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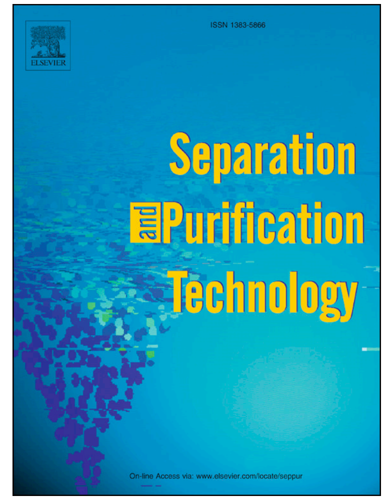

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Electro-concentration for chemical-free nitrogen capture as solid ammonium bicarbonate

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Abstract

Source-separated urine is a promising stream for nutrient capture using electrochemical technologies. It contains the majority of macronutrients present in municipal wastewater in a concentrated, high ionic conductivity liquid and in N:P:K ratios suitable for agricultural application. The purpose of this study was to recover nutrients from urine, and particularly nitrogen as a solid without any chemical addition. Simulated source-separated urine was concentrated using a three-compartment electrochemical system, applying a range of current densities and feed compositions. Electro-concentration into a liquid concentrate reached maximum recovery of 72:61:79 % for N:P:K, respectively, from a synthetic feed simulating ureolysed and digested urine, with a specific electrical energy consumption of 47 MJ/kg N and current efficiency of 67 % for ammonium. Cooling the concentrate to -18°C resulted in solid ammonium bicarbonate crystal formation in samples with high ammonium bicarbonate ionic product and high relative ammonium bicarbonate ionic strength. Precipitation started to occur when ammonium bicarbonate ionic product was higher than 2.25 M^2 and ammonium bicarbonate accounted for more than 62 % of the total ionic strength of the feed. The maximum observed nitrogen recovery into solid ammonium bicarbonate reached 17 % using a current density of 100 A m^{-2}. Based on these results, electro-concentration is a promising technology for urine nutrient capture. However, capture as solid ammonium bicarbonate is feasible only if higher recovery efficiencies are achieved by removing competing ions.

Keywords: nutrient recovery; urine; electro-concentration; ammonium bicarbonate precipitation

1 Introduction

Source-separated, decentralized systems offer promising alternatives for the future of human sanitation enabling localised recovery of nutrients and water resources [1]. While planetary boundaries of Earth are under unprecedented stress by population growth and climate change [2],