Zurich University
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Life Sciences and
Facility Management

Institute of
Natural Resource Sciences

Pyrolytic conversion of human waste

An element of a closed-loop system?

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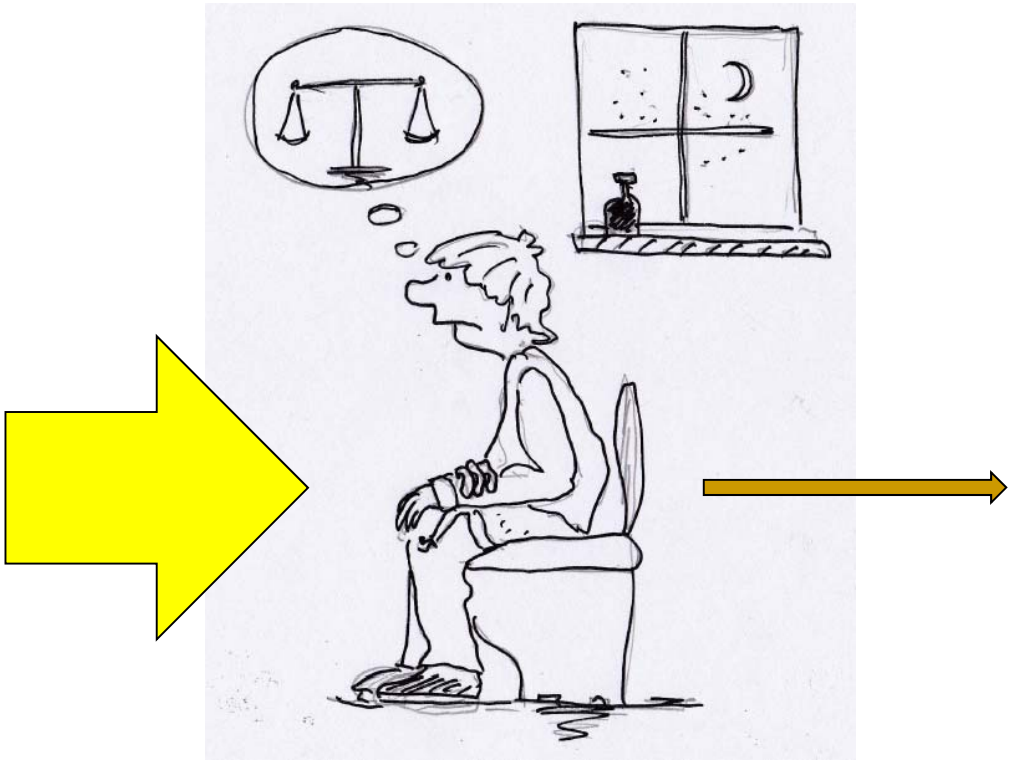
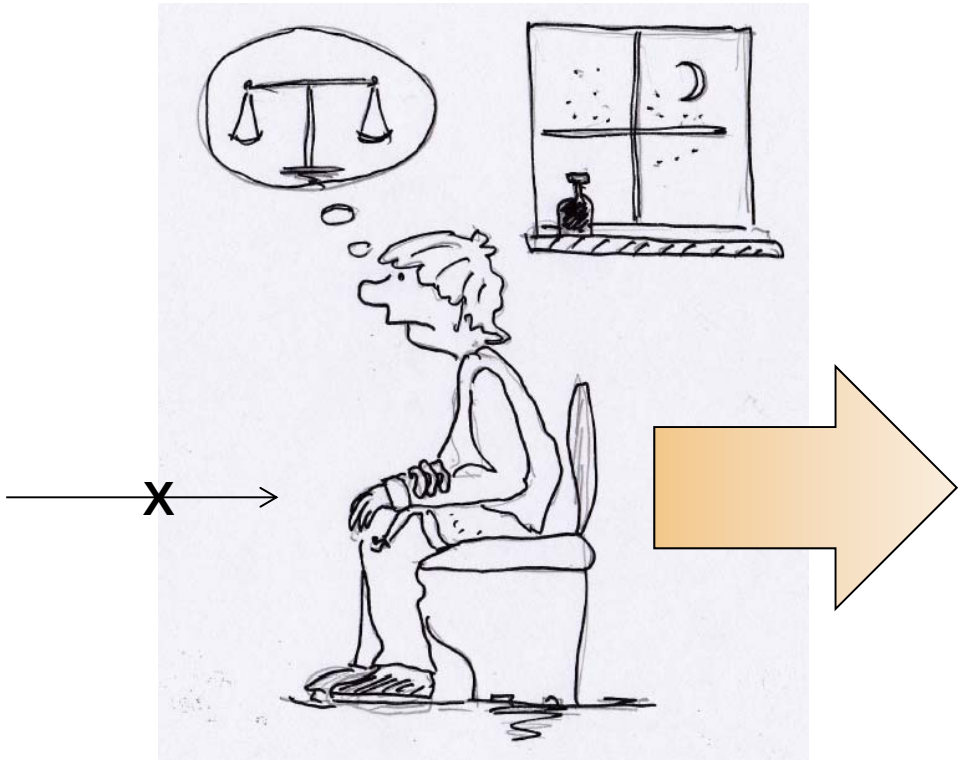
June 8, 2016 // MELiSSA Wokshop

Zürcher Fachhochschule

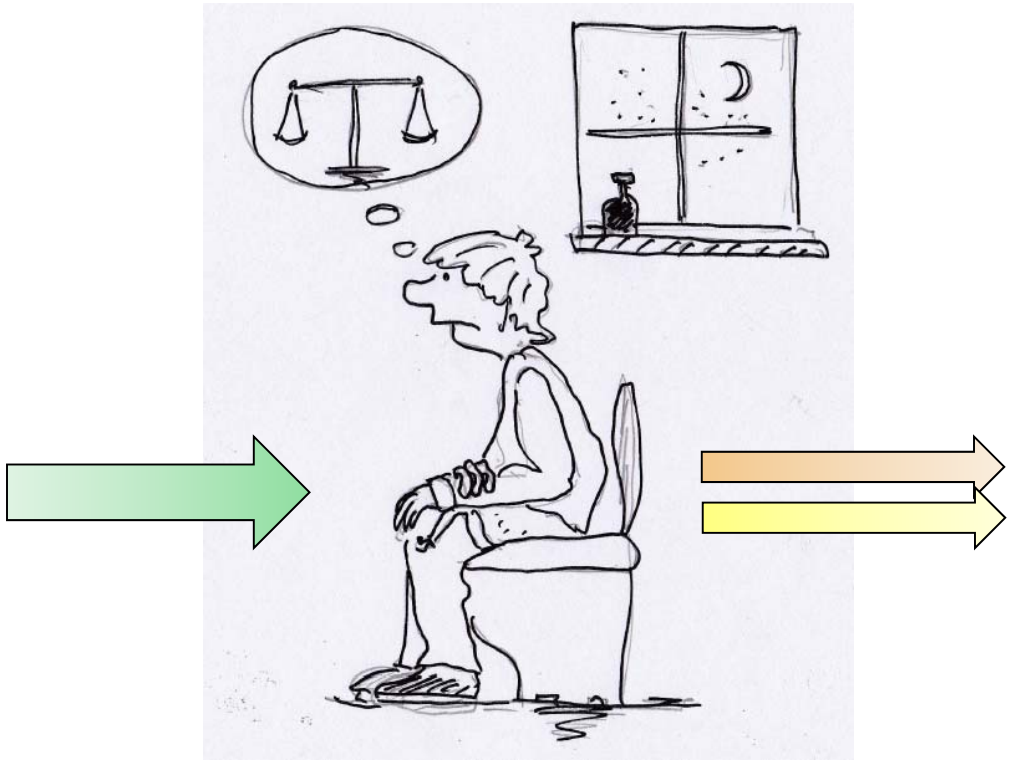


Energy IN >> Energy OUT



Pathogens IN <<< (potential) pathogens OUT

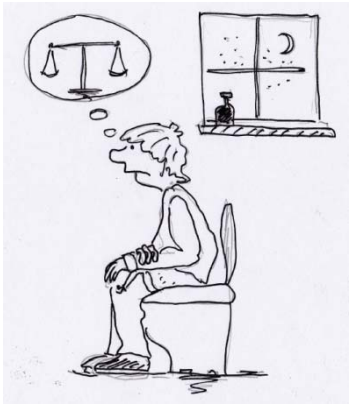
(same issue for pharmaceuticals, hormones etc.)



Nutrients IN == Nutrients OUT

(same issue for water)

Needed for closed-loop systems:



A recycling approach which…

… safely links excretion and food production

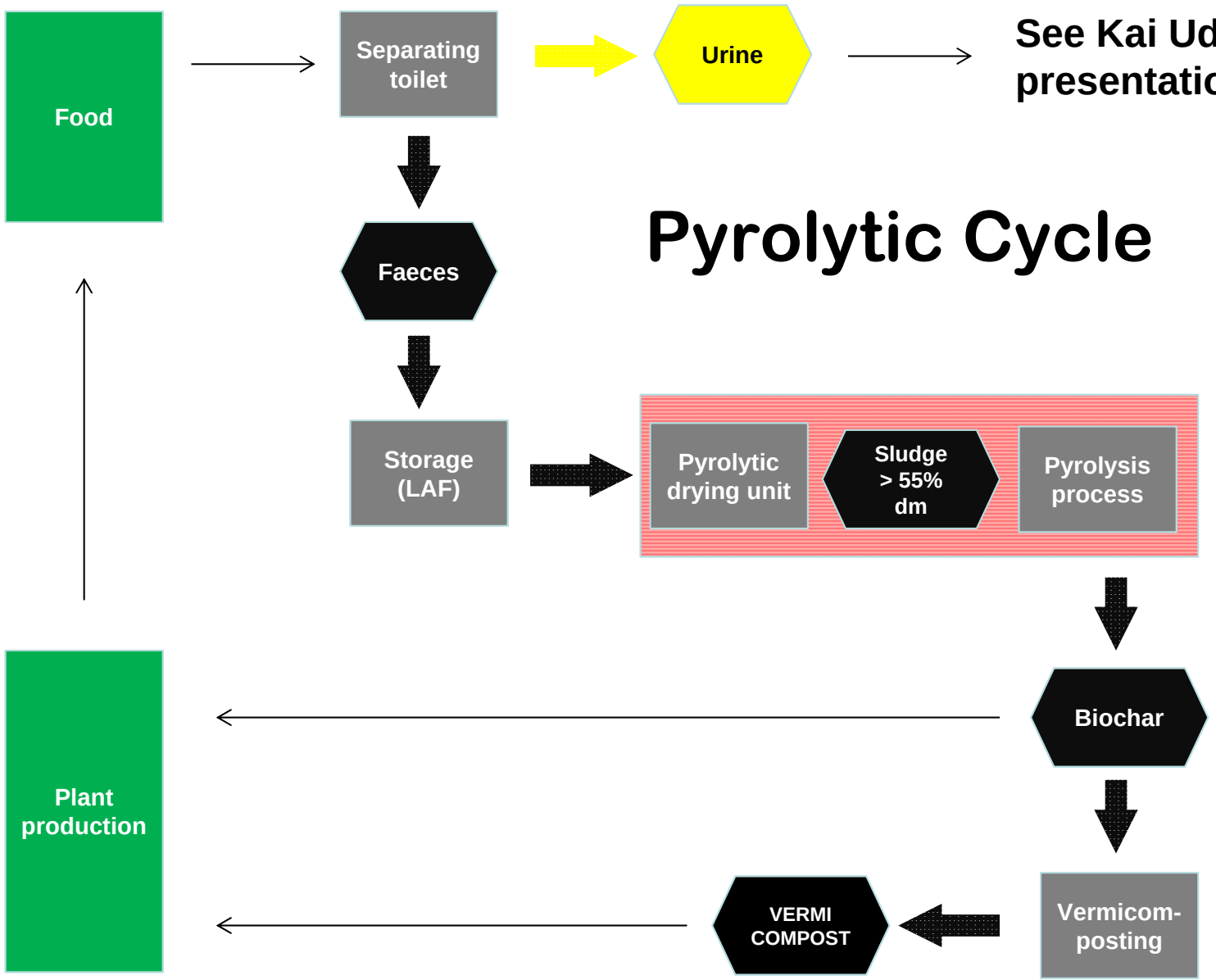
… completely eliminates pathogens, endocrine disruptors, pharmaceuticals etc

… recovers as much of the nutrients as possible

… ideally has a positive net-energy balance

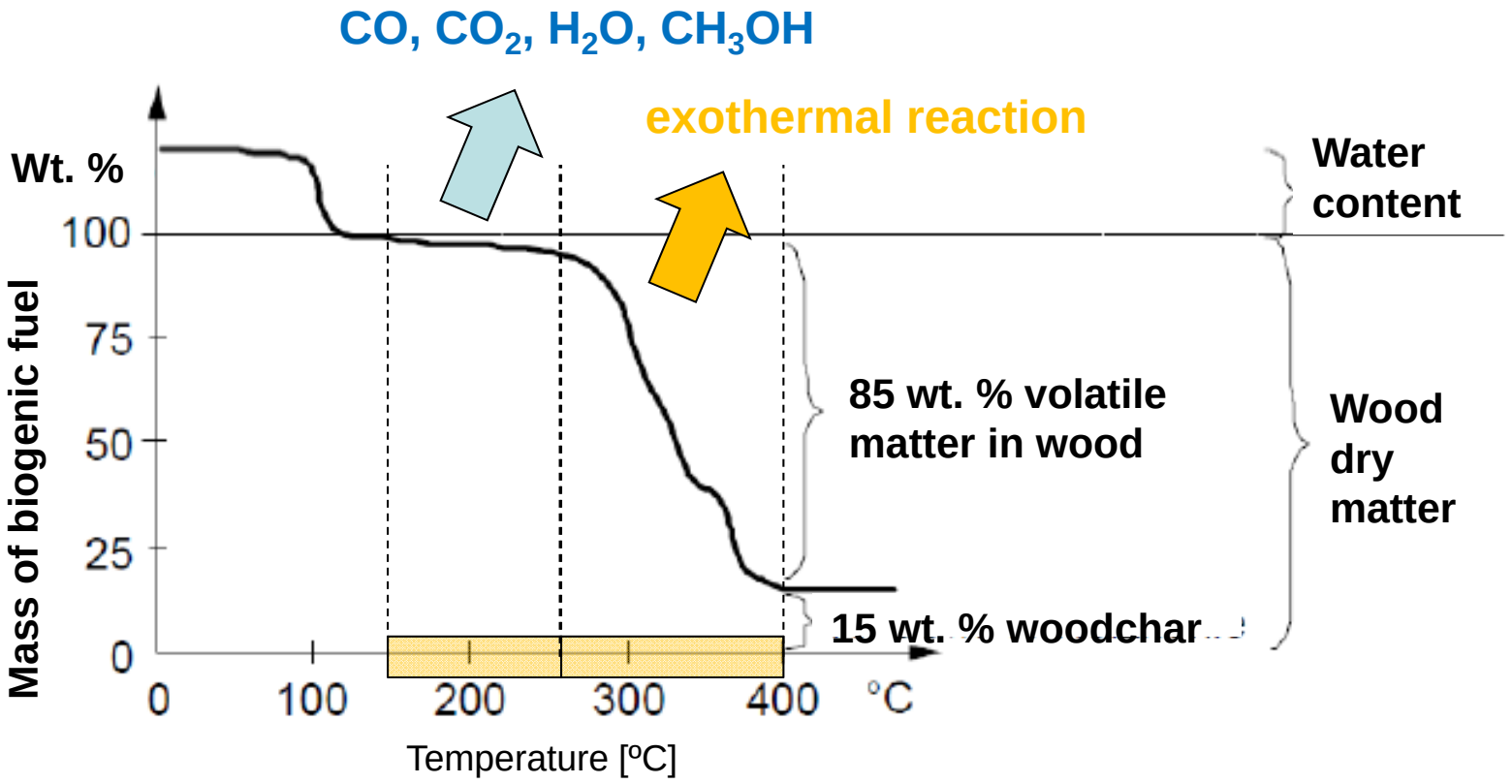
… links in with the water recycling systems

… is simple to operate



LAF = lacto-acid-fermentation

Pyrolysis:
Thermo-gravimetric curve (beech wood)



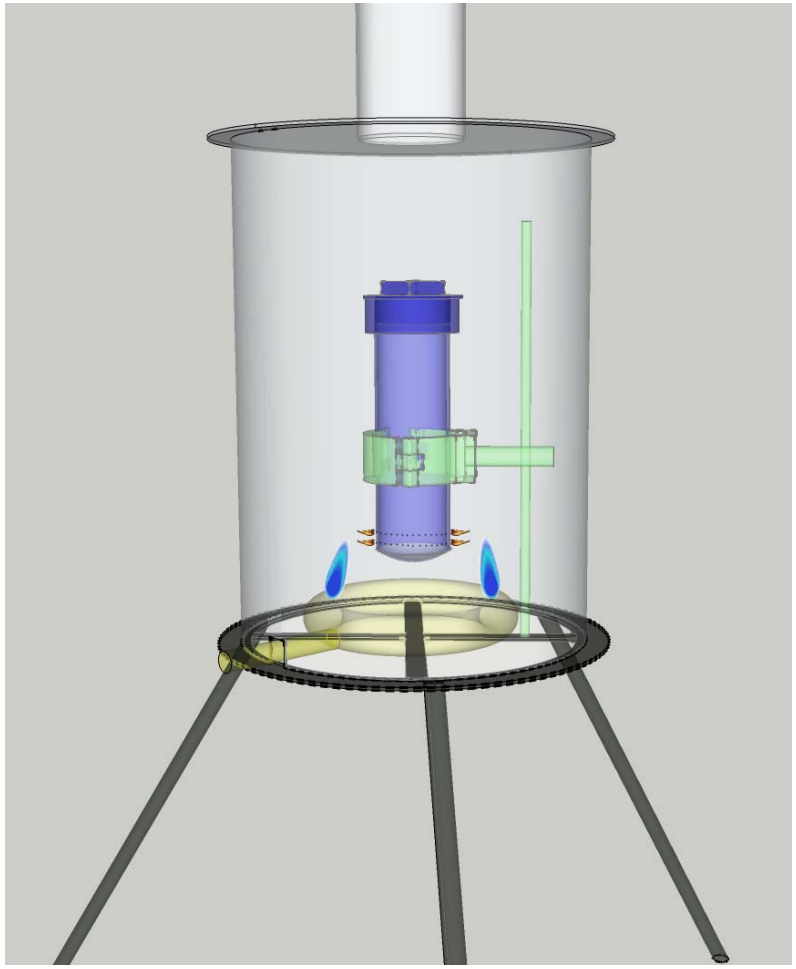
Source: Kaltschmitt, Hartmann, & Hofbauer, 2009

Human waste substrate

Photo: Nicola Bulant

Photo: www.kompotoi.ch

Construction of batch reactor (ZHAW)



Sketch and photo: Nicola Bulant

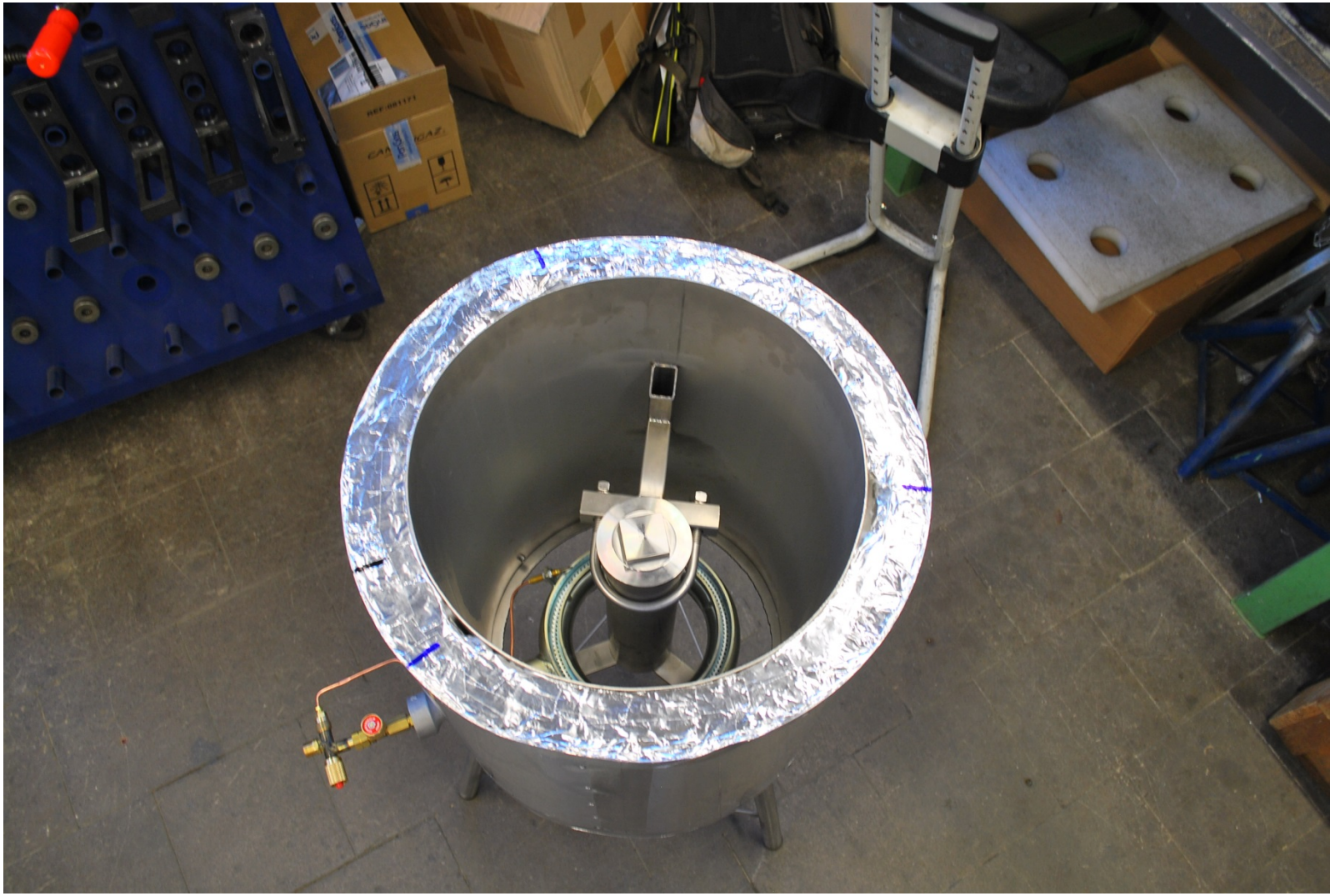
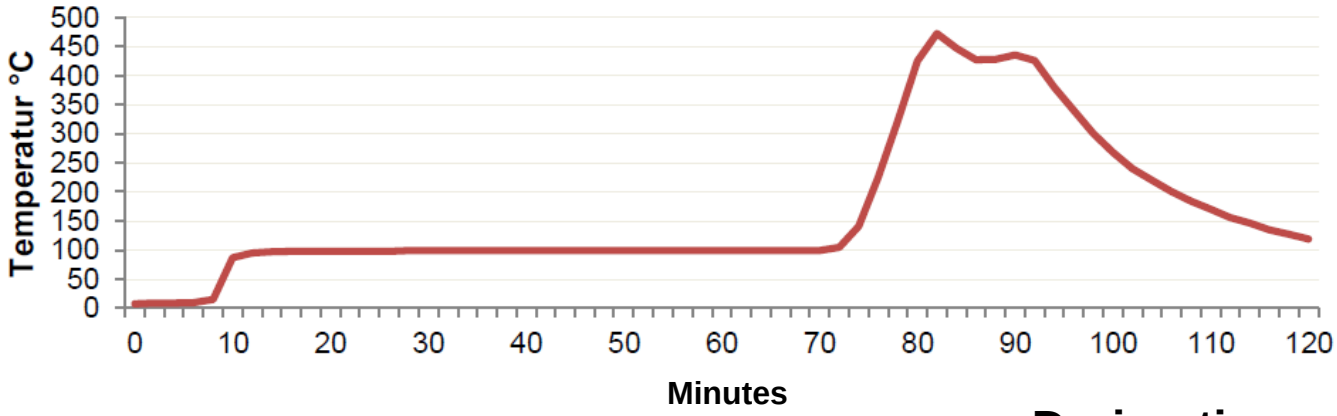


Photo: Nicola Bulant

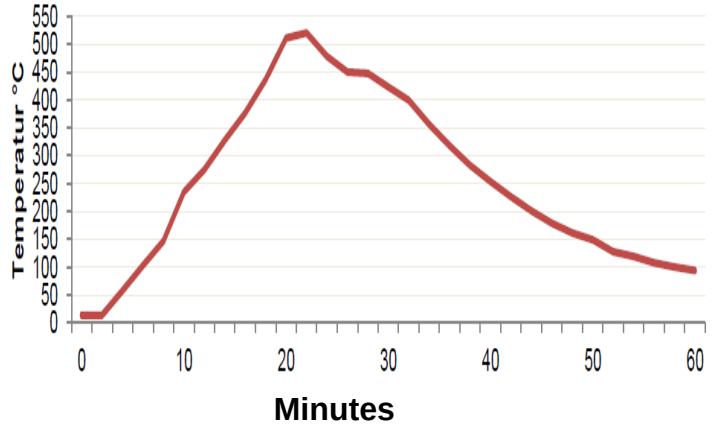
Photo: Andreas Schoenborn

Water content controls energy demand

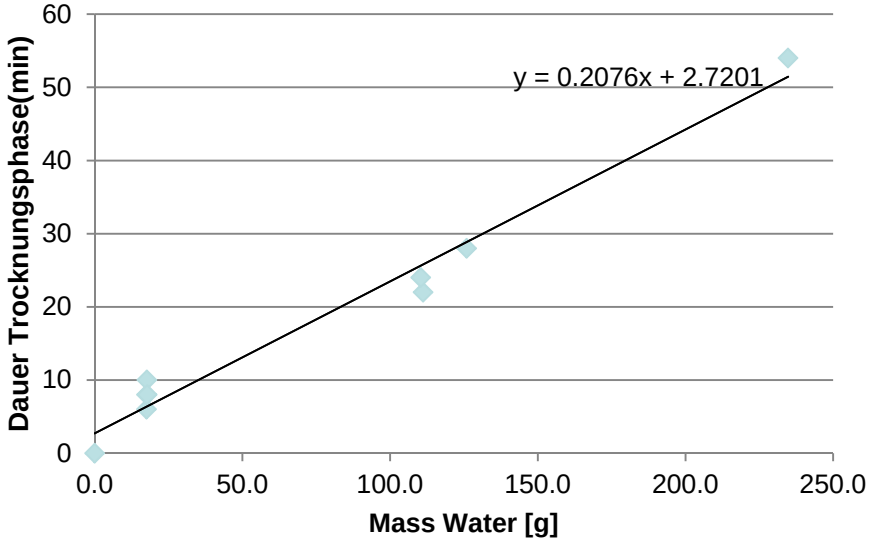
36.2% dry matter



> 98% dry matter

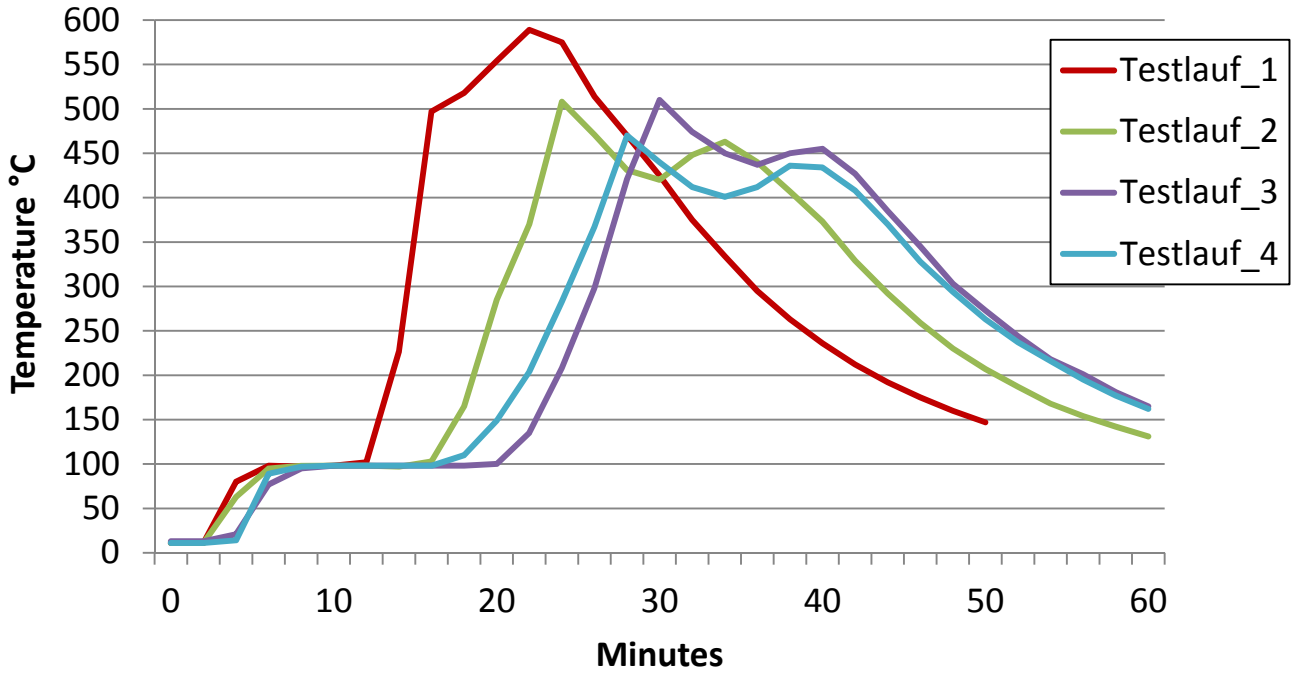


Drying time vs water [g]



Data from Bulant, BSc. Thesis 2015

Reactor temperature over time



Data from Bulant, BSc. Thesis 2015

Physico-chemical properties

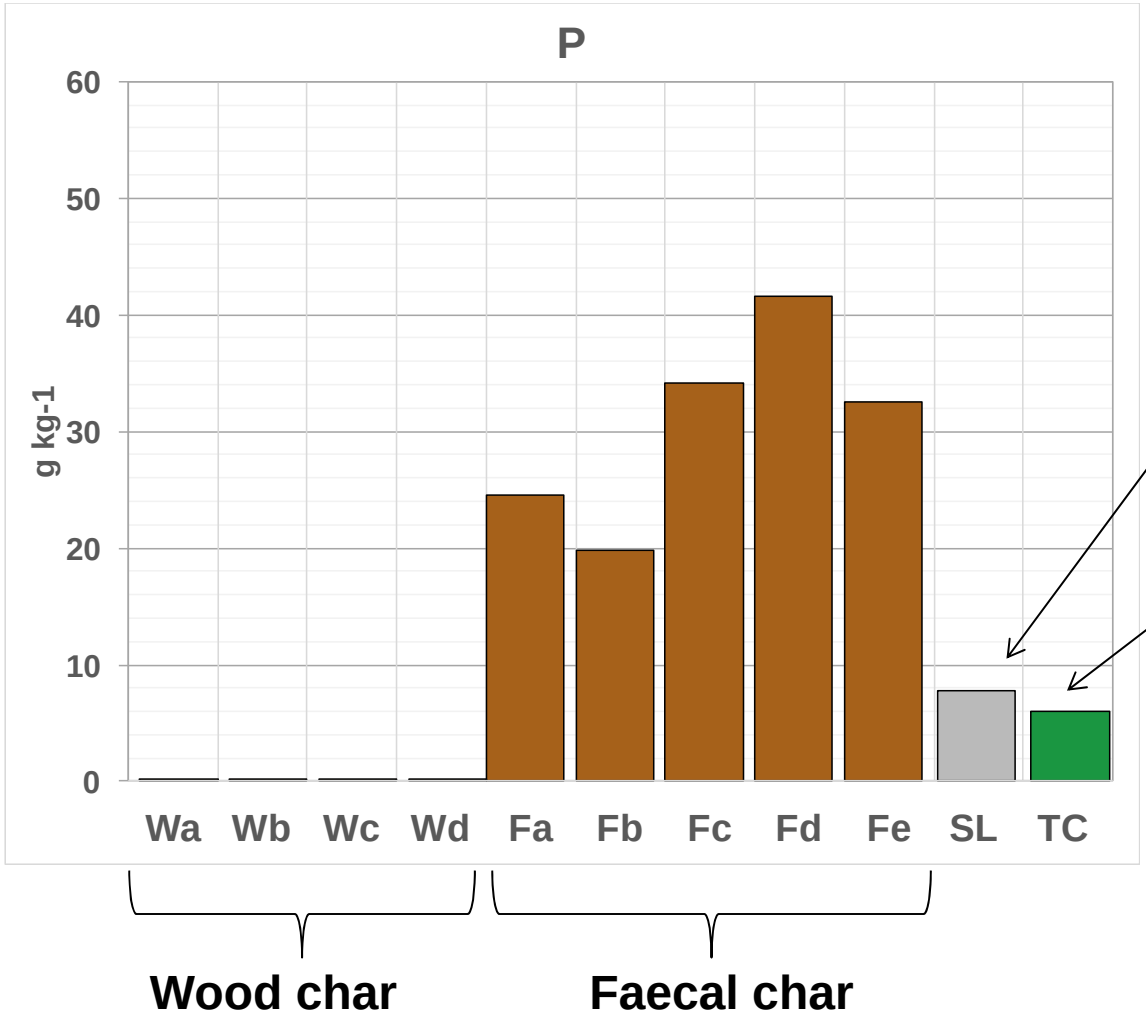
Test	Unit	Wood chars (group mean)	Faecal chars (group mean)	Sewage sludge char	Tree cuttings char
pH	-	7.5 ± 0.3	8.7 ± 0.2	9.5	8.8
Elec. conductivity	mS cm^{-1}	0.8 ± 0.3	2.8 ± 2.1	1.0	1.3
Ash content	%	6.0 ± 3.7	17.4 ± 3.5	27.7	10.1
Number of chars	-	4	5	1	1

Bleuler, Schoenborn & Bulant (in prep.)

C H N

Data from Bleuler, Schoenborn & Bulant (in prep.)

Phosphorous



Data from Bleuler, Schoenborn & Bulant (in prep.)

Nutrients: Expected vs. measured

	P	Cu
Dry mass content of feces (g/kg)	9.8-14.7	0.05
Mass reduction by pyrolysis	70%	
Feces : Sawdust ratio	2:1	
Expected content in biochar (g/kg)	21.5-32.3	0.12
Measured content in biochar (g/kg)	20.8-48.9	0.07-0.16

Heavy metals

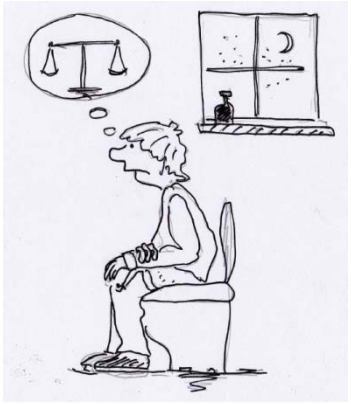
	Pb	Cu	Cd	Ni	Hg	Zn	Cr
	mg kg-1	mg kg-1	mg kg-1	mg kg-1	mg kg-1	mg kg-1	mg kg-1
Maximum threshold							
EBC Basic	<150	<100	<1.5	<50	<1	<400	<90
EBC Premium	<120	<100	<1.2	<30	<1	<400	<80
Measured values							
ICP-OES mean	<LOD	59.5	<LOD	-	-	535.9	-
XRF mean	14.2	113.6	<LOD	17.5	<LOD	693.0	<LOD

EBC = European biochar certificate
LOD = level of detection
LOQ = level of quantification

System potential

Safely links excretion and food production	✚
Completely eliminates pathogens, endocrine disruptors, pharmaceuticals etc	✚
Recovers as much of the nutrients as possible	✚
Ideally has a positive net-energy balance	?
Links in with the water recycling systems	?
Is simple to operate	?

Outlook & next steps



- Effects of faecal biochar on germination
- Toxicity of faecal biochar
  (PAH? Dioxins?)
- Fate of nitrogen
- Optimization of energy balance
- Plant availability of nutrients
- Reactor design

Funded by:

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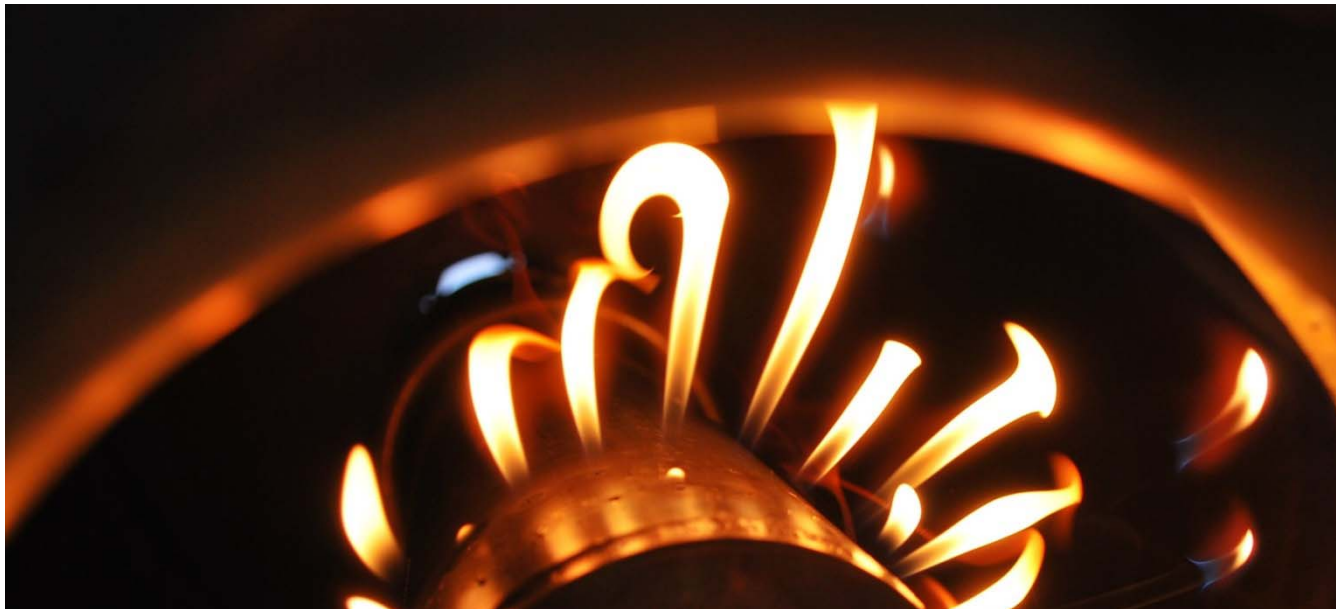

Thank you for your attention!