood chip bioreactor

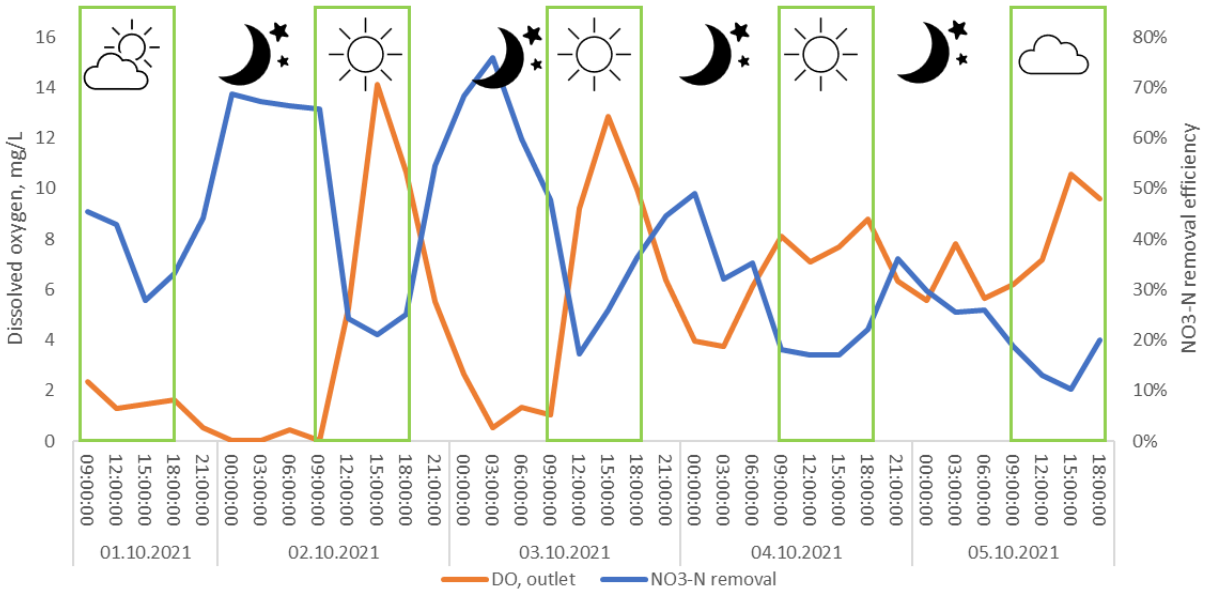


Channel dimensions: 14,6 x 3 m
Water level: 0,66 … 1,05 m
Sediment layer: 0,2…0,4 m
Wood chips placed: 7,5 m^3
Q = 1,6 … 2,5 l/s

Reinforcing nets were placed on top of the bags to secure and immerse the wood chips, at the ends of which hollow blocks were placed as an additional weight.

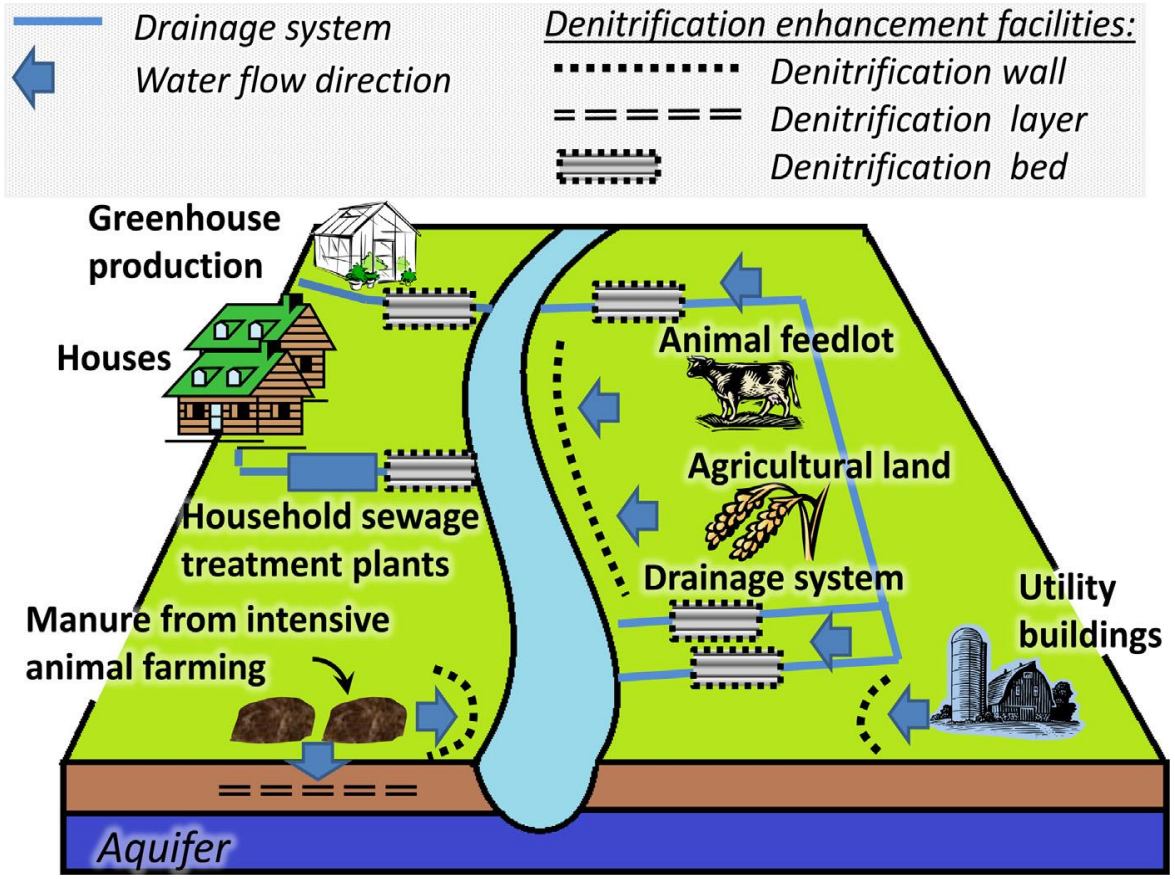
Cause and effect or vice versa?

- While analyzing the **sensor data** we noticed relevant differences in the reactor performance
- According to the sensor data the reduction in nitrate concentrations during the daytime averaged 36.4 ± 13.0 %, while during the night-time it was significantly higher (48.8 ± 14.4 %).
- An average NO_3-N removal rate was 43.7 gN m^{-3} d^{-1}, but it varied between 9.5 and 99.3 gN m^{-3} d^{-1}.
- Bioreactor efficiency was negatively correlated to dissolved oxygen concentration in the end of the bioreactor (Pearson's P –0.57; p-value 9.78e^{-61}) which in turn explains fluctuations in bioreactor performance.



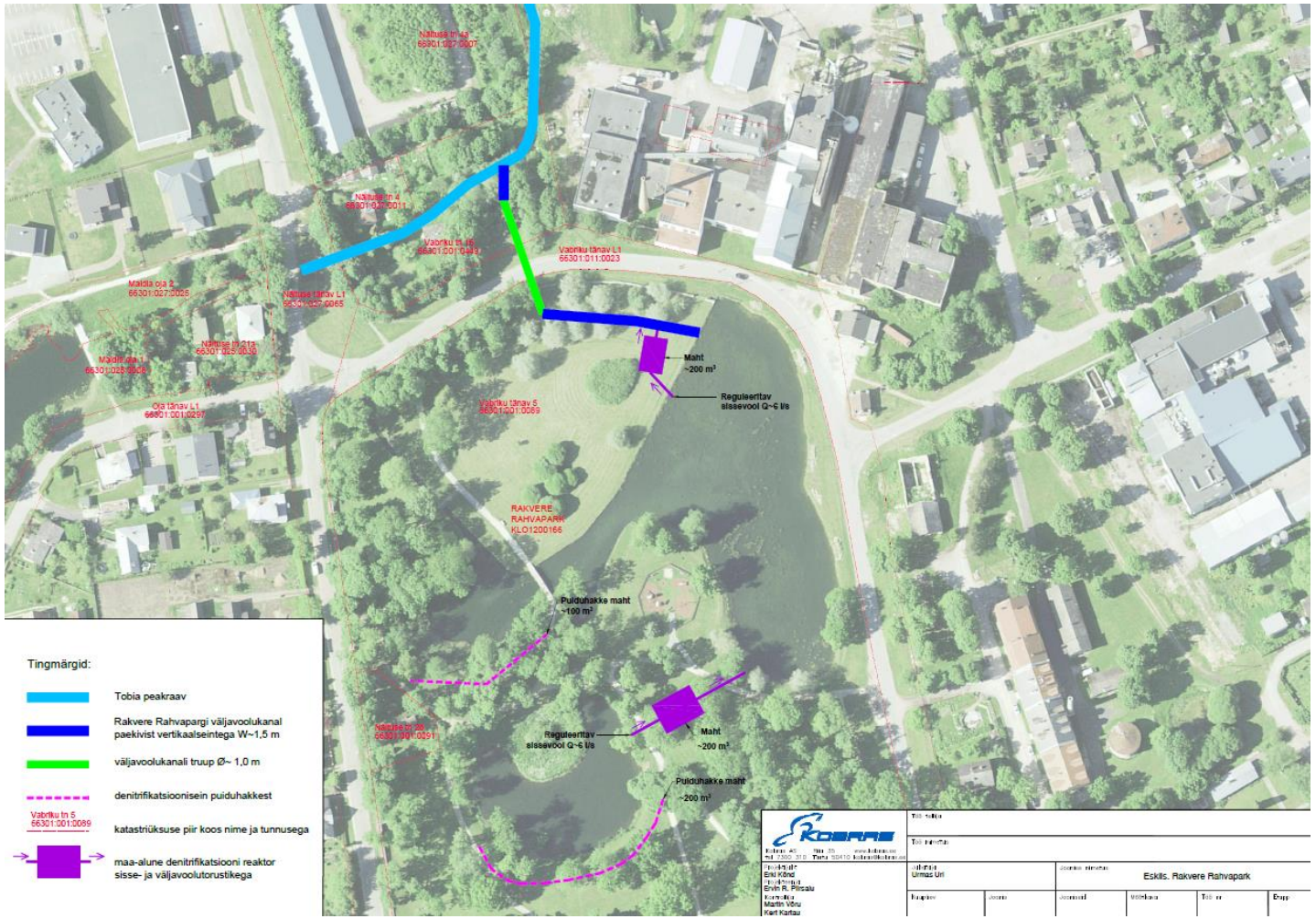
Think it through

- How to avoid anoxia in the river?
- Possible P-release if nitrates are consumed
- Where would it be most effective?



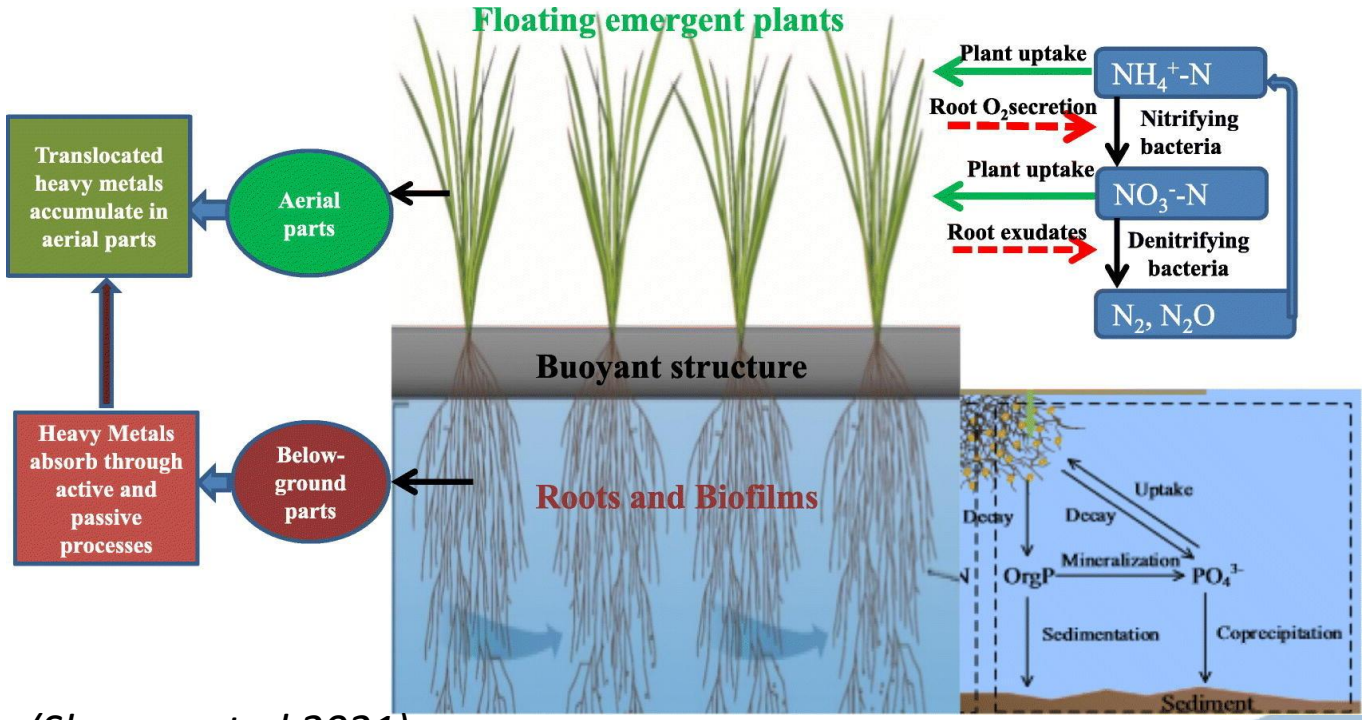
(Bedarnek et al., 2014).

Where to put what?



Floating treatment wetlands

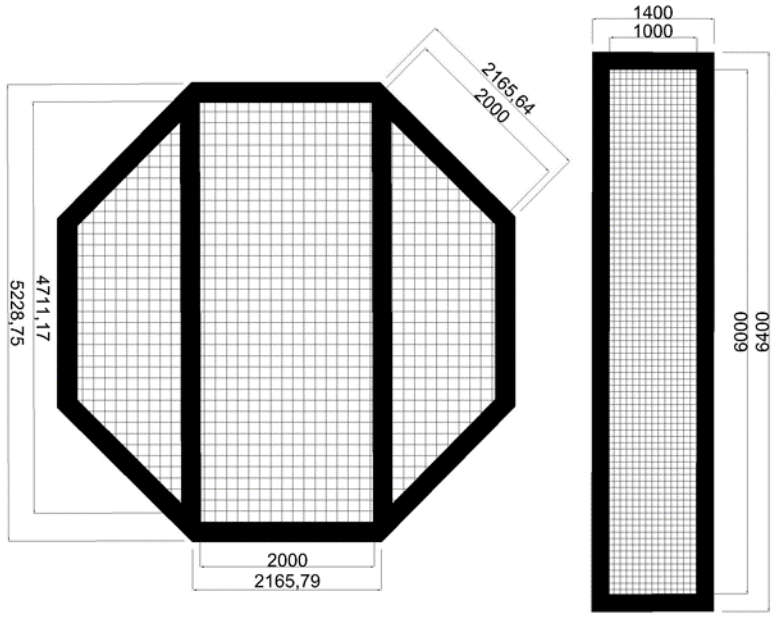
- Floating treatment wetlands (FTWs) or islands are small artificial platforms that allow aquatic emergent plants to grow in water that is typically too deep for them.



(Sharma et al 2021)

Floating treatment wetlands (FTW)

- Floating islands were built from 200 mm PEM pipes which were connected to create octagonal and rectangular frames, the bottom of which is made of metal mesh.
- Coconut mat and rock wool were installed on the net as the soil for the plants.
- The plants (mainly irises and cat-tail) were planted in a way so that the roots reach the water.



- 11 FTWs in three ponds
- Total area 172,4 m^2

Supeluse park

Allika dam lake

Thank you!

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Now let’s build some!

- https://www.youtube.com/watch?app=desktop&v=mqitvLXDRCs