

Avløpskonferansen 2012, Campus Ås 25 - 26 april.

Avløpsvann som ressurs - kretsløpsteknologi

Professor Petter D. Jenssen
Institutt for plante og miljøvitenskap (UMB)

www.umb.no

Manhattan

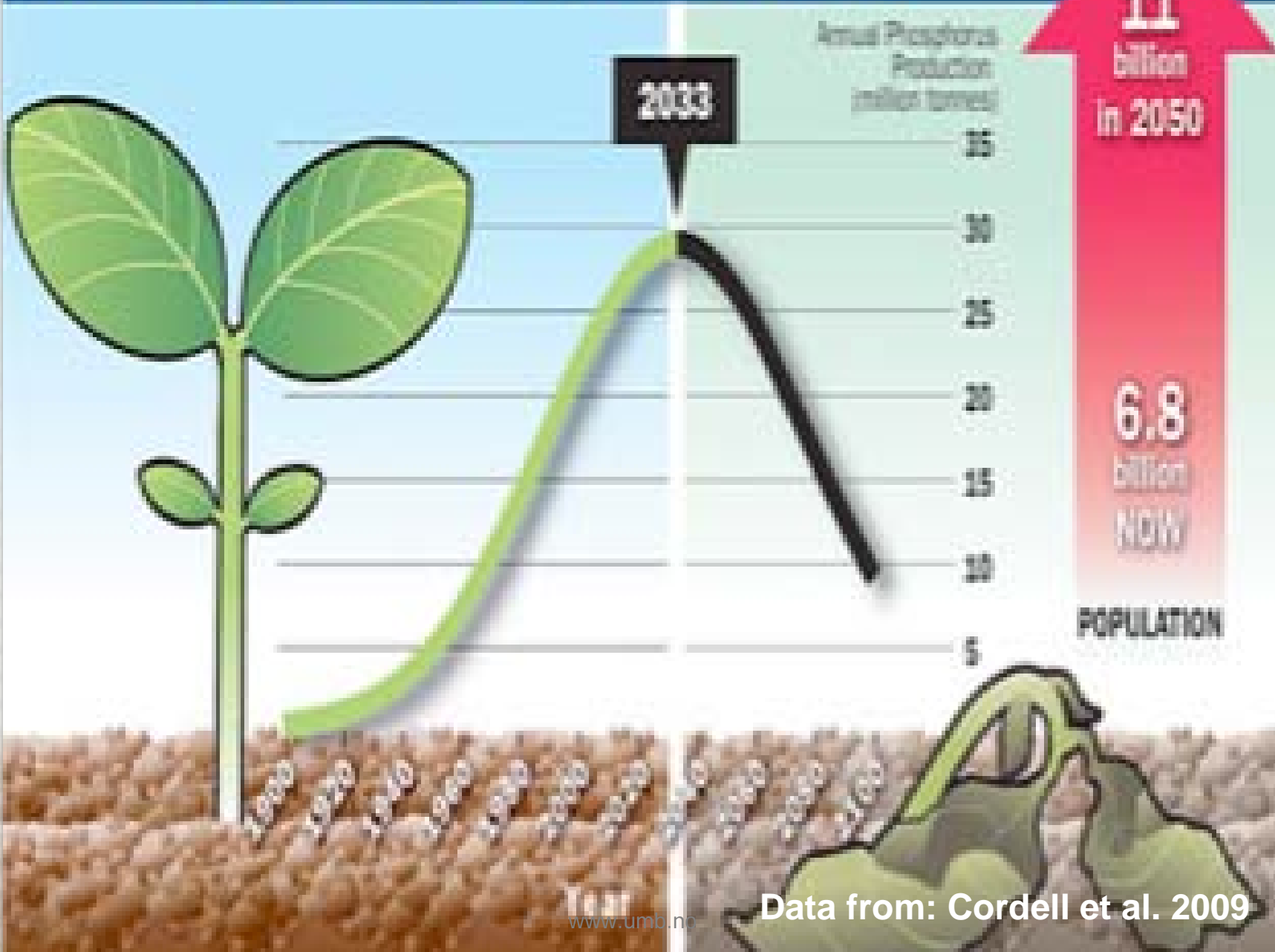


Photo: P. Jenssen

**20-40% of the water consumption
in sewered cities is used
for flushing toilets**

(Gardner 1996)

NO PHOSPHORUS, NO FOOD



Resources in wastewater

Annual discharge from one person

- Nitrogen (N) 4.5 kg
- Phosphorus (P) 0.6 kg
- Potassium (K) 1.0 kg
- Organic matter (BOD) 35 kg

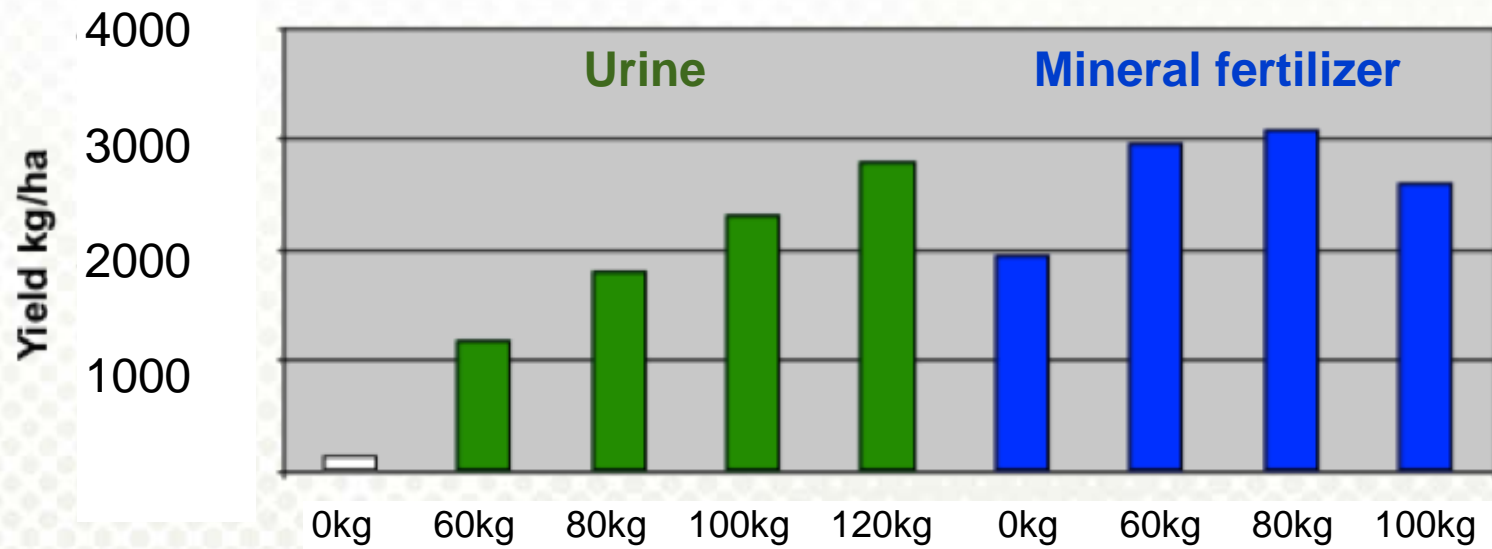
Resources in wastewater

Annual discharge from one person

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- Potassium (K) 1.0 kg
- Organic matter (BOD) 35 kg

This amount of nutrients is enough to fertilize 300 - 1000 m² or 0,03 - 0,1ha

Yield - urine vs. mineral fertilizer



(Cottis 2000)

The wastewater resource

The fertilizer value of the nutrients discharged to the sewer systems in **Norway**

30 million USD

(Jenssen and Vatn 1991)

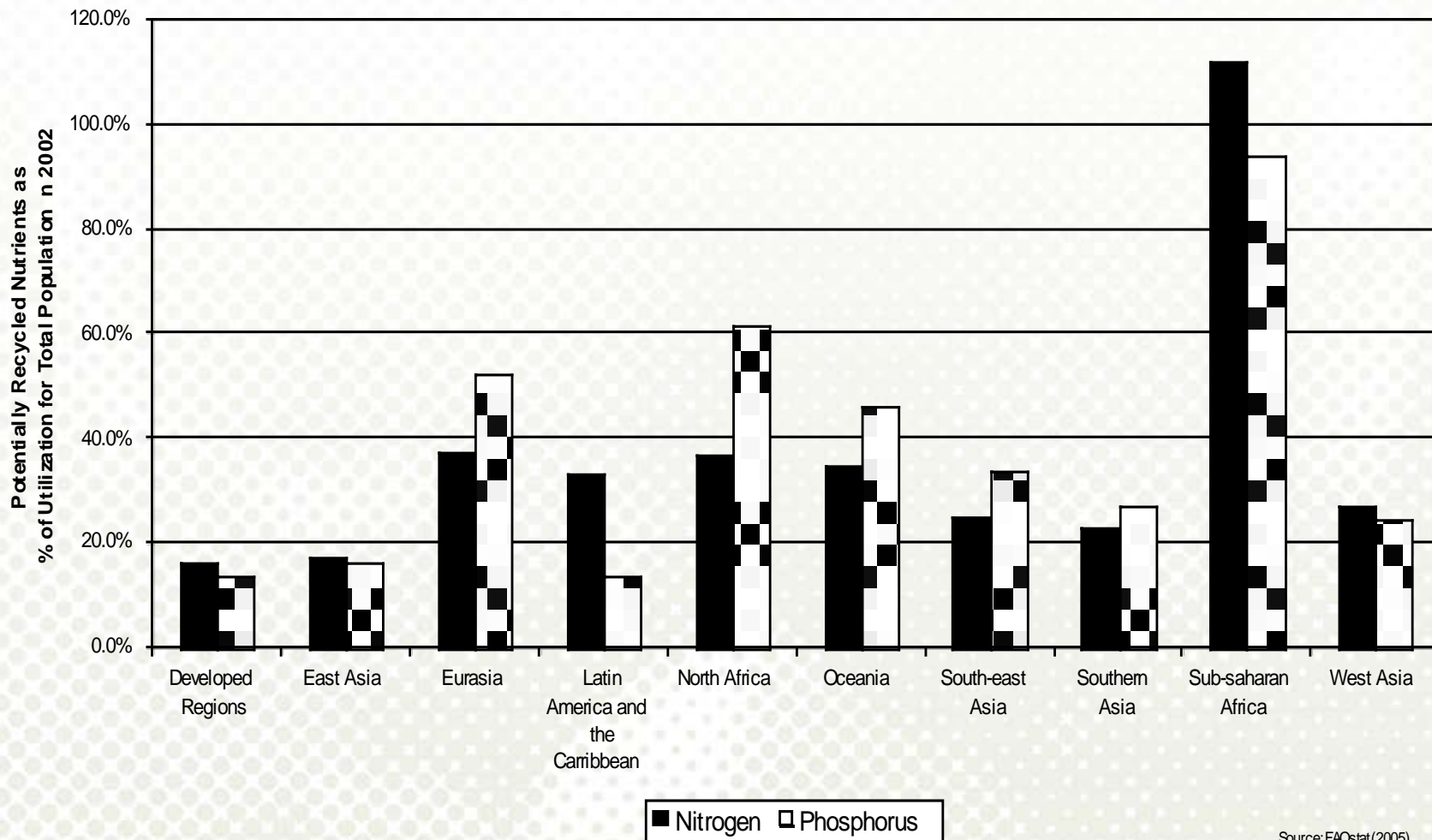
The wastewater resource

The fertilizer value of the blackwater from
900 Mio people in rural **China**

2.5 billion USD

(UNESCO 2001)

Potentially recycled nutrients from excreta as % of currently utilized chemical fertilizer nutrients in 2002



Recycle?

Phosphorus is a limited resource.

**Present mineral P-sources
will last 100 - 200 years.**

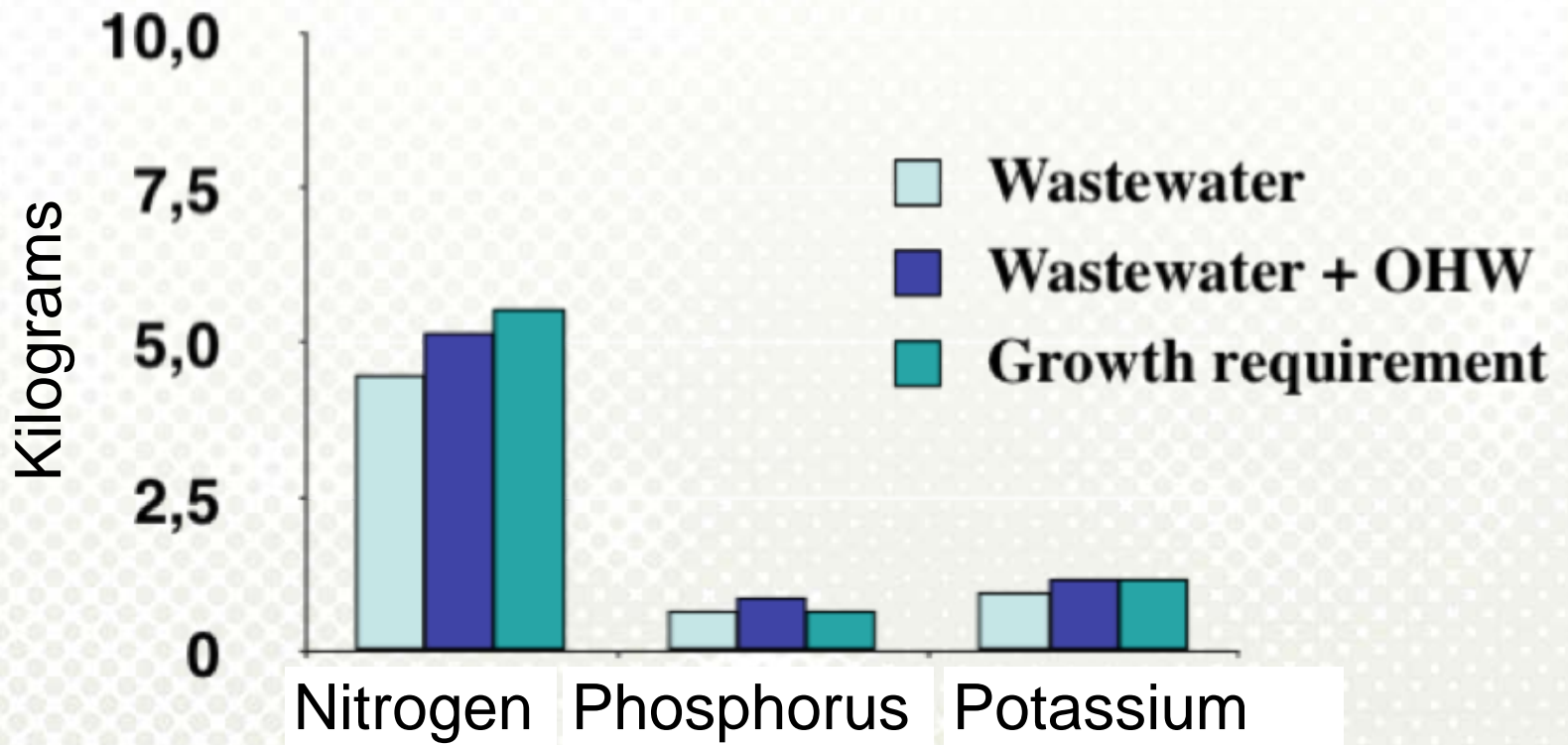
(Bøckman et al. 1991)



**Production of 1kg mineral
nitrogen fertilizer requires
38 MJ = 10.5kWh of energy.**
(Refsgaard 1997)

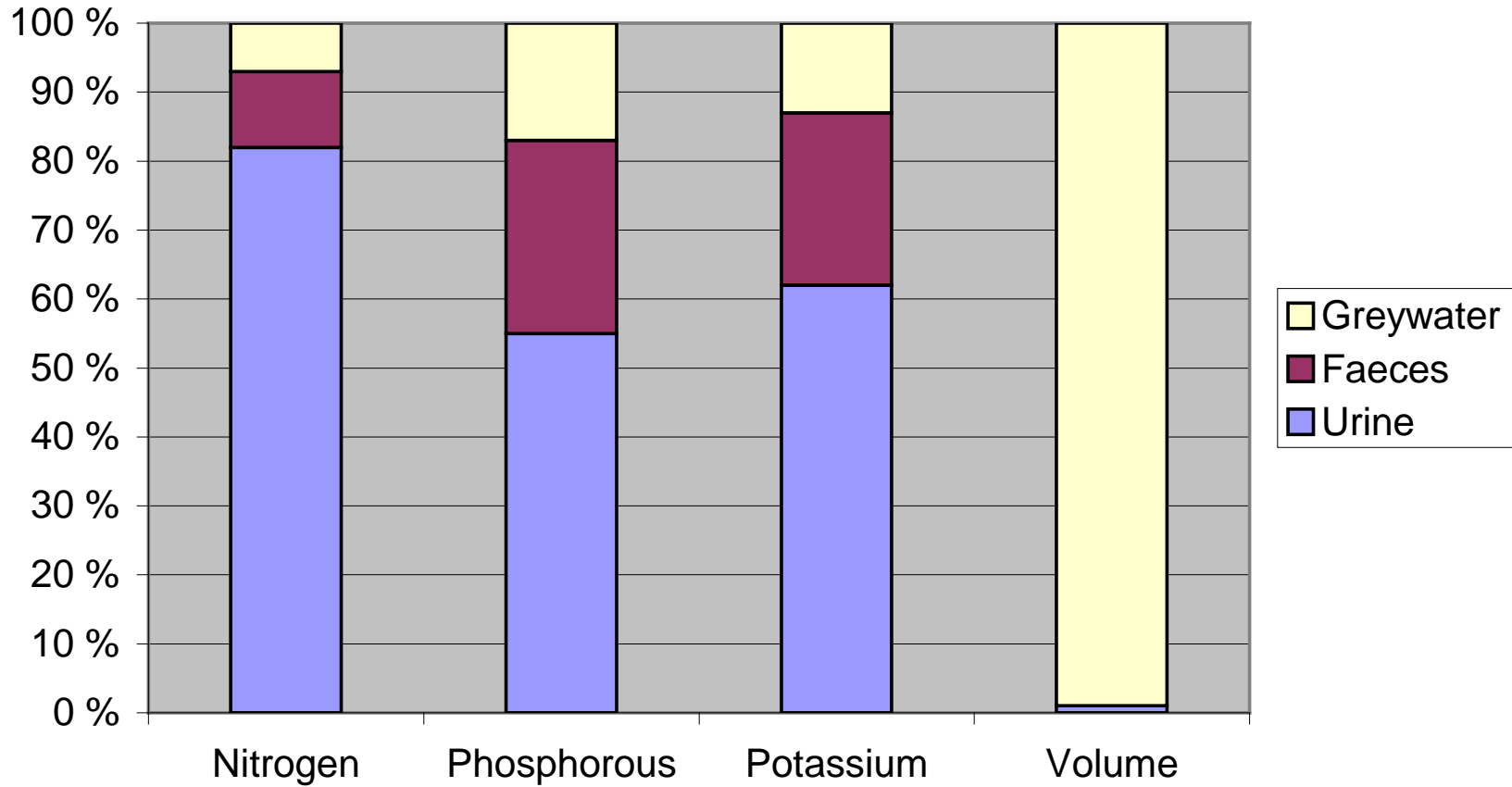
**It is enough plant nutrients in domestic
sewage and organic household waste
to grow food for the world population.**
(Wolgast 1991)

Nutrient content in wastewater + organic household waste vs. nutrient requirement to grow 250 kg wheat

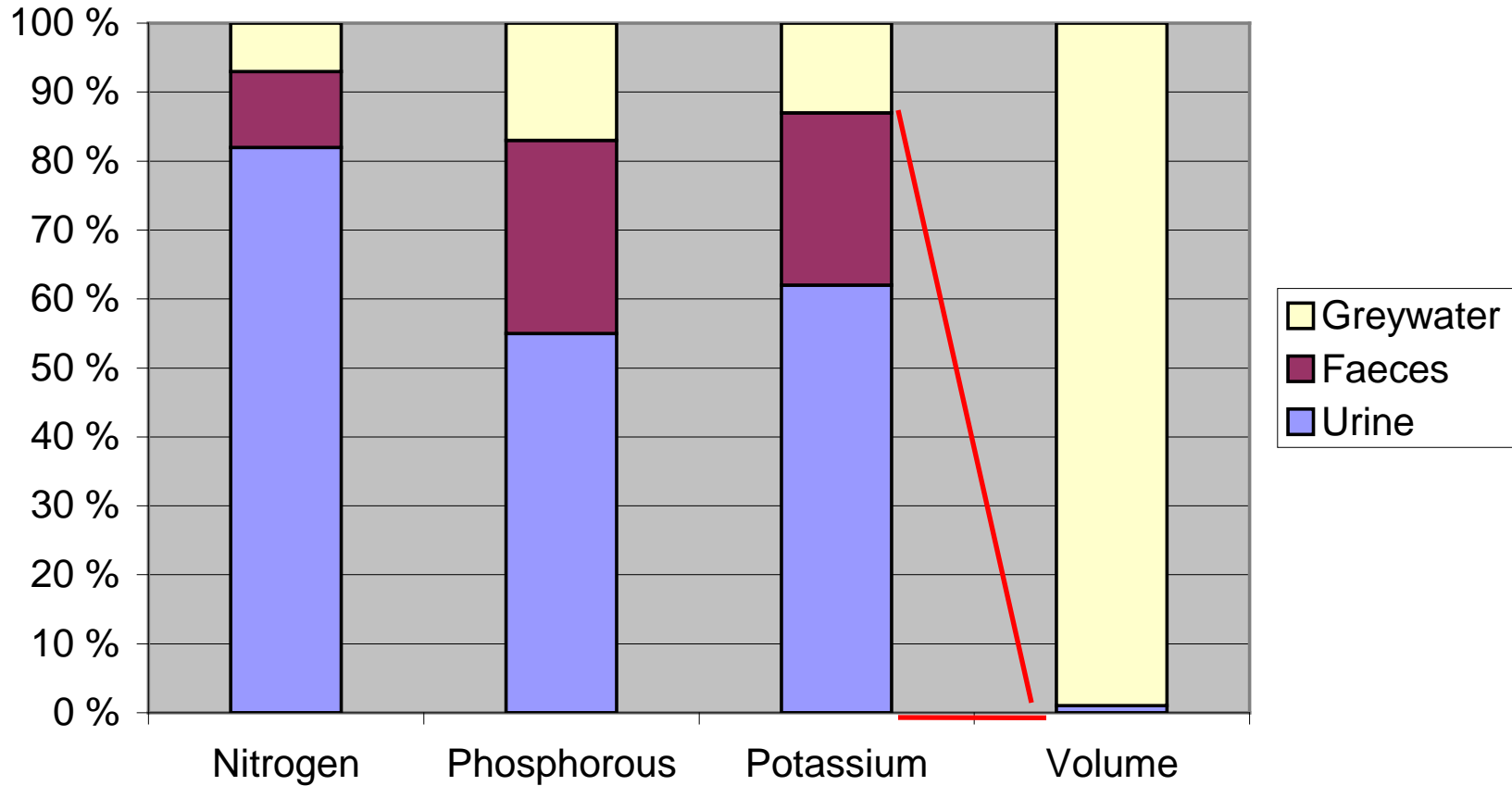


Wolgast (1993), Jenssen & Skjelhaugen (1994)

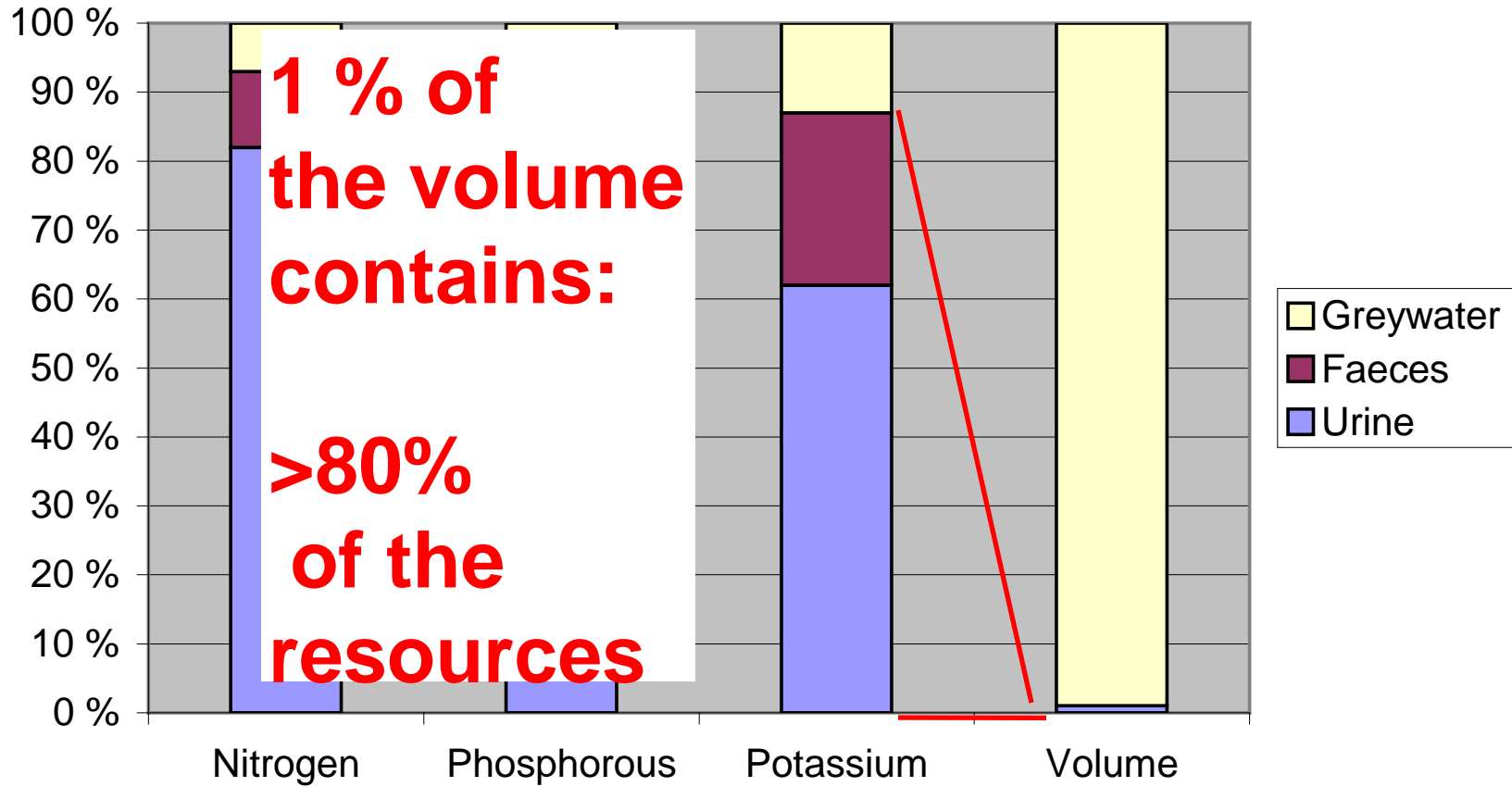
Nutrients and volume of domestic wastewater fractions



Nutrients and volume of domestic wastewater fractions



Nutrients and volume of domestic wastewater fractions

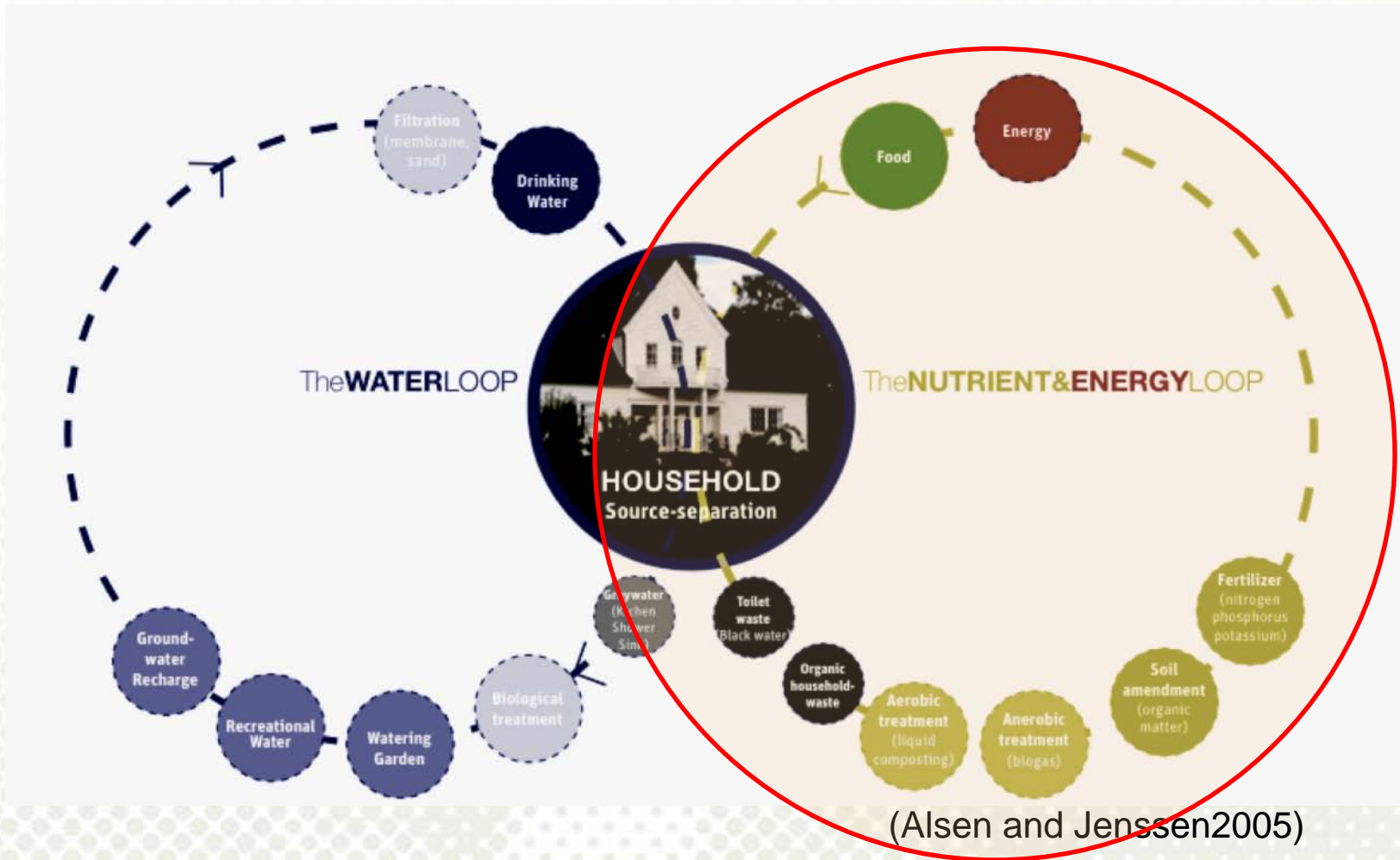


**1 % of
the volume
contains:
>80%
of the
resources**

Greywater
Faeces
Urine



Løsninger med kildeseparering



Volvo Bokenäs

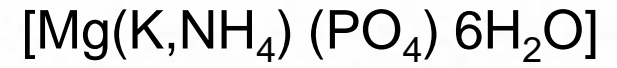
A step towards the future

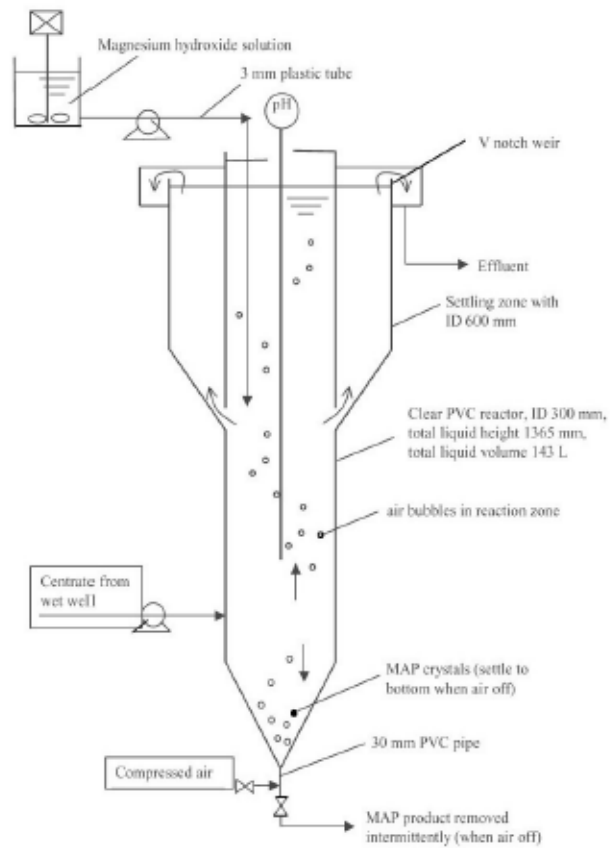


Volvo Bokenäs

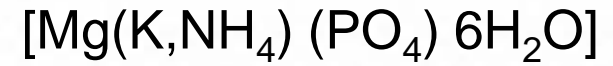


Struvite (MAP) produksjon



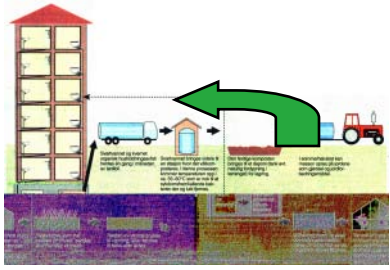


Struvite (MAP) produksjon



Ostara prosessen (Prasad et al. 2009)

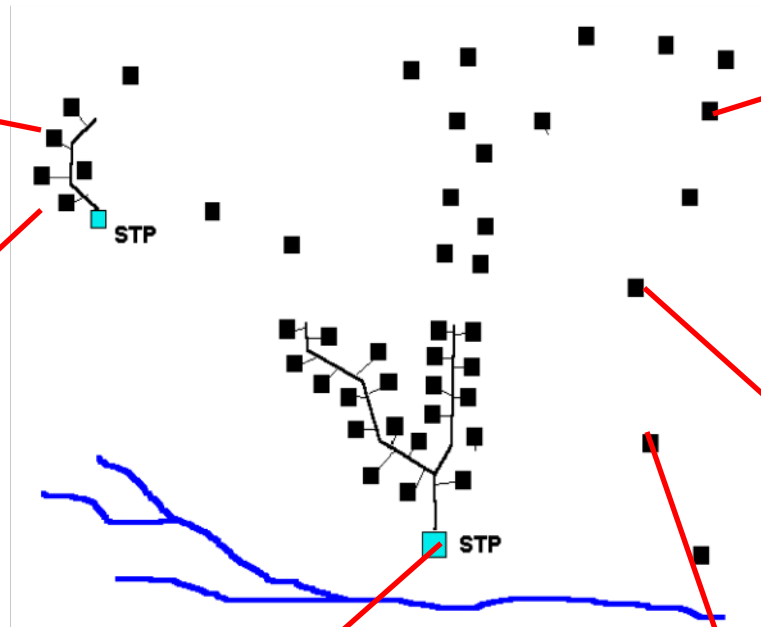
Mindre/desentrale avløpsløsninger



Systemer med
kildesortering



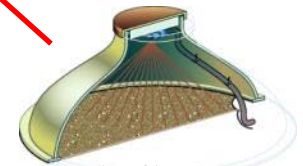
Dammer



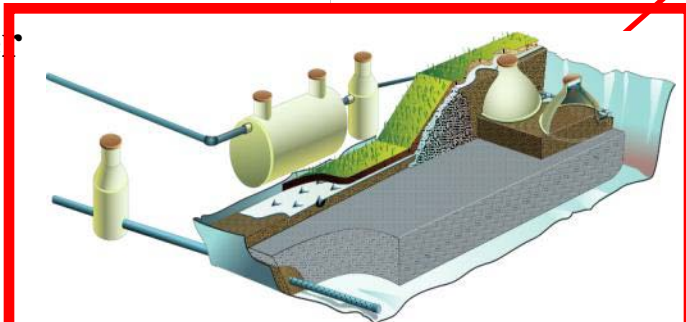
Minirensanlegg



Slamavskiller



Biofilter

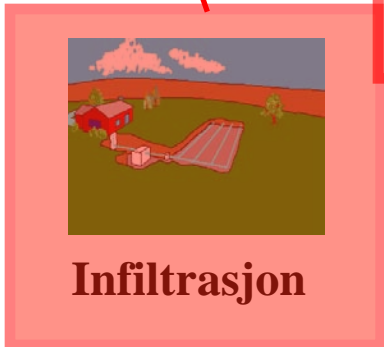
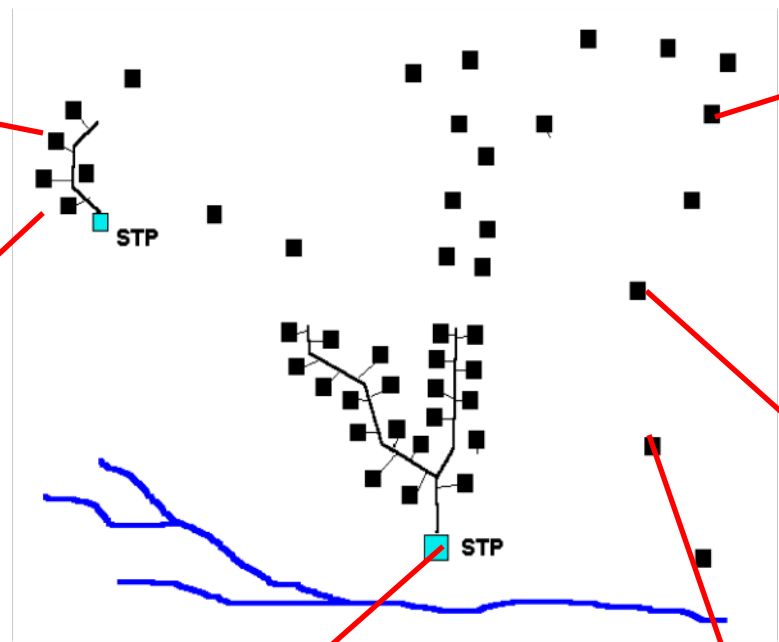
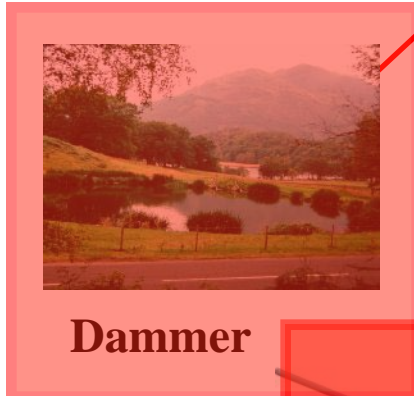
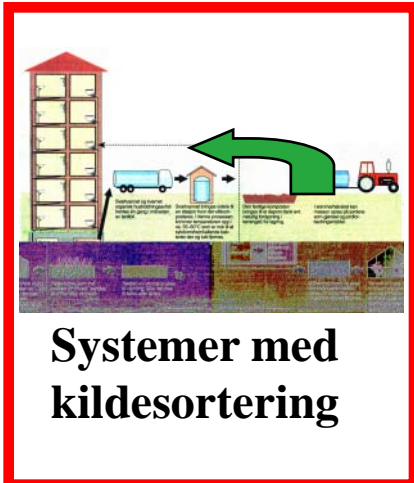


Konstruert våtmark/filterbed



Infiltrasjon

Mindre/desentrale avløpsløsninger



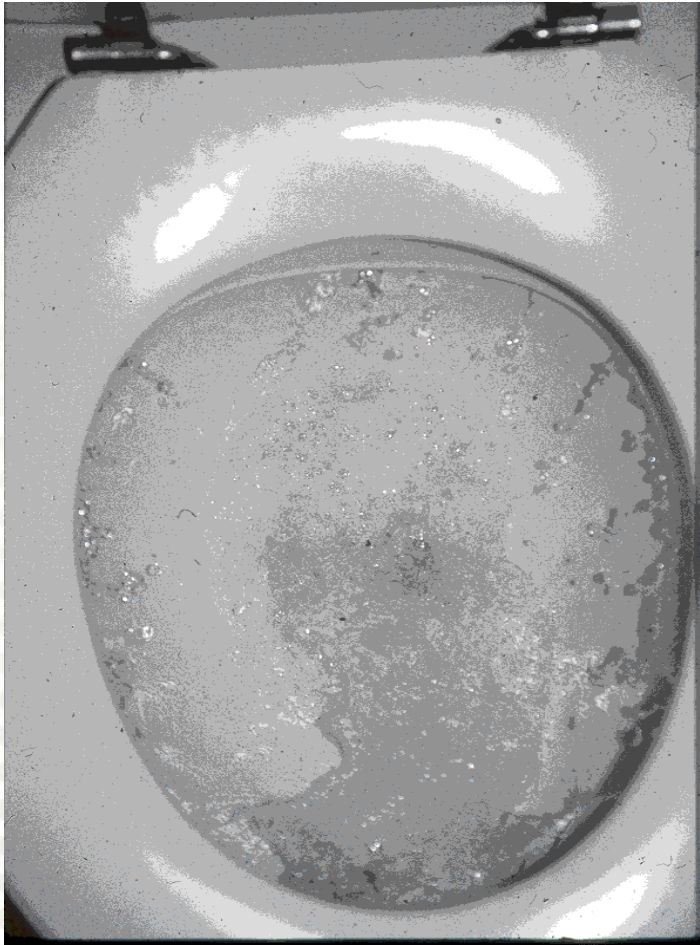
Løsninger med kildeseparering



WC bidrar med:

- * 90 % of N
- * 80 % of P
- * 80 % of K
- * 40-75 % av org. materiale
- * Mesteparten av de sykdomsframkallende organismene

WC - vannforbruk



- **4 - 20 liter/spyling**
- **20 - 40 % av vannforbruket i byer**

Framtidens toaletter (Kan kjøpes idag)

- Komposterende /tørre 0 - 0.1 liter/spyling
- Urinsorterende 0.1 - 4.0 liter/spyling
- Vannsparende
(vakuum&gravitasjon) 0.5 - 1.0 liter/spyling

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Komposterende do ved E6 "Tegen rastplats" i Tanum



*Valgt til beste
rasteplass i
Sverige i 2003*

Av Motormännens Riksförbund
utsedd till

**Bästa
Rastplats
2003**



Komposterende do ved E6 "Tegen rastplats" i Tanum



*Rene og luktfrie
toaletter*

Framtidens toaletter (Kan kjøpes idag)

- Komposterende /tørre 0 - 0.1 liter/spyling
- **Urinsorterende** **0.1 - 4.0 liter/spyling**
- Vannsparende
(vakuum&gravitasjon) 0.5 - 1.0 liter/spyling

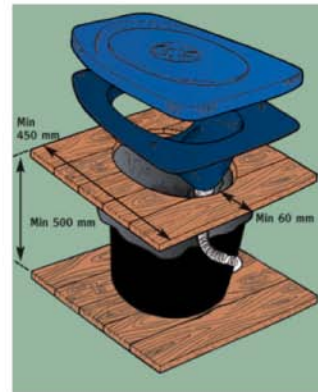
Urinsorterende toaletter



(a)



(b)



(c)



(d)

Dobbeltspylende
a og b

Enkeltspylende
c og d

Urinsorterende toaletter

Enkeltspylende urinsorterende toaletter ved Tingvall konferansesenter - Sverige



Urinsorterende toaletter

Enkeltspylende urinsorterende toaletter ved Tingvall konferansesenter - Sverige



Vannfrie urinaler

**Kastrup airport
Copenhagen**



se: www.intra.no og www.uridan.no

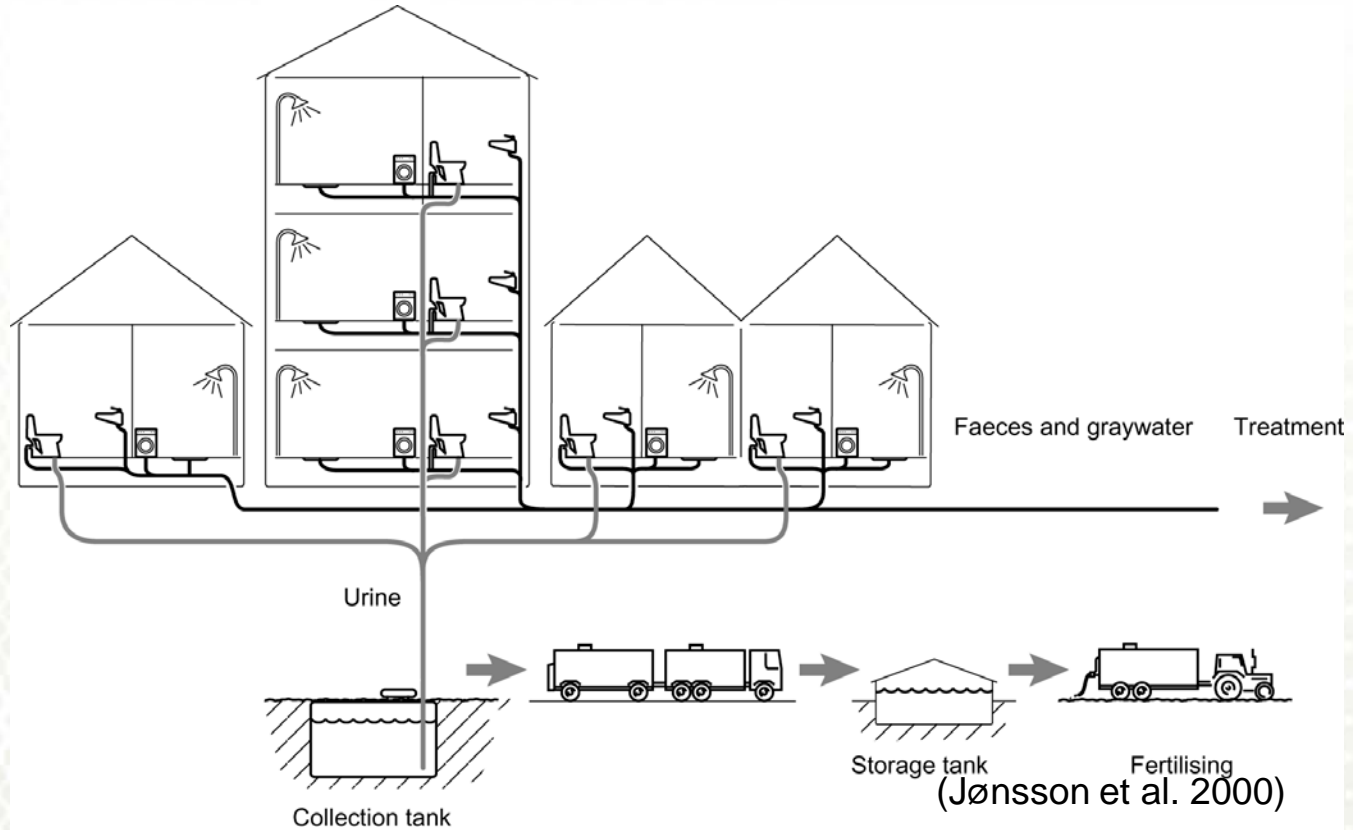
www.umb.no

Vannfrie urinaler for menn og kvinner!!!!



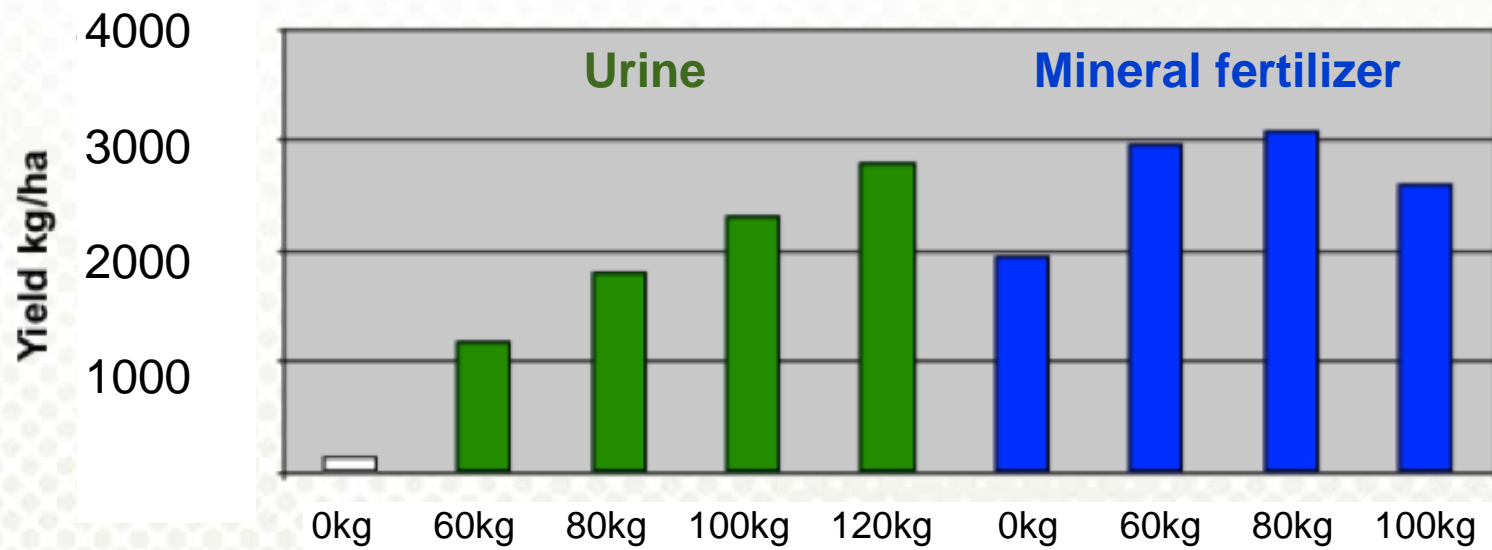
Photo: Uridan/Jan Moe

Urinsorterende toaletter – dobbeltspylende



- Urin spylevolum 0.1 – 1,6 liter
- Fekalier spylevolum 2 - 4 liter

Yield - urine vs. mineral fertilizer



(Cottis 2000)

Biodiesel fra alger dyrket i urin



S. Eikås 2008

Framtidens toaletter (Kan kjøpes idag)

- Komposterende /tørre 0 - 0.1 liter/spyling
- Urinsorterende 0.1 - 4.0 liter/spyling
- **Vannsparende**
(vakuum&gravitasjon) 0.5 - 1.0 liter/spyling

Lavtspykende toaletter

Vakuum

0.5 - 1.5 liter/spyling



Gravitasjon

1 liter/spyling



Vakuumpoletter - energiforbruk



**4 - 10 kWh/person og år
ved bruk i helårsbolig**



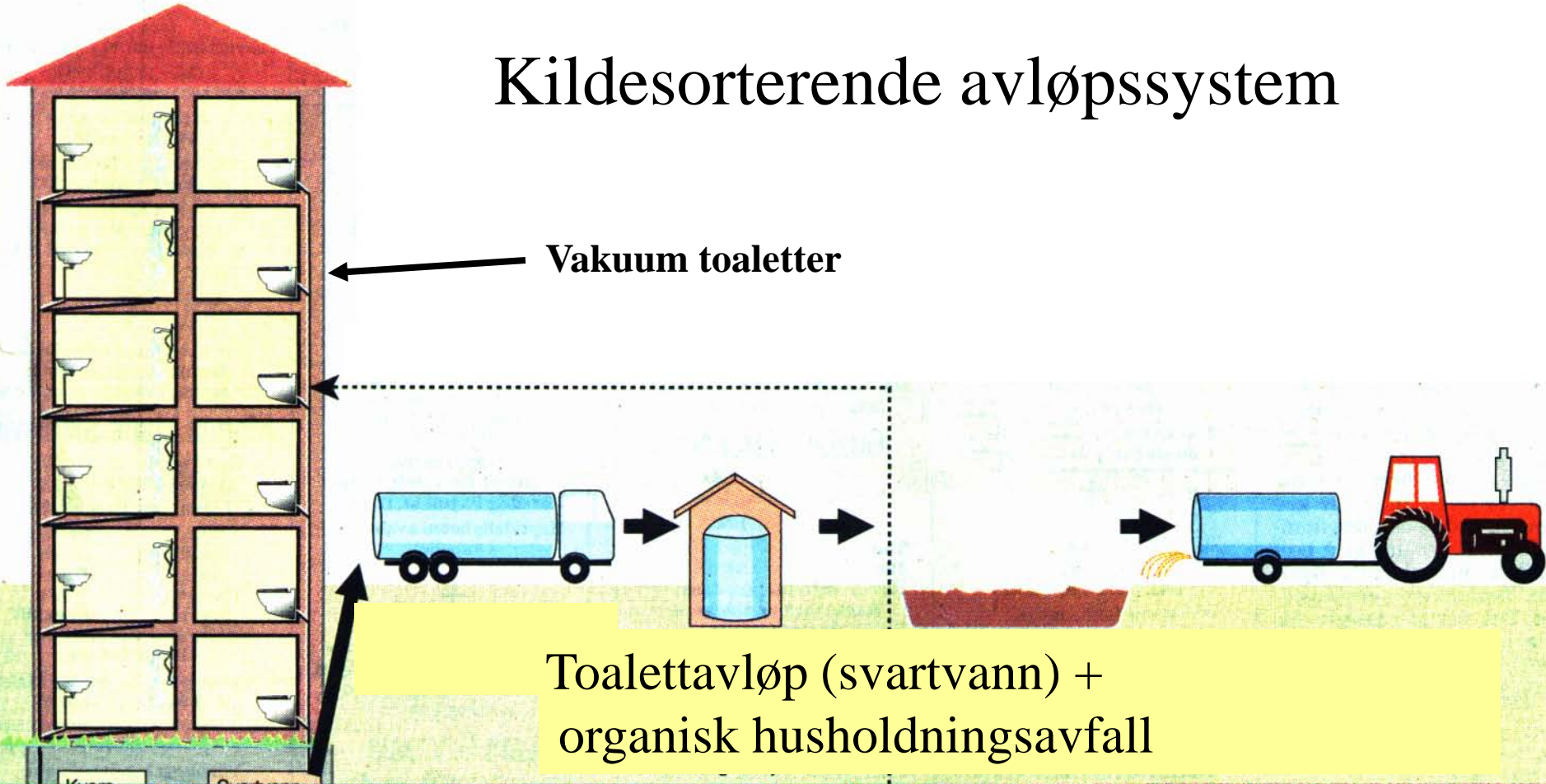
Vakuum teknologi Marine installasjoner



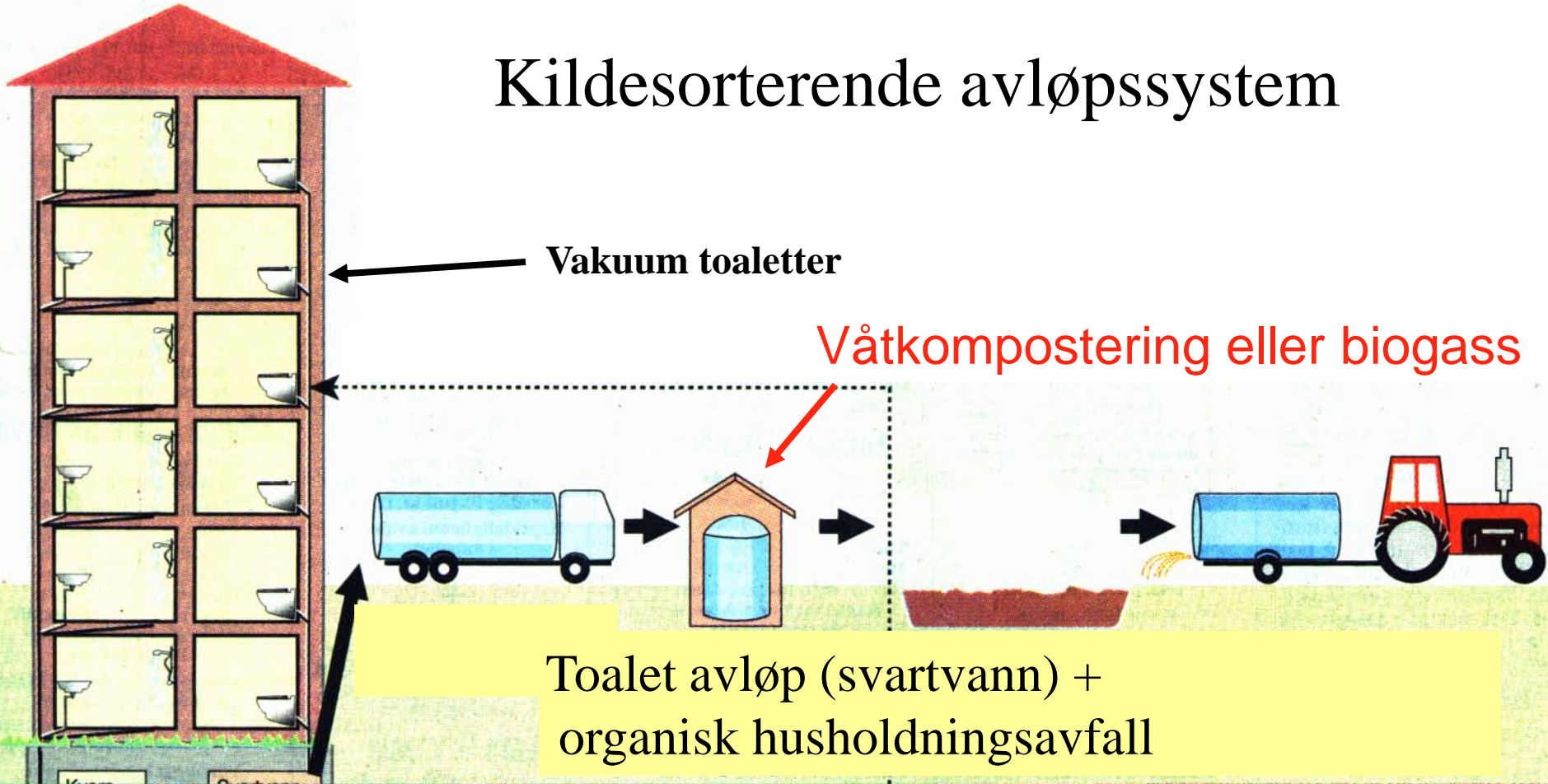
- 1660 vakuum toaletter
- > 2km vakuum ledninger

(Jets™)

Kildesorterende avløpssystem



Kildesortierende avløpssystem



Våtkompostering

- Aerob prosess
- Temperatur 50-60°C
- Ingen lukt
- Ikke tap av nitrogen
- Positiv energibalanse

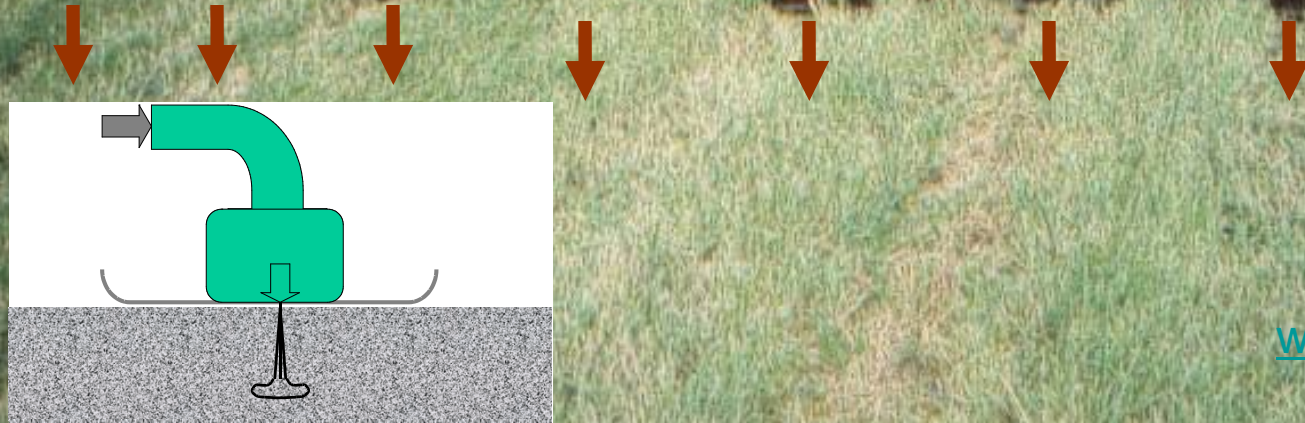


4 anlegg i Norge

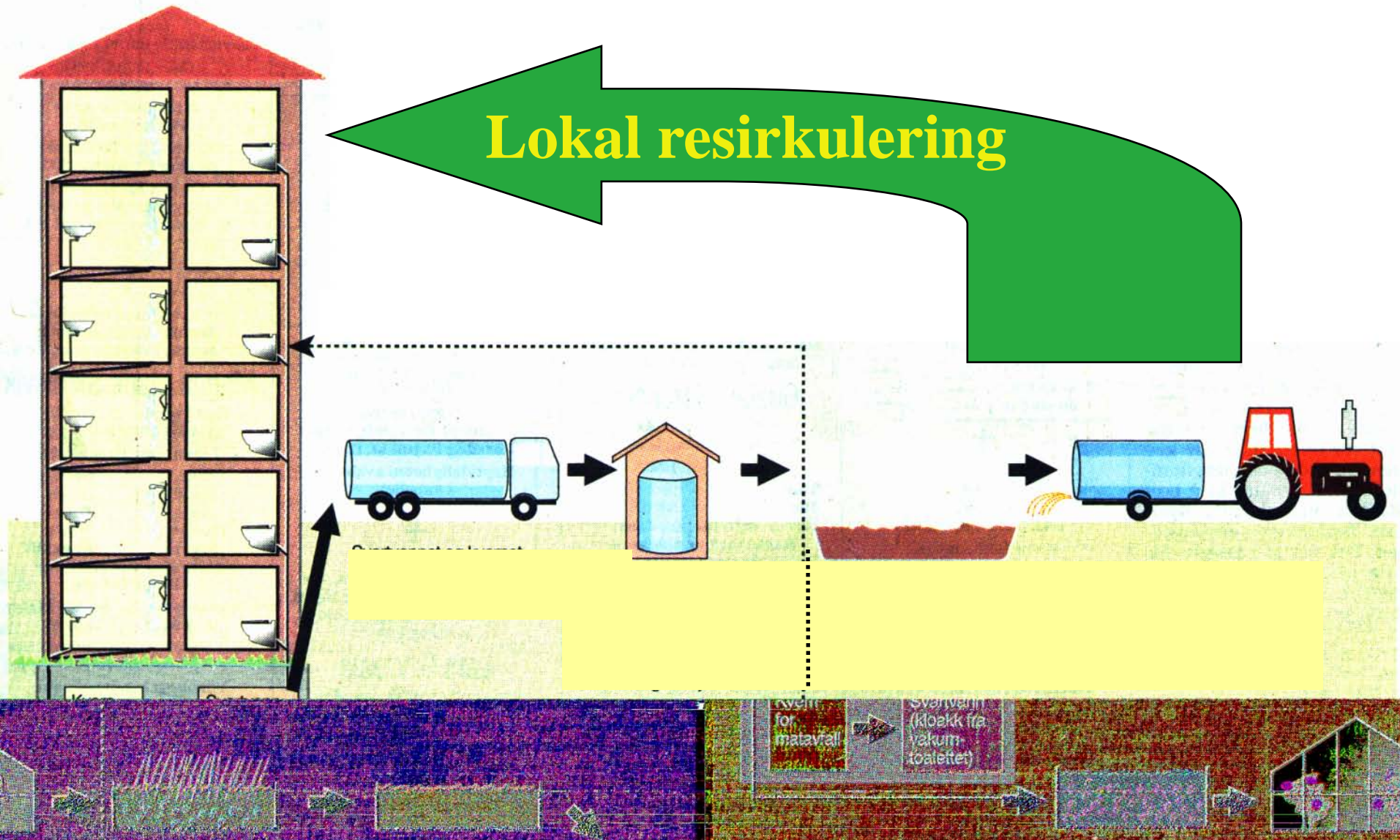
Våtkompostering Norrtälje kommun, Sverige



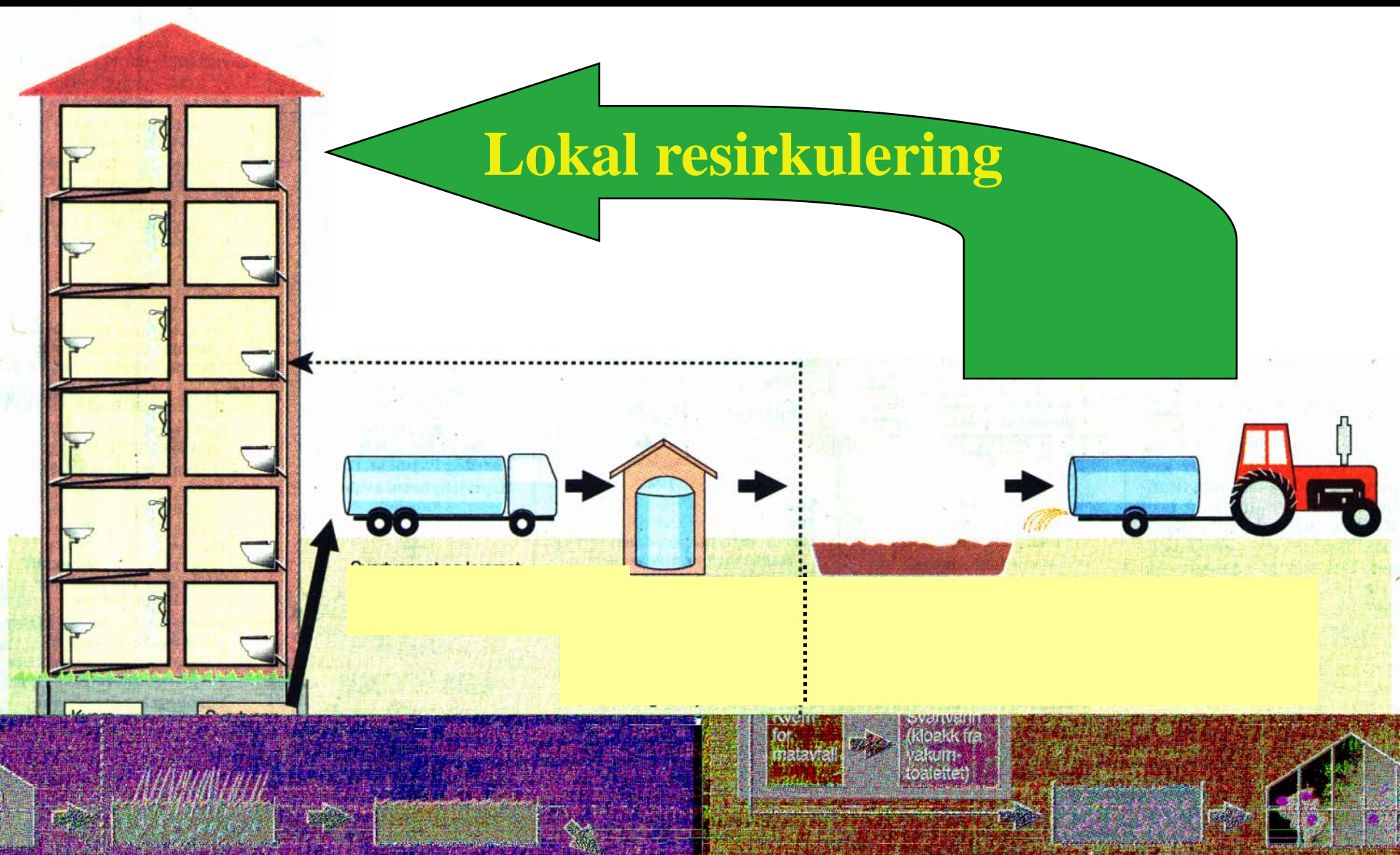
Direct Ground Injection (DGI)



Lokal resirkulering

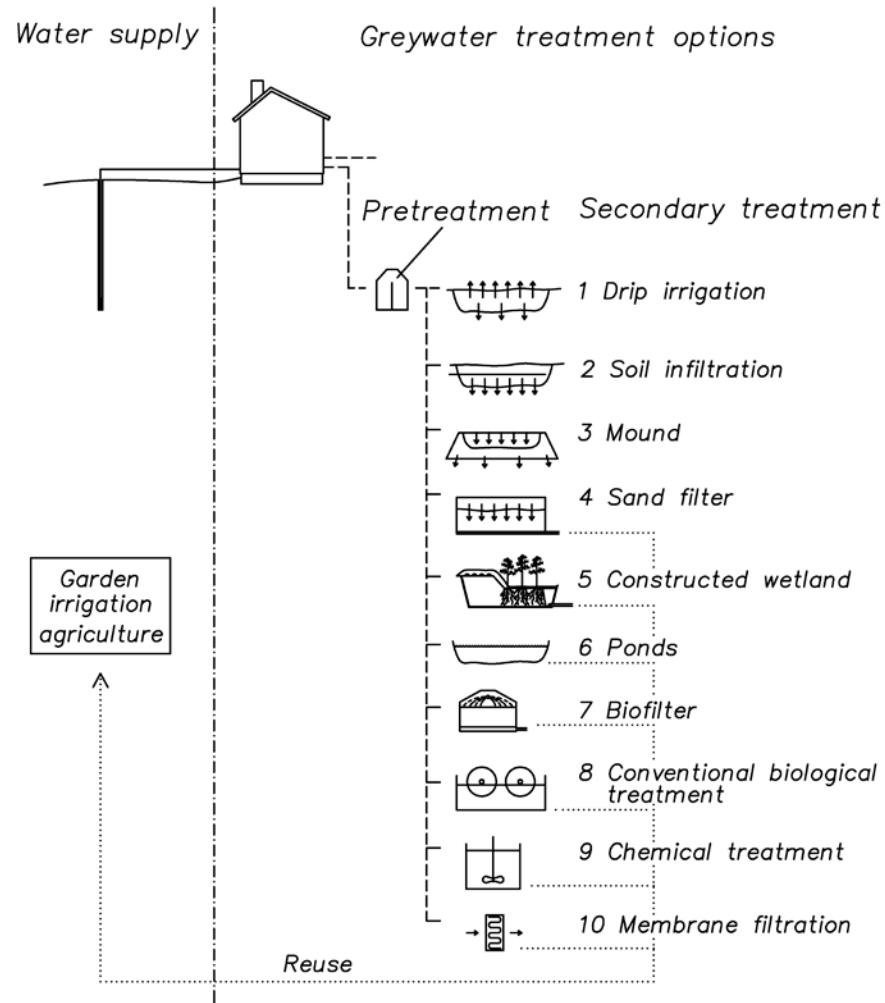


Lokal resirkulering

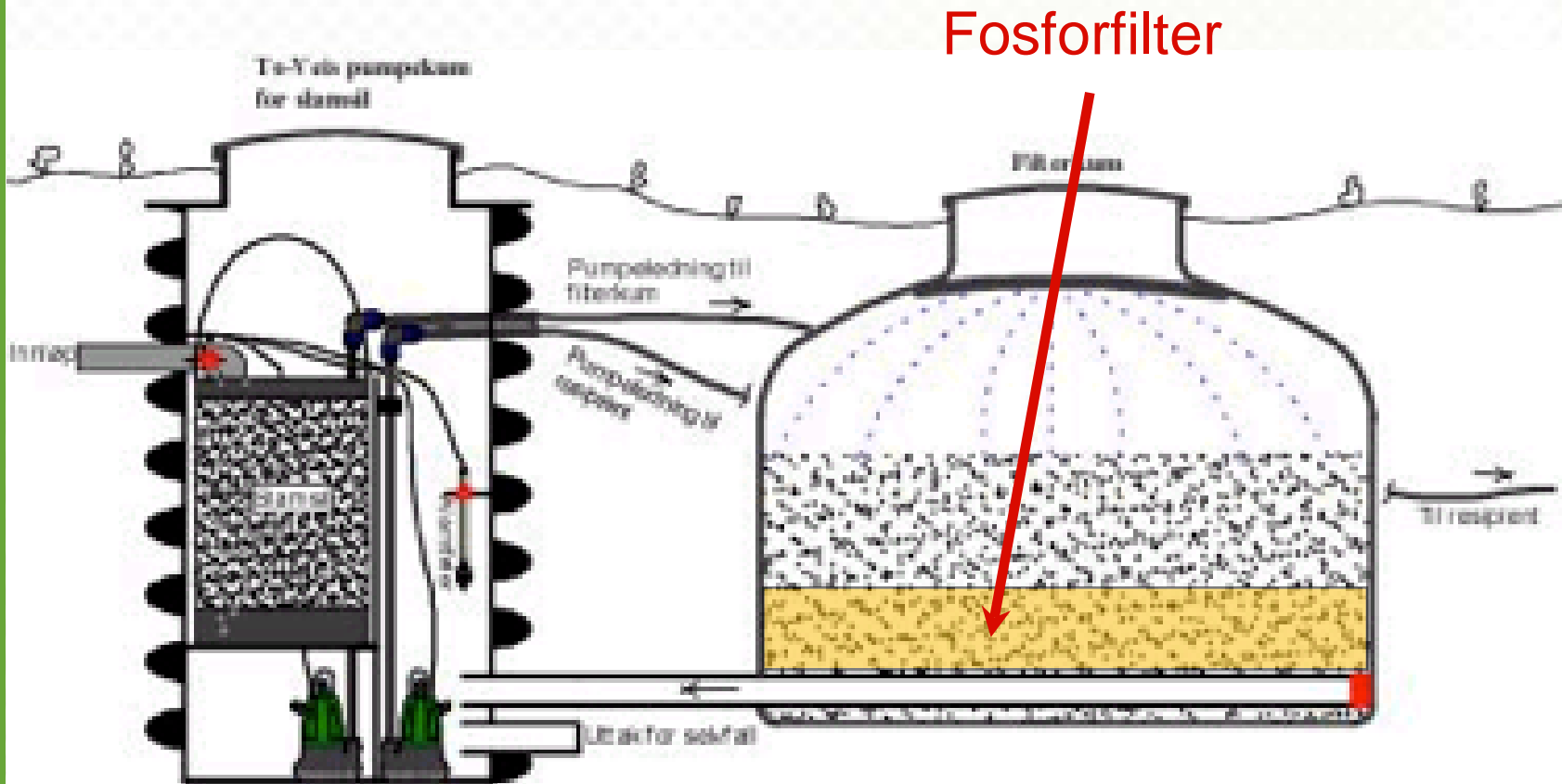


Gråvann

Gråvannsløsninger



Gråvannsanlegg for hytte med filterposekum, biofilter og fosforfilter



Kompakt gråvannsrensaneanlegg



BOF < 5 mg/l
SS < 2 mg/l
E.coli 2-3 log reduksjon

Decentralized systems in urban areas - OSLO

Klosterenga



Greywater treatment in OSLO



Pretreatment
Biofilter (PBF)

Horizontal
subsurface
flow CW

- 33 apartments
- 100 persons
- Area 1m²/person

Greywater treatment at Klosterenga



Text



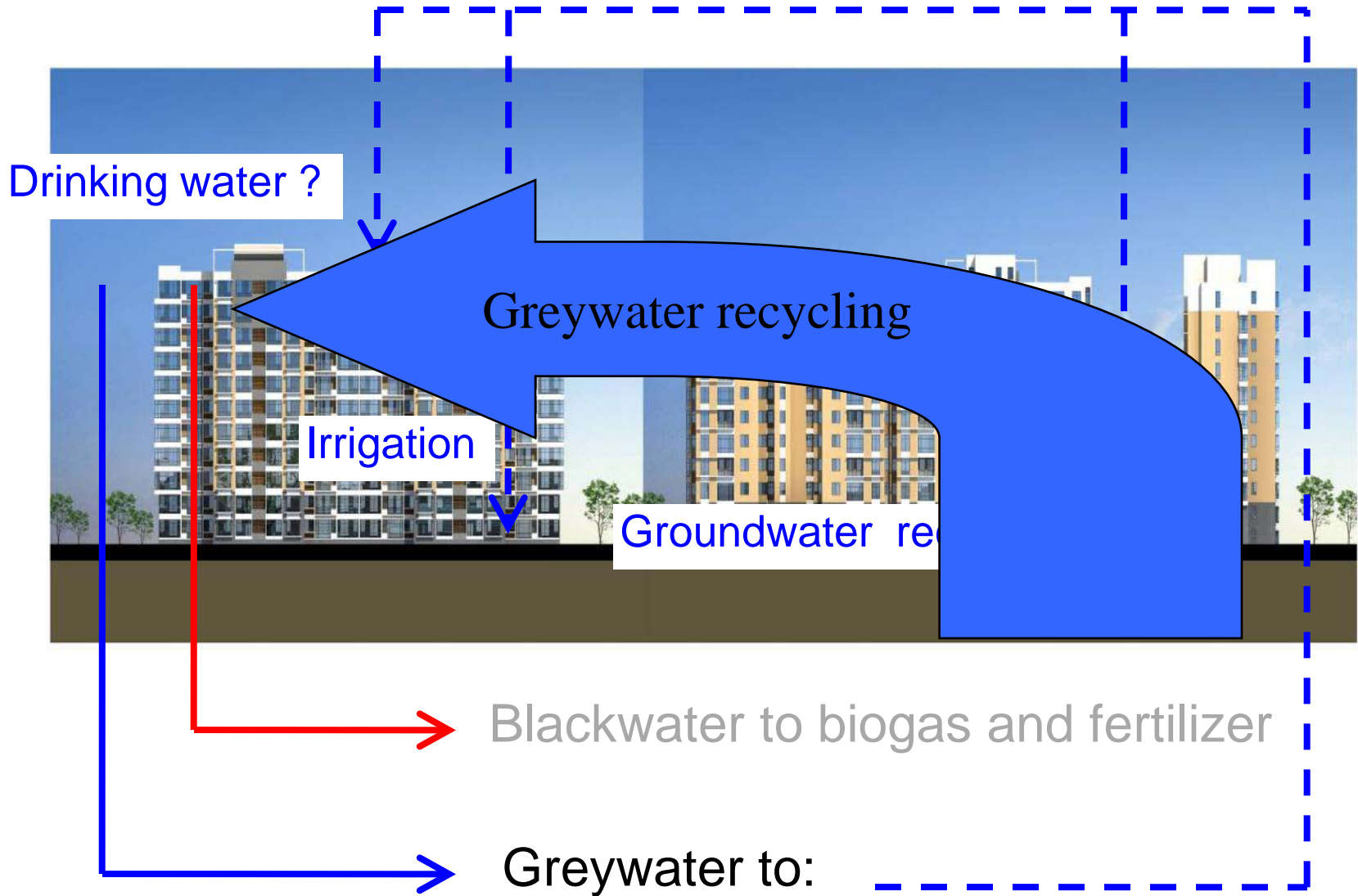
Effluent values:

Fecal coliforms:	<10
Total-N:	2,5 mg/l
Total-P:	0,02 mg/l

Greywater treatment at Klosterenga



90% watersaving is possible !



Studentboliger Ås

- 48 studenter
- Vakuum toaletter
- Gråvannsrensing i konstruert våtmark

Studentboliger Ås 28% vannsparing

WC
51
liter

Grå
vann
109
liter

115

Grå
vann
109
liter

Vakuum 6 liter

Daglig vannforbruk/person

Renseevne (%) Kaja studentboliger

Parameter	Utløp slamavskiller mg/l	Utløp våtmark mg/l	Rensegrad %	Total rensegrad %*
BOF	87	5,6	94	97
Totalt fosfor	0,97	0,05	95	99
Totalt nitrogen	8,7	2,6	70	97

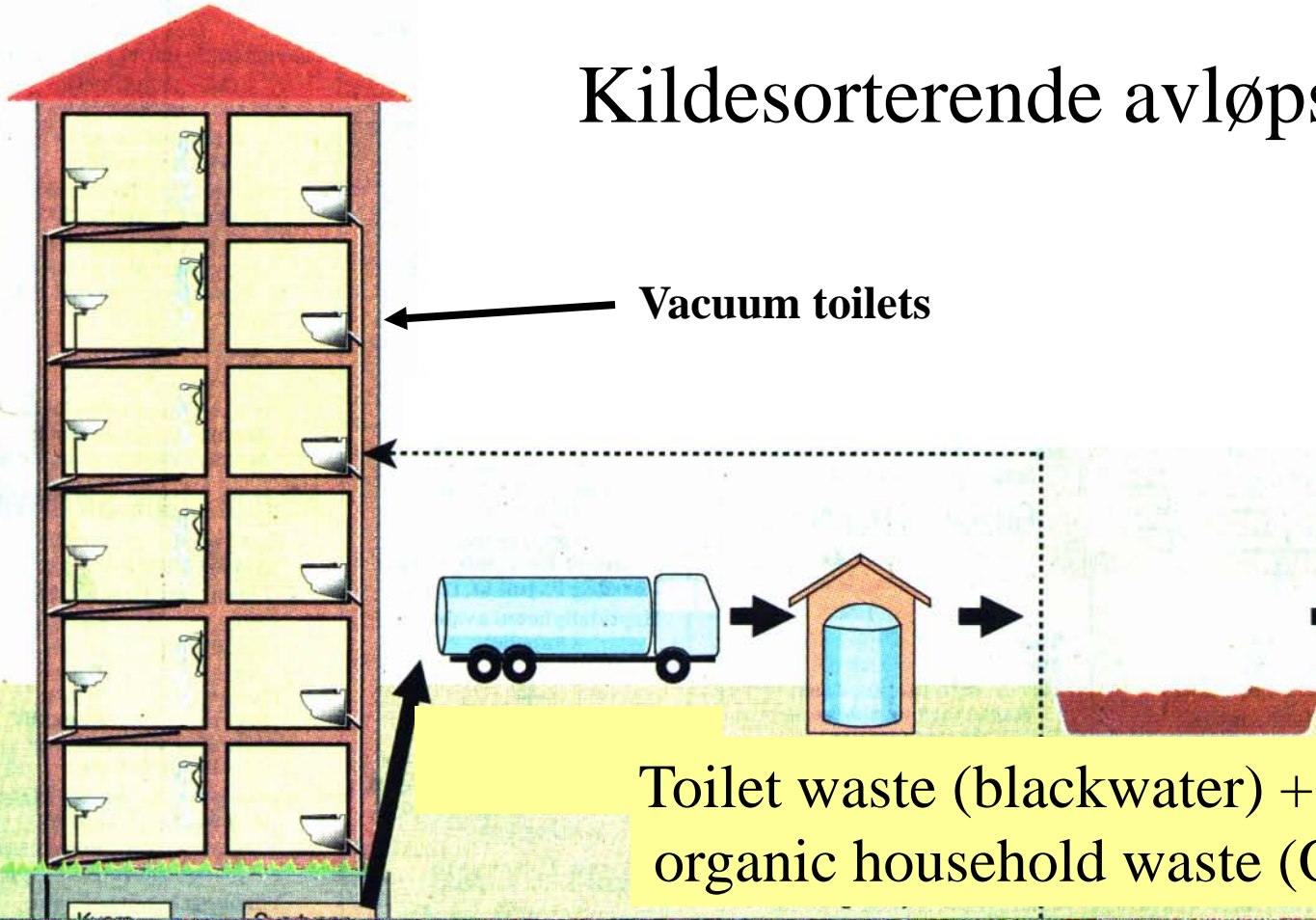
*forutsetter 90% av N, 80% av P og 50% av BOF i svartrank

(Jenssen & Heyerdahl 2006)



www.umb.no

Kildesortierende avløpssystem



Renseeffekter*

Organisk stoff (BOD):

> 95 %

Suspendert stoff (SS):

> 95 %

Fosfor (P):

> 95 %

Nitrogen (N)

> 95 %

Bakterier:

4-6 log reduksjon

Greywater treatment at Klosterenga



Text



Effluent values:

Fecal coliforms: <10
Total-N: 2,5 mg/l
Total-P: 0,02 mg/l



Upscaling decentralized urban systems



● *Treatment/collection site*



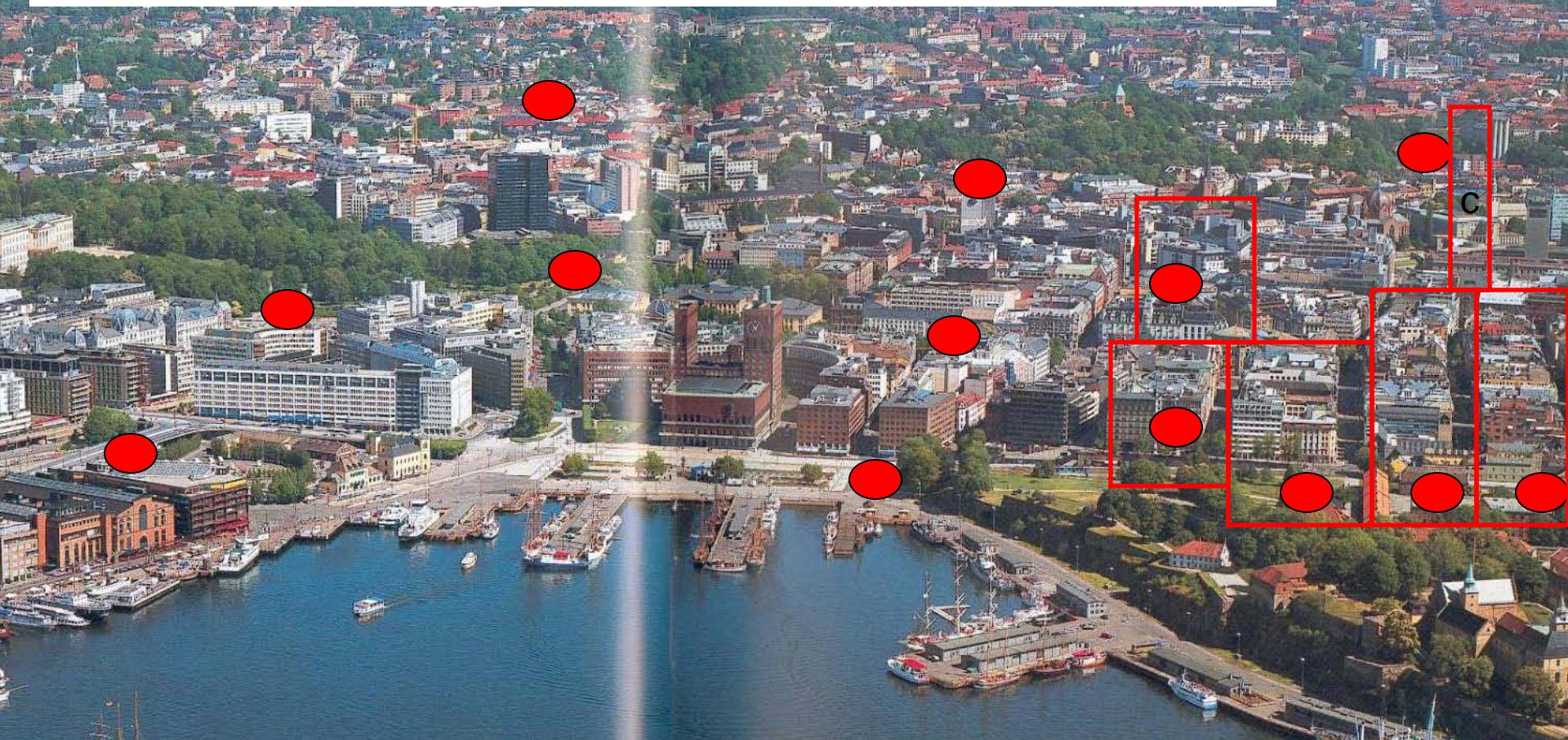
Upscaling decentralized urban systems



● *Treatment/collection site*



Upscaling decentralized urban systems



● *Treatment/collection site*



Decentralized in megacities ?



Photo: P. Jenssen

Vacuum technology Marine installations



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

(Jets™)

Vacuum technology

Marine installations



(Jets™)



Photo: P. D. Jenssen



Rensing av gråvann

Kompakt biologis anlegg m/biorotor



Storskala implementering av
kildesorterende løsninger er
teknisk mulig!



Kildesortering - fordeler og ulemper

+++

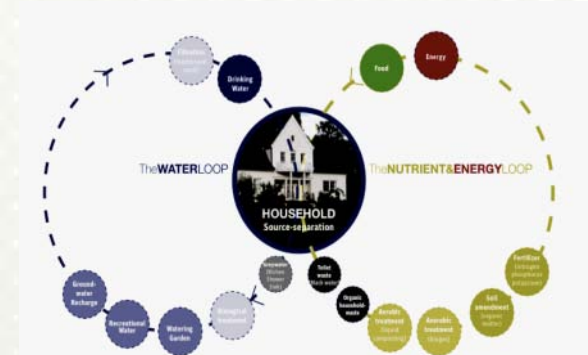
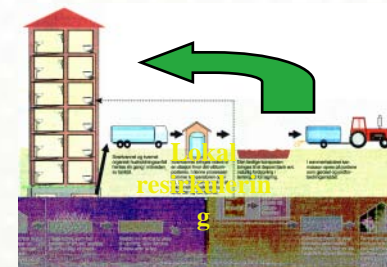
- Gir svært høg renseevne for alle parametere
- Gir gode muligheter for resirkulering av vann og næringsstoffer
- Muligheter for å spare mye vann
- Kan tilpasses ulike teknologinivå brukerkrav og type bebyggelse

- Har en annerledes infrastruktur
- Brukeraksept av andre toaletter
- Tette tanker er ikke tette



Kildesortering - bruksområder

- Områder med svært følsomme resipienter
- Hytter, eneboliger
- Turistbedrifter
- Større bygg
- Landsbygd og by
- I- og U-land



Kretsløpsteknologi med kildesortering



Source: GTZ