

Circular Economy

Feedstock-Technologies-Products

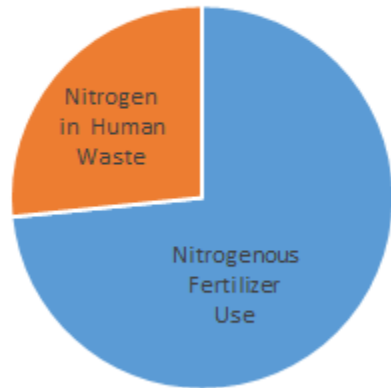
Kartik Chandran
Columbia University

WRC Symposium
September 13th, 2019
Johannesburg, South Africa

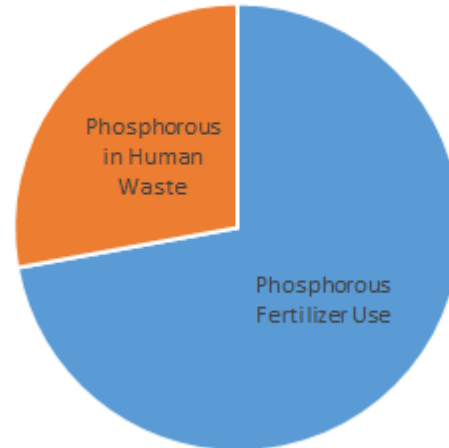


Does resource recovery even make sense?

Nitrogen



Phosphorous (P₂O₅)

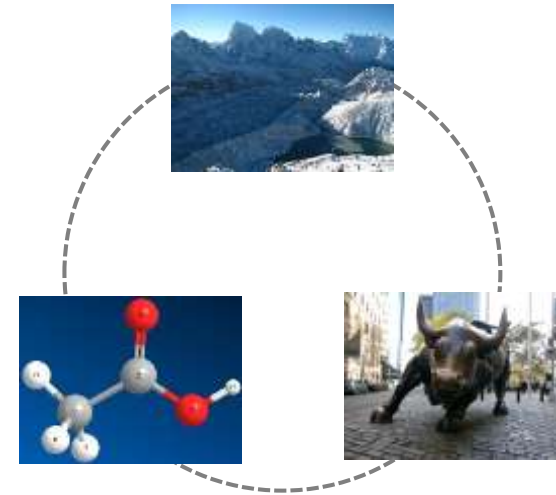
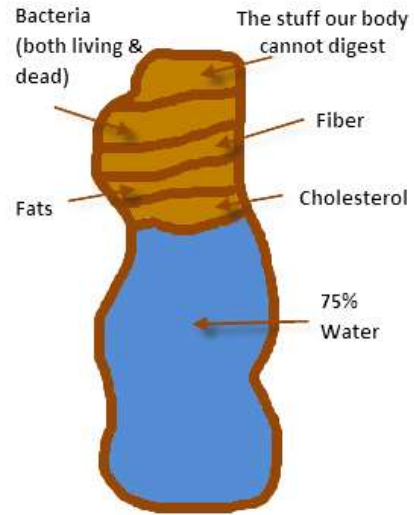


C



Overall approach

Need improved
characterization
of feedstock

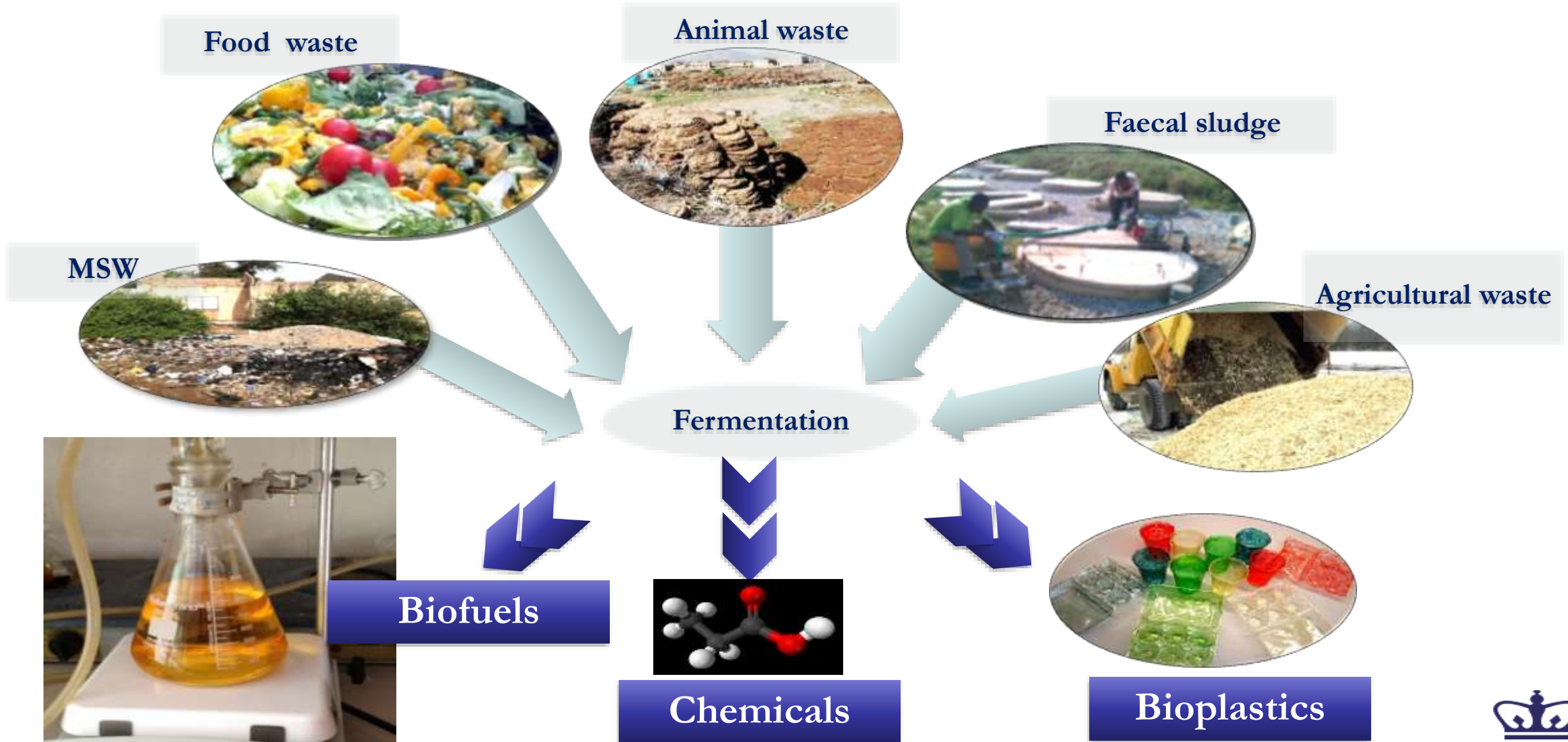


Technologies informed by
sounds science

End products driven by
appropriate business models

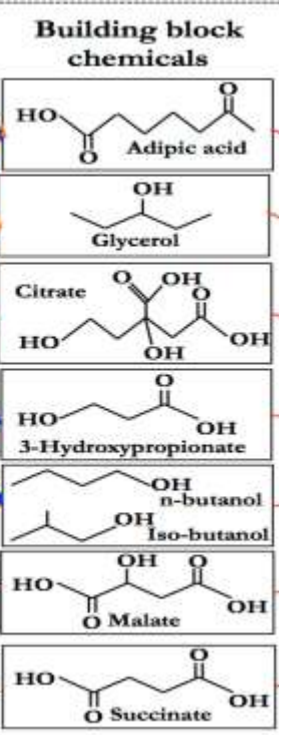
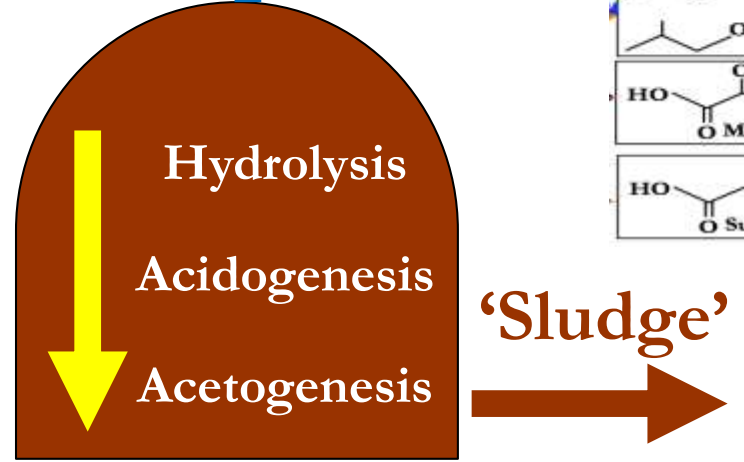
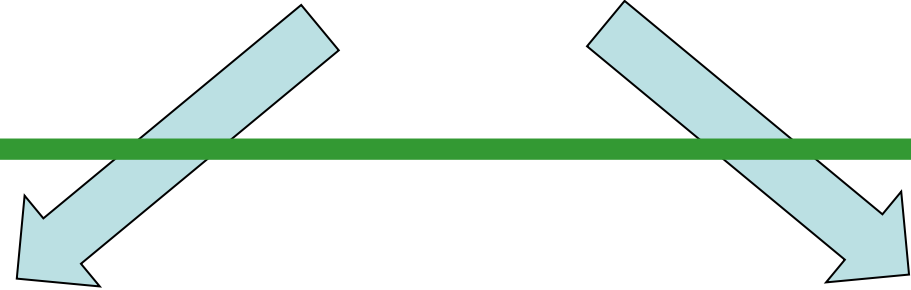
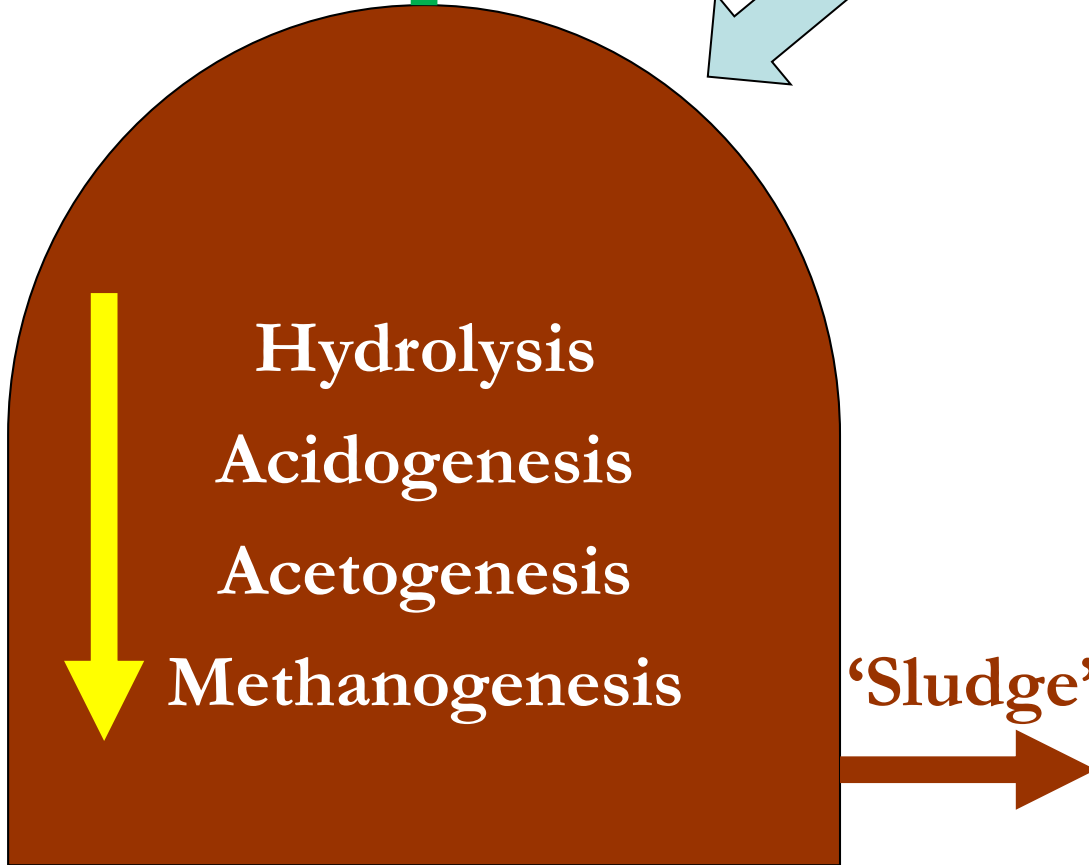


Biorefining Waste to Commodities (think > CH₄)





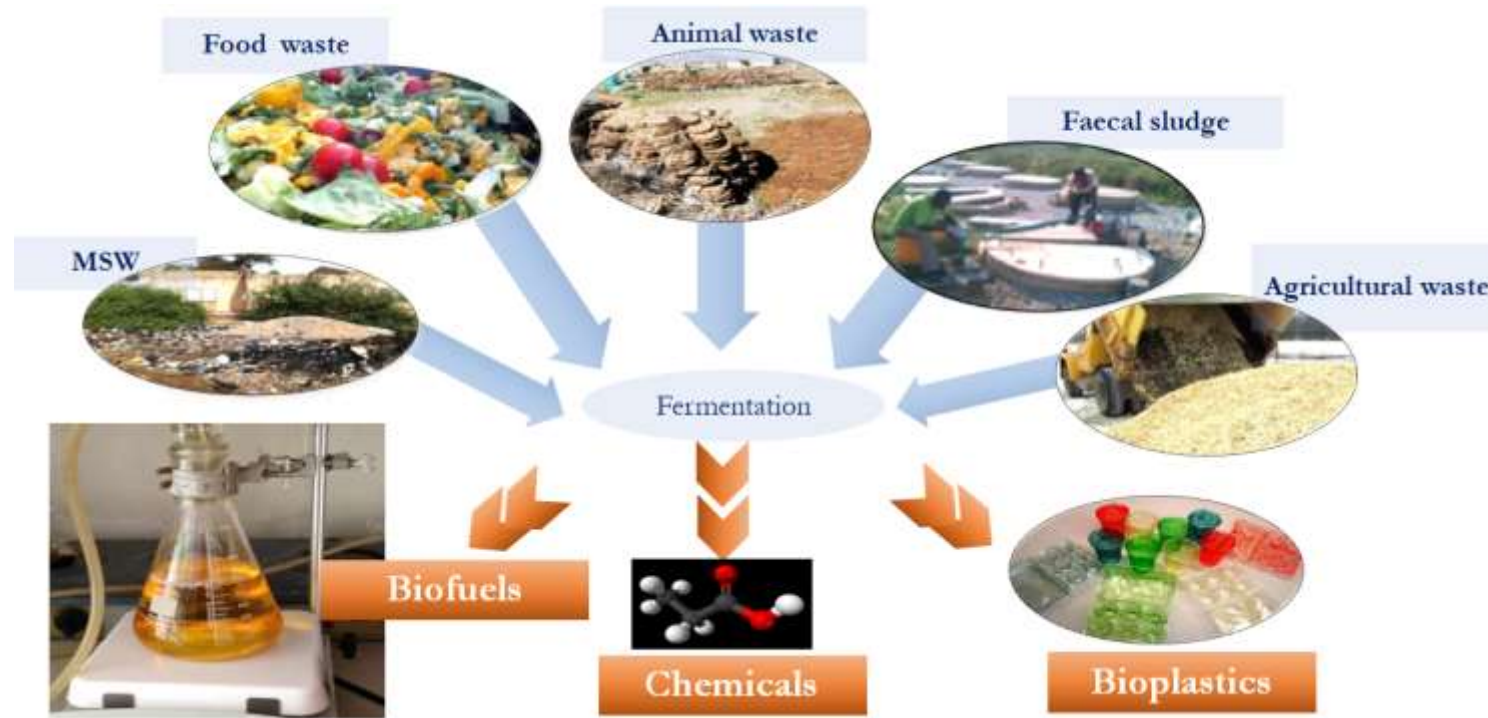
'Biogas'



VFA



Potential for resource-recovery is immense, but...

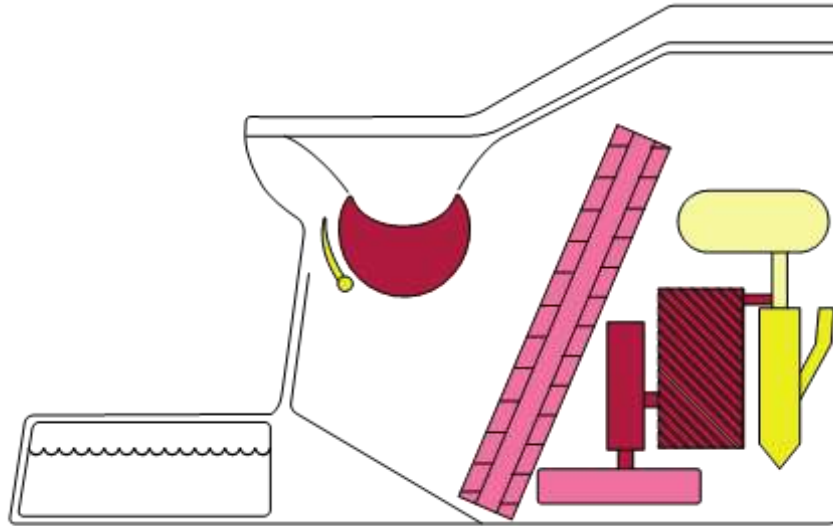


... needs to address a higher objective



Sanitation needs

- **ELIMINATE PATHOGENS**
 - Eliminate safety concerns via handling
 - Reduce disease burden
 - Improve environmental safety
- **OPERATE OFF GRID**
 - Eliminate need for external inputs such as water and energy
 - Make portable and easy to install



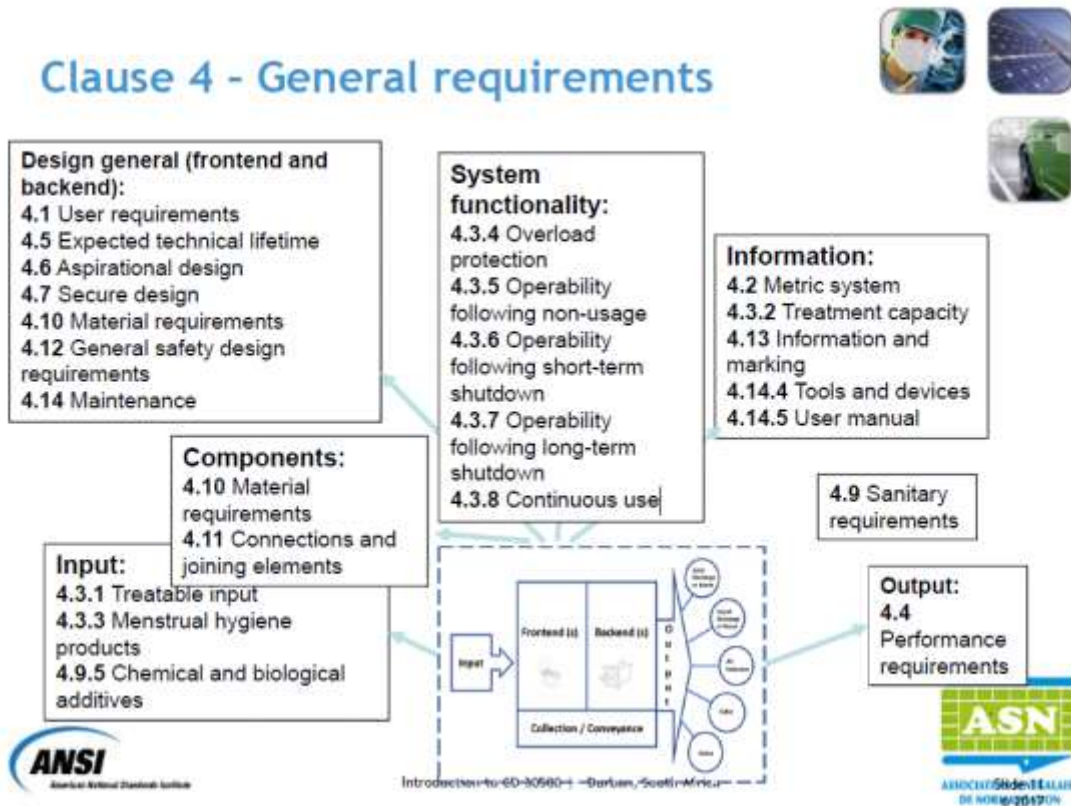
- **CONVEY LOW LIFE-CYCLE COSTS**
 - Reduce need for pit emptying
 - Ensure a sustainable business model, including maintenance via service providers
- **PRESENT MODULAR, ATTRACTIVE INTERFACE**
 - Reduce / eliminate construction costs
 - Provide clean and dignified product
 - Eliminate odors and waste

The Reinvented Toilet is a modular, transformative technology that offers a non-sewered sanitation solution, eliminating the need for a piped collection system. The aim of the Reinvented Toilet is to: destroy all pathogens onsite and recover valuable resources, operate without sewer, water or electricity connections and cost less than \$0.05/user/day in a sustainable business model.



Standards (PC 305) to drive resource recovery through policy change

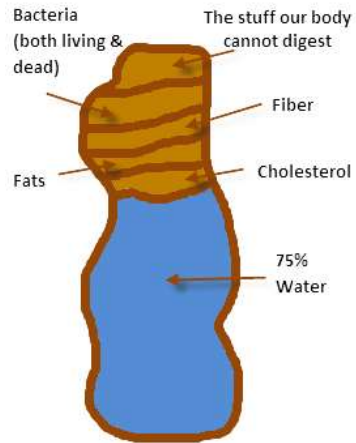
Clause 4 - General requirements



Parameters	Justification	Threshold
Human Enteric Pathogens	Bacteria (E. coli as surrogate)	≤100 per liter
	Virus (MS2 Coliphage)	≤10 per liter
	Protozoa (Clostridium perfringens spores)	≤1 per liter
Helminth eggs	Helminth eggs are considered a major health burden in many developing countries (Ascaris suum ova - surrogate)	≤ 1 eggs per litre
COD	Standard environmental performance parameter	≤ 50 (Category A) ≤ 150 (Category B)
TSS	Standard environmental performance parameter	≤ 10 (Category A) ≤ 30 (Category B)
Total nitrogen	Nitrogen is a pollutant for surface water and can cause eutrophication.	> 70% reduction
Total phosphorous	Phosphorous is a pollutant for surface water and can cause eutrophication	> 80% reduction
pH	Too high or too low pH is harmful to biological life.	6-9
Odor	Indicator of pleasantness and comfort - Maximum percentage of observations reported as “unacceptable”	< 2%
PM2,5 (µg/m³)	Air pollution indicator - Emission thresholds (1 h average)	< 10
Noise	Noise pollution indicator over the course of 24h	≤ 70 dBA (L _{EX,24h})



What is missing?



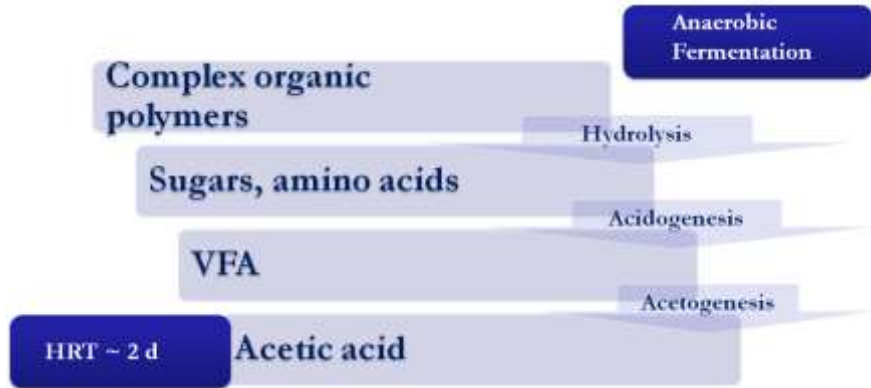
Developing better strategies for FS management by opening up its black-box

Fecal sludge

Microbial composition
Chemical composition
'Designed' treatment and recovery strategies



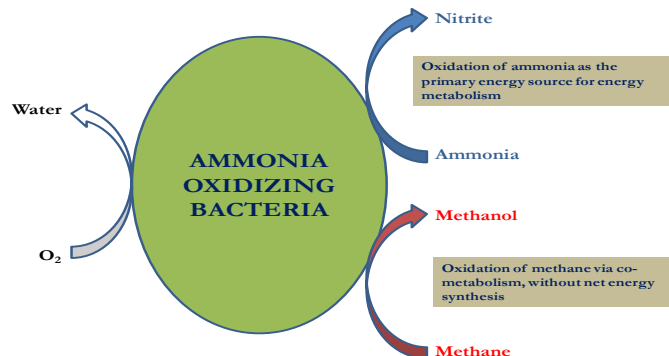
Where do we stand now?



FS and other “+x” streams can offer attractive flexible prospects for resource recovery
Detailed understanding in conjunction with reductionist approaches needed to advance implementation



Wide variety of endpoints (chemicals, fuels..) possible
Disrupting sanitation as well as conventional agro- or fossil-based pathways



Links to other applications needed and possible
Resource efficient options for wastewater treatment and sanitation



Discussion

BILL & MELINDA
GATES foundation



THE
Water
Research
FOUNDATION



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