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Nitrogen recovery from digester reject water using selective gas-permeable membrane

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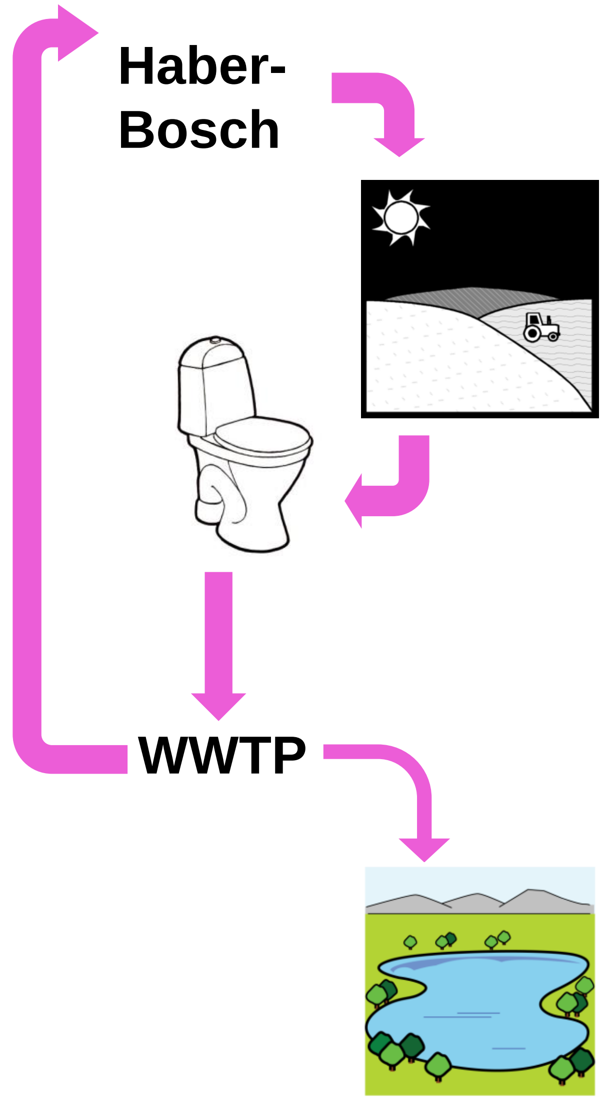
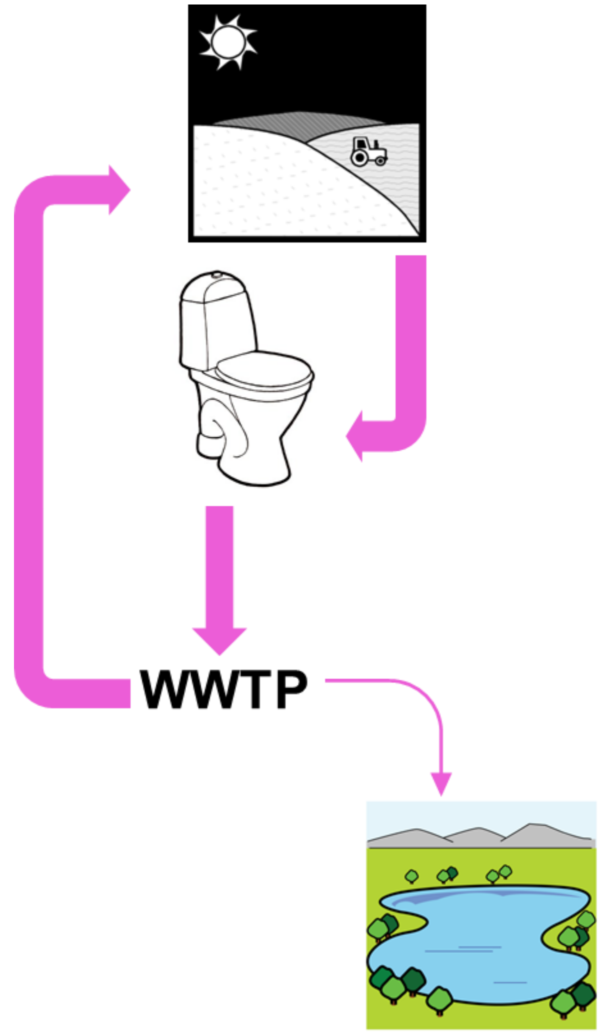
Background

- Increased agricultural production has led to growing nitrogen fertilizer use as well as loads to water bodies.
- Nitrogen fertilizer production is an energy intensive process.
- Removing nitrogen from wastewaters accounts for about 50% of the treatment process energy consumption.



Background

- **Increased agricultural production has lead to growing nitrogen fertilizer use as well as loads to water bodies.**
- **Nitrogen fertilizer production is an energy intensive process.**
- **Removing nitrogen from wastewaters accounts for about 50% of the treatment process's energy consumption.**
- **Using wastewater's nitrogen directly would offer significant energy savings and decrease the load to the water environment.**



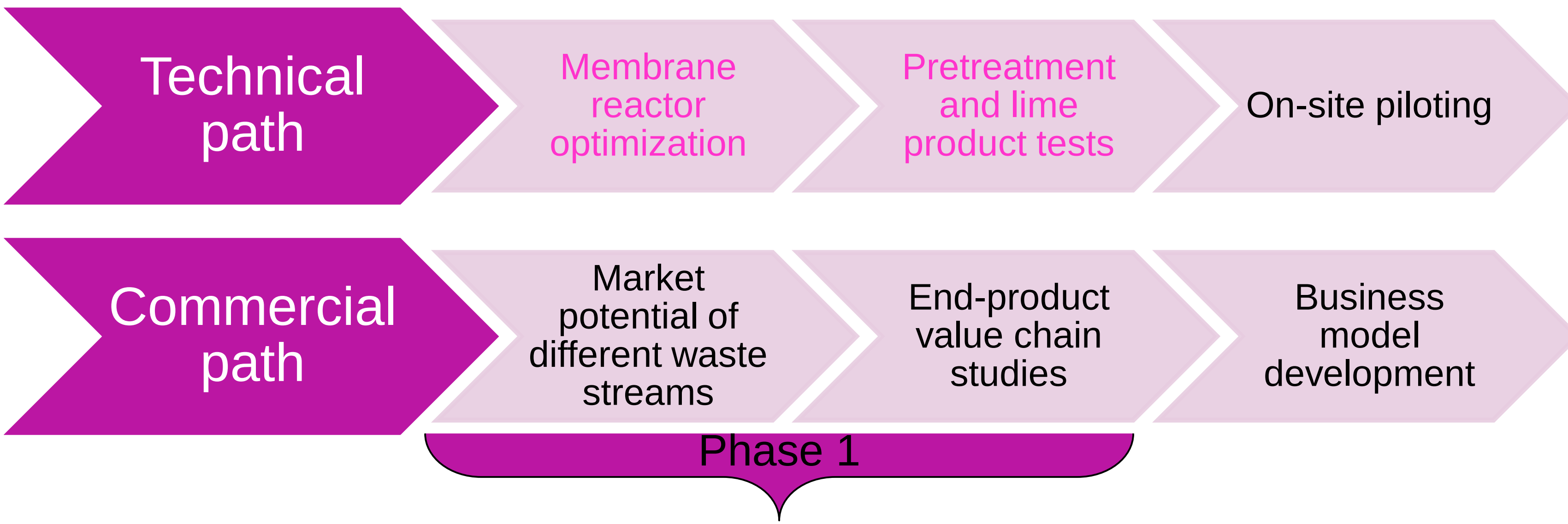
Current challenges with nutrient harvesting

- Cost-effectiveness
- Only nitrogen is often harvested
- Lack of demand for end-products
- Unsuitable end-products for fertilizer industry

NPHarvest project

The overall objective:

- an improved nitrogen stripping-absorption process for different concentrated liquid waste streams.
- optimal end-product quality by combining lime addition and phosphorus recovery
- resource optimization by using waste materials for pH control and for recovery



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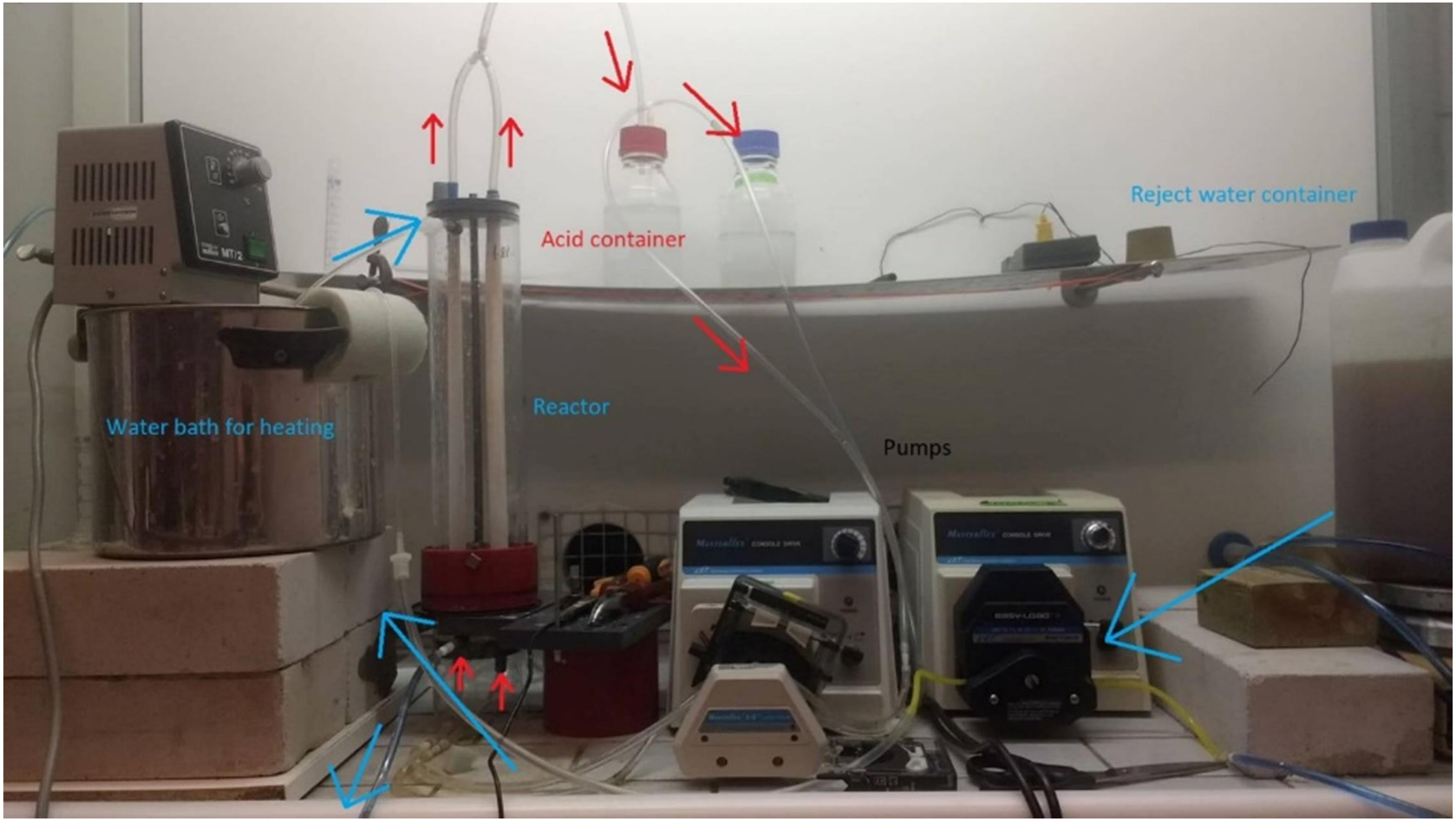
Objectives of Phase 1

- Optimize the membrane reactor = nitrogen recovery step

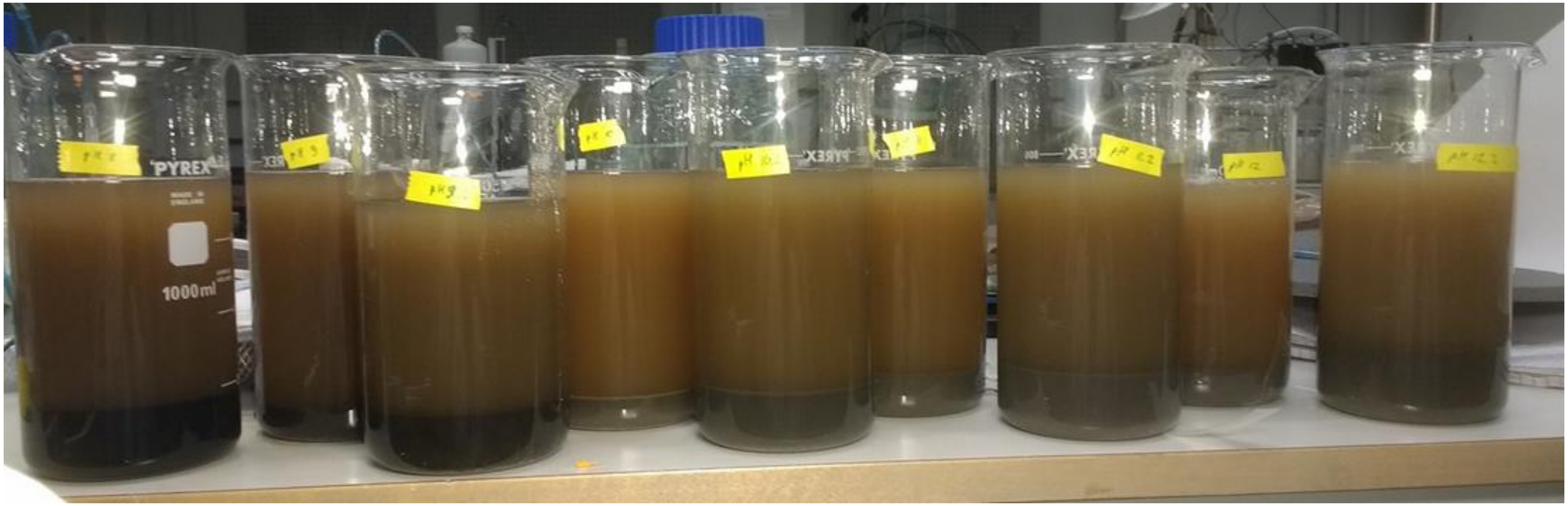
Dates	Number of runs	HRT (h)	Acid flow (l/h)	Acid type	Notes
8.5.-17.5.17	4	8	1-9	H_2SO_4	Acid flow optimization
19.5.-31.5.17	6	2-120	9	H_2SO_4	HRT optimization
20.6.-23.6.17	2	8	9	H_2SO_4	Reject water pH optimization
27.6.17	1	8	9	H_3PO_4	Different acid type
3.7.17	2	28	9	H_2SO_4	Membrane thickness

Methodology – Membrane reactor



Objectives of Phase 1

- Find a cost-efficient pretreatment for solid separation



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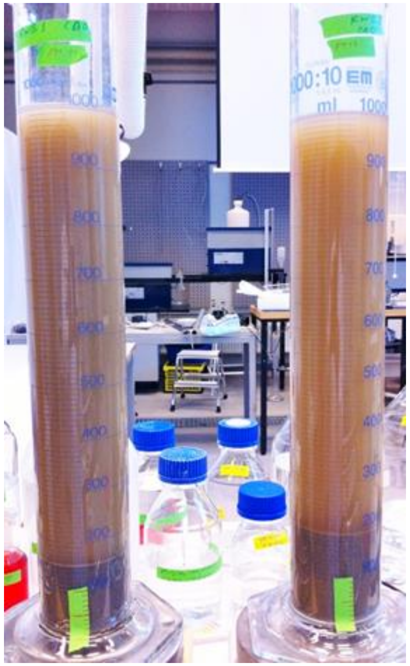
Methodology of Phase 1

- Tests using different solid separation methods
  - Characterization of the water in the lab: settling tests, filtration tests and centrifugation
  - Lab-scale pilot tests: Disc filtration, rotating mesh filtration, flotation, ballasted settling
- Study the potential of lime products in solid separation
- Study the possibilities of waste lime products
    - Lime kiln dust (LKD)
    - Recycling of Ca(OH)2



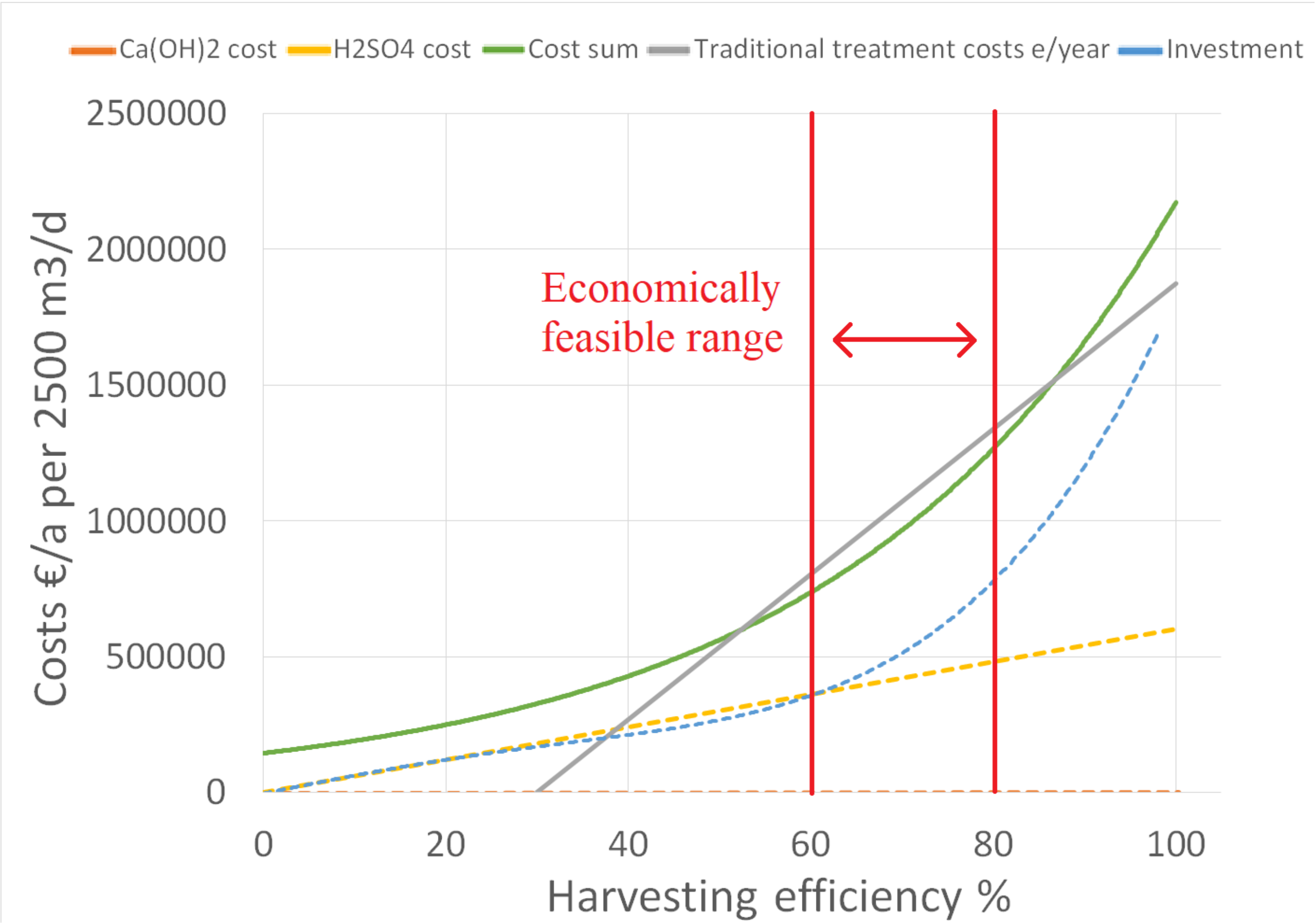
Characteristics of the treated water

	Average	Min	Max
BHK7ATU (mg/l)	530	320	1140
SS (mg/l)	980	560	4200
Total-P (mg/l)	13	10	47
PO_4-P (mg/l)	1.4	0.5	2.7
Total-N (mg/l)	980	820	1250
NH_4-N (mg/l)	790	680	900
pH	8	7.5	8.1
Alkalinity (mmol/l)	67	57	77
CODCr sol (mg/l)	1380	860	2100

Optimization of the membrane reactor

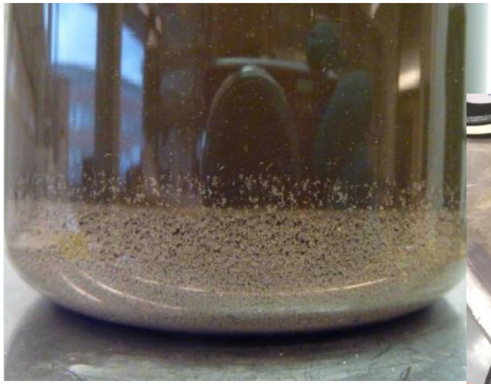
- The recovery efficiency improved linearly between 2 to 8-hour hydraulic retention time (HRT)
- Optimal acid circulation rate was determined to be 300 $l/h/m^2$ related to reactor membrane surface area.
- The efficiency was also affected by the pH of the reject water.
- Membrane thickness and acid type did not have any significant impact on harvesting efficiency.

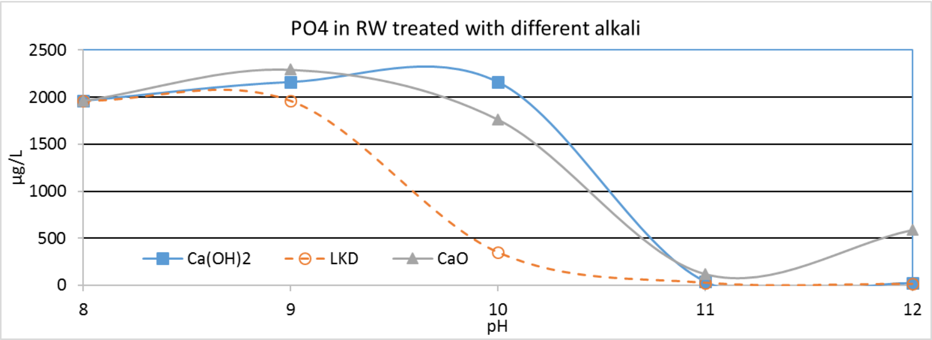
Economical assessment of the recovery process



Solid separation tests

- Lime addition efficiently improved reject water's characteristics for solid separation.
- Both disc filtration and ballasted settling showed promising results.
- Waste lime products showed similar results to $Ca(OH)_2$, but dosed amounts were larger.
- Recycling lime allows for savings of 10% of required lime.
- Dissolved phosphorus was precipitated and could be recovered with the sludge.





Conclusions

- The economic feasibility of a recovery process can rely on the avoided costs from a waste treatment.
- The cost comparison to the alternative treatment at a wastewater treatment plant with a conventional nitrogen removal process showed that the harvesting process can be economically feasible.
- Removal of suspended solids is crucial, but less efficient reactor has also the benefit of being less sensitive to SS in the treated water.
- Lime products offer several benefits in combination to a nitrogen recovery process using membrane stripping:
- While increasing the pH and precipitating the dissolved phosphorus, they improve the solid separation during pre-treatment.
- Lime also adds value to the end-product.

Acknowledgements

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