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

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Abstract: 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, bine (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.
The addition of chemicals was based on the initial concentration of P in the effluent (brewery and dairy industry), and different molar ratios (salt:P) 1:1, 2:1, 3:1 or 4:1 were applied.
P precipitation using $FeCl_3$, at the different Fe:P ratios, showed a P-recovery between 88-100 % and 57-85% in brewery and dairy wastewaters, respectively. With the addition of $CaCl_2$, for the different Ca:P ratios, and adjusting the pH to 10, the P recovery ranged between 58-84% and 92-95% in brewery and dairy wastewaters, respectively. The experiments carried out with mussel shells (only with dairy wastewater, but for the different Ca:P ratios) demonstrated a P-recovery of 12-41%, 89-99%, and 98-99% when using raw shells, calcinated shells, and hydrated-calcinated shells, respectively. The seawater was tested in synthetic wastewater, at a 20% (v/v) ratio, showing a P recovery of 64%. 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.