Optimization of Phosphorus Recovery from Anaerobic Digester Effluents in Agro-industry

University of Minho
School of Engineering

CENTRE OF BIOLOGICAL ENGINEERING

P. Ricardo G. Cerqueira[1,2], Luciana Peixoto[1,2], M. Alcina Pereira[1,2], Gilberto Martins[1,2*]

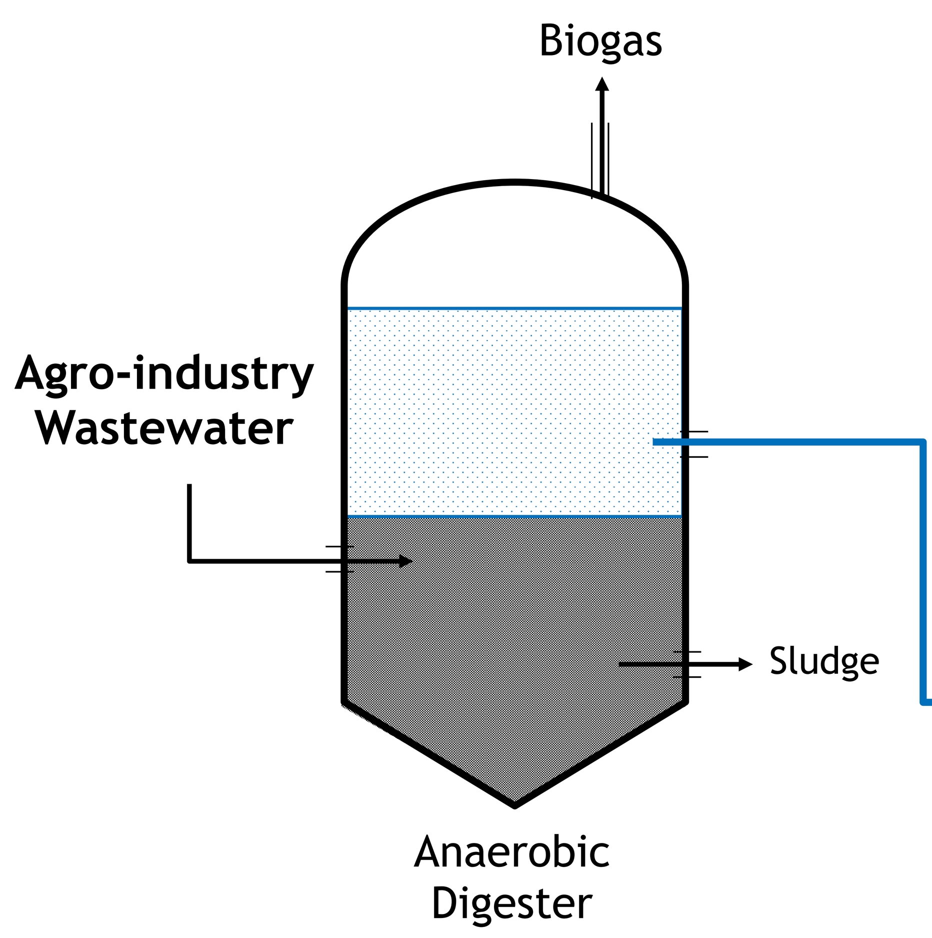
[1] CEB - Centre of Biological Engineering, University of Minho, 4710-057 Braga, Portugal
[2] LABBELS - Associate Laboratory, Braga/Guimarães, Portugal
[*] Correspondece: gilberto.martins@deb.uminho.pt

Introduction

Phosphorus (P) is an essential nutrient to sustain life. P is widely used by agriculture sectors as fertilizer to secure food production and sustain human necessities. Since the major sources of P come from non-replaceable and non-renewable natural phosphate rock reserves, it is expected a depletion of this raw material in the next 80 years. In addition, every year, it is estimated that up to 10 Mt are wasted into the hydrosphere causing serious environmental damage in water bodies (e.g., eutrophication). Alongside climate change and the increased risk of draughts in the near future, it is important to guarantee the quality of those water bodies and secure food and feed production in the agriculture sector. Therefore, to reduce the pressure in water bodies, we should increase the efforts to treat wastewater before release, which in turn can be used as a source for P recovery.

Thus, the main objective of the present work was the optimization of P recovery from full-scale Anaerobic Digestion (AD) effluents using precipitation methods with the addition of chemical (e.g., Mg, Ca or Fe salts), as well as exploring alternatives to conventional chemicals, such as seawater, brine (Mg-rich sources), and mussel shells and cork ashes (Ca-rich sources). This work is integrated in BIOECONORTE project - water and nutrients management based on BIOrefinery and circular ECOnomy towards a sustainable agri-food system of the NORTE of Portugal.

Methods



Phosphorus Precipitation Tests

Synthetic Wastewater

vs

Brewery wastewater
Dairy wastewater

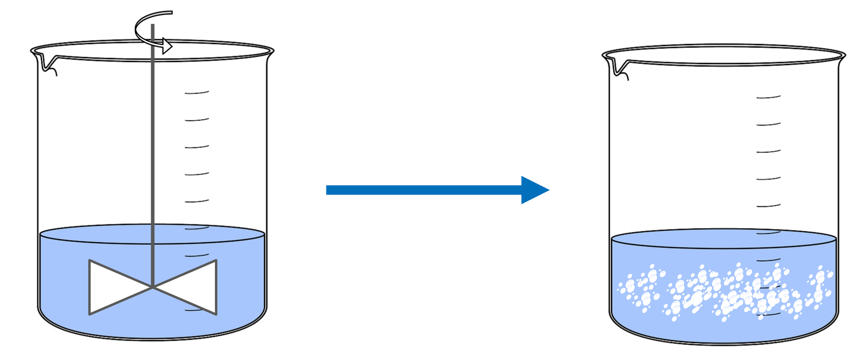
Characterization:
- pH
- TSS/VSS or TS/VS
- COD
- TN and NH_4^+-N
- TP and PO_4^{3-}-P

Conventional Chemicals:
- Mg (e.g. $MgCl_2$, MgO)
- Ca (e.g. $CaCl_2$)
- Fe (e.g. $FeCl_3$)

vs

Alternative Chemicals:
- Seawater or brine
- Mussel shells
- Cork ashes

- Addition of Salt:P in a molar ratio of 1:1, 2:1, 3:1, and 4:1
- No pH or pH adjustment to 9 / 10



V_T = 200 mL
Stirring = 50 rpm
t_{mix} = 10 min

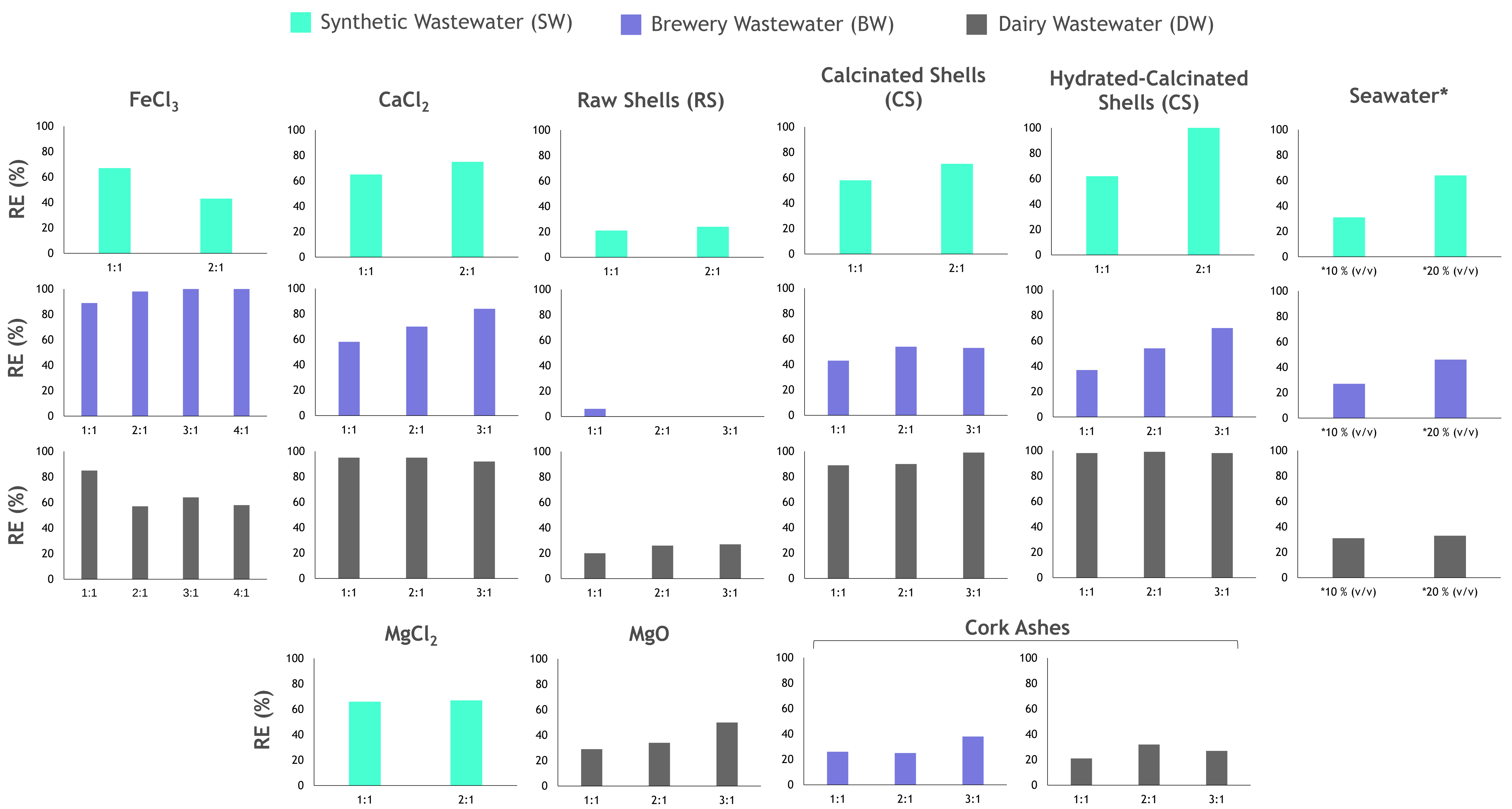
$t_{reaction}$ = 60 min

Removal Efficiency Analysis

$$RE\ (\%) = \frac{Pi - Pf}{Pi} \times 100$$

Pi - Inicial P
Pf - Final P

Results



Conclusions

P precipitation using different molar ratios of $FeCl_3$ showed a P-recovery between 43-67%, 88-100% and 57-85% for SW, BW, and DW, respectively. With the addition of different molar ratios of $CaCl_2$, and adjusting the pH to 10, the P recovery ranged between, 65-75%, 58-84% and 92-95% for SW, BW and DW, respectively. The results of P recovery with $MgCl_2$ and MgO ranged between 66-67% in SW and 29-50% in DW, respectively. The experiments carried out with mussel shells in different physicochemical states demonstrated a P-recovery of 0-27%, 43-99%, and 62-100% when using distinct molar ratios of RS, CS, and HCS in each effluent, respectively. The addition of 10% and 20% (v/v) seawater tested in SW, BW and DW showed a P recovery of 31-64%, 27-46%, and 31-33%, respectively. Finally, the P recovery with Cork Ashes in BW and DW ranged between 25-38% and 21-32%, respectively. In conclusion, these results demonstrate the viability of the use of alternative salt sources for P precipitation and recovery, contributing to the circular economy of agri-food industry.

This study was supported by the BioEcoNorte project (NORTE-01-0145-FEDER-000070) funded by the European Regional Development Fund under the scope of Norte2020 - Programa Operacional Regional do Norte and by the Portuguese Foundation for Science and Technology (FCT) under the scope of the strategic funding of UIDB/04469/2020.

FCT Fundação para a Ciência e a Tecnologia
MINISTÉRIO DA EDUCAÇÃO E CIÊNCIA
CCDR NORTE
PORTUGAL 2020
NORTE 2020 PROGRAMA OPERACIONAL REGIONAL DO NORTE
UNIÃO EUROPEIA Fundo Europeu de Desenvolvimento Regional