

Fermentation of urine results in electrochemical production of industrial resources

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Abstract

Urine contributes only 1% in volume to domestic wastewater (Larsen & Gujer, 1996) but carries about 80% of nitrogen, 50% of phosphorus, and 70% of potassium to a conventional treatment plant (Udert, 2002). These high concentrations create potential for resource recovery on source-separated urine resulting in more efficient grey water treatment. A combination of urine fermentation and electrochemical extraction of NH_3 , CO_2 , H_2 , and O_2 is proposed.

A fermentation batch test of 37.5% diluted fresh men's urine with addition of an inoculum ran for 14 days at 34°C. Hydrolysis of the urine buffered the solution at a pH around 9.2. Conductivity was not higher than 35 mS/cm. A positive (urine without inoculum, C real) and negative (inoculum without urine, C inoc) control were taken into account. Acetate production for urine with inoculum (In real) reached levels of 1200 mg/L equivalent to 40% of the soluble COD while 80% of the total kjeldahl nitrogen (>90% urea) was hydrolysed into NH_4^+ (2.8 g N/L).

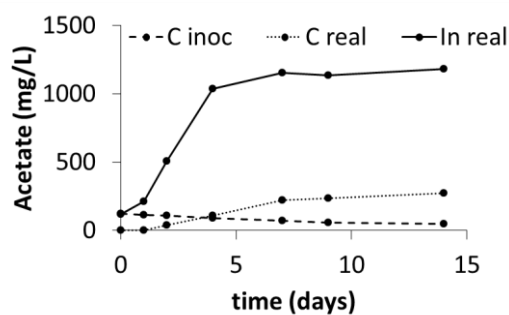


Fig. 1 Acetate production during fermentation of 37.5% fresh urine

Recovery of NH_4^+ from fermented urine combined with the production of CO_2 , H_2 , and O_2 was obtained in an electrochemical cell coupled to a strip and absorption column. Synthetic hydrolysed urine (10 g N/L, 2 g acetate/L, modified after Udert 2002) was fed to the cathode compartment and after passing the strip column, into the anode compartment, at an HRT of 6 h per reactor compartment. Increased pH in the catholyte drives the stripping process, while pH is lowered again in the anolyte, enabling additional recovery of NH_4^+ over a cation selective membrane. A current density of 48 A/m² yielded 75% of NH_4^+ -N removal via the strip and absorption column. About 60% of nitrogen was removed in the cathode while 50% of the remaining nitrogen fed in the anode was extracted to the cathode via the cation exchange membrane. On average, 600 L/m²_{membrane area}/d NH_3 and 0.75 L/m²_{membrane area}/d H_2 was produced in the cathode compartment and 0.5 L/m²_{membrane area}/d O_2 and 0.6 L/m²_{membrane area}/d CO_2 were formed in the anode compartment at 22°. Gasses obtained can serve as building blocks for industrial products. Moreover, acetate concentration remained unchanged, opening possibilities to feed the effluent to a conventional wastewater treatment plant requiring a readily biodegradable carbon source, at low nitrogen load.

The coupling of urine fermentation and electrochemical production of gasses could be an interesting route for production of value added products from waste and energy. In depth characterization in terms of energy demand, opex, and capex of this technology is however required to assure a well-thought competition with current technology and resources.

References

- Larsen, T.A. and Gujer, W. (1996), Separate management of anthropogenic nutrient solutions (human urine). *Water Science and Technology*, **34**(3-4), 87-94.
- Udert, K.M. (2002), The fate of nitrogen and phosphorus in source-separated urine. Doctoral dissertation, Swiss Federal Institute of Technology, Zürich, Switzerland, 132p.