DairyWater Project

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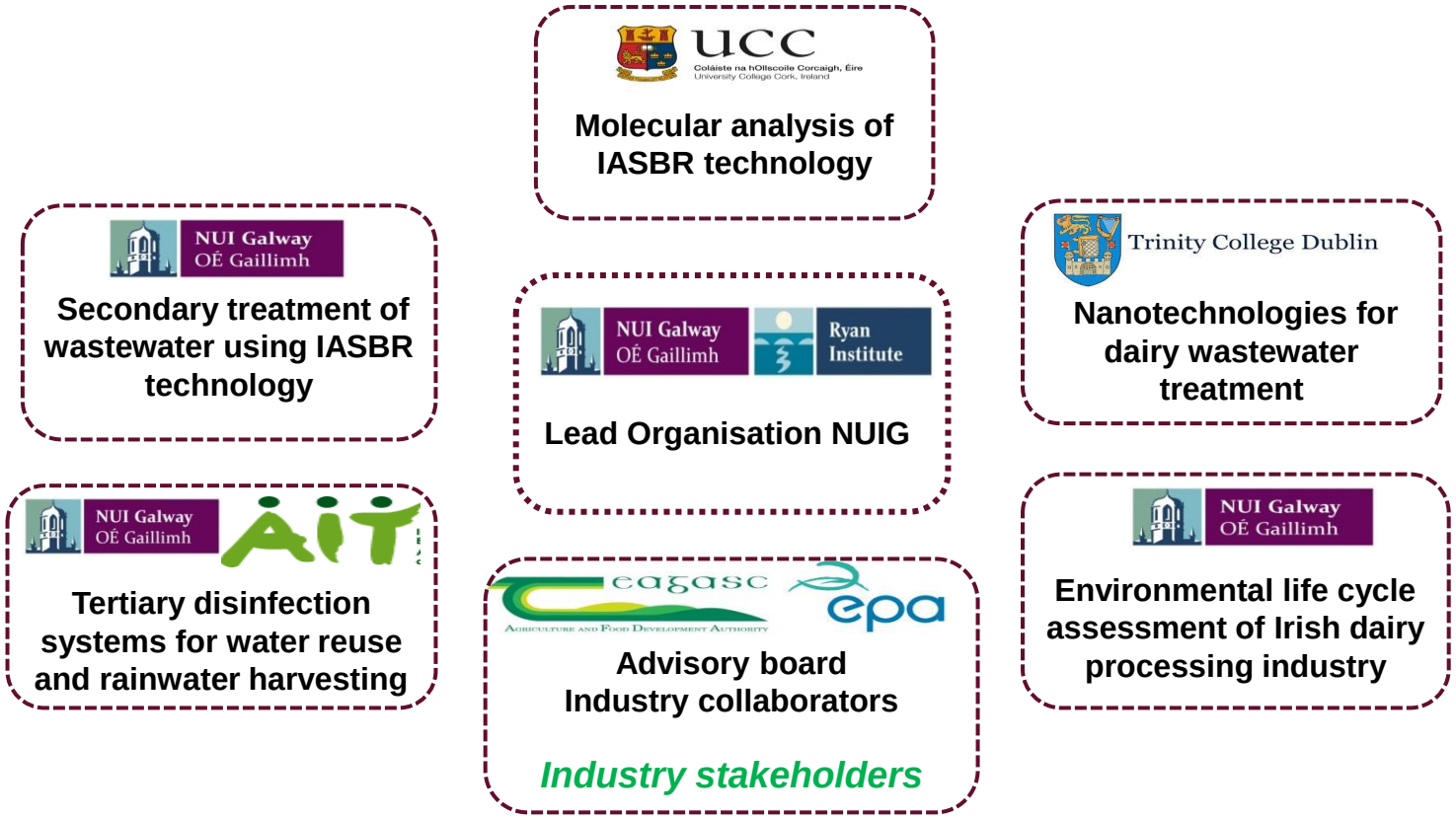
DairyWater

DairyWater Overview

- Funded by the Department of Agriculture, Food and the Marine
- Aims to help the dairy processing industry increase its sustainability through increased efficiency of resource consumption



Environmental LCA of Irish dairy products

- **Aim**: Develop strategies to reduce the environmental impact of the Irish dairy processing industry
- Objectives:
  - Perform an initial assessment of the global warming potential of the Irish dairy sector
  - Assess the environmental impact of the manufacture of Irish dairy products (using a detailed survey of factories)
  - Calculate potential mitigating effects of DairyWater technologies

Discussion points

- The results of this study will serve as a **benchmark for the Irish dairy industry** as individual producers and processers can evaluate and compare their performance in comparison.
    - Inform policy makers (e.g. EPA) of the significant contributors to environmental impacts as there is evidence for the inclusion of indirect impacts
    - Methods used in the current study may be incorporated into similar international studies.
- The findings of this research highlight a number of areas where plans may be implemented in order **to achieve more 'environmentally friendly' production of dairy products in Ireland**.
- How do the **seasonal variations** in milk production affect the Irish dairy processing industry?

Environmental LCA of Irish dairy processing plants

Science of the Total Environment 579 (2017) 159–168

Contents lists available at ScienceDirect

Science of the Total Environment

journal homepage: www.elsevier.com/locate/scitotenv

Environmental impacts of milk powder and butter manufactured in the Republic of Ireland

William Finnegan [a,b], Jamie Goggins [a,b,c,*], Eoghan Clifford [a,b], Xinmin Zhan [a,b]

[a] College of Engineering and Informatics, National University of Ireland, Galway, Ireland
[b] Ryan Institute for Environmental, Marine and Energy Research, National University of Ireland, Galway, Ireland
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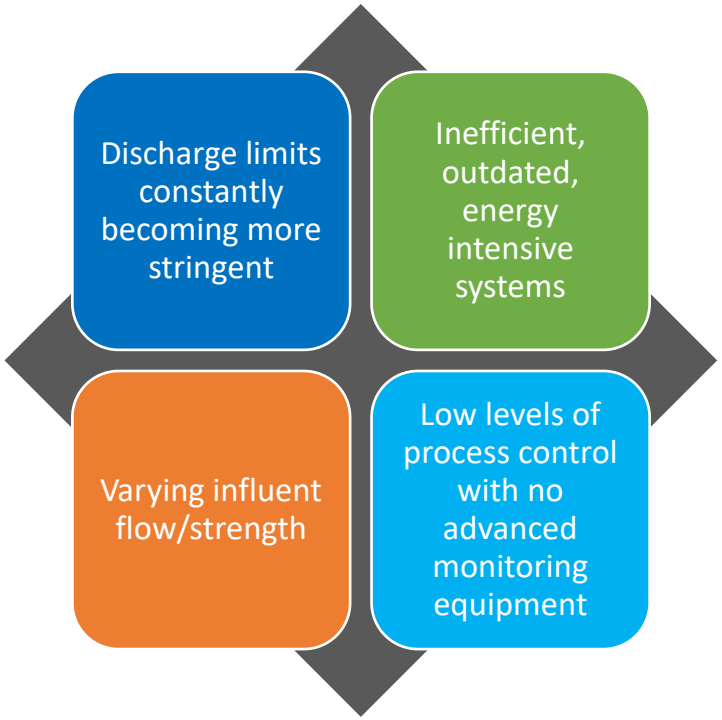
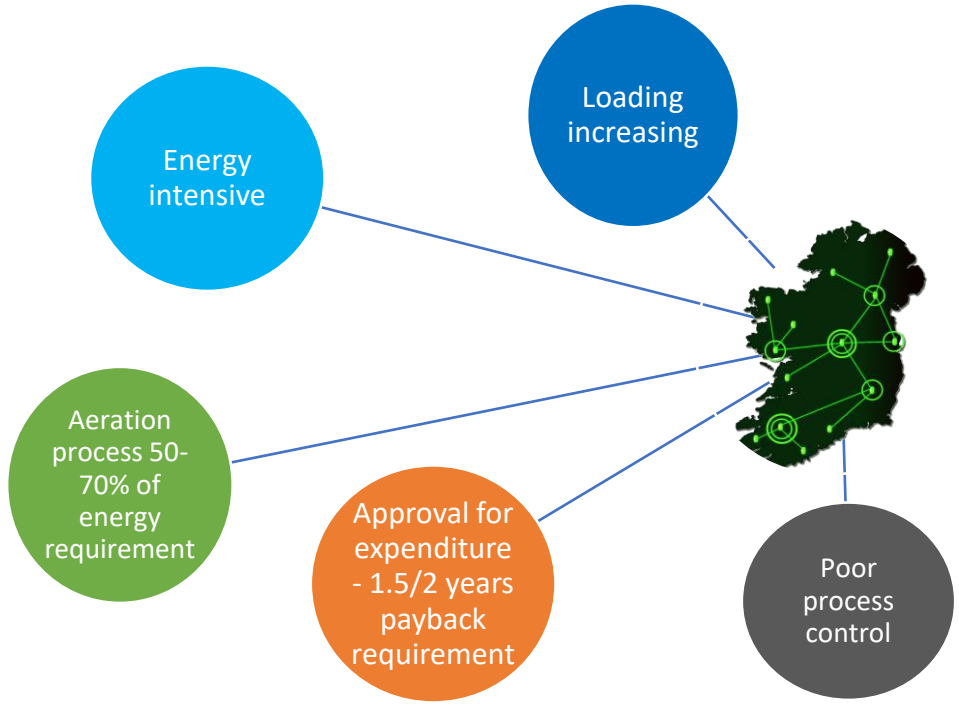
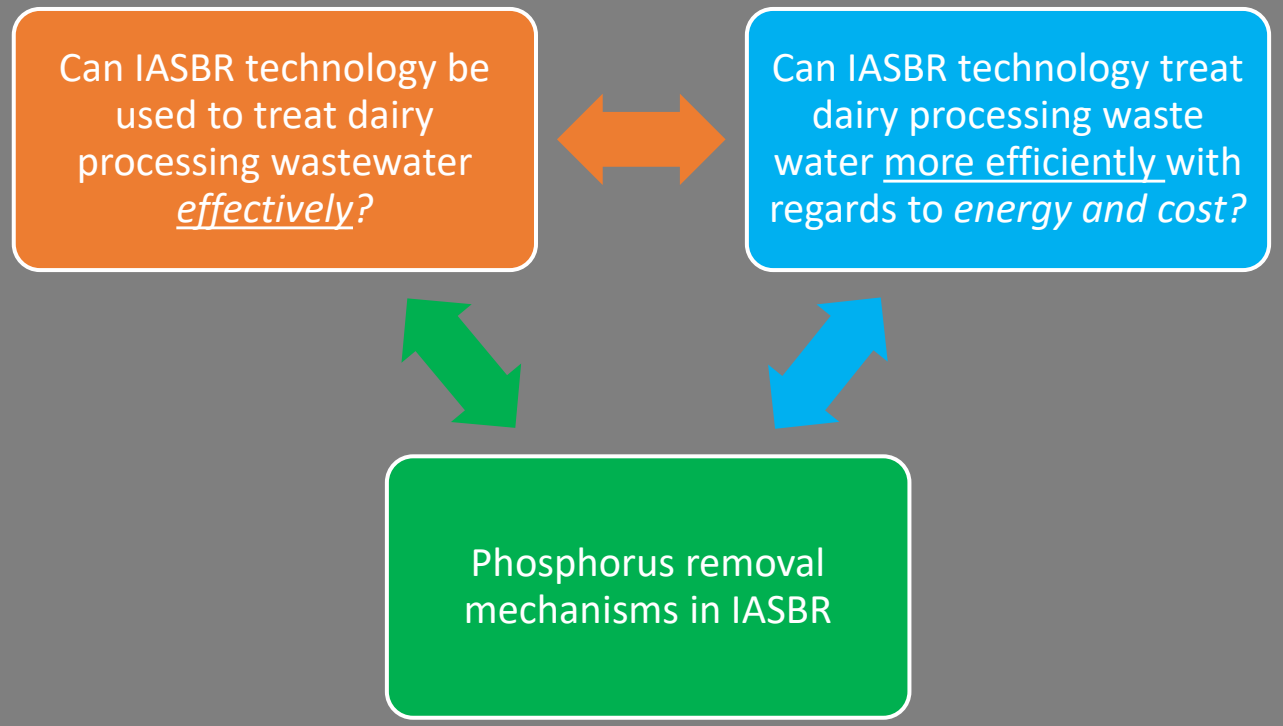
Challenges in dairy processing wastewater treatment





Key Research Questions

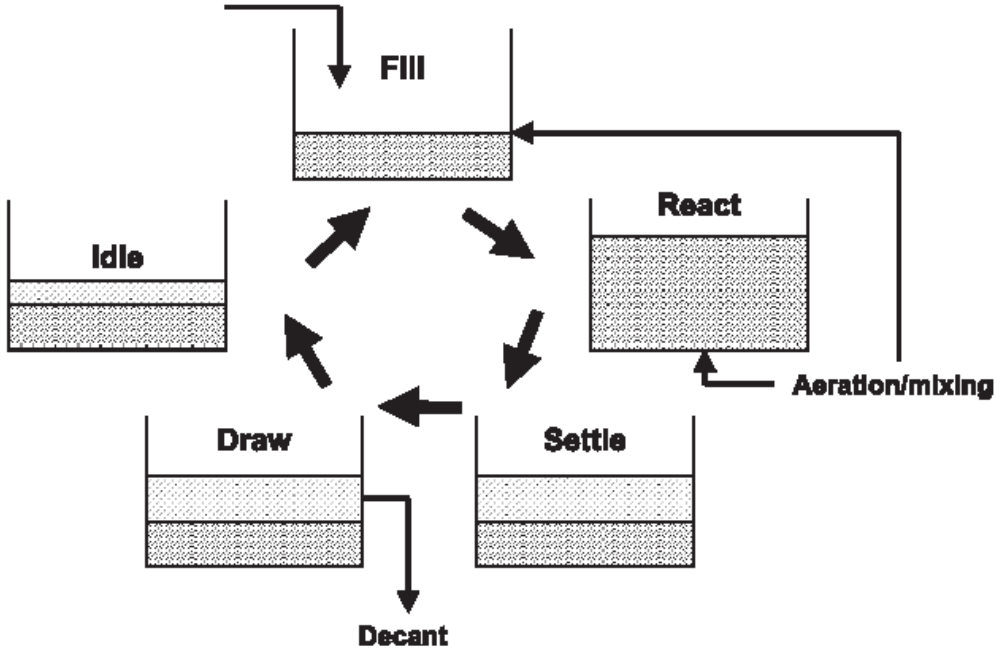


Sequencing Batch Reactors

Activated sludge treatment system

Time-oriented system as opposed to space-oriented, all process occur in one tank.

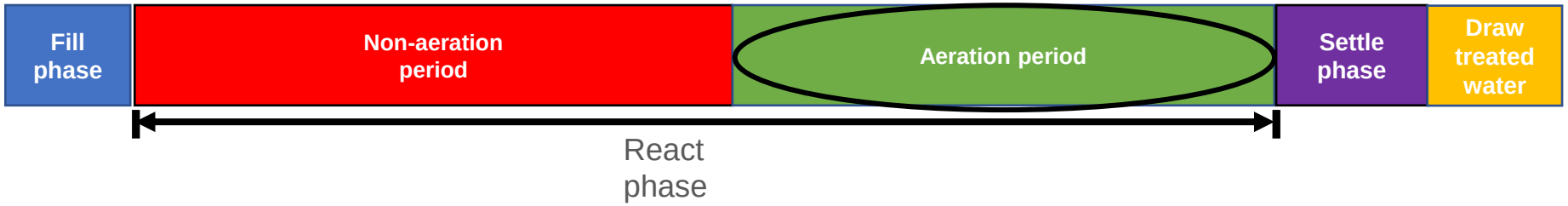
Can remove phosphorus and nitrogen along with organics.



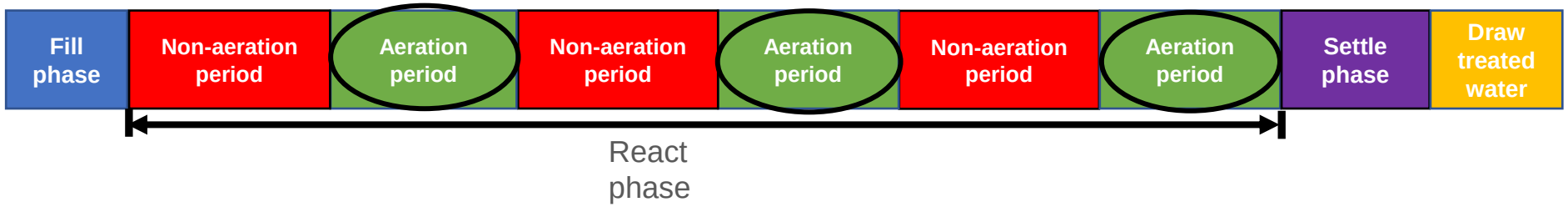
Background

What is an IASBR?

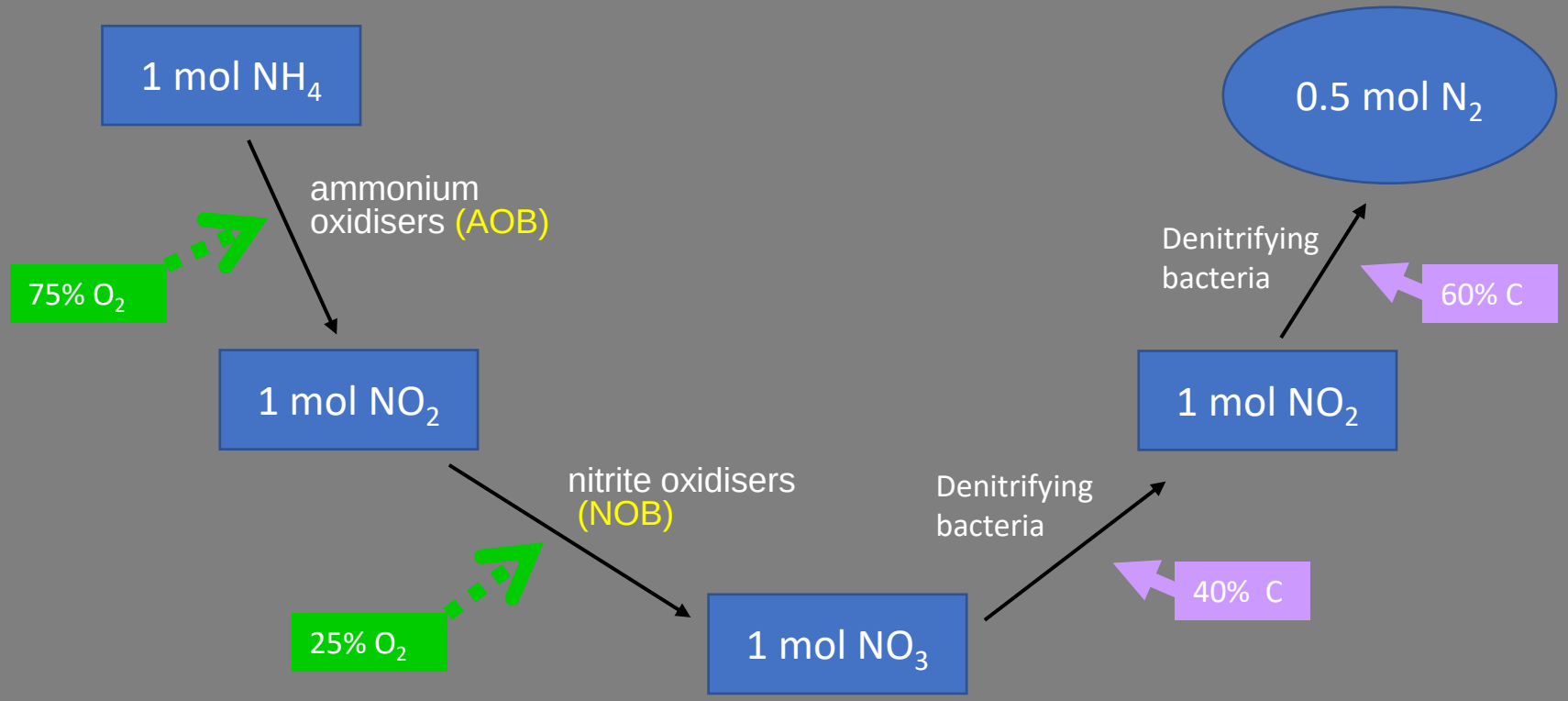
SBR – **S**equencing **B**atch **R**eactor



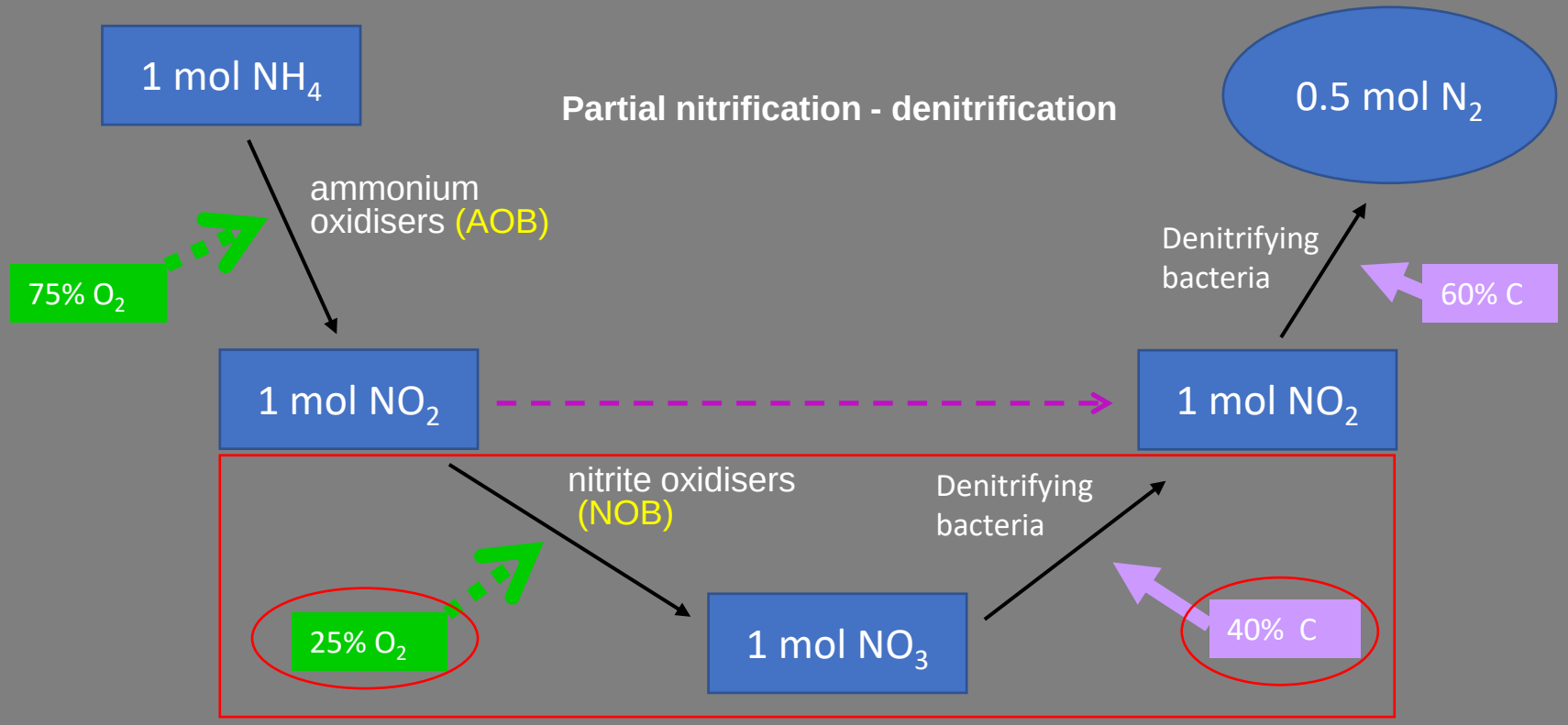
IASBR – **I**ntermittently **A**erated **S**equencing **B**atch **R**eactor



Conventional Biological nitrogen removal (BNR) pathway



IASBR Nitrogen removal pathway (via PND)



NITRIFICATION

$NH_4^+ + 1.5\ O_2 \rightarrow NO_2^- + H_2O + 2H^+$

$NH_4^+ + 2.0\ O_2 \rightarrow NO_3^- + H_2O + 2H^+$

25% ENERGY SAVED

DENITRIFICATION

$6NO_2^- + 3CH_3OH + 3CO_2 \rightarrow 3N_2 + 6HCO_3^- + 2H^+$

$6NO_3^- + 5CH_3OH + CO_2 \rightarrow 3N_2 + 6HCO_3^- + 2H^+$

40% METHANOL SAVED

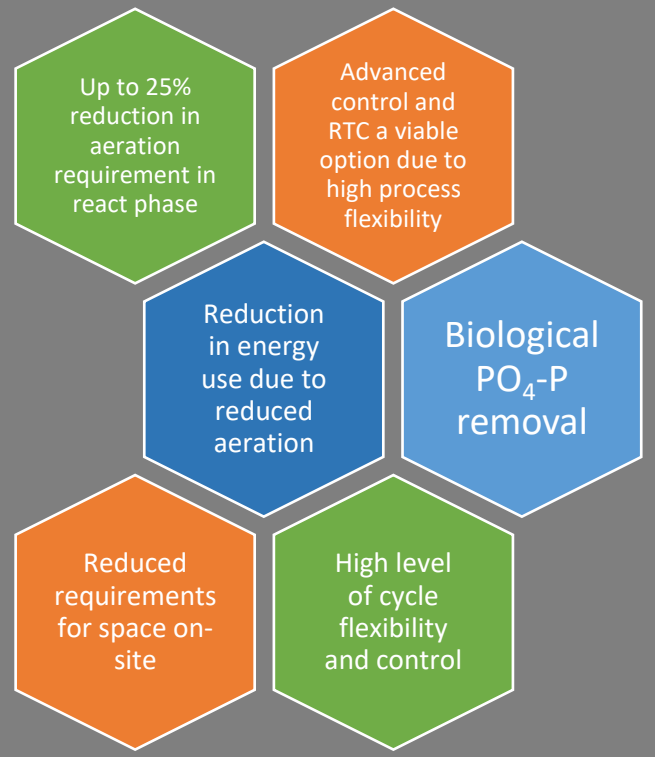
IASBR Advantages

Intermittent aeration in the react phase can achieve more efficient PND if managed correctly

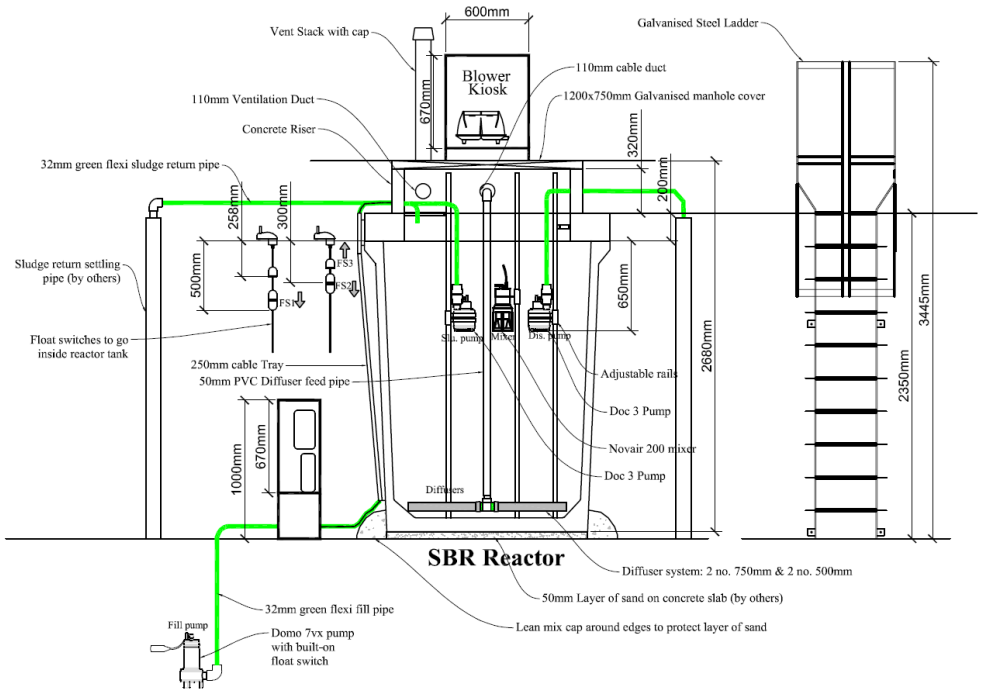
Reduced energy requirement

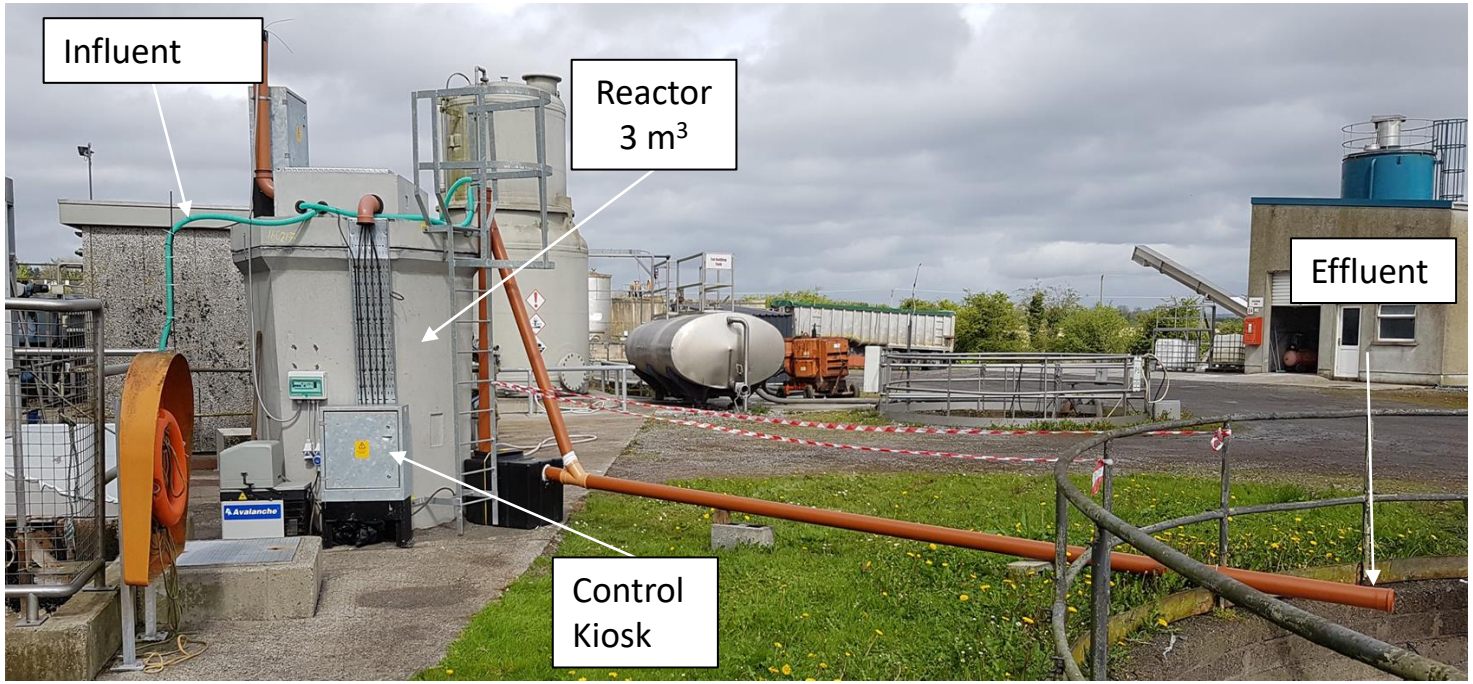
IASBR offers a degree of process control that other systems do not (advanced control, RTC potential)

System highly resilient to shock loads and changes in influent strength

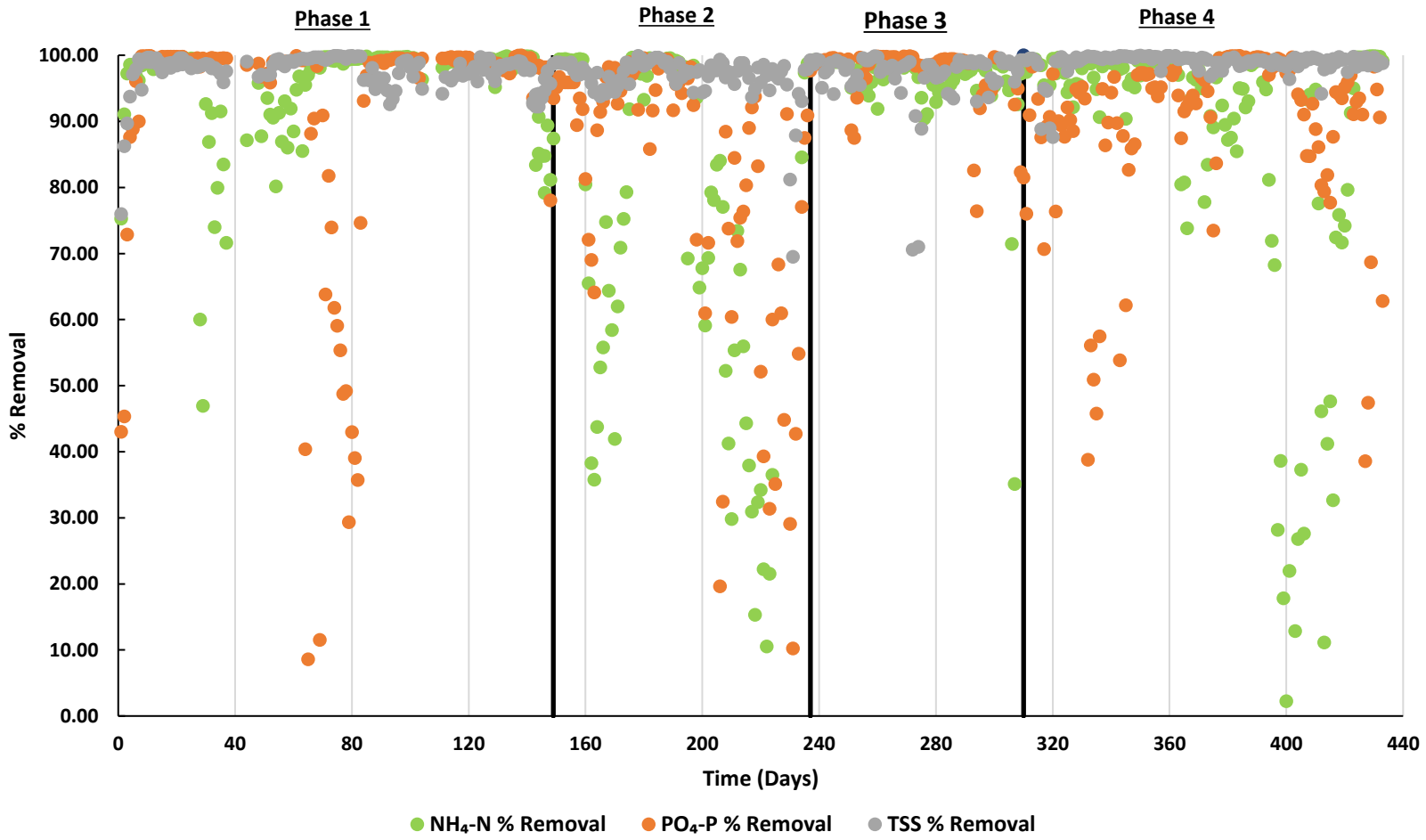


IASBR Pilot: Irish Dairy Processing WWTP

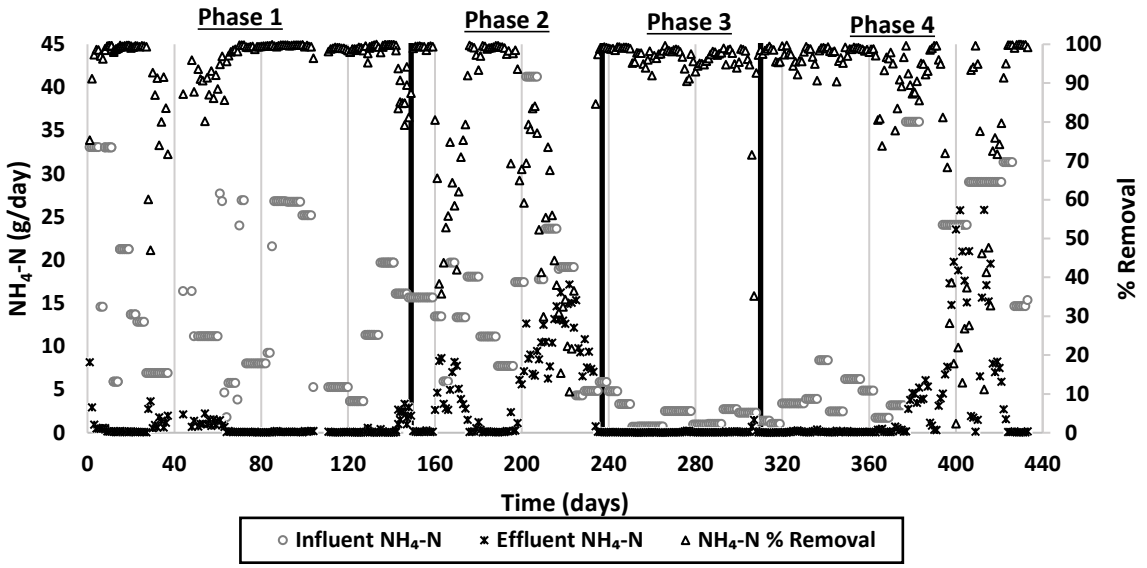


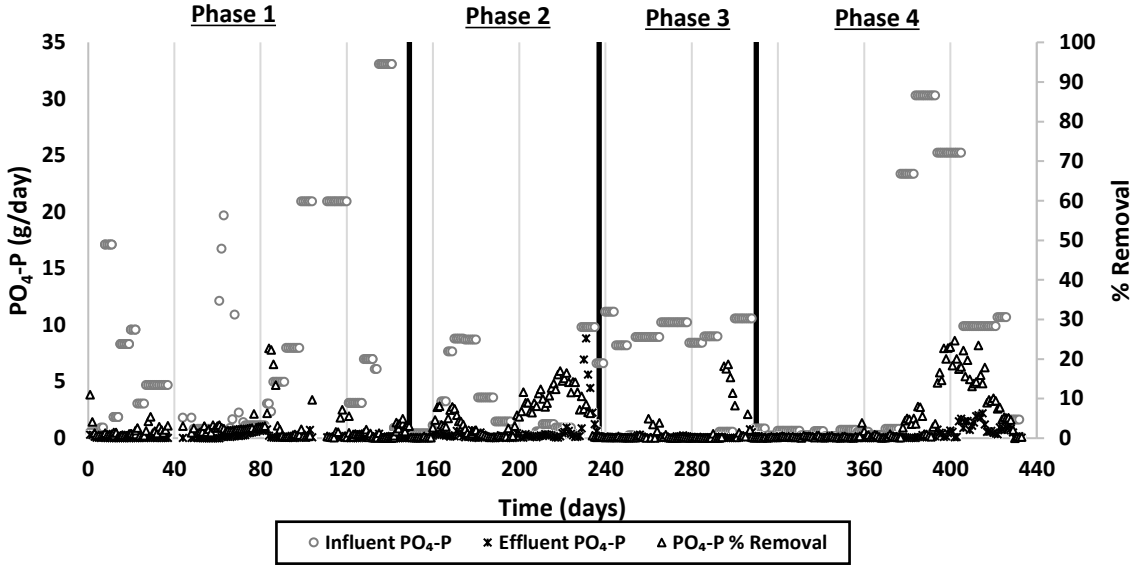


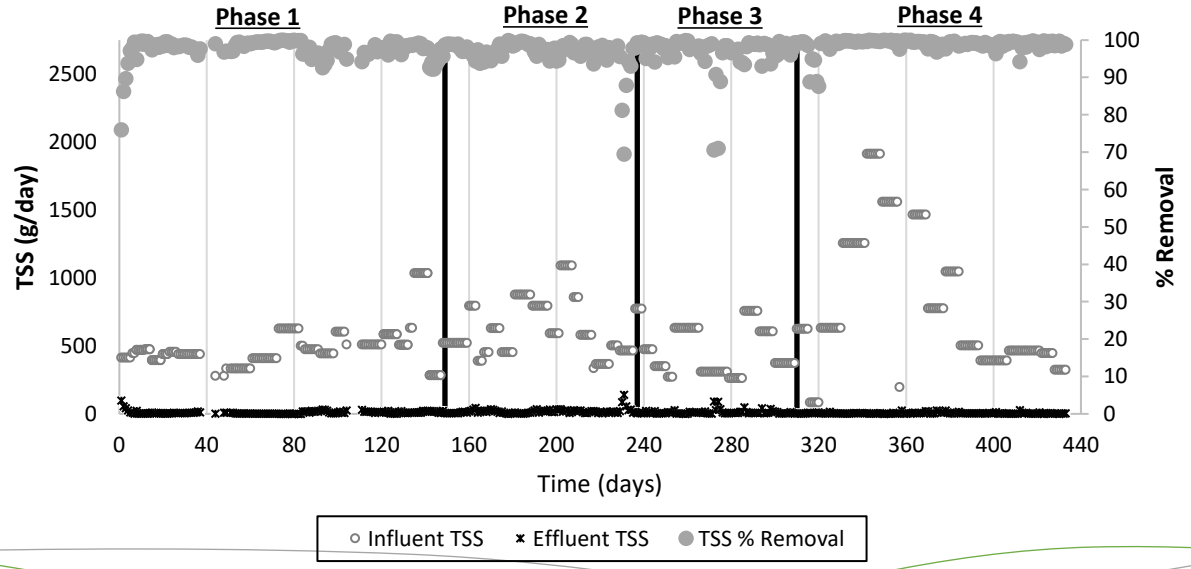
Results: Pilot scale IASBR testing

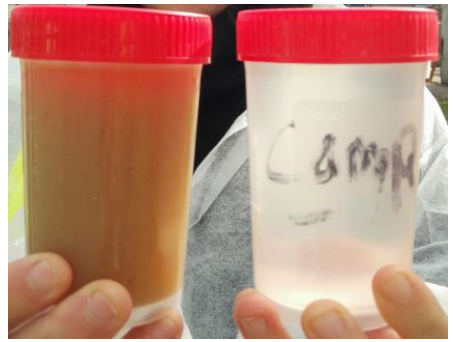


Results: Pilot scale IASBR removals









IASBR - Conclusions

Investigation has exhibited that the IASBR system has a high capacity to simultaneously remove the following from wastewater:

- Suspended solids
- Organic carbon
- Nitrogen (Organic N, NH_4-N, NO_3-N, NO_2-N)
- Phosphorus (PO_4-P)

Biological system - More economical and sustainable wastewater treatment option than requiring chemical P removal

Technology can be easily scaled up for industrial use and has been demonstrated effective at full scale in municipal treatment

Removal efficiencies are high and demonstrates high performance of the system – further optimisation will enhance system efficiency and effectiveness

Under varying wastewater strengths energy can be wasted in a constant mode reactor, savings have been demonstrated using RTC

IASBR for dairy processing wastewater

energies

MDPI

Article

Deployment and Optimisation of a Pilot-Scale IASBR System for Treatment of Dairy Processing Wastewater

Peter Leonard [1,2], Eoghan Clifford [1,2,*], William Finnegan [1,2,3], Alma Siggins [1,2,4] and Xinmin Zhan [1,2,3]

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2 Ryan Institute for Environmental, Marine and Energy Research, National University of Ireland, H91 TK33 Galway, Ireland

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Molecular analysis of IASBR

- To investigate changes in the microbial ecological structure of laboratory-scale and pilot-scale intermittently aerated sequencing batch reactors (IASBRs) treating dairy influents.
- To correlate ecological shift with the biological nutrient removal profiles in the bioreactors (efficiency and stability in bioreactor performance).
- Analysis of relevant functional gene diversity during high efficiency nutrient removal.
- Recommendation for optimal system design of bioreactors.

Molecular ecology based analysis of IASBR

Biotechnology Reports 19 (2018) e00263

Contents lists available at ScienceDirect

Biotechnology Reports

journal homepage: www.elsevier.com/locate/btre

Evaluation of dairy processing wastewater biotreatment in an IASBR system: Aeration rate impacts on performance and microbial ecology

Beatriz Gil-Pulido[a,b], Emma Tarpey[c], Eduardo L. Almeida[a,b], William Finnegan[c], Xinmin Zhan[c], Alan D.W. Dobson[a,b], Niall O'Leary[a,b,*]

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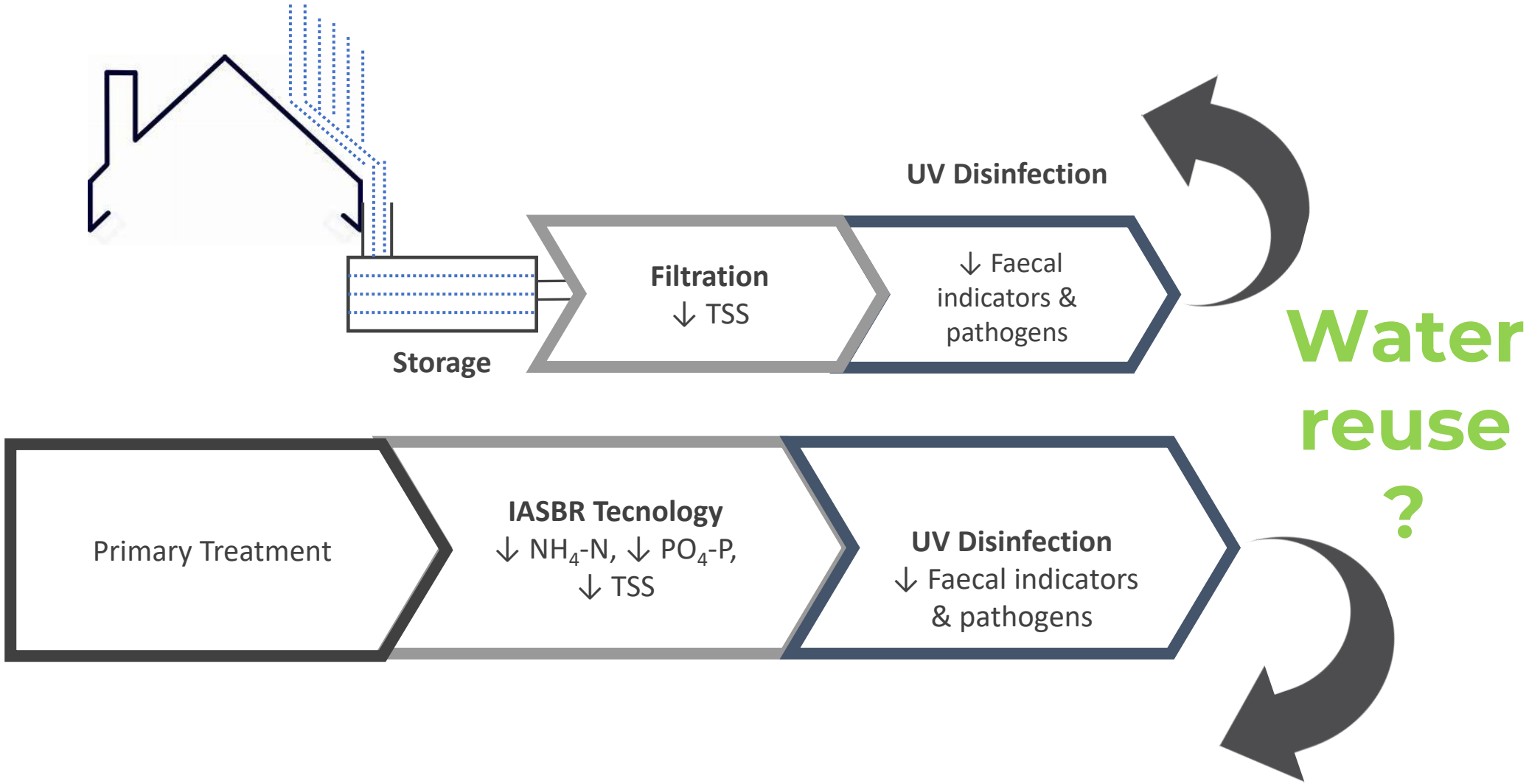
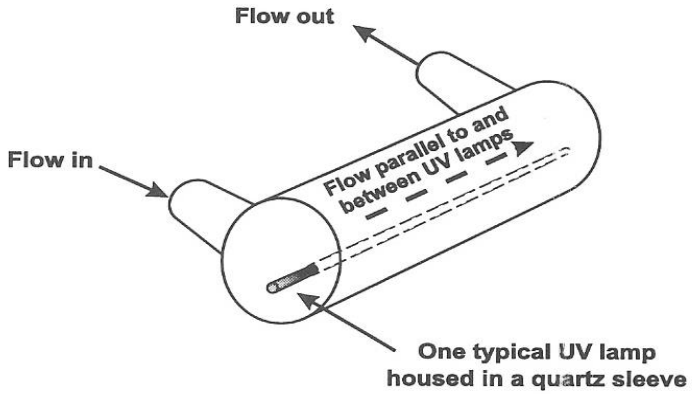
IASBR AND UV TECHNOLOGY



UV TECHNOLOGIES FOR WASTEWATER DISINFECTION & REUSE IN THE IRISH DAIRY INDUSTRY

STANDARD LPUV DISINFECTION SYSTEM

- Stainless steel, fixed power, closed system
- Continuous flow
- Monochromatic UV light



VS.

PULSED UV TECHNOLOGY

- Typically used as a static system
- Voltage box & xenon flash lamp
- High energy, polychromatic light
- *Claranor* – food industry

UV TECHNOLOGIES FOR WASTEWATER DISINFECTION & REUSE IN THE IRISH DAIRY INDUSTRY

Journal of Water Process Engineering 41 (2021) 102070

Contents lists available at ScienceDirect

Journal of Water Process Engineering

journal homepage: www.elsevier.com/locate/jwpe

Bacterial inactivation, photoreactivation and dark repair post flow-through pulsed UV disinfection

Kelly Fitzhenry [a], Eoghan Clifford [a,b,*], Neil Rowan [c], Angeles Val del Rio [a,d]

[a] School of Engineering, NUI Galway, Ireland
[b] Ryan Institute for Environment, Marine and Energy, NUI Galway, Ireland
[c] Bioscience Research Institute, Athlone Institute of Technology, Ireland
[d] School of Engineering, Universidade de Santiago de Compostela, Spain

Journal of Water Process Engineering 27 (2019) 67–76

Contents lists available at ScienceDirect

Journal of Water Process Engineering

journal homepage: www.elsevier.com/locate/jwpe

Inactivation efficiency of *Bacillus* endospores via modified flow-through PUV treatment with comparison to conventional LPUV treatment

K. Fitzhenry[a,*], N. Rowan[b], A. Val del Rio[a,d], A. Cremillieux[e], E. Clifford[a,c]

[a] College of Engineering and Informatics, NUI Galway, Ireland
[b] Bioscience Research Institute, Athlone Institute of Technology, Ireland
[c] Ryan Institute for Environment, Marine and Energy, NUI Galway, Ireland
[d] School of Engineering, Universidade de Santiago de Compostela, Spain
[e] Département Génie Énergétique et Environnement, INSA Lyon, France

Publications

Peer-reviewed Journal papers:

- Leonard, P.; Clifford, E.; Finnegan, W.; Siggins, A.; Zhan, X. Deployment and Optimisation of a Pilot-Scale IASBR System for Treatment of Dairy Processing Wastewater. *Energies* **2021**, *14*, 7365. https://doi.org/10.3390/en14217365
- Fitzhenry, K., Clifford, E., Rowan, N., Val Del Rio, A., 2021. Bacterial inactivation, photoreactivation and dark repair post flow-through pulsed UV disinfection. Journal of Water Process Engineering 41, 102070.. doi:10.1016/j.jwpe.2021.102070
- Fitzhenry, Rowan, Val Del Rio, Cremillieux, and Clifford. "Inactivation Efficiency of Bacillus Endospores via Modified Flow-through PUV Treatment with Comparison to Conventional LPUV Treatment." *Journal of Water Process Engineering* 27 (2019): 67-76.
- Gil Pulido, Beatriz & Tarpey, Emma & Almeida, Eduardo & Finnegan, William & Zhan, Xinmin & Dobson, Alan & O' Leary, Niall. (2018). Evaluation of dairy processing wastewater biotreatment in an IASBR system: Aeration rate impacts on performance and microbial ecology. Biotechnology Reports. 19. e00263. 10.1016/j.btre.2018.e00263.
- Leonard, P., Finnegan, W., Barrett, M., & Zhan, X. (2018). Efficient treatment of dairy processing wastewater in a pilot scale Intermittently Aerated Sequencing Batch Reactor (IASBR). *Journal of Dairy Research, 85*(3), 384-387. doi:10.1017/S0022029918000596
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- C. O'Donoghue, A. Chyzheuskaya, E. Grealis, K. Kilcline, W. Finnegan, J. Goggins, S. Hynes and M. Ryan, 2018. *Measuring GHG Emissions Across the Agri-Food Sector Value Chain: The Development of BIO - a Bio-economy Input-Output Model*.
- W. Finnegan, M. Yan, N. Holden and J. Goggins, 2018. *A review of environmental life cycle assessment studies examining cheese production*. The International Journal of Life Cycle Assessment.
- W. Finnegan, J. Goggins, A. Chyzheuskaya, X. Zhan, 2017. *Global warming potential associated with Irish milk powder production*. Frontiers of Environmental Science & Engineering
- W. Finnegan, J. Goggins, E. Clifford, X. Zhan, 2017. *Environmental impact of milk powder and butter manufactured in the Republic of Ireland*. Science of the Total Environment.
- W. Finnegan, J. Goggins, E. Clifford, X. Zhan, 2015. *Global warming potential associated with dairy products in the Republic of Ireland*. Journal of Cleaner Production.

Acknowledgements

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