Effect of rain variability and water retention measures on phosphorus loads at the farm scale

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Phosphorus (P) is an essential nutrient that when present in excess can cause algae blooms and eutrophication. In industrialized countries waste water treatments plants do a good job removing P from industries and municipalities. The challenge is to remove P leaching from agriculture. Even if farmers decrease the amount of P applied in manure and fertilizers there is an accumulated pool of legacy P that will continue to leach into surface waters for the next decades. The transport and bioavailability of P in surface waters is strongly determined by the Fe present in groundwater.

Rain variability is a stress factor for crop growth and farmers implement water retention to adapt

Water is a stress factor for crop growth and climate change is causing greater rainfall variability (Masson-Delmotte et al., 2021). To adapt against rain variability farmers often adopt water retention measures (i.e. adding weirs along the ditch). However, the effect of water retention on P transport is still not fully understood.

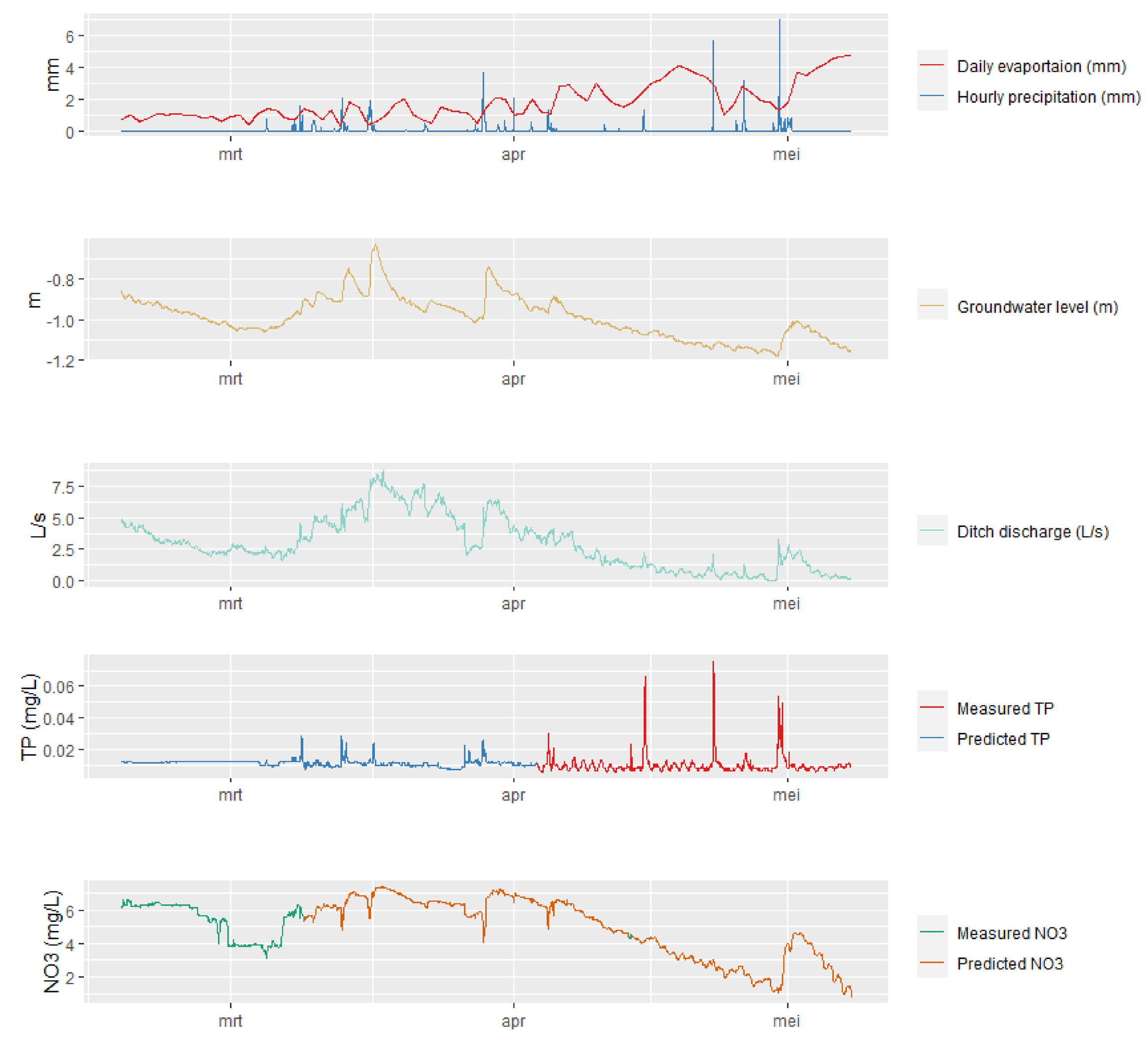

Figure 1 High frequency measurements in 2018, measured and predicted data for rain, evaporation, discharge, TP and nitrate at the ditch draining the farm

Multiple effects of of water retention on P transport

In the groundwater Fe is usually reduced, however, when it seeps into surface water it gets in contact with oxygen forming Fe-Hydroxides which can adsorb or co-precipitate with P. In areas with high Fe in the groundwater P is present as particles in surface waters.

The topsoil is rich in P and the subsoil has Fe and Al which can retain P. Changes in the groundwater levels modify the flow paths of P from the soil into the.

Effect of water retention measures

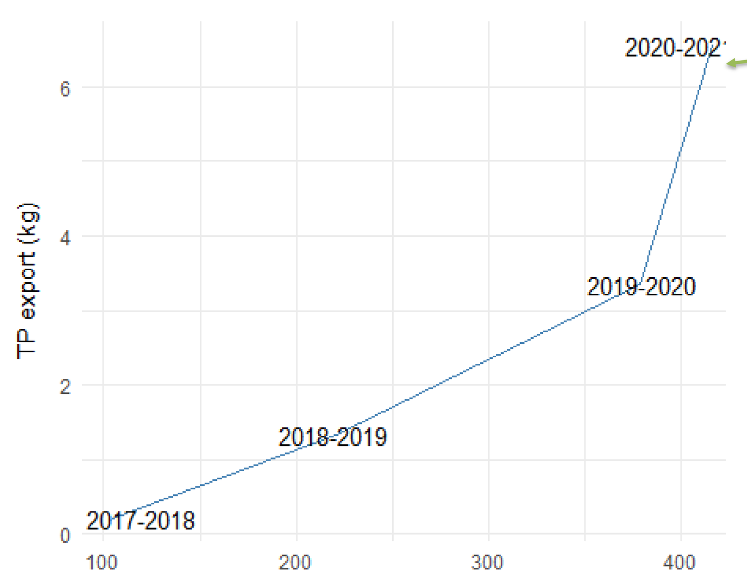

Figure 2 P load measured in 4 drainage seasons vs seasonal rainfall. Notice the load increased the last year when water retention was implemented

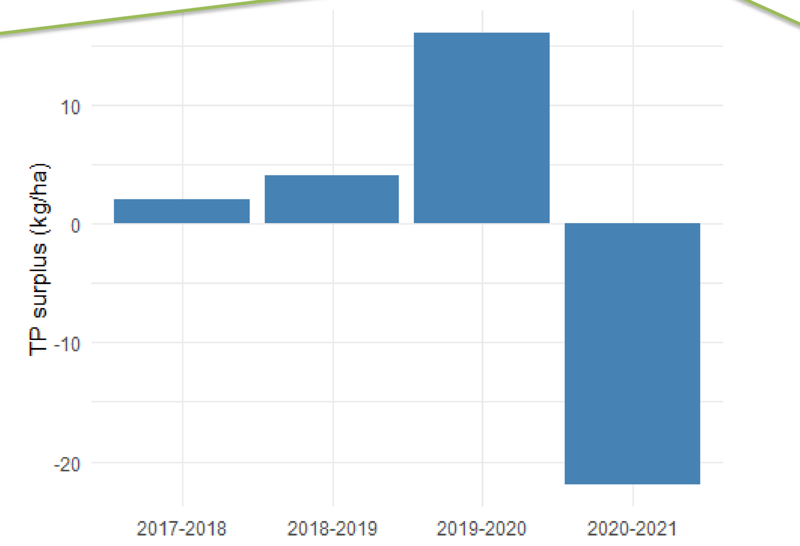

Figure 3 P surplus applied to the soil each season. Notice the P surplus (manure – plant uptake) was negative the last season

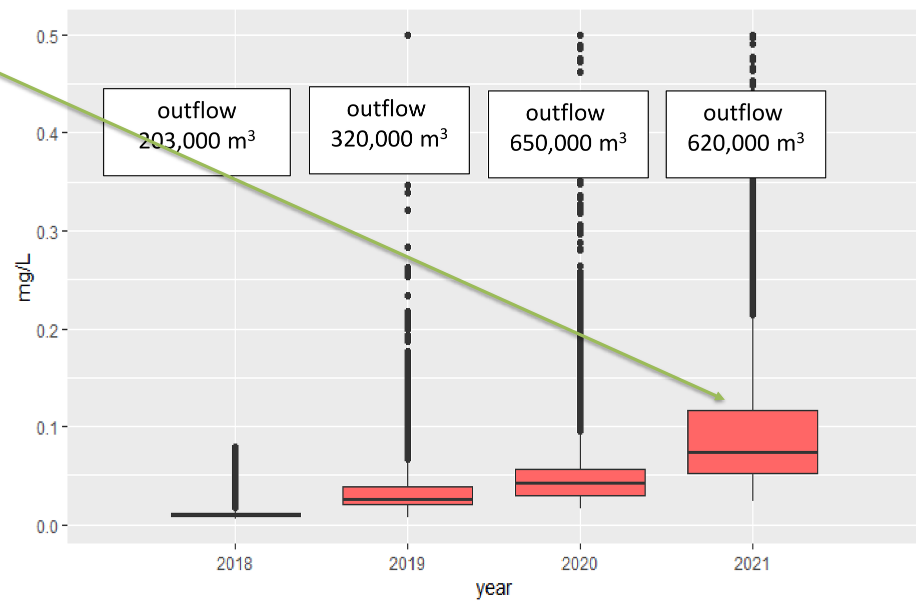

Figure 4 Boxplot of TP (mg/L) in the ditch. The P load increase is not a product of higher rainfall but of higher TP concentrations.

Figure 5 Sediment sample campaign at the farm

Water retention increased P loads as higher ground water levels transported more P from the topsoil

We placed a high frequency station in a ditch draining one farm. TP, nitrate, turbidity, and flow were measured every 15 minutes for 4 years. Water retention measures were implemented on the last year.

To complete missing data we used random forest algorithm, Breiman (2001), with 0.98 R2.

Before water retention, the yearly phosphorus loads increased linearly with rainfall. Turbidity was the most important predictor for phosphorus i.e. most phosphorus was transported with particles.

Although water retention measures were expected to reduce peak discharge and particulate phosphorus transport, more phosphorus was transported. This increase could be explained by the rise in groundwater levels that mobilized more phosphorus from the topsoil towards the surface water system.

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