
Photo: J. Heeb
www.ecosan.no

Ecosan - Projects with Norwegian connections

Professor Dr. Petter D. Jenssen

The Norwegian University of Life Sciences

DWA-BMZ-GTZ Symposium, Neue Sanitärkonzepte (ecosan), Eschborn October 26. 2006

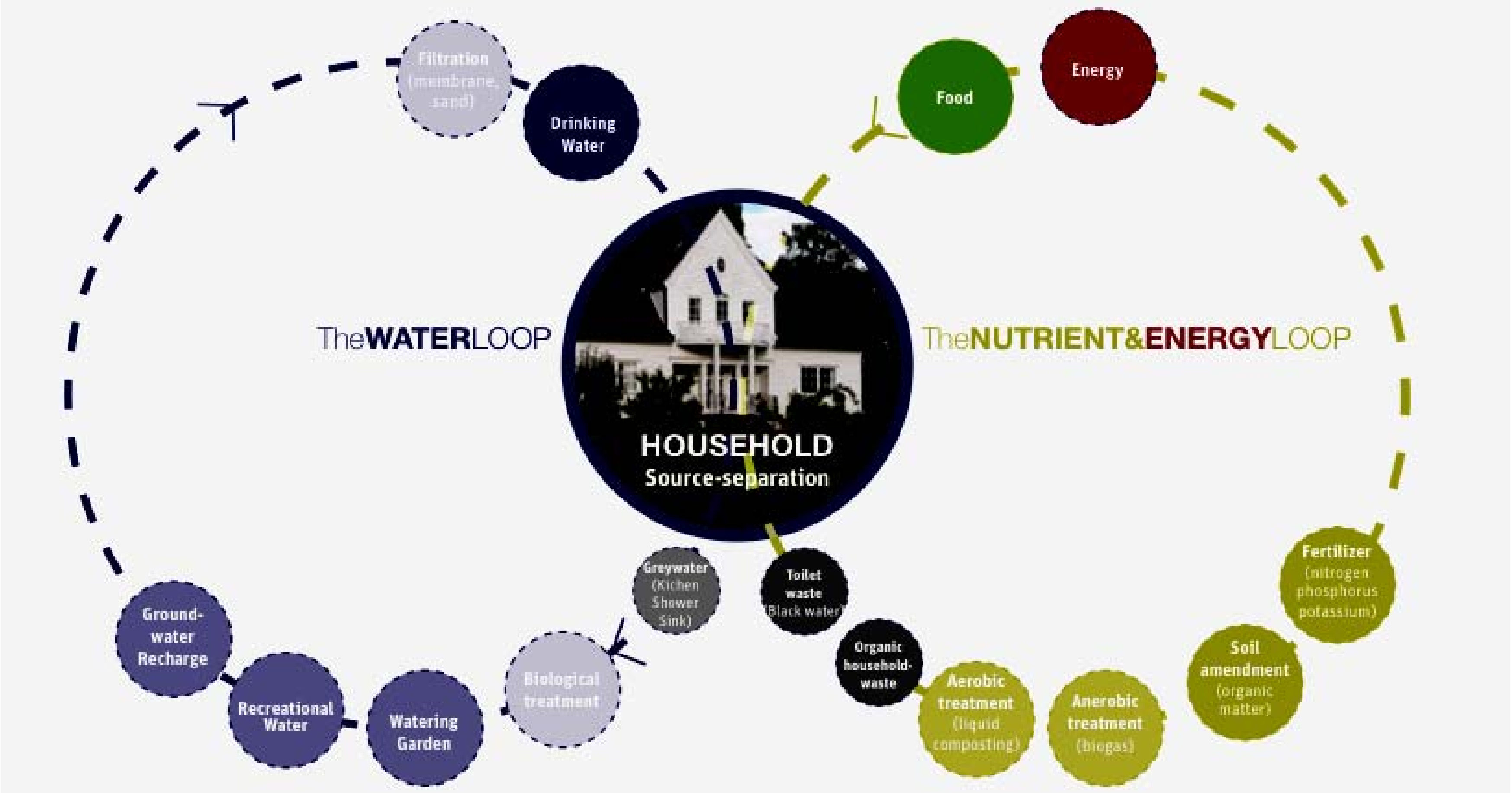

World Toilet Summit & Expo 2006
6-9 September 2006, Moscow, Russia
www.toiletexpo.ru
www.worldtoiletsummit.ru
RUSSIAN STAR TOILETS
Star City Tour
ЗАРЯ
See MIR and other International Space Stations
Feel yourself a cosmonaut and...
VISIT OUR
SPACE
TOILET!

The toilet!

Contribution from the toilet

* 90 % of N
* 80 % of P
* 80 % of K
* 40-75 % of org. matter
* Majority of the pathogens

Source separation of wastewater



(Alsen and Jenssen 2005)

An ordinary toilet
uses 6 - 20 litres/flush

20 - 40% water consumption in sewered cities is due to the water toilet

(Gardner 1997)

Future toilet types
(commercially available today)

- Composting /dry sanitation 0 - 0.1 liter/visit
- Water saving (vacuum&gravity) 0.5 - 1.5 liter/visit
- Urine diverting 0.1 - 4.0 liter/visit

Future toilet types
(commercially available today)

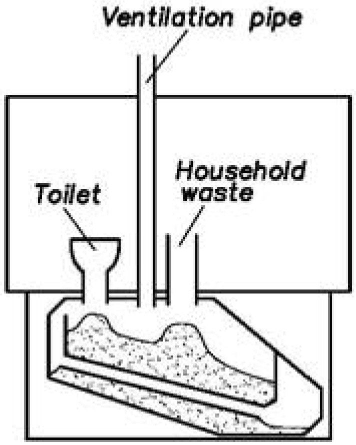
- Composting /dry sanitation 0 - 0.1 liter/visit
- Water saving (vacuum&gravity) 0.5 - 1.5 liter/visit
- Urine diverting 0.1 - 4.0 liter/visit

Future toilet types
(commercially available today)

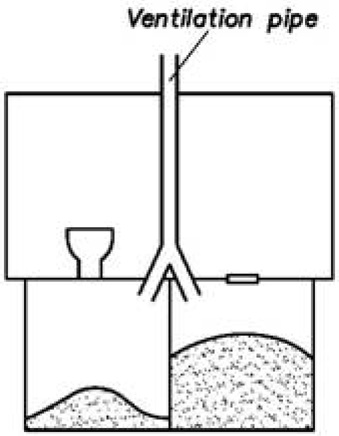
- **Composting /dry sanitation 0 - 0.1 liter/visit**
- Water saving (vacuum&gravity) 0.5 - 1.5 liter/visit
- Urine diverting 0.1 - 4.0 liter/visit

- **500 000 cabins /recreational homes in Norway**
- **Composting toilets are the major sanitary solution**

Composting toilets



A



B

C

A: single chamber **B**. Dual chamber **C:** Removable compartments

(Illustration: Jenssen et al. 2006)

Composting toilet

Reduces toilet waste to:
10 - 30 % of
original volume

(Del Porto and Steinfeld 1999)

Photo: Vera Miljø A/S

Composting toilet

Reduces toilet waste to:
10 - 30 % of
original volume

50 - 150 liters per person and year

(Del Porto and Steinfeld 1999)

Illustration: Vera Miljø A/S

Composting toilet

Removes:

90% of N
60 - 90% of P
40 - 60% of BOD
Majority of the pathogens

Composting toilet

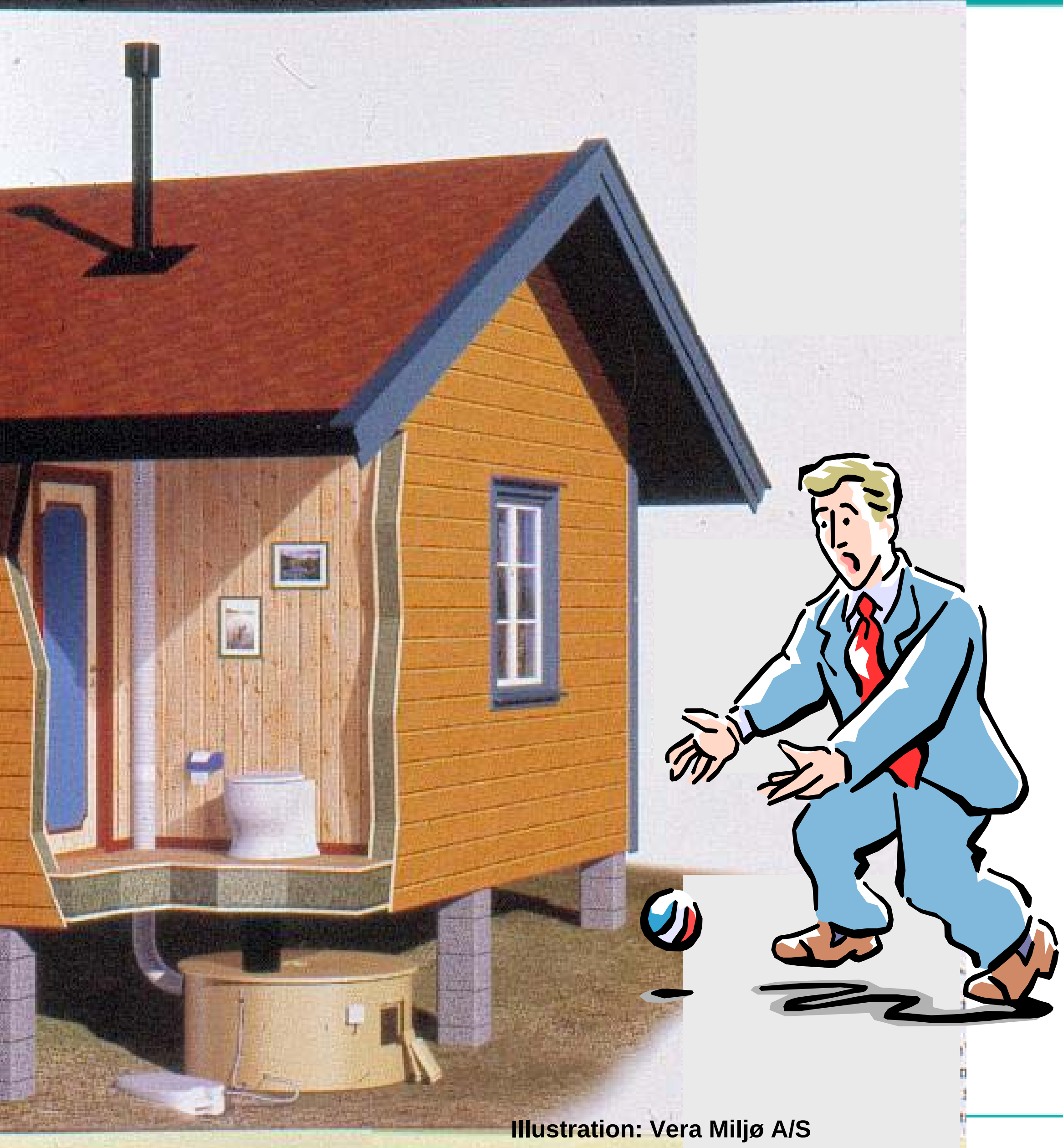
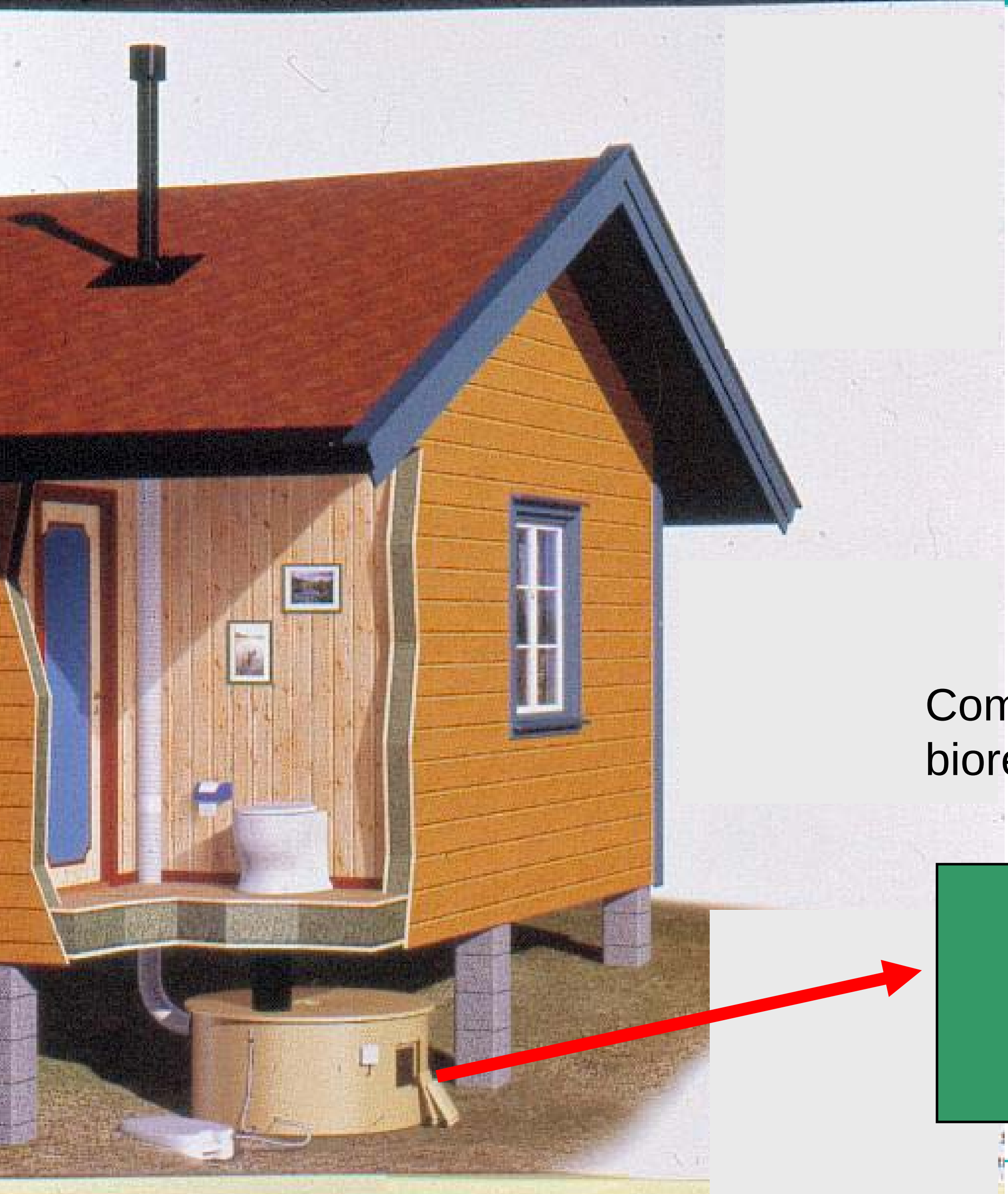


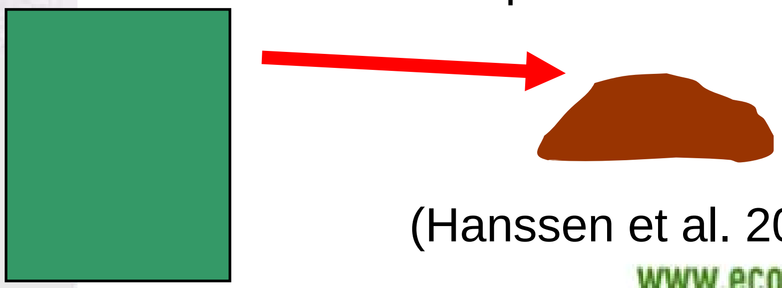
Illustration: Vera Miljø A/S

- Nitrogen loss
- To wet/dry
- **Hygiene**
  - **-** no system above 43°C
  - - risk of handling

Secondary composting



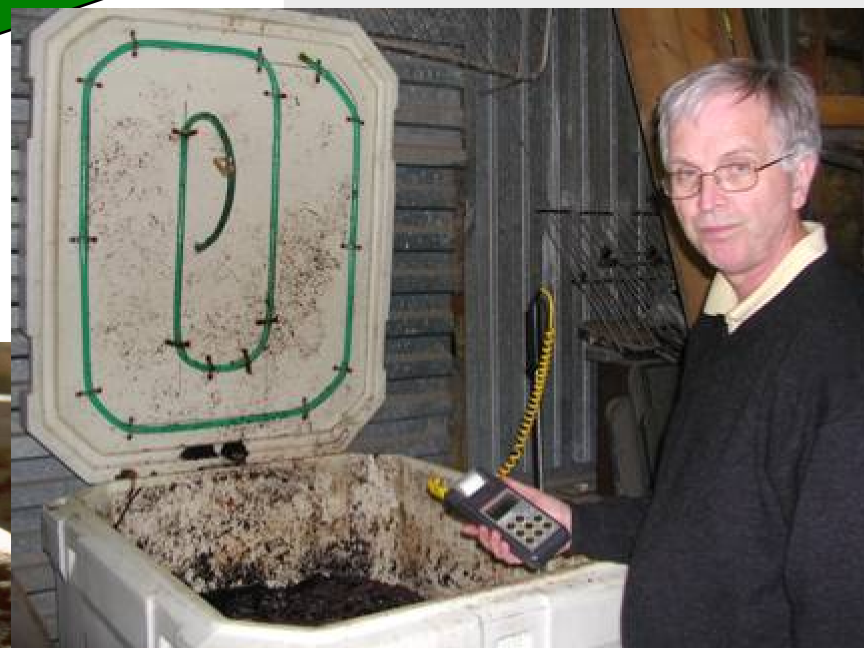
Composting bioreactor

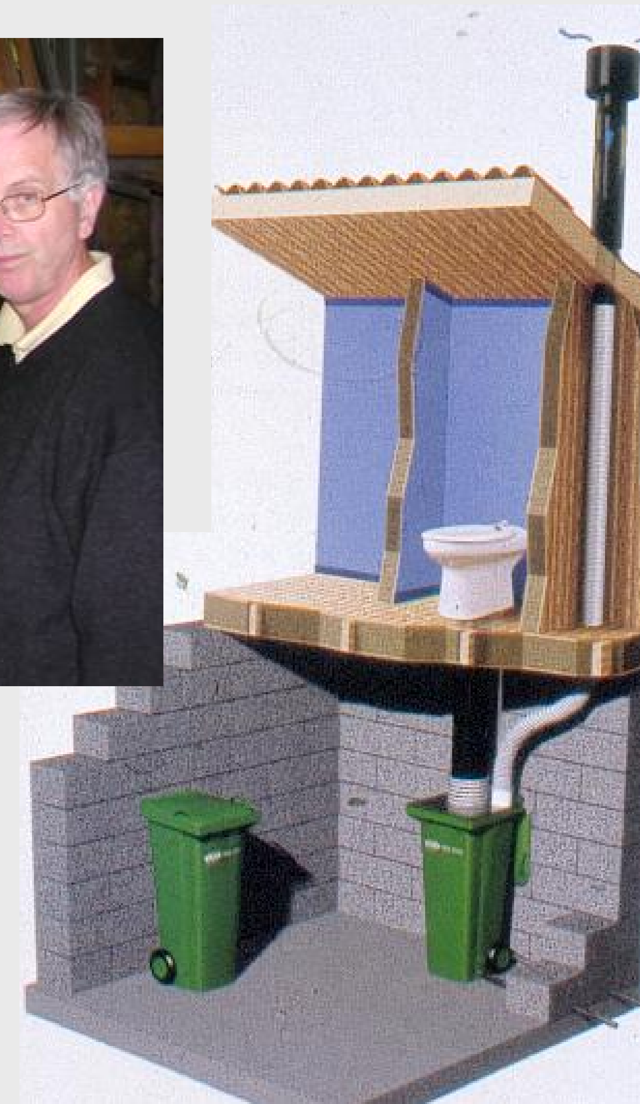


Final hygienized product

(Hanssen et al. 2005)

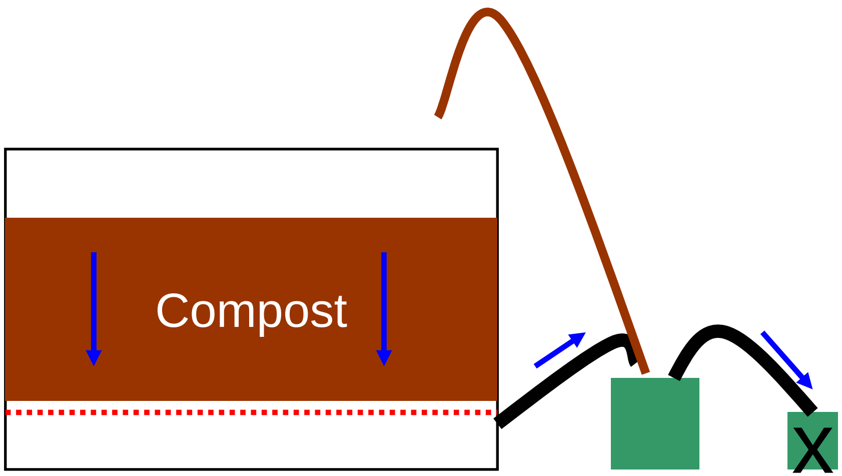
Secondary composting





(Hanssen et al. 2005)

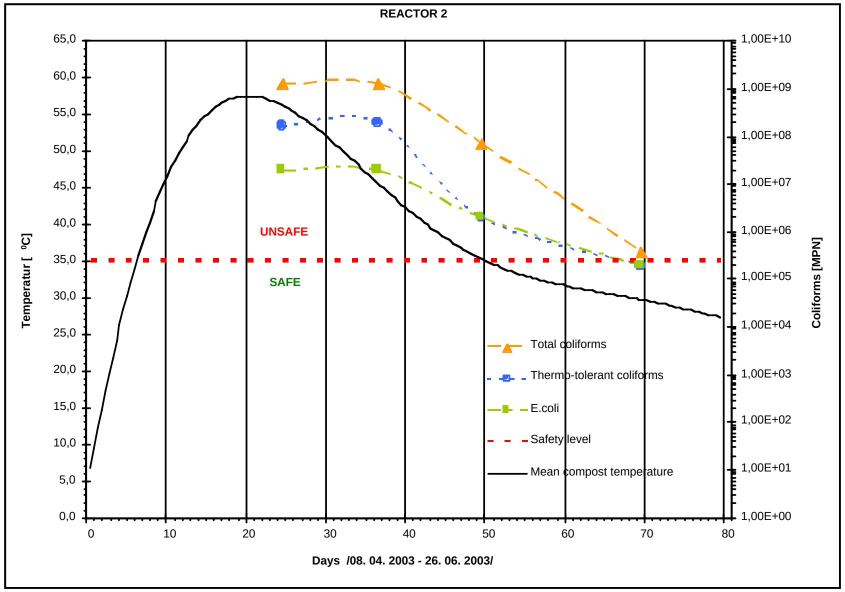
Conclusions



- The secondary bioreactor reduce the nitrogen loss compared to windrow composting, thus producing a more valuable compost

(Hanssen et al. 2005)

Conclusions



- Secondary composting can produce a safe soil amendment in about two months – in contrast to the generally recommended six months

(Hanssen et al. 2005)

Conclusions

- Secondary composting opens for professional collection and treatment of material from composting toilets- thus reducing health risk

(Hanssen et al. 2005)

Dry sanitation - hygiene

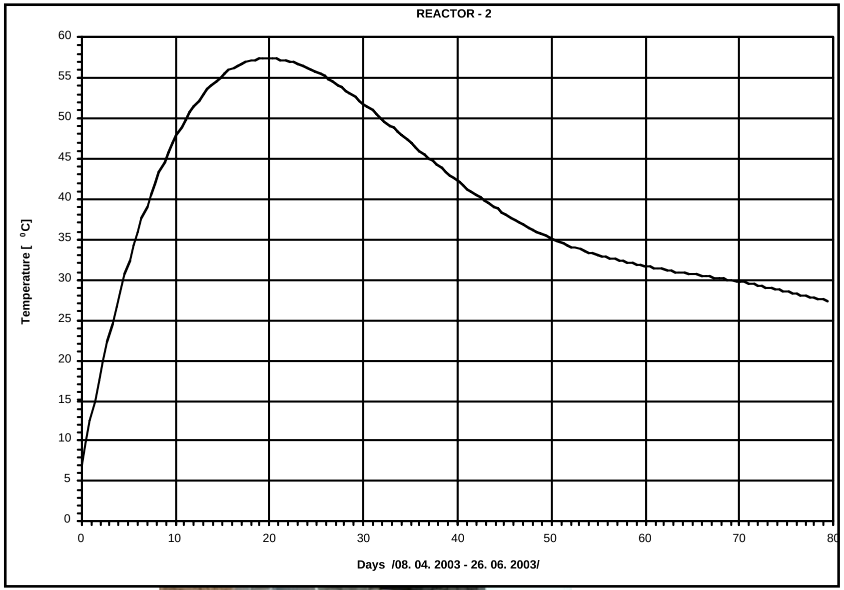


Photo: P.D. Jenssen

- International research show that composting/dry sanitation may give an equal or higher reduction of pathogens and a high reduction in risk of exposure.

(Stenström 2001)

Composting toilet at roadside facility - Sweden

Elected the best roadside facility in Sweden 2003

Composting toilet at roadside facility - Sweden

Clean odourless toilets


Antartica

Future toilet types
(commercially available today)

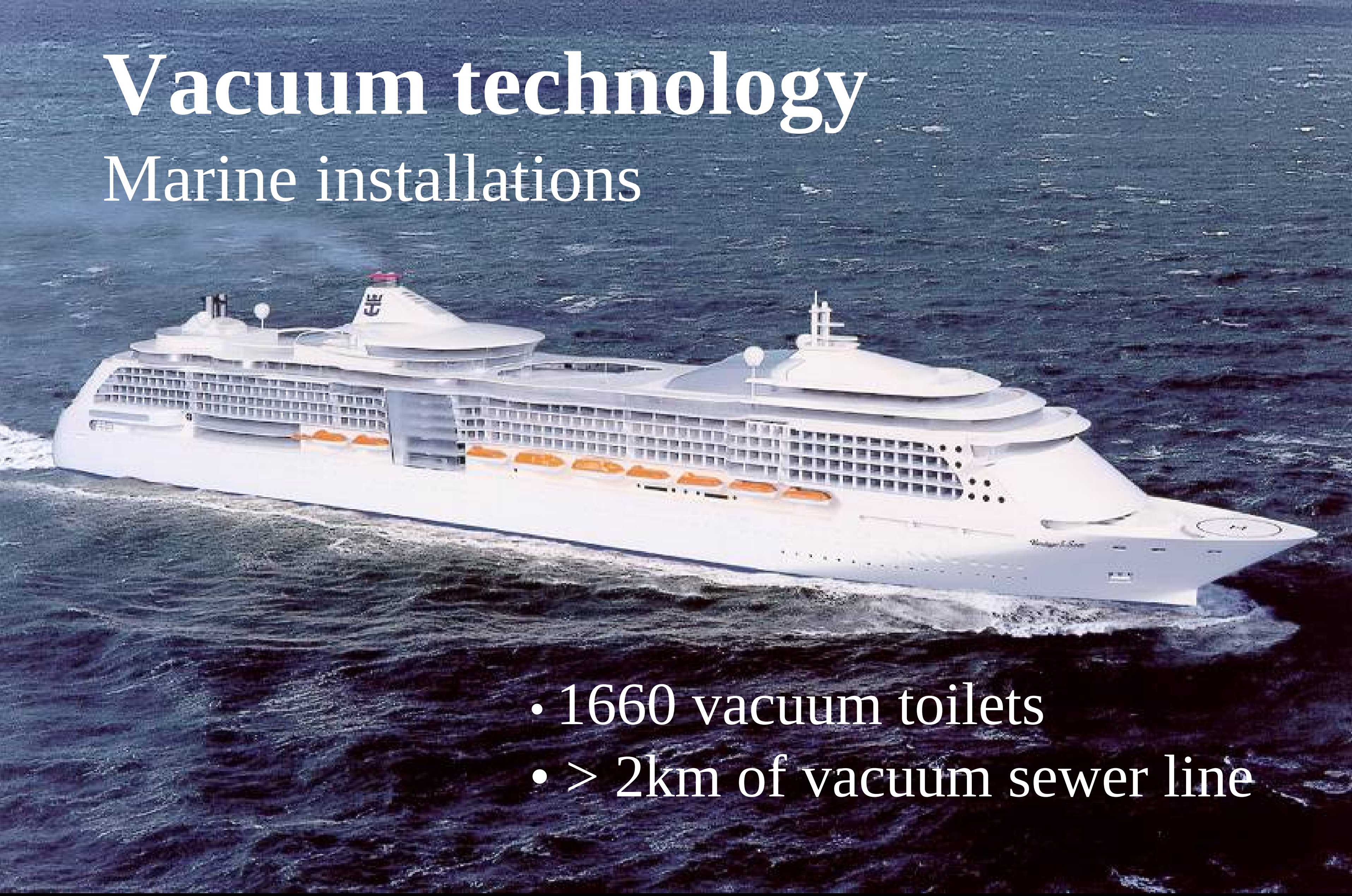
- Composting /dry sanitation 0 - 0.1 liter/visit
- **Water saving (vacuum&gravity) 0.5 - 1.5 liter/visit**
- Urine diverting 0.1 - 4.0 liter/visit

Low flush toilets

Vacuum
0.5 - 1.5 liters/flush

Gravity
1 liter/flush

Vacuum technology
Marine installations



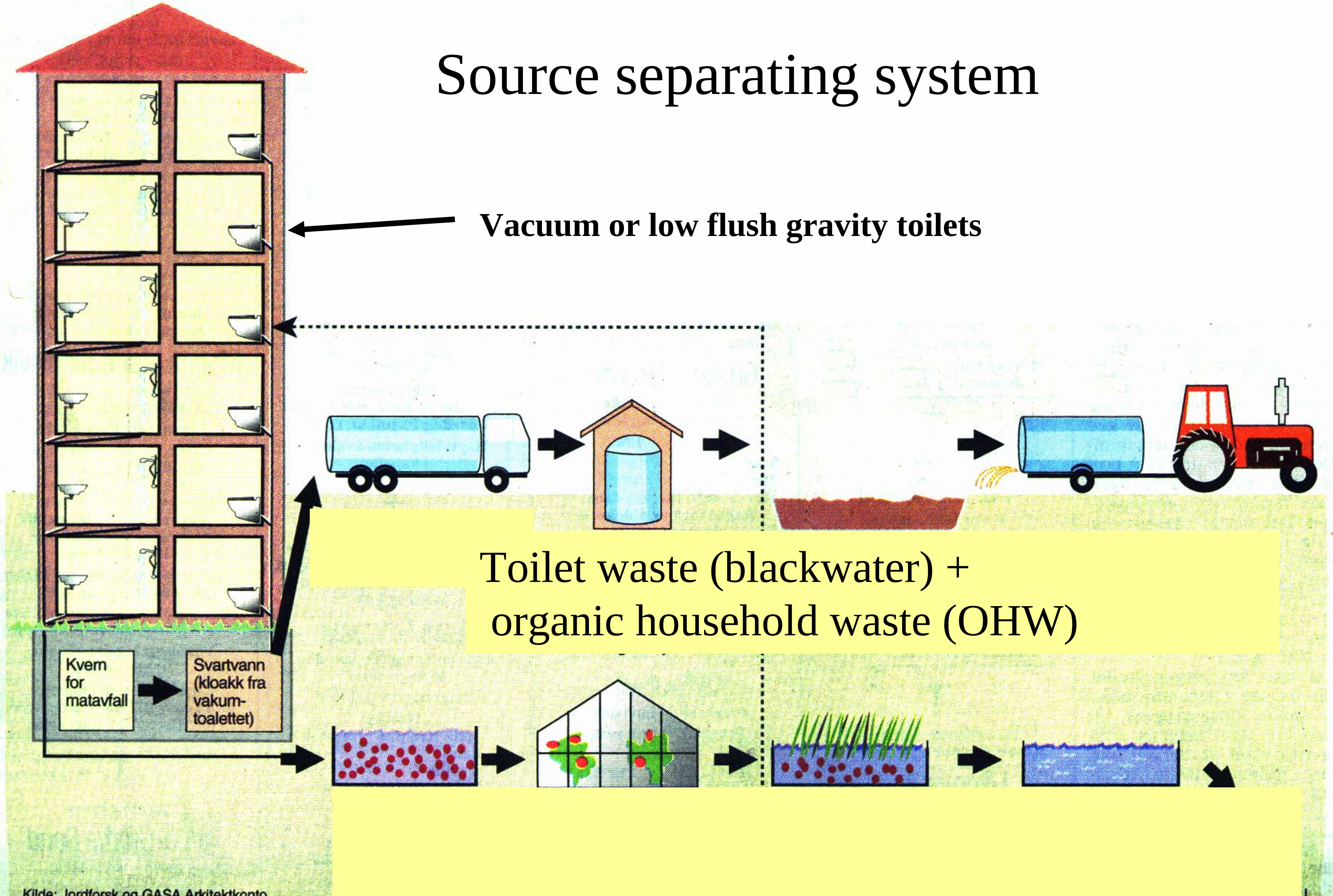
- 1660 vacuum toilets
- > 2km of vacuum sewer line

(Jets ™)

Vacuum toilets - energy use

4 KWh/person and year

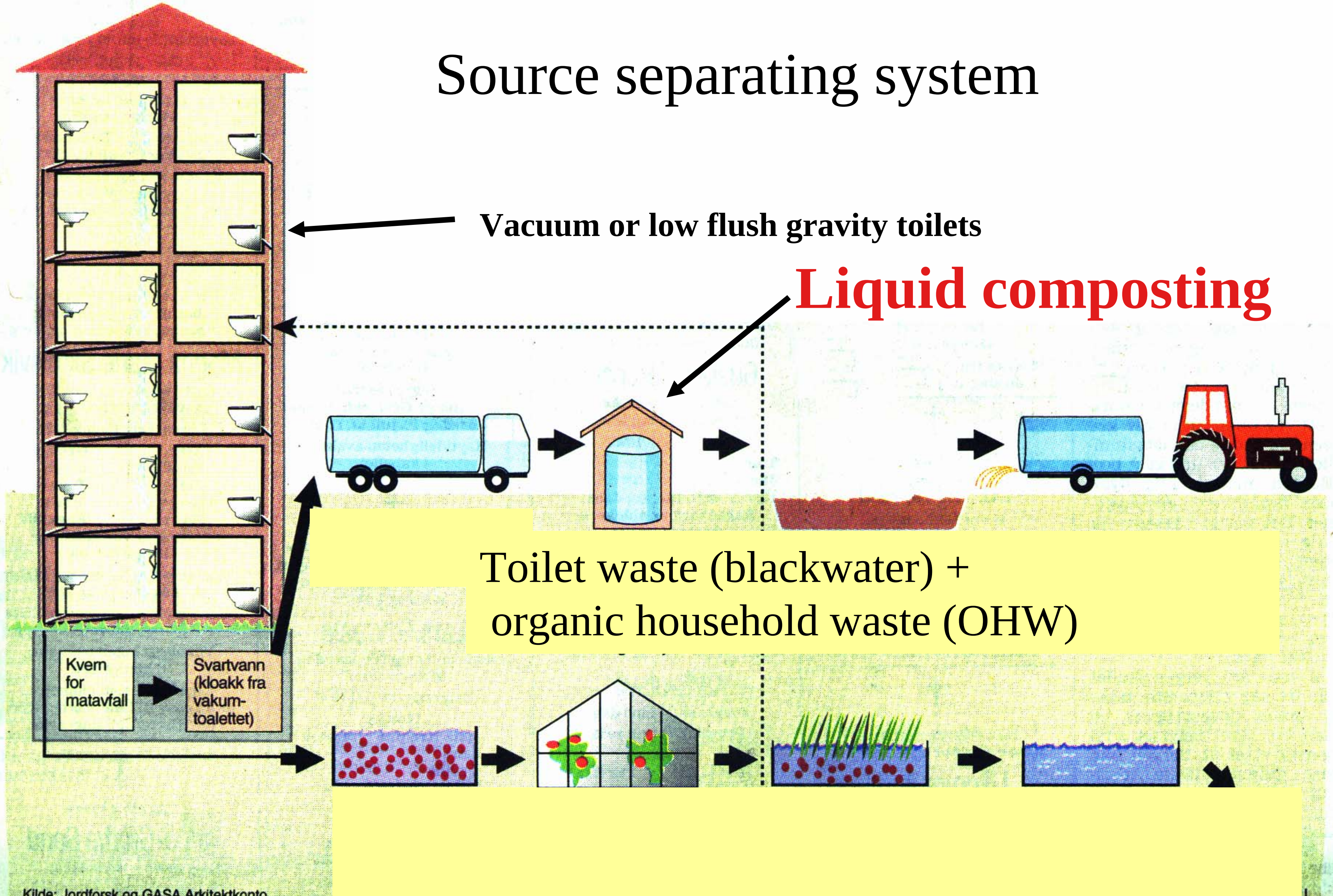
Source separating system



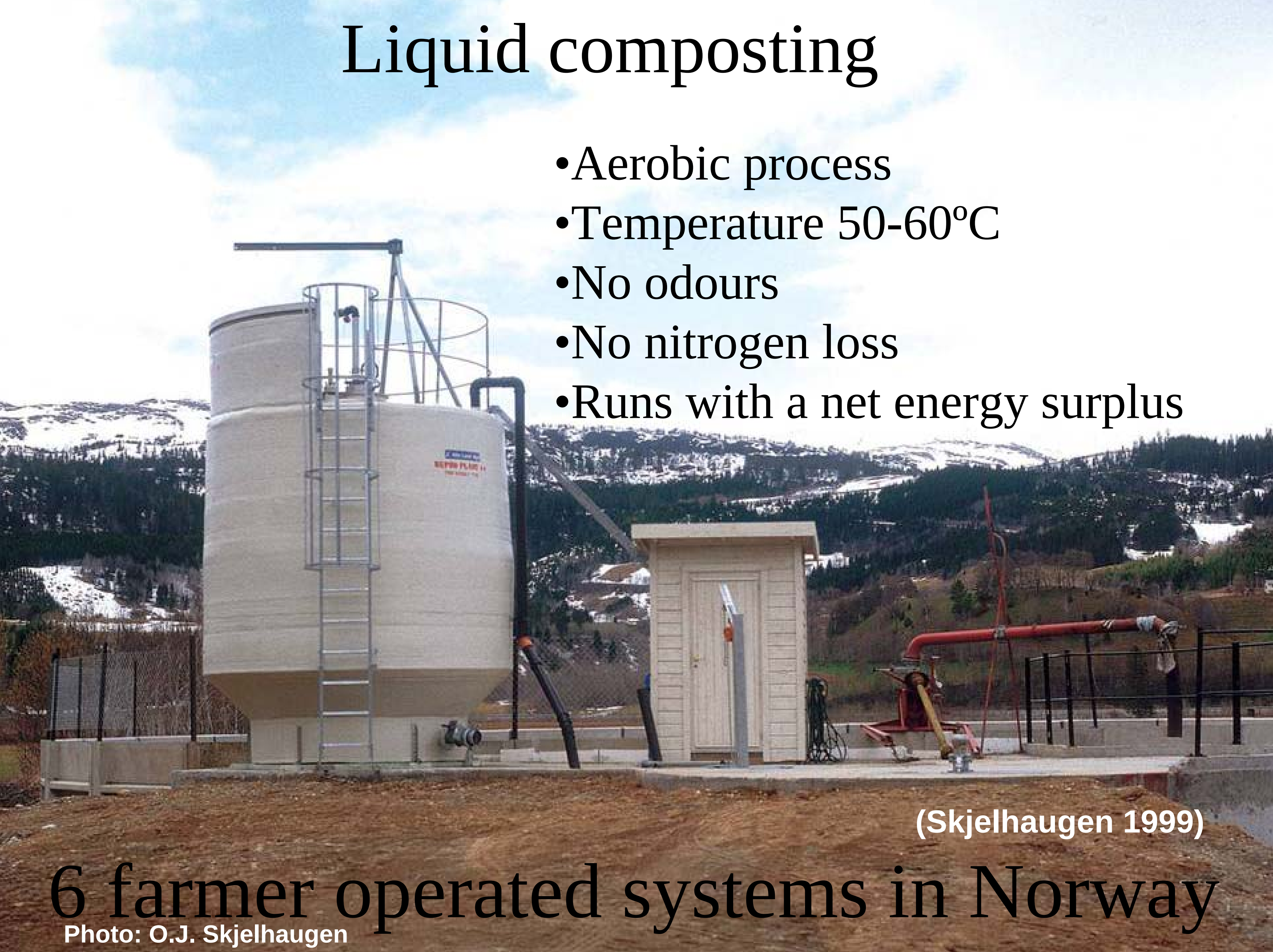
Vacuum or low flush gravity toilets

Toilet waste (blackwater) +
organic household waste (OHW)

Source separating system



Liquid composting



- Aerobic process
- Temperature 50-60ºC
- No odours
- No nitrogen loss
- Runs with a net energy surplus

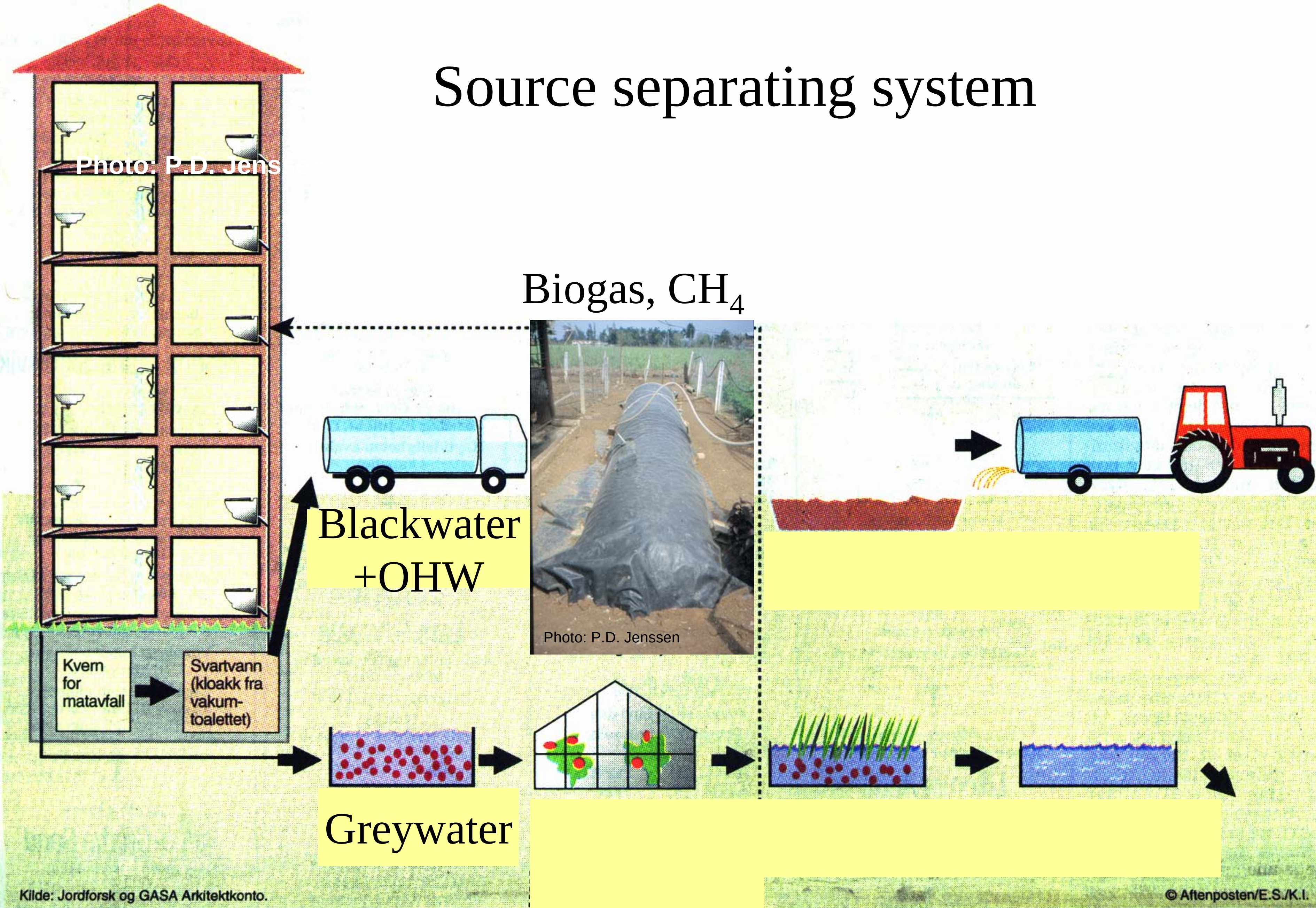
(Skjelhaugen 1999)

6 farmer operated systems in Norway

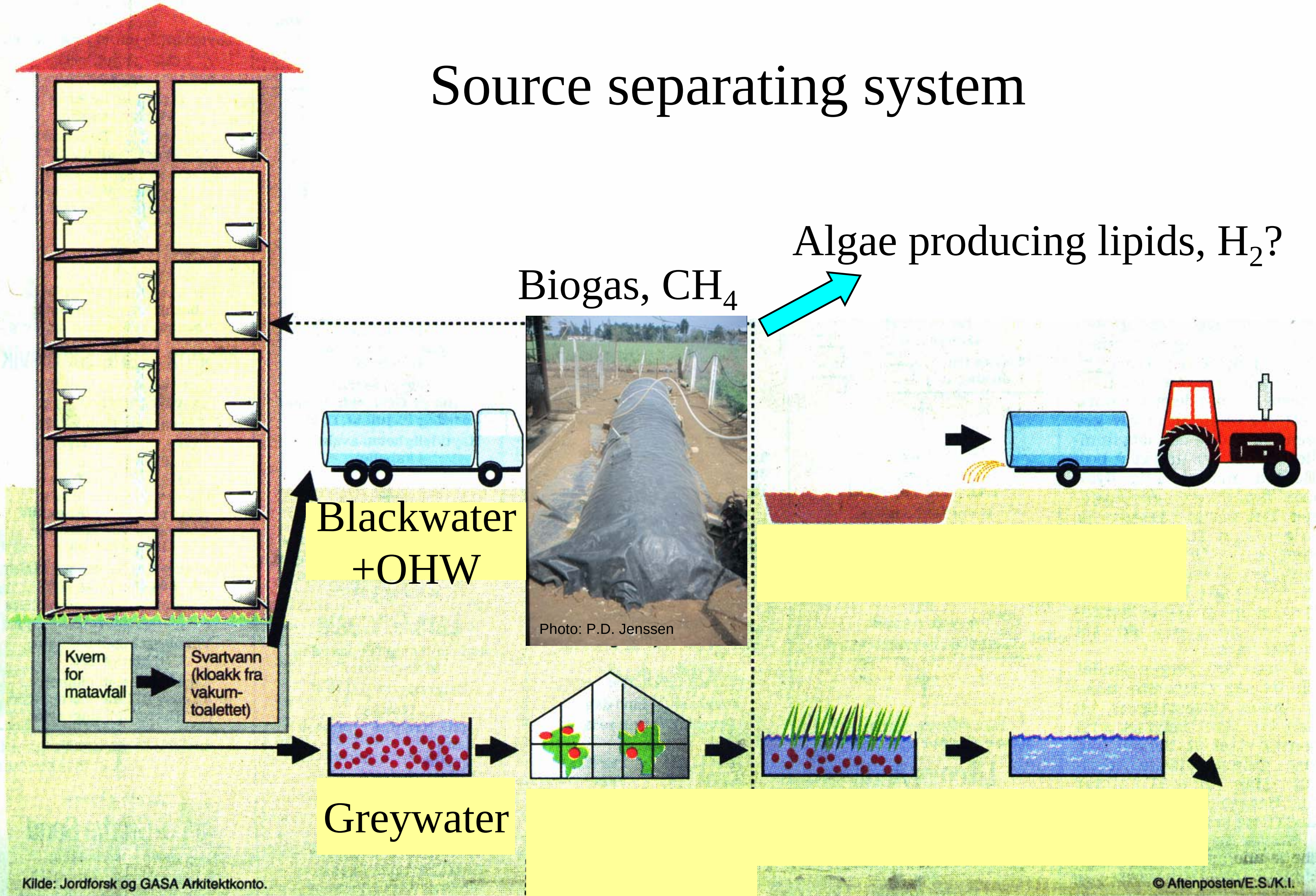
Photo: O.J. Skjelhaugen

Liquid composting at Norrtälje Municipality, Sweden

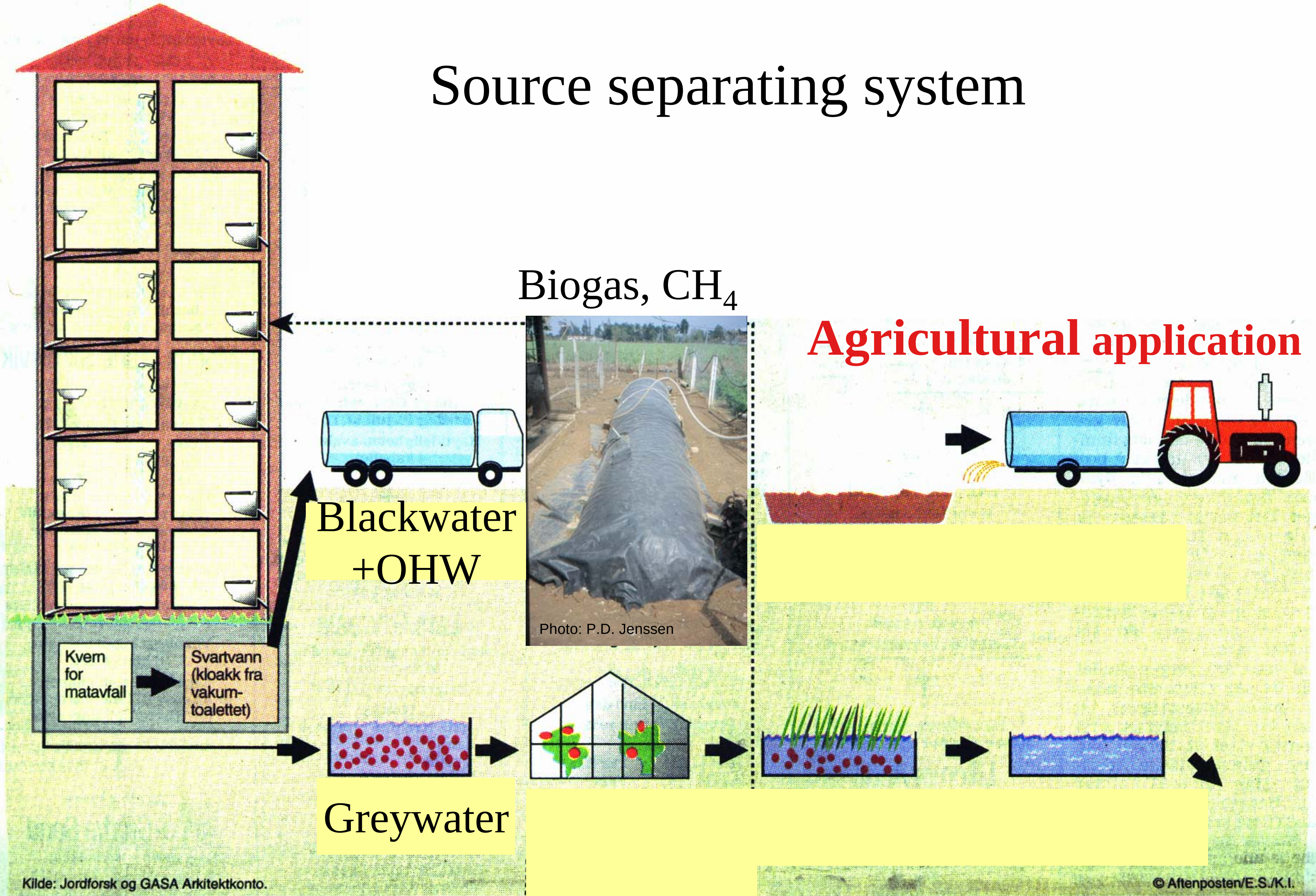
Source separating system



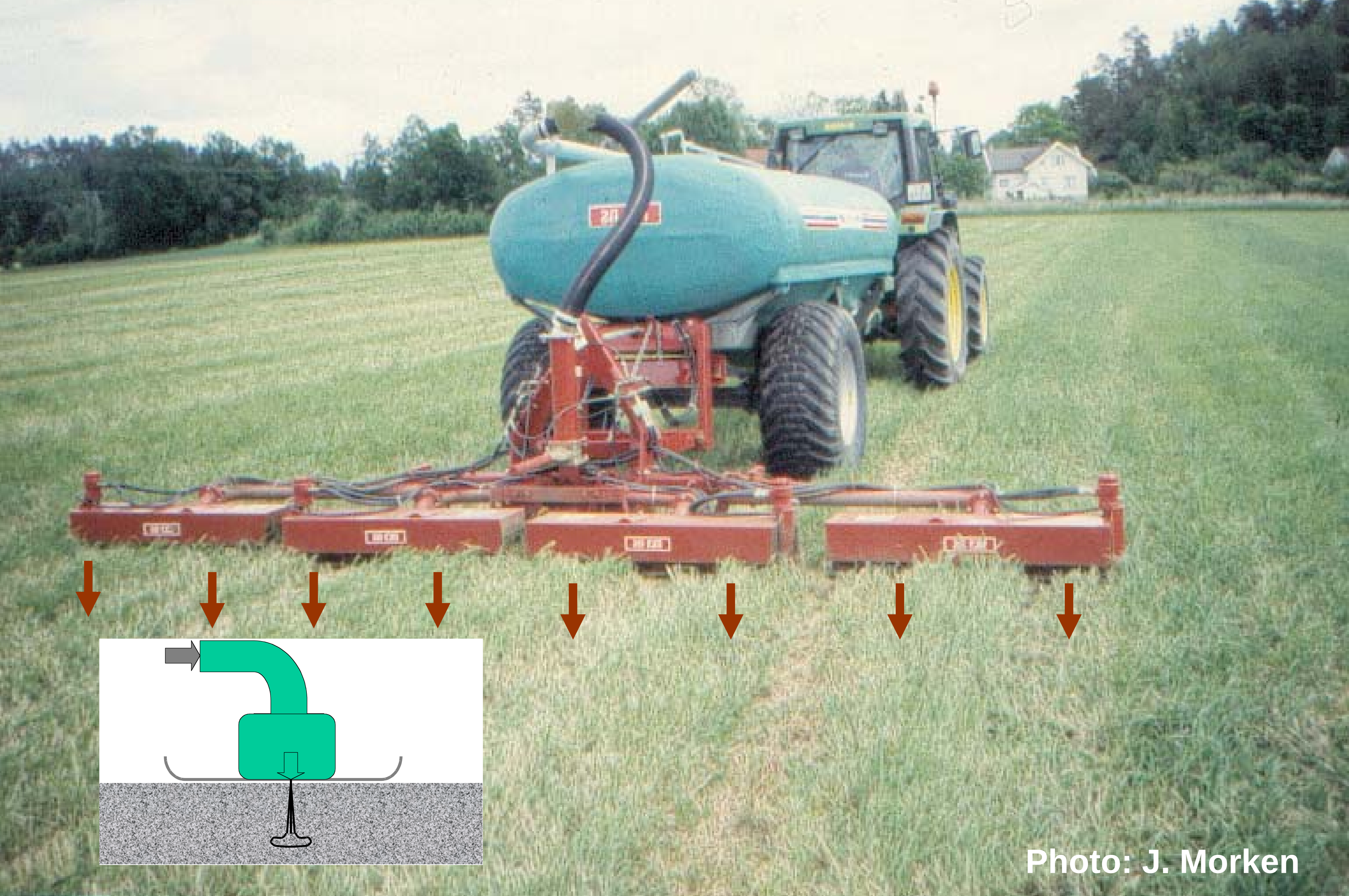
Source separating system



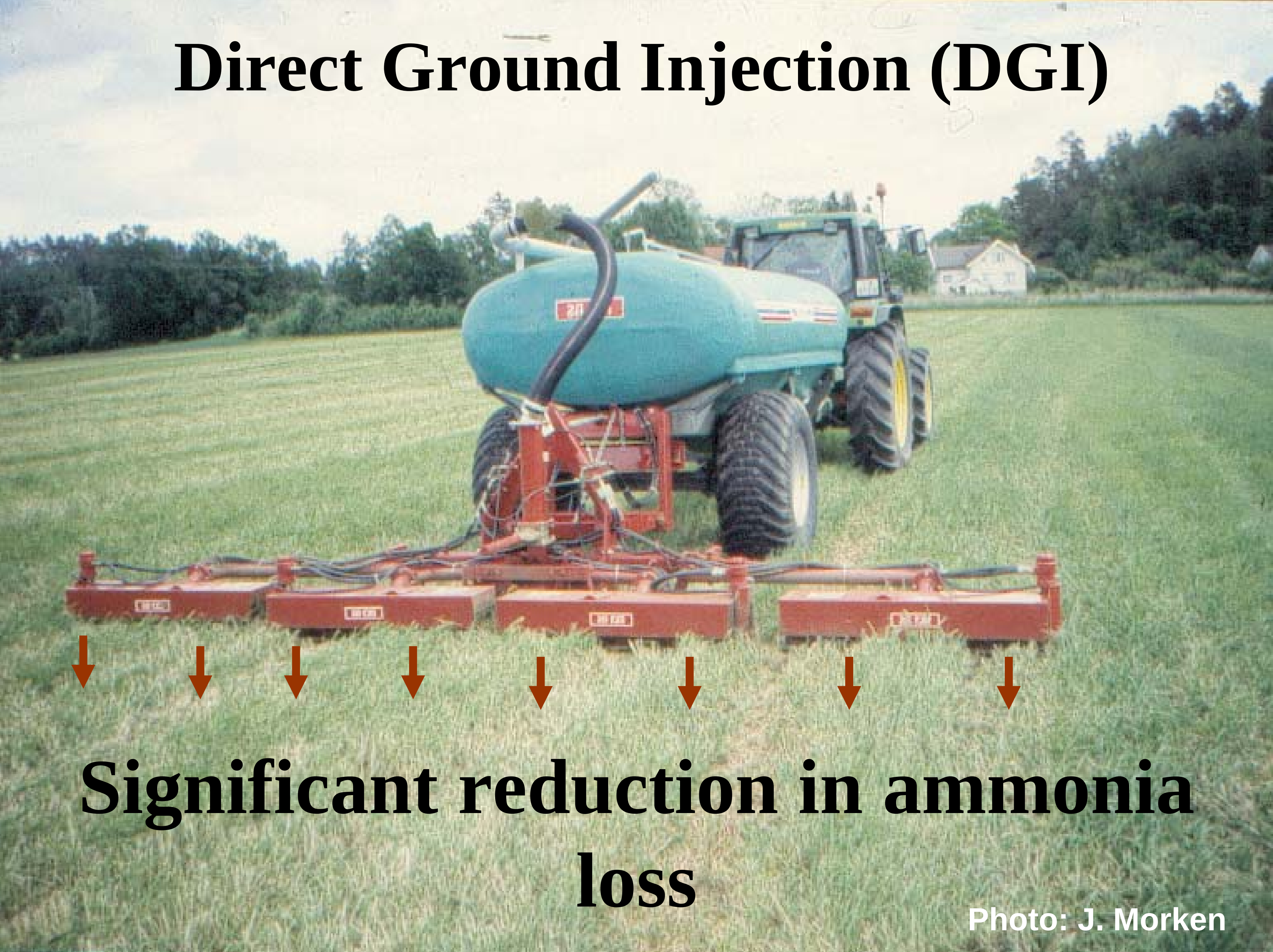
Source separating system



Direct Ground Injection (DGI)



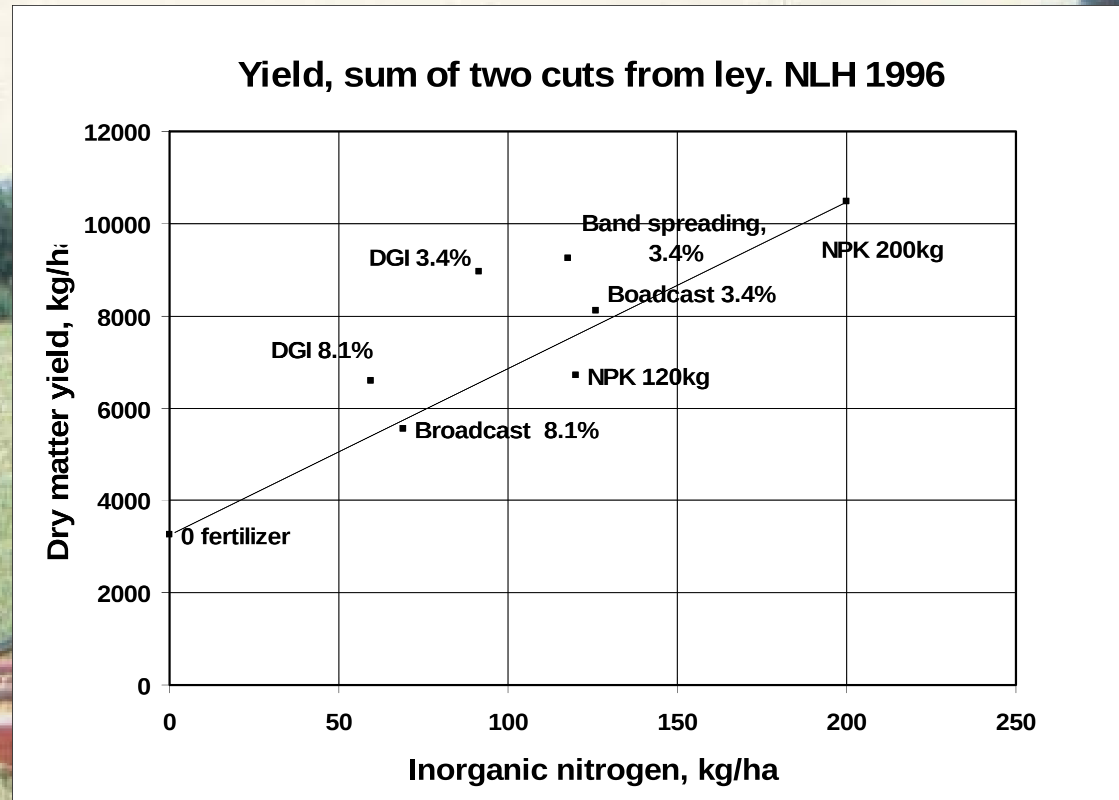
Direct Ground Injection (DGI)



Significant reduction in ammonia loss

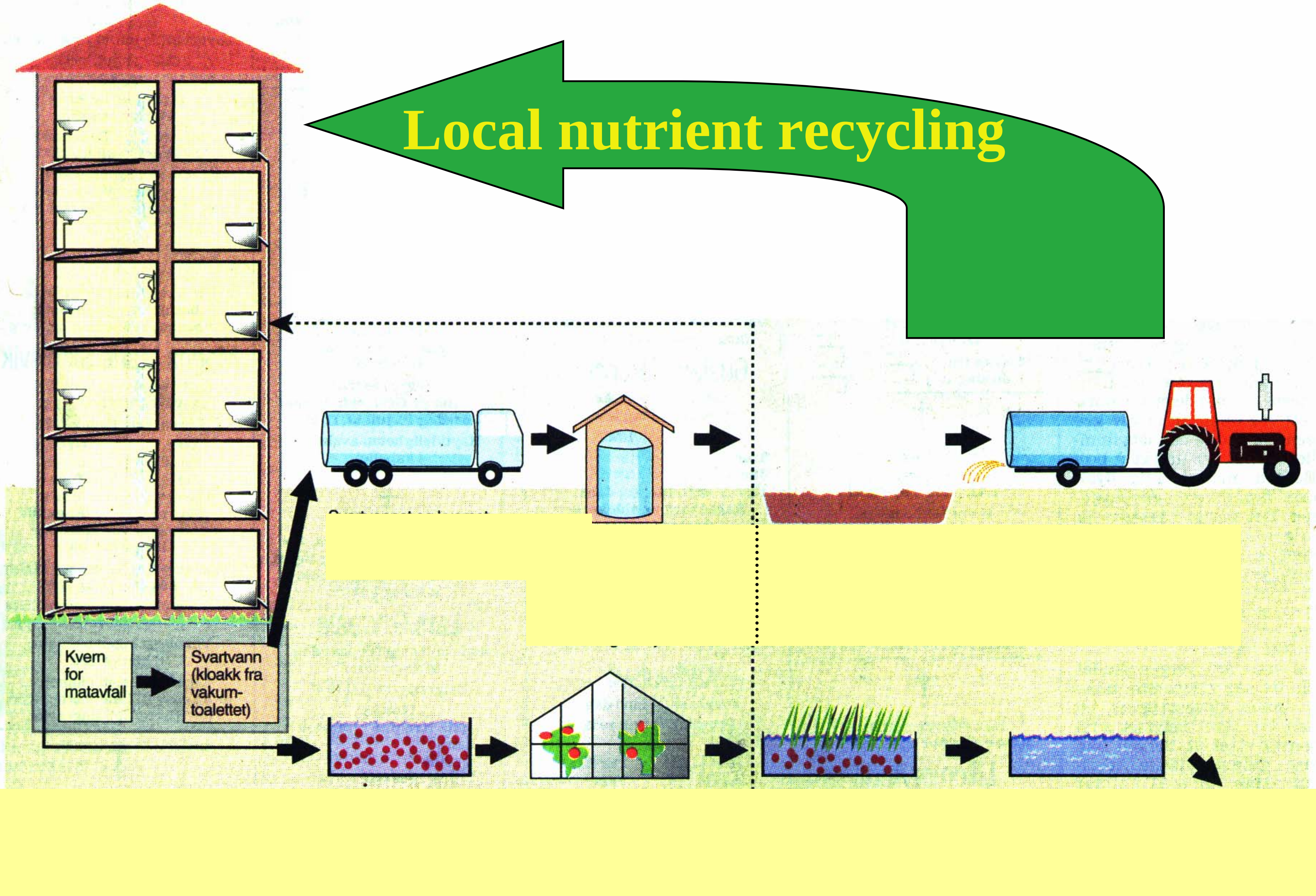
Photo: J. Morken

Direct Ground Injection (DGI)

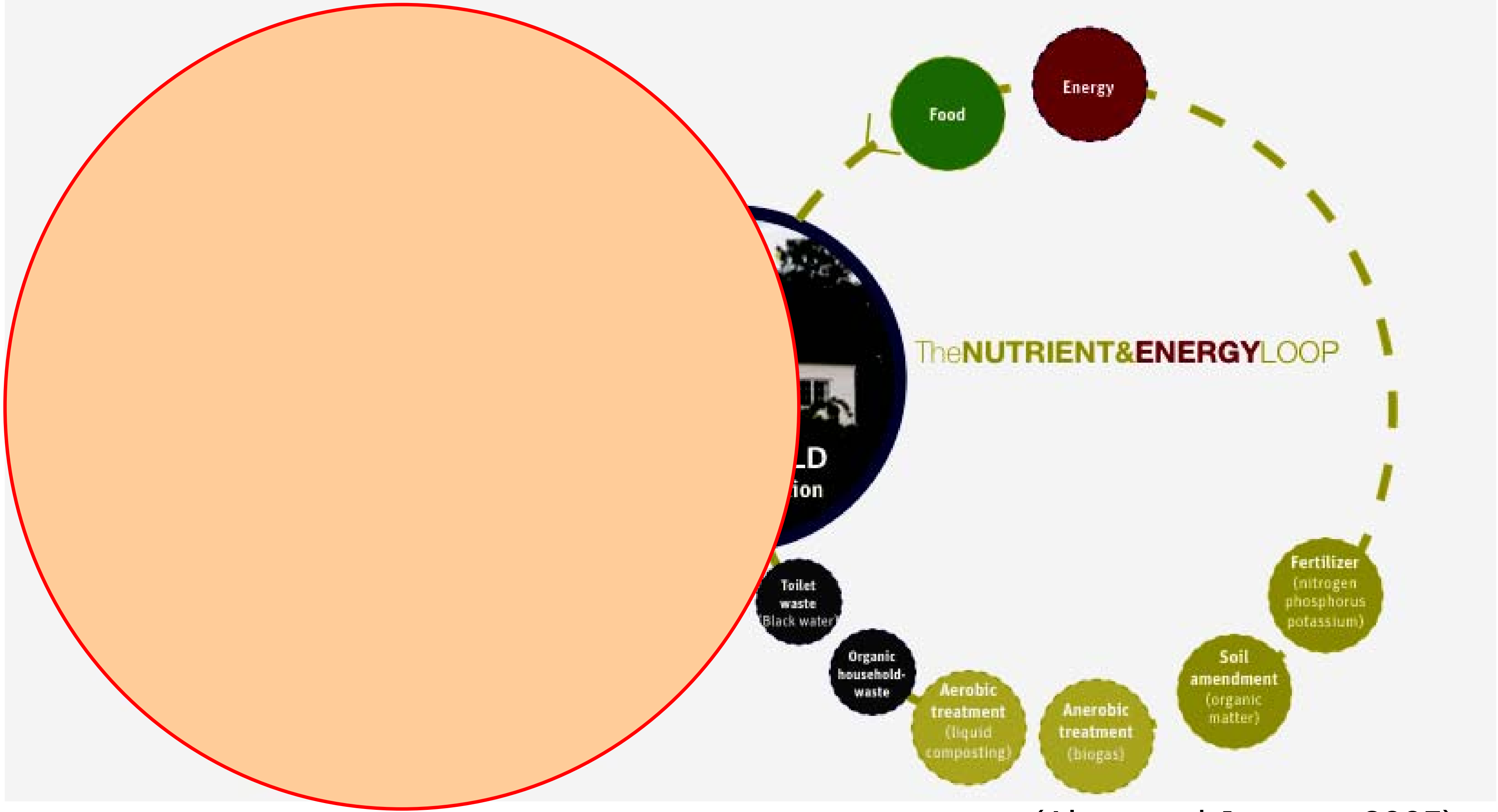


Yields comparable to mineral fertilizer (Morken 1998)

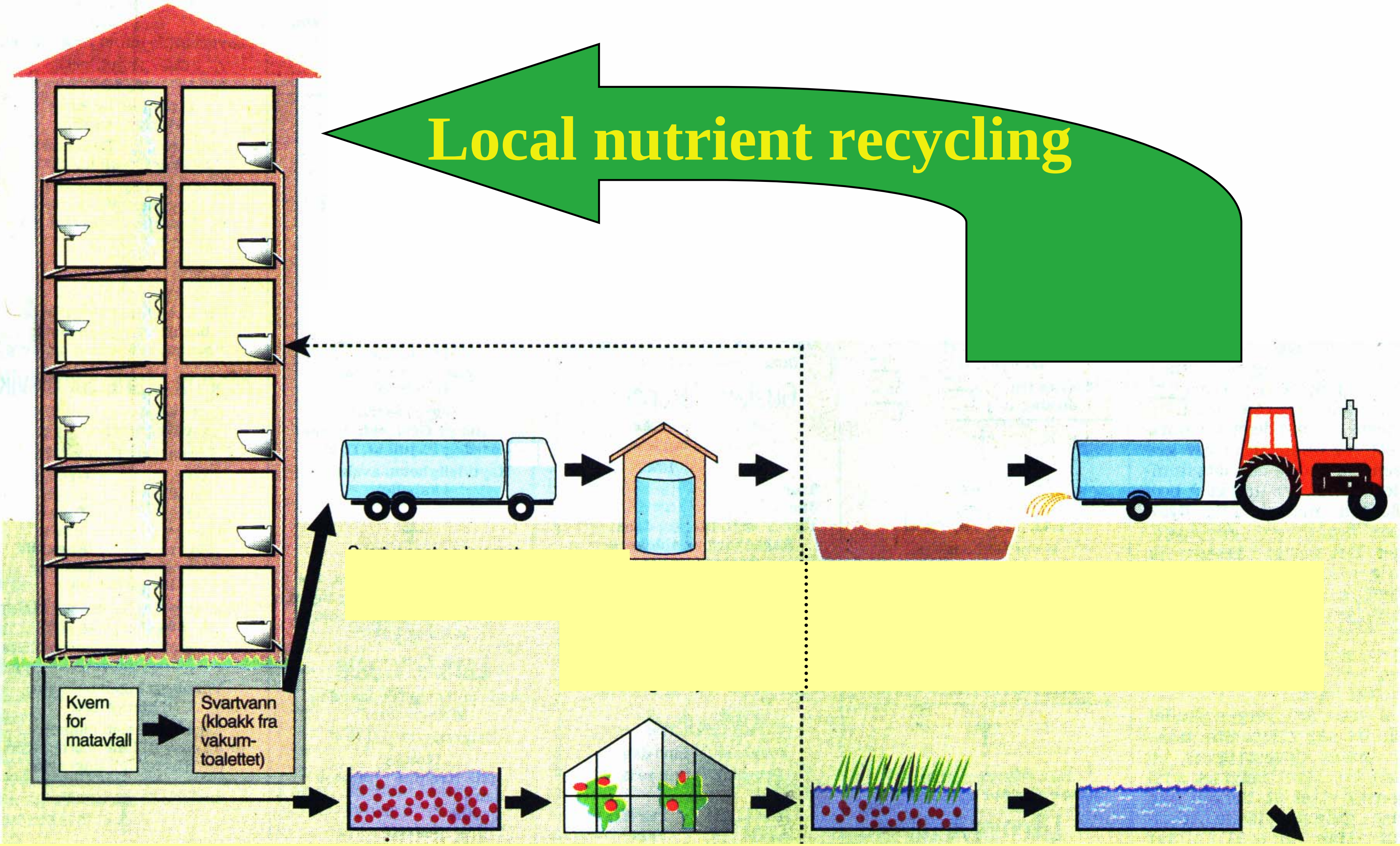
Photo: J. Morken


Local nutrient recycling
Kvern for matavfall
Svartvann (kloakk fra vakum-toalettet)

Source separation of wastewater

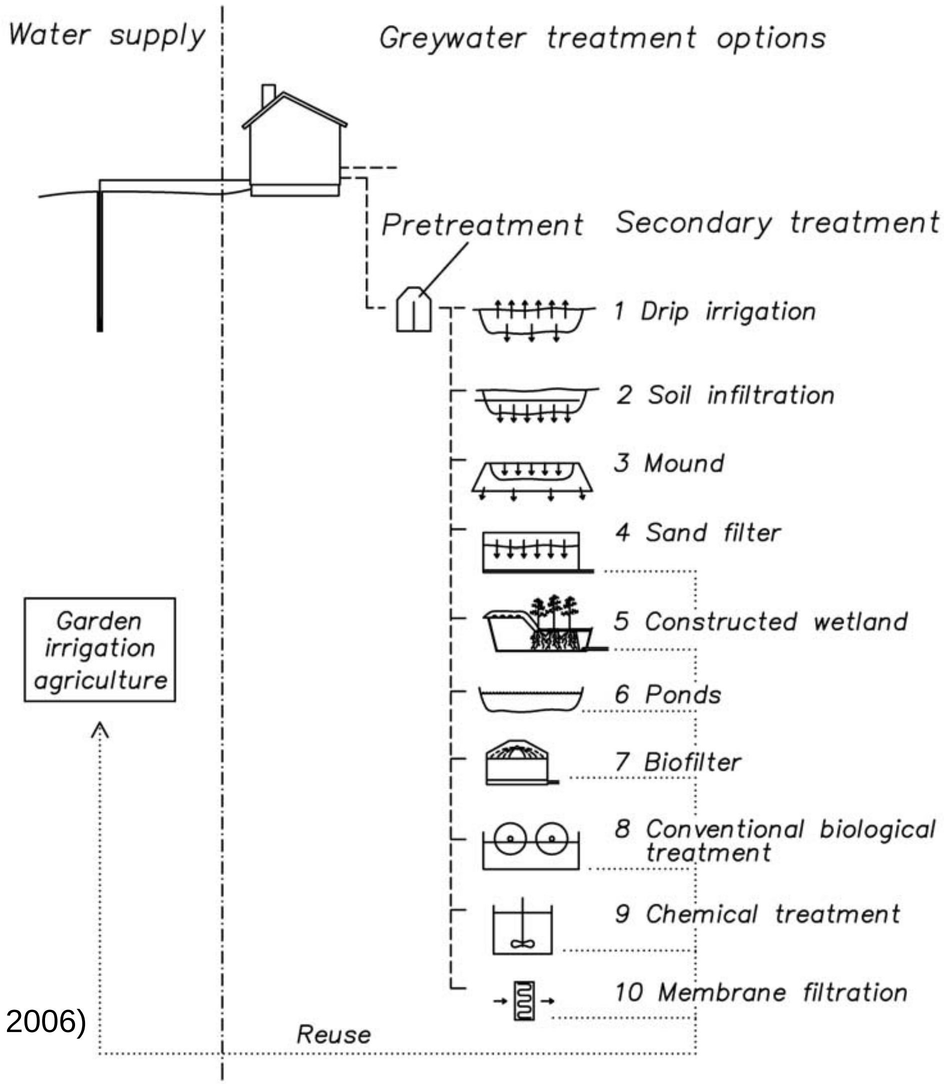


(Alsen and Jenssen 2005)



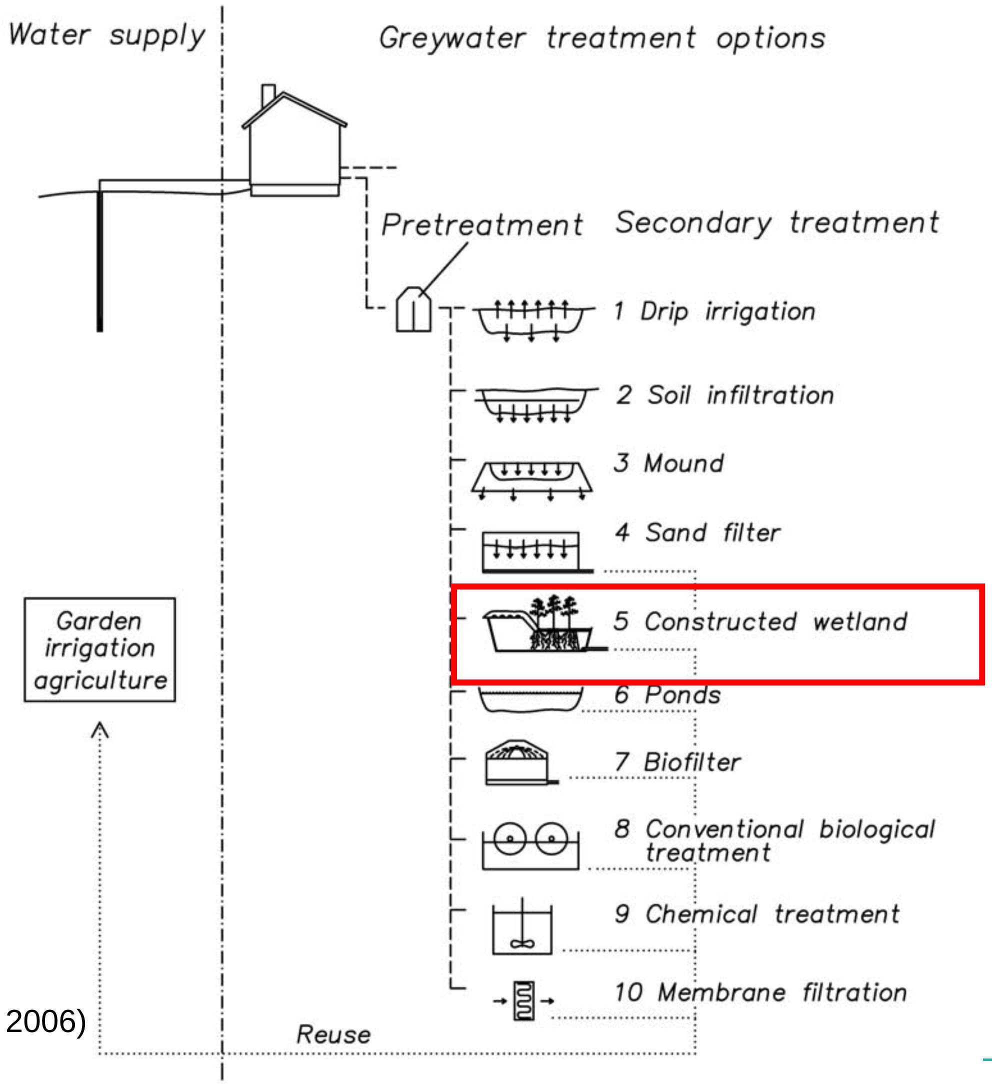
Greywater treatment

Greywater treatment options



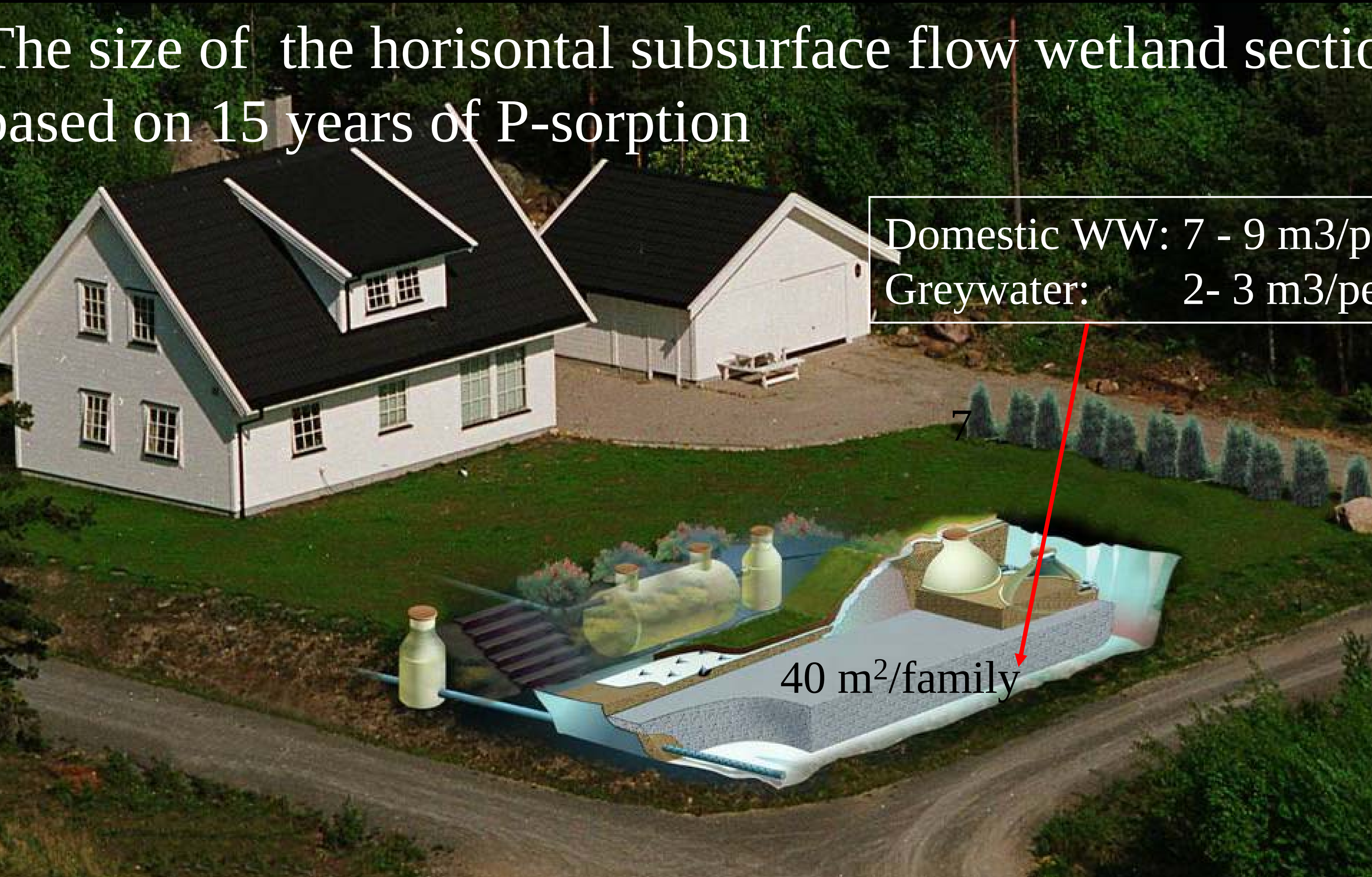
(Illustration: Jenssen et al. 2006)

Greywater treatment options



(Illustration: Jenssen et al. 2006)

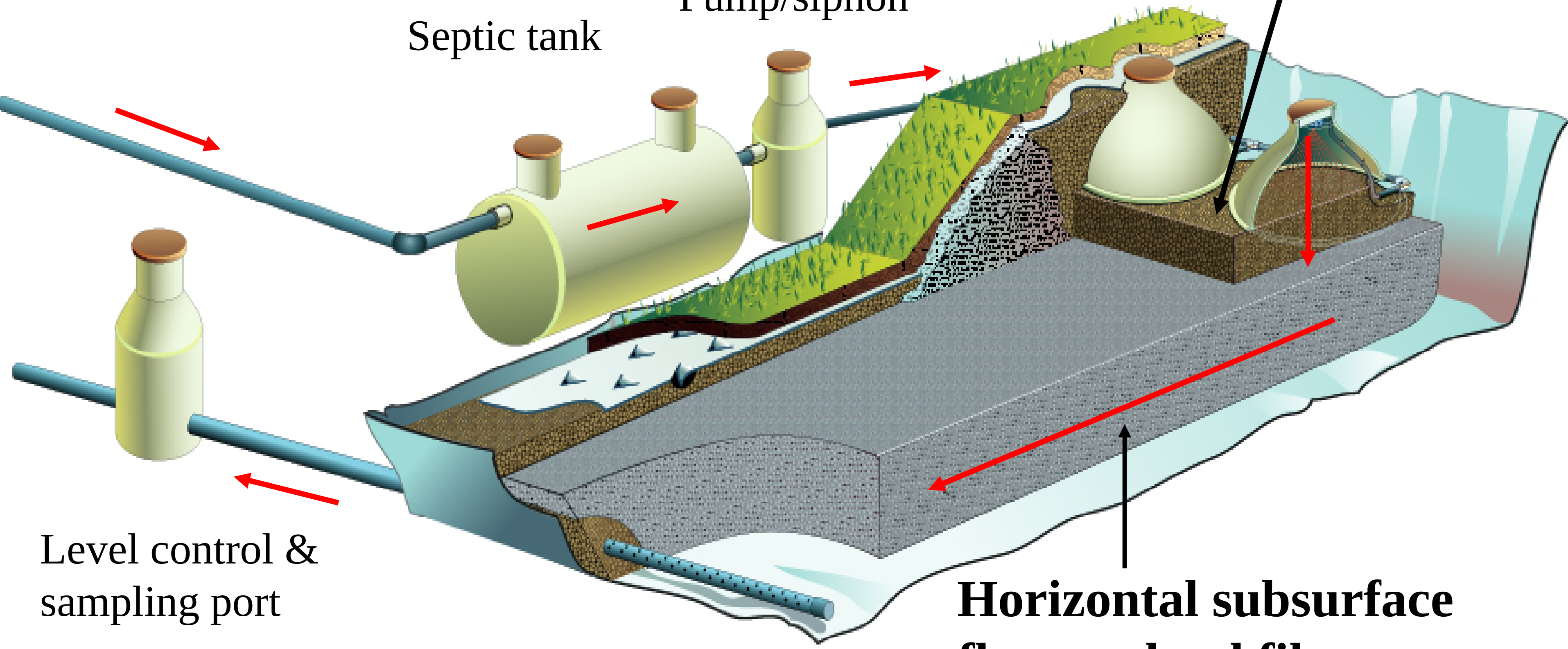
The size of the horisontal subsurface flow wetland section based on 15 years of P-sorption



(Illustration: Maxit Group)


Greywater - 1/4 the area of greywater +WC
(Photo: P.D. Jenssen

Greywater treatment



(Jenssen and Vråle 2004)


1st chamber of
the septic tank
Pump
chamber
Final discharge
Photo: Y. Fevang

Ecosan Norway - Domestic project examples

Location	Construction year	Blackwater vacuum / gravity	Urine diversion	Persons served
UMB Ås	1998	x		48
Bergen	1998-2000	x		150
Oslo	2000	x		100
Frogn	2003 - 2009	x	x	800
Oslo	2006 - 2008		x	350
UMB Ås	2005 - 2015	x	x	5000
Vang	2006 - 2015	x		3500

Student dormitories in Norwa

27% water saving (Jenssen et al. 2003)

Wastewater production/person and day

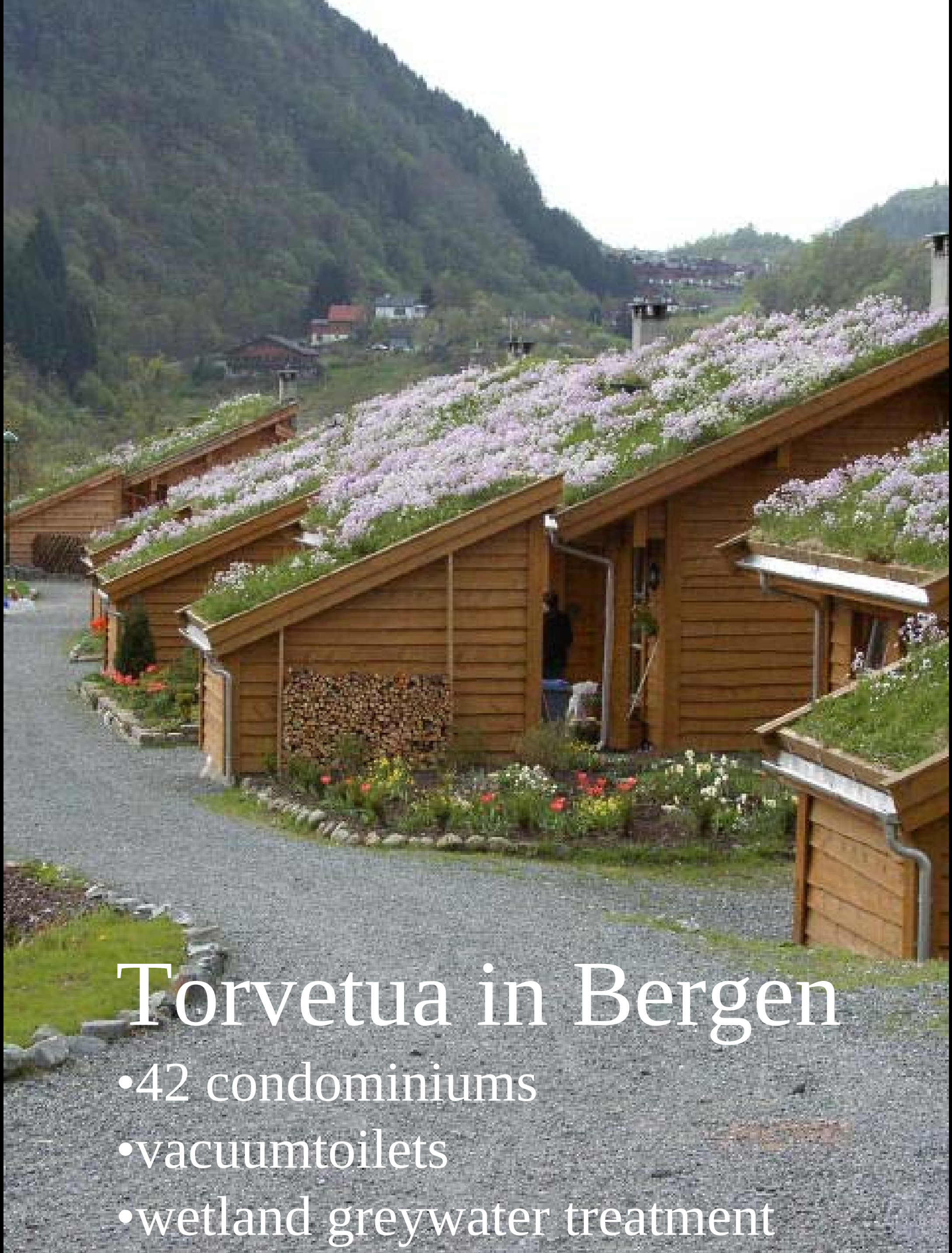
Photo: P.D. Jenssen

Greywater treatment student housing Norway
Effluent values

Total - P	0,04 mg/l
Total - N	2,2mg/l
BOD	3,9 mg/l
Termotolerant coli	<100

(Jenssen and Vråle 2004)

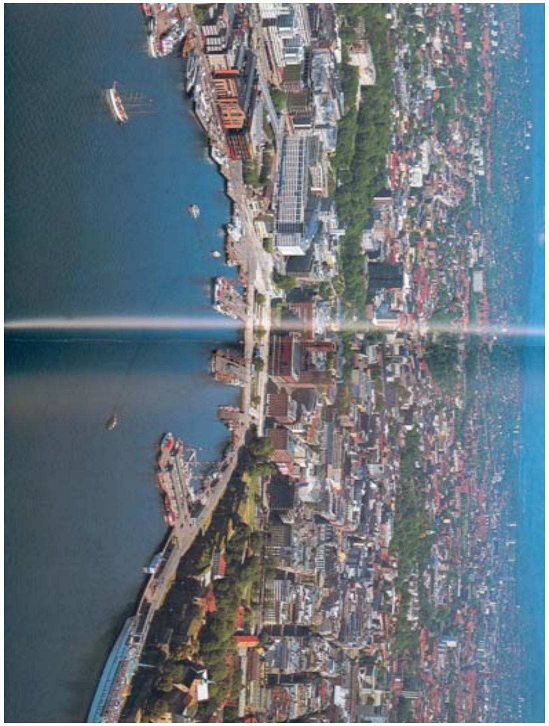
Foto: P. Jenssen



Torvetua in Bergen

- 42 condominiums
- vacuumtoilets
- wetland greywater treatment

Contemporary Scandinavian bathroom design using ecological sanitation



Photos: P.D. Jenssen

Torvetua - Local greywater treatment

Treatment results

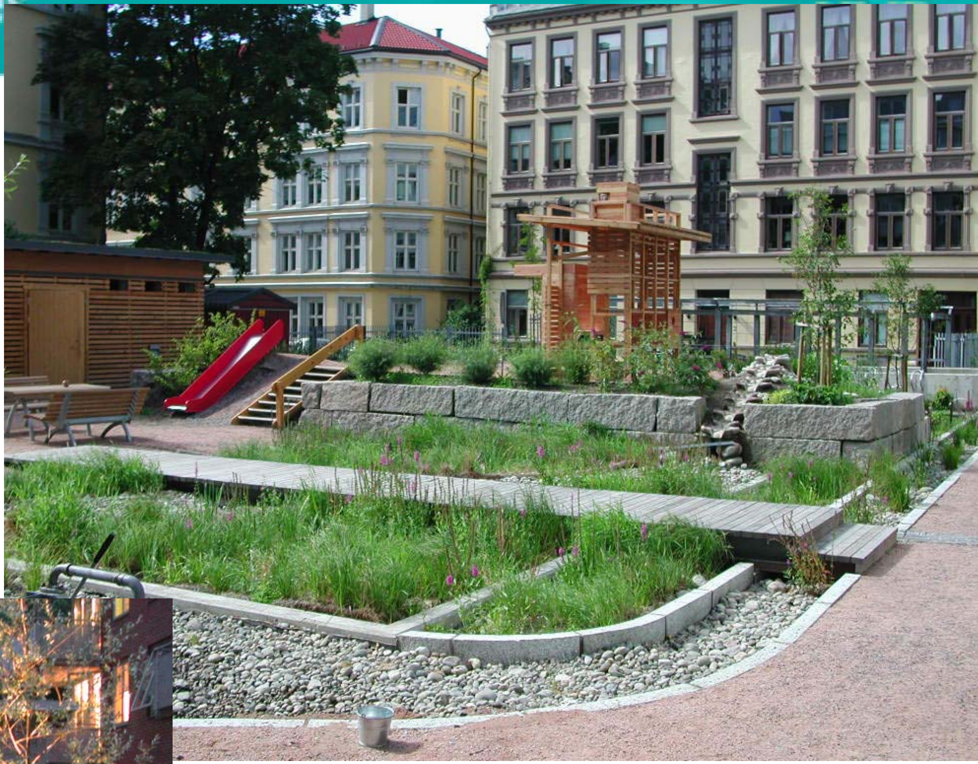
BOD	<10 mg/l	
Phosphorus	0,2 mg/l	> 80 %
Nitrogen:	3,0 mg/l	40 - 70%

Bacteria: swimming water quality

(Jenssen and Vråle 2004)

Ecosan in urban areas - OSLO


Greywater treatment in OSLO
Pretreatment
Biofilter (PBF)
Horisontal
subsurface
flow
Constructed
Wetland
• 33 apartments
• 100 persons
• Area 1m²/person
Photo: P. D. Jenssen

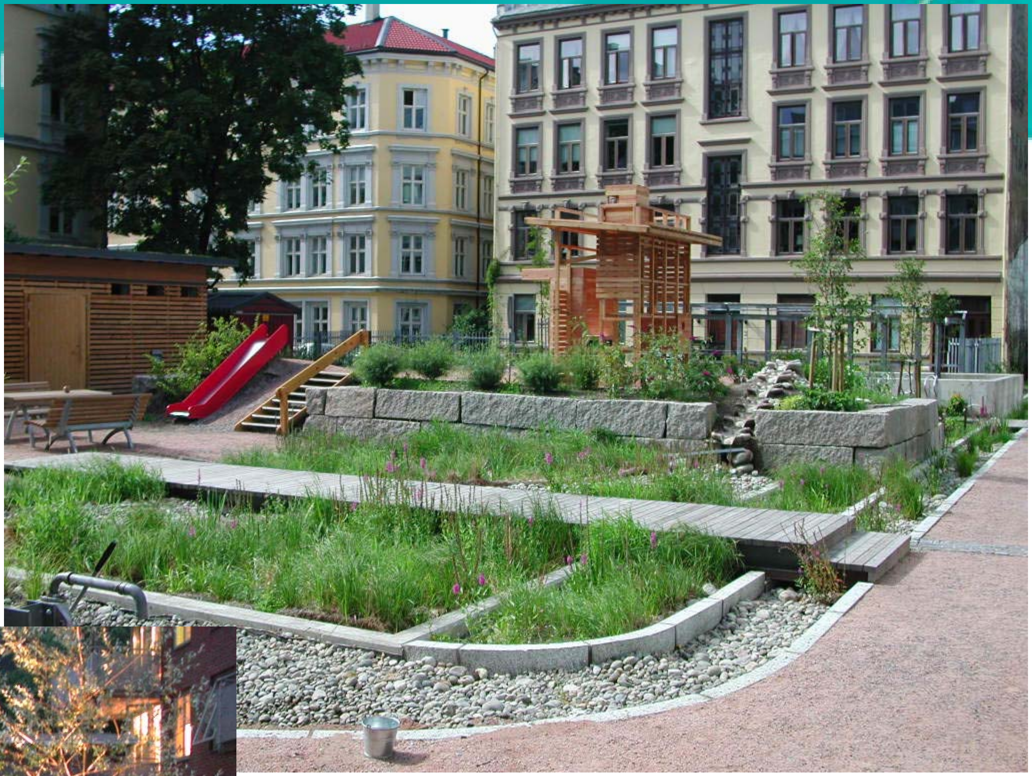


Photos: P. D. Jenssen

Greywater treatment at Klosterenga Oslo

Effluent values:

Fecal coliforms:	<2
BOD	< 5 mg/l
Total-N:	2,5 mg/l
Total-P:	0,02 mg/l



The effluent meets:

*** DRINKING WATER QUALITY**
with respect to nitrogen and
*** SWIMMING WATER QUALITY**
with respect to bacteria

(Jenssen and Vråle 2004)

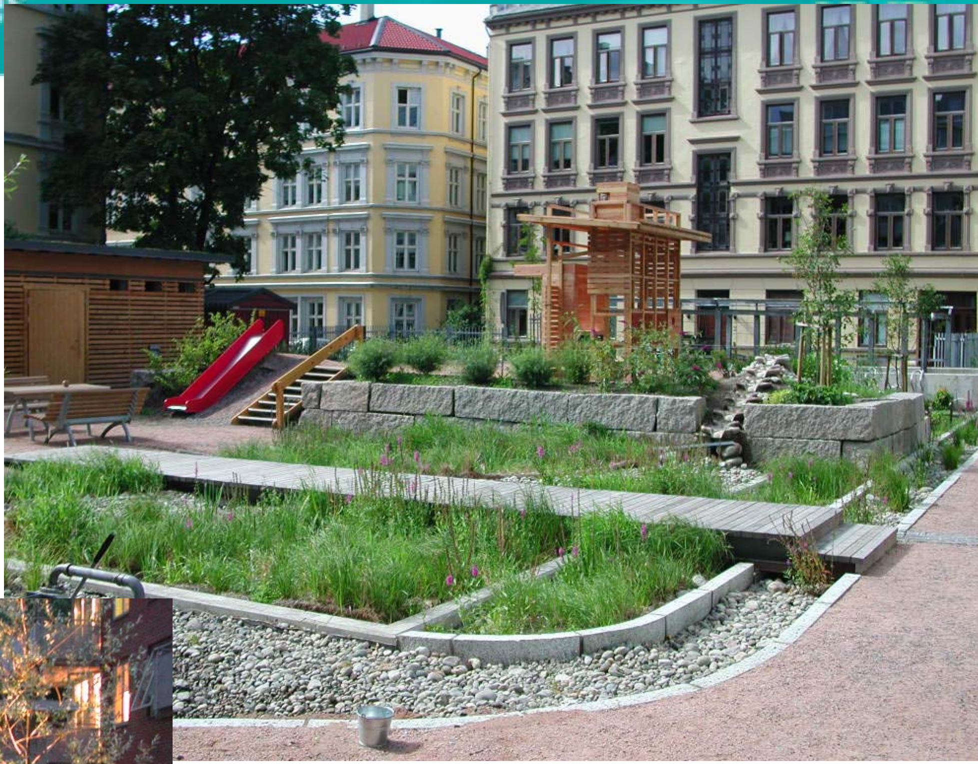
www.ecosan.no

Photos: P. D. Jenssen

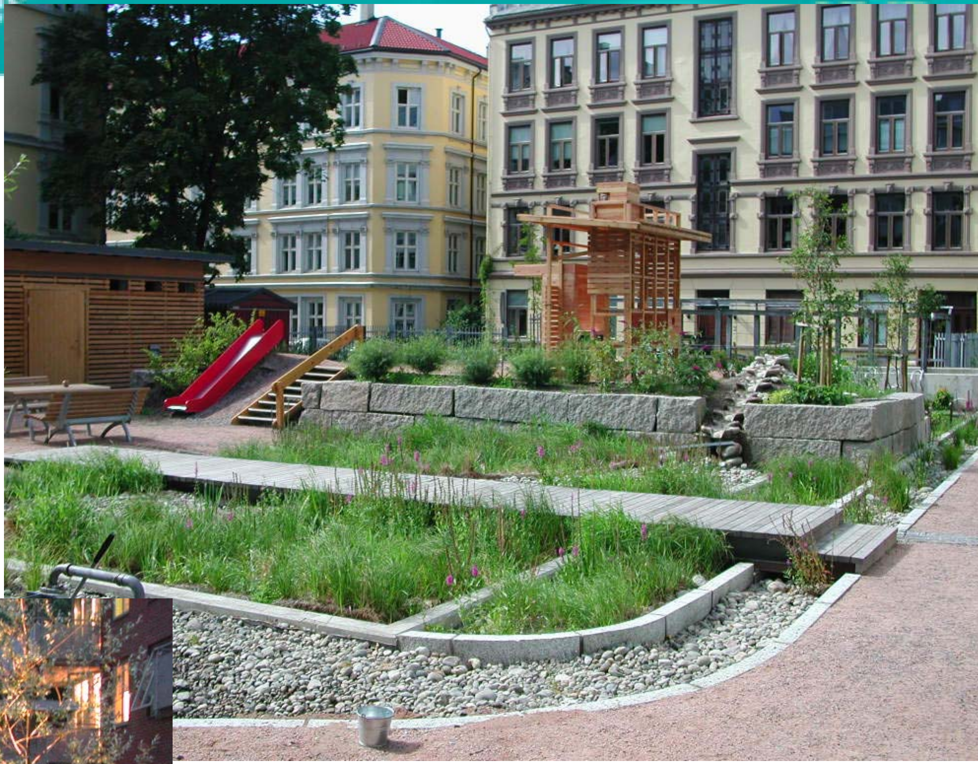
Greywater treatment at Klosterenga Oslo

Effluent values:

Fecal coliforms:	<2
BOD	< 5 mg/l
Total-N:	2,5 mg/l
Total-P:	0,02 mg/l



Local discharge



Irrigation

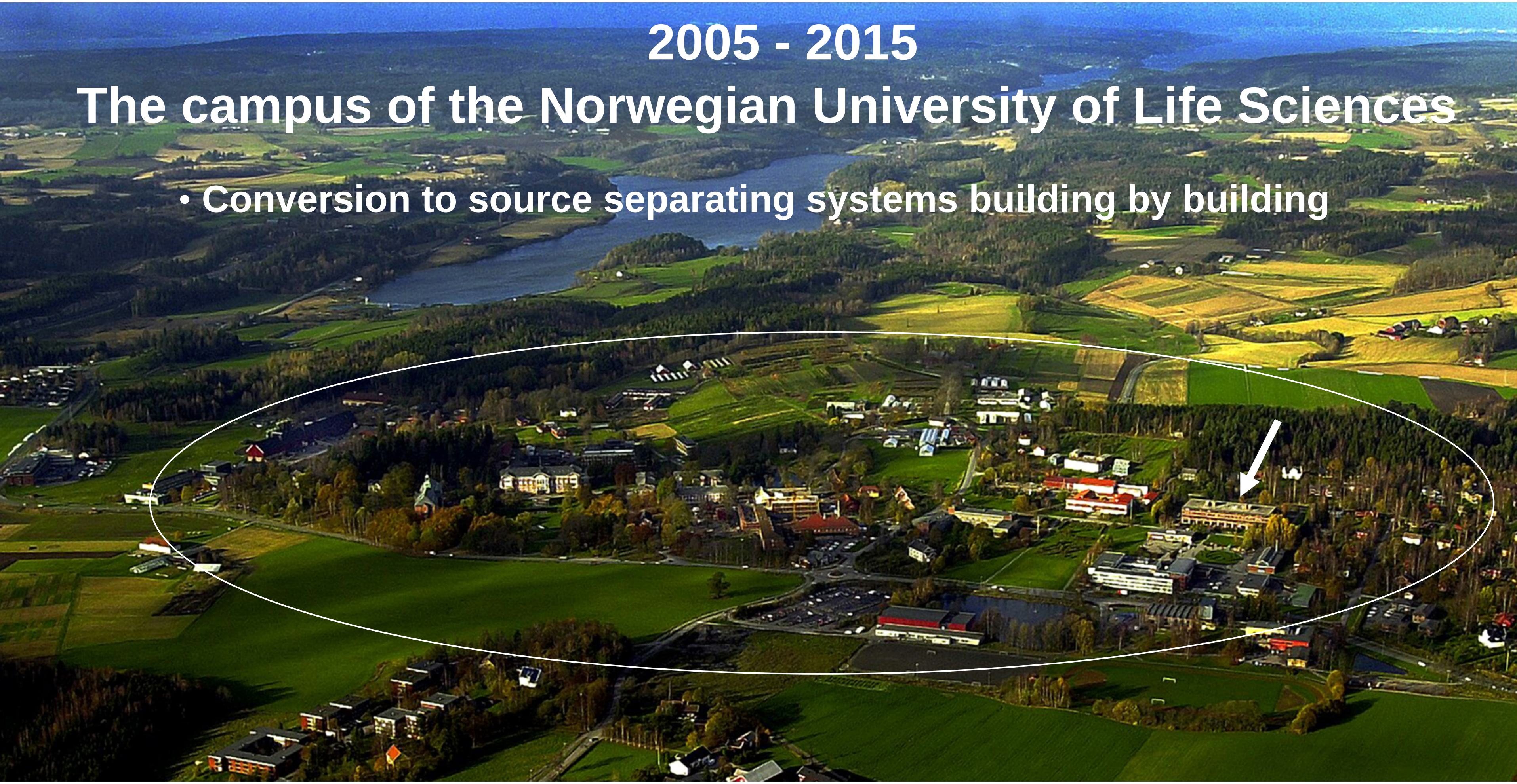
Photos: P.D. Jenssen

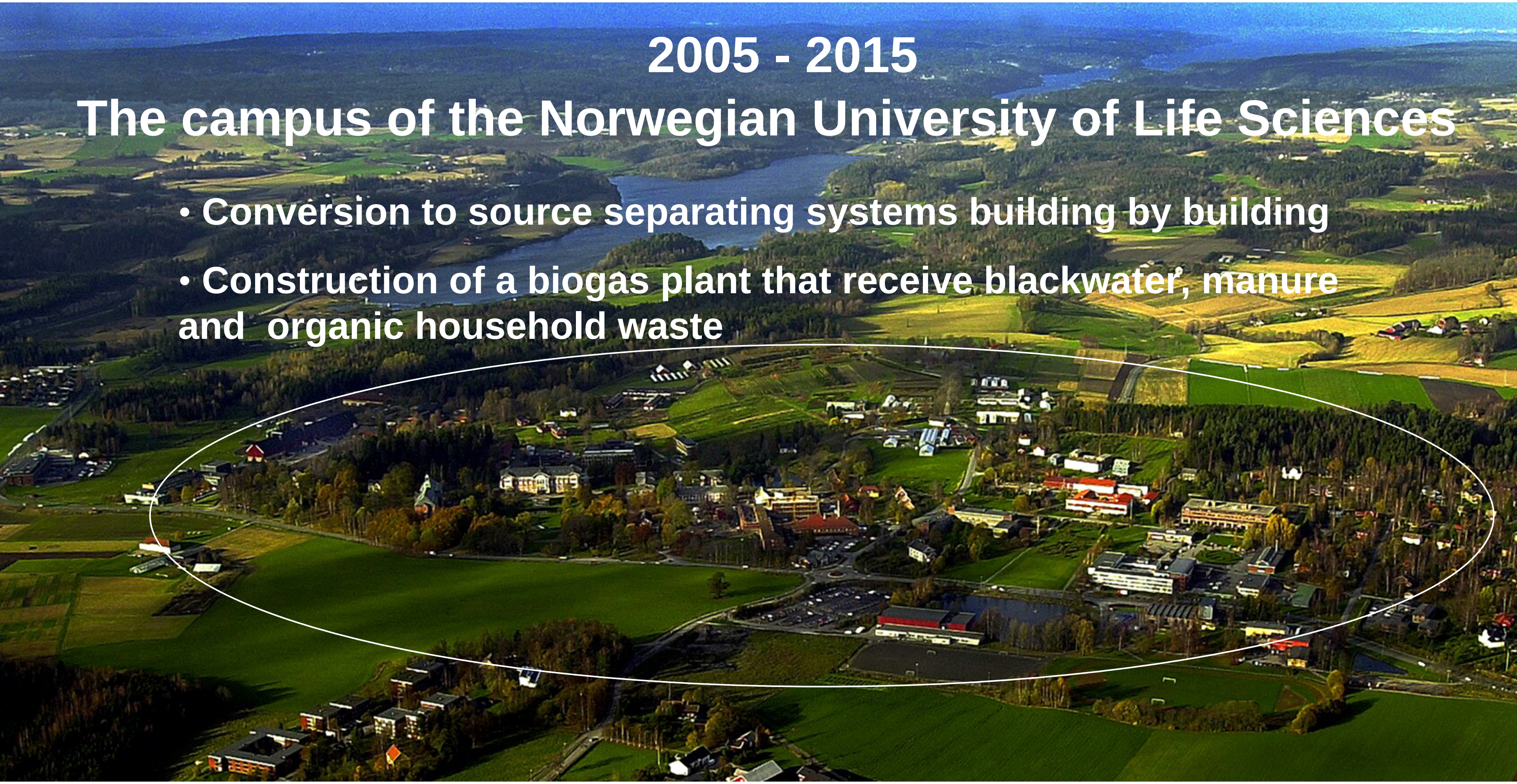
Groundwater recharge

2005 - 2015

The campus of the Norwegian University of Life Sciences

- Conversion to source separating systems building by building

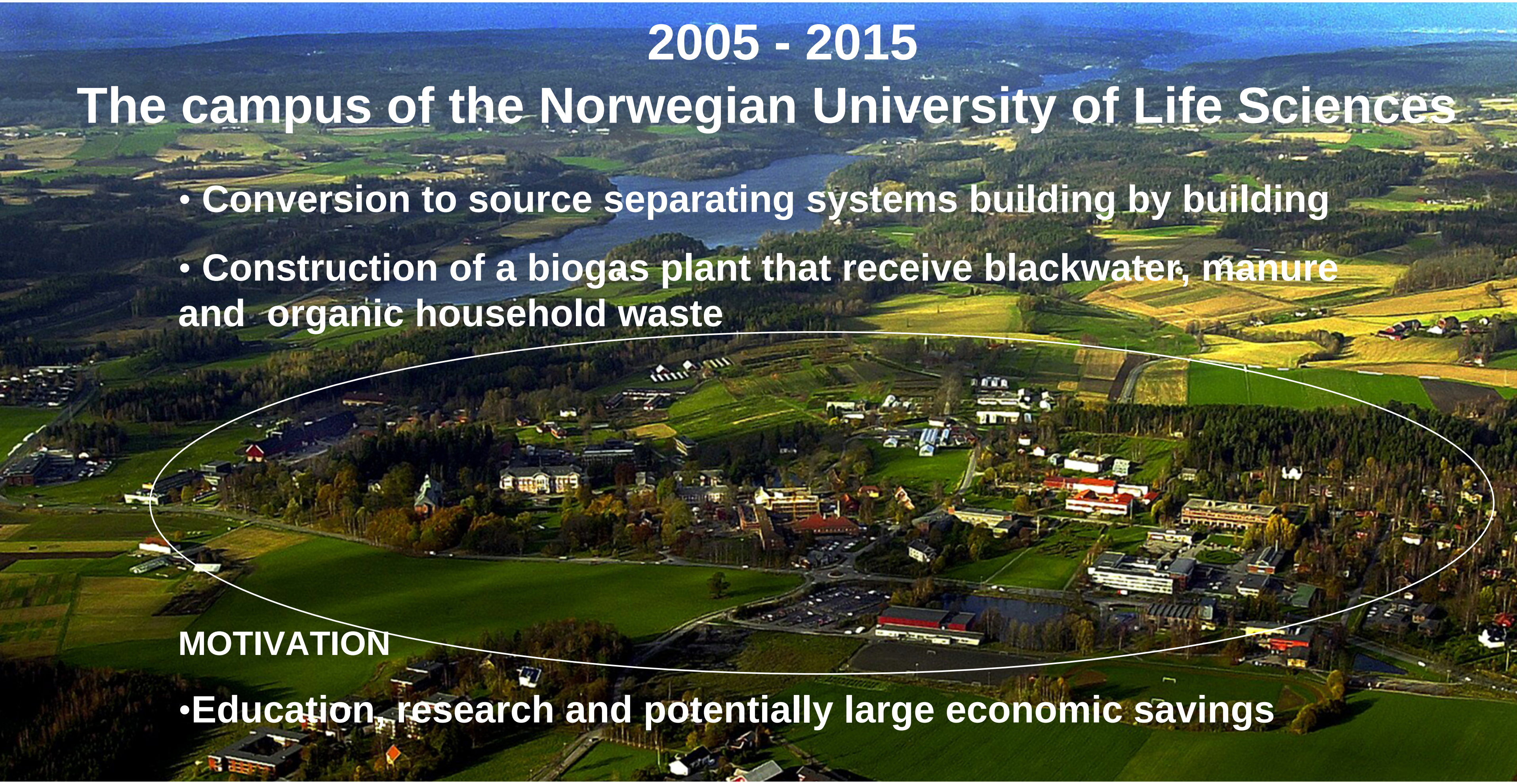




2005 - 2015

The campus of the Norwegian University of Life Sciences

- Conversion to source separating systems building by building
- Construction of a biogas plant that receive blackwater, manure and organic household waste



2005 - 2015

The campus of the Norwegian University of Life Sciences

- Conversion to source separating systems building by building
- Construction of a biogas plant that receive blackwater, manure and organic household waste

MOTIVATION

- Education, research and potentially large economic savings

Norwegian University of Life Sciences

Oppdatert: 040105

2006 - 2008
Øverland - suburban Oslo

- 100 flats with urine diverting double flush toilets
- Wetland treatment of faeces and greywater

MOTIVATION

- An example of modern environmentally friendly sanitary solutions
- Integration and cooperation with agriculture
- Promoting The Royal Norwegian Society for Rural Development

Grindafjell: 2006 - 2115

- 900 cabins (3600 persons)
- Individual vacuum toilets and greywater treatment systems

Grindafjell: 2006 - 2115

- 900 cabins (3600 persons)
- Individual vacuum toilets and greywater treatment systems

MOTIVATION

- Environment, water availability, economic savings

Ecosan - examples
Projects with Norwegian involvement

Location	Construction year	Blackwater combined	Urine diversion	Persons served
Volvo, Sweden	1991	x		500
Bangalore, India	2001		x	700
Havana, Cuba	2002 - 06	x		54
Kuching Malaysia	2003	x		50 (300 000)

Volvo's Conference Center - Bokenäs

Photo: P. D. Jenssen

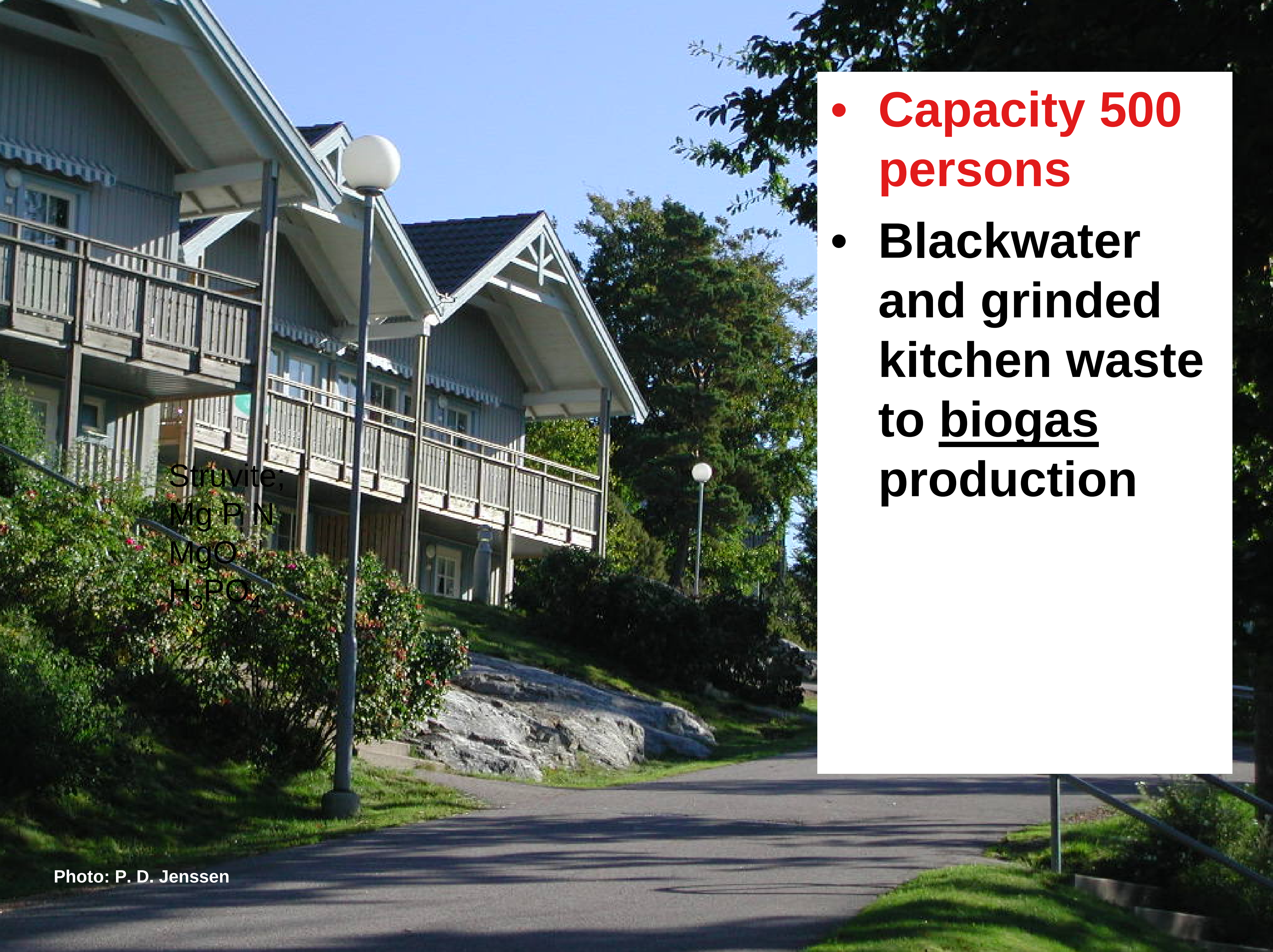
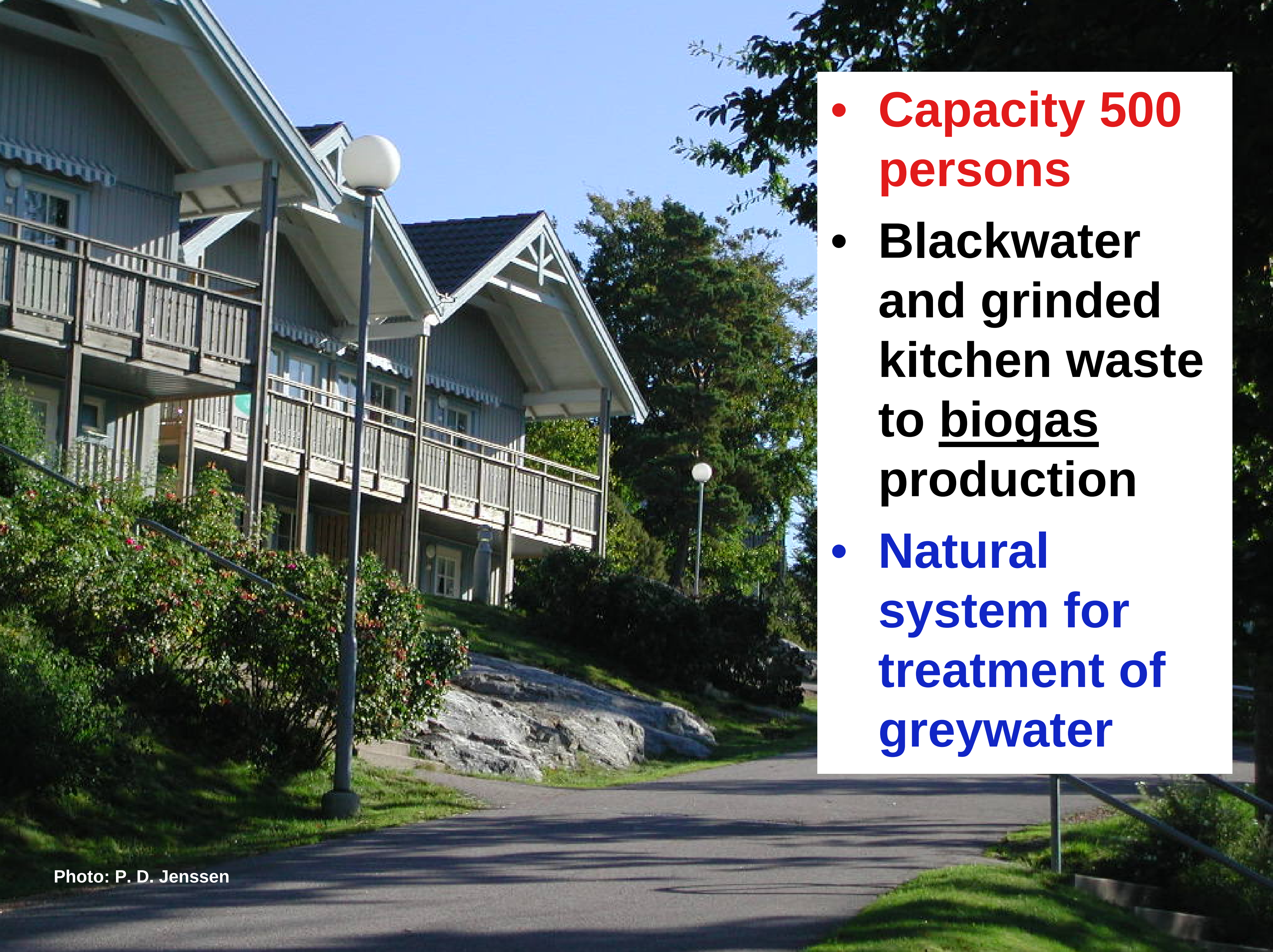


Photo: P. D. Jenssen

- **Capacity 500 persons**
- **Blackwater and grinded kitchen waste to biogas production**



- Capacity 500 persons
- Blackwater and grinded kitchen waste to <u>biogas</u> production
- Natural system for treatment of greywater

Photo: P. D. Jenssen


La Habana, Cuba
Photo: P. D. Jenssen

”Zero emission house”

16 viviendas

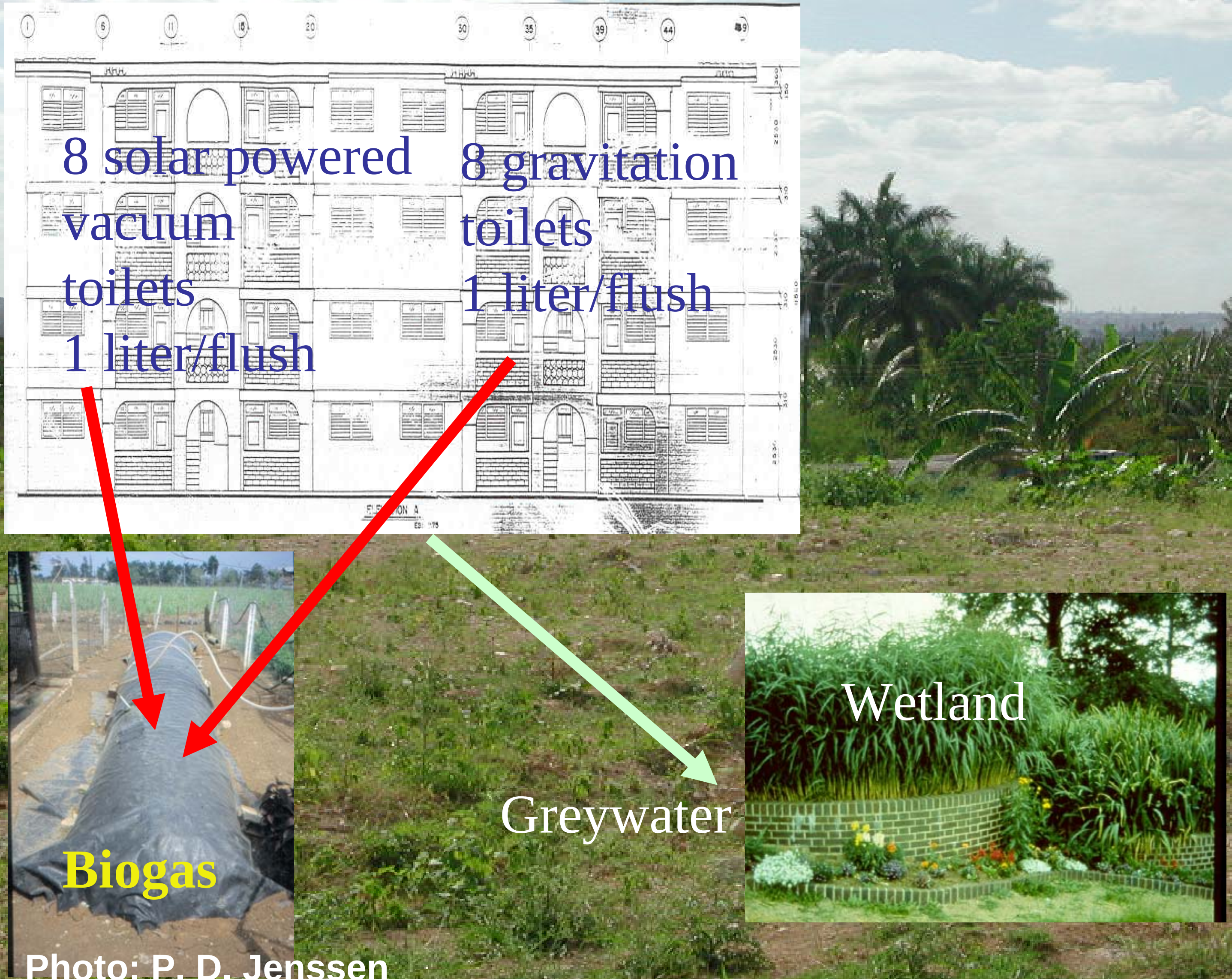
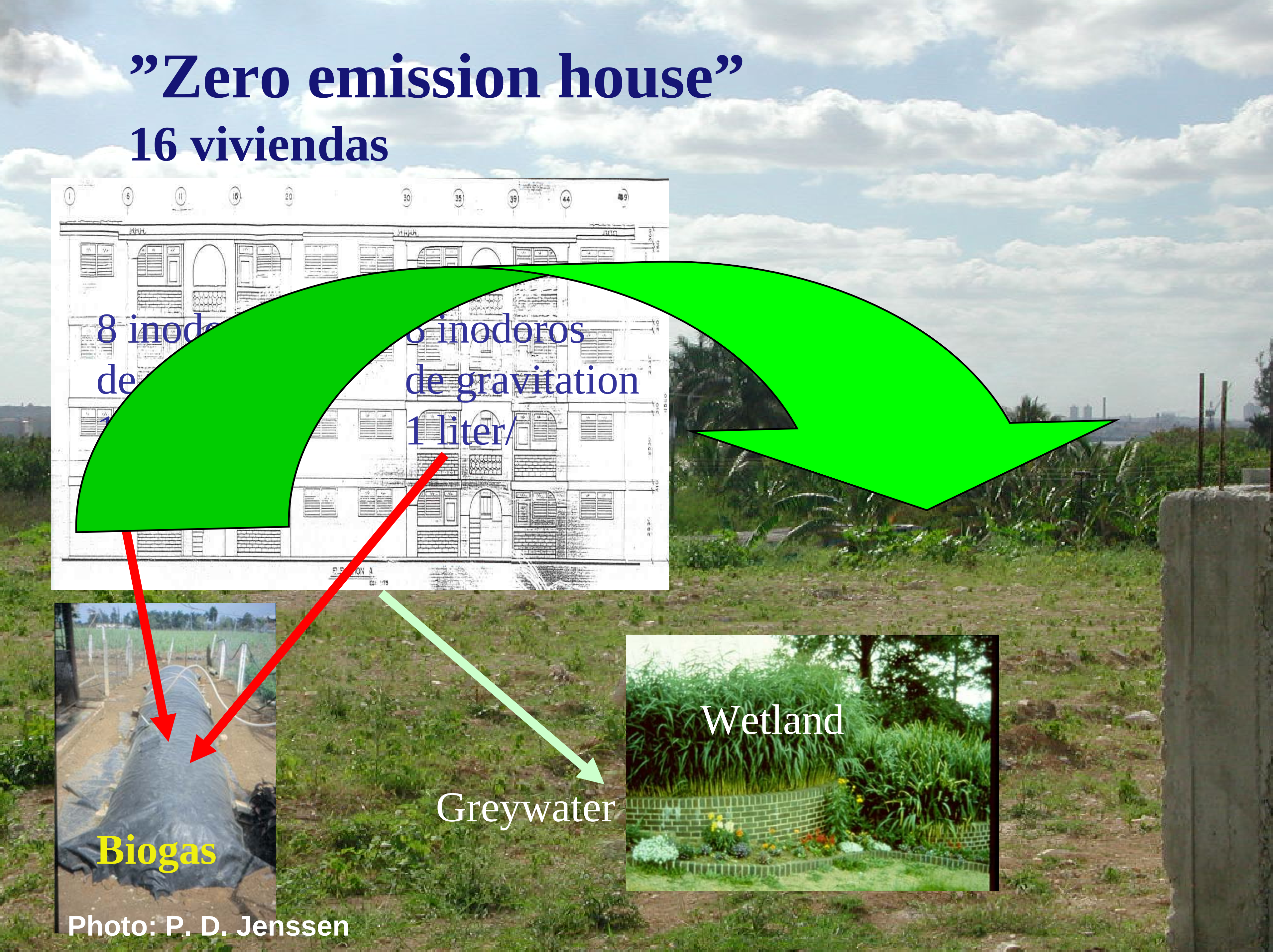


Photo: P. D. Jenssen


”Zero emission house”
16 viviendas
inodoros
de gravitation
1 liter/
Wetland
Greywater
Biogas
Photo: P. D. Jenssen

- 80% of the vegetables consumed in urban areas in Cuba are grown within urban areas

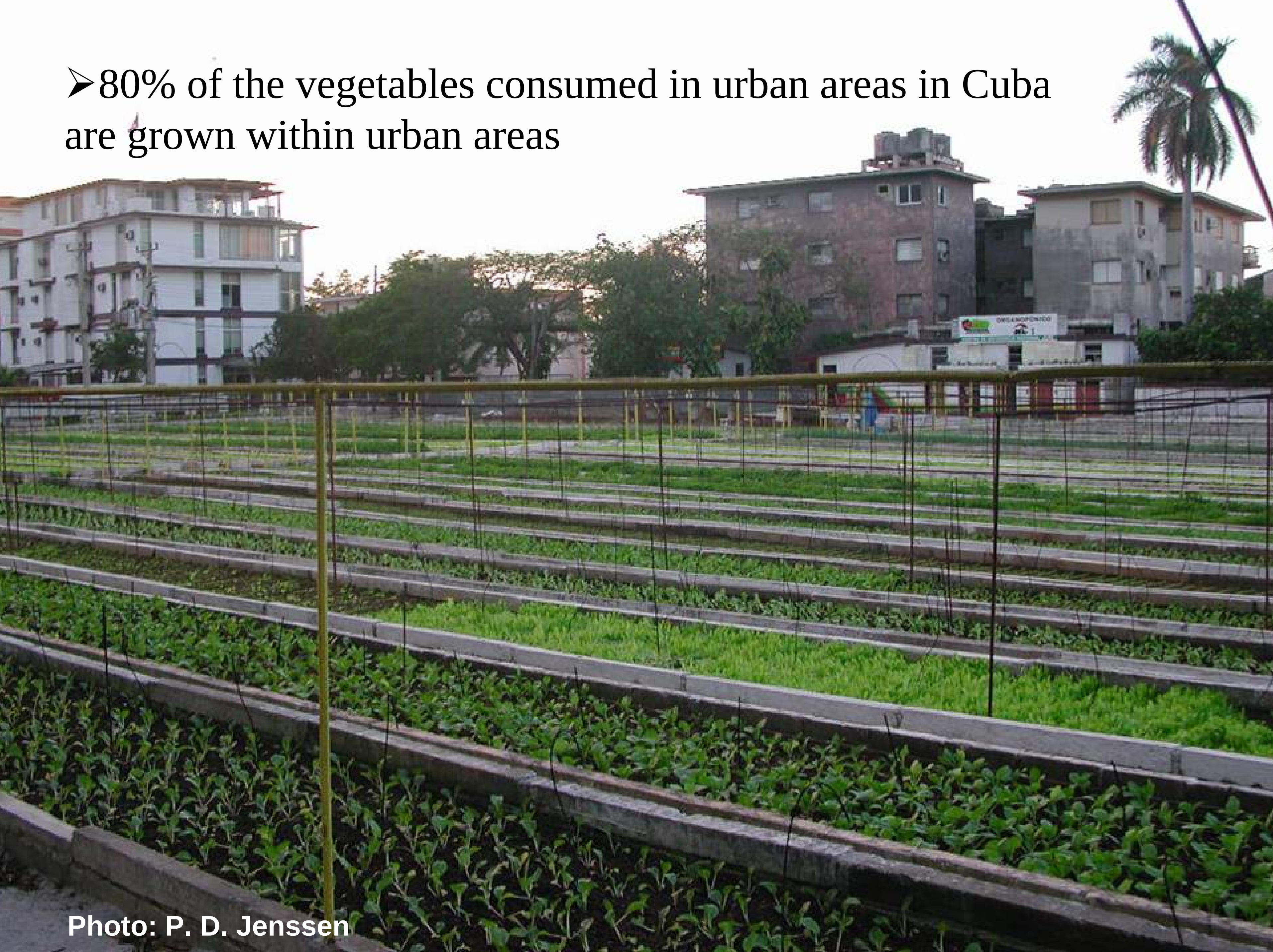


Photo: P. D. Jenssen

Bangalore India

Photos: J. Heeb

Ecosan toilet center Bangalore India

Photo: J. Heeb

- Serves 700 people
- Produces 50 tonn bananas/year
- Produces compost for sale
- Employs 10 people
- Annual cost 10 US$/user

Experience from Bangalore

- Application of **compost** increases the plants tolerance to water stress

(Stakland 2004)

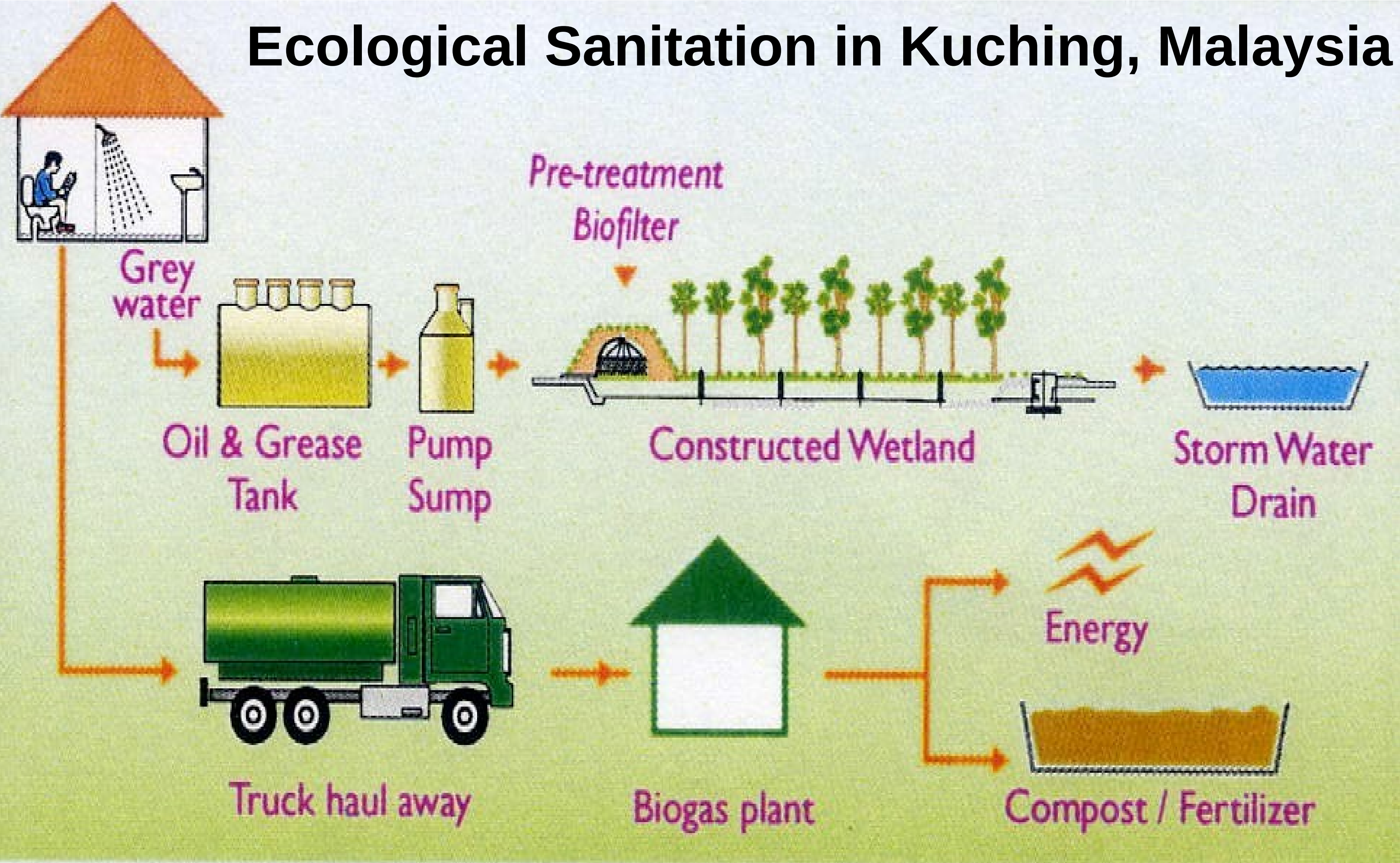
Experience from Bangalore

- Application of **compost** increases the plants tolerance to water stress
- Application of **compost** is essential for nutrient utilization in weathered (red) tropical soil

(Stakland 2004)


Kuching
Sarawak Malaysia
Photos: P. D. Jenssen

Ecological Sanitation in Kuching, Malaysia



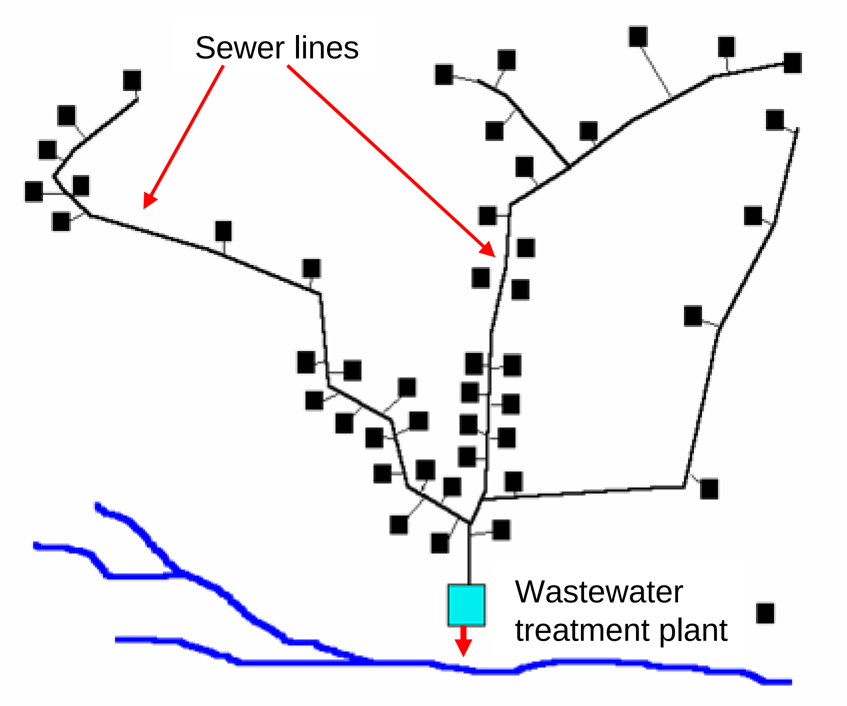
Biogas plant

Preliminary Assessment of Investment Cost

Conventional Centralized Sewage System	3,000 Million MYR
Ecological Sanitation	1,000 Million MYR

(Mamit et al. 2005)

Investment cost
of centralized sewer systems



- Collection system **70 - 90 %**
- Treatment **10 - 30 %**

(Otis 1996, Mork et al. 2000)


Pilot project Hui Sing Garden
Greywater treatment
Photo: P. D. Jenssen

Greywater treatment - Hui Sing Garden

- Preliminary results:

BOD	< 2 mg/l
Total N	2.2 mg/l
Total P	1.9
Faecal coliforms	50/100ml

(Jenssen et al. 2005)

Photos: P. D. Jenssen

Urban ecosan

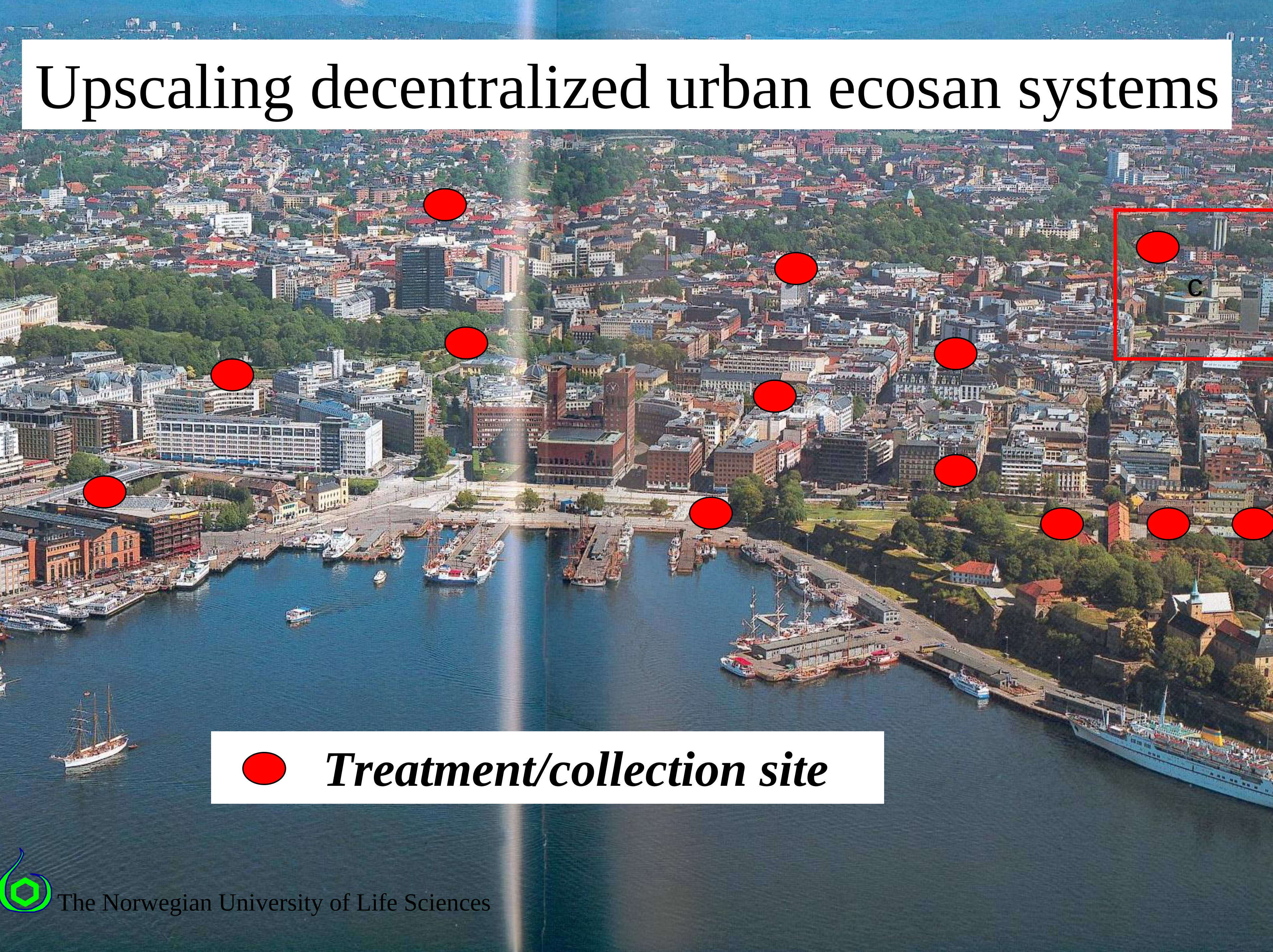
Greywater treatment at Klosterenga Oslo

Effluent values:

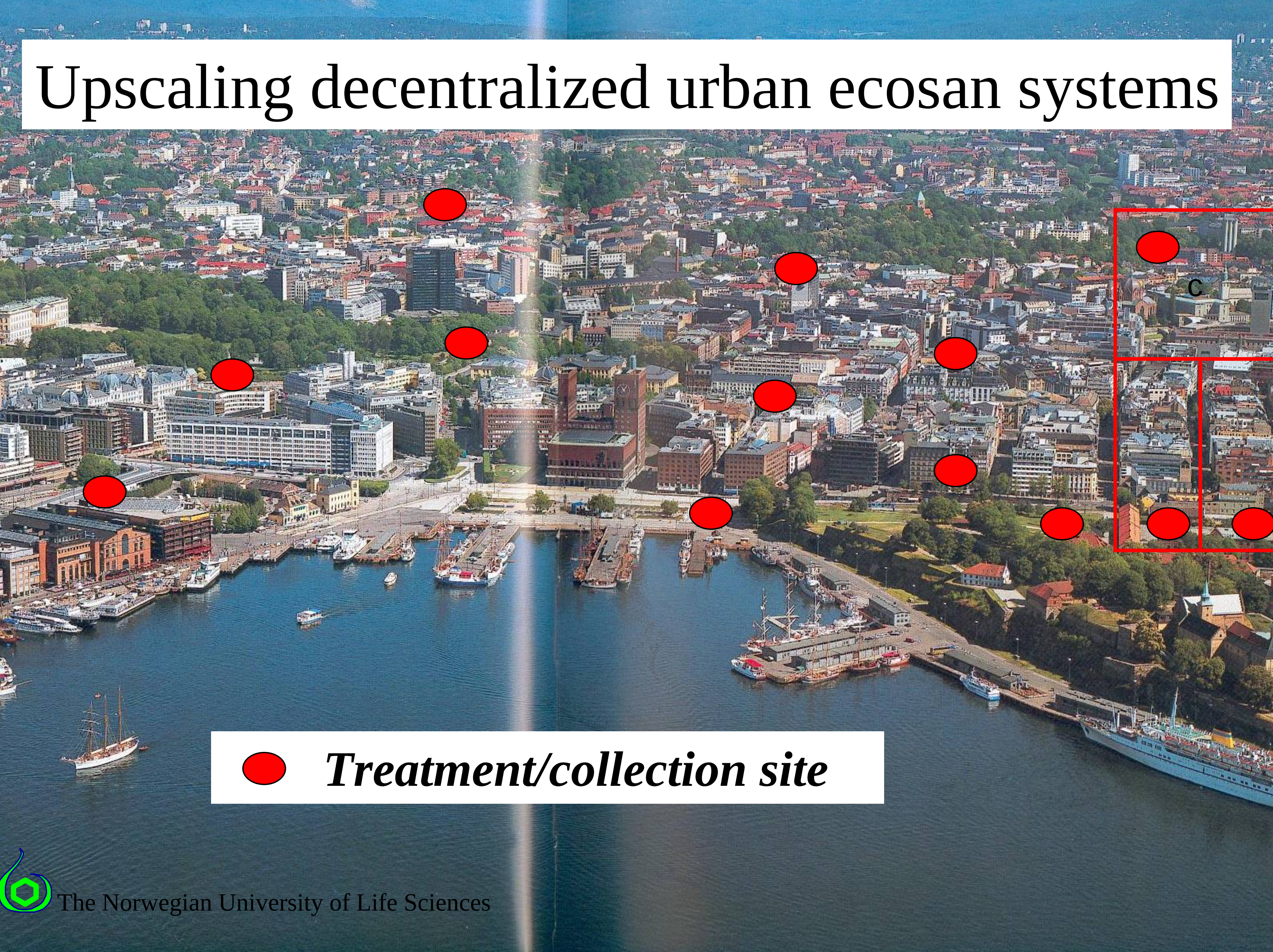
Fecal coliforms: 0
Total-N: 2,5 mg/l
Total-P: 0,02 mg/l

Photos: P. D. Jenssen

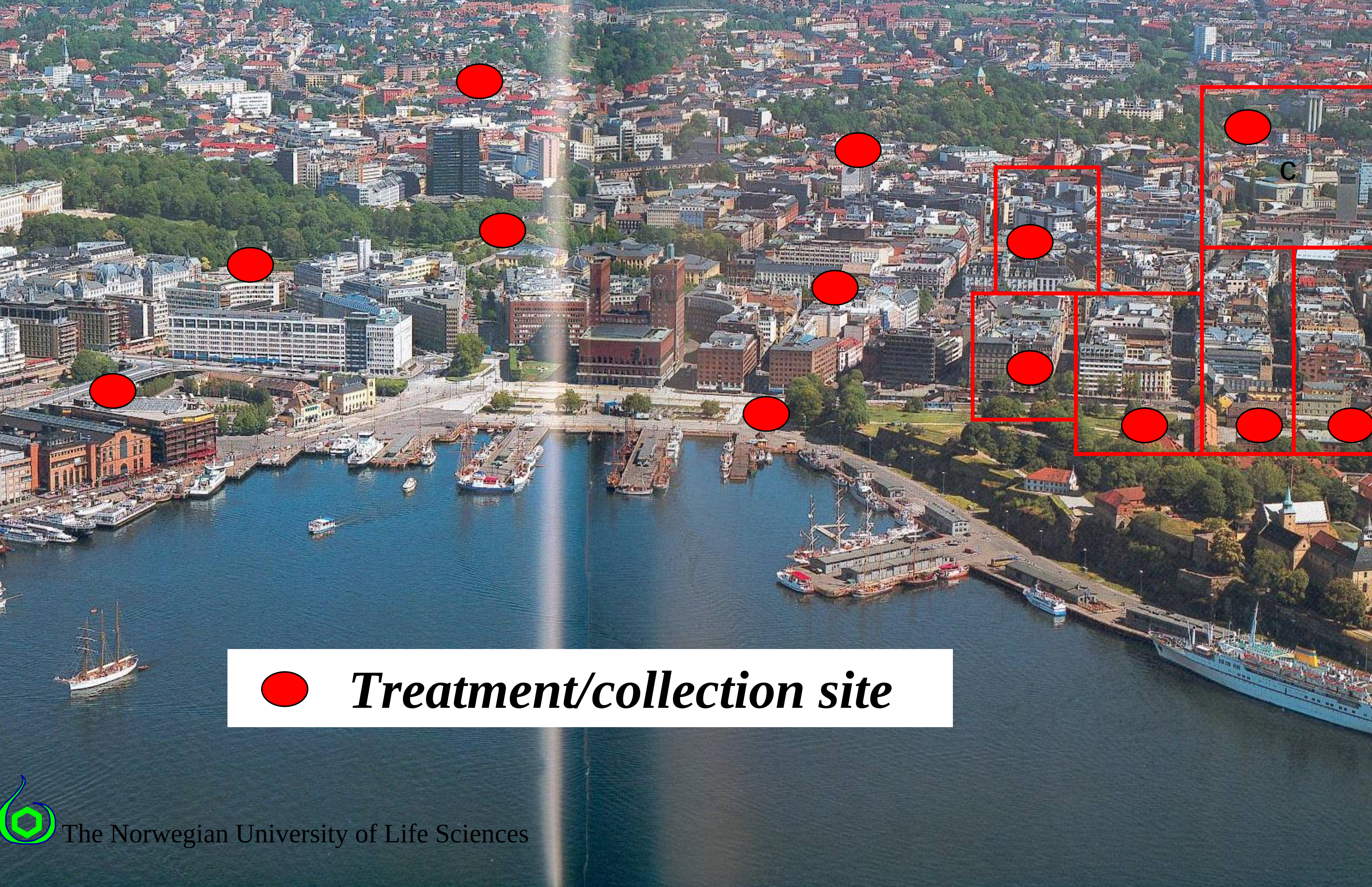
Upscaling decentralized urban ecosan systems



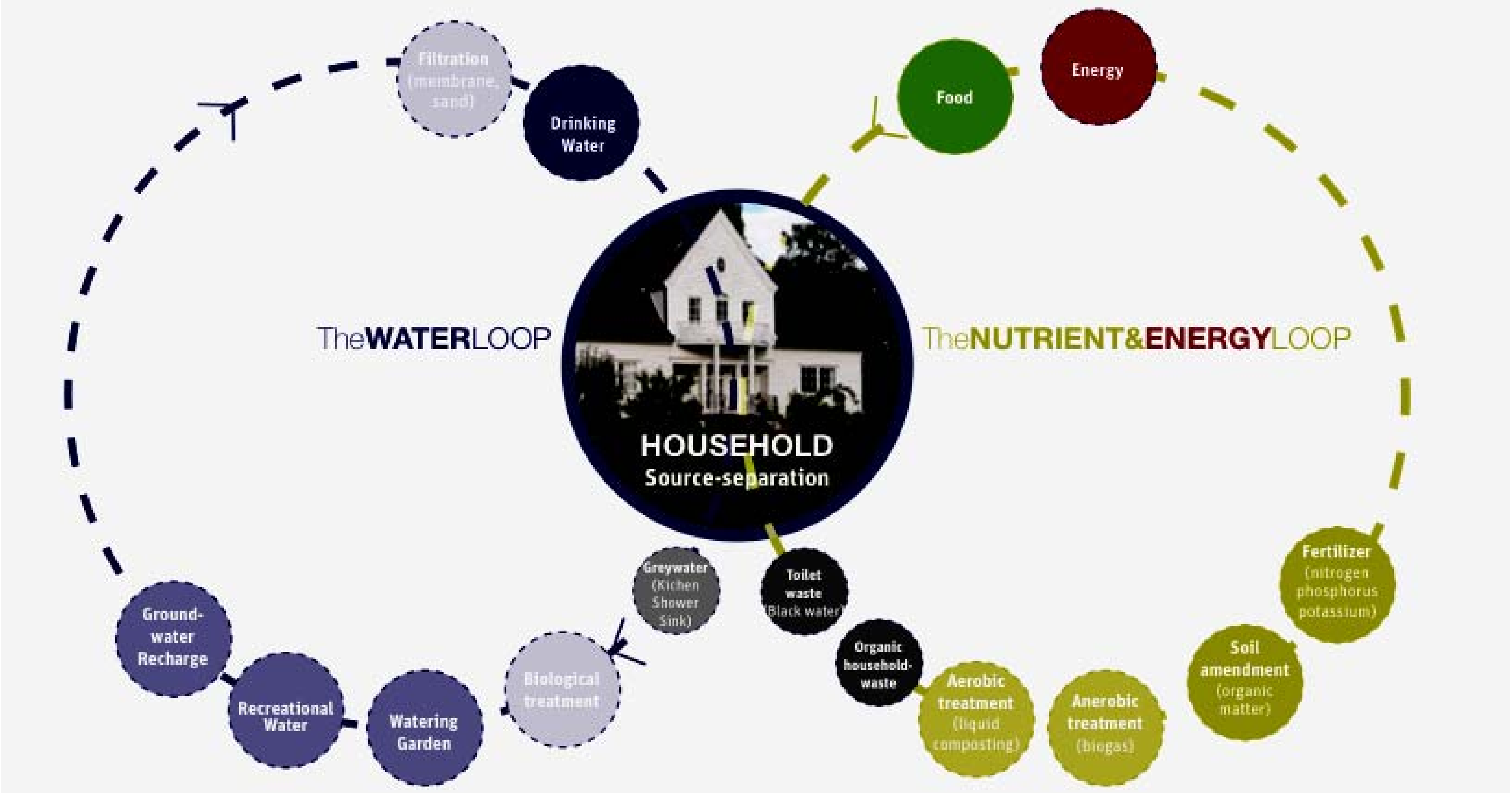
Upscaling decentralized urban ecosan systems



Upscaling decentralized urban ecosan systems



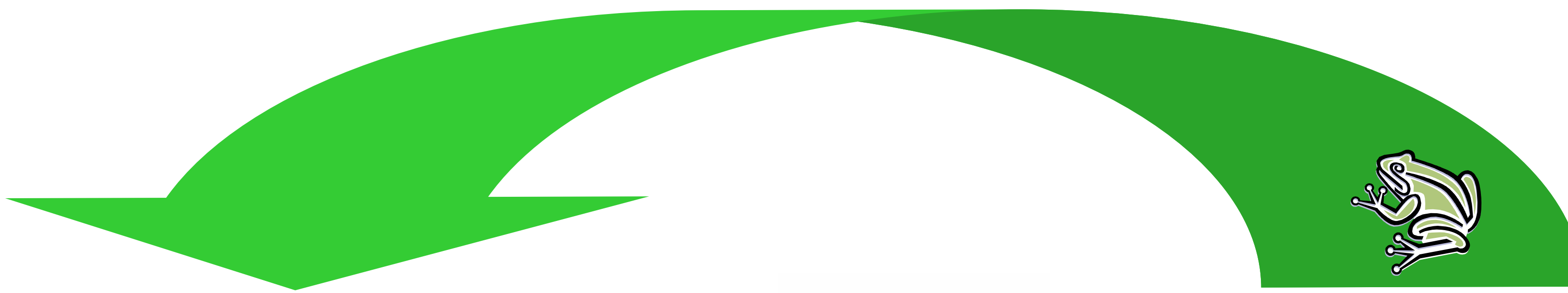
Ecosan - 2nd generation systems are emerging



(Alsen and Jenssen2005)

Conclusion

Consider to leapfrog the conventional centralized sewers
Go straight to modern sanitation based on ecological principles



Ecosan education

The Norwegian University of Life Sciences

- MSc programs
- Short courses

www.ecosan.no


Midnight in July - Northern Norway
Photo: R. Gjørven
www.ecosan.no

Main references

- Alsén K.W. and P.D. Jenssen 2005. Ecological Sanitation – for mankind and future. Information folder prepared for the UN-conference CSD-13 New York April. www.ecosan.no
- DelPorto D and C. Steinfeld, 1999. The composting toilet system book.The Center for Ecological Pollution Control. Concord MA.
- Gardner, G. 1997. Recycling organic waste: From urban pollutant to farm resource. Worldwatch Institute, paper 135, 58 p.
- Hanssen J.F., W.Warner, A.Paruch and P.D. Jenssen. 2005. Sanitizing partially composted human waste. Ther use of a secondary bioreactor. Paper at the Third International Conference on Ecological Engineering, May 23-27, Durban South Africa.
- Jenssen, P. D. and L. Vråle. 2004. Greywater treatment in combined biofilter/constructed wetlands in cold climate In: C. Werner et al. (eds.). Ecosan – closing the loop. Proc. 2nd int. symp. ecological sanitation, Lübeck Apr. 7-11. 2003, GTZ, Germany, pp:875-881.
- Jenssen P.D., J. Heeb, K. Gnanakan and K. Conradin 2006. Ecosan Curriculum Module 3, Prepared for the World Water Forum in Mexico, Seecon/GTZ/UNEP/UMB/ACTS.
- Jenssen P.D., L. Seng , B. Chong, T. H. Huang4, Y. Fevang, I. Skadberg, 2005c. An urban ecological sanitation pilot study in humid tropical climate. Proc. 3rd. International conference on ecological sanitation. Durban, South Africa pp 257-265.
- Mamit, J.D., P. Sawal, I. Larsen, T.H. Huong 2005. ”Integrating conventional and ecological sanitation in urban sanitation for the future”. Paper at the Third International Conference on Ecological Engineering, May 23-27, Durban South Africa.
- Mork, K., T. Smith og J. Hass 2000. Resurssinnsats, utslipp og rensing i den kommunale avløpssektoren. 1999. SSB-rapport 2000:27
- Morken, J. 1998. Direct ground injection - a novel method of slurry injection. Landwards, winter 1998, pp. 4-7.
- Skjelhaugen, O.J. 1999. A farmer-operated system for recycling organic wastes. Journal of Agricultural Engineering Research, 73, 373-382.
- Stakland R. 2004. Agricultural aspects of recycling from Ecosan toilets in Bangalore India. MSc Thesis. Department of Plant and Environmental Sciences, Norwegian University of Life Sciences.
- Stenstrøm T.A. 2001. Reduction efficiency of index pathogens in dry sanitaion compared with traditional and altenative wastewater treatment systems. Paper at the First international conference on ecological sanitation, Nannning China. www.ecosanres.org