KNOWLEDGE CENTRE FOR AGRICULTURE

Manure management in Denmark

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- Danish N-regulation
- Digestion of slurry
- Separation of slurry

PARTNER IN DLBR

The Danish N-regulations

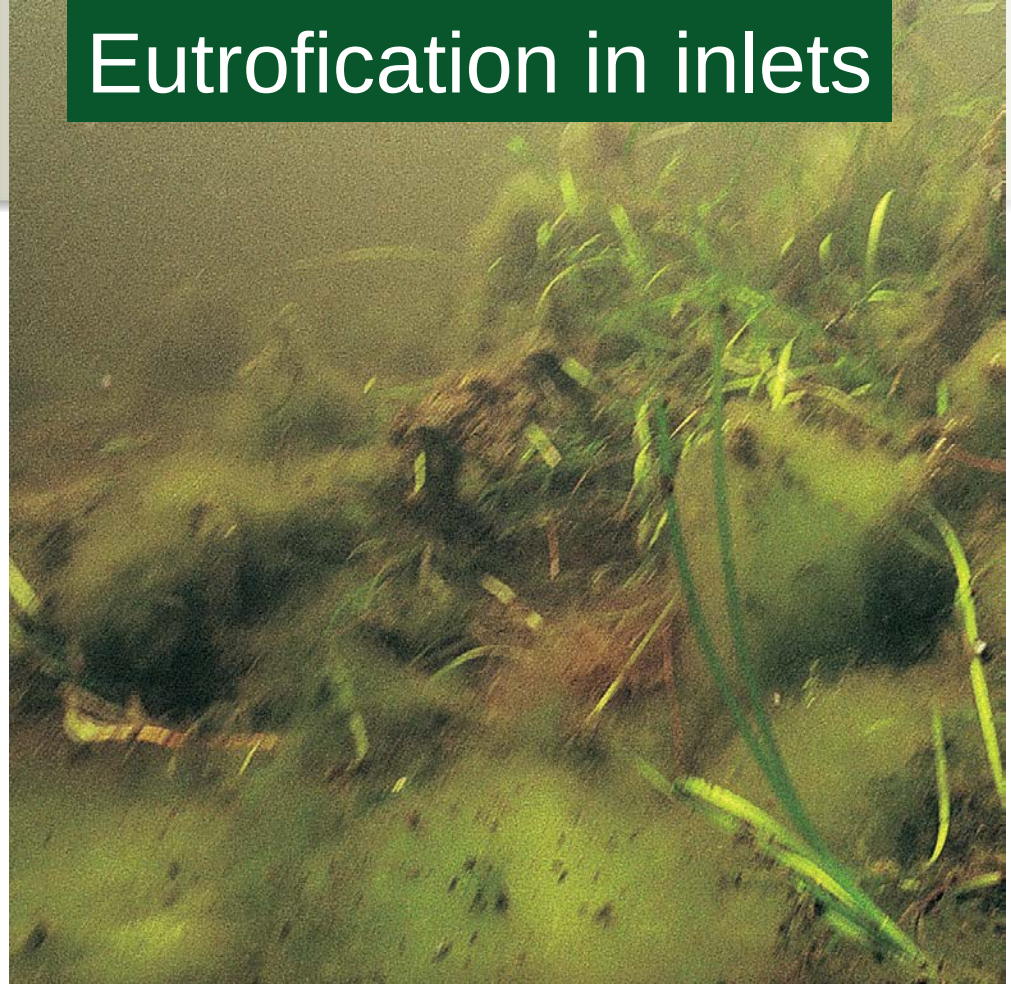
- Probably The most restrictive N-regulation in the World
  - Inlets and lakes
  - Groundwater for drinking

- A full fertiliser plan must be made and uploaded to the Ministry of Agriculture – for every farmer, every year

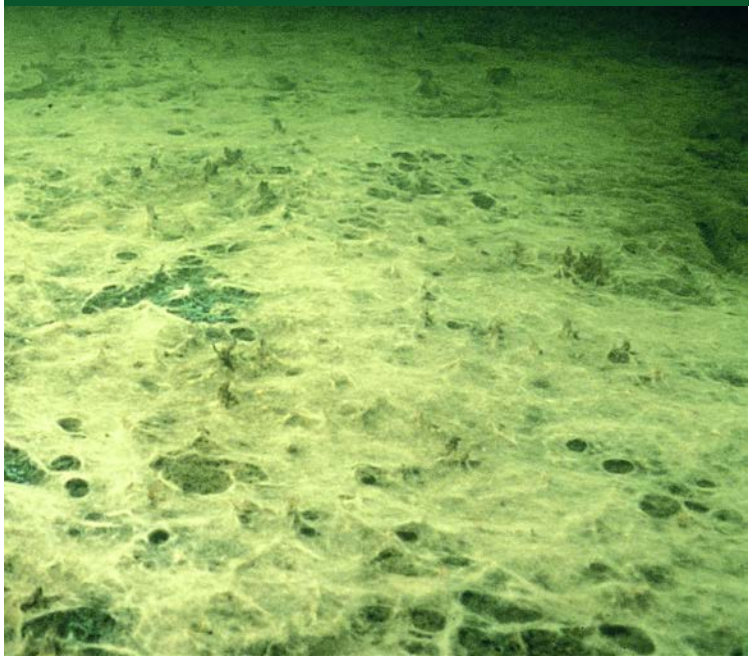
Background for the Danish regulations

	Problem	Impact
Organic matter	Direct pollution gives immediately depletion of oxygen in watercourses	Dead fish in lakes, streams
Nitrogen	Ammonium is extremely toxic to fish Nitrogen gives eutrofication in the marine sea	Dead fish in streams, lakes Depletion of nitrogen at the bottom
Phosphourous	Phosphorous is causing eutrofication mainly in lakes but also in marine inlets	Low sightdepth in the sea. Other fish……

Eutrofication in inlets



Cover on buttom after an incident of lack of nitrogen



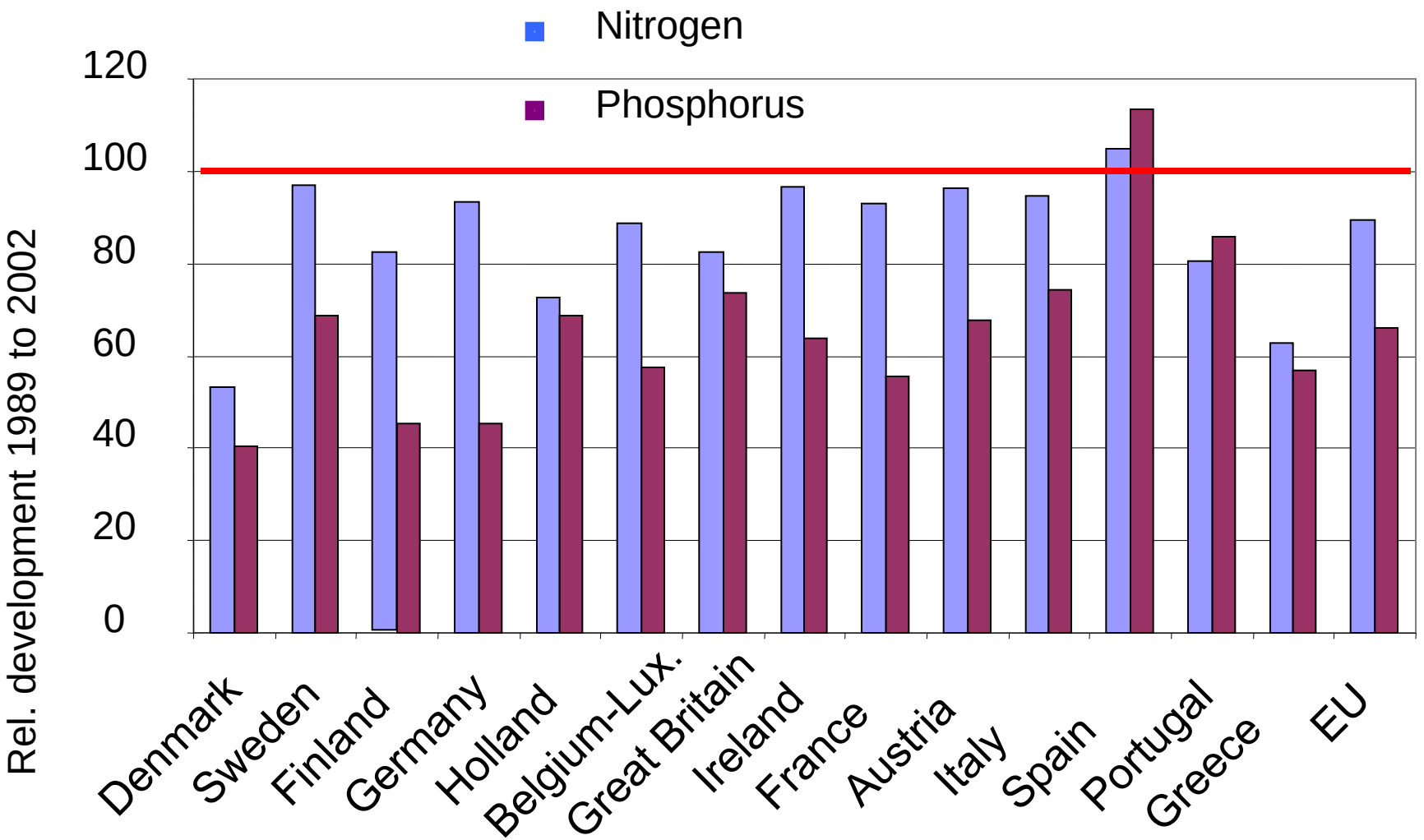
Depletion of oxygen has always occured.

Depletion of oxygen is more common with high N and P content.

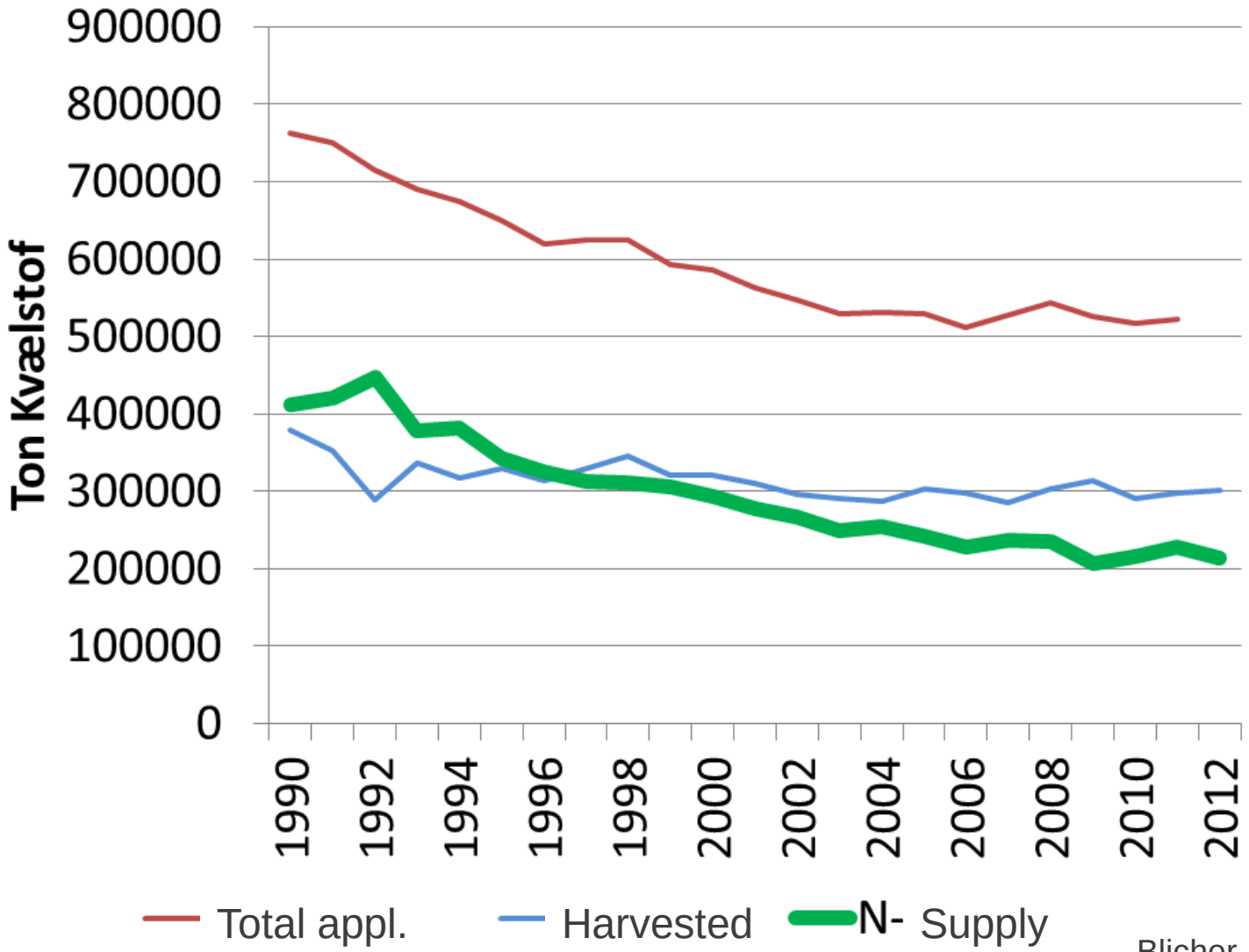
Depletion of oxygen was more common in the 80’th and 90’th than before.

Time	Plan	Significant elements in legislation:
1985	NPO-plan	-regulation of allowed animal unit per ha. - min. storage capacity for animal manure
1987	Water Environm. Plan I	-50 pct reduction in N-leaching from agr. -65 pct ”autumngreen fields” -Slurry in autumn only to wintercov. fields
1992	Sustainable agriculture	-Slurry only to grass or oilseed rape in autumn -Max. N-standards for crops (N-quata per farm) -Min. utilisation of nitrogen in animal manure -Fertilizer plans and -accounts.
1998	Water Environm. Plan II	-10 pct decrease of N-standards (The N-quota) - 6 percent ”super” green fields in autumn -15 pct higher utilization of N in animal manure
2003	WMP III	-Target for decrease of P surplus -More wetlands - 10/14 pct. covercrops
2011-2013	Waterframe directive	-More cover crops -Establishment of wetlands

Nitrogen and phosphorus in artificial fertiliser 1990-2002

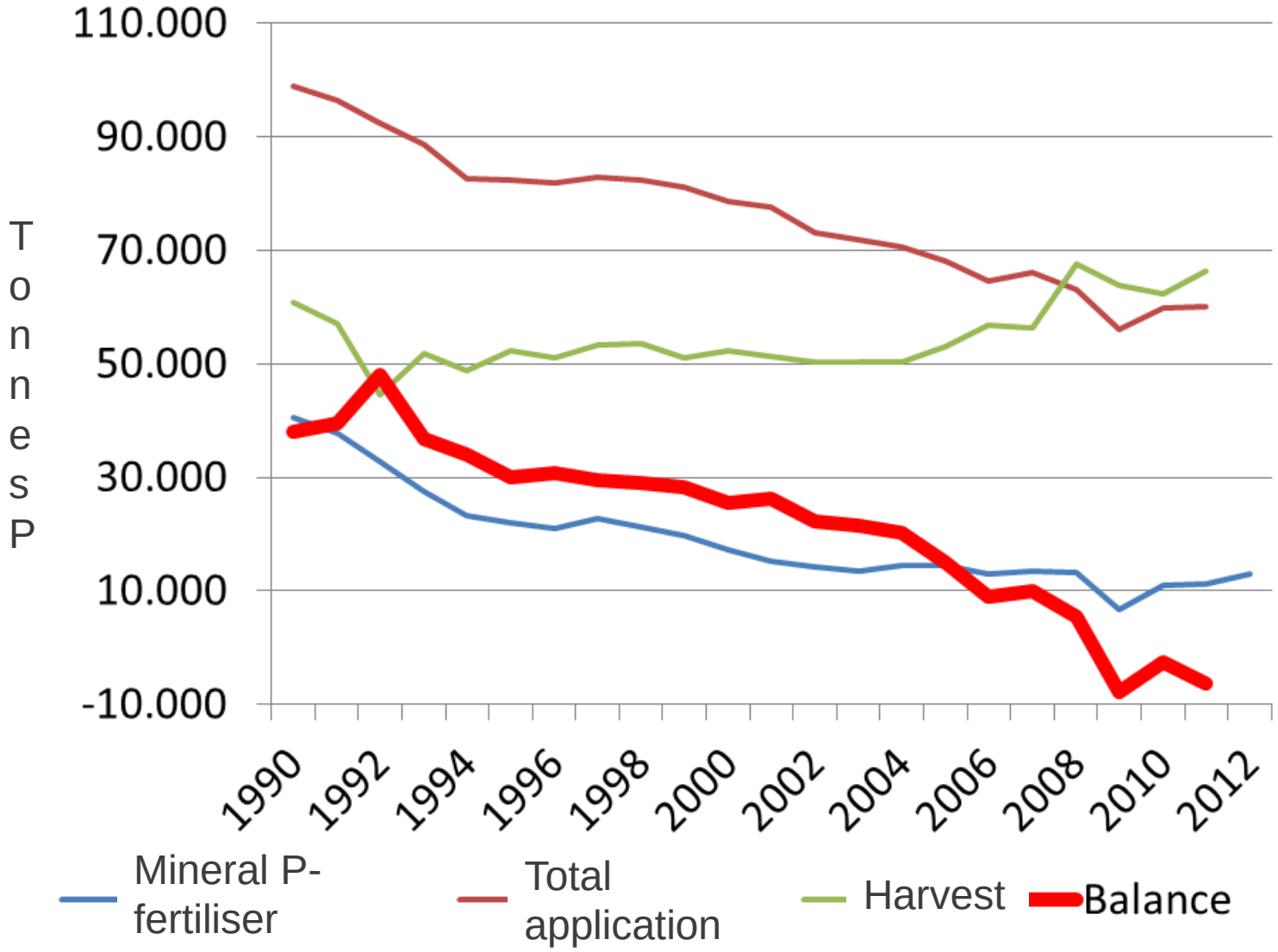


Use of N in Danish plant production



Blicher-Mathiasen, 2012

Use of P in Danish plantproduction



N-regulation in Denmark

lower N-leaching

Catch crops:

10/14 percent of the area must be ”supergreen fields”: catch crops of undersown grass or Crucifers.

Fertilisation

- Every Crop has a specifik N-quote and instructions for P and K supply in kg/ha
  - Soil type
  - Watering
  - Previous crop
  - Yield
  - For grass, the quote also depends on
    - The use
    - The percentage of clover

Examples of Danish N-quotas for different crops

	Coarse sand		Loam	
Crop	Yield Hkg/ha	Kg N/ha	Yield Hkg/ha	Kg N/ha
Winter wheat after cereals	50	145	85	172
Winter wheat after Wi.rape	56	123	93	150
Spring barley after cereal	40	104	61	121
Spring barley after clovergrass	44	58	67	67

Maximum allowed animals per ha

Animal Category	Animal unit per ha	Number of animals per ha
Dairy cows	1,7/2,3	1,3/1,7
Sows	1,4	6,0
Piglet 7,5-32 kg	1,4	280
Pigs, 32-107 kg	1,4	50
Hens	1,4	232
Chickens	1,4	4.200

1 Animal Unít = 100 kg N ab storage

	Minimum demands for utilization of total N in manure
Pig slurry	75
Cattle slurry	70
Solid manure + urine	65
Deep litter	45
Sewage sludge	45

Calculation of fertiliser use:

	Nitrogen quota for each crop
+/-	Correction for annual N-prognosis
-	Effect of catch crops from last year (17/25 kg N/ha of catch crop)
-	Minimum utilisation of Animal manure
=	**Nitrogen quota in mineral fertiliser for the farm**

Animal manure and slurry

- Content of nutrients
  - Norm values and analysis
- Maximum Animal production per hectare

Optimized:

- Storage
- Spreading period
- Spreading technics

Content of Nutritions is calculated

- In princip N,P,K: $Input_{feed}$ – ($growth_{meat}$ + $growth_{embryo}$ + milkproduction) = $output_{fæces/urin\ per\ animal}$

Example: Dairy cow, heavy race:

Assumptions:

Milkproduction, kilo per year:	9420
Milk-protein, kilo per cow:	318
Milk-protein, %:	3,38
FeedUnits (FU), per cow	7015
Protein (albuminoid), g per FU	172
Protein (digestible), g per FU	128
P, g per FU	4,25
Feeding efficiency, %:	83

- Result:

22 tons produced:

141,4 kg N

20,3 kg P

102,0 kg K (potassium)

Examples: Nutrients ab storage

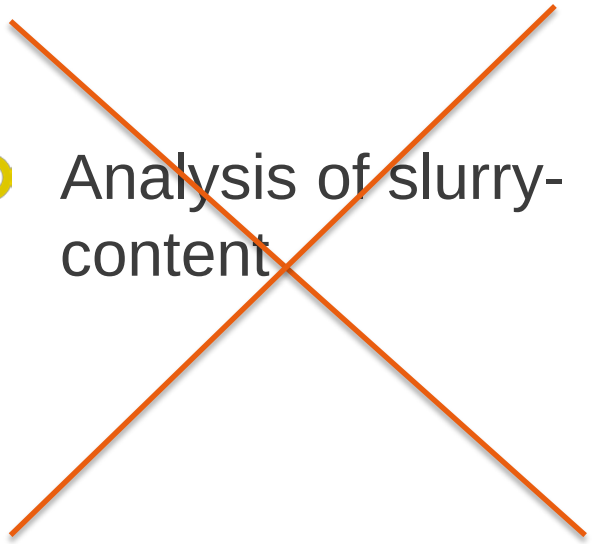
Type		Ton-nes	DM %	Total Kg produced				Content kg / ton			
				N	NH_4-N	P	K	N	NH_4-N	P	K
Diary Cow	Manure Urine	10,98 12,74	20 3,4	66,51 57,11	16,63 51,40	18,37 2,01	30,13 76,38	6,06 4,48	1,51 4,03	1,67 0,16	2,74 6,00
D. Cow	Slurry	22,46	11,1	137,06	82,24	20,38	106,51	6,10	3,66	0,91	4,74
D. Cow	Deepl.	15,51	30,0	147,27	29,45	22,66	155,94	9,49	1,90	1,46	10,05
Calf 0-6 m	Deepl.	1,89	30,0	26,68	5,34	3,28	23,98	14,1	2,82	1,73	12,67
C. 6-27m	Manure Urine	4,51 3,17	18,2 3,4	21,10 23,26	5,28 20,93	6,09 0,60	16,54 34,68	4,67 7,35	1,17 6,61	1,35 0,19	3,66 10,96
C. 6-27m	Slurry	7,22	12,3	48,14	28,88	6,69	51,22	6,66	4,00	0,93	7,09
C. 6-27m	Deepl.	5,52	30,0	52,62	10,52	7,49	68,66	9,54	1,91	1,36	12,45
Beef Cow	Manure Urine	3,72 4,17	22,8 3,8	20,63 35,17	5,16 31,65	5,40 0,74	14,22 51,39	5,54 8,42	1,39 7,58	1,45 0,18	3,82 12,31

The only possible way of changing the values, is

- Correction of milk-production
- FU per cow
- Protein and
- P per FU

Documentation

- Analysis of slurry-content



Analysis: Only for optimising the fertiliser plan

The N quotas leaves us in a lack of N

- The main ”growth-challence” in Danish Agriculture is to maximize the utility of nitrogen, during:

Increased utility of N in slurry and manure

  - Minimizing the loss from stable, tank and field
  - Slurry to gassification
  - Separation of slurry
- Increased utility of catch-crops
- Optimized growth parameters

Storage and applicationtechniques

Storage capacity for animal manure

Normal: At least 9 months on pig farms.
7 months on dairy farms with Animal grasing in summer

New stables: farmers normally invest for 12 month of storage capacity

Minimizing the loss from stable, tank and field

Storage of manure: Focus on NH_3-loss

Cover of liquid manure:	Natural crust is enough if the surface is tight and dry. If not, there must be a solid cover

Self-policing system: Intensified control of data and slurry tank

Dato	**Kun ved naturligt flydelag :** Er flydelaget skorpet og fri for sprækker med blank gylleoverflade?		Er overdækningen tæt og sammenhængende samt stabil i blæsevejr ?		Har overdækningen en tør overflade (i tørvejr) ?		Noter pct. overflade med tilfreds-stillende overdæk ning	Eventuel henvis-ning til række nr. på skema 2
	Ja	Nej	Ja	Nej	Ja	Nej		
							pct.	
							pct.	
							pct.	
							pct.	
							pct.	

Straw-cover

DK: Ammonia loss from deeplitter from cattle and pigs without cover is 25 pct. Plus a loss of 5 pct. and 15 pct. from denitrification

Allowed spreading time, slurry

- From harvest to the 1st of February spreading of liquid manure is banned, except:
  - On winter-oilseed rape: from harvest to the 1st of October
  - on grassland (overwintering): untill 1st of October
  - On grass for seed: untill the 15.th of October

Allowed spreading time, manure, deep litter, fertilizer

- 1.st of february to 15.th of November
  - Before sowing: Ploughed or Harrowed within 6 hours
  - On a growing crop before harvest
    - From harvest to the 15.th of November: To an over wintering crop

Application

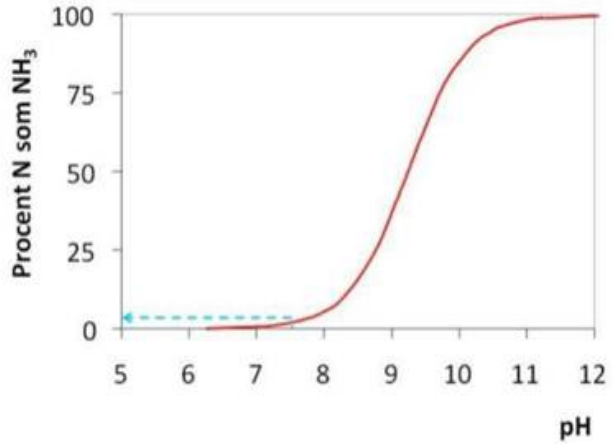
Spreading technique:

- Use of broadcasting is banned.
- All liquid manure must be spread with trailing hoses or direct injection

2011 New regulation for application

- All liquid manure on "bare soils"/before sowing must be injected or acidified
- Liquid manure must be injected to grass for feed
- Addition of acid can be used as an alternative to injection at grasslands

pH værdi afgørende for NH3 eller NH4+ (ammoniak – ammonium)



Acidification:

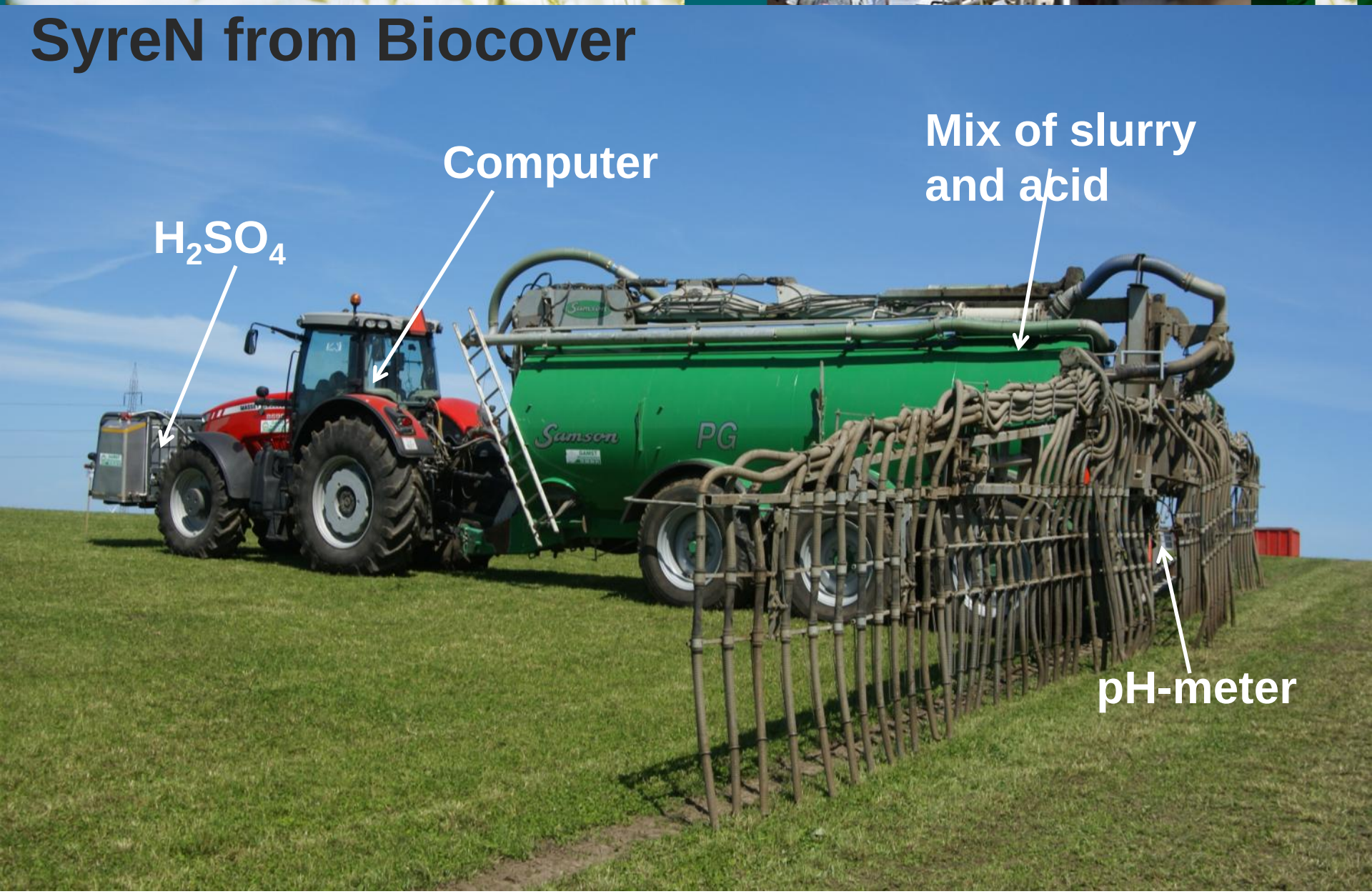
$$H_2SO_4 + 2NH_3 \leftrightarrow SO_4^{2-} + 2NH_4^+$$

Injection of slurry

Acidification and trail hose application


KAWECO

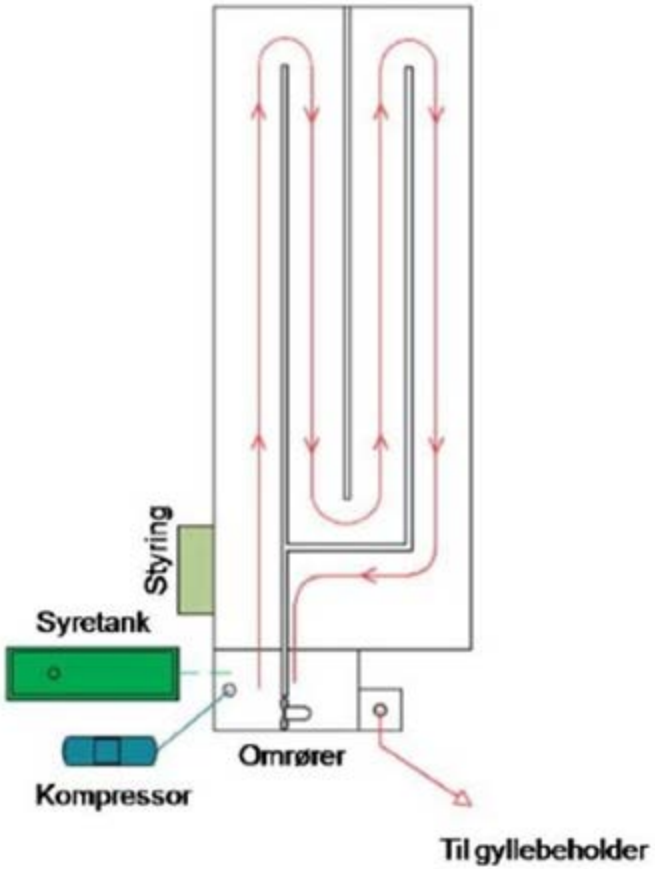
SyreN from Biocover



Acid tank in "cage"

Harsø/Ørumsmedens Acidification in the slurry tank

Acidification in the stable


Styring
Syretank
Kompressor
Omrører
Til gyllebeholder


No need for cover of slurry tank, when pH = 5,5

Effect of acidification

- Acidification reduces the NH_3 volatilasation with:

70% in pig stables
50% in cattle stables
50% from storage
65% during application in the field (trail hose)

Conclusion recomandation

Apply acid to your slurry when:

- pH in slurry is high (>7)
- DM in slurry is high
- The forecast say warm, sunny, windy weather around application
- If you need N at your farm!

Optimized utility

N effect (% of total-N) of pig slurry, 70% ammonia

	Spring		Summer		Autumn	
	Injection	Trailhose	Injection	Trailhose	Bef. sowing	After sowing
Springcrops	75	70*)	-	45	-	-
Beets and corn	75	70*)	70	40	-	-
Wintercrops	70	65	-	65	-	-
Oil seed rape	-	65	-	-	65	55
Grass seedl.	-	60	-	-	-	60
Grass, fodder	60	60**)	55	55**)	-	55

- * Only allowed for organic farming
- ** Only if acidified
- All effects of trail hose application will increase with 5% if acidified

N effect (% of total-N) of cattle slurry, 60% ammonia

	Spring		Summer		Autumn	
	Injection	Trailhose	Injection	Trailhose	Bef. sowing	After sowing
Springcrops	70	50*)	-	35	-	-
Beets and corn	70	55*)	60	35	-	-
Wintercrops	55	45	-	40	-	-
Oil seed rape	-	45	-	-	50	35
Grass seedl.	-	45	-	-	-	45
Grass, fodder	50	45**)	45	45**)	-	40

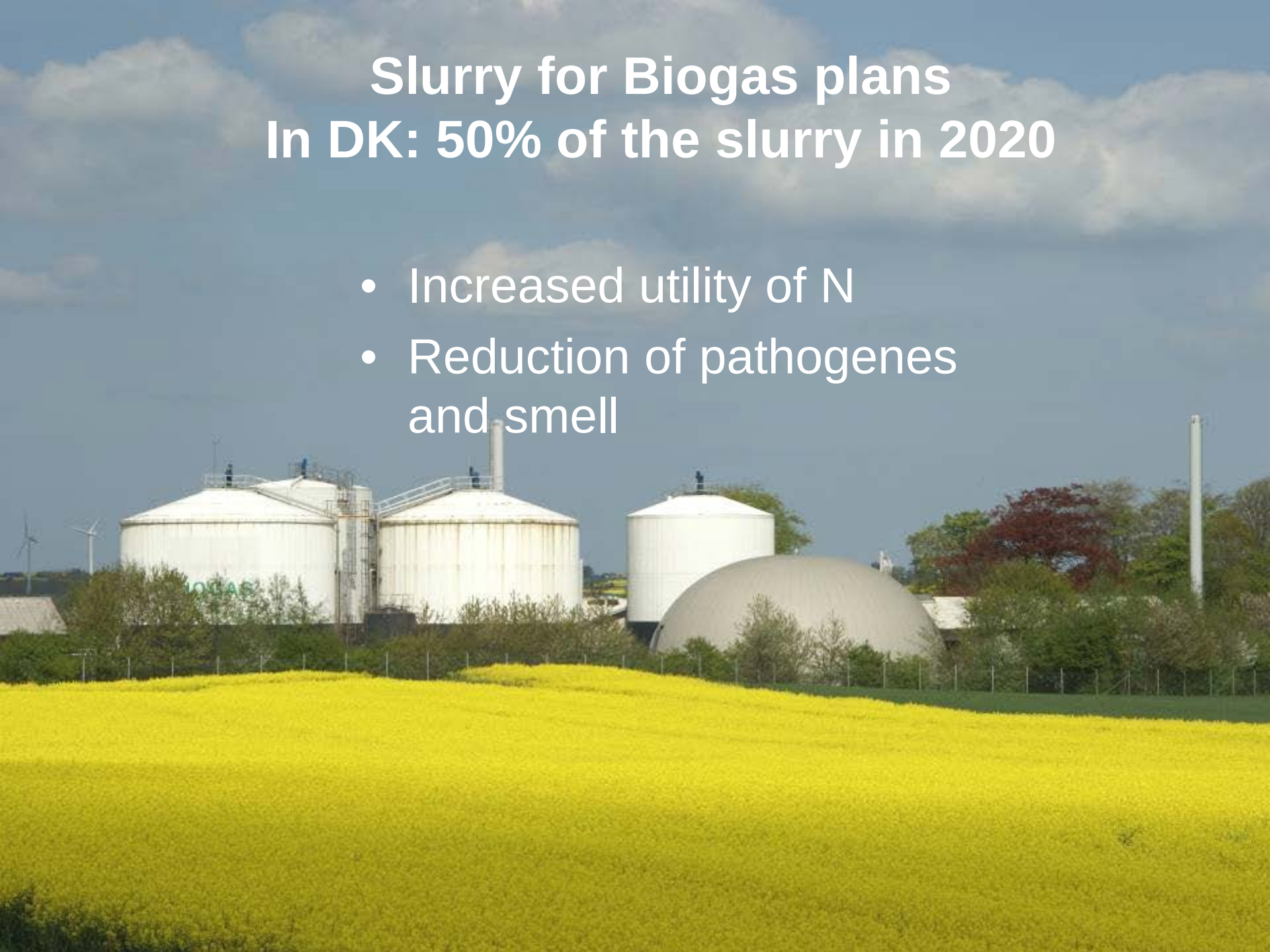
- * Only allowed for organic farming
- ** Only if acidified
- All effects of trail hose application will increase with 5% if acidified

Conclusion

- Spring time application, injection and springcrops, turnips and corn gives the highest N-utility

Slurry for Biogas plans
In DK: 50% of the slurry in 2020

- Increased utility of N
- Reduction of pathogenes and smell



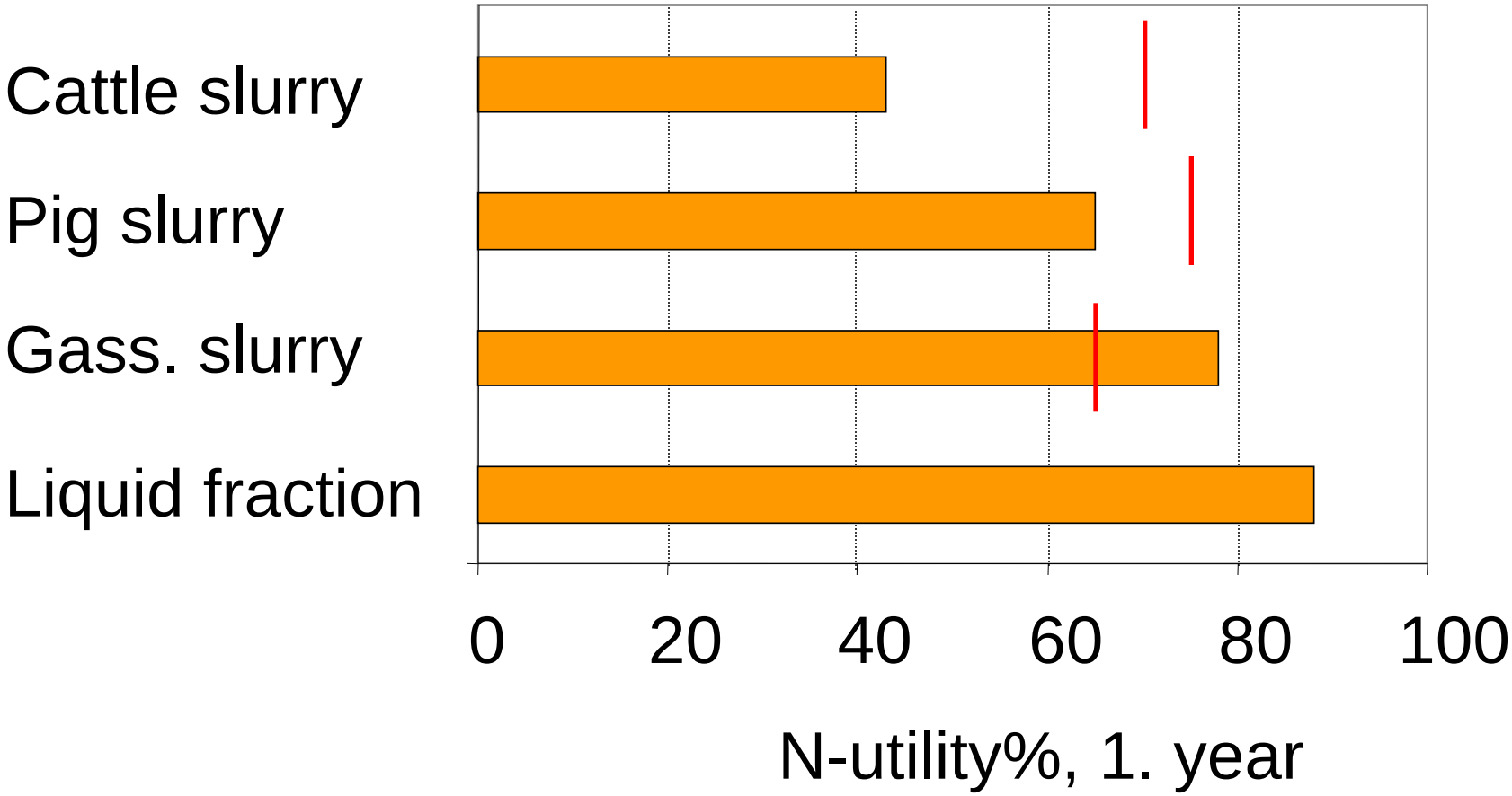
Better fertilizer

1. Higher infiltration to soil – lower ammonia loss
2. Lower organic matter and more N for directly uptake
3. Better balance between P- og K-need to application of P and K (pig and plant production)
4. Reuse of organic wastes

Mixing of slurry and gassification changes the characteristica of the slurry

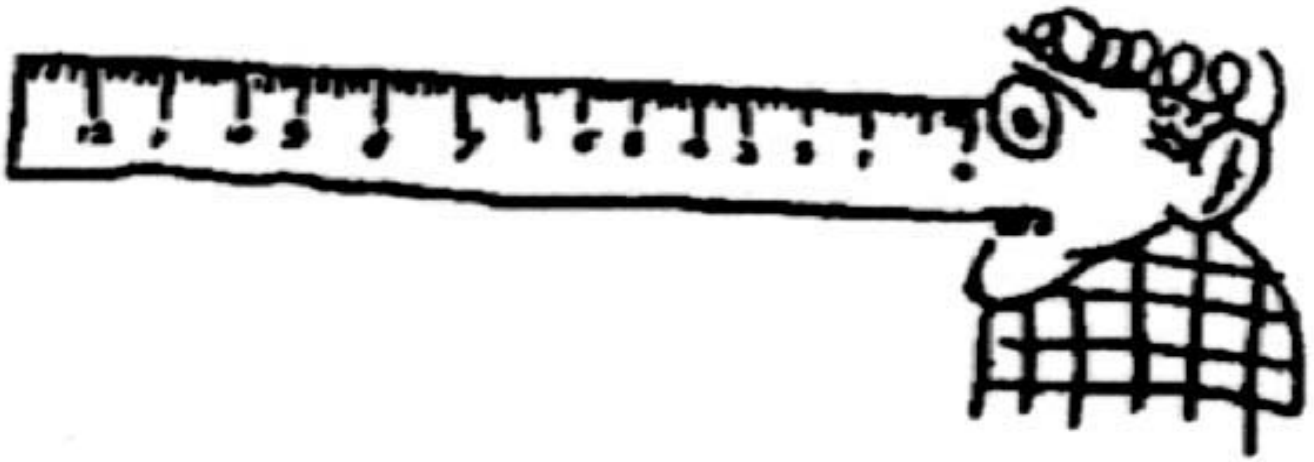
	DM, %	N-tot, kg/t	NH_4-N, kg/t	P, kg/t	K, kg/t	pH	NH_4-N, %
Gassified slurry	4,8	4,4	3,5	1,0	2,3	7,6	81
Pig slurry	5,0	4,8	2,9	1,1	2,3	7,1	74
Cattle slurry	7,5	3,9	2,4	0,9	3,5	6,8	61

N-utility of different types of slurry to winter wheat

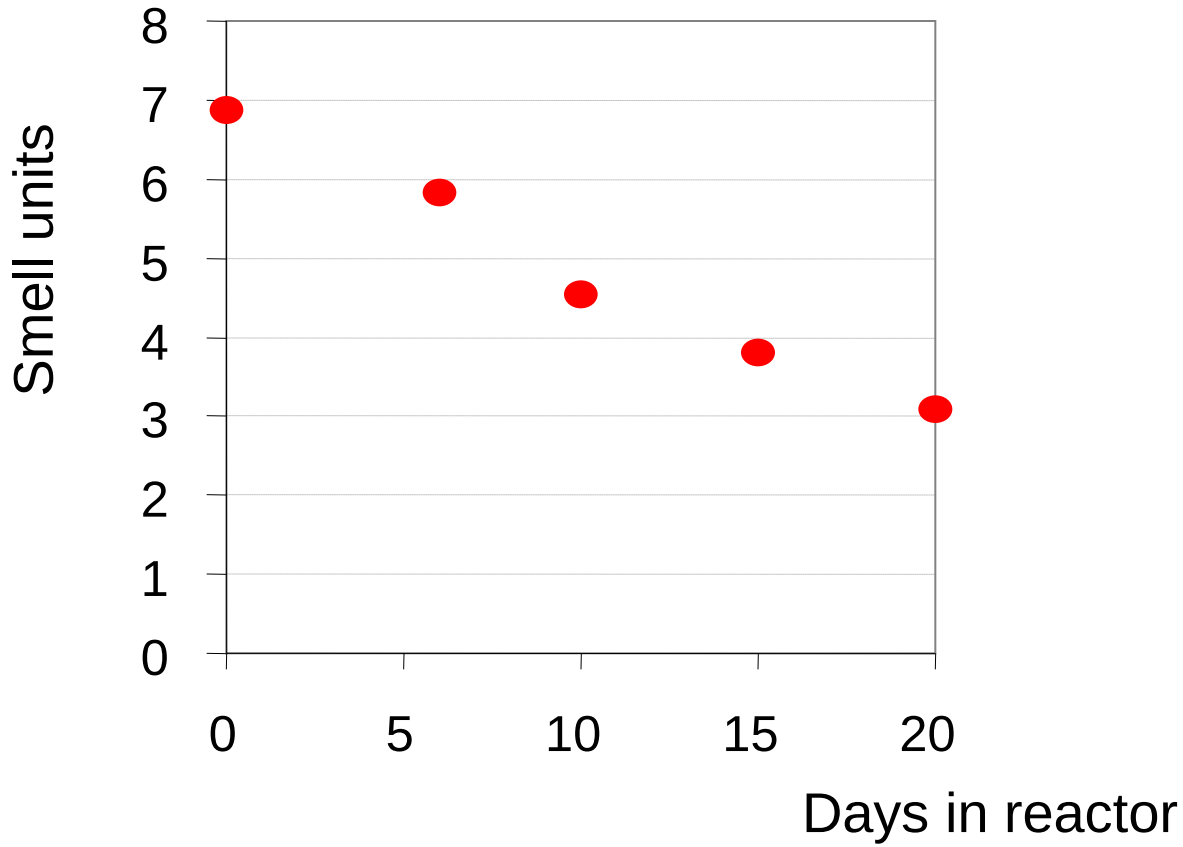


Kilde: Oversigt over Landsforsøgene

Gassification reduces smell

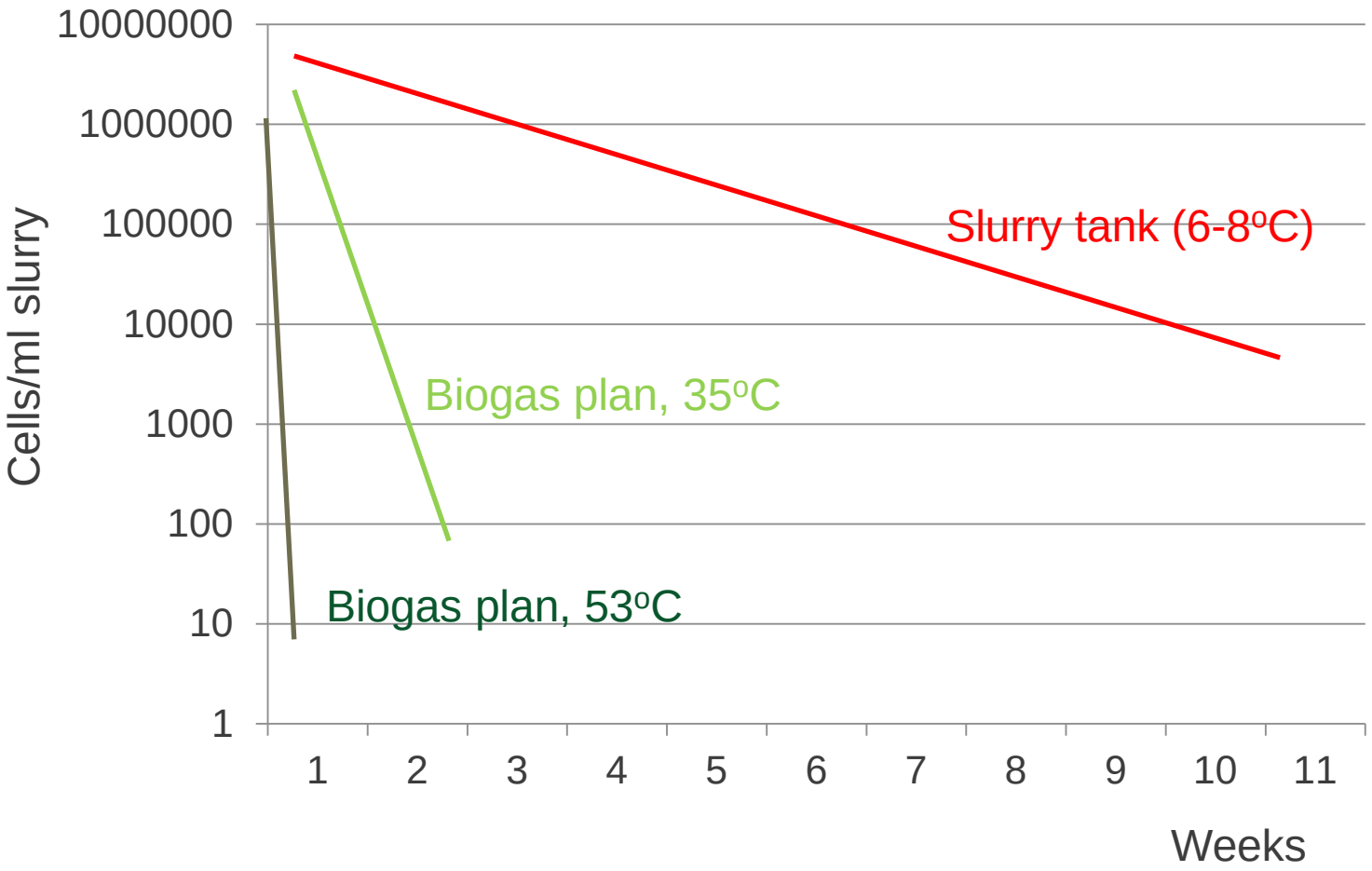


Reduction of smell units in biogas reactor



Kilde: Powers *et al.*, 1999

Reduction of bacteria population:
Salmonella typhimurium from cattle slurry



Calculated from the input material	Minimum demands for utilization of total N in digested slurry	For example % of input
Pig slurry	75 %	30 %
Cattle slurry	70 %	30 %
Solid manure + urine	65 %	10 %
Deep litter	45 %	10 %
Sewage sludge	45 %	20 %
Digested slurry		**63,5%**

N effect (% of total-N) of gassified slurry, 80% ammonia

	Spring		Summer		Autumn	
	Injection	Trailhose	Injection	Trailhose	Bef. sowing	After sowing
Springcrops	75	70*)	-	50	-	-
Beets and corn	75	70*)	70	45	-	-
Wintercrops	75	75	-	65	-	-
Oil seed rape	-	75	-	-	65	55
Grass seedl.	-	70	-	-	-	60
Grass, fodder	65	65**)	60	60**)	-	60

- * Only allowed for organic farming
- ** Only if acidified
- All effects of trail hose application will increase with 5(maybe more)% if acidified

Barriers of biogas plans

- Economy (energy prise and subsidy)
  - Transport costs
- Placement
- Marketing / upgrading

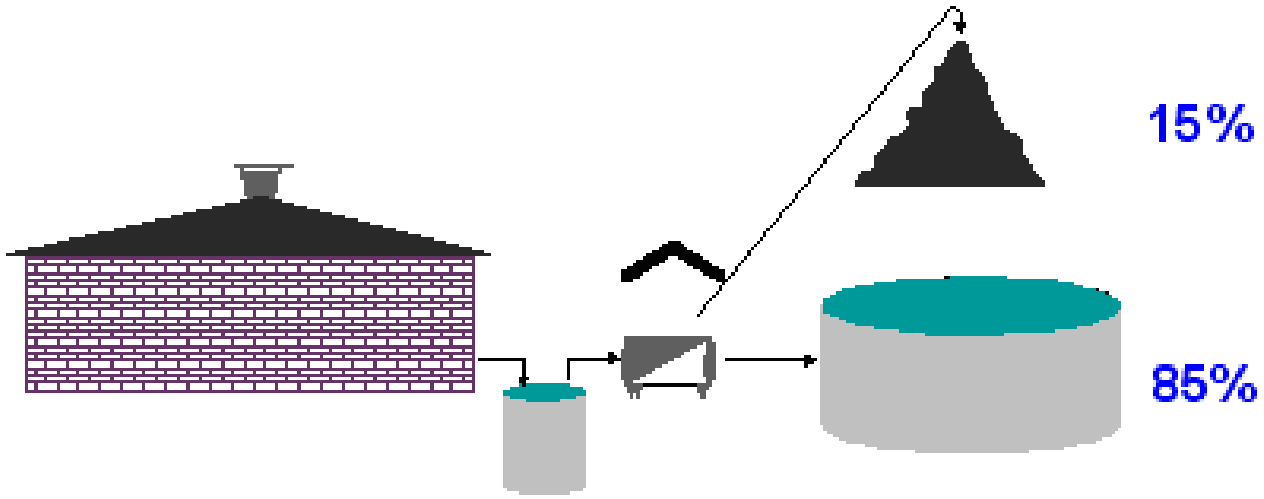
Possible advantages

- Increased N effect of the slurry!
- Less smell during application time
- Balance in P og K (pig farms and milk production at clay soil)
- Homogeneous slurry
- No pathogenes and weeds
- Crops for biogas = increasing prices?

- Whatch out for the costs

Separation of slurry

Slurry separation



slurry ⇨ Liquid fraction + fiber fraction

High NH_4

High org. matter,
High P-content

Advantages

Export of nutrients (increased household)

- Export of fiber to a biogasplan
- Use of fiber for energy
- Lower transport costs

Use of fiber as Litter

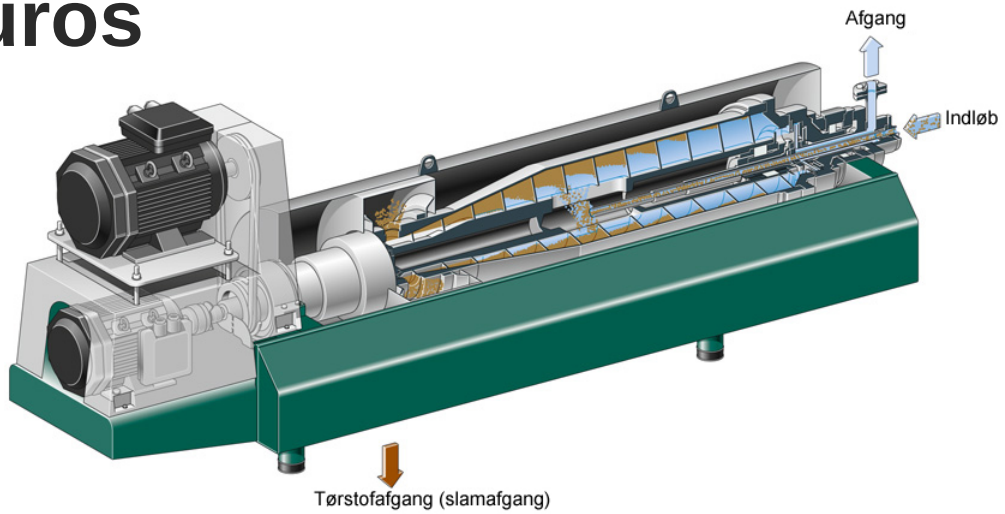
(Increased availability of nutritions)

- Increased infiltration
- Optimized use in different crops

Different types of separation

- Mechanical
  - Decanter centrifuge
  - Screw press
  - Filter
- Chemical improvement of separation
  - Polymer

Decanter centrifuge: 115.000 euros
mobile: 190.000 euros



Canister

Srew: 20-28.000 euros


Is it a good idea to let the cows sleep in their own shit??

Using fiber as litter:

- Nice comfort of legs and hocks
- Watch out for Klebsiella → mastitis
  - Fresh litter every day (recomended)
  - Remove old fiber
  - Dry the fiber before use (+/-)
  - Apply acid
  - Apply lime
  - Never mix with other herds
  - USE fiber from biogasplans!

Environmental focus on separation

- Liquid fraction:
  - Ammonia-loss
  - Pathogenes
- Fiber fraction:
  - Ammonia-loss
  - Nitrate leaching
  - Inc. concentration of P and metals, hormones

Separated slurry	Minimum demands for utilization of total N in manure	For example 90 % liquid, 10 % fiber
Pig slurry, both fractions used for fertilizer/litter/biogas	75 %	90 * 80% 10 * 30 %
Cattle slurry	70 %	90 * 74,4 % 10 * 30 %
Separated and burned fiber	85 %	

N effect (% of total-N) of liquid fraction, 90% ammonia

	Spring		Summer		Autumn	
	Injection	Trailhose	Injection	Trailhose	Bef. sowing	After sowing
Springcrops	90	90*)	-	70	-	-
Beets and corn	90	90*)	90	70	-	-
Wintercrops	90	85	-	85	-	-
Oil seed rape	-	85	-	-	85	70
Grass seedl.	-	85	-	-	-	75
Grass, fodder	80	80**)	75	75**)	-	70

- * Only allowed for organic farming
- ** Only if acidified
- Acidification?

N effect (% of total-N) of fiber fraction, (decanter), 50% ammonia

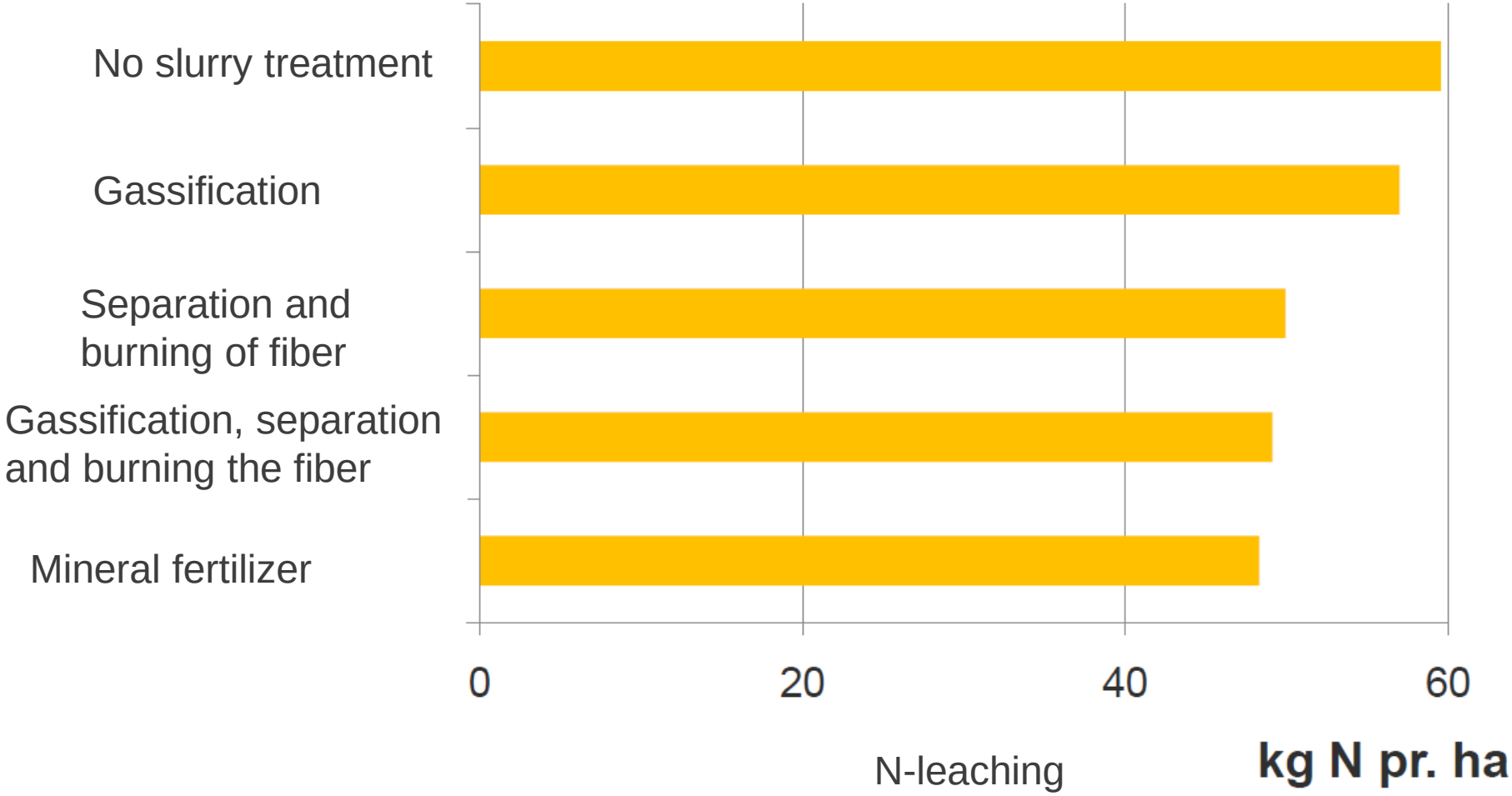
	Spring	Before sowing	Autumn	Vinter
Springcrops	50	-	30	35
Turnip and corn	55	-	35	40
Wintercrops	30	20	-	-
Oil seed rape	30	50	-	-

Conclusion
Relevans for the farmer:

- Increasing household is limited by P/N-production
  - Export of fiber
- Use of fiber as litter
- If increasing prices on the fiber for energy

If the farmer will use both fractions for fertilizers, its not good business!

Calculated nitrate leaching



Slurry is gold

Slurry and manure is gold:

N-price: 1,2 euro/kg

P-price: 1,9 euro/kg

K-price: 0,9 euro/kg

+C-effect

NPK, cattle slurry: 7,7 euro/t

Thank you for your attention