Håkan Jönsson´s «Farewell Symposium» 25. oktober, 2017

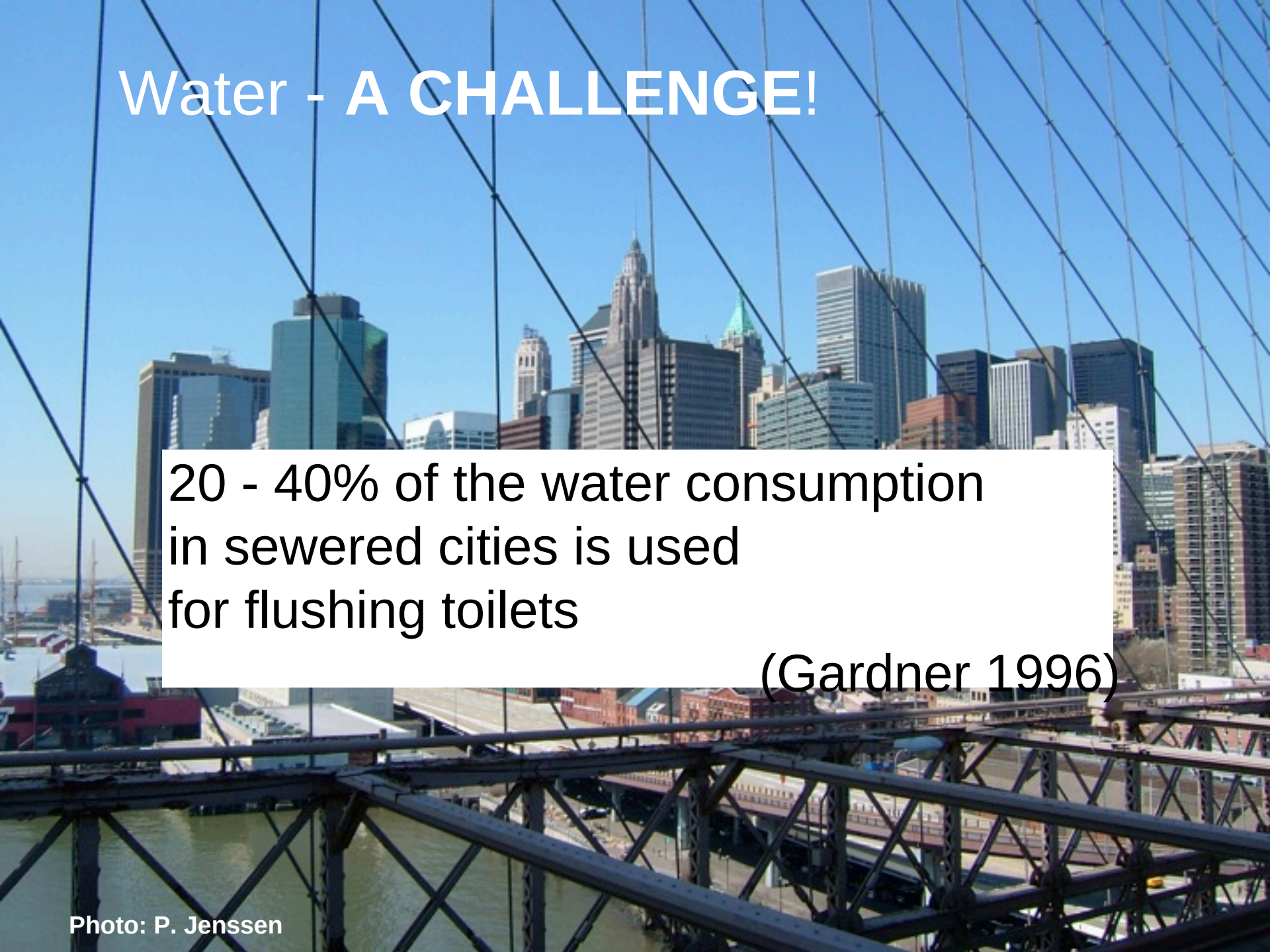
Sustainable technologies to meet the future needs for sanitation

Petter D. Jenssen
Faculty of Environmental Sciences and Natural Resource Management (MINA)
Norwegian University of Life Sciences (NMBU)

https://www.startupbootcamp.org/blog/2016/11/smart-cities/


MANHATTAN
Photo: P. Jenssen

Water - **A CHALLENGE**!



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

(Gardner 1996)

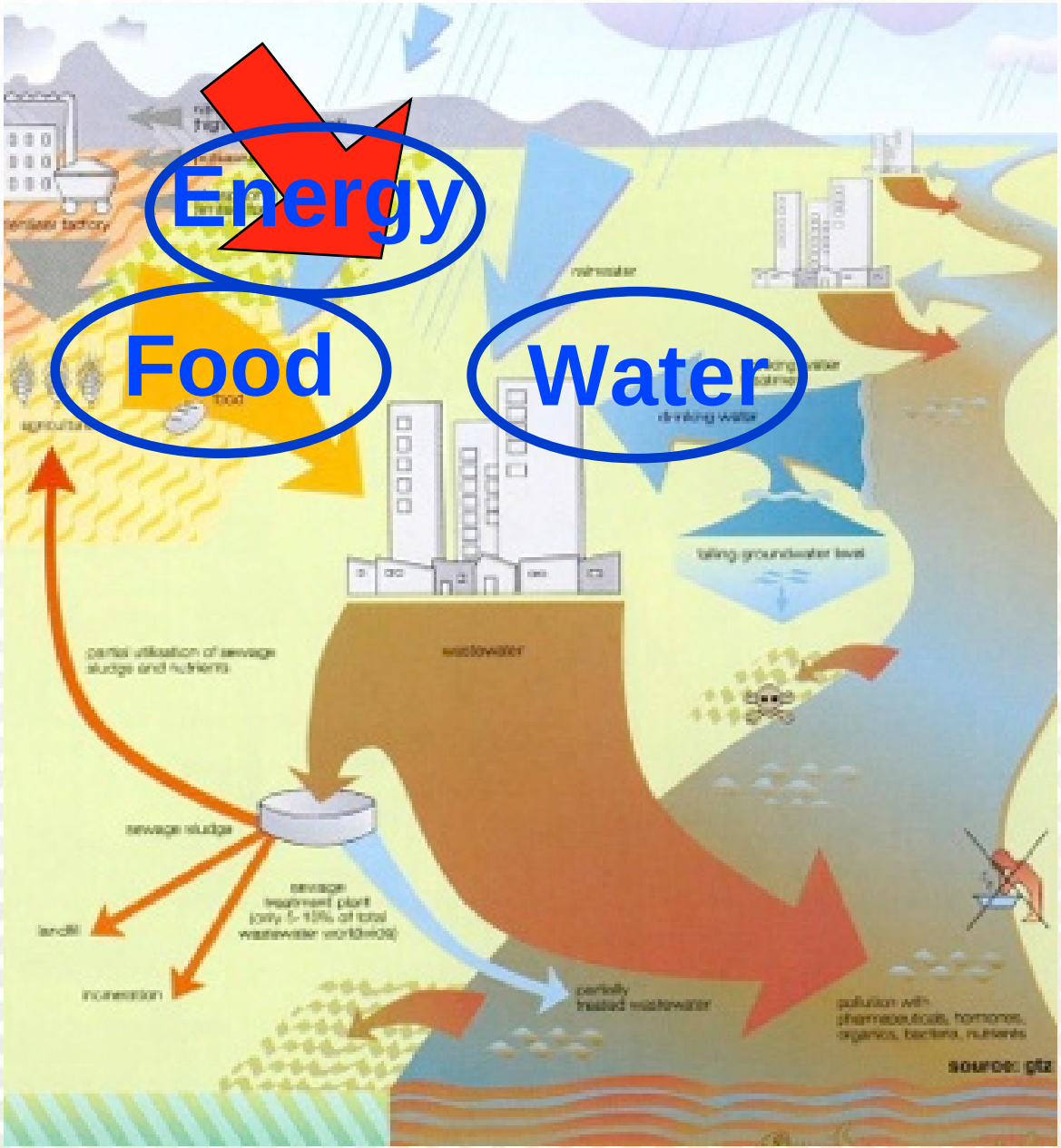
Photo: P. Jenssen

Water - **A CHALLENGE**!

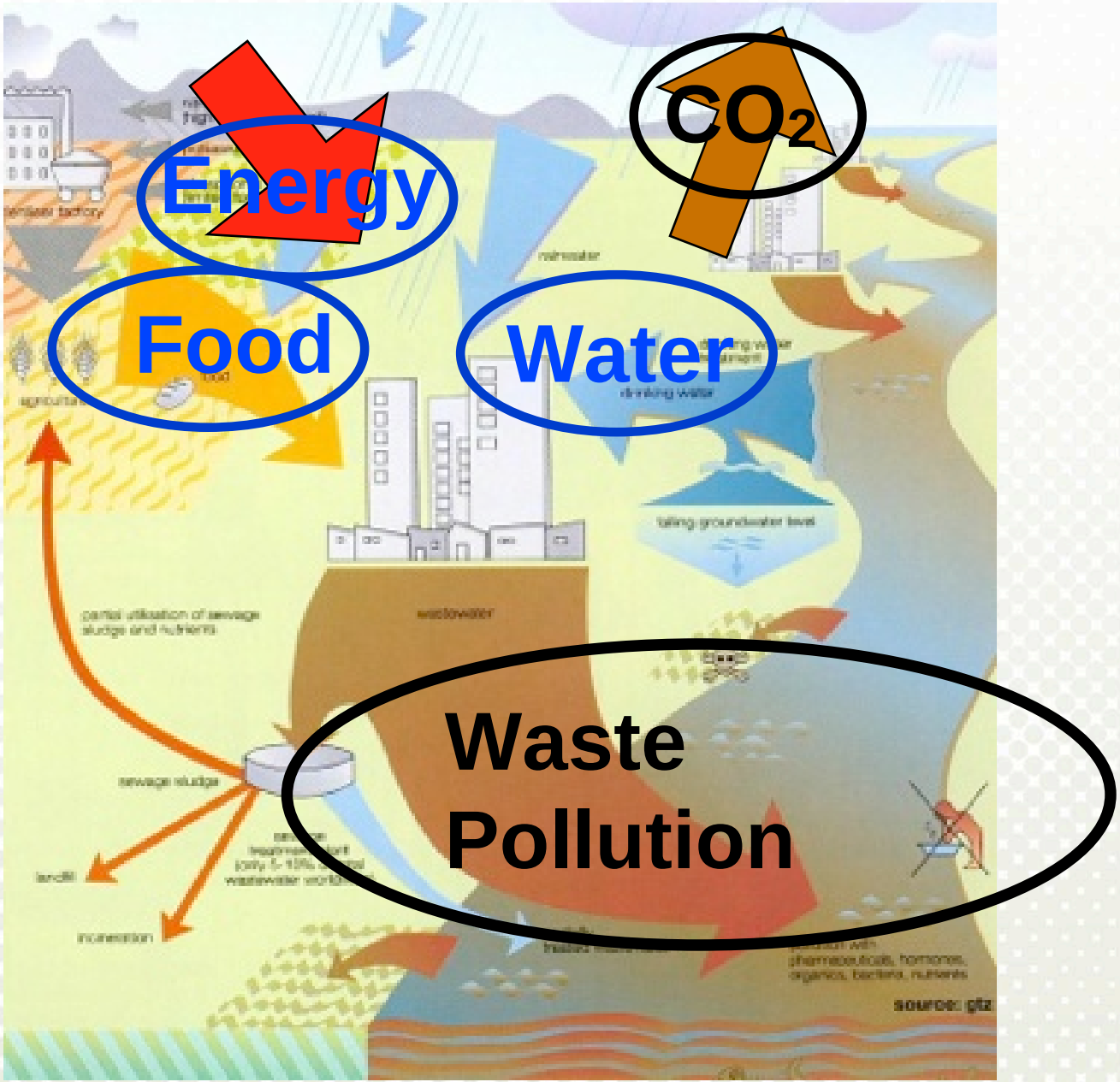
Can we reduce the water footprint of a city to 1/10th without sacrificing comfort?

Photo: P. Jenssen

Flow of resources - import

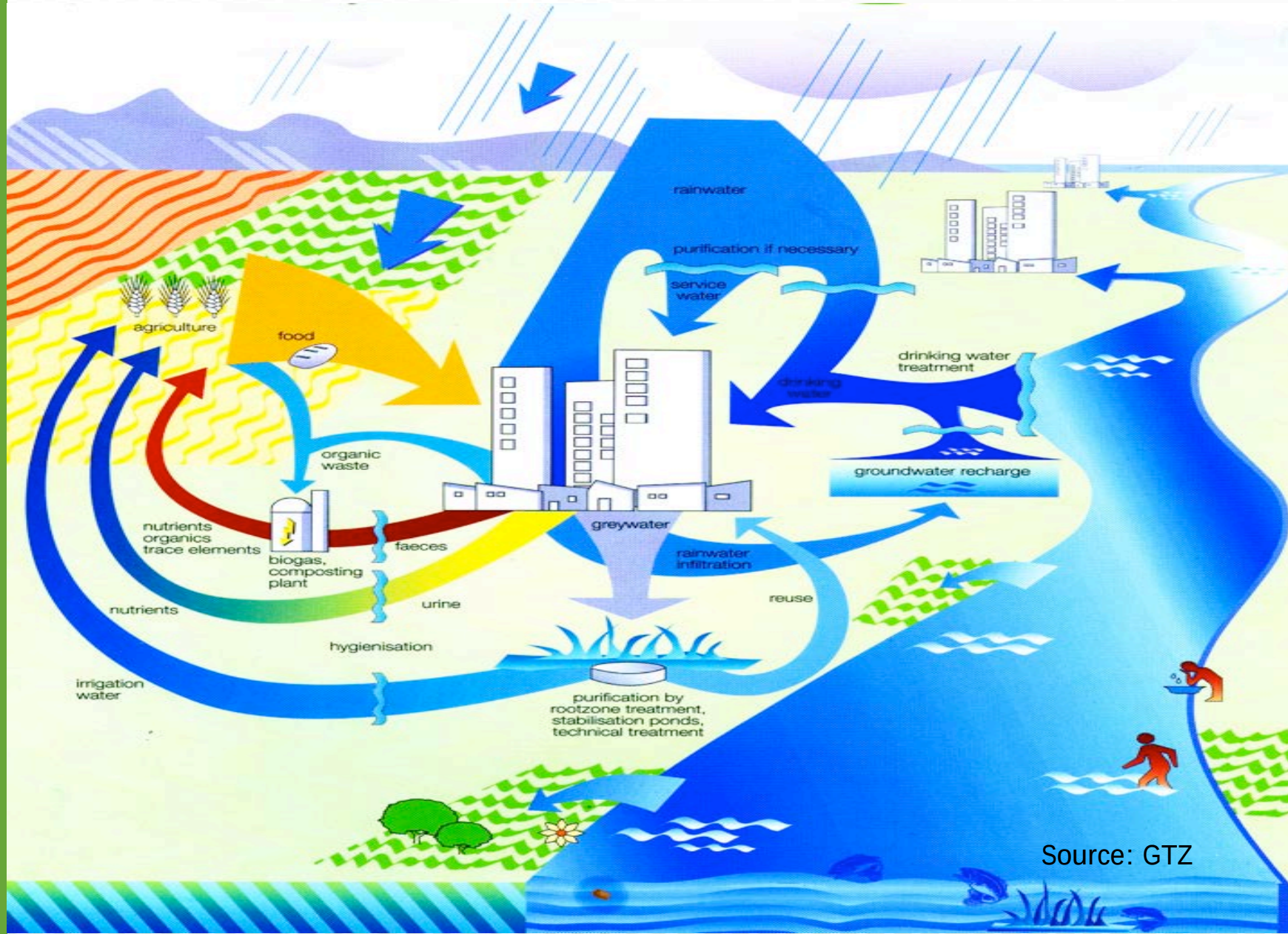


Flow of resources - import/export



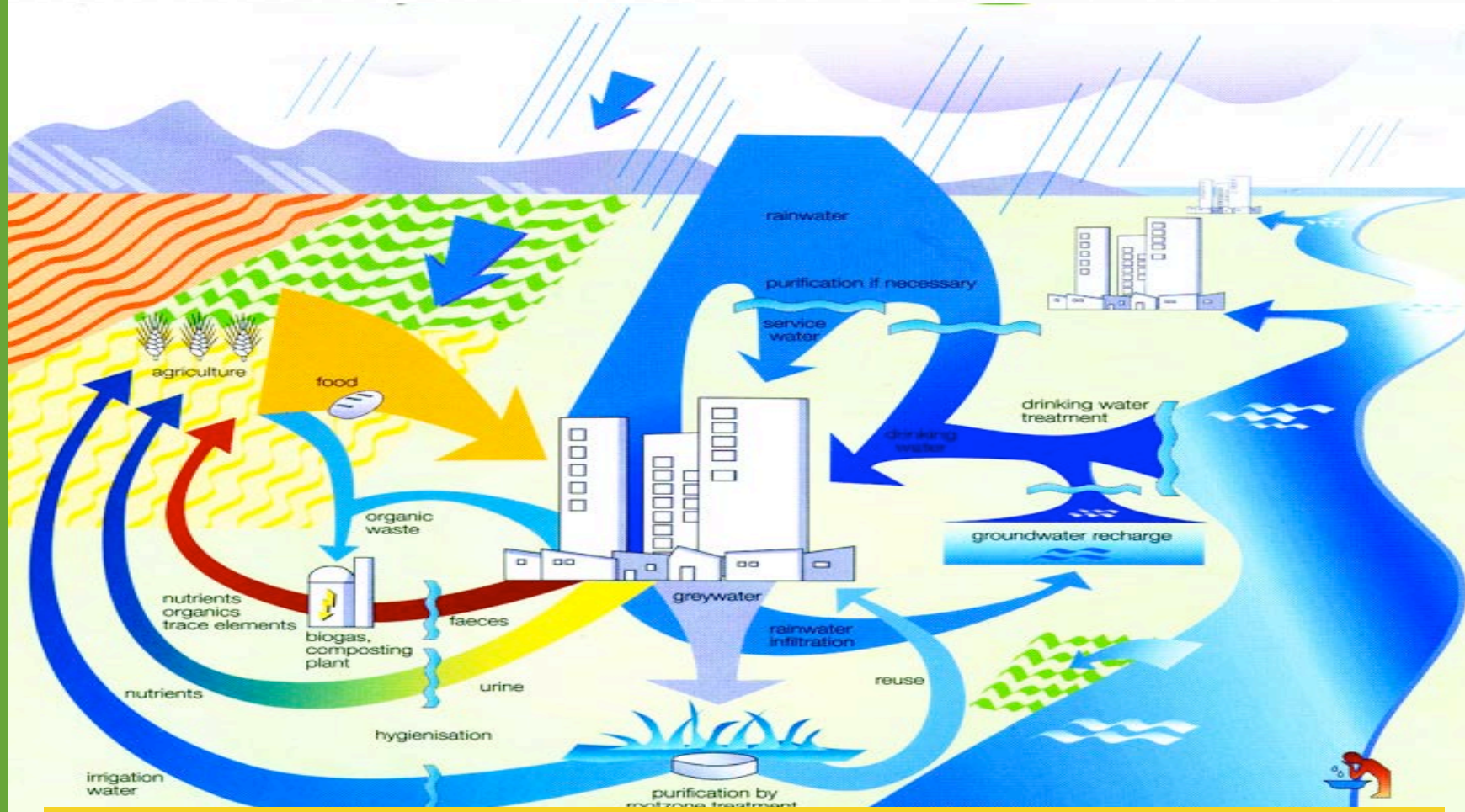

Kathmandu, Nepal
Baghmati river
Dry season:
DO less than 1 mg/l
BOD - 250 mg/l
(Pandey et al. 2005)
MAY 4 2005

The sustainable «green» city - vision



Source: GTZ

The sustainable «green» city - vision



«Circular economy»

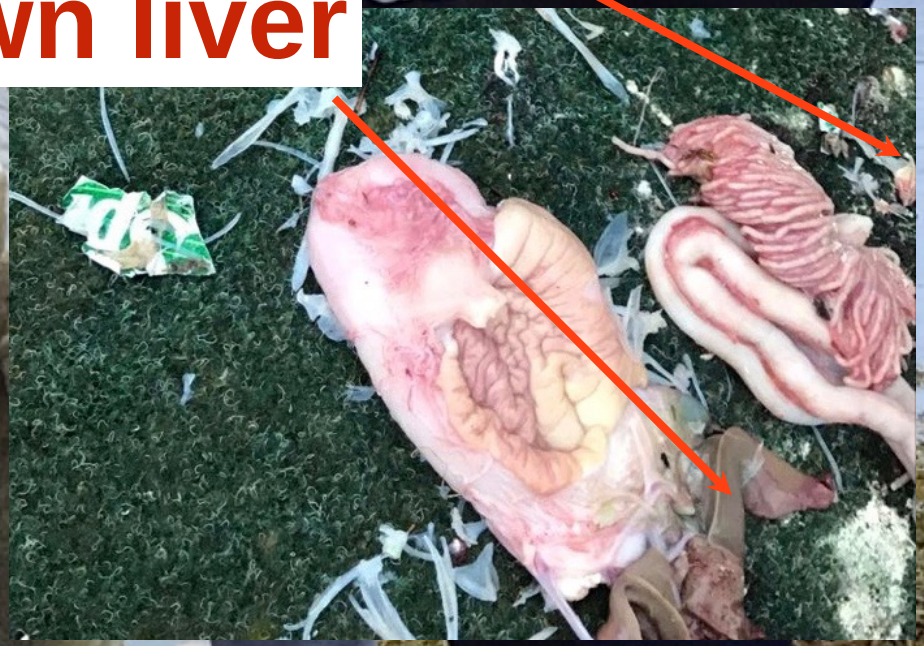
Codfishing Norwegian coast 2017

Codfishing Norwegian coast 2017

Pieces of a soda can & plastic!

Codfishing Norwegian coast 2017

Dark brown liver



Svolværpostei

Made from cod roe and cod liver

Popular on sandwiches

Svolværpostei

Made from cod roe and cod liver

Popular on sandwiches

WARNING: Not to be consumed by pregnant women!

Organic micropollutants (PPCP´s PCB´s) in polar mammals

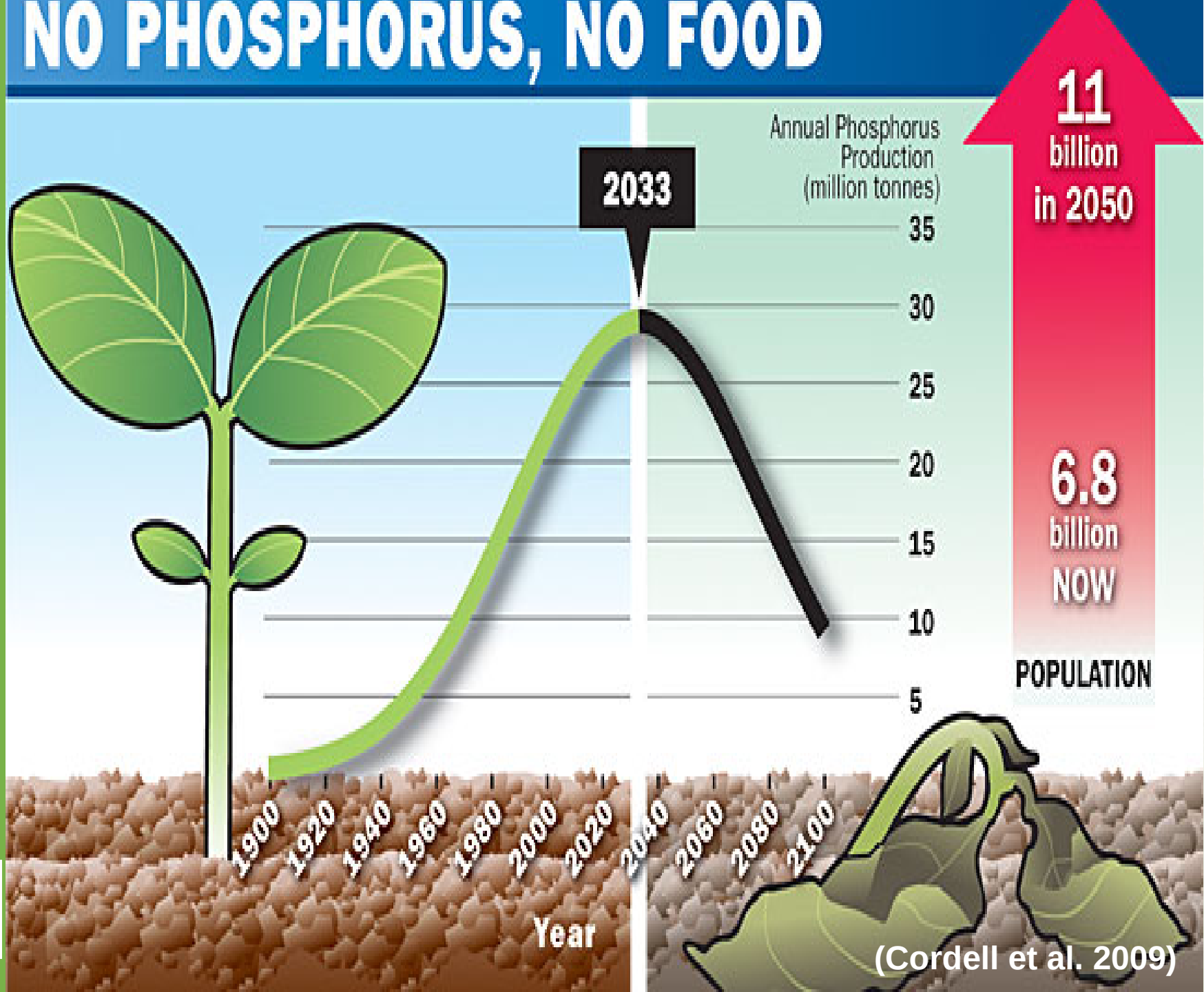
Kallenborn et al. 2016

Wastewater discharge to arctic waters – problems?

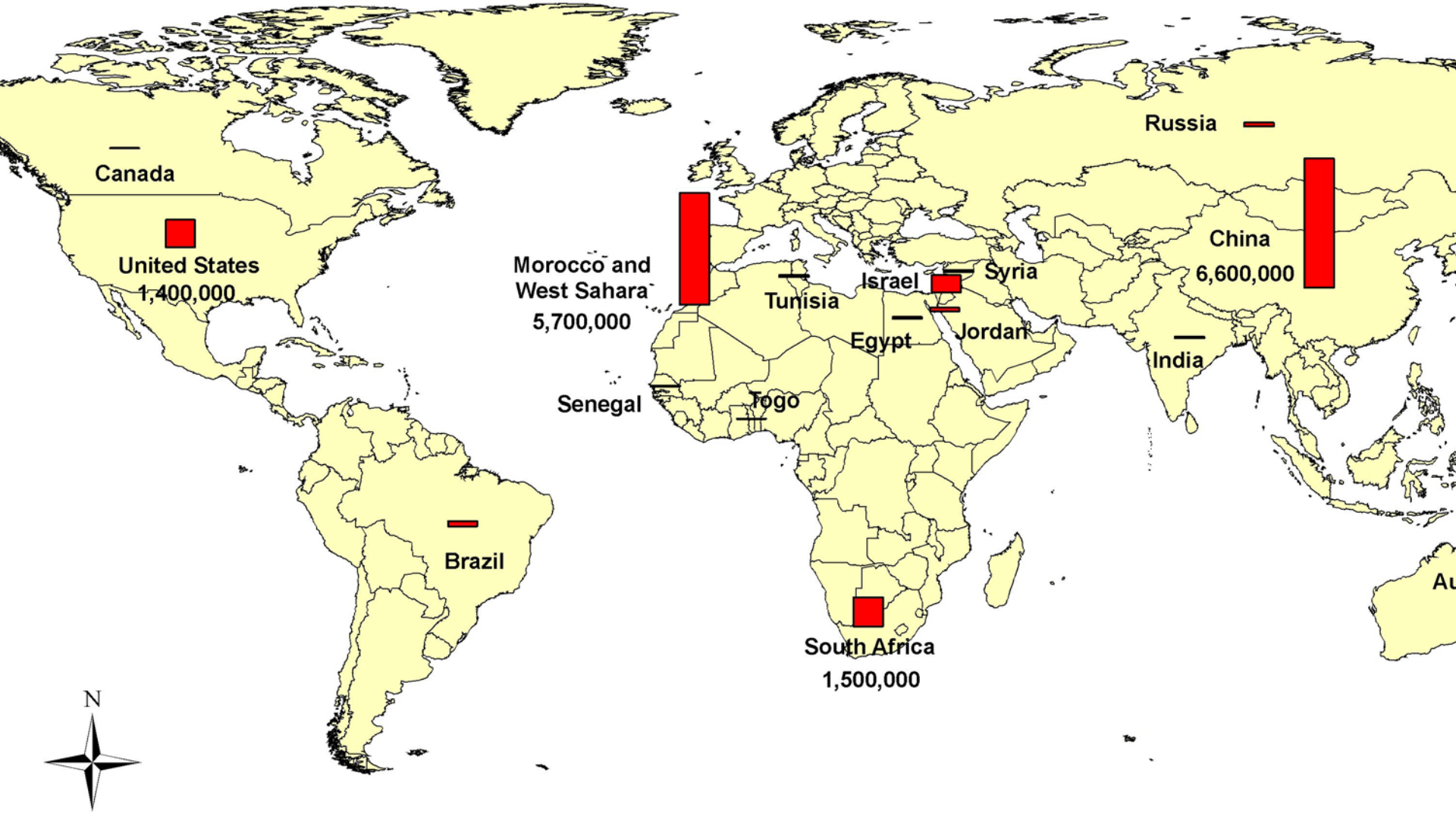
- Nutrients (nitrogen and phosphorus)
- Organic matter
- Particles (TSS)
- Microorganisms
- **Organic micropollutants as PPCP´s**
- **Nanoparticles**

(Gunnarsdottir et al. 2012, Jenssen et al. 2015)

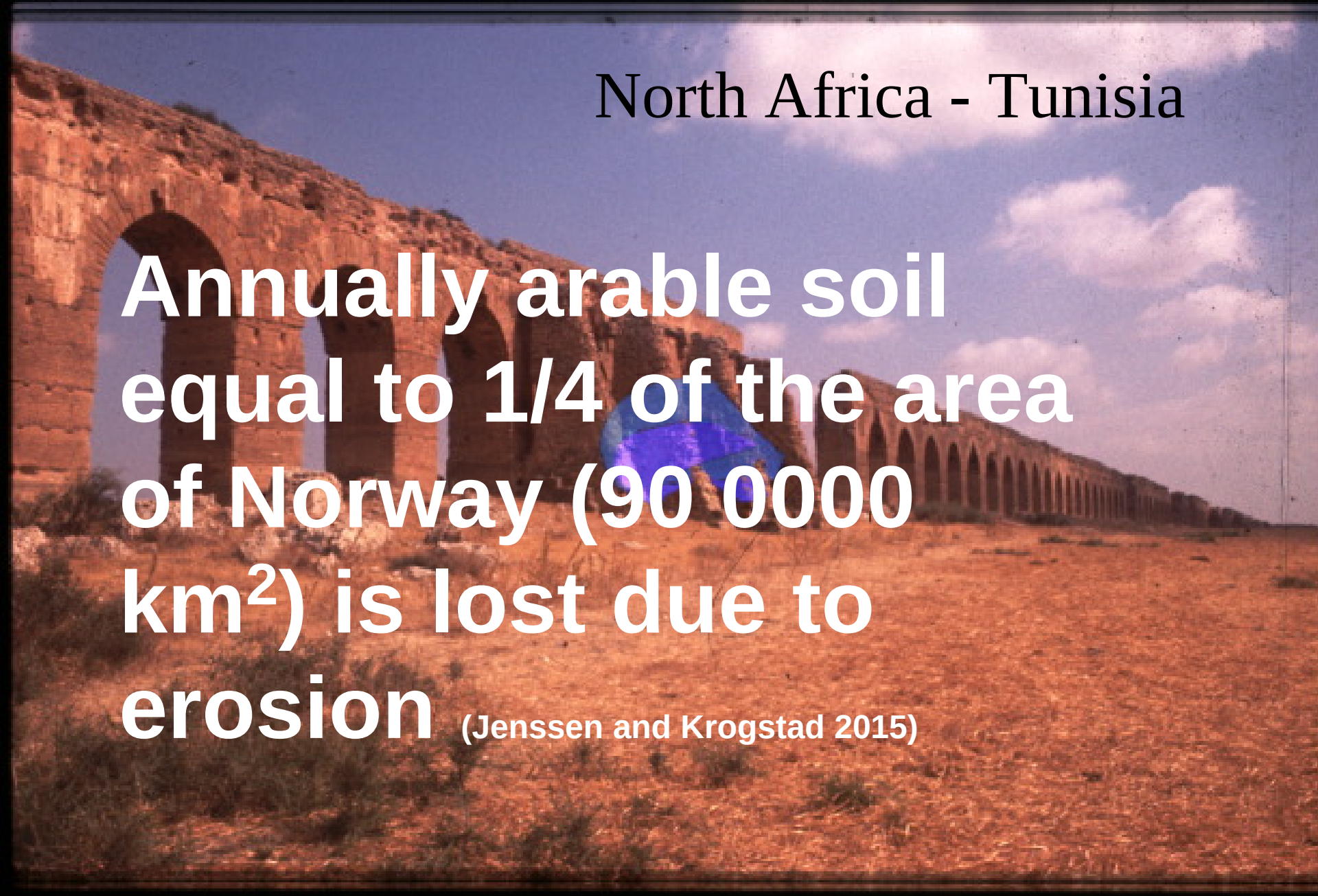
Photo P.D. Jenssen


NO PHOSPHORUS, NO FOOD
Annual Phosphorus Production (million tonnes)
2033
35
30
25
20
15
10
5
11 billion in 2050
6.8 billion NOW
POPULATION
1900
1920
1940
1960
1980
2000
2020
2040
2060
2080
2100
Year
(Cordell et al. 2009)

Phosphate Rock - Worldwide Reserve Estimates (thousands of metric tons)



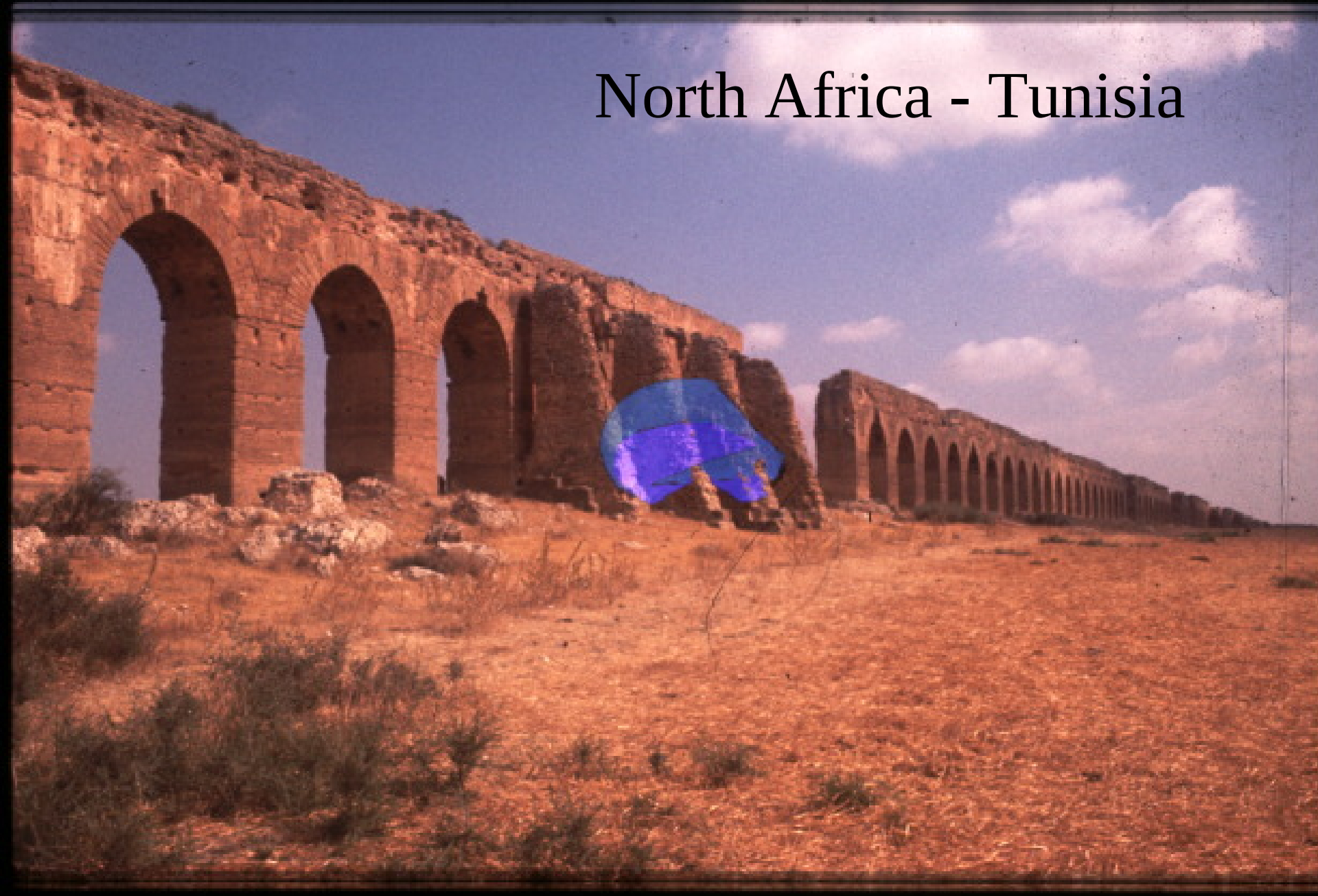
Source: USGS and ESRI


North Africa - Tunisia
Annually arable soil equal to 1/4 of the area of Norway (90 0000 km^2) is lost due to erosion (Jenssen and Krogstad 2015)

Loss of Soil Fertility, slow but dramatic at global scale can be counteracted by **returning treated biowaste**

(Map from WWW.FAO.ORG)

North Africa - Tunisia

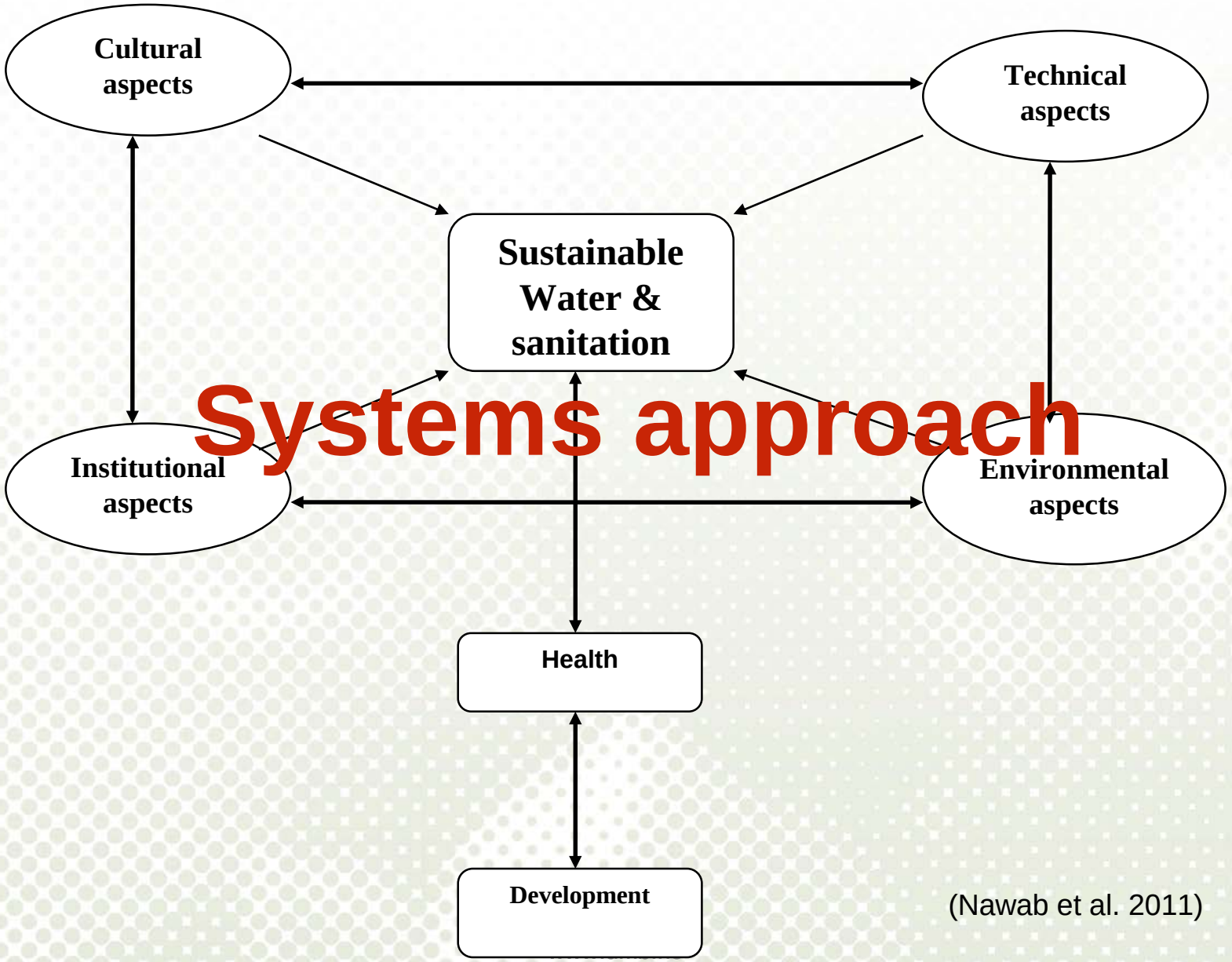


Ecological Engineering - Ecotechnology

”The development of human society with nature for the benefit of both”

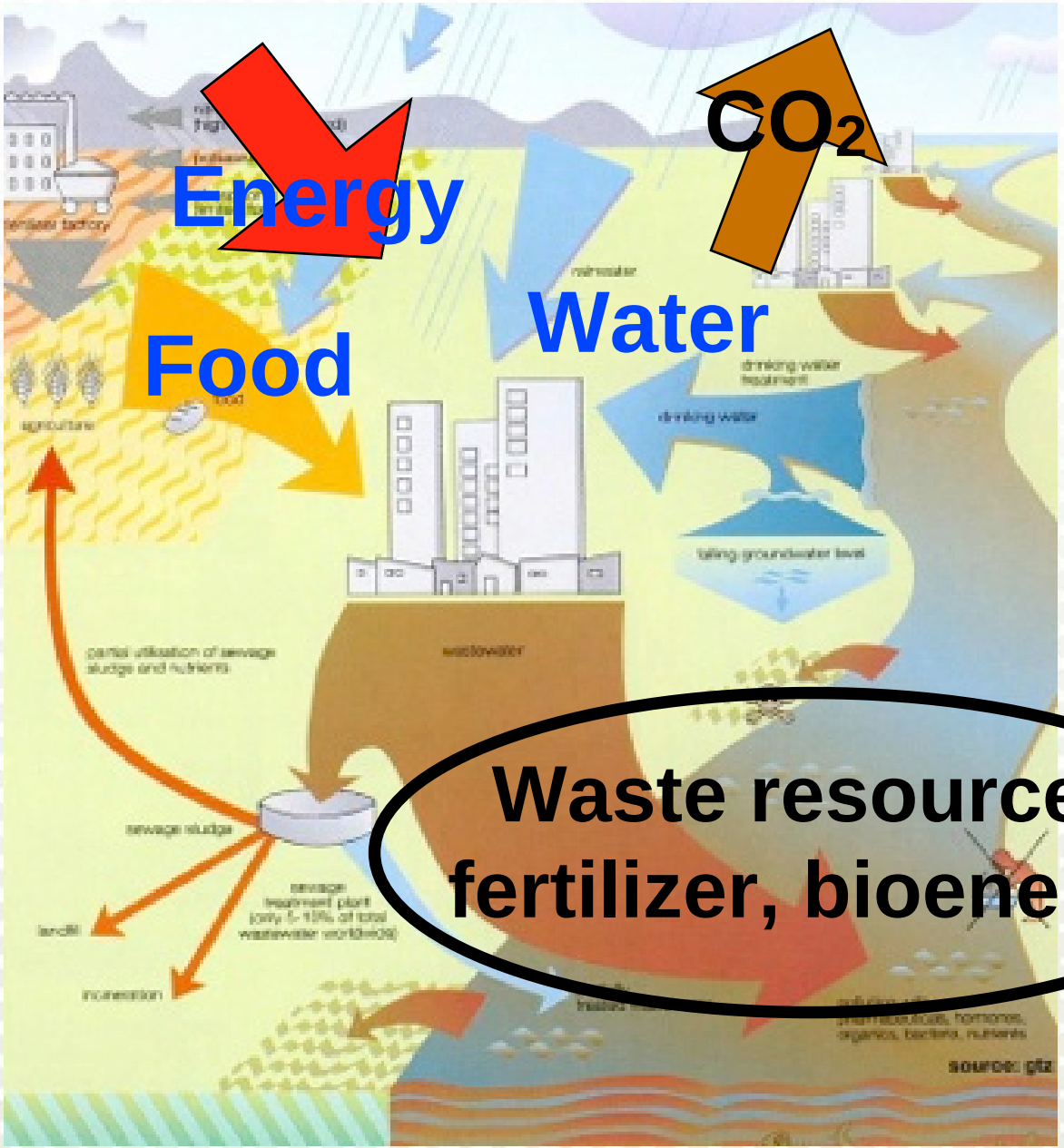
(Mitsch and Jørgensen 1989)

Framework for Sustainable Sanitation



(Nawab et al. 2011)

Flow of resources - import/export

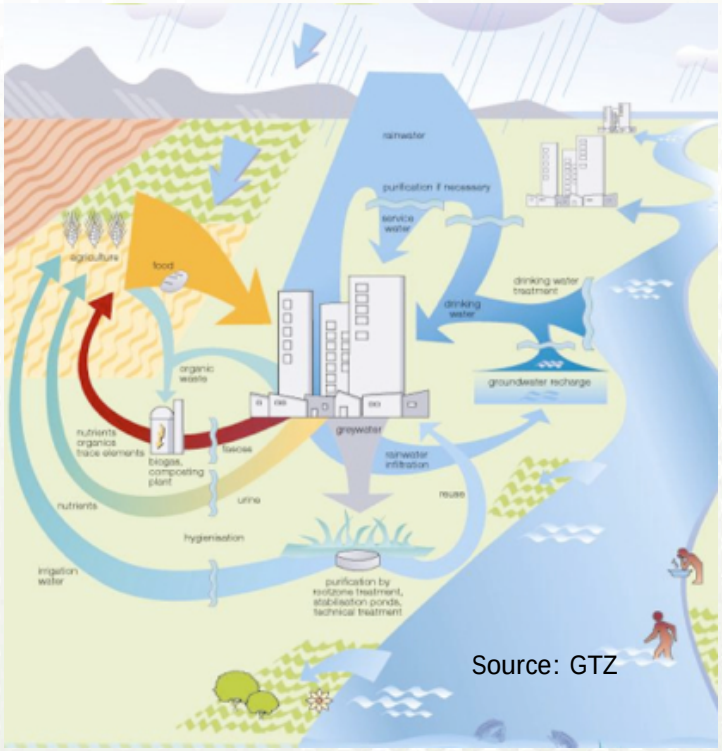


How can we recycle nutrients from wastewater?

Reuse of sewage sludge from current treatment plants (**mainly P recycled**)

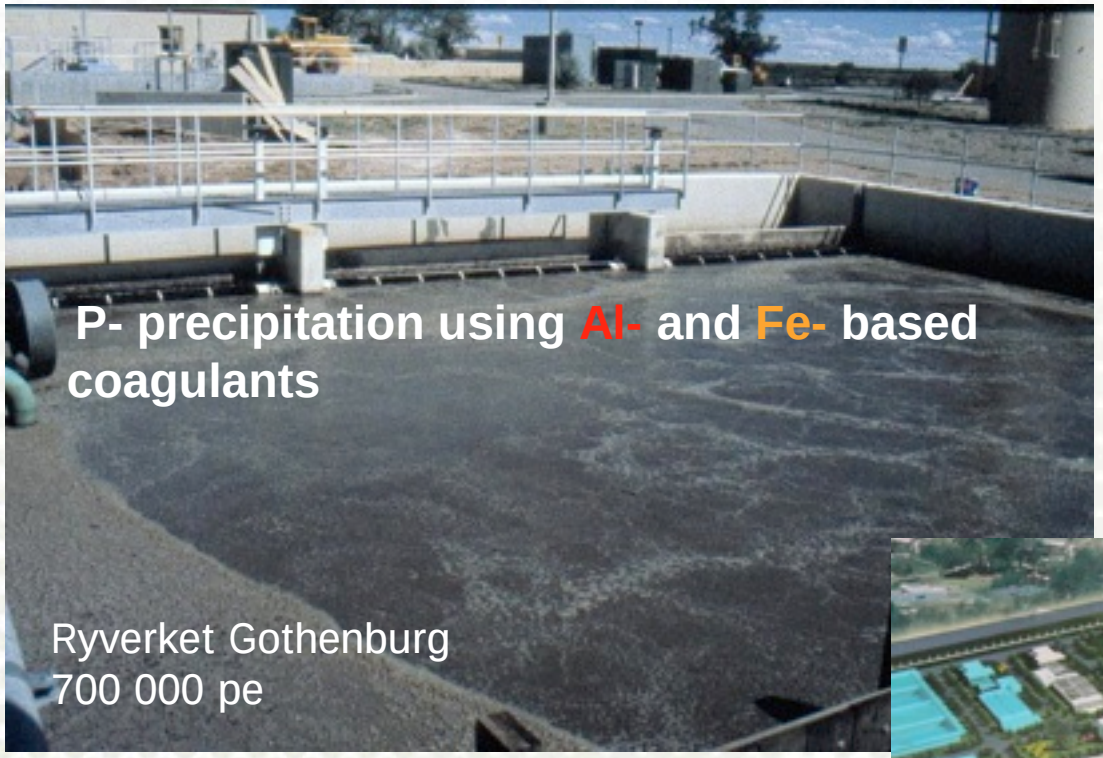
Precipitation of struvite from wastewater **(N and P recycled)**

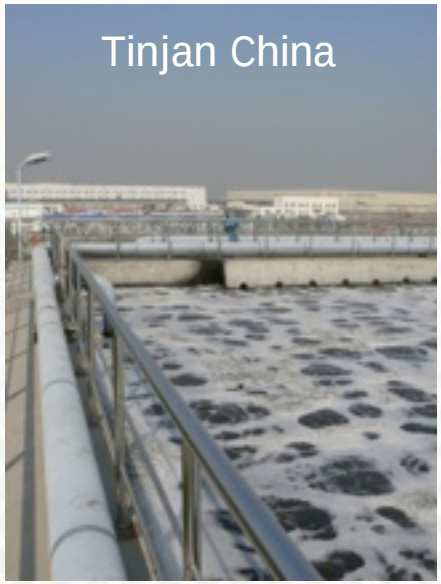
Recycle human excreta by the use of source separating systems **(N,P and K recycled)**



Source: GTZ

Conventional wastewater treatment – technically advanced, energy consuming





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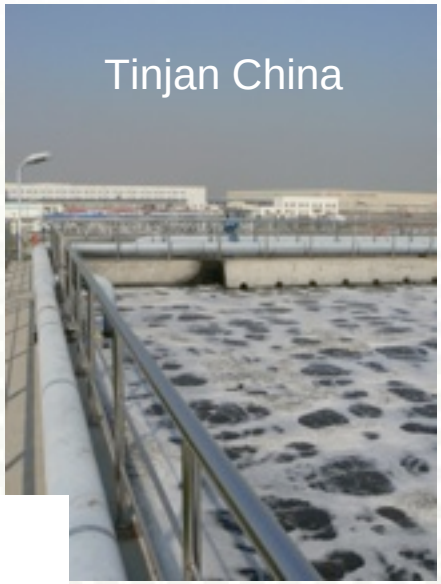
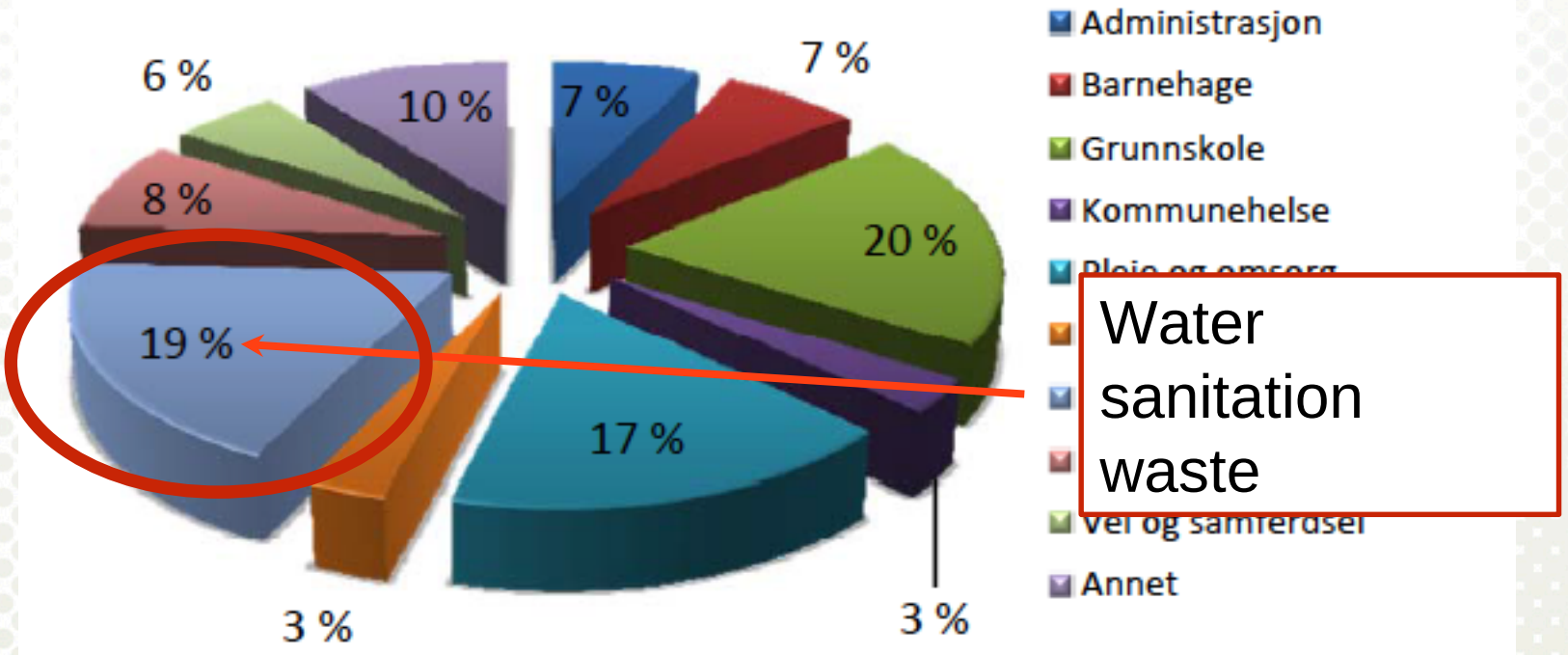


The water industry is the fourth most energy intensive sector in the UK!

Parliament Office of Science and Technology, Postnote 282, 2007

CO_2 footprint (CO_2 ekvivalents) for different sectors i Oppland county Norway (Larsen et al. 2013)



Figur 2: *Fordeling av klimafotavtrykk per tjenestefunksjon, samlet alle kommuner for 2011*

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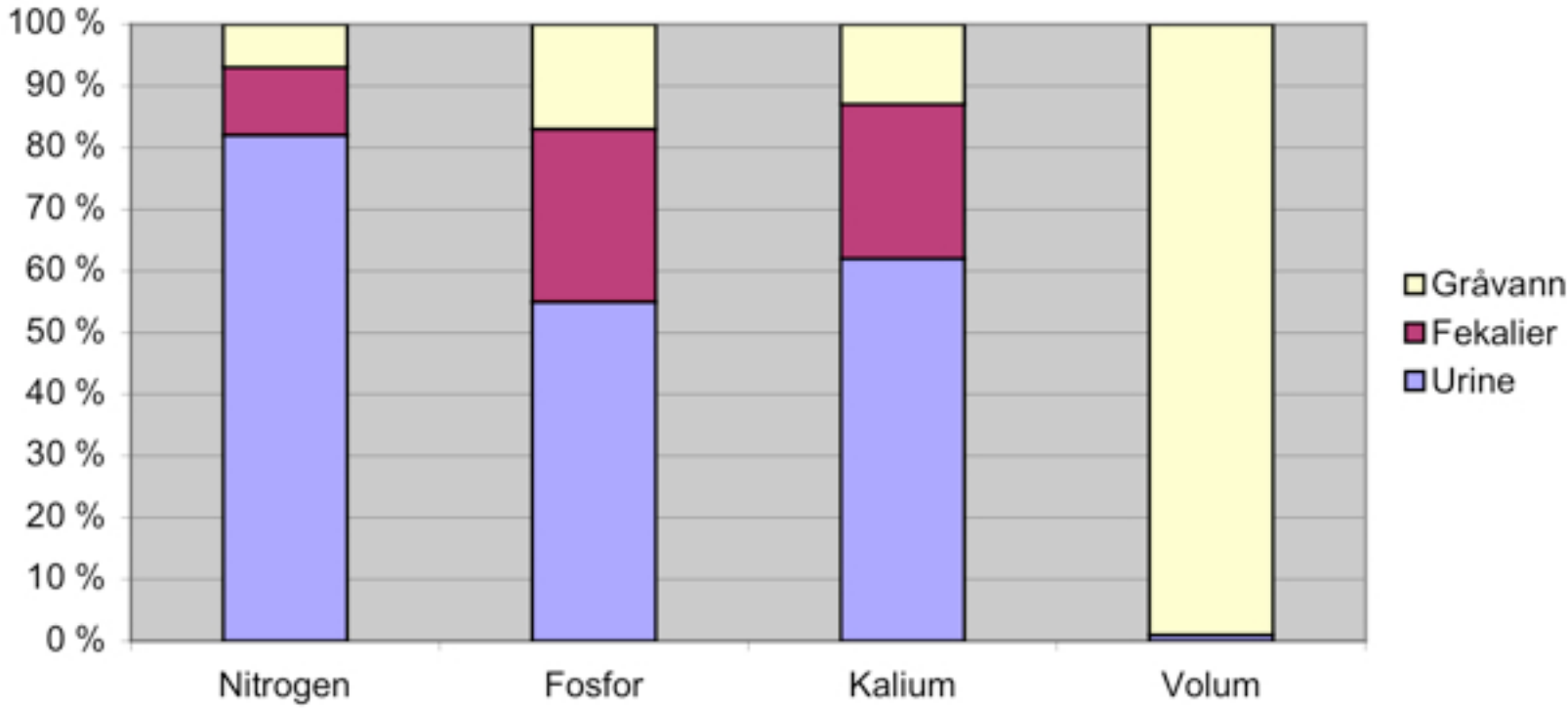
Source: GTZ

Source separation of wastewater

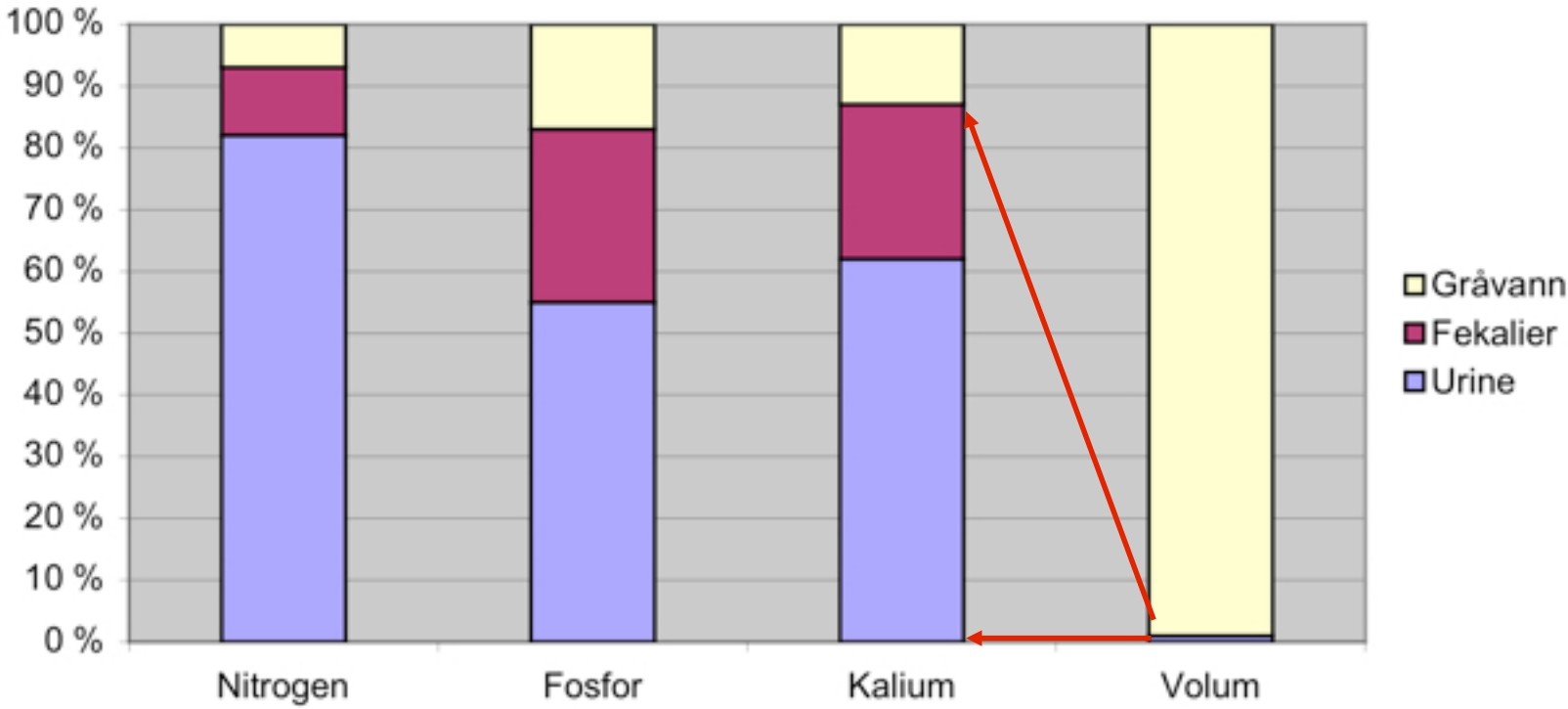
(Alsen and Jenssen2005)

ntent of nutrients and volume in wastewater fr



Source: Jönsson et al. 1999

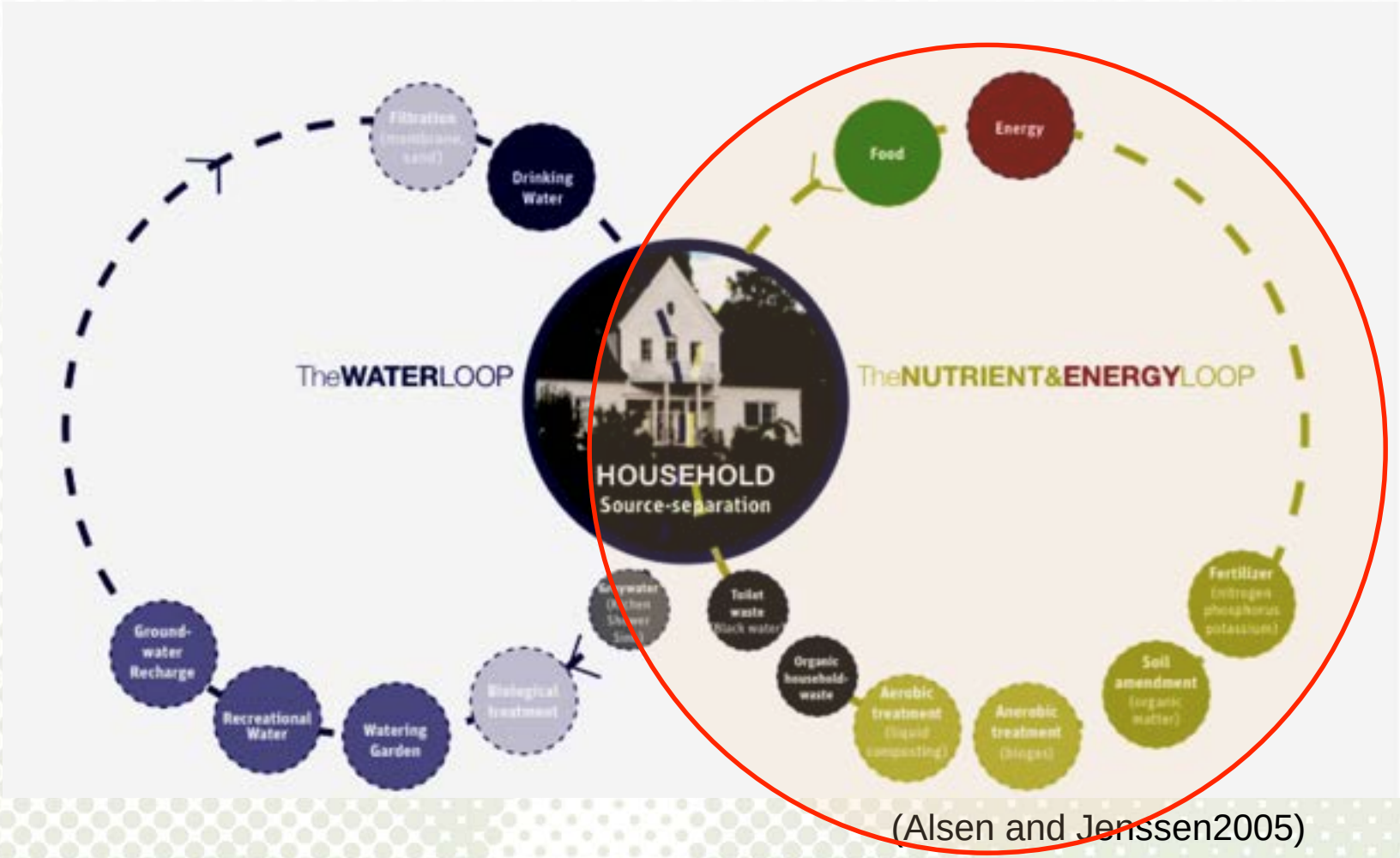
ntent of nutrients and volume in wastewater fr



Source: Jönsson et al. 1999

1% of the volume contains 80 - 90% of the resources

Source separation of wastewater



(Alsen and Jenssen2005)

The majority of the nutrients and the organic matter is in our excreta or toilet waste often termed blackwater

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

Todt et al. (2015)

Future toilet types

In order to collect excreta we have to use very water efficient toilets. Such «future toilet types» are commercially available today.

• Composting /dry sanitation	0 - 0.1 liter/visit
• Urine diverting	0.1 - 4.0 liter/visit
• Water saving*	0.5 - 1.5 liter/visit

*(vacuum&gravity)

Contemporary Scandinavian bathroom design using vacuum toilets

Comfort and design is not inferior using extremely low flush toilets

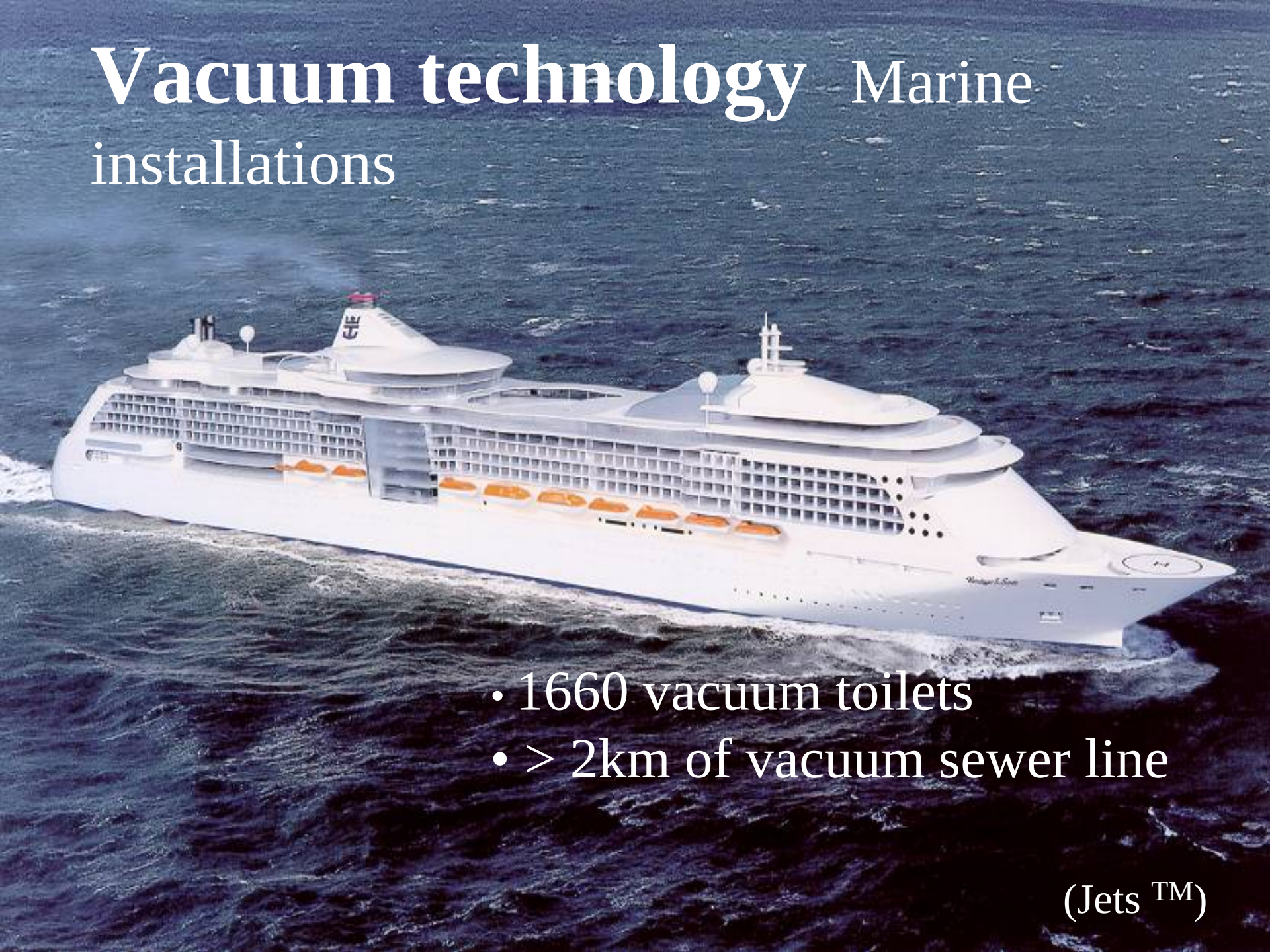
Photos: P.D. Jenssen

Water - **A CHALLENGE**!

Can we reduce the water footprint of a city to 1/10th without sacrificing comfort?

Photo: P. Jenssen

Vacuum technology Marine installations

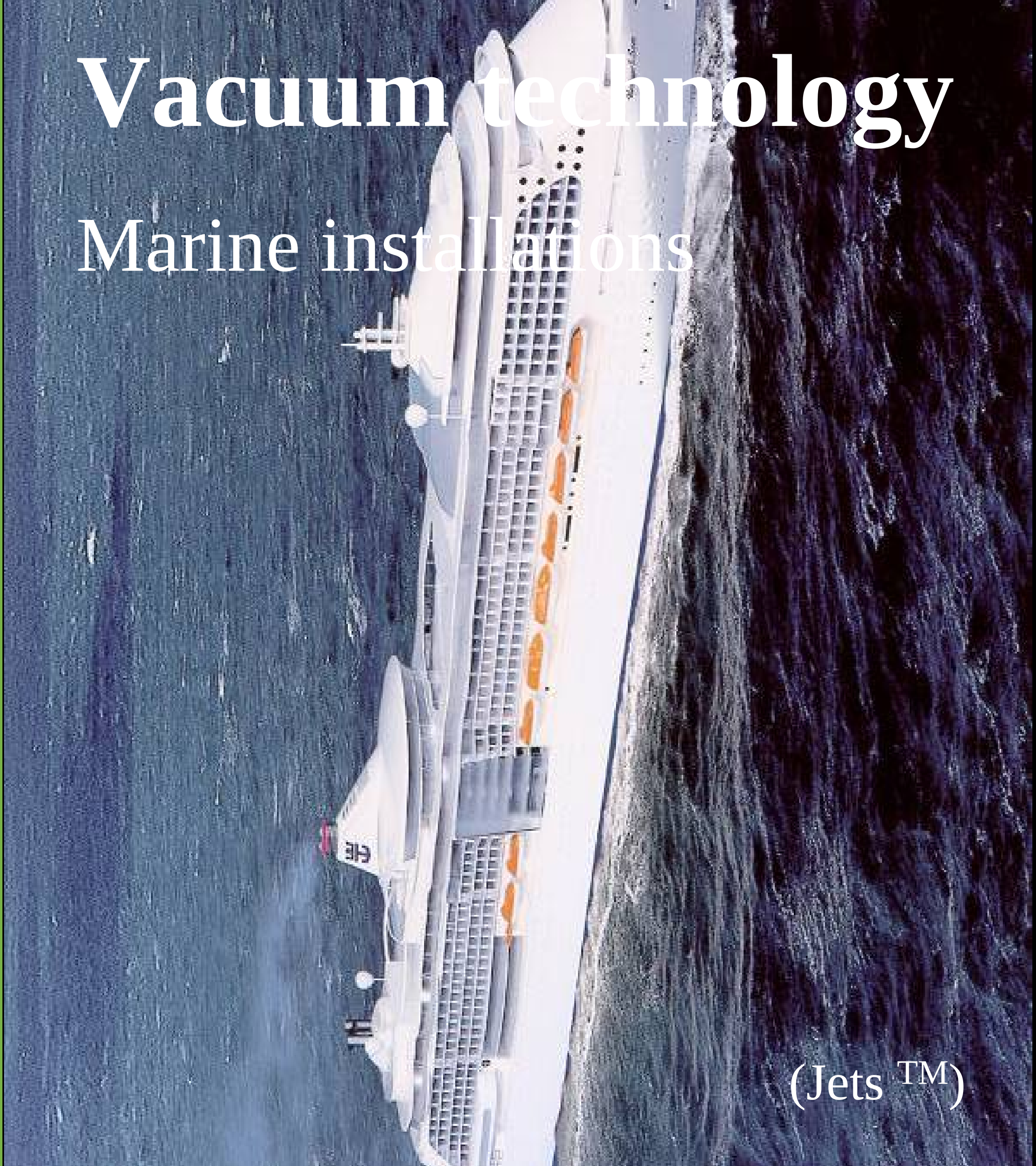


- 1660 vacuum toilets
- > 2km of vacuum sewer line

(Jets ™)

Vacuum technology

Marine installations



(Jets ^{TM})

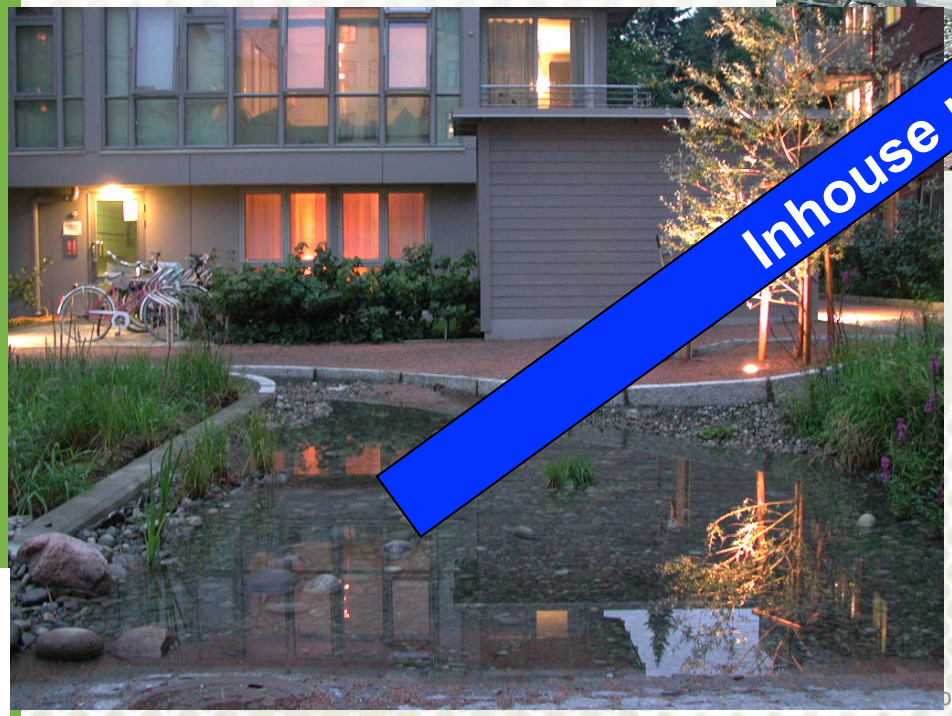
Department of Environmental Sciences (IMV) Petter D. Jenssen
NORWEGIAN UNIVERSITY OF LIFE SCIENCES


INTRODUCING SOLARIS™ 10 OS
solaris
10
POSITION
YOUR
NAVY
REUTERS

Greywater treatment

Rotating biological contactors

Department of Environmental Sciences (IMV) Petter D. Jenssen
NORWEGIAN UNIVERSITY OF LIFE SCIENCES



Inhouse use ?

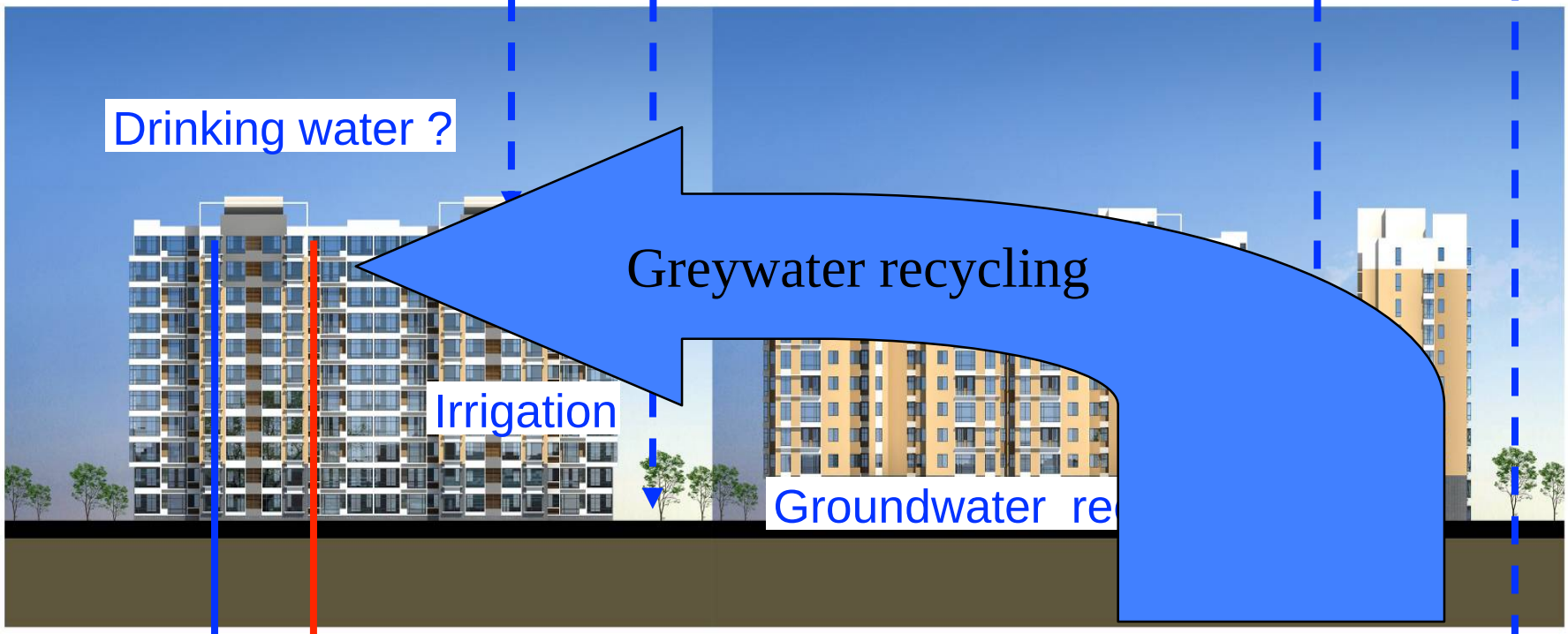
Greywater treatment at Klosterenga Oslo

Effluent values:

Fecal coliforms:	<20
Total-N:	2,5 mg/l
Total-P:	0,03 mg/l

(Sagen 2014)

90% watersaving is possible !



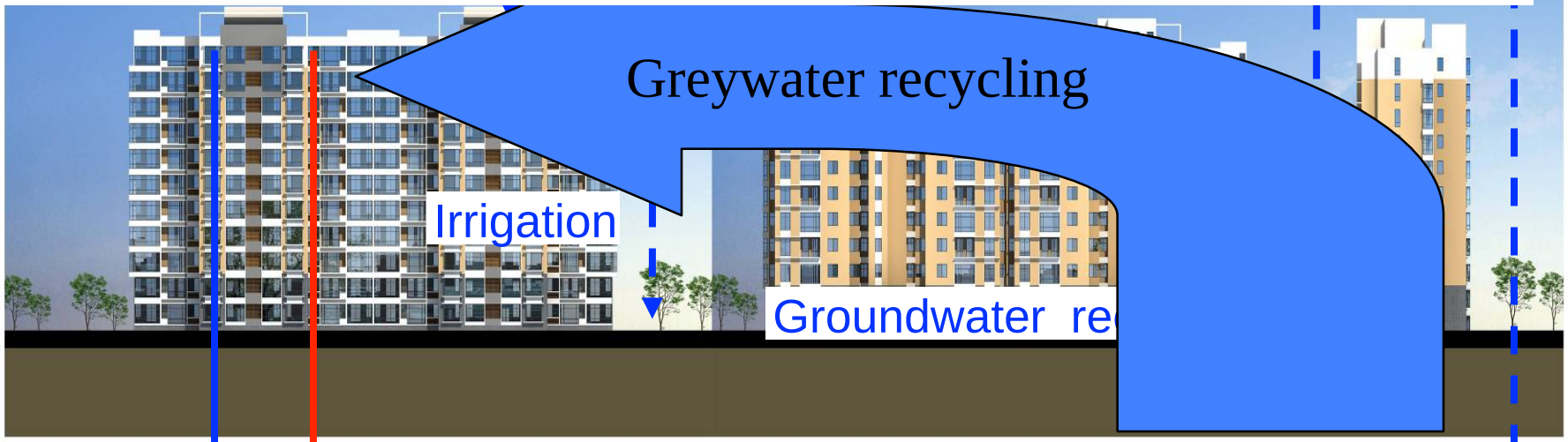
Blackwater to biogas and fertilizer

Greywater to:

90% watersaving is possible !

SiEUGreen:

«Sustainable Food Security – Resilient and resource-efficient val

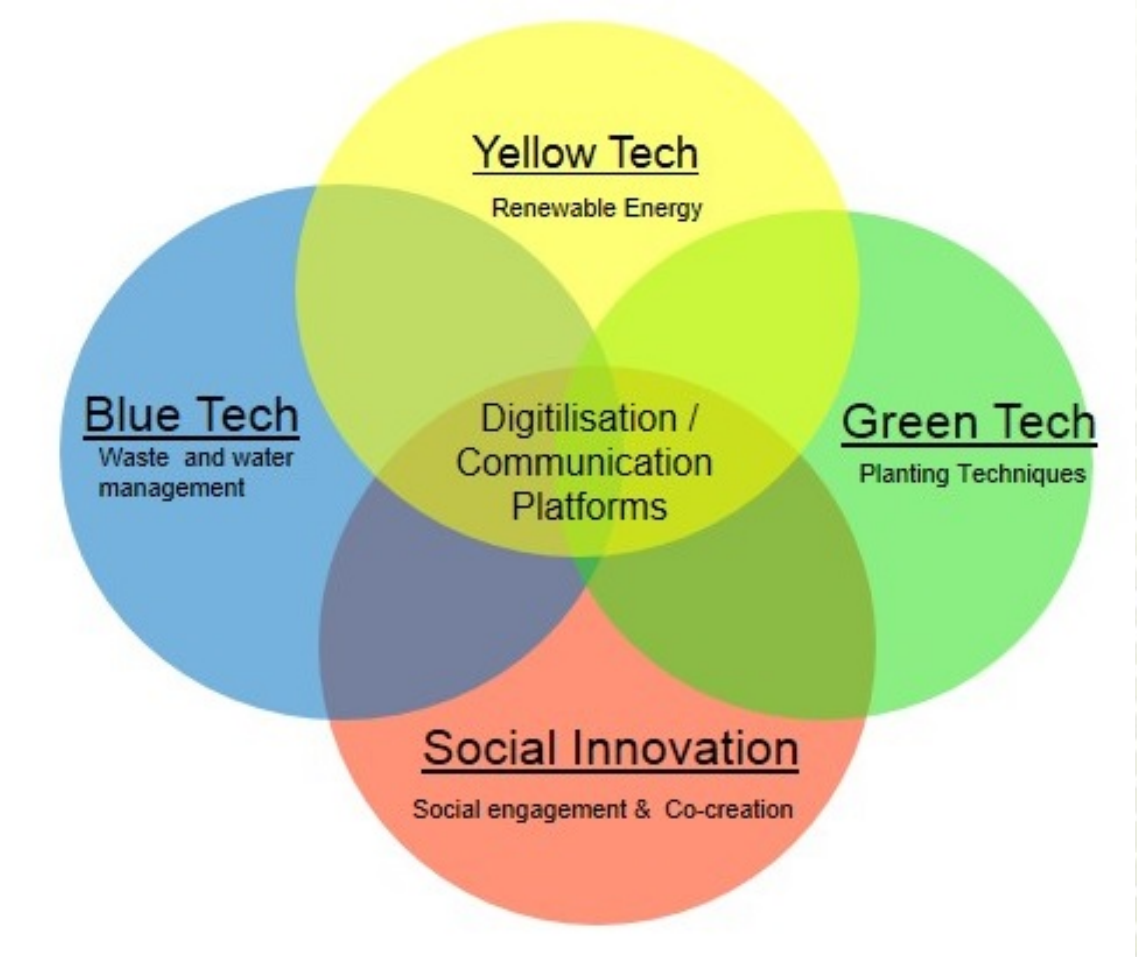


Blackwater to biogas and fertilizer

Greywater to:

SiEUGreen

«Sino-European innovative green and smart cities»



NIBIO

NIELSTORP+

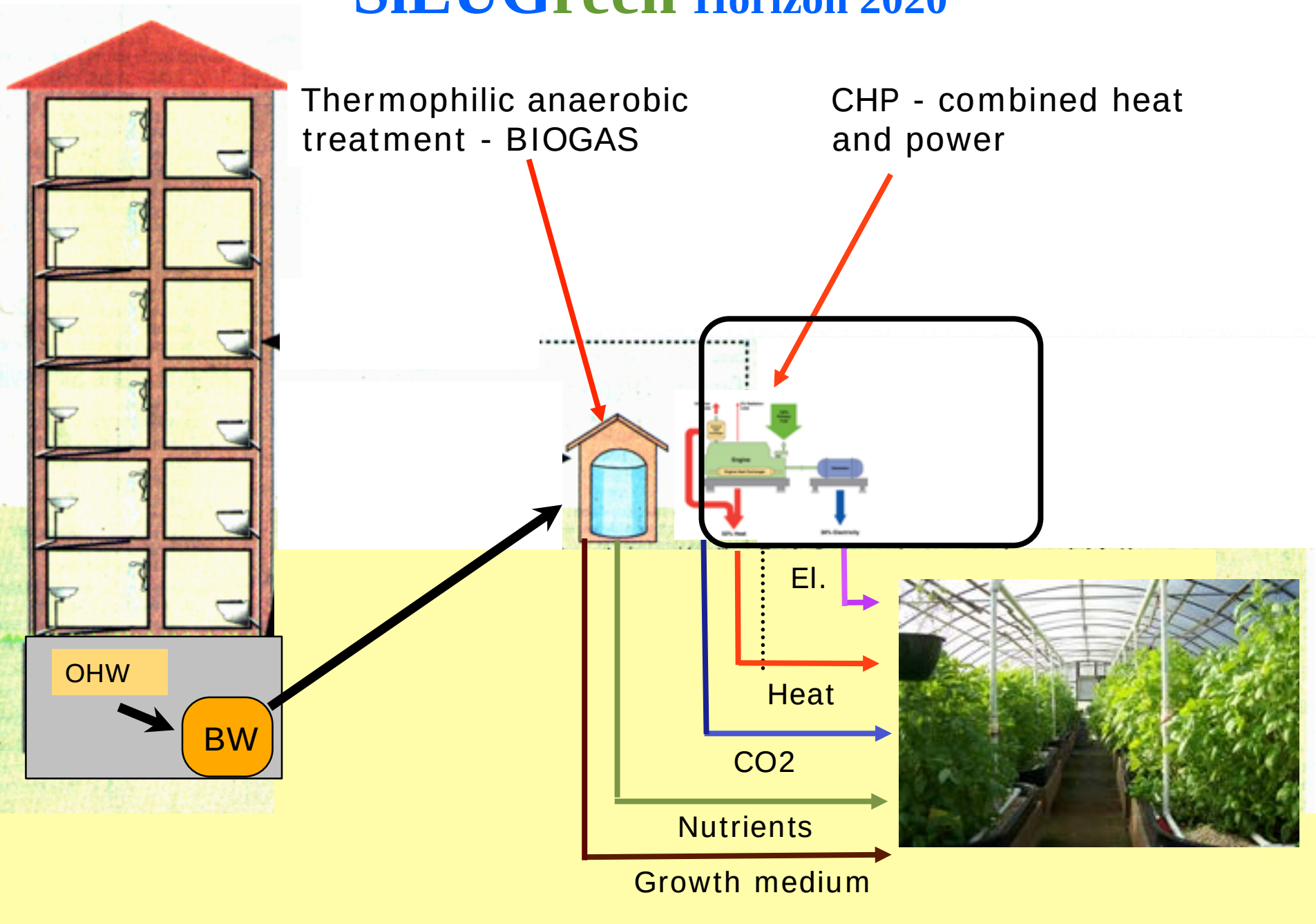
11.10.2017

PERSPEKTIV AV BLOKK B FRA SYDØST

NIELSTORP+

11.10.2017

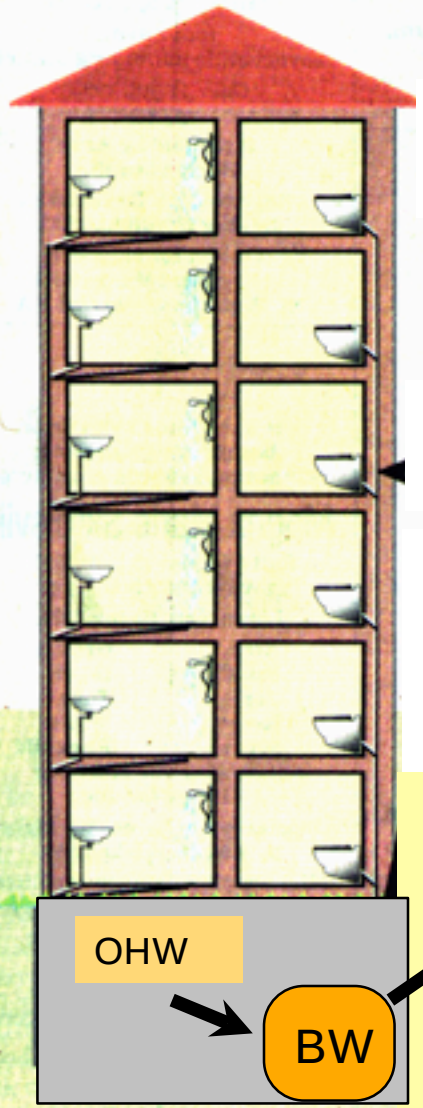
SiEUGreen Horizon 2020

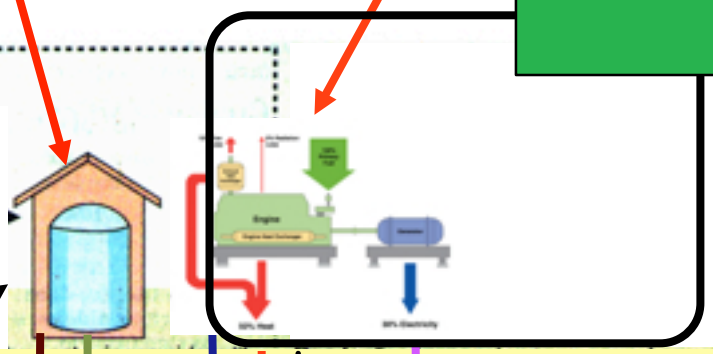


SiEUGreen Horizon 2020

Thermoph… …aerobic… CHP - combined heat tr…

Local nutrient recycling





El.

Heat

CO2

Nutrients

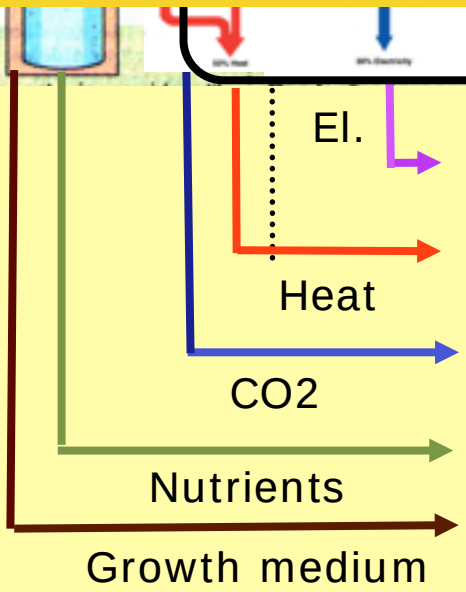
Growth medium

SiEUGreen Horizon 2020

Thermoph… …aerobic… CHP - combined heat tr…

Local nutrient recycling

«Circular economy» New possibilities



«Circular economy» New possibilities

Peckas Naturodlingar fortsätter resa mot klimatsmart mat i Sverige

Peckas Naturodlingar växlar upp till storskalig produktion av kretsloppsodlade, högkvalitativa matprodukter – utan gifter, utsläpp och långa transporter. Bolaget bygger första anläggningen i Härnösand och genomför nu en nyemission inför planerad aktielistning och etablering i landets storstadsregioner.

8 av 10 svenskar handlar idag regelbundet ekologiska livsmedel. Med en ny och revolutionerande kretsloppsodling möter Peckas Naturodlingar den starkt växande marknaden för närproducerade och hållbart odlade matprodukter.

– Vi bygger vår första anläggning i Härnösand för produktion av regnbågslax och tomater. Samtidigt projekteras en större anläggning i anslutning till något av landets tre storstadsområden. Det finns redan aktörer som visat stort intresse för idén, berättar Hugo Wikström, VD i Härnösandsbaserade Peckas Naturodlingar AB (publ).

Hela årsproduktionen från den första

Peckas Naturodlingar odlar fisk och tomater året runt i en modern akvaponi bestående av en fiskbassäng och ett växthus där fisken ger näring till växterna och växterna renar vatten

ECF-farmsystems Gmbh - Berlin

Department of Environmental Sciences, P.D. Jenssen
NORWEGIAN UNIVERSITY OF LIFE SCIENCES (NMBU)

SiEUGreen Horizon 2020

Resourses	Treatment options	Products	Green – Blue Reuse options/ Urban food production
Water Nutrients Energy	**Yellow water** • Nitrification • Hygienisation • Storage • Fractionation/Struvite precipitation	Liquid fertilizer Concentrated fertilizer	
	Brown water • Biogas production and dewatering, composting of bioresidue and • Struvite precipitation of liquid • Compost dry excreta	Methane/energy Liquid fertilizer Concentrated fertilizer Compost/soil conditioner	
	Grey water • Biofiltration/oxidation • Membrane filtration • Soil infiltration • Storage in ponds or tanks	Irrigation/washing Potable water Groundwater recharge	Green house foodproduction (eg at roof) Balcony food production Urban farmland Periurban farmland
	Rain water • Membrane filtration • Storage	Irrigation/washing Potable water	
	Kitchen waste • Vermicompost • Traditional warm compost • Composting in reactor • Biogas production • Feed for worms/insects	Compost Digestate Potting soil Liquid fertilizer Methane/energy Fish feed	Aquaponics production Hydroponics Toilet flushwater & water for washing
	Black water • Biogas prodution and dewatering, composting of bioresidue	Compost Methane/energy Liquid fertilizer	Park, flowerbeds & green walls Blue green recreational areas with ponds and wetlands

Components:
Rainwater
Yellow water = Urine
Brown water = Faeces
Greywater = From washing
Kitchen waste
Black water = mixed

Circular economy - New possibilities

Biodiesel from algae grown in urine

(Eikås 2008)

Research at NMBU:

Greywater irrigation of lettuce on vertical walls

Eregno et al. 2017

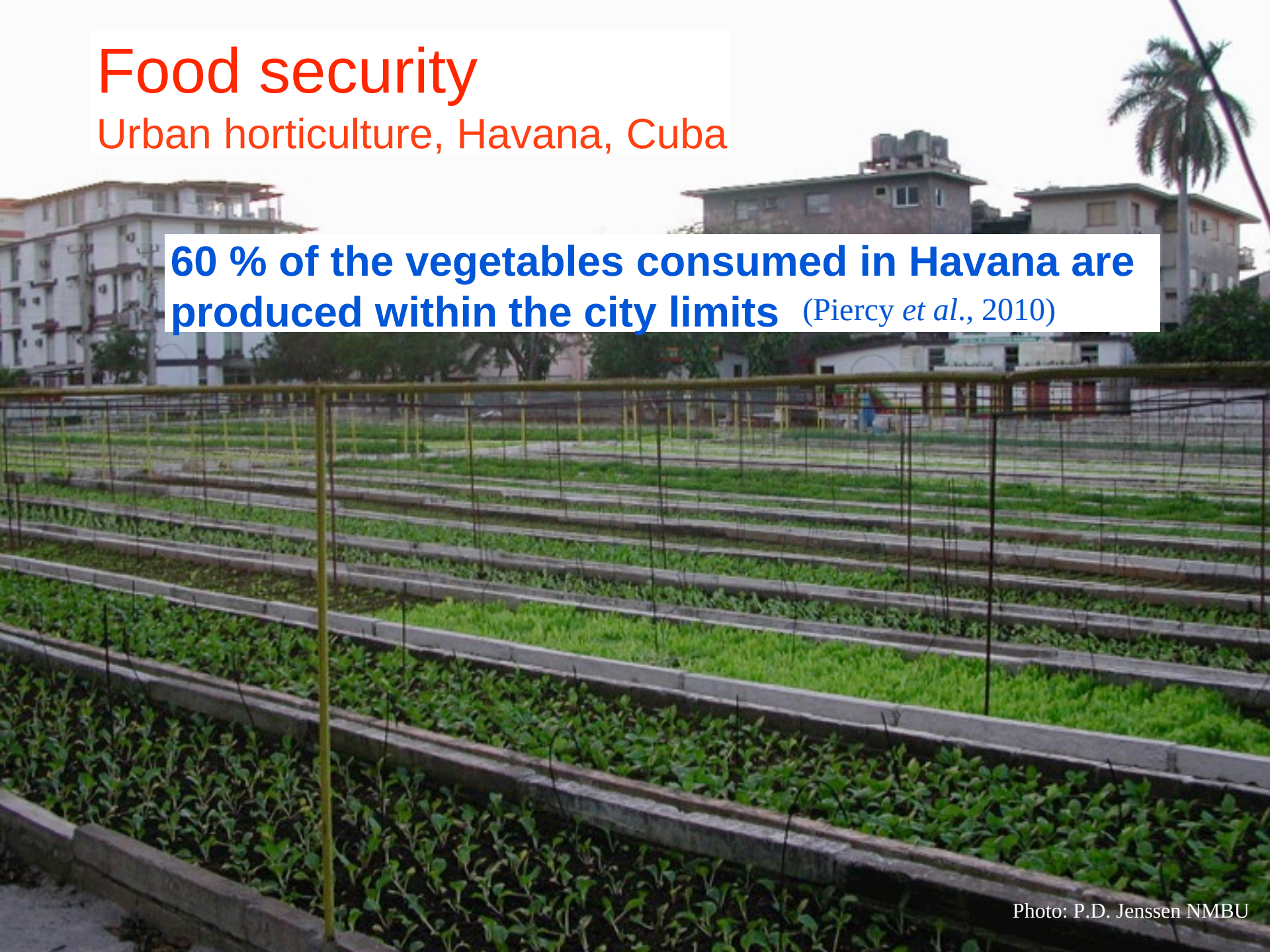
Urban vertical growth spaces

https://www.youtube.com/watch?v=kH_94v67upo

Urban vertical growth spaces

Food security

Urban horticulture, Havana, Cuba



60 % of the vegetables consumed in Havana are produced within the city limits (Piercy *et al*., 2010)

Photo: P.D. Jenssen NMBU

Urban agriculture

Urban agriculture has positive effects on health and happiness and increases food security

Waliczek *et al.*, 2005

Photo: P.D. Jenssen NMBU

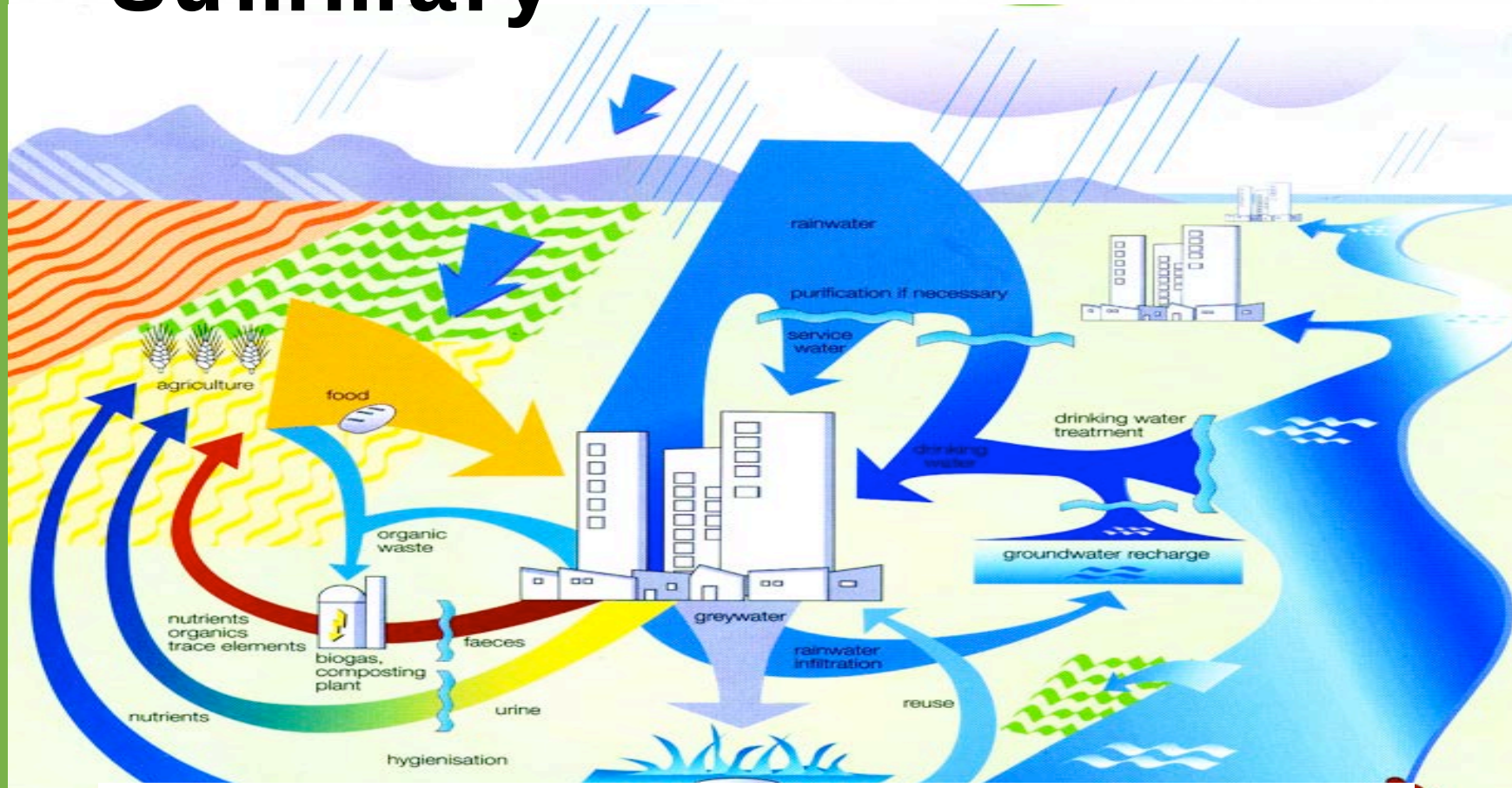
Summary

The future green cities will be hubs in a «circular (green) economy»

Summary

The future cities provide enormous possibilities for sustainable/green technology development and new job opportunities

Summary



The future cities will be net exporters of soil amendment and fertilizer products - «urban mining»

Summary

Recycling of phosphorus is necessary to obtain future food security - and the technology is here

Summary

Return og treated biowaste from urban areas can counteract desertification

Summary

It is possible to lower the water footprint to 1/10th without loosing comfort - and the technology is here

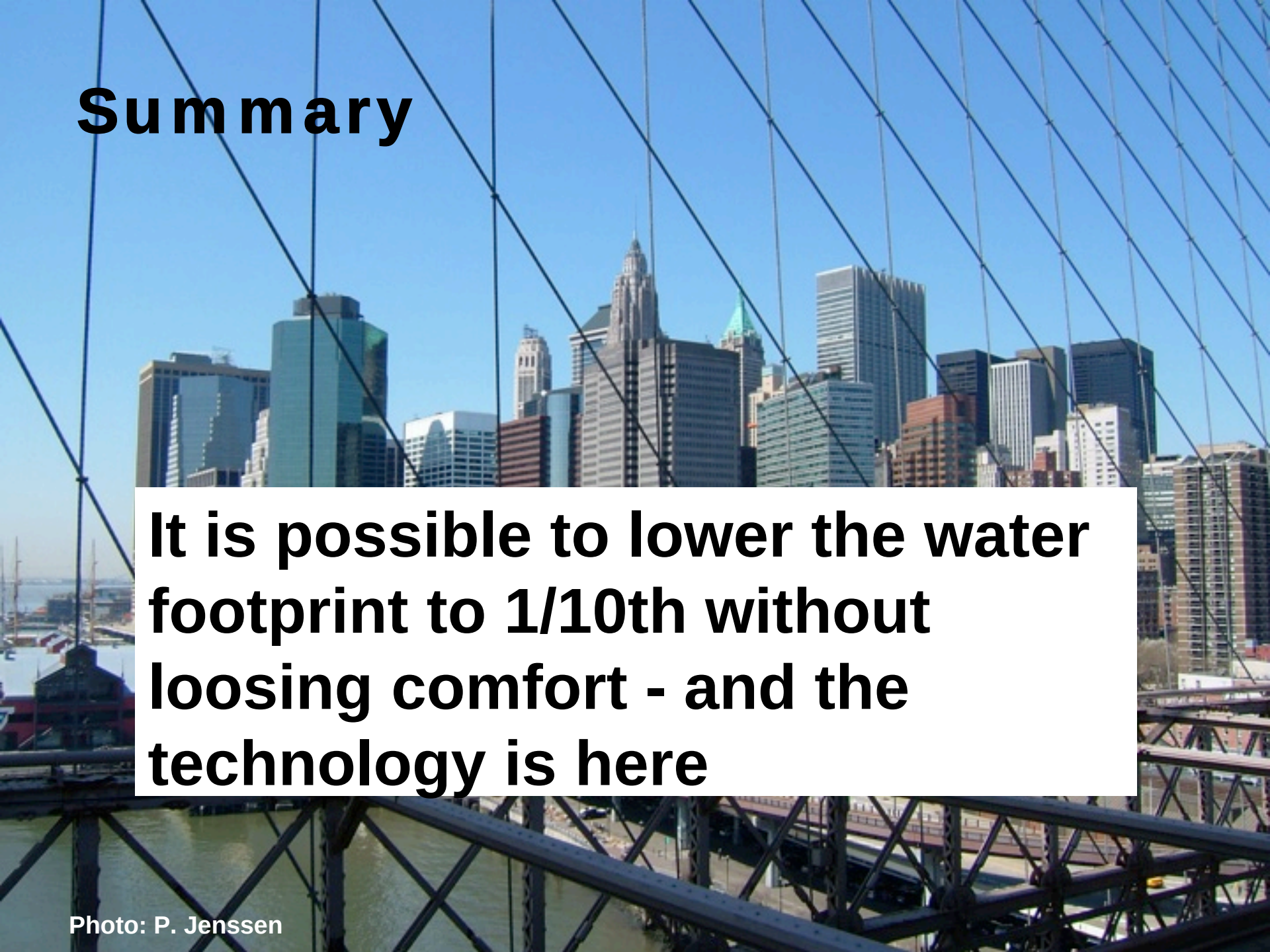


Photo: P. Jenssen

Summary

We need social innovation

Photo: www.shutterstock.com

Summary

We need social innovation

Photo: www.shutterstock.com

Summary

Act personally and locally! Don´t wait for international agreements or politicians (Brox 2008)

Summary

The market economy has no «environmental nose»

Therefore we need politicians that give adequate boundary conditions under which market economy can operate

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