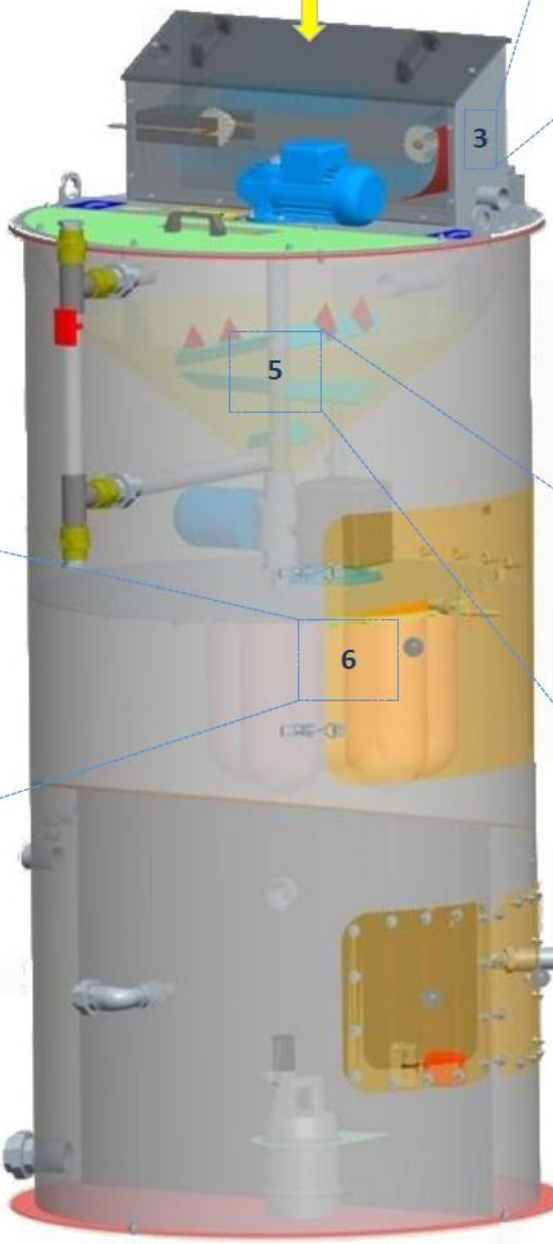
Magnesium-Ammonium-Phosphate (MAP) reactor

1 - NoMix toilet

2 - Urine tank

3 - Dosing unit



4 - Magnesium oxide

6 - Filter bags

5 - Precipitation tank (with stirrer)

7 - Struvite

SPONSORED BY THE

Federal Ministry of Education and Research

Magnesium-Ammonium-Phosphate (MAP) reactor

1 Process principle

Simplified equation: $NH_4^+ + Mg^{2+} + PO_4^{3-} \rightarrow MgNH_4PO_4$

Ammonium (NH_4^+):	Ammonium ion, available in excess in urine
Magnesium (Mg^{2+}):	Magnesium ion, develops in the reaction chamber of the added MgO (magnesium oxide)
Phosphate (PO_4^{3-}):	Phosphate ion, present dissolved in urine
MAP ($MgNH_4PO_4$):	Reaction product (also known as struvite)

2 Process technology

2.1 Removal of nutrients

P_{total} in influent:	180 mg/l (average)
P_{total} in effluent:	36 - 72 mg/l
P removal:	60 - 80 %
N_{total} in influent:	2700 mg/l
N_{total} in effluent:	540 – 1080 mg/l
N removal:	60 - 80 % (Probably mainly due to ventilation)

2.2 Cycle data and amount of urine

10 cycles per day	
Duration of one cycle:	135 min
Urine flow rate:	171 l/d
Per cycle:	40 l (theoretically possible: 50 l)
Amount treated:	400 l/d (theoretically possible: 500 l/d)
Usable urine storage:	7.5 m^3 (in 4 storage tanks)
Duration to process 7.5 m^3:	4 weeks if operating at 5 days per week and at full load

3 MAP recovery

MAP recovery:	
➢ with technical grade MgO	50 - 65 %
➢ with analytical grade MgO	90 - 95 % (only a few experiments in the laboratory)
Estimated recovery:	0.8 g MAP_{dried} / l urine
MAP production with technical MgO:	263 g MAP/d
	69 kg MAP/year

4 Operating costs

MgO bag:

- Total material costs: 0.31 €/bag
- Bag material: polyvinyl alcohol
- Bag content: 14 g MgO/bag (for cycle with 40 l urine)

Needle felt filter:

- Costs: 3 €/filter bag
- Life time: single use
- MAP loss: 37 - 12 % (remains in the filter)

Nylon filter (alternative option): (only a few experiments)

- Costs: 45 €/filter bag
- MAP loss: negligible loss

World market price MAP: approx. 300 €/t (conservative estimate)
Value of the produced MAP: 21 €/year

Theoretical costs (€) to fertilise 1 ha summer wheat for one year:[1]

Urine	MAP (Pilot plant)	NPK (Mineral fertiliser)
560	112,000,-	120

Reason for the high MAP costs:
1) at the moment there is a lot of manual labour necessary to produce MAP
2) MAP reactor was a new development, therefore very high investments cost

5 Field tests near Bonn

Soil: Supply level C (nutrient-rich soil)
Fertiliser: 100 - 140 kg N/ha for summer wheat, 40 kg N/ha for miscanthus
Urine application: 3-4 l/m² or 30-40 m³/ha (see table)

Date comparison:

	Data from Bonn	Technology Review [2]
N concentration in urine (gN/l)	2.3 – 3.9	maximum 7
Amount per area (l/m²)	3 – 4	1.5
N content per area (kgN/ha)	70 – 100	maximum 105

[1] Braum, C. (2011). Economical feasibility of using urine versus struvite as fertilizer. Using the example of GIZ in Eschborn. Bachelor thesis. Institute of Soil Sciences and Soil Conservation, Justus Liebig University Gießen, Germany
http://www.saniresch.de/images/stories/downloads/Bachelor%20Thesis%20Christina%20Braum.pdf

[2] von Muench, E., Winker, M. (2011). Technology review of urine diversion components - Overview on urine diversion components such as waterless urinals, urine diversion toilets, urine storage and reuse systems. Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH, Eschborn, Germany.
http://www.susana.org/lang-en/library?view=ccbktypeitem&type=2&id=875

6 Project partners (all in Germany)

HUBER SE
Industriepark Erasbach A1
92334 Berching

THM University of Applied Sciences
Wiesenstraße 14
35390 Gießen

University Bonn
INRES - Department of Plant Nutrition
Karlrobert-Kreiten-Strasse 13
53115 Bonn

RWTH Aachen
Institute for Environmental Engineering (ISA)
Institute of Sociology (IfS)
52056 Aachen

Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH
Sustainable sanitation – ecosan program
Dag-Hammarskjöld-Weg 1-5
65760 Eschborn

Roediger Vacuum GmbH
Kinzigheimer Weg 104-106
63450 Hanau

7 Contact

Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH
Sustainable sanitation – ecosan program
Dag-Hammarskjöld-Weg 1-5
65760 Eschborn, Germany

Contact person:
Dr.-Ing. Martina Winker
Email: martina.winker@giz.de / saniresch@giz.de
Tel: 49 (0)6196 79 3298

Authors:
Martina Winker, Amel Saadoun
(GIZ, Sustainable sanitation – ecosan program)