gtz Partner für Perspektiven. Weltweit.

Two years of experiences from a urine diversion project

in gtz Headquarters, Eschborn, Germany

Steffen Blume (gtz – ecosan)

www.gtz.de/ecosan

partner of sustainable sanitation alliance

HESSEN

gtz ecosan program recycling oriented wastewater management and sanitation systems

commissioned by Federal Ministry for Economic Cooperation and Development

GTZ main building in Eschborn

- **main building was renovated between 2004 and 2006**
- **provides office facilities for 650 employees, canteen, meeting and conference rooms**
- **opportunity to introduce a high-comfort urban ecosan system**

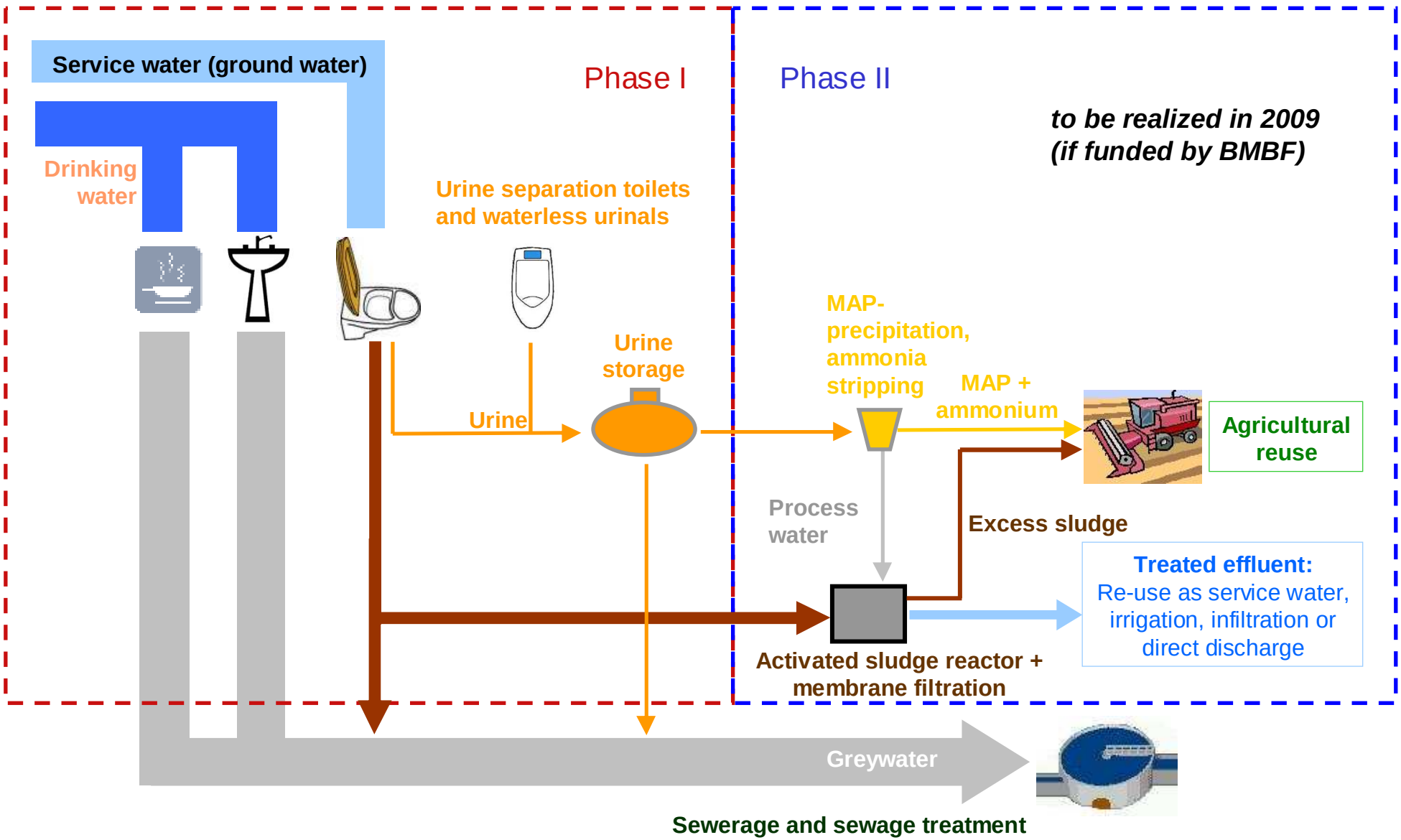
source: GTZ

GTZ main office building under construction (GTZ)

source: (ttsp-HWP-Seidel

New design of the GTZ main building

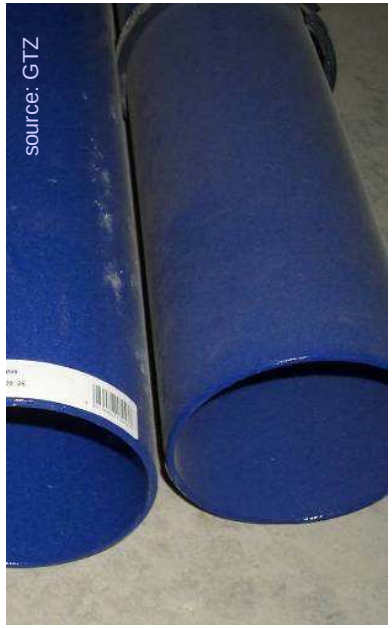
Ecosan concept (only Phase I realized)



Technical components installed

42 low flush urine separation toilets (1 L per urine flush, 6 L per faeces flush)

25 waterless urinals (Keramag - Centaurus)



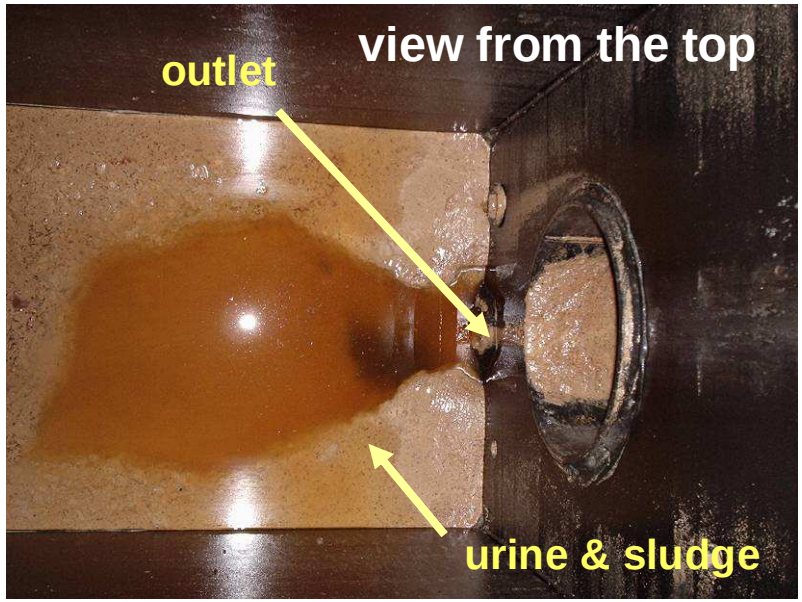
urine pipes 50, 80 and 100 mm made of cast iron with an enamel coating

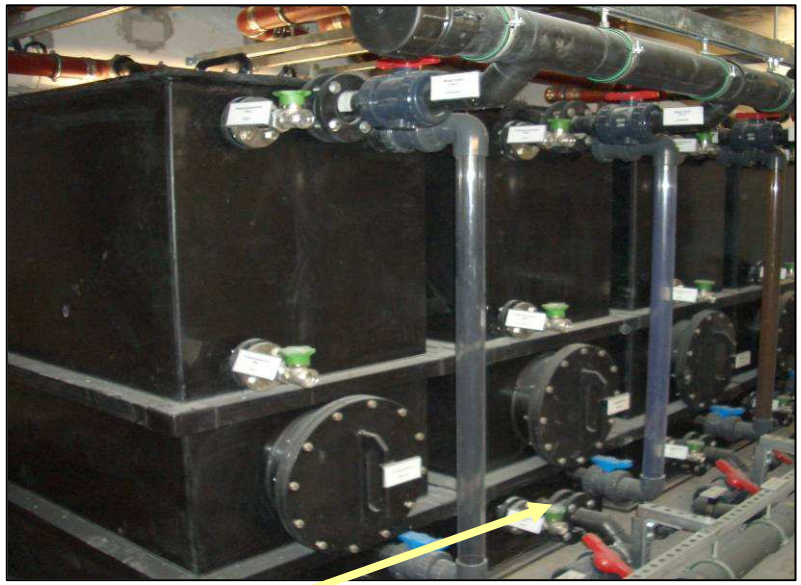
urine storage tanks (4 x 2500 L)

docking station for vacuum tanker

Urine production and uses

- **approx. 110 L urine per day**
  → approx. 90 days filling time
- **emptying can be by vacuum tanker**
- **precipitation inside of storage tank**
- **precipitation tests at Uni RWTH Aachen and treatment tests at Uni Gießen**





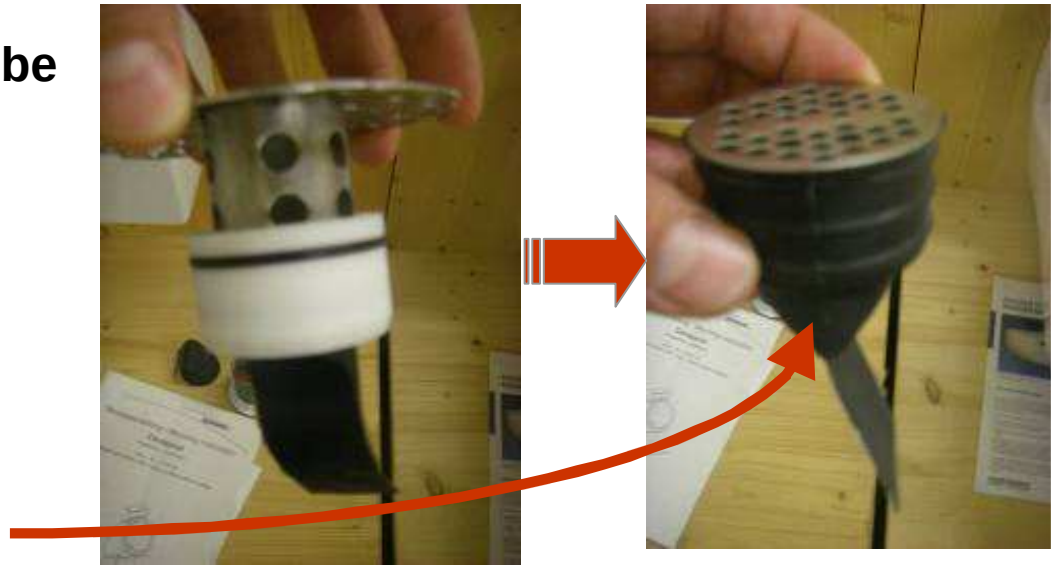
gtz Partner für Perspektiven. Weltweit.

Problems with the waterless urinals

- **if maintenance neglected: precipitations on rubber tube odour seal (not closing properly anymore)**
- **leakage of the drainage cylinder due to small vertical downwards movements of urinal on wall**
- **some pubic hairs in the urinal sticking to surface**

…and how we solved them

- **daily cleaning of urinals and of rubber tube seal**
- **exchange of the rubber tube seal after about 6 months**
- **micro-biological cleaning agent**
- **fresh air circulator**
- **2nd version of rubber tube odour seal**



Problems with the toilets

- **toilet paper or faeces do not always get flushed away with one flush**
- **some females do not sit down on public toilets → their urine not collected**
- **toilet maintenance neglected → urines valves clog due to precipitation (31 toilets showed this problem in Aug. 08) → urine flows away with flush water**

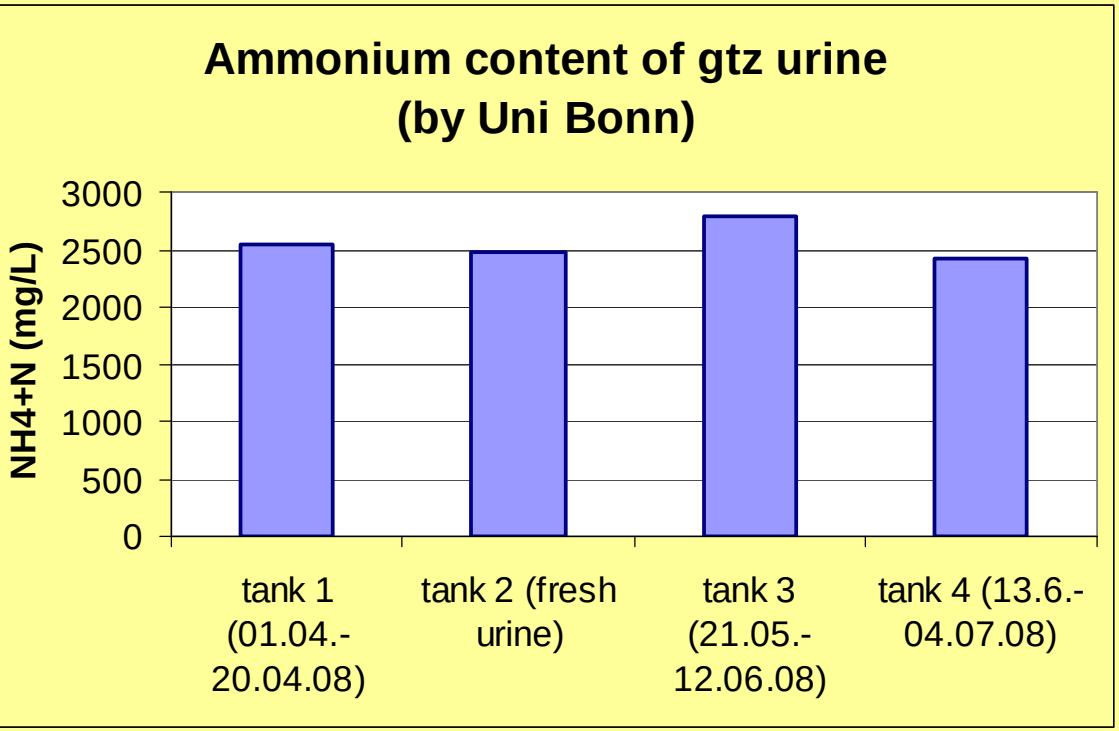
…and how we solved (or will solve) them

- **in future: toilet seat covers for the ladies room, or disinfection spray in the cubicles**
- **“coffee test” to regularly check if urine valve is opening properly or not**
- **acid cleaning agent to dissolve precipitation on urine valve → contact time over night**
- **more collaboration with toilet maintenance crew**
- **user information poster in cubicles**

gtz Partner für Perspektiven. Weltweit.

Problems with low ammonium content in urine (one third of expected)

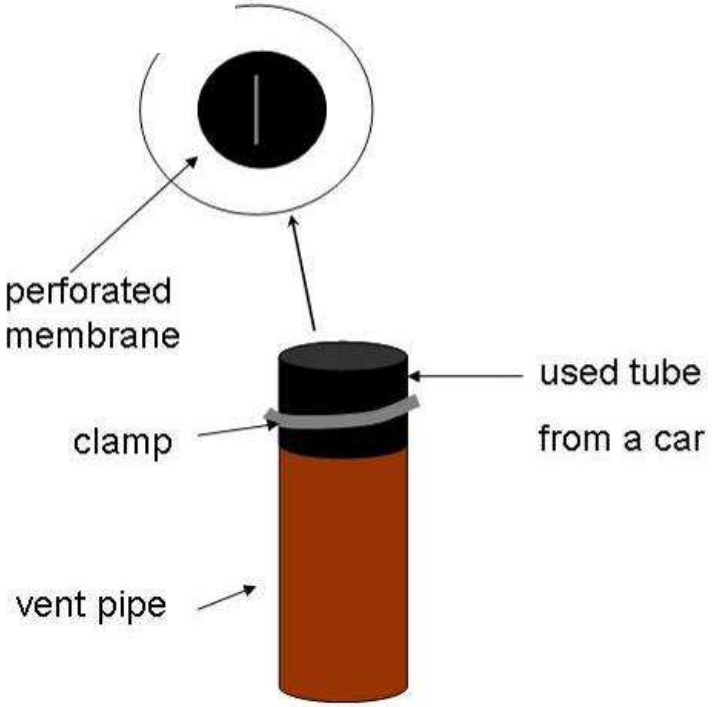
- **ammonium content ca. 2800 mg/L**
- **literature value stored undiluted urine: 7000 - 9000 mg/L**



Vent pipe

…and how to reduce ammonium stripping

- **reduce the ventilation**
  - **cover the ventilation pipe from the urine storage tank on the roof**



other possible reasons for low ammonium content

- **no high concentrated morning urine**
- **diluted with flush water if user flushes toilet while sitting down**

Software and promotion

- **user information on the toilets**
- **ecosan Information Poster at the canteen**
- **guided tours to the urine storage and show room**
- **demonstration garden**
- **promotion event on the world water day**
- **online survey**

Demonstration garden

- **application of urine to: tomato, lettuce, basilica, paprika, roses**
- **clearly shows the benefit of using urine as a fertilizer**
- **people can see and understand**
- **fruits can be eaten - and taste even better (?!)**
- **change from the “toilet guys” to the “tomato guys”**

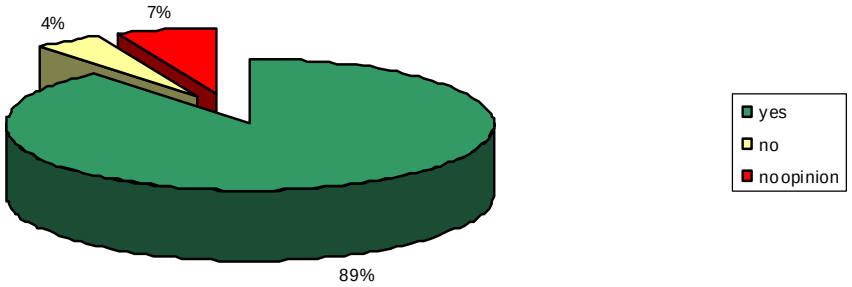
Tours and “show room”

- **regular tours for visitors and student groups**
- **show room of different technologies**

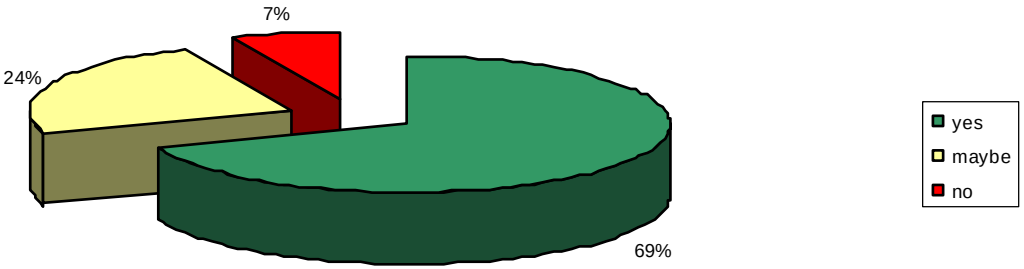
Online survey from 1 Sept. 2008

- **182 participants (gtz employees)**
- **majority (89%) think the separate collection of urine and usage as fertilizer is a good idea**
- **majority (69%) would buy fruits which are fertilized with urine**
- **44% think it should be allowed to use urine as a fertilizer for organic farming**

Do think the separate collection of urine and usage as fertilizer is a good idea?



Would you buy fruits which are fertized with urine following the WHO guidelines for the safe use of urine in agriculture?



Feedback from the survey

- ***"…the approach is good, but the technical realization of the toilets could be done better"***
- ***"…solid matters stick in the toilet!"***
- ***"…I fear that hormones and drugs end up into the plants"***
- ***"…is water saving in Germany really necessary?"***
- ***"…gtz is probably the only company which asks their employees about their sanitation habits."***

Conclusions

1. possible to implement urine diversion systems in an urban office building in Germany

2. people accept waterless urinals and new toilet designs, and the idea of using urine as fertilizer

3. room for improvement of design of UD flush toilets (valve and bowl design; ventilation system)

4. urine-fertilized tomato plants have sparked even more interest from gtz colleagues than the UD toilets! (→ mainstreaming ecosan in gtz)

Planned future work

- **More promotion and awareness raising: posters in toilets, FAQs on website, more user online surveys and feedback**
- **Investigating use of different systems (UD toilet without flush water ?)**
- **More lobby work to get funding for Phase 2 off the ground (reuse of urine in agriculture)**
- **Promoting installation of waterless urinals in gtz offices around the world**

for further information:
www.gtz.de/ecosan and
www.susana.org

Appendix

Appendix – water saving

Berechung der gesparten Wassermengen in Haus1

		ecosan System	konventionell	Ersparnis
Anzahl der Urinalbenutzung pro Tag		4,0	4,0	
Spülwassermenge Urinale	Liter [l]	0	3	
Handwaschmenge	Liter [l]			
männliche Nutzer (Mitarbeiter-+ Gäste)	[n]	80	80	
männliche Nutzer (Gäste)		0	0	
Mitarbeiterarbeitstage pro Jahr	d/a	250	250	
Summe	kbm/a	0	240	240
Anzahl der Toilettengänge pro Tag (urinieren) Frauen		4,0	4,0	
Spülwassermenge	Liter [l]	1	8	
weibliche Nutzerinnen (Mitarbeiterin)		80	80	
weibliche Nutzerinnen (Gäste)		0	0	
Mitarbeiterarbeitstage pro Jahr	d/a	250	250	
Summe	kbm/a	80	640	560
Anzahl der Toilettengänge pro Tag (defäkieren) Männer		1	1	
Toilettenspülwassermenge	l	6	8	
männliche Nutzer (Mitarbeiter-+ Gäste)	[n]	80	80	
männliche Nutzer (Gäste)		0	0	
Mitarbeiterarbeitstage pro Jahr	d/a	250	250	
Summe	kbm/a	120	160	40
Anzahl der Toilettengänge pro Tag (defäkieren) Frauen		1	1	
Toilettenspülwassermenge	l	6	8	
weibliche Nutzerinnen (Mitarbeiterin)		80	80	
weibliche Nutzerinnen (Gäste)		0	0	
Mitarbeiterarbeitstage pro Jahr	d/a	250	250	
Summe	kbm/a	120	160	40
Summe alle	kbm/a			880
	l/d			**3.520**
	l/(d*Pers)			22

Appendix - costs of the system

	Conventional system (€)	GTZ building prototype (€)	ecosan large-scale (€)
Sanitary infrastructure			
Conventional urinals	10.000	-	-
Waterless urinals		10.000	10.000
Conventional toilets	15.000	-	-
UD toilets		76.000	25.000
Blackwater pipe system	35.000	-	-
Urine pipe system	-	33.000	20.000
Brownwater pipe system	-	35.000	20.000
Greywater pipe system	-	20.000	20.000
Urine collection tank + pumps	-	45.000	20.000
Subtotal Sanitary Infrastructure	**60.000**	**219.000**	**115.000**
Treatment infrastructure			
Urine treatment	-	45.000	20.000
Brownwater treatment	-	60.000	30.000
Greywater treatment	-	-	30.000
Sewerage network (proportionately)	450.000	450.000	
Sewage treatment (proportionately)	45.000	23.000	-
Subtotal Treatment	**495.000**	**578.000**	**80.000**
Total	**555.000**	**797.000**	**195.000**
Difference (compared to conventional scenario)	**+ 0**	**+ 242.000**	**-360.000**

source: GTZ

Appendix - costs of the system

	Conventional system (€/year)	GTZ building prototype (€/year)	ecosan large-scale (€/year)
Water supply			
urinals	1100	0	0
toilets	4800	0	0
kitchenettes, sanitary sinks	1600	1600	1600
Wastewater fees	7500	1600	0
Onsite treatment + transport			
yellowwater	0	5000	2500
brownwater	0	7000	3500
greywater	0	0	3000
Income from products			
fertilizer value of urine and sludge	0	not considered	not considered
Total	**15000**	**15200**	**10600**
Difference (compared to conventional	**0**	**200**	**-4400**

source: GTZ

Appendix

ammonium concentrations

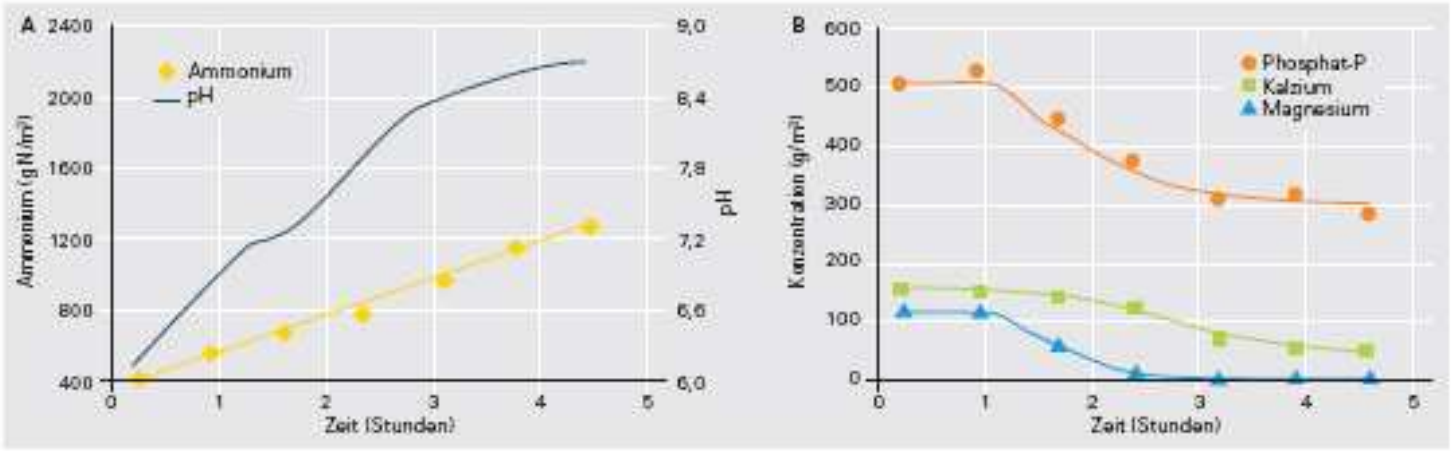
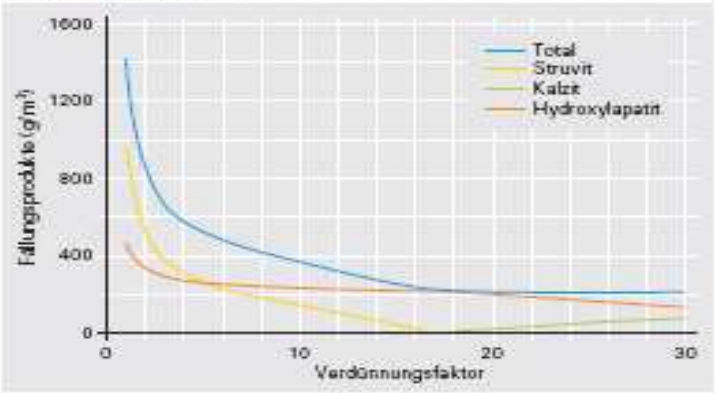


Abb. 1: Als Folge der Harnstoffhydrolyse im Urin steigen die Ammoniumkonzentration und der pH an (A), wogegen die Kalzium-, Magnesium- und Phosphatkonzentrationen im Urin abnehmen.

precipitation

Abb. 2: Die Ausfällung von Struvit, Hydroxylapatit und Kalzit ist abhängig von der Verdünnung des Urins.



Appendix

content of urine

Tab. 1: Chemische Zusammensetzung von gesammeltem, gelagertem Urin aus einem Haushalt mit gespülten Trenn-WCs [2] und dem Eawag-Bürogebäude mit wasserlosen Urinalen [3] im Vergleich zu frischem Urin [4]. CSB = Chemischer Sauerstoffbedarf, ein Mass für die organischen Bestandteile.

	Gelagerter Urin		Frischer Urin
	mit Spülwasser Haushalt	ohne Spülwasser, Bürogebäude	unverdünnt Literaturdaten
Verdünnung $V_{Urin}/(V_{Urin}+V_{Wasser})$	0,33	1	1
pH	9,0	9,1	6,2
N_{Gesamt} [g/m³]	1795	9200	8830
$NH_4^+ + NH_3$ [g N/m³]	1691	8100	463
$NO_3^- + NO_2^-$ [g N/m³]	0,06	0	–
P_{Gesamt} [g/m³]	210	540	800–2000
CSB [g O_2/m³]	–	10000	–
K [g/m3]	875	2200	2737
Na [g/m³]	882	2600	3450
Cl [g/m³]	2500	3800	4970
Ca [g/m³]	15,75	0	233
Mg [g/m³]	1,63	0	119

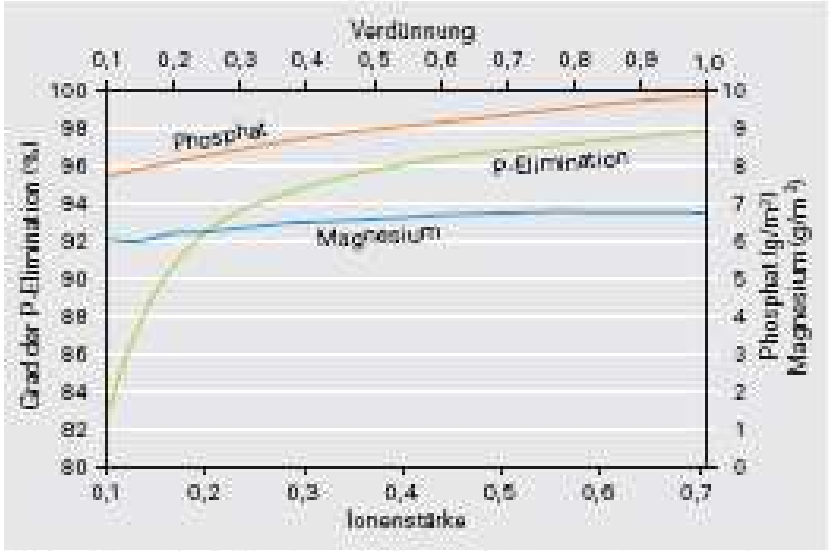
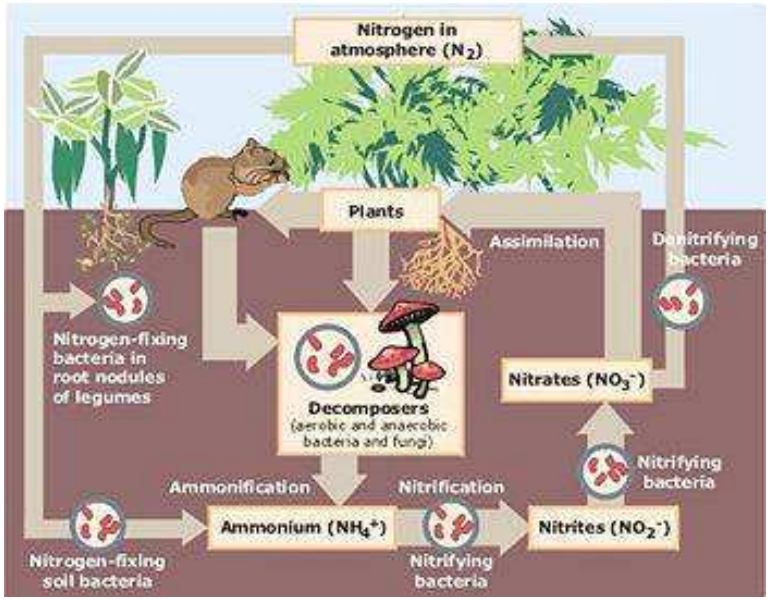


Abb. 1: Die gelösten Phosphat- und Magnesiumkonzentrationen nach der Struvit-Fällung sind abhängig von der Verdünnung des Urins mit Spülwasser (1 = unverdünnt, 0,1 = 10-fach verdünnt). Ausgangskonzentrationen der Nährstoffe im unverdünnten Urin: Phosphat = 440 g P/m³; Ammonium = 7850 g N/m³. Zugabe einer equimolaren Menge von Magnesiumchlorid (bezogen auf Phosphat).

Appendix

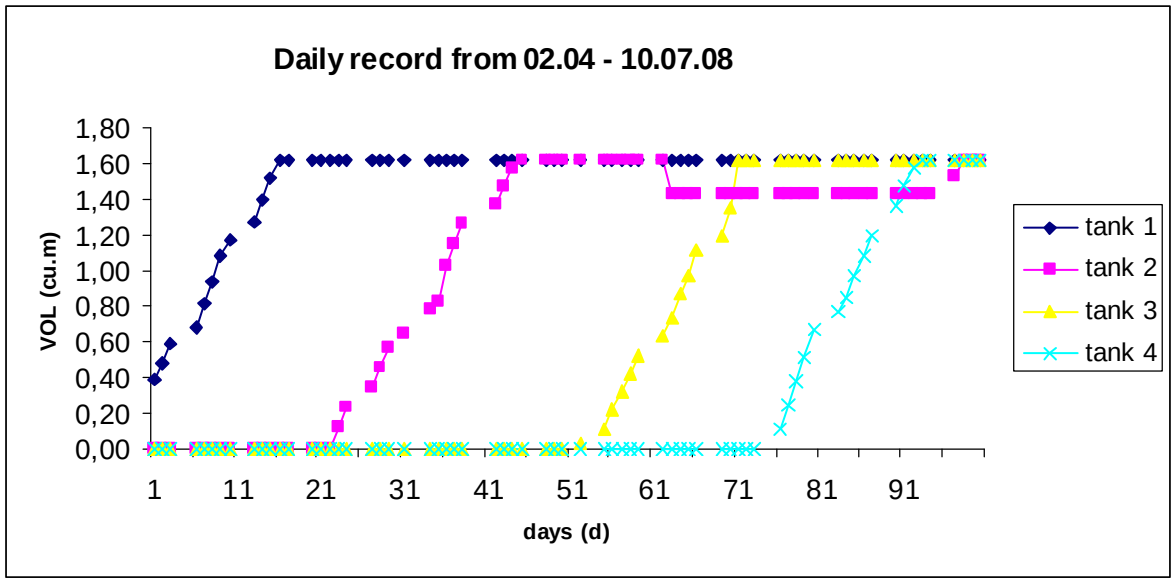
Nitrification is the biological oxidation of ammonia with oxygen into nitrite followed by the oxidation of these nitrites into nitrates. Degradation of ammonia to nitrite is usually the rate limiting step of nitrification. Nitrification is an important step in the nitrogen cycle in soil. This process was discovered by the Russian microbiologist, Sergei Winogradsky.



Chemistry

- Nitrification is a process of nitrogen compound oxidation (effectively, loss of electrons from the nitrogen atom to the oxygen atoms) :
- NH3 + CO2 + 1.5 O2 + Nitrosomonas → NO2- + H2O + H+
- NO2- + CO2 + 0.5 O2 + Nitrobacter → NO3-
- NH3 + O2 → NO2− + 3H+ + 2e−
- NO2− + H2O → NO3− + 2H+ + 2e−

[http://en.wikipedia.org/wiki/Nitrification]


Daily record from 02.04 - 10.07.08
VOL (cu.m)
1,80
1,60
1,40
1,20
1,00
0,80
0,60
0,40
0,20
0,00
1
11
21
31
41
51
61
71
81
91
days (d)
tank 1
tank 2
tank 3
tank 4