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Fertiliser products generated within new sanitation systems

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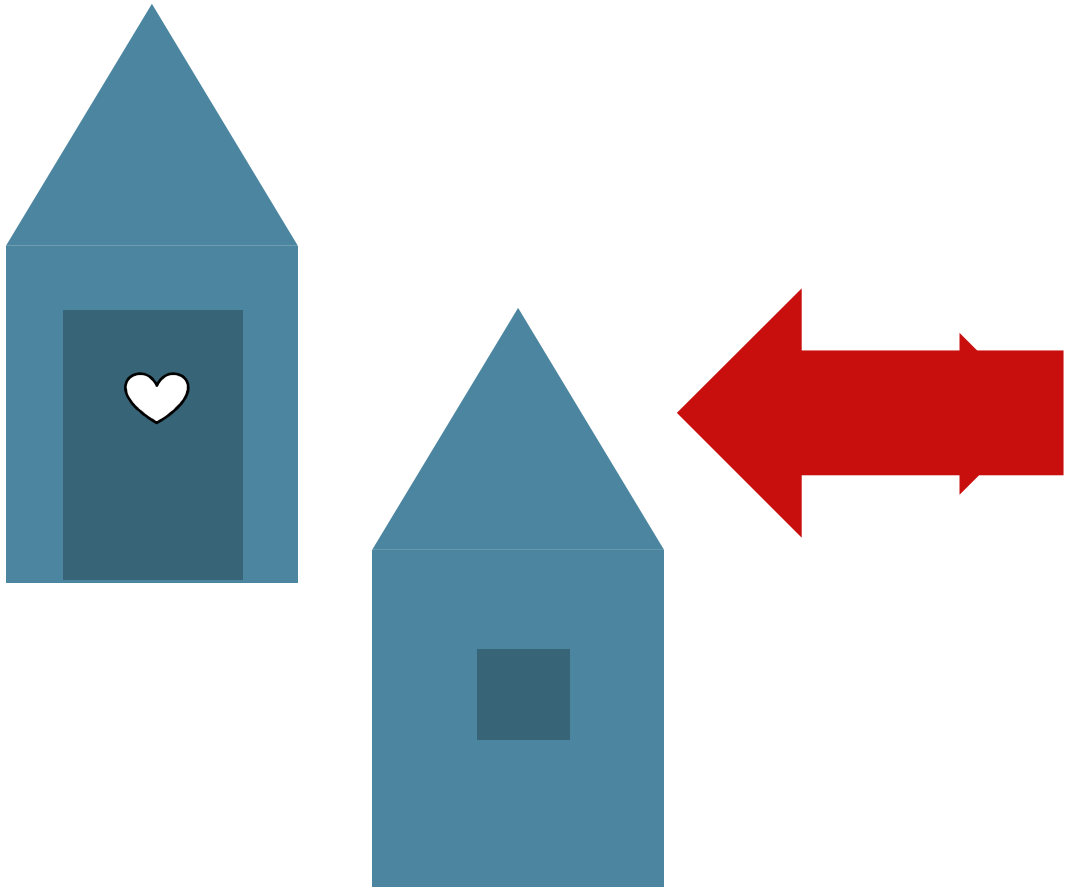
Introduction

- Loss of consumed nutrients
- Potential of source separated nutrient streams
- Raising energy and fertiliser prices

- Source: *Winker et al. (2009), Bioresource Technology 100, pp. 4090-4096*

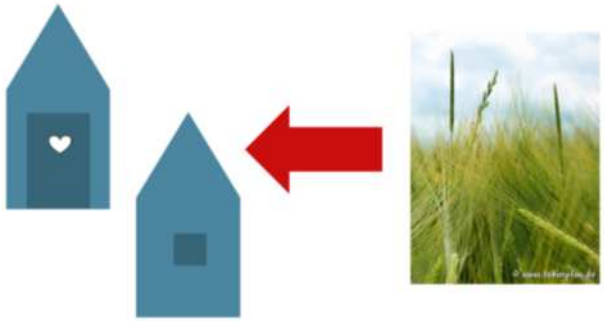
Change of perspective



Change of perspective

Matching of capabilities of existing fertiliser application technologies:

- 10 - 50 m^3 ha^{-1} – liquid fertilisers
- ≤ 40 t DM ha^{-1} – solid fertilisers
- 100 - 600 kg ha^{-1} – granulates



Properties of products

Fertilising type (FT)	Product	Level of knowledge	TS [%]	COD [g l^{-1}]	N [g l^{-1}]	P [g l^{-1}]	K [g l^{-1}]	Reference
Liquid mineral	Urine	+	1.5-3	4-11	1.8-17.5	0.2-3.7	0.7-3.3	Meinzinger and Oldenburg, 2008
	Concentrated urine e.g. Urevit	(+)		10	11	0.65	5.7	Boller, 2007
	Ammonia solution	(+)			120	n.r.	n.r.	Tettenborn et al., 2007
Liquid organic mineral	Digestate	-	≤ 1	2.8	1.5	-	0.14	Wendland, 2008
	Untreated sludge blackwater	-						
Solid mineral	Struvite	(+)			60	130	n.r.	Calculated stochiometrically
Solid organic	Compost	-		100	5-20	2-4	3-10	Simons et al. (2005)
Solid organic mineral	Sludge with DM >20 %	-						

Urine

- High concentrations of N and P as well as other nutrients
- Low ammonia emission
- Comparable to liquid manure after field application
- Multi-component fertiliser


Winker, 2007


Vinnerås

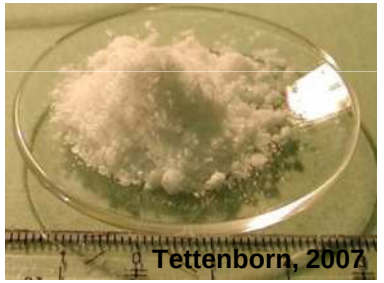

Muskolus, 2006

Urine's fertiliser products

- Mostly derived in high-tech solutions
- Achieved through a combination of various treatment steps
- Limiting factor in production: energy costs
- Different plant availability of different MAP products according to specific crop (Simons, 2008)

Potassium Ammonium Phosphate

Stercorit



Blackwater

- Multi-component fertilisers with large amounts of carbon
- Dilution due to flush water
- Overall, collection of a larger fraction possible
- Treatment is required for stabilisation and sanitisation

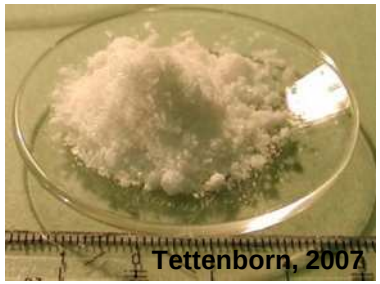

Muskolus

Alp, 2008

Blackwater's fertiliser products

- Anaerobic treatment
  - reduction of carbon content
  - addition of organic matter
- Minor loss of N and S
- MAP precipitation after anaeorbic step
- Sanitisation via ammonia addition


Kujawa-Roeleveld, 2008


Tettenborn, 2007

Alp, 2008

Faecal matter

- Collection of faecal matter: not widely implemented in Europe
- Stabilisation & sanitisation required
- Nutrient concentration comparable to urine – much lower volume
- Lower nutrient availability – organic bounds


Muskolus


Wirseen et al., 2009


Muskolus

Faecal matter's fertiliser products

- Main product: solid compost or vermicompost
- Toilet additives influence quality & quantity
- Lower nutrient content and availability (especially N)
- Soil conditioner


Muskolus

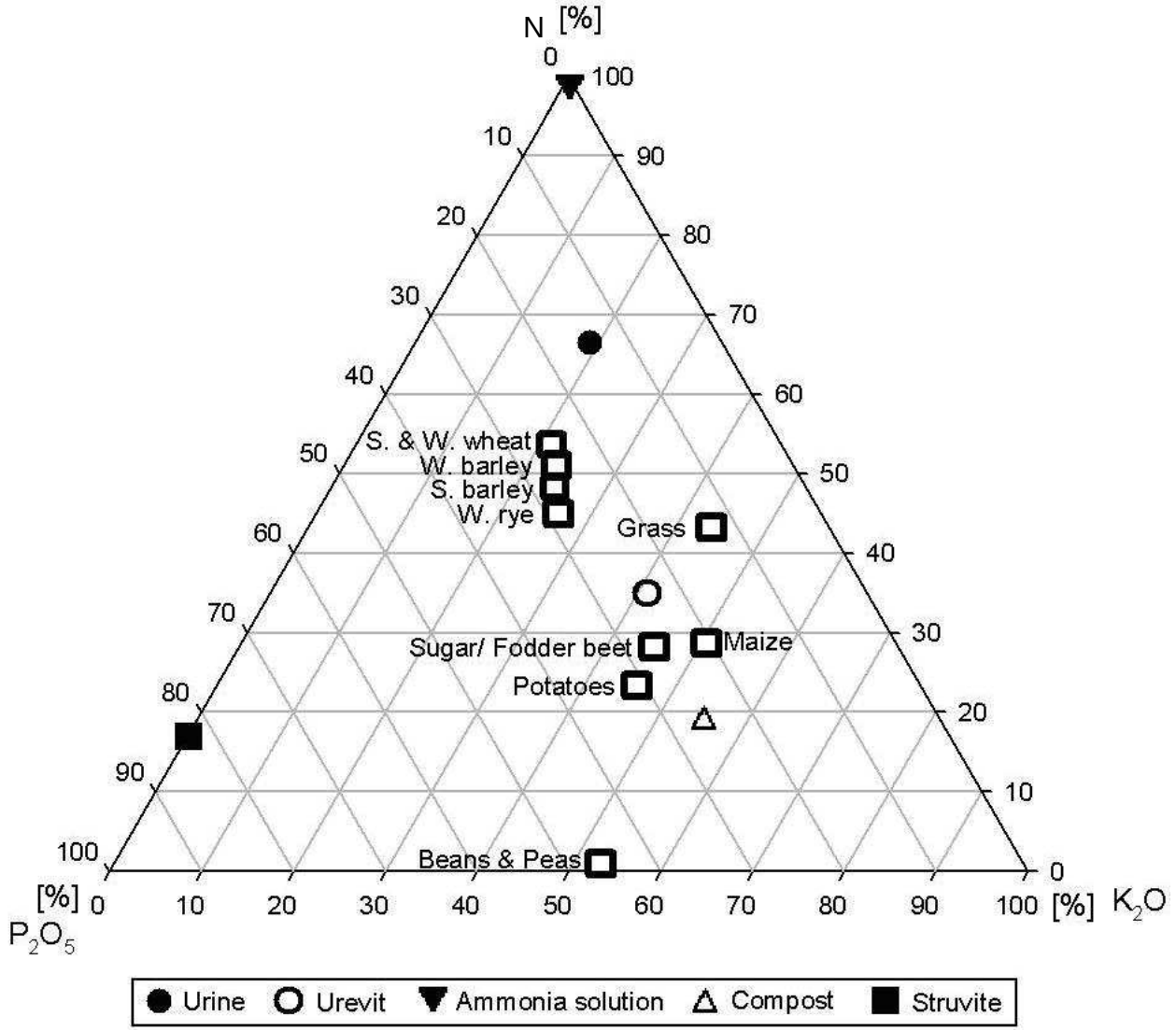

Wirseen et al., 2009


Muskolus

Other products

- Sludge with DM >20%
- Mainly sediments generated during collection and treatment
- Low level of knowledge
- Can contain larger nutrient fractions

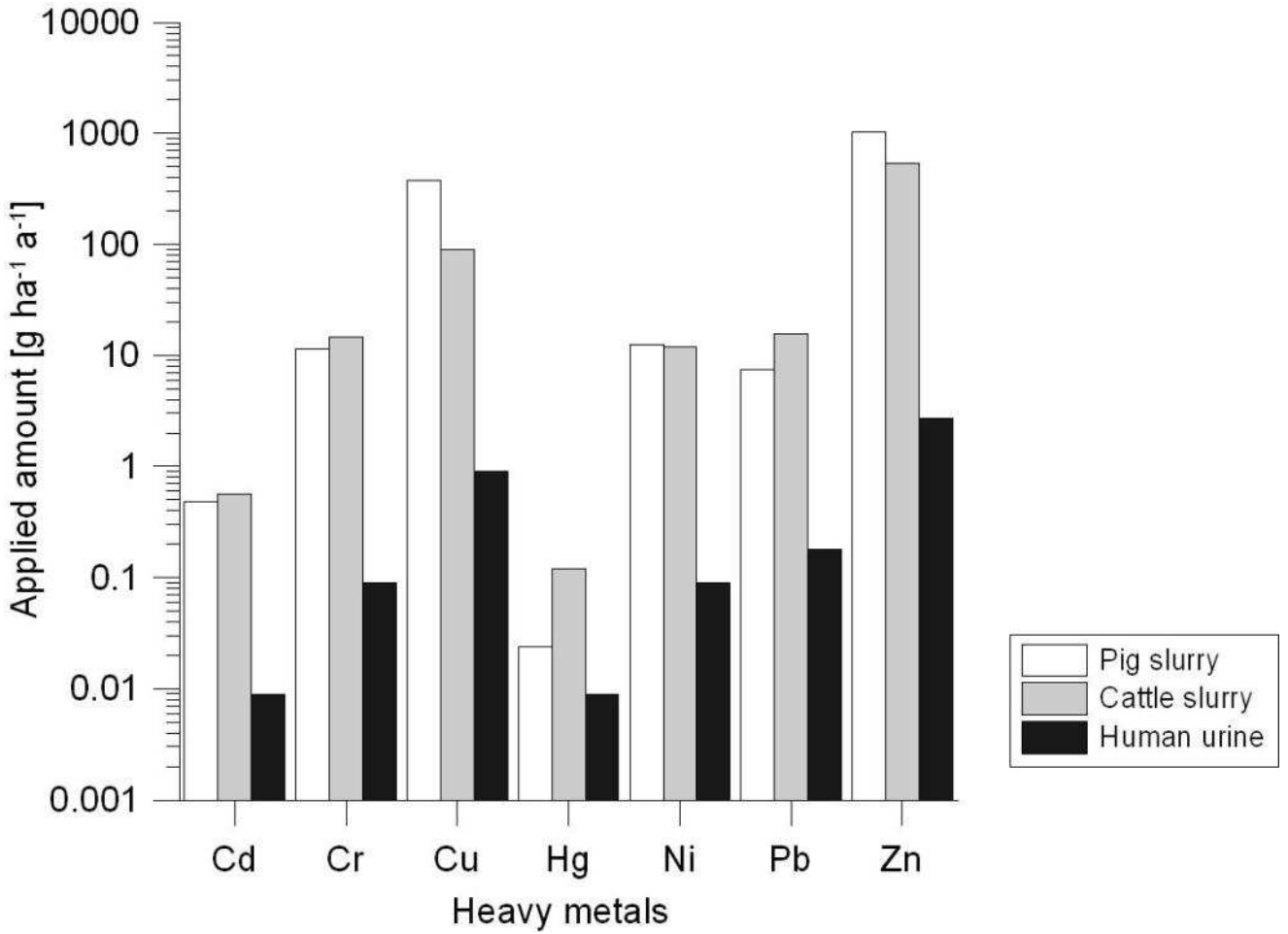
Nutrient compositions and crop requirements



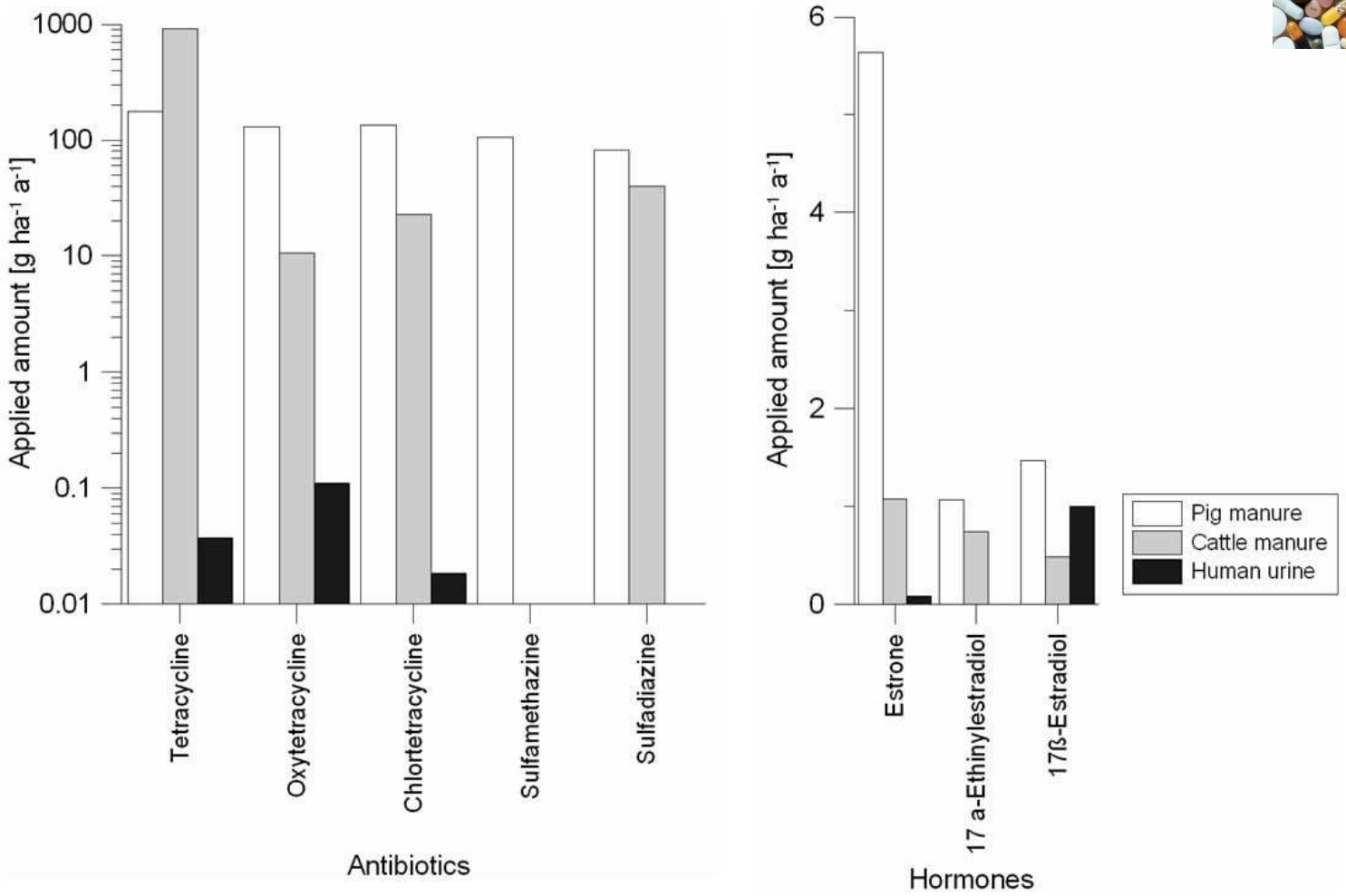
Expected nutrient availability

Fertilising type (FT)	Expected availability [%] N (in year of application)	P (3 year crop rotation)	K (3 year crop rotation)
Liquid mineral	100	100	100
Liquid organic mineral	$N_{mineral}$ + approx. 10 % of $N_{organic}$	100	100
Solid mineral	100	100	100
Solid organic	<10	100	100
Solid organic mineral	$N_{mineral}$ + approx. 10 % of $N_{organic}$	100	100

Heavy metals



Micropollutants



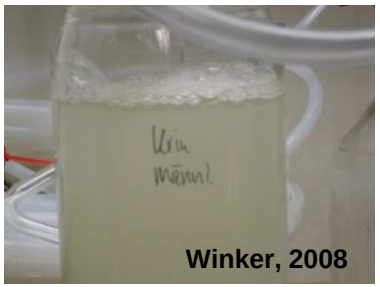
Micropollutants

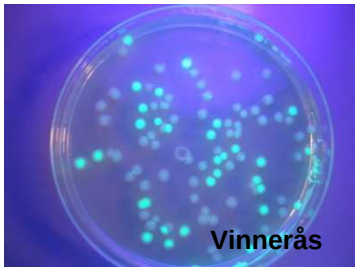
- All wastewater streams can contain pharmaceutical residues
- Storage is not sufficient for complete elimination
- Treatment is required
- Precipitation seems to be promising
- By-products & metabolites


Tettenborn, 2007

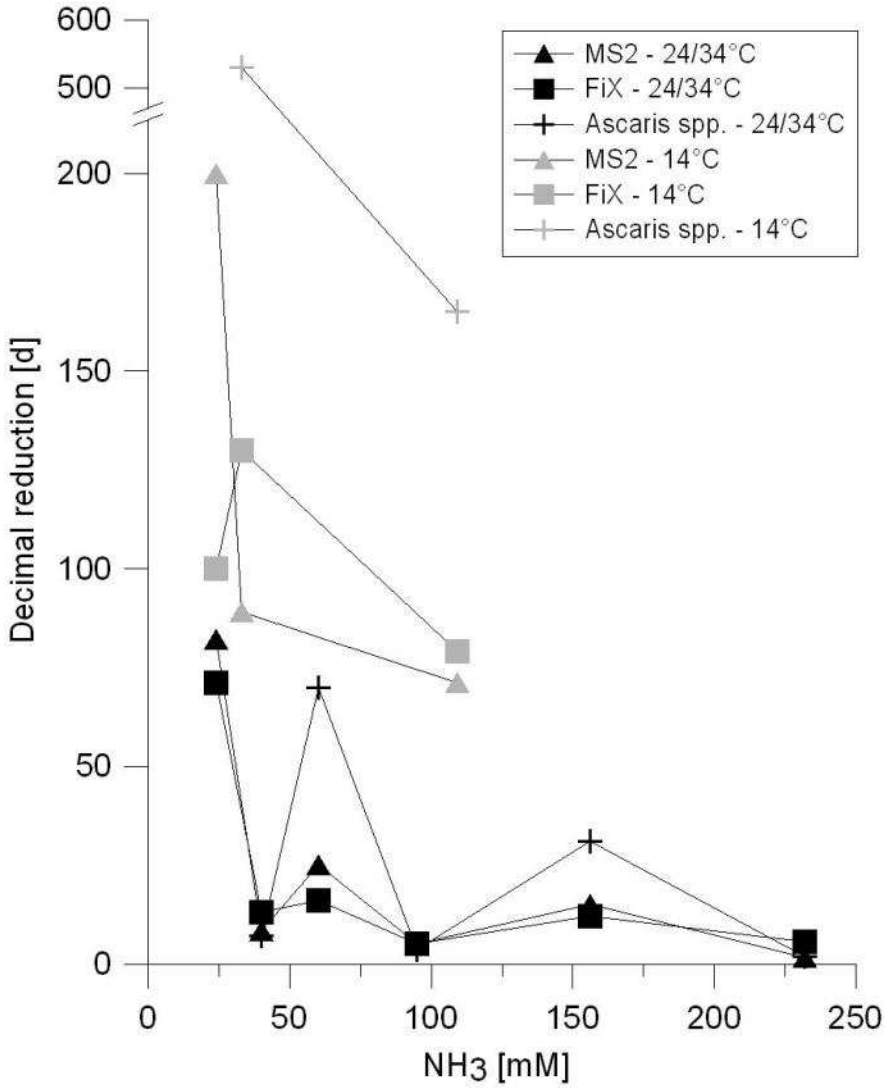

GTZ


Tettenborn, 2007


Winker, 2008

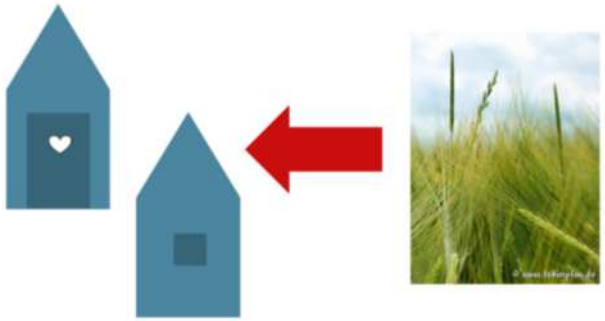

Vinnerås

Pathogens


MS2 - 24/34°C
FiX - 24/34°C
Ascaris spp. - 24/34°C
MS2 - 14°C
FiX - 14°C
Ascaris spp. - 14°C
Decimal reduction [d]
600
500
200
150
100
50
0
0
50
100
150
200
250
NH3 [mM]

Conclusion

- Products show promising results
- Treatment needs to be adopted according to the desired fertiliser
- Products have to remain in the range of available application techniques



THANK YOU!

Substance	Soil type	Min	C_P	Max	SD	CI 95% (%)	N°. of DS
Chlorotetracycline	agricultural land	0.5	6.7	13.6	4.0	14	23
Ciprofloxacin	agricultural land	57.5	98.0	157.5	39.5	12	6
Norfloxacin	agricultural land	5.5	106.1	200.0	55.3	15	6
Oxytetracycline	agricultural land	0.5	0.6	2.5	0.6	57	3
Oxytetracycline	clay loam	3.8	116.3	430.0	123.5	28	19
Oxytetracycline	sandy loam	25.0	109.2	526.0	156.8	41	12
Sulfamethazine	agricultural land	15.0	116.2	230.0	125.3	172	3
Sulfamethazine	loam	240.0	327.1	470.0	105.0	12	5
Tetracycline	agricultural land	0.5	31.6	198.7	42.1	39	19
Tylosin	agricultural land	0.5	12.6	423.3	14.8	39	7
Sulfachloropyridiazine	clay loam	3.8	35.2	140.0	34.5	28	18
Sulfachloropyridiazine	sandy loam	18.0	229.6	756.0	269.9	34	12

Substance	Sorption capacity[1]	N°. of DS considered[2]	Contained in *AGU*
Iopromide	very low	1	no
Acetylsalicylacid	low	1	yes
Carbamazepine metabolite[3]	low	1	no
Hydroquinone	low	1	no
Metronidazole	low	4	yes
Sulfamethazine	low - medium	15	no
Sulfamethoxazole	low - high	2	yes
Clofibric acid	medium	2	no
Ketoprofen	medium	2	yes
Phenol	medium	2	no
Salicylic acid	medium	1	yes
Sulfachlorpyridazine	medium	1	no
Sulfadiazine	medium	2	yes
Sulfadimethoxine	medium	2	no
Sulfanilamide	medium	1	no
Sulfapyridine	medium	3	no
Sulfathiazole	medium	2	no
Carbamazepine	medium-high	3	yes
Diclofenac	medium-high	4	yes
Diazepam	medium -high	3	yes
Estriol	high	4	yes
Ibuprofen	high	3	yes
Isobutyric acid	high	1	no
Testosterone	high	2	yes
17ß-Estradiol	high - very high	7	yes
Estrone	high - very high	6	yes
Paracetamol	high - very high	2	yes
Propranolol	high - very high	2	yes
Tylosin	high - very high	4	no
17α-Ethinylestradiol	high - very high	5	yes
Ciprofloxacin	very high	1	yes
Enrofloxacin	very high	11	no
Ofloxacin	very high	4	yes
Oxytetracycline	very high	4	yes
Tetracycline	very high	1	yes

[1] The underlined end of the range was represented by more datasets. The capacity was defined along Table 3.

[2] Only datasets with information on soil type in the entry field "Media" (Figure 7) were considered.

[3] Denotes 10,11-Dihydro-10-hydroxycarbamazepine.