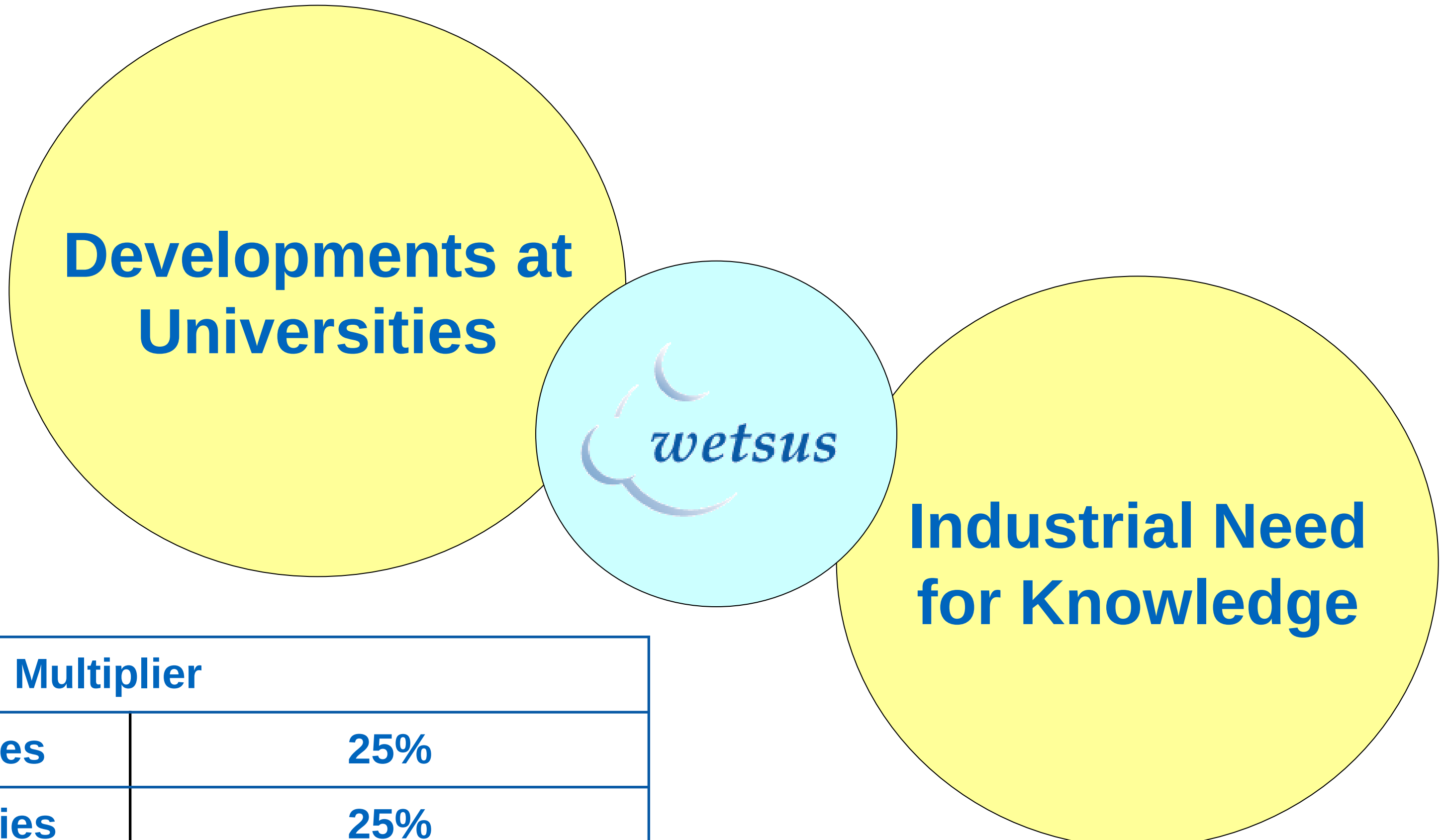
wetsus
centre of excellence for
sustainable water technology

Sustainable Water Technology key for Global Nutrient Recovery

Bert Hamelers

12-08-2014

Technological Top Institute Model



Financial Multiplier	
Companies	25%
Universities	25%
Government	50%

Strategic cooperation with 89 companies

2003
Alliander
Vitens
Shell
Unilever

2004
Bioclear
Magneto
Energy Valley
Landustrie/Hubert
Pentair/X-flow
Grontmij
Heineken

2005
Nalco
Esco/Frisia Zout
Waterb. Groningen
Waterm. Drenthe
Paques
DHV
Evides
Rabobank
Wetterskip Fryslân
Bright Spark

2006
WS Hunze en Aa's
Schlumberger
TCNN
Friesland Campina
Lionix
Kurita

2007
Aquacare
PWN
Brabant Water
Dow Chemicals
Coram
Stowa
Trojan UV
EasyMeasure
CvO-BTO

2008
Fuji Film
Oasen
GMB
Syngenta
Neste Oil
AF&F
Feyecon

2009
Philips
Dutch Rainmaker
Arcadis
Avebe
Purac
AquaExplorer

2010
Femto Invest
Pure Green Techn.
Biaqua
IMD
Van Remmen
Water ProMaSys
MAST Carbon
IPF/Grander
TailTec

2011
Water Alliance
General Electric
A. Hak Beheer
Algae Biotech
Aqua Nirvana Foundation
O2 Environmental
EFCseparations
Paqell
Voltea

2012
Anglian Water
WS Noorderzijlvest
Berson UV
Brightwork
Kuraray
Duplaco
De Friesland Zorgverzekeraar
Abengoa Water

2013
Kemira
Skion
Veolia Eau
CEW
REDstack
Stork Veco
DeSaH
BioTrack
BioCompact

2014
WML
DMT
HDM Pipelines
Metalmembranes

16 knowledge institute participants (38 scientific chairs)

Wageningen University

TU Delft

Deltares
Enabling Delta Life

rijksuniversiteit groningen

University of Twente
Enschede - The Netherlands

FOM

TU Graz

KWR

Universitas Masarykiana Brunensis

Universität Duisburg Essen

Kauno Technologijos Universitetas

TU/e technische universiteit eindhoven

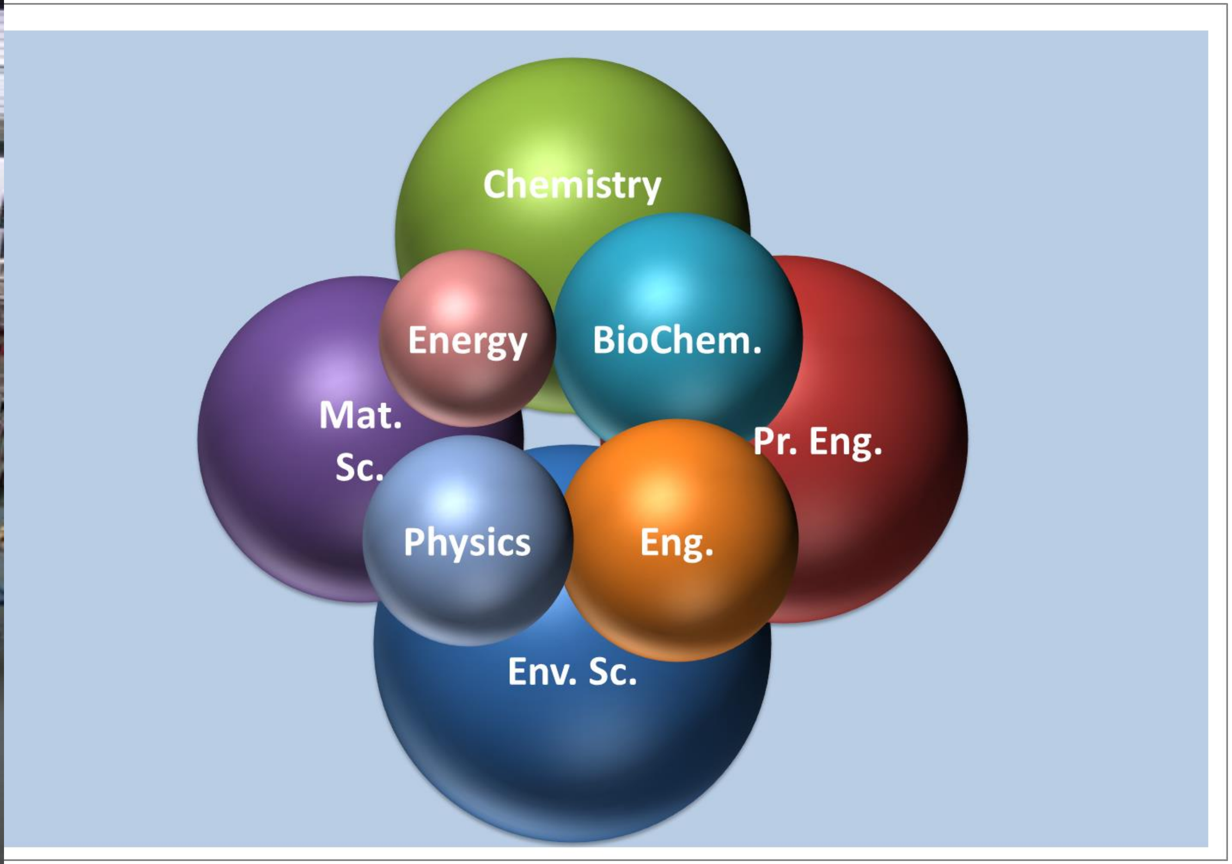
UNESCO-IHE
Institute for Water Education

Wrocław University of Technology

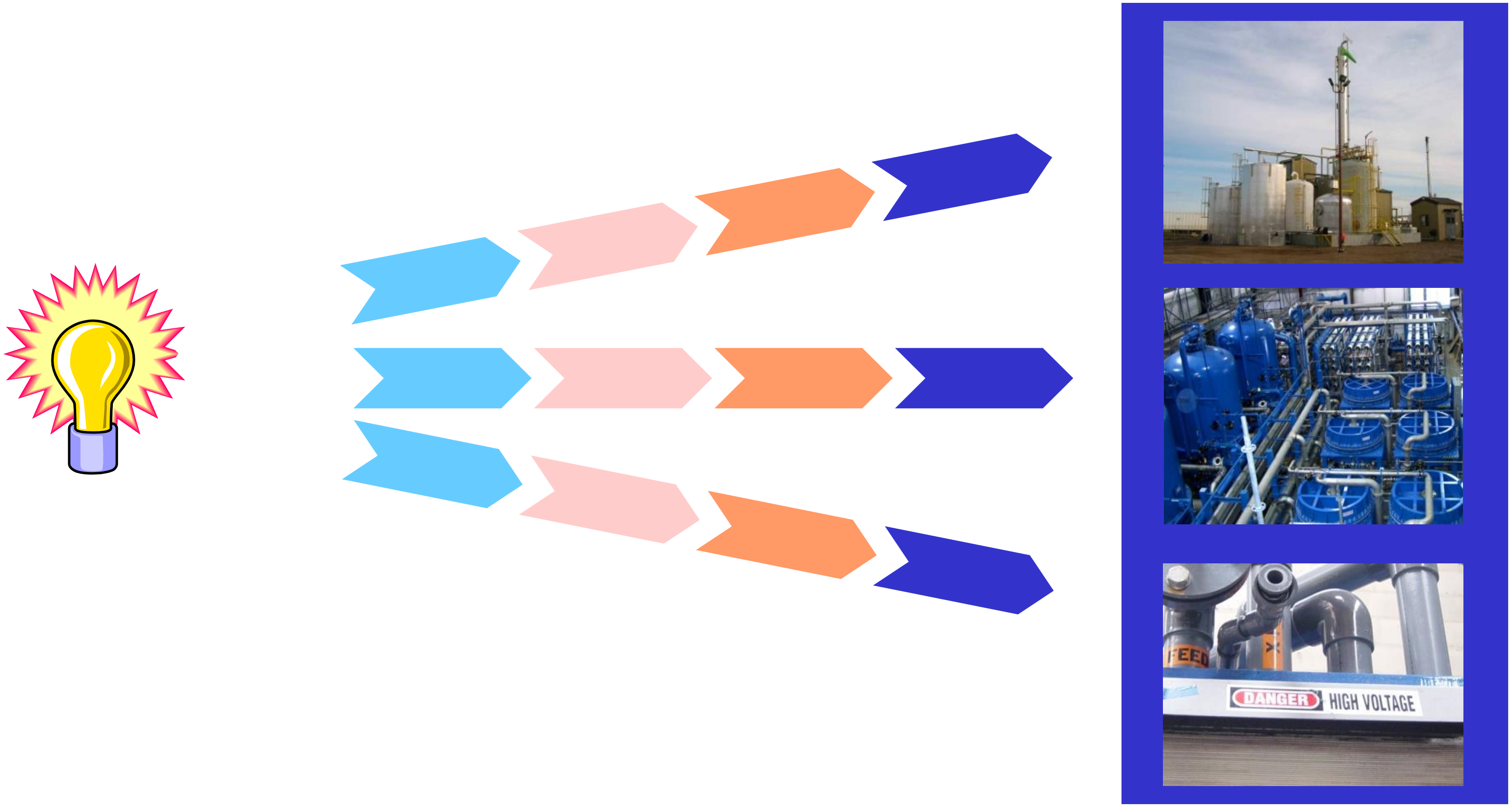
University of Minho

Universiteit Gent

Multi Disciplinary Environment



Idea Driven Technology Development

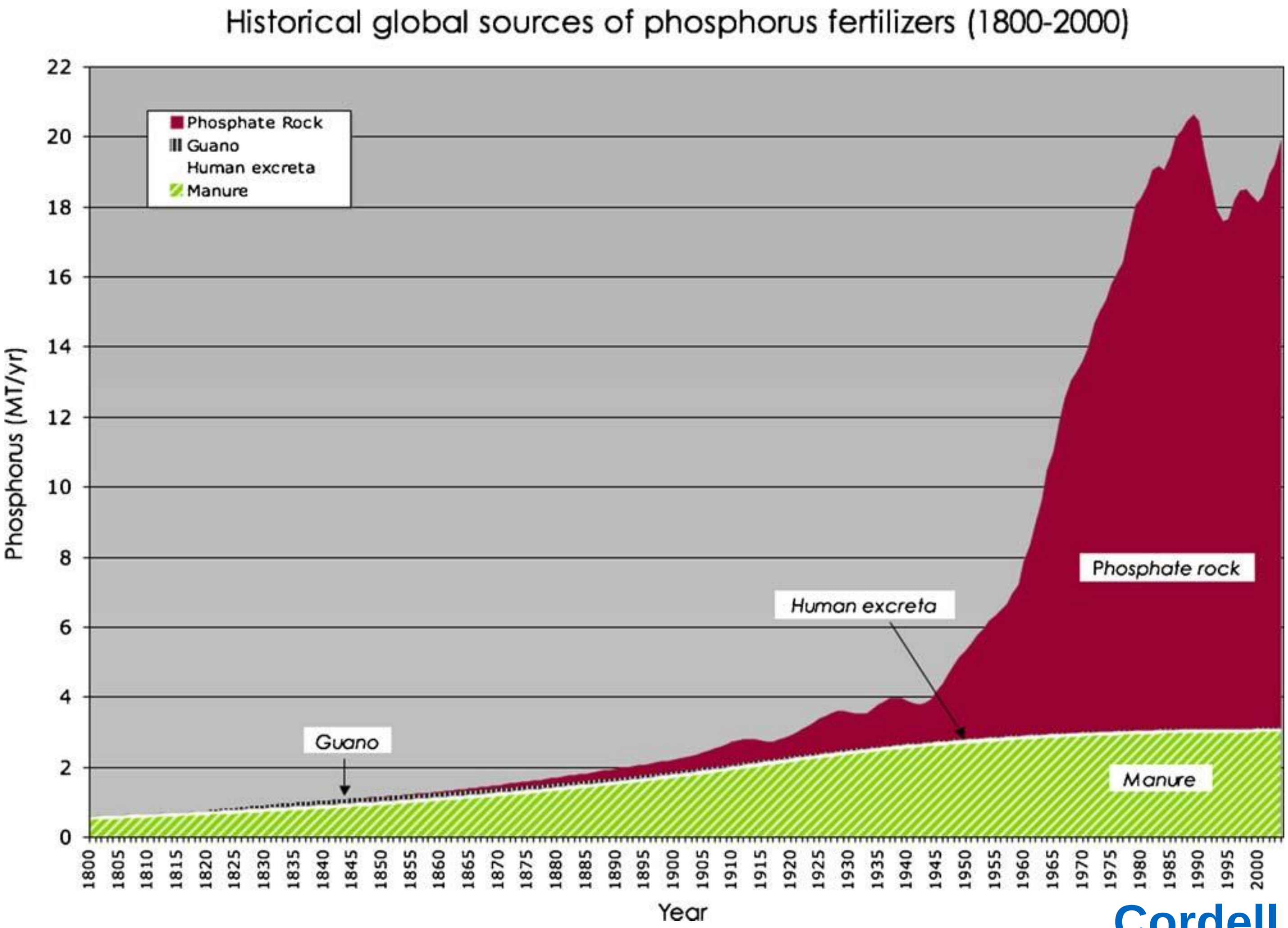


Land+Energy + Irrigation + Nutrients = Food Supply

70 % world water use = irrigation
30% world energy use = food chain

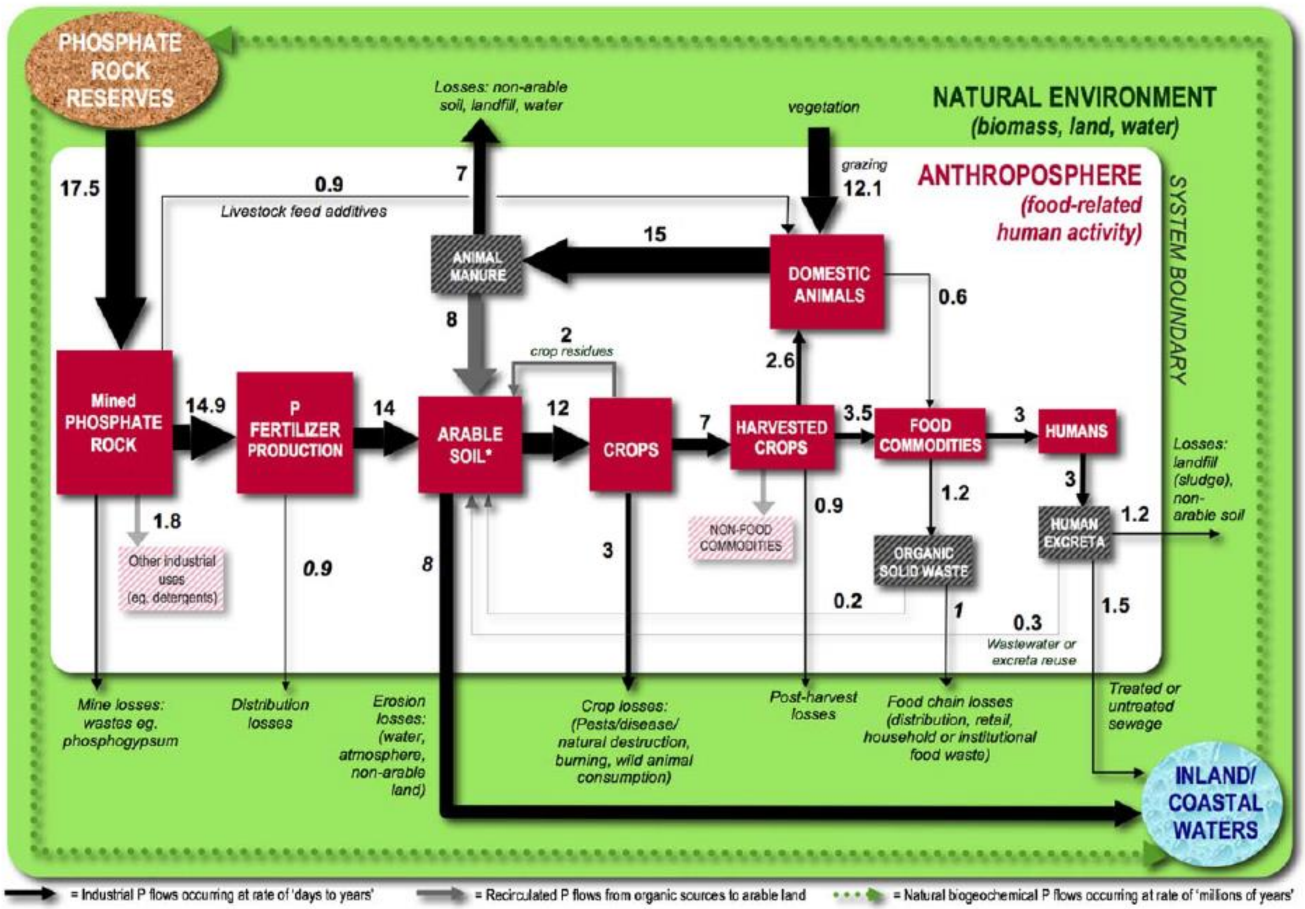
Plants need Nutrients

P depending on Phospate Rock



Cordell 2009

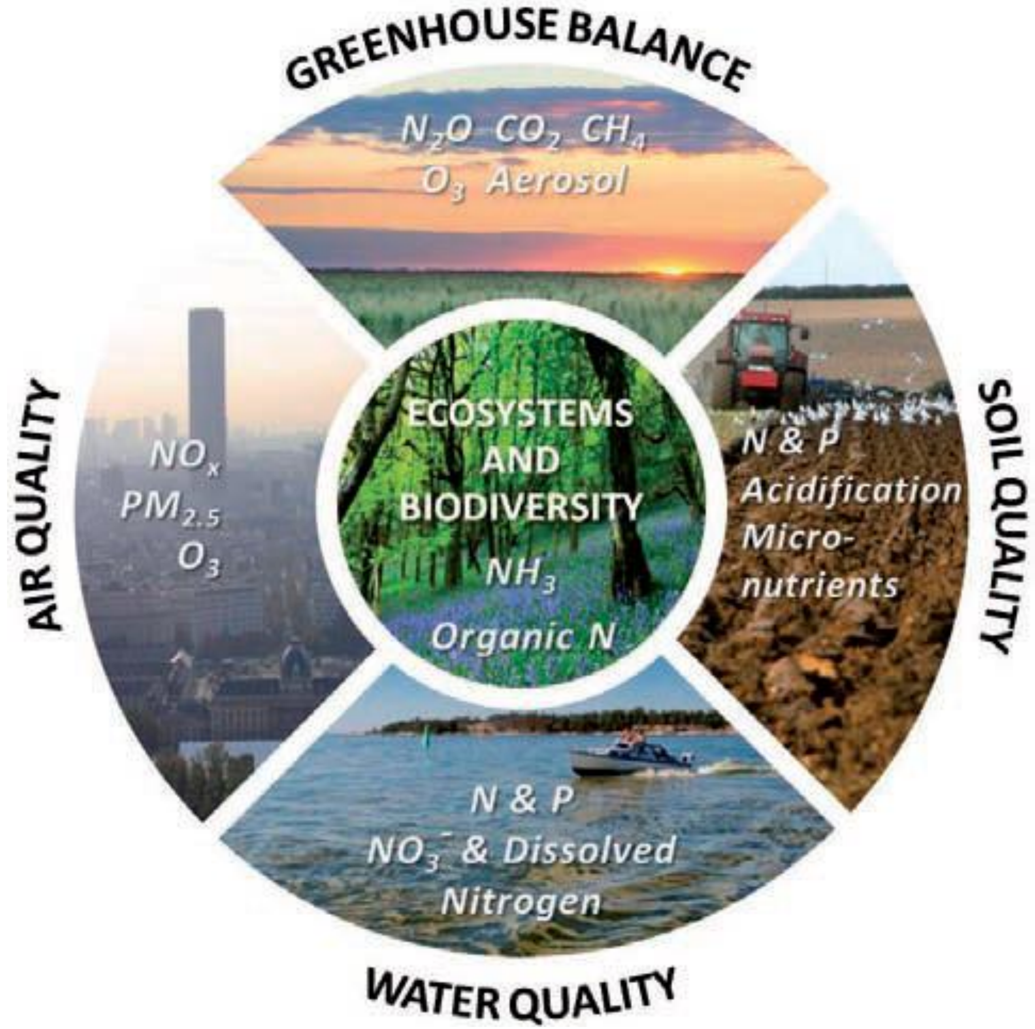
P Flows



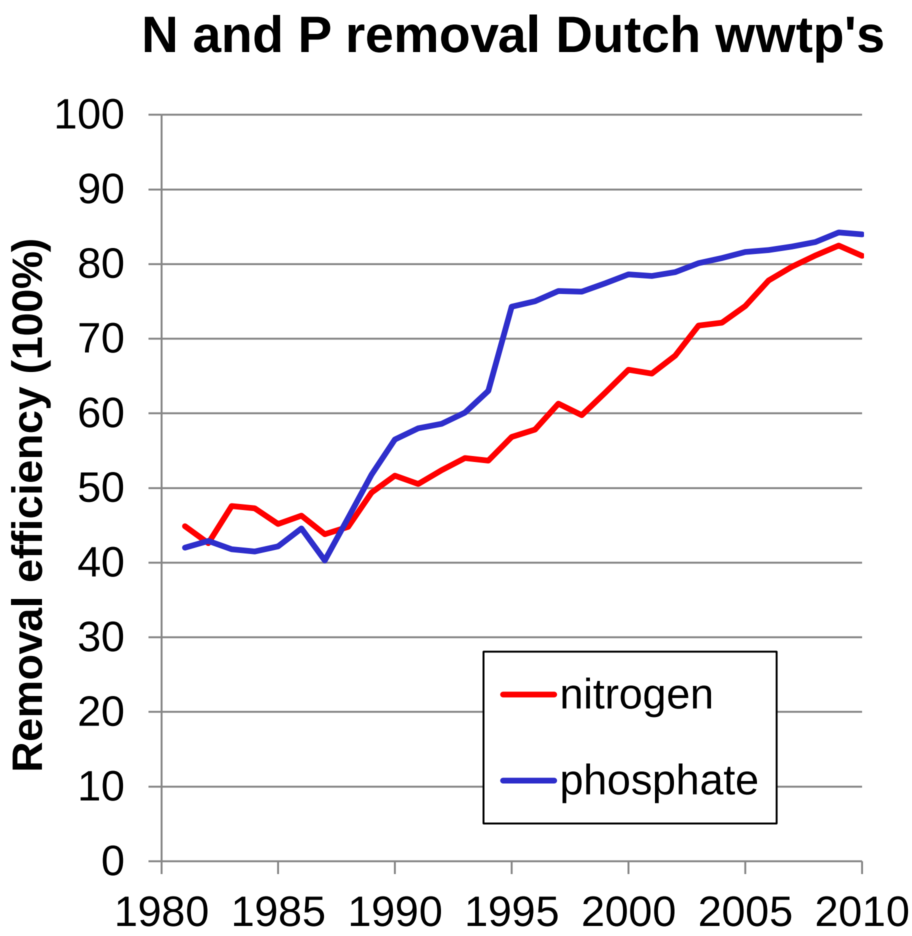
* only a fraction of applied mineral P is taken up by crops in a given year, the balance comes from the soil stocks, either from natural soil P, or build up from previous years and decades of fertilizer application.

Cordell 2009

N&P lead to environmental damage



N & P removal



- N to N_2
- P to sludge

Resource Recovery

N-example

Human & livestock excreta

NH_4^+-N

WWTP

Nitrification/ de-nitrification

(109 kJ/g $_N$)[1]

N_2

Haber-Bosch Process

(37 kJ/g $_N$)[1]

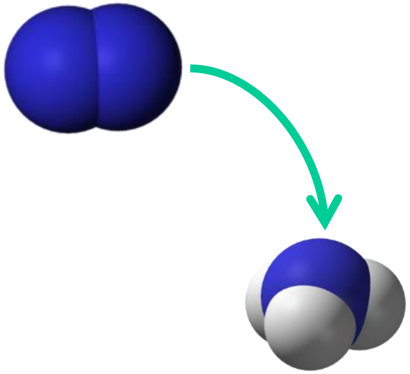
NH_3

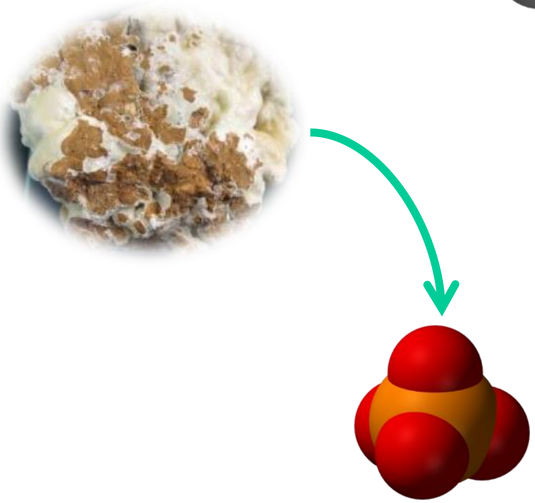
NH_3

[1] Maurer et. al., 2003 *Nutrients in urine: energetic aspects of removal and Recovery* Water Science and Technology Vol. 48 No 1 pp 37–46

Scarce Resources & Energy Intensive Processes

- **Fertilizers necessary**
- **P-rock resources for about 70 -300 years**
- **NH_3 production is energy intensive (2.6 EJ/yr)**
- **N-removal/recovery is energy intensive**



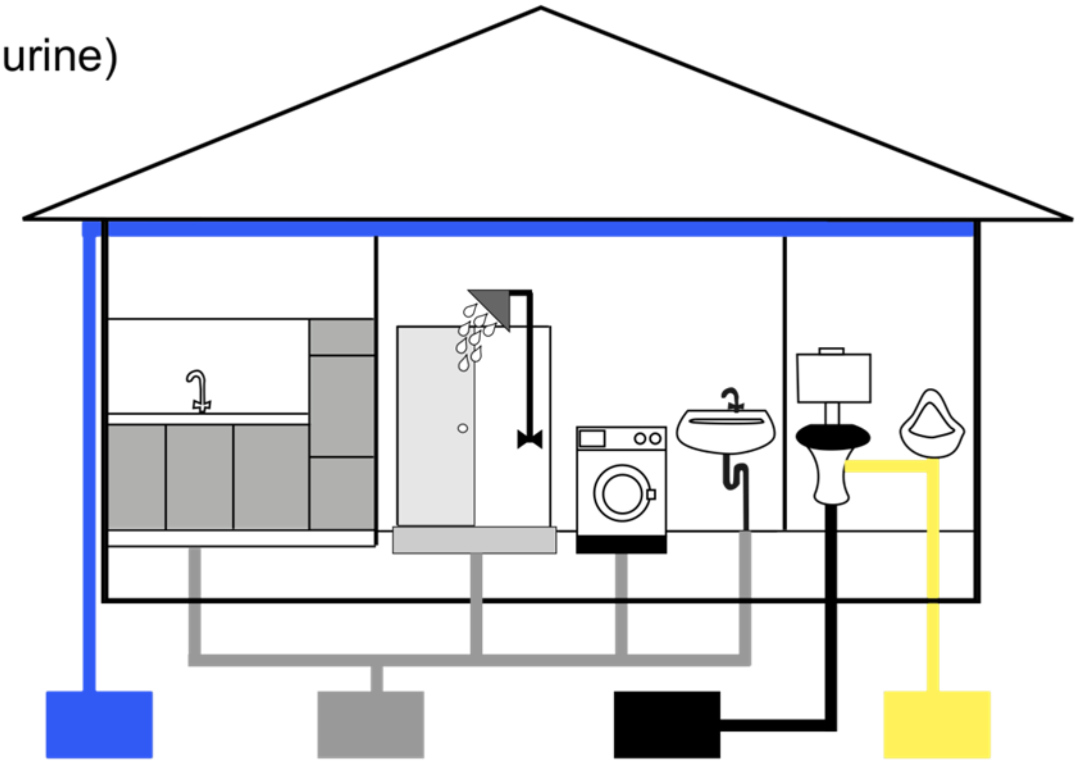


Source Separated Sanitation allows nutrient recovery

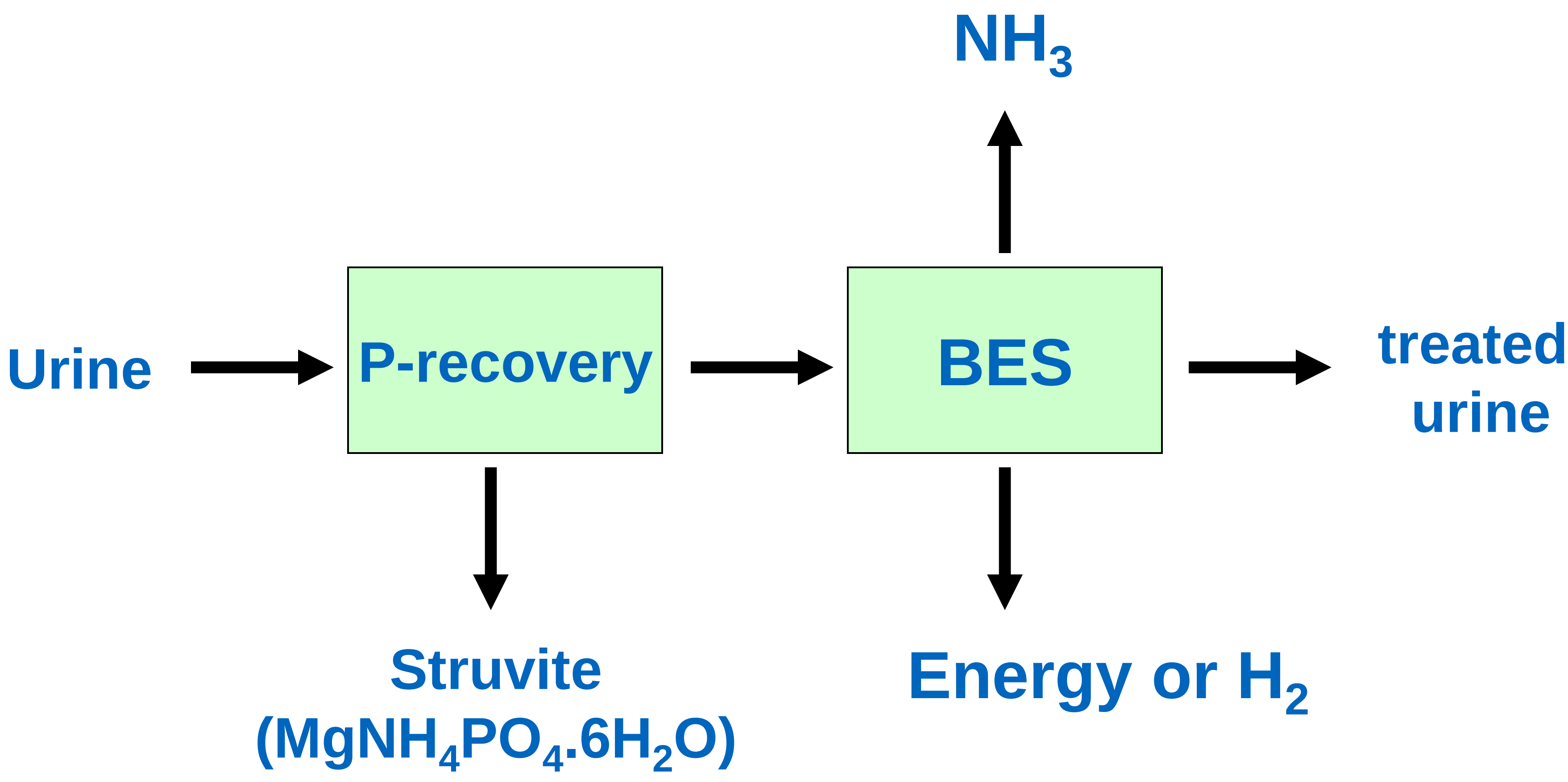
toilet water (without urine)
46 % of COD
32 % of P
14 % of N

urine
10 % of COD
45 % of P
76 % of N

grey water
44 % of COD
23 % of P
10 % of N



Treatment scheme for resource recovery



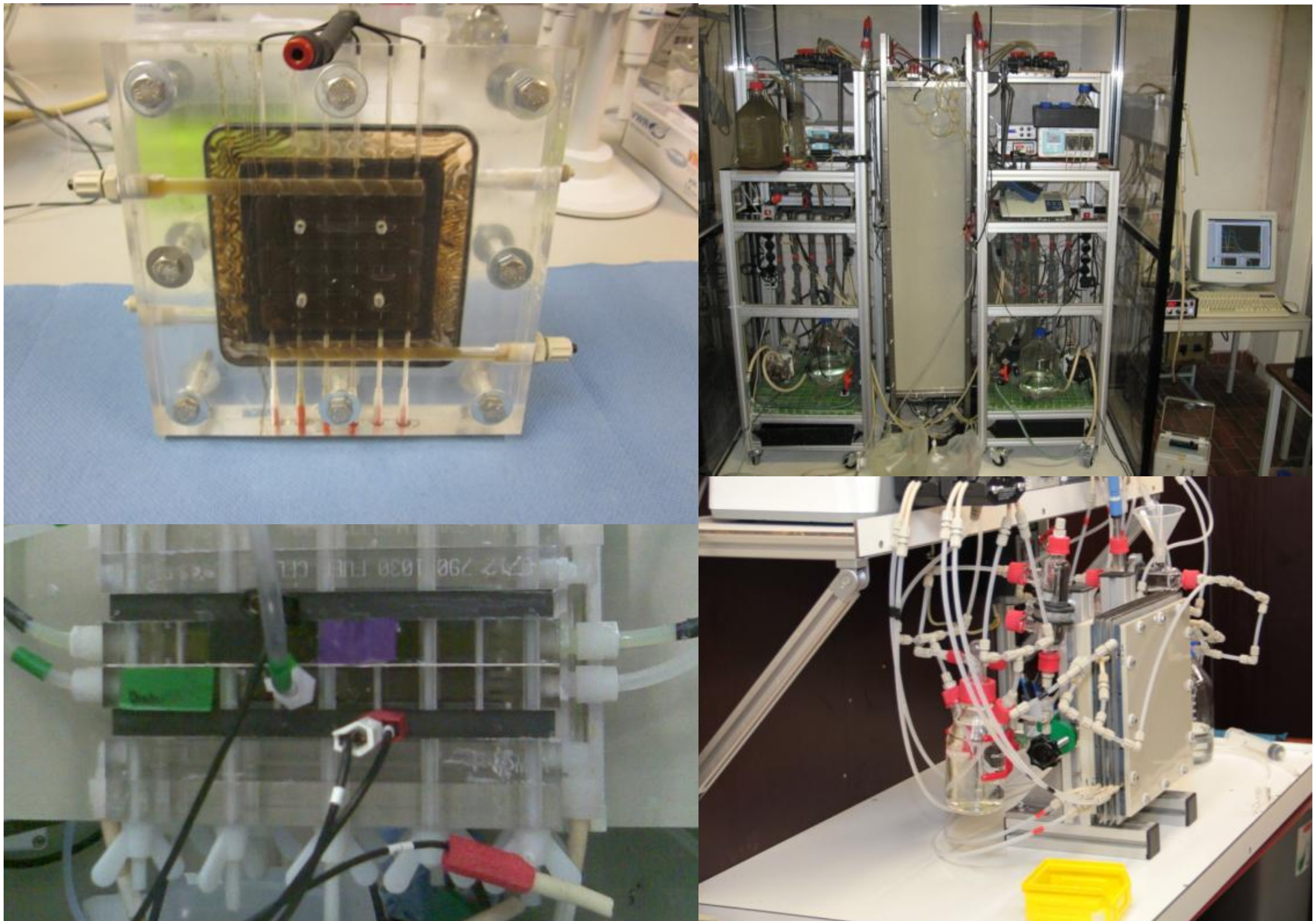
Phosphate recovery through Struvite precipitation

Urine

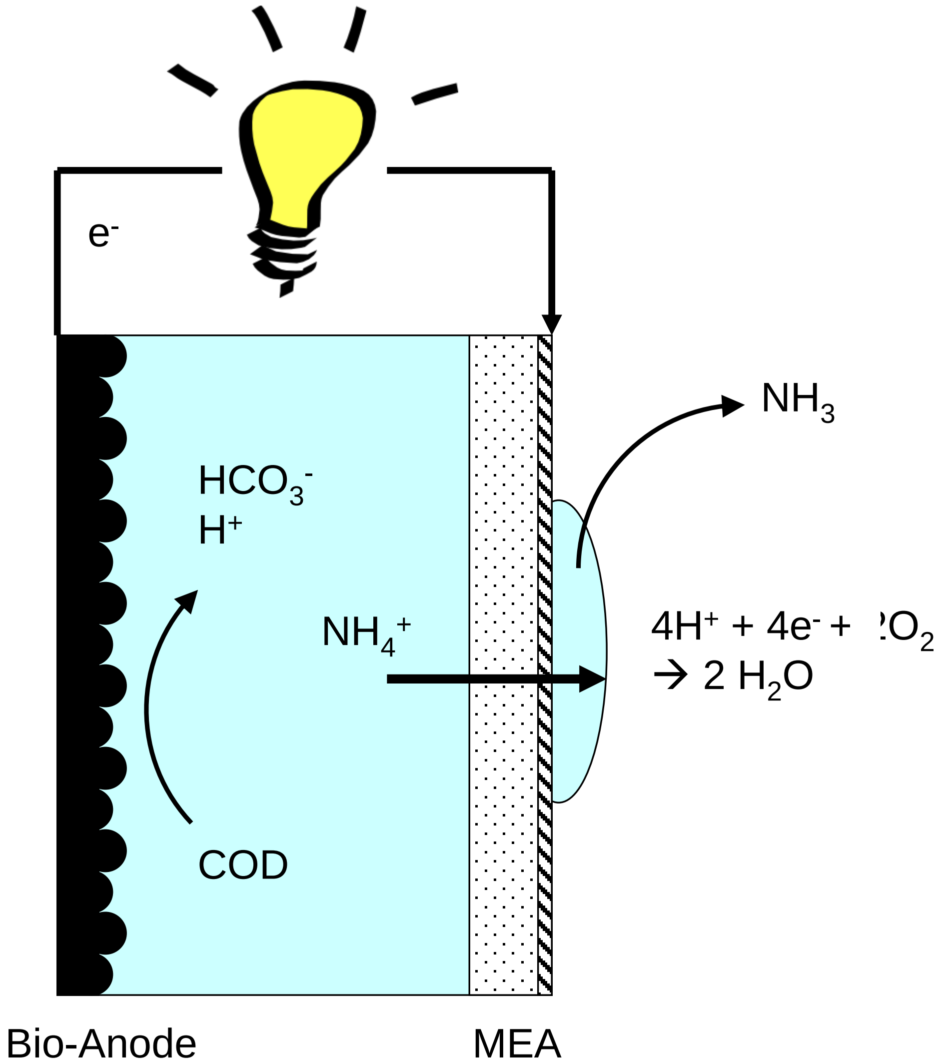
Mg-addition

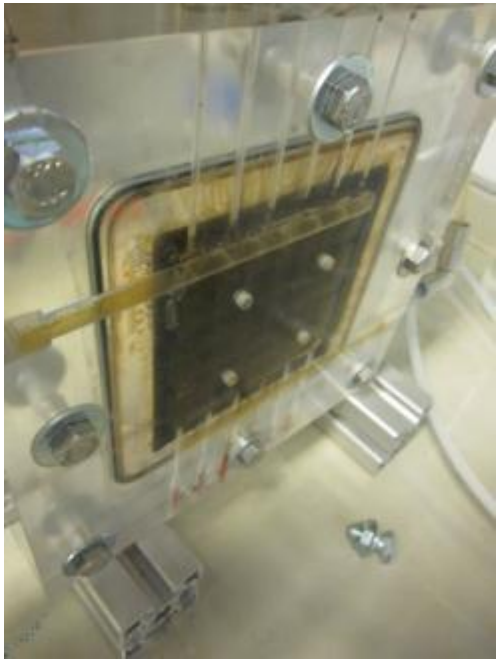
Struvite

Bio electrochemical system (BES)



Energy efficient NH_3 recovery by MFC from urine



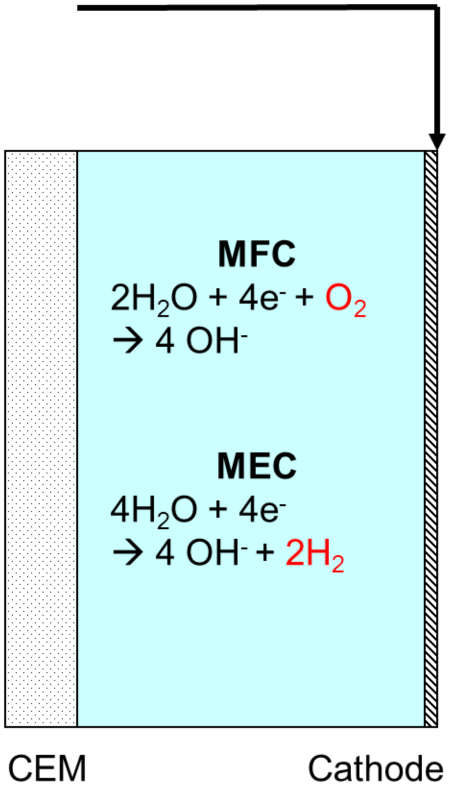


- 280 days stable operation
- 2.6 A/m^2

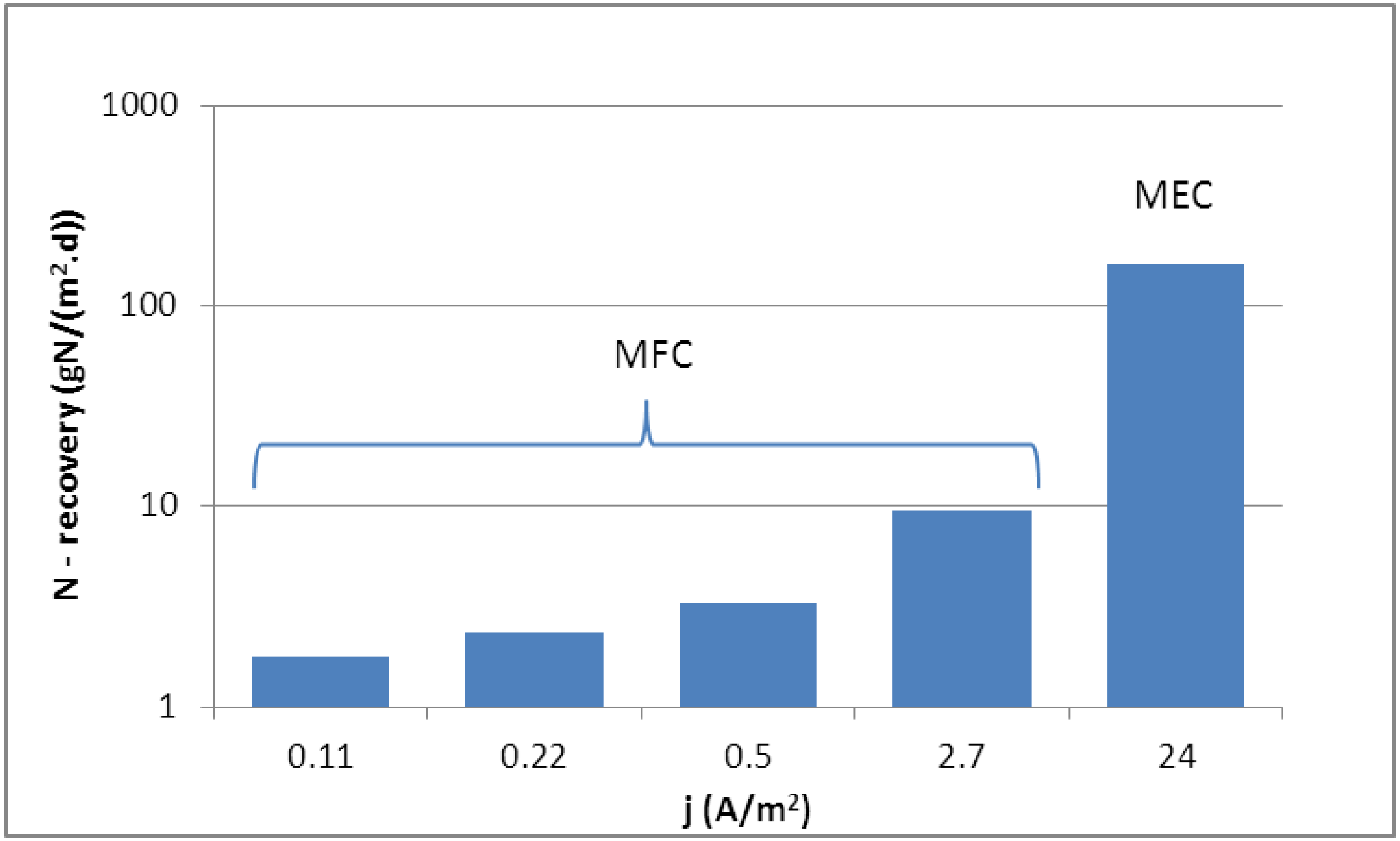
Bioelectrochemical system (BES) Cathode side

MFCs for electricity production

MECs for hydrogen production

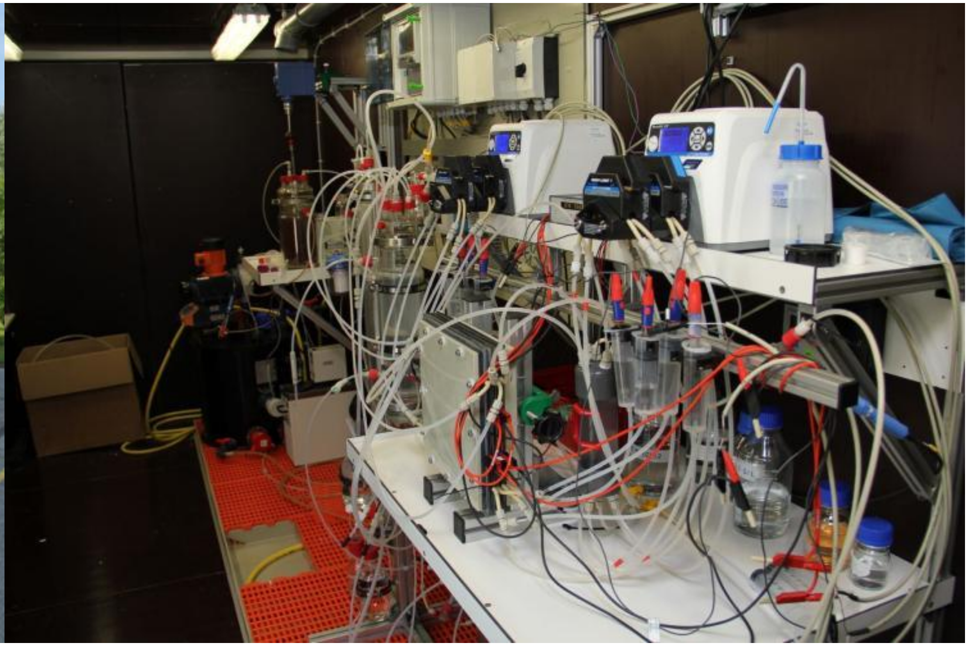


MEC for enhanced NH_3 recovery

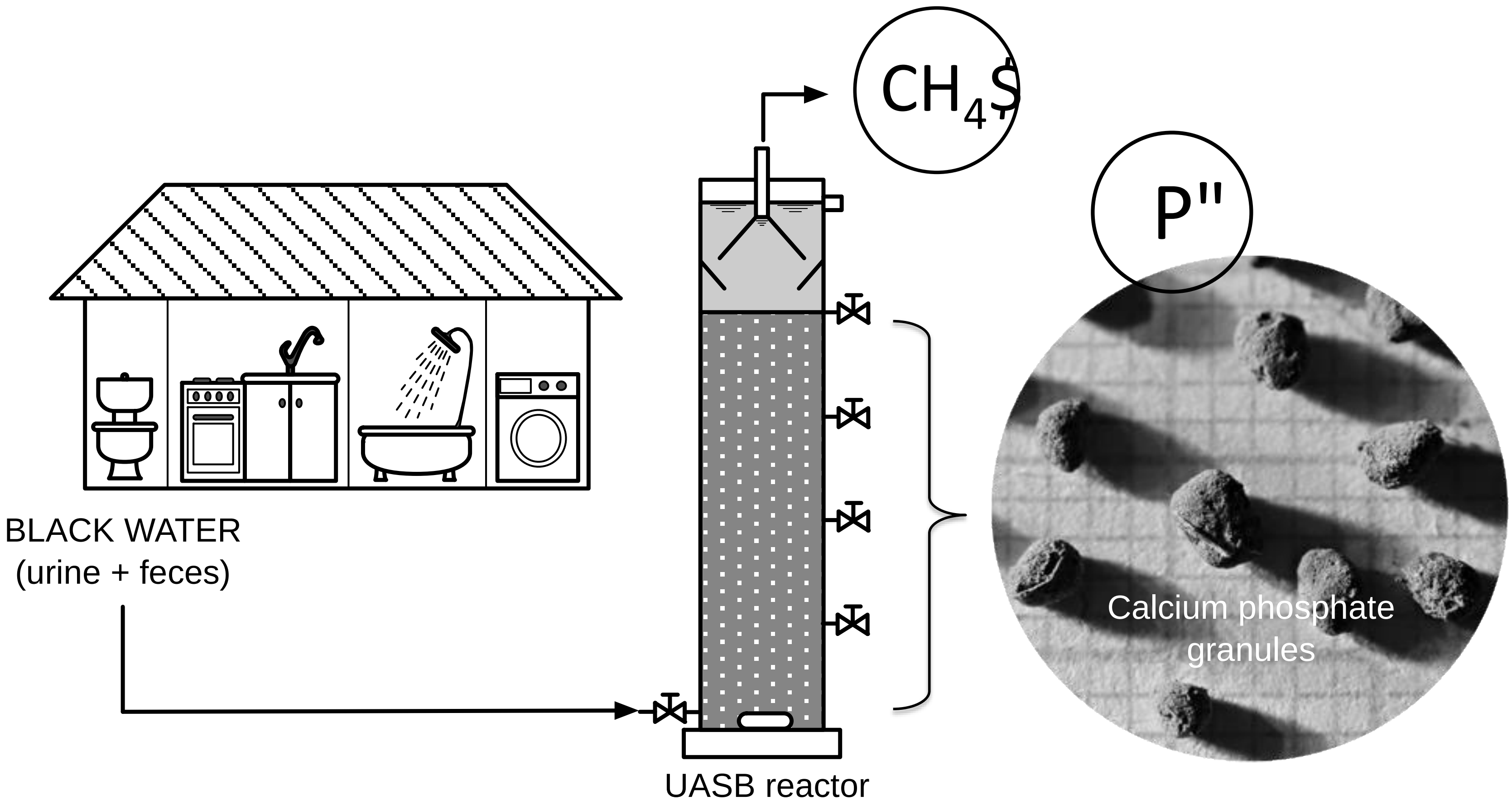


Kuntke et al., 2013 Submitted

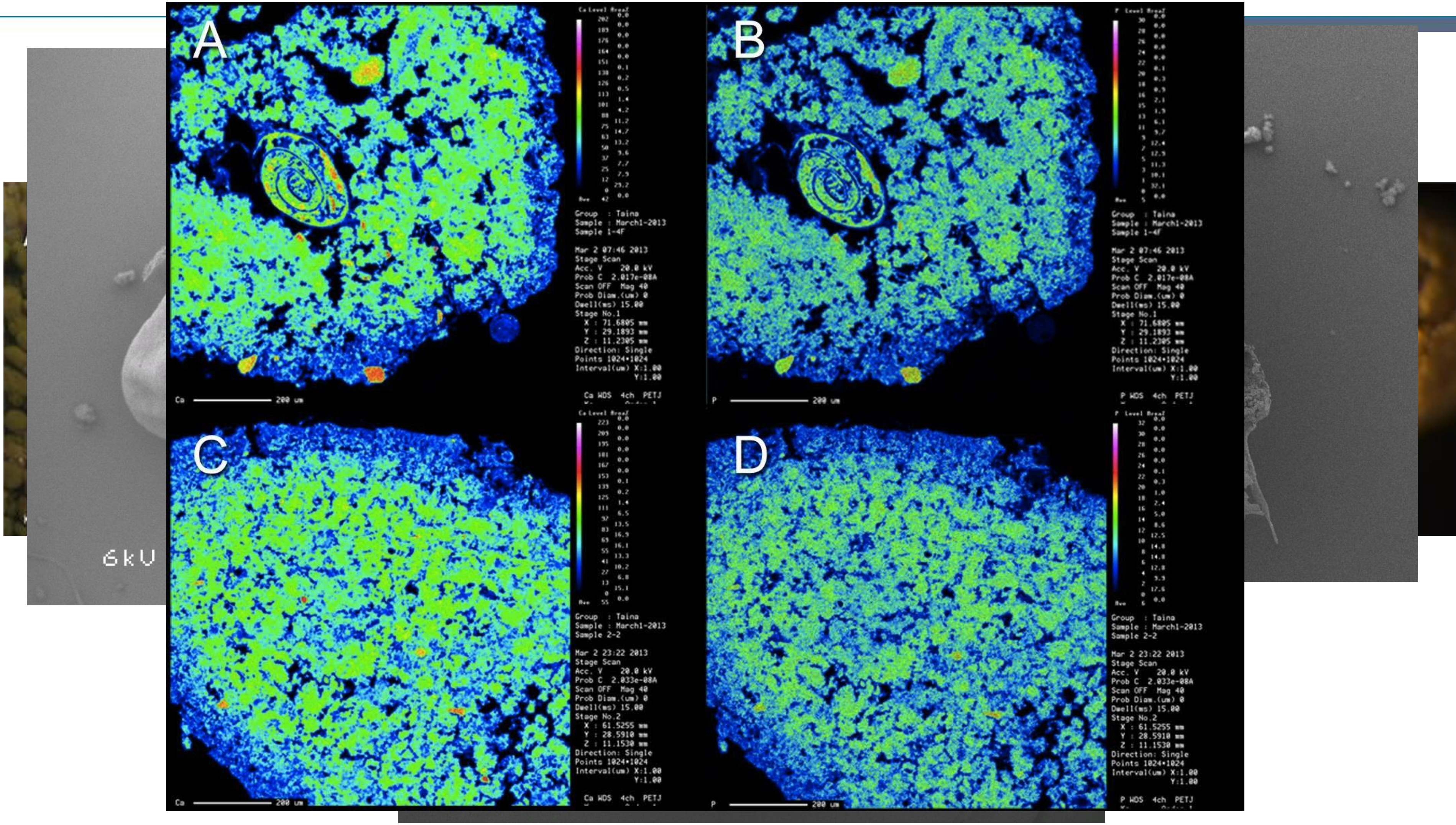
Pilot experiments



Calcium phosphate granulation



Calcium Phosphate granulation



Heavy metals in BW sludge

Element	BW sludge	Cow manure[1]	P-fertilizer[2]
As	10	nd	33
Cd	10	33	91
Cr	513	1145	1245
Cu	2884	14397	207
Hg	nd	nd	0.7
Ni	330	1472	202
Pb	57	695	154
Zn	10747	25947	1923

Unit mg/kgP

(1) van Dooren *et al.*, (2005)

(2) Remy and Ruhland (2006)

nd = not detected

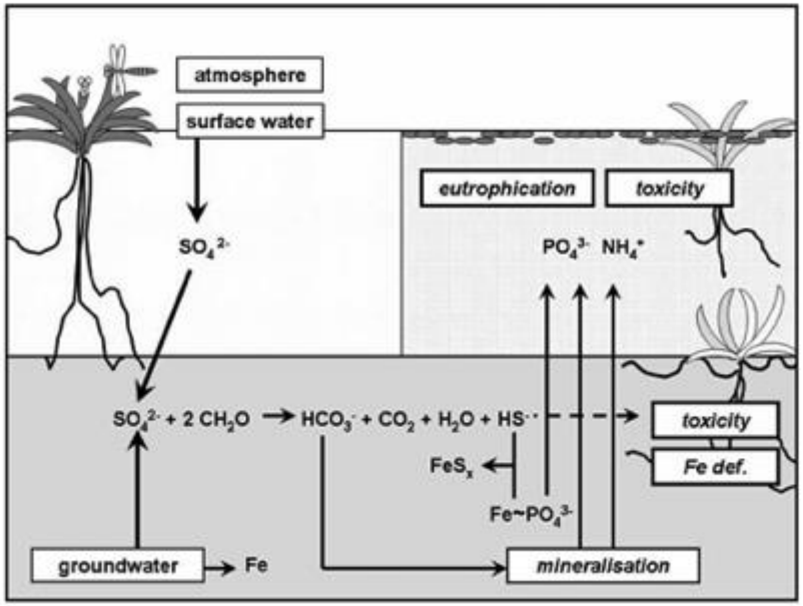
P from Iron Phosphate

Objectives:

- **To extend P-recovery to majority of wwtp's**
- **At higher recovery efficiencies**

Technology:

- Release of P through reduction of iron and precipitation as Fe(II)S
- Inspired on natural processes in lake sediments



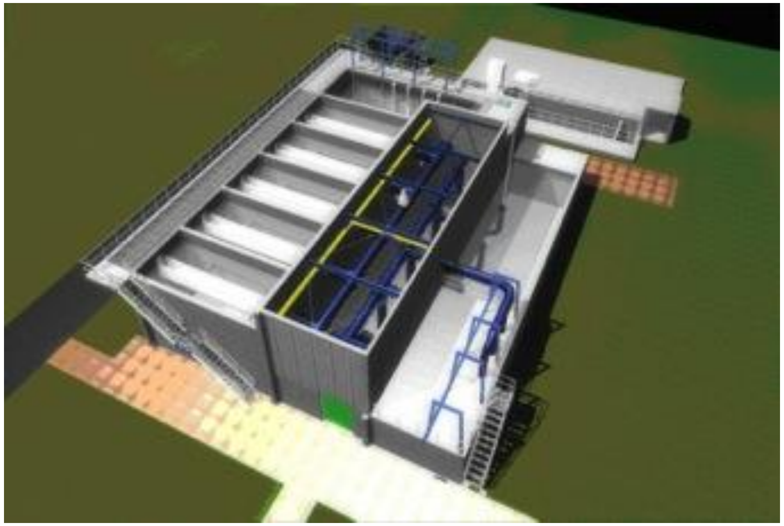
Reversible P-adsorption

Objectives:

- Very low effluent concentrations
- High quality recovery product (calcium phosphate)

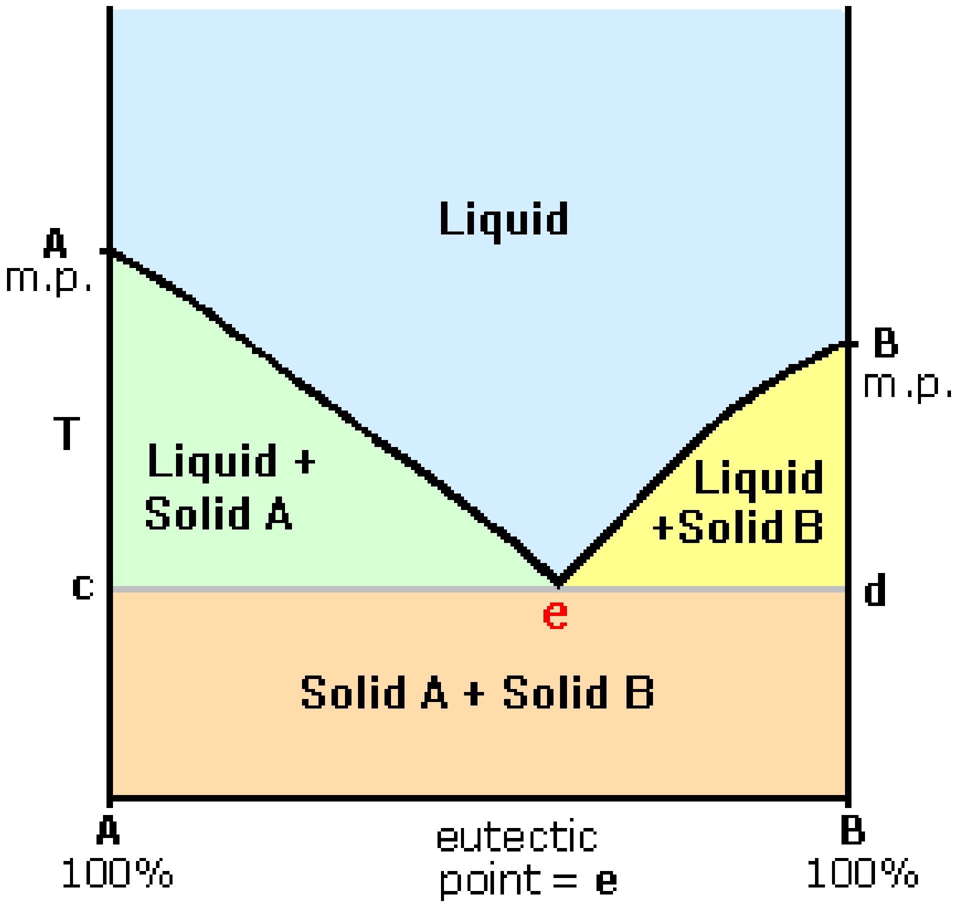
Technology:

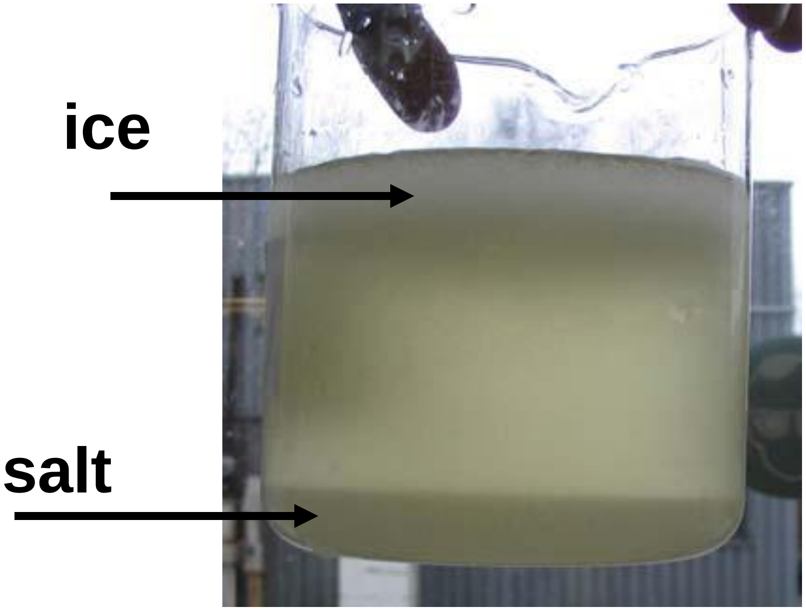
- High adsorption capacity using nano-Fe particles
- Focus on cheap and integrated regeneration and recovery



1-Step filter wwtp Horstermeer

Freeze desalination





Wrap Up

- N & P important
- Recycling crucial
- Innovation needed
- Examples shown