

Phosphorus Removal and Recovery with STRUVIA™ at a Small-Scale WWTP

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Phos4You final conference, Essen & online, 22 – 23 September 2021

Background



The following work was conducted (as part of Work Package 16):

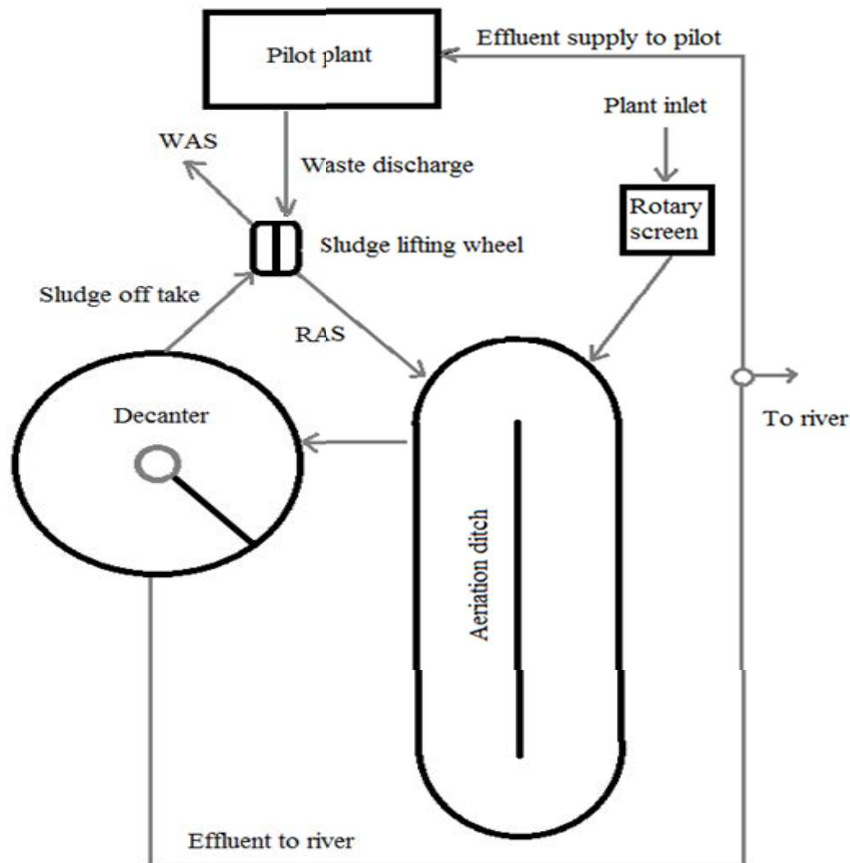
- The Macroom Wastewater Treatment Plant was selected as the site for the Struvia™ P-Recovery Pilot Plant after an extensive regional search which commenced in September 2017
- Final Agreement was formally reached with Irish Water, the owner, in September 2019
- The Macroom WWTP serves a Population Equivalent (PE) of approximately 8,000 which is typical of many Irish WWTPs which have PE ranges from 2,000 to 10,000
- The startup of the Struvia™ Pilot Plant took place on the 4th November 2018
- The Pilot Plant was fully commissioned on the 27th January 2020 (after up to 6 weeks of onsite pre-commissioning work)
- The Pilot Plant was in steady state operation for the period from the 20th February to the 12th March 2020 (when it was shut down due to Covid19 considerations)
- The Pilot Plant again commenced operations on the 18th November 2020 with completion on the 11th February 2021, followed by full decommissioning.
- The Pilot Plant was removed from the Macroom WWTP site on the 27th August 2021.
- Stringent Health & Safety Procedures were adhered to at all stages of the work.

Macroom WWTP – Some Information

- Macroom WWTP is representative of a typical Irish WWTPs in terms of the population equivalent (PE) served, the influent type, the treatment processes etc.
- The plant has a design load of 5,230 PE, but operates at a higher PE load (circa. 8,000 PE)
- The treatment process is comprised of primary screening, an extended aeration tank and sedimentation
- Chemical or biological P removal is not practiced
- Influent Ortho-P values are typically in the range 10-12 mg/l
- There is a significant reduction in P-levels through the WWTP
- The Treatment Plant is located 35km west of Cork City
- Some upgrading/capital works of the Treatment Plant is scheduled in the near term.



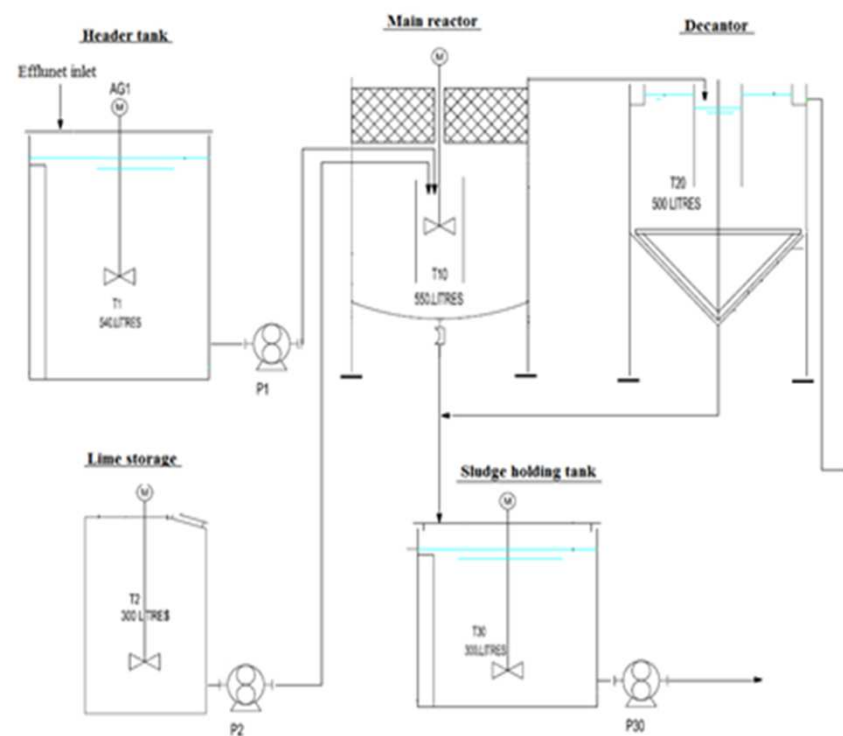
P-Recovery from the Macroom WWTP Process



Initial configuration of the Struvia™ Plant

Jar tests were conducted using lime addition to establish the pilot plant base settings as follows:

- pH maintained above 10.5
- Hydraulic retention time of 30 minutes
- 0.4mg/l of cationic polymer was dosed to improve flocculation
- Chemical sludge produced in the decanter was recirculated as seed material.



The Struvia™ Plant at the Macroom WWTP



The Struvia™ Plant at the Macroom WWTP



Stages of work

Stage 1:

Commissioning was conducted over a number weeks, matching the physical and chemical recovery process characteristics to the plant effluent (4/11/2019 to 2/12/2019)

Stage 2:

The fluidised bed was established and monitored until bed loading equilibrium was achieved (27/01/2020 to 19/02/2020)

Stage 3:

Steady state operation was conducted over a period of 3 weeks, harvesting recovered P product daily (20/02/2020 to 12/03/2020)

Stage 4:

Testing recommenced on the 18/11/2020 with a period of recommissioning, followed by further steady state operation at an incrementally reducing pH levels (from 10.8 to 10) until the 22/12/2020.

Stage 5:

Testing commenced on recycled calcium products from the 11/1/2021 and concluded on the 20/1/2021.

Stage 6:

Pilot plant decommissioning process commenced on the 11/2/2021; the pilot plant is now fully decommissioned. The Pilot Plant was removed from site on the 27/8/2021.

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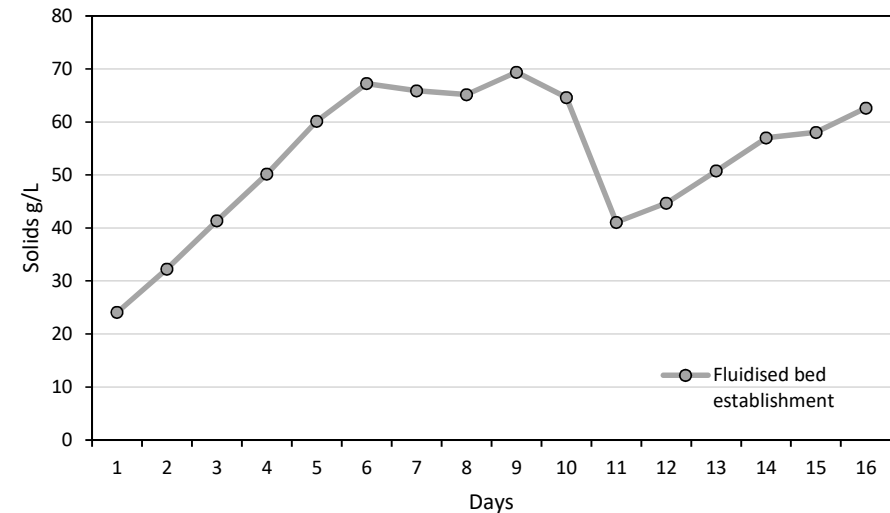


Struvia™ Pilot Plant – Results (Stage 2)



Establishment of the Fluidised Bed

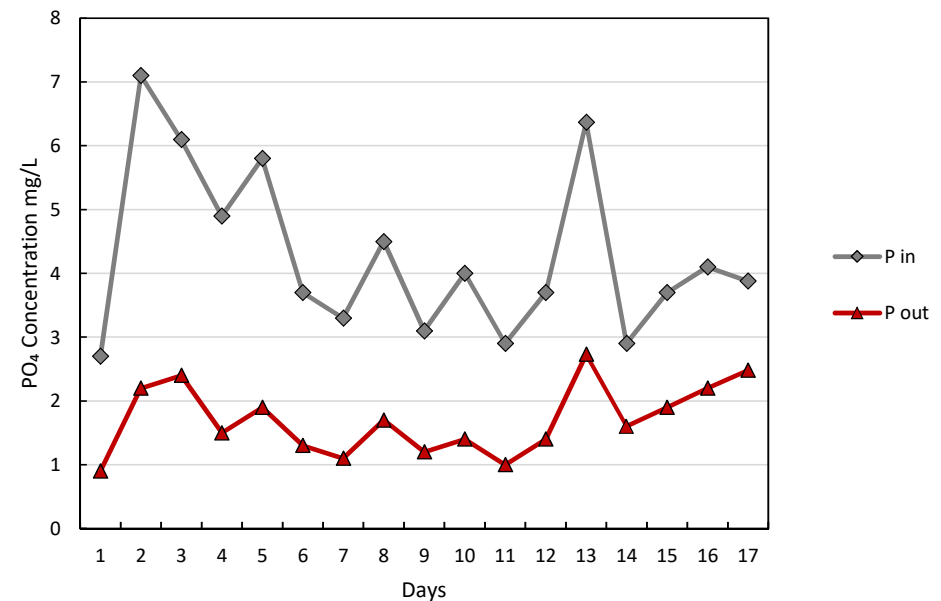
- 3kg of crushed limestone fines was added to the reactor as a calcium based seed material
- The solids content of the fluidised bed normalised between 60 and 70 g/l for a period of time, suggesting that the reactor had reached a solids equilibrium
- In consultation with Veolia the solids extraction point was then set at 60 g/l.



Struvia™ Pilot Plant - P removal at a pH of 10.8 of 10.8



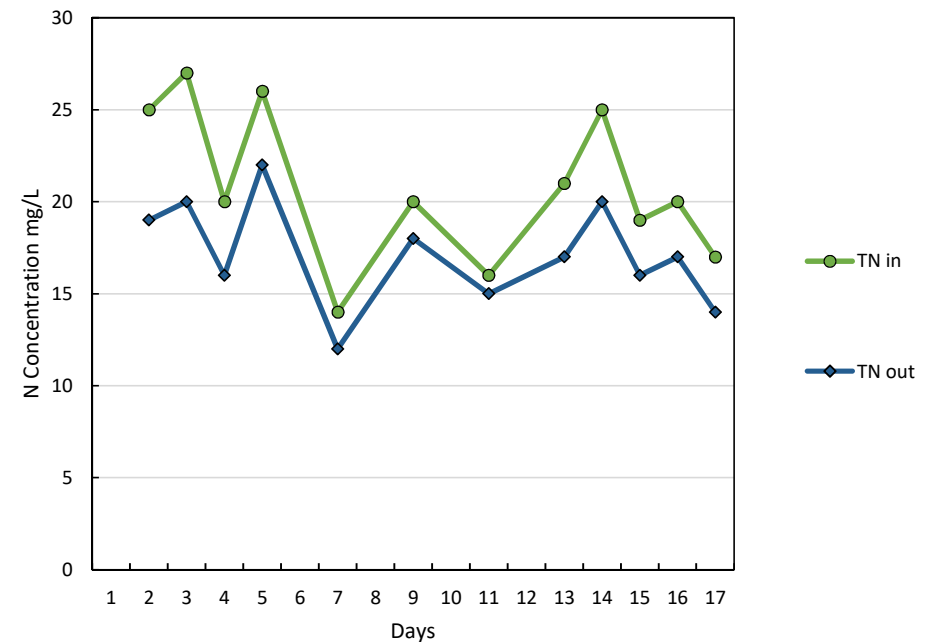
- Throughout the operation at pH of 10.8 the pilot plant had a average influent P content of 4.28 ± 1.29 mg/l PO_4^{3-}
- The pilot plant removed on average 2.58 mg/l, with the average pilot plant effluent P content of 1.70mg/l
- Pilot plant operation at a pH of 10.8 had a removal efficiency of 60.26%.



Struvia™ Pilot Plant - Nitrogen removal at a pH of 10.8



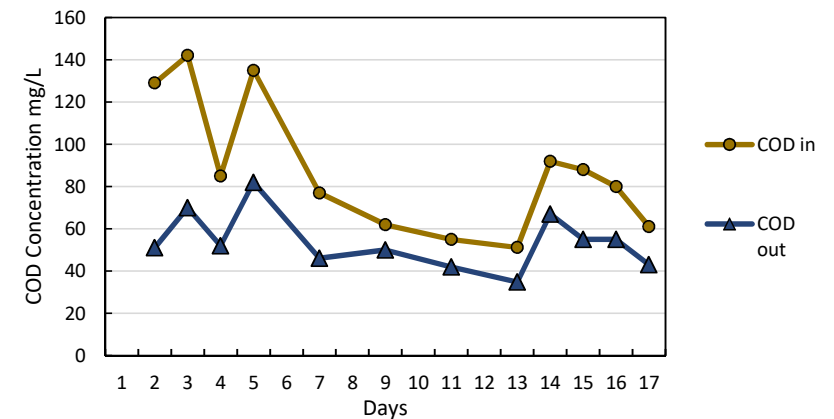
- Nitrogen is co-removed by the recovery process
- The TN removal was most probably through the release of ammonia gas and the inclusion of organic matter in the recovered product
- The Pilot Plant had an average nitrogen influent content of 20.83 ± 3.98 mg/l N
- The Pilot Plant removed an average of 3.67 mg/l TN, which equates to an overall average reduction of 17.6%.



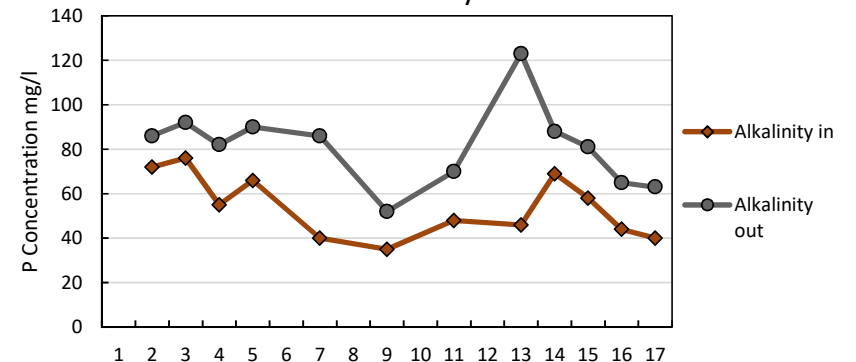
Struvia™ Pilot Plant – COD and Alkalinity removal at a pH of 10.8

- On average there was approximately a 38.7% reduction in Chemical Oxygen Demand (COD) from 88.1 – 53.98 COD mg/l
- The reduction of COD is likely due to the removal and inclusion of organic solids in the final recovered product
- The inclusion of lime increased the alkalinity of the pilot plant effluent from 54.08 mg/l to 81.50 mg/l CaCO_3
- The pH of the outgoing wastewater increased from 6.91 to 10.8.

COD removal



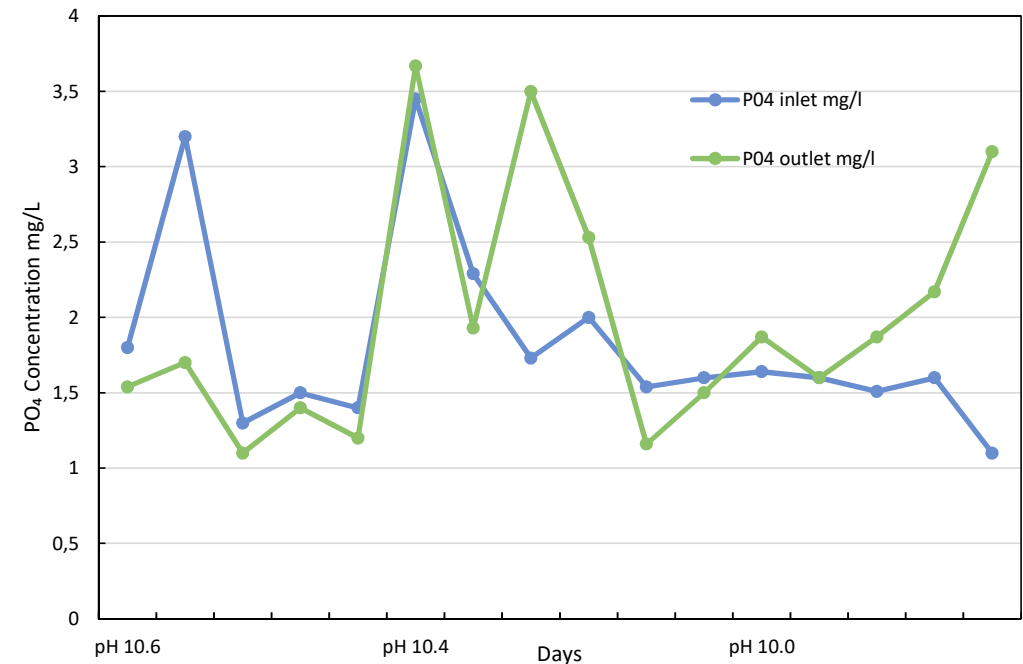
Alkalinity



Struvia™ Pilot Plant – pH reduction



- From the jar tests conducted it was observed that P removal occurred at or above a pH of 10, however this did not transfer to the pilot plant
- Consistent P removal only occurred at or above a pH of 10.6 in the Pilot Plant
- At a pH of 10.6 a P removal rate of 0.45mg/l PO_4^{3-} occurred
- This resulted in a removal efficiency of 24.5% which is substantially less than for a pH of 10.8.



Summary

- The original commissioning process took longer than initially anticipated from the 4th November 2019 to the 26th January 2020, due to mechanical issues and the production of fine material
- The Struvia™ pilot plant was visited 107 times over the trial period by two people each time, totalling close to 6400km travelled by the team. The Health & Safety requirements were onerous and exacerbated by the Covid pandemic and associated requirements.
- Once Stage 3 commenced the Pilot Plant operated efficiently within the project constraints, however high rainfall levels impacted on influent P conditions and the plant operation
- Over the trial duration 60kg of dry recovered calcium phosphate product was recovered at 4.6±0.2 % P₂O₅, 2kg were forwarded to UGhent for further analysis and 5kg used on the MTU field trials (and additional Final Product for the Closing Event!)
- Work on the pilot plant was temporarily suspended on the 12th March 2020, as a result of the Covid19 pandemic, work recommenced on the 18th November 2020 and finished on the 11th February 2021.



pH of 10.8 - Summary of Results	
PO ₄ removal mg/l	2.58
PO ₄ removal %	60.26%
TN removal mg/l	3.67
TN removal %	17.6%
Increase alkalinity mg/l	27.42
% increase in alkalinity	50.69%
COD removal mg/l	34.12
COD removal %	38.72%

Conclusions

- Overall, this research has provided significant insight into the effectiveness and limitations of the Struvia™ process through installation at the Macroom WWTP.
- The primary benefits of the Struvia™ process are its simplicity and flexibility of application; lower demand for chemicals, production of recovered P from wastewater, reduction in P emissions and overall improvement to the environment.
- The pilot plant operated most efficiently at a pH of 10.8 and less so in the range from 10 to 10.4.
- The pilot plant has operated successfully at the Macroom WWTP, reducing the wastewater PO₄³⁻ content from 4.28 mg/L to 1.70 mg/L, resulting in a removal efficiency of 60.26%.
- The removal and recovery of phosphorus led to a simultaneous reduction in total nitrogen and COD content of the effluent.
- The effluent from the pilot plant has an elevated pH and alkalinity, the broader effect of which would require further investigation.



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Conclusions (continued)

- A potential issue with the Struvia™ pilot plant at the Macroom WWTP is the lower product output, which may be attributed to the relatively low phosphorus content in the Macroom WWTP effluent
- The average pH of the effluent from the pilot plant was 10.37 (for a pilot plant pH of 10.8). A full-scale P-recovery plant at this location, for example, would thus require pH correction
- Full scale P-recovery at this location would involve an annual lime requirement in excess of 100 tonnes
- The results indicate satisfactory pilot plant effluent parameter values (relative to the Emission Limit Values for the Macroom WWTP) for COD, TSS and PO_4^{3-} but not for pH. The Macroom WWTP influent P values are relatively low, further test applications of this technology at WWTPs with higher influent P levels would provide additional and valuable information.

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Acknowledgements



We wish to acknowledge the substantial support provided by Irish Water for this research.

We also wish to acknowledge the EU INTERREG North-West Europe (NWE) VB Programme for funding received for the Phosphorous for Your Life (Phos4You) project.

Thank you for listening!

