Pilot Experiments with Electrodialysis and Ozonation for the Production of a Fertilizer from Urine

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Why urine separation and treatment?

Ca. 80 % of N and 50 % of P in WWTP influent come from urine as well as pharmaceuticals and hormones

- Nutrient recovery instead of removal
- Closure of nutrient cycle
- Load relieving of WWTP‘s
- Decreased pollution of surface water
  - Elimination of micropollutants
  - Removal of N, P, etc.

What is needed for urine separation and treatment? (CH)

- Separation and collection technologies
- Public acceptance of these systems
- Appropriate technologies to:
  - recover nutrients
  - eliminate micropollutants, such as pharmaceuticals and hormones (precaution principle)
  - remove hygienic risks
- Registration of the product as a fertilizer

UrinPur – cantonal library in Baselland

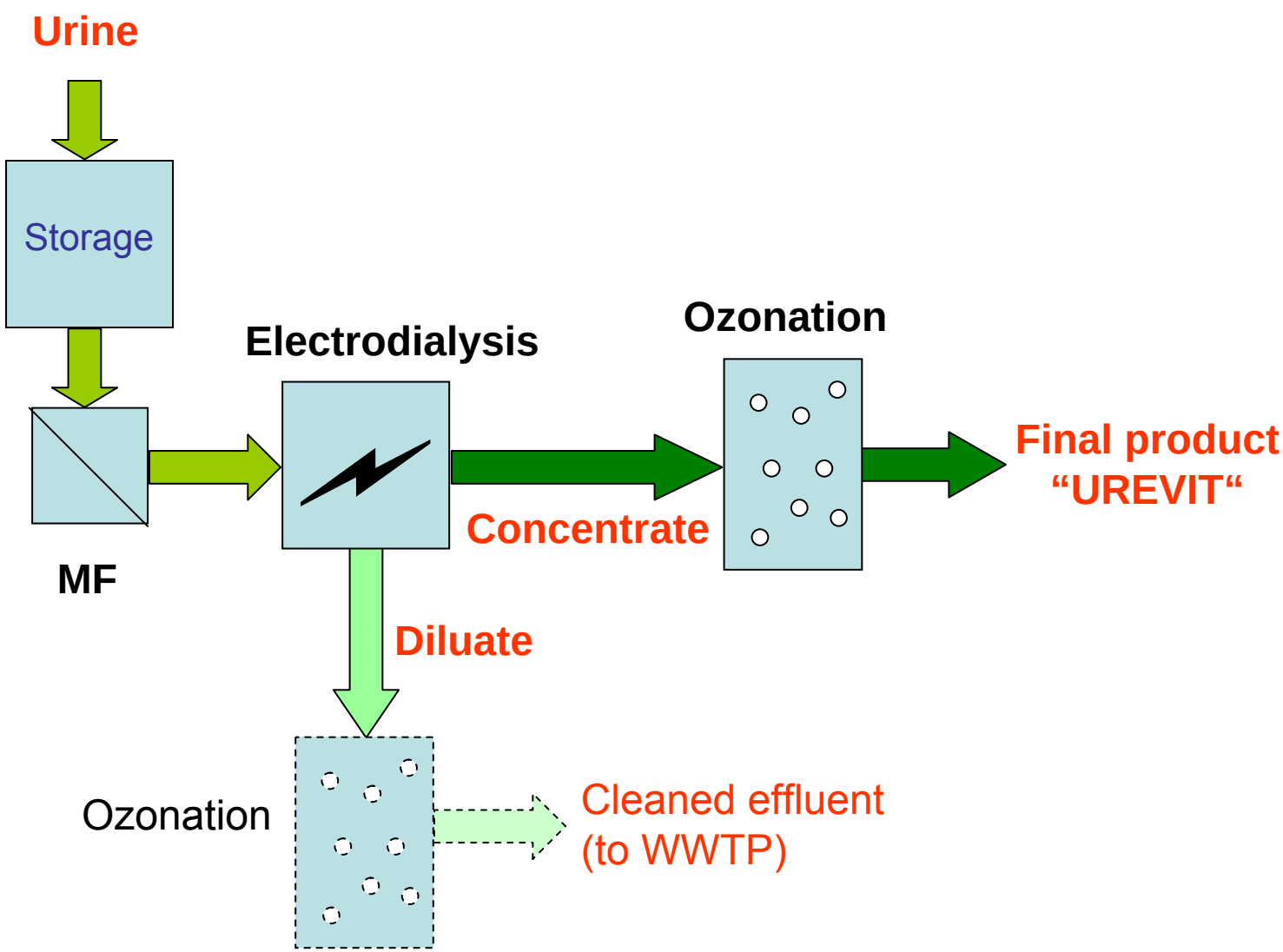
Parameters of the collected urine

- Weekly amount of collected urine approx. 90 litres
- Storage time approx. 4-5 months
- High turbidity
- Completely hydrolyzed (contains no urea)
- Content:

NH_4-N	PO_4-P	K^+	pH	Alkalinity
2.9 g/L	0.18 g/L	1.4 g/L	8.7	220 mM
Na^+	Cl^-	SO_4^{2-}	COD	DOC
1.6 g/L	3.0 g/L	0.7 g/L	3.6 g/L	1.5 g/L

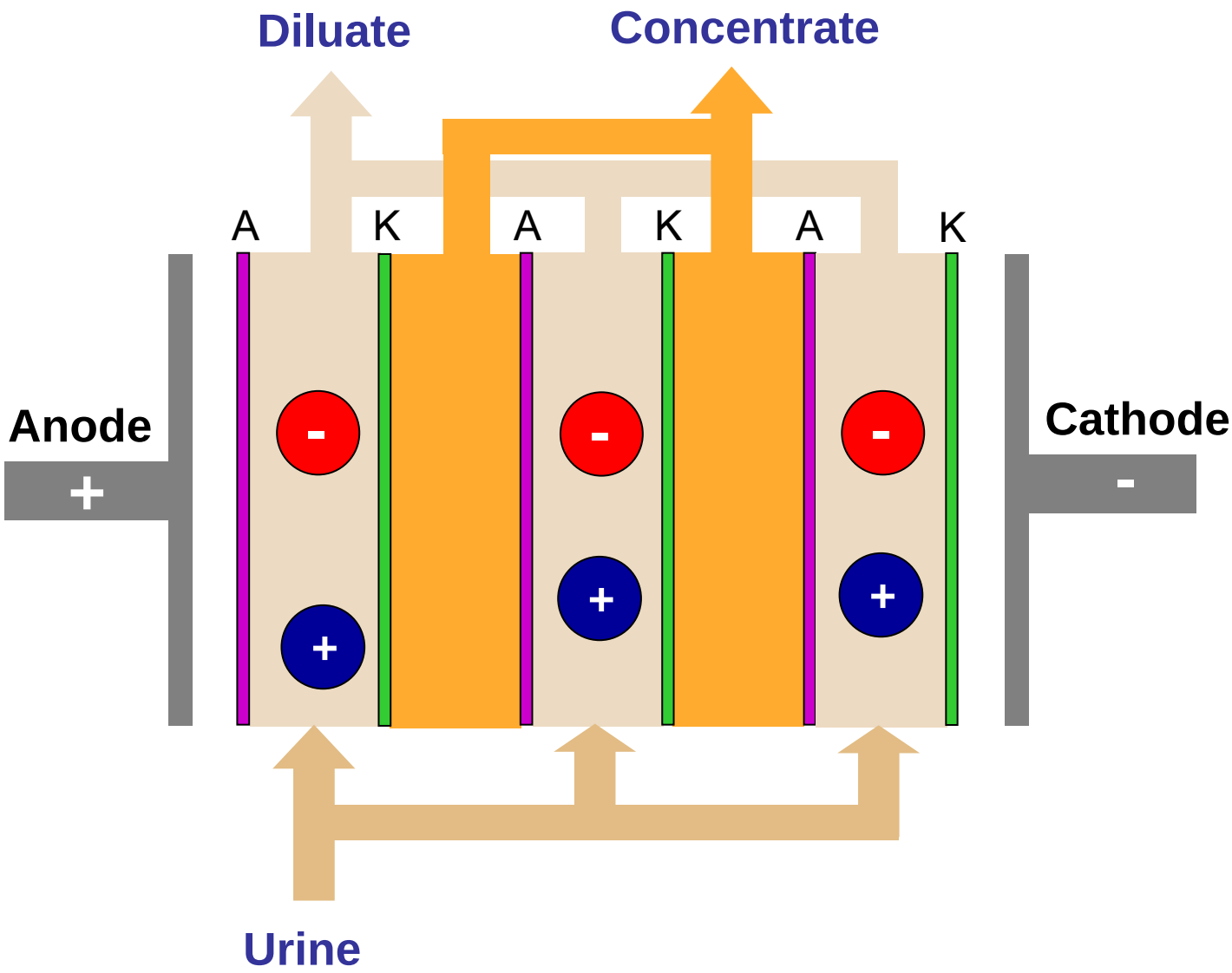
- Partially diluted, possibly due to actuation of the valve of the urine pipe during flushing the toilet

Treatment scheme



Pilot plant - Installation

Electrodialysis



Electrodialysis – Continuous experiments

Flow rate Feed	CF	Product loss	Cond Conc	Cond Diluate	Flow rate Conc	Flow rate Diluate
40 L/day	2.8	7.0 %	77 mS	2.9 mS	0.55 L/h	1.15 L/h
60 L/day	3.5	13.8 %	92 mS	3.5 mS	0.50 L/h	2.02 L/h

- Nutrient concentration in the product depending on feed flow rate
  - NH_4-N: 9.2 – 11.8 g/L
  - PO_4-P: 0.5 – 0.8 g/L
  - K: 4.5 – 7.7 g/L
- Stable operation during experimental periods
- Due to standstill periods some membrane fouling occurred

Ozonation

- Required ozone dose (lab experiments):
  - Concentrate: 2 – 2.5 g O_3/L
  - Diluate: 1.4 – 1.6 g O_3/L

- Foam formation
  - Feed turbidity ↔ bacterial growth
  - Related to EPS formation

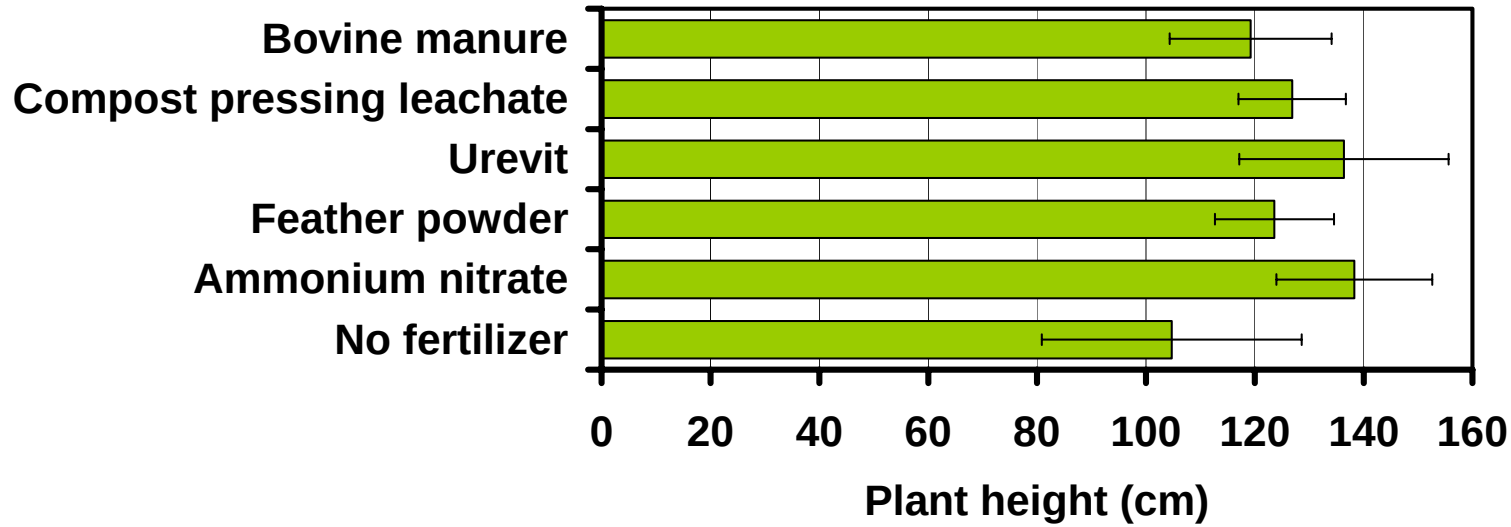
  - Foam control strategy:
    - Batch operation: Filtration (MF)
    - Continuous operation: Low residence times after ED

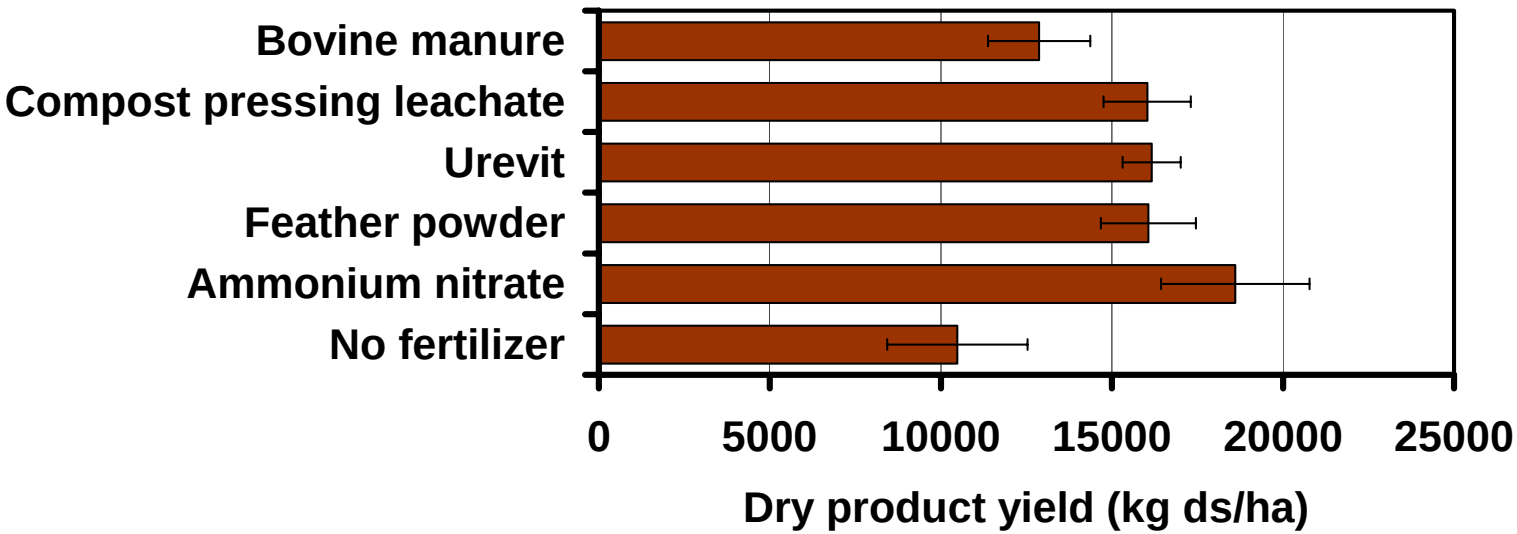
Registration of Urevit as a commercial fertilizer

- Strict regulations for new fertilizers in CH

- Large range of tests required
  - Micropollutants
  - Heavy metals
  - Hygienic factors
  - Field crop growth test

Field crop growth test





Removal of micropollutants

Analysis of single compounds

- Propranolol, Carbamazepine, Diclofenac, Ibuprofen, Ethinylestradiol as representative pharmaceuticals
- All compounds below detection limit in product
- E.g.: Ibuprofen removal:
  - detection limit = < 2 μg/L
  - influent concentration ca. 200 μg/L
  - > 99 % removal

Removal of micropollutants

Non-specific toxicity

- Bioluminiscence inhibition test
- Decrease during ozonation

Estrogenicity

Yeast Estrogenic Screening method (YES-test)

- Removal in ED: ca. 90 %
- After ozonation: Estrogenic activity in product below detection limit of < 2 ng/L (influent concentration ca. 600 ng/L)

Summary

- Stable operation of ED + O_3 during more than one year
- Membrane fouling was limited
- Microbial growth in ED product caused foaming problems during ozonation
- ED: a concentration factor of 3.5 can be achieved with a product loss of ca. 14 % at a feed flow rate of 60 L/d
- Micropollutants are effectively eliminated (below detection limit)
- Obtained product “Urevit” is an effective fertilizer
- Requirements for the registration have been fulfilled