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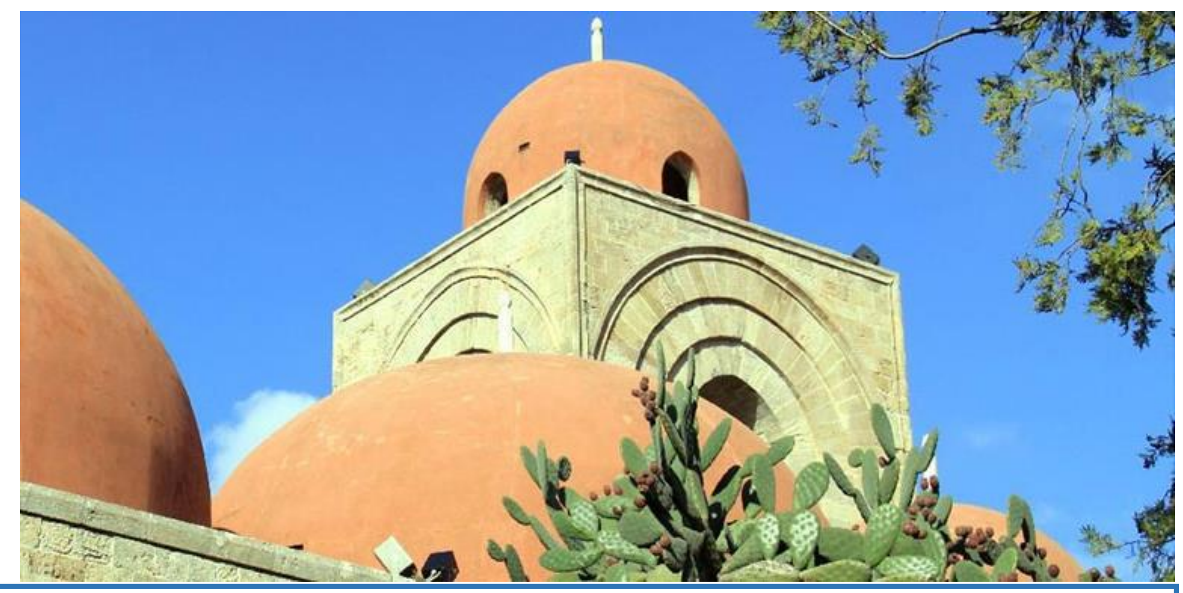

# Combining anammox with struvite precipitation for multi-nutrient recovery

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## SUMMARY

Potassium is a key macronutrient in mineral fertilizer, but is often overlooked when nutrient recovery is discussed although the EU is relying on imports of potash for fertilizer production.

In this study the recovery of potassium in the form of potassium struvite ($MgKPO_4 \cdot 6H_2O$) is assesed in side-stream conditions. Simultaneous recovery of all three macronutrients N, P and K is achieved in a multi-nutrient product.

## 1 THE PROBLEM STATED

Recent years has seen a shift from removal to recovery of phosphorus at wastewater treatment plants, with several full-scale applications of struvite ($MgNH_4PO_4 \cdot 6H_2O$) in operation. Potassium can substitute for ammonium in the struvite crystal lattice and form potassium struvite. The formation is strongly affected by the presence of ammonium and precipitation should thus be placed after nitrogen removal.

The concept has been demonstrated on denitrified calf manure (Schuling & Andrade, 1999) and urine (Xu et al, 2011) but has yet to be investigated on urban wastewater. The rising number of anammox installations opens the possibility to implement recovery of potassium together with ammonium struvite in side-stream conditions.

## 2 OUR APPROACH

A lab-scale PNA sequencing batch reactor was operated on centrate from an urban wastewater treatment plant to provide effluent for precipitation experiments.

The influence of pH, Mg:P ratio and temperature on nutrient removal was investigated in batch experiments conducted in 1 L glass beakers fitted with water jackets for temperature control. pH and Mg:P ratio were adjusted using NaOH and magnesium chloride respectively.

The software Visual MINTEQ was used for chemical equilibrium calculations.

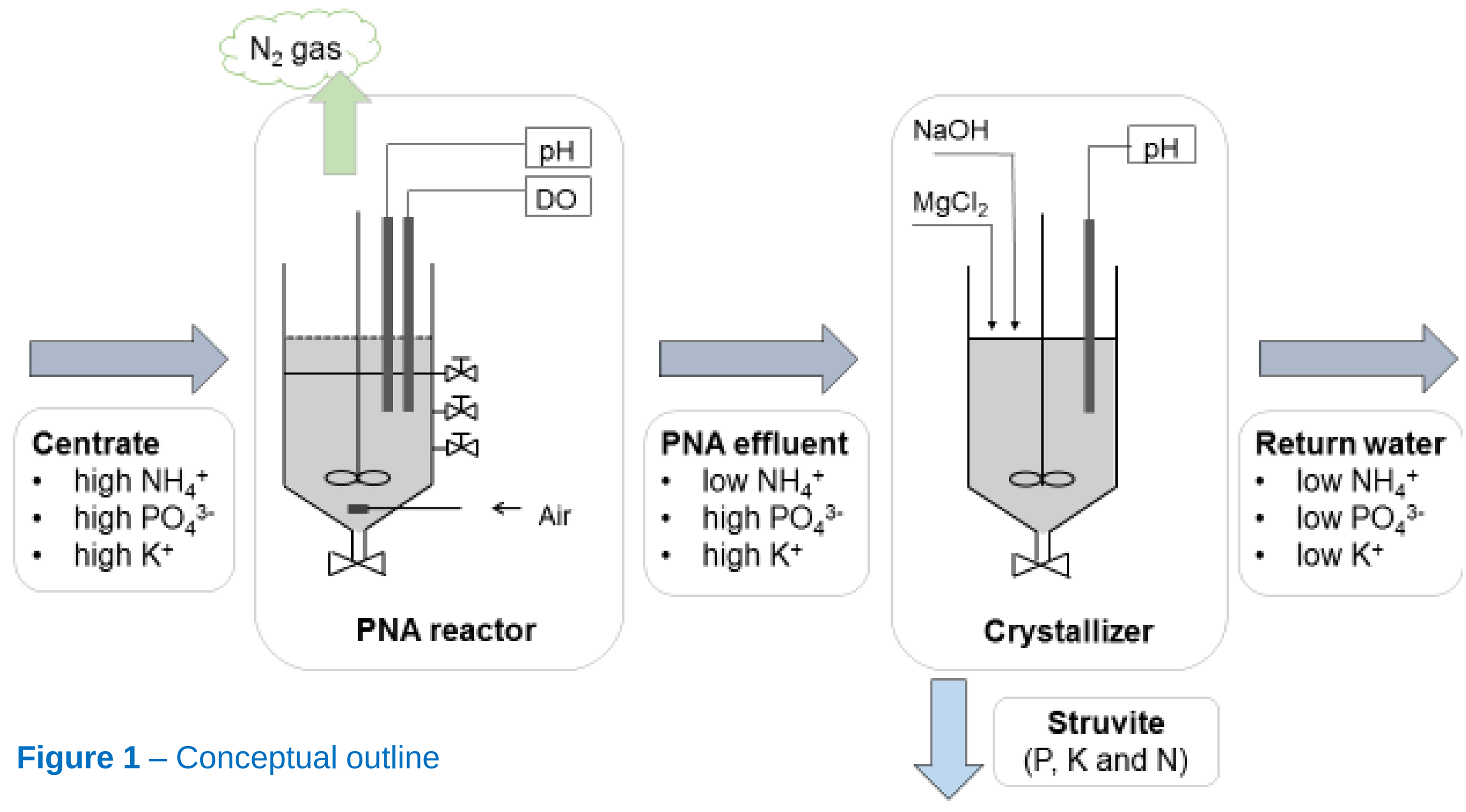


**Figure 1** – Conceptual outline

**Table 1** – Composition of the centrate and effluent used for the different experiments

| Parameter | Centrate | std | PNA effluent | std |
|---|---|---|---|---|
| **pH** | 8.0 | 0.02 | 7.7 | 0.05 |
| **Alkalinity (mg $CaCO_3$ /L)** | 3276 | 174 | 366 | 30 |
| **P-$PO_4^{3-}$ (mg/L)** | 59 | 6.0 | 55 | 3.3 |
| **N-$NH_4^+$ (mg/L)** | 949 | 80 | 130 | 15 |
| **$K^+$ (mg/L)** | 251 | 2.1 | 270 | 6.5 |
| **$Mg^{2+}$ (mg/L)** | 12 | 0.3 | 9.0 | 3.9 |
| **$Ca^{2+}$ (mg/L)** | 54 | 0.55 | 36 | 2.4 |

## 3 CENTRATE BEFORE AND AFTER PNA

The PNA reactor decreased ammonium concentration by >85%, while K and P remained at incoming levels (Table 1). The effluent had an excess of potassium and nitrogen for struvite formation with molar K:P and N:P ratios of 3.9 ± 0.2 and 5.2 ± 0.5 respectively.

Consumption of bicarbonate by the autotrophic biomass decreased the alkalinity by 90% implying that struvite precipitation placed after a PNA unit would require less input for pH adjustment compared to when applied directly on centrate.

## 4 NUTRIENT REMOVAL

Nutrient removal was favoured by increasing pH up to pH 11 (Fig 2a) and a mix of potassium and ammonium struvite was confirmed by XRD at this condition (Fig 2d). At pH 12 a collapse of nutrient removal occurred. Chemical equilibrium simulations showed that this was due to formation of magnesium hydroxides.

Removal of ammonium and phosphate increased with increasing magnesium dosing while potassium removal remained around 5% (Fig 2b). A Mg:P ratio of 1.25 was enough to achieve phosphate removal of 90%.

Nitrogen removal is due to struvite precipitation as well as ammonia stripping, the latter being enhanced by increasing pH as well as increasing temperature (Fig 2a and 2c).

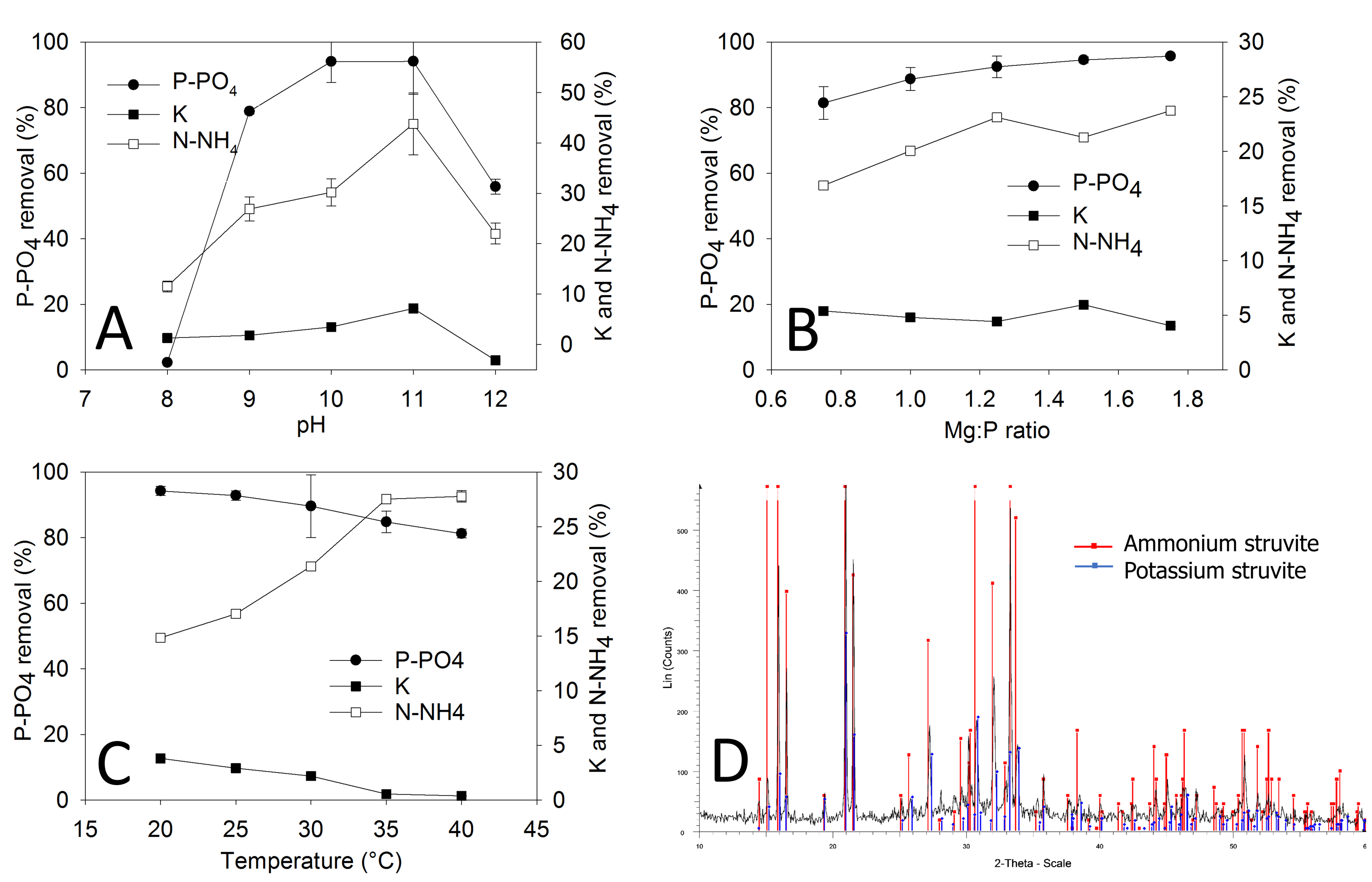


**Figure 2** – Influence of pH (a), Mg:P ratio (b) and temperature (c) on nutrient removal, and a diffractogram obtained from precipitates at pH 11, Mg:P ratio 1.25 and 25°C

## CONCLUSION

The study showed that it is possible to recover potassium together with phosphorus and nitrogen in side-stream conditions and obtain a multi-nutrient product

Placing struvite precipitation after a PNA unit can reduce the need for chemical and energy input for pH adjustment since the autotrophic biomass functions as a biological $CO_2$ stripper.

**REFERENCES**

Xu et al. (2011) Simultaneous removal of phosphorus and potassium from synthetic urine through the precipitation of magnesium potassium phosphate hexahydrate, Chemospere, 84:2, 207-212

Schuling & Andrade (1999) Recovery of struvite from calf manure, Env. Tech., 20:7, 765-768

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