FACULTY OF BIOSCIENCE ENGINEERING

Center for Microbial Ecology and Technology

CARBON AND NITROGEN RECOVERY IN A SEWAGE CONTEXT

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Present address: Berkeley Water Centre, UC Berkeley

Ghent University

⇒ Faculty of Bioscience Engineering

⇒ Department of Biochemical & Microbial Technology

⇒ Center for Microbial Ecology and Technology

http://cmet.ugent.be

CAPTURE – A center focusing on resource recovery



CAPTURE

R^2T – industry platform

nijhuis INDUSTRIES

umicore materials for a better life

Avecom

PAQUES

Waterschap De Dommel

UW WATERSCHAP

MAGNETO SPECIAL ANODES B.V.

FARYS

DOW

pidpa water in beweging

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Witteveen Bos

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ADVANCED WASTE WATER SOLUTIONS
INNOVATIONS IN SUSTAINABLE WATERTECHNOLOGY

RESOURCE QUANTITIES SEWAGE (EUROPEAN CONTEXT)

- Water: 72 billion m^3
- Nitrogen: mainly ammonia
  - Typical concentration: ~40 g/m^3
  - Mass flux EU: 2.9 MT p.a.
  - To compare: total soy import represents 1.3MT p.a.
- Carbon: complex mixture
  - Typical concentration: ~500 g/m^3
  - Mass flux EU: 36 MT p.a.
  - Can enable energy neutrality

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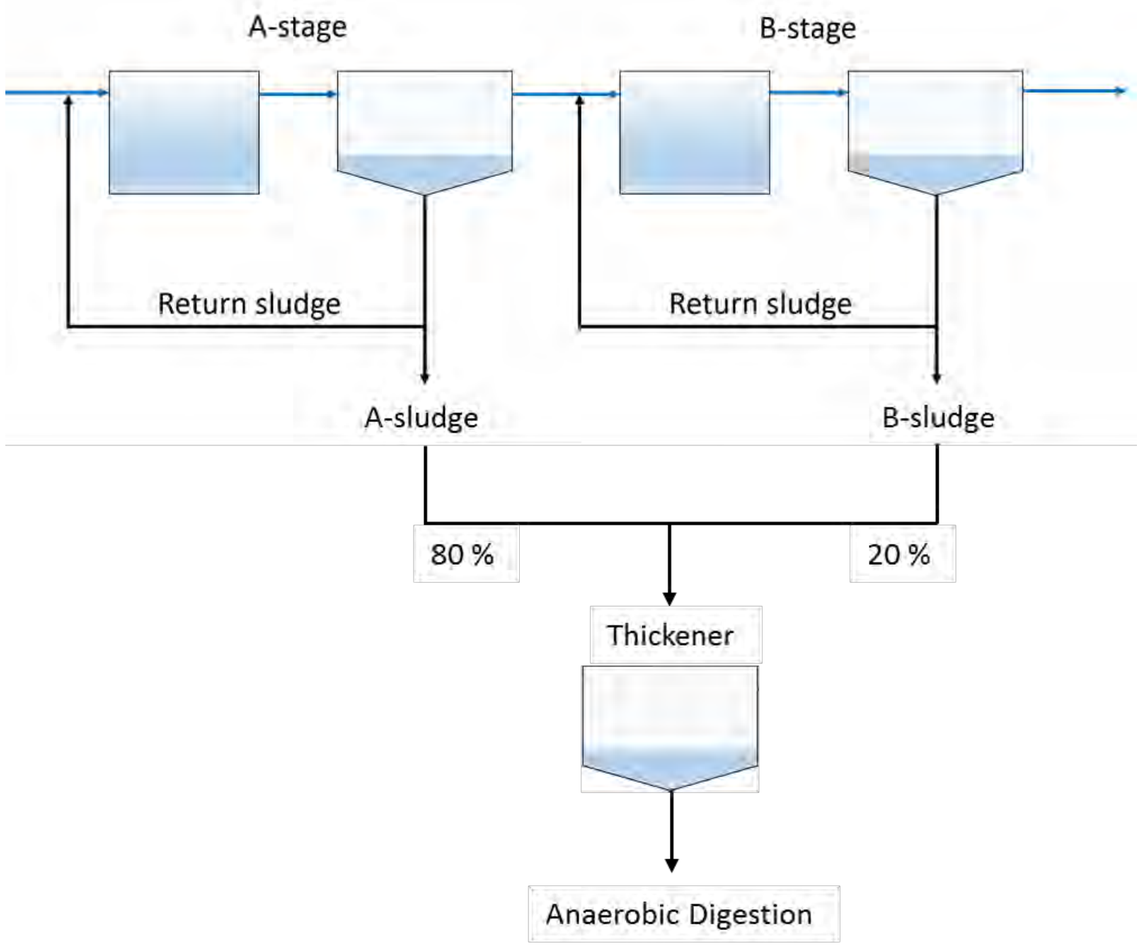

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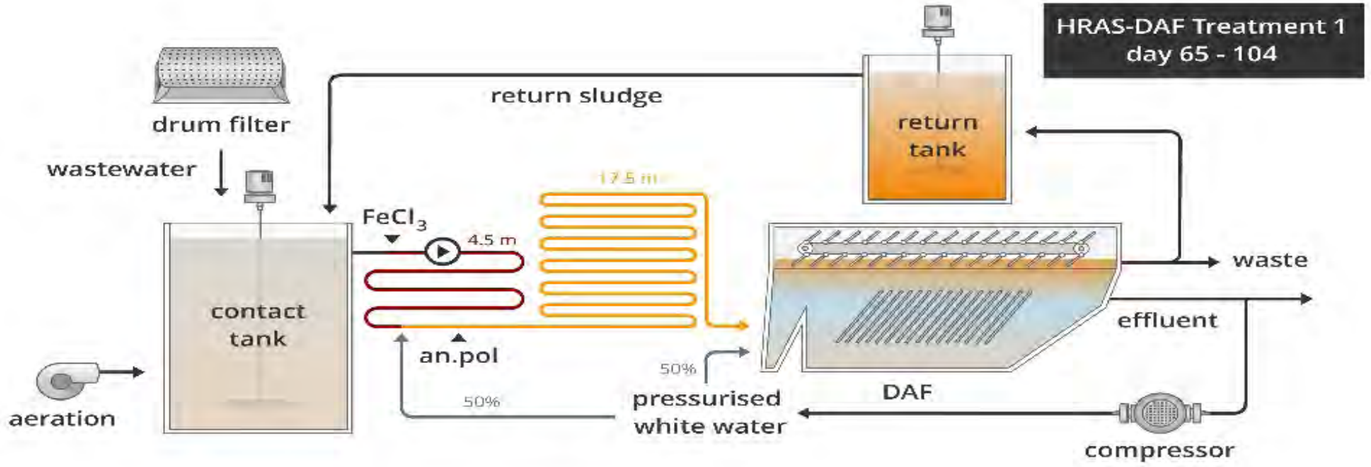

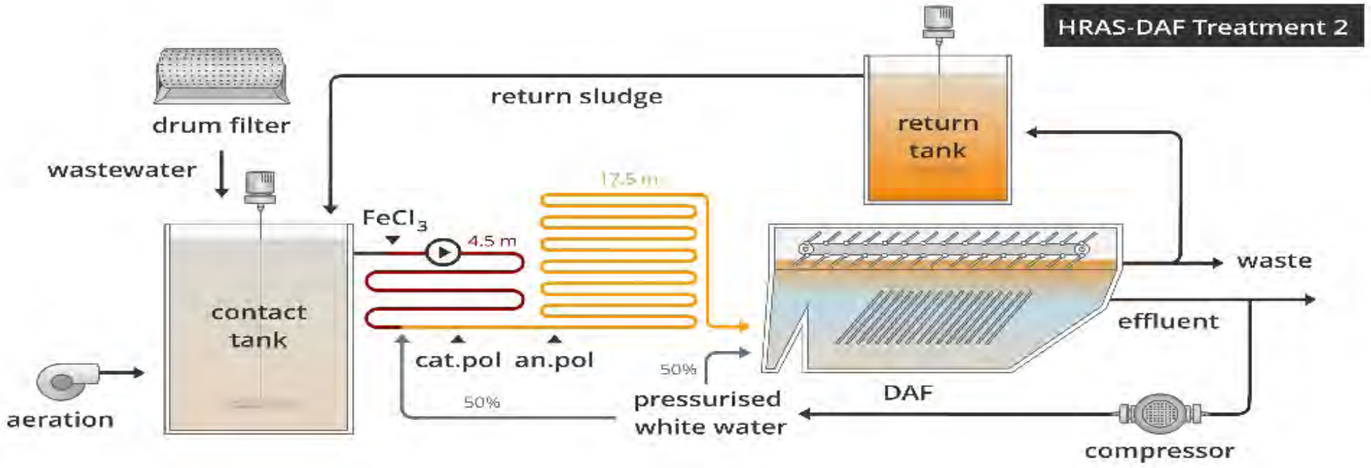

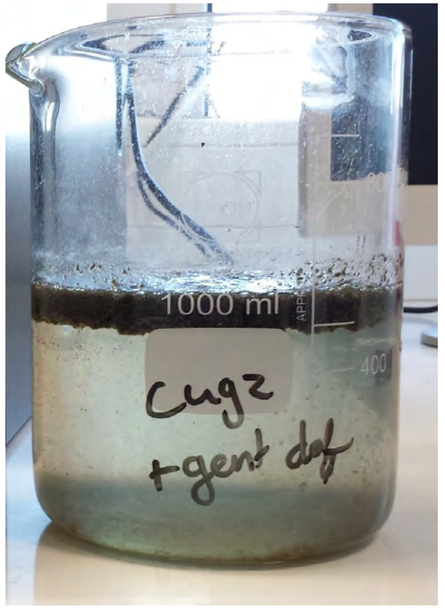

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GENIAAL

Modular concept to turn manure into **green minerals** and **clean water**

Flush Liquid

Manure

Flotation sludge

UF concentrate

Primary Separation Systems

60-70%*
Sand, fiber and grid

Decanter

10-20%**
Organic Fertilizer
with 3-6 % P

DAF

Liquid
Manure land
spreading

Ammonia Recovery

5-10%**
Nitrogen
Artificial Fertilizer
with 7-8 % N

Membrane Filtration

10-15%**
Potassium Fertilizer
with 1-2 % K

60-80%*
Feed water for animals
or surface water

Primary Separation Systems	Decanter & screen Module without polymer	DAF Module Including polymer	Ammonia Recovery Module	Clean Water Module	GENIAAL concept
TSS Removal: 15 - 25%	TSS Removal: 60 - 70%	TSS Removal: 85 - 99%	TSS Removal: 90 - 99%	TSS Removal: 100%	TSS Removal: 100%
N Removal: 1 - 5%	N Removal: 20 - 30%	N Removal: 30 - 45%	N Removal: 70 -90%	N Removal: 100%	N Removal: 100%
P Removal: 1 - 3%	P Removal: 60 - 75%	P Removal: 80 - 95%	P Removal: 80 - 95%	P Removal: 100%	P Removal: 100%
K Removal: 0 - 2%	K Removal: -	K Removal: -	K Removal: -	K Removal: 100%	K Removal: 100%
S Removal: -	S Removal: -	S Removal: -	S Removal: -	S Removal: 100%	S Removal: 100%
Cost*** -	Cost*** 1,20 - 1,50 €/m³	Cost*** 1,30 - 1,60 €/m³	Cost*** 4,20 - 5,00 €/m³	Cost*** 5,00 - 6,00 €/m³	Cost*** 11,70 - 14,10 €/m³
Cost*** -	Cost*** 0,005 - 0,007 $/Gallon	Cost*** 0,005 - 0,007 $/Gallon	Cost*** 0,016 - 0,020 $/Gallon	Cost*** 0,020 - 0,024 $/Gallon	Cost*** 0,046 - 0,058 $/Gallon

* The solid output value may vary according to operation conditions, manure type and its composition and other external equipment factors.

** % volume based on ingoing flow (100 %).

*** yearly cost is based on CAPEX (depreciation in 10 years) + OPEX (chemicals, labour, energy and maintenance)

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THE GENIUS PRODUCTS

% IS BASED ON VOLUME

Digestate after digestion **100%**

Clean water **60-80%**

Potassium fertilizer **5-10%**

Organic P rich fraction **10-20%**

Ammonium fertilizer **5-10%**

N RECOVERY

- N destruction €1-3/kg NDN
- N recovery €2-3/kg

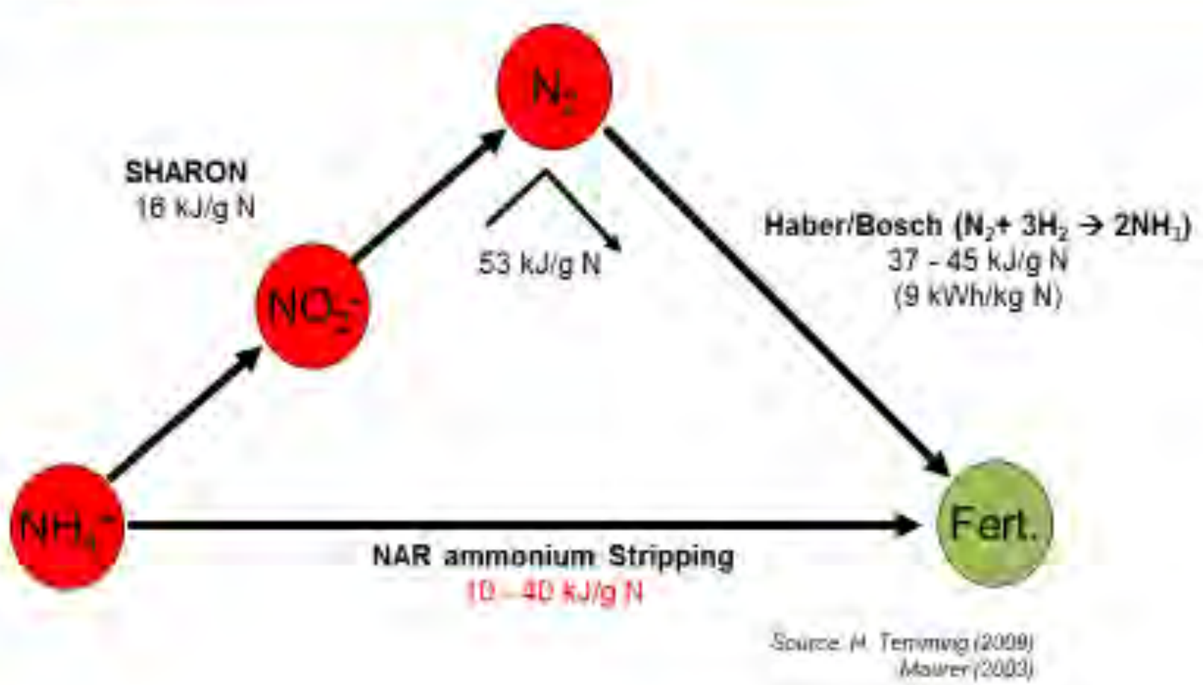

Figure: courtesy Wilbert Menkveld

Key aspects:

- To produce sufficient value!
- To maximize reliance on sustainable energy sources

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EXISTING OPTIONS

- Ammonium sulfate
  - Value €100/T but highly variable
  - Not popular with farmers if risk for acidification
  - Produced via “conventional” stripping
- Ammonium carbonate
  - Preferred by farmers
  - Need for acidified CO_2 solution e.g. from biogas
- Ammonium condensate for e.g. BioDeNox

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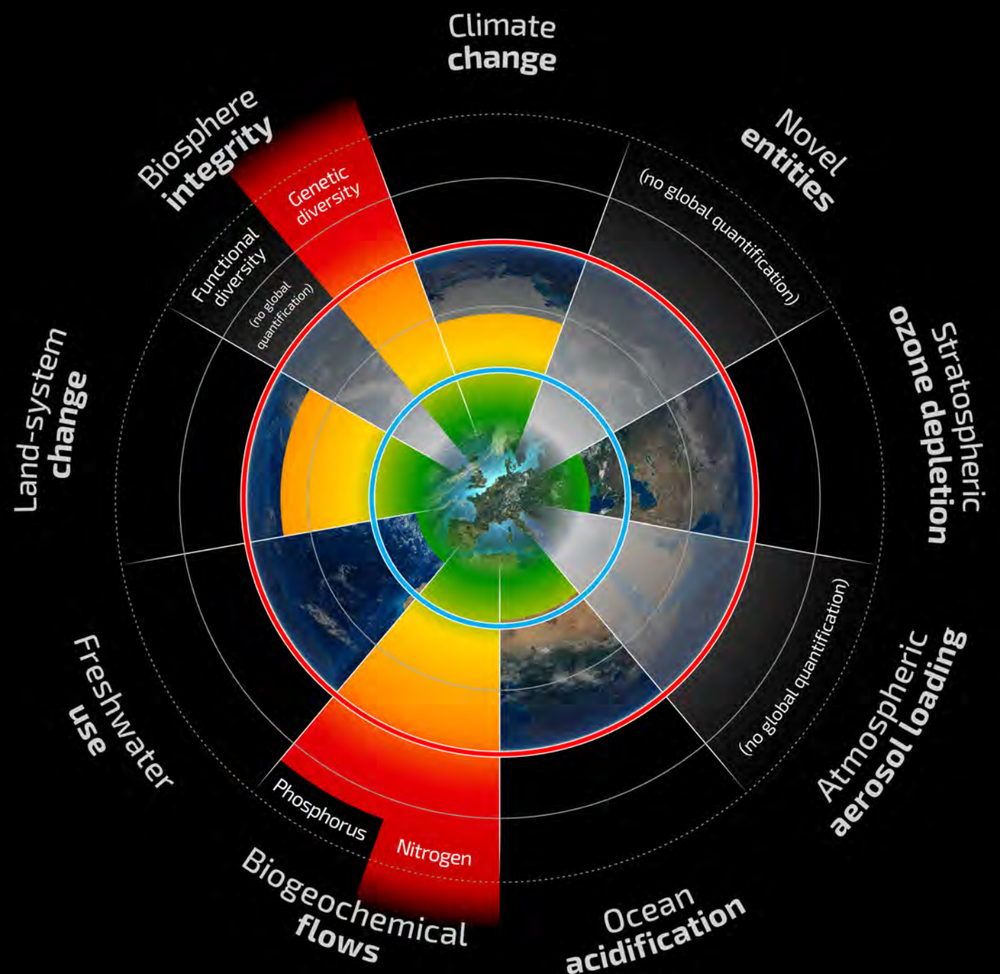
Planetary Boundaries

A safe operating space for humanity



- **Beyond zone of uncertainty** (high risk)
- **In zone of uncertainty** (increasing risk)
- **Below boundary** (safe)
- **Boundary not yet quantified**

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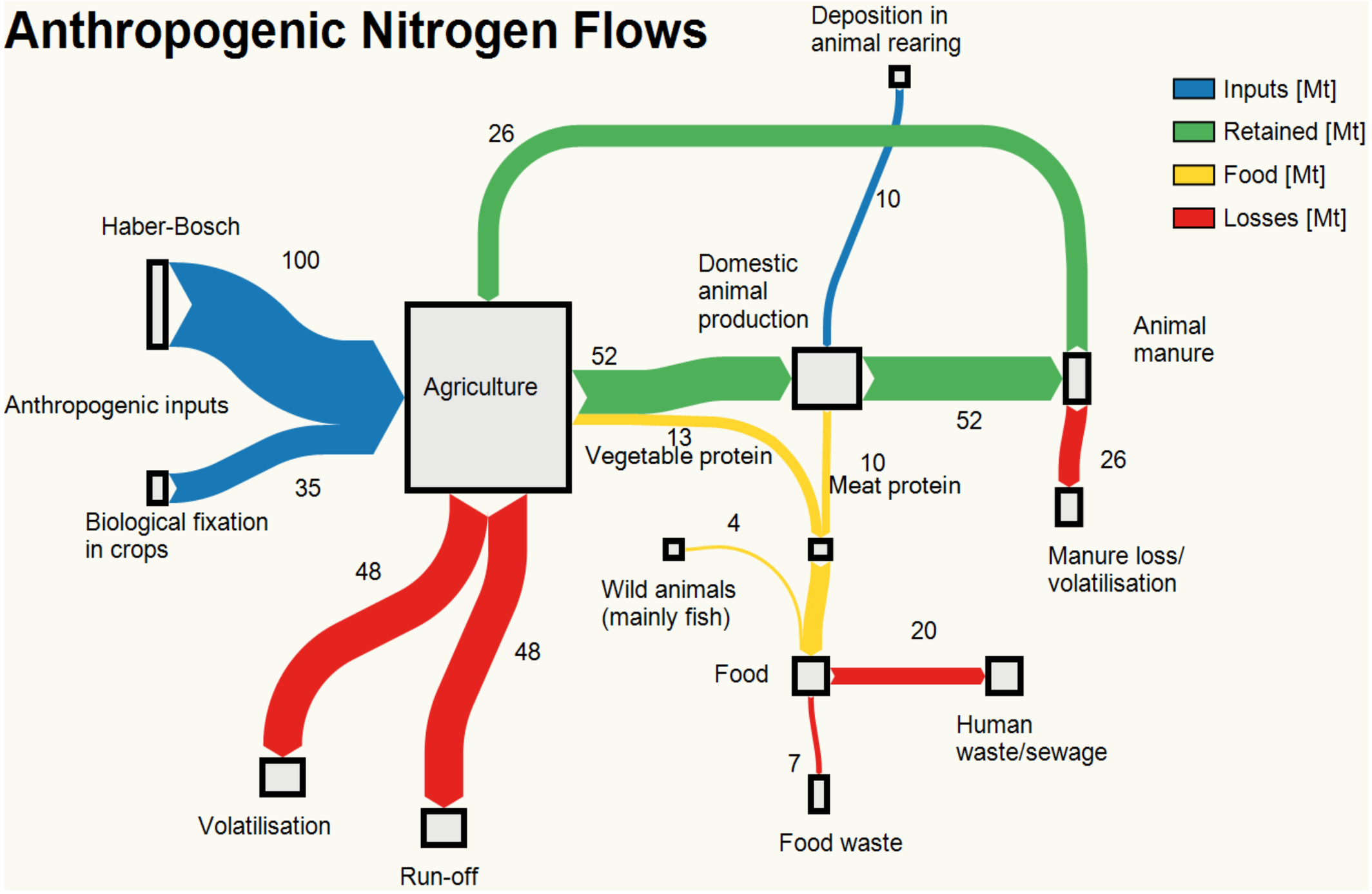
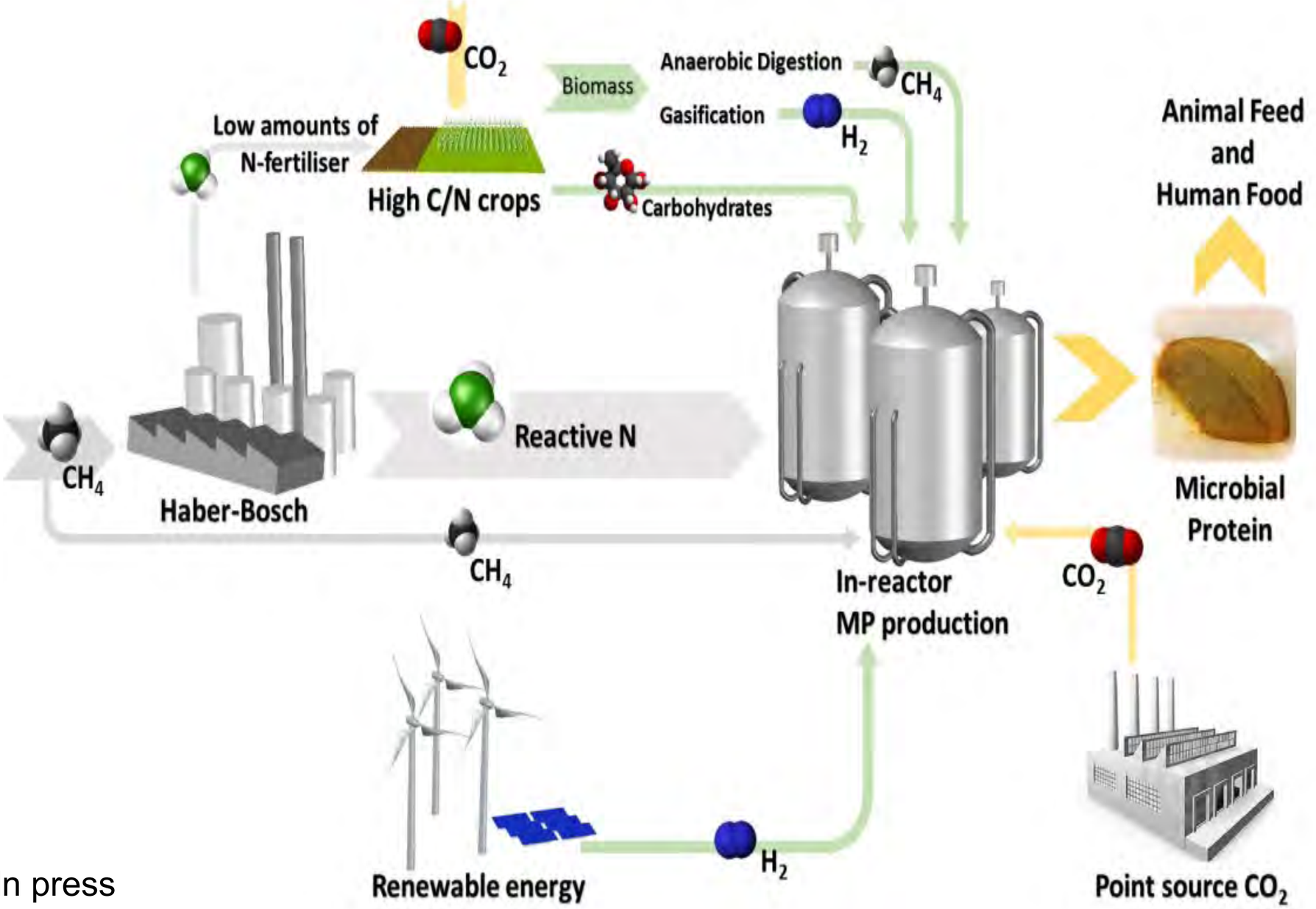
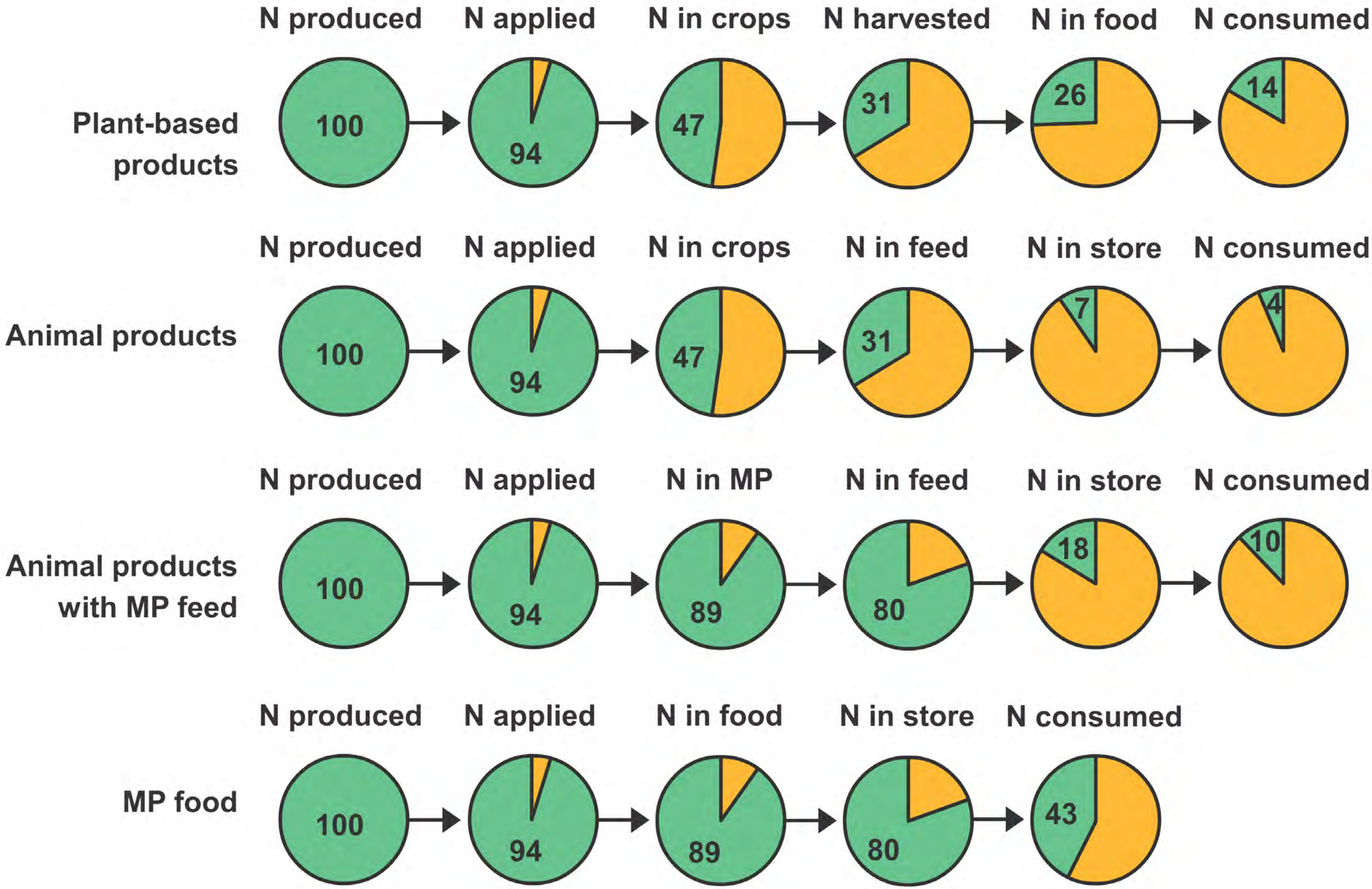
Rockstrom Science 2015


Anthropogenic Nitrogen Flows
Deposition in animal rearing
Inputs [Mt]
Retained [Mt]
Food [Mt]
Losses [Mt]
26
10
Haber-Bosch
100
Domestic animal production
Animal manure
Agriculture
52
Anthropogenic inputs
52
13
Vegetable protein
10
Meat protein
26
35
Biological fixation in crops
4
Manure loss/ volatilisation
48
Wild animals (mainly fish)
20
48
Food
Human waste/sewage
Volatilisation
7
Food waste
Run-off



Pikaar *et al.* In press



Pikaar *et al.* In press

STATUS OF SCP

- Has been around for > 50 years, several types on the market (e.g. Quorn^{TM})
- Current market animal feed around 200 MT p.a.

  Value: ~ €750/T soy protein, ~ € 2600/T fishmeal
- Legally accepted also for recovered N under certain circumstances
- N availability far outweighs N requirement
- Technically shown at 100 m^3 scale on industrial wastewater, at 1 m^3 scale on H_2
- Many challenges still including acceptance, ethics, drying,…and for sewage treatment mainstream N recovery

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CMET

support good ideas

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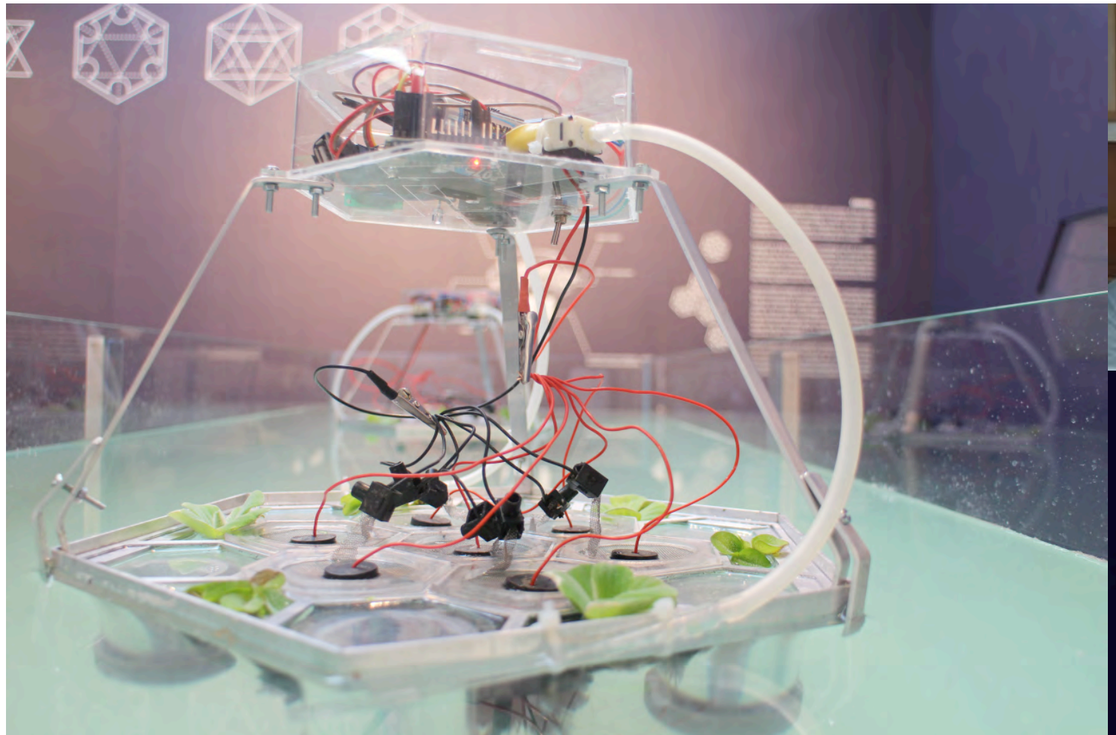
Caravel-Ivan Henriques, 2016



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