Urban sanitation in the Global South: the necessity of innovative solutions

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Citywide Inclusive Sanitation Research Group

IHE Delft Institute for Water Education

IHE DELFT Institute for Water Education

unesco Centre Under the auspices of UNESCO

7 Billion
people in the

6 Billion
have access to

but...only

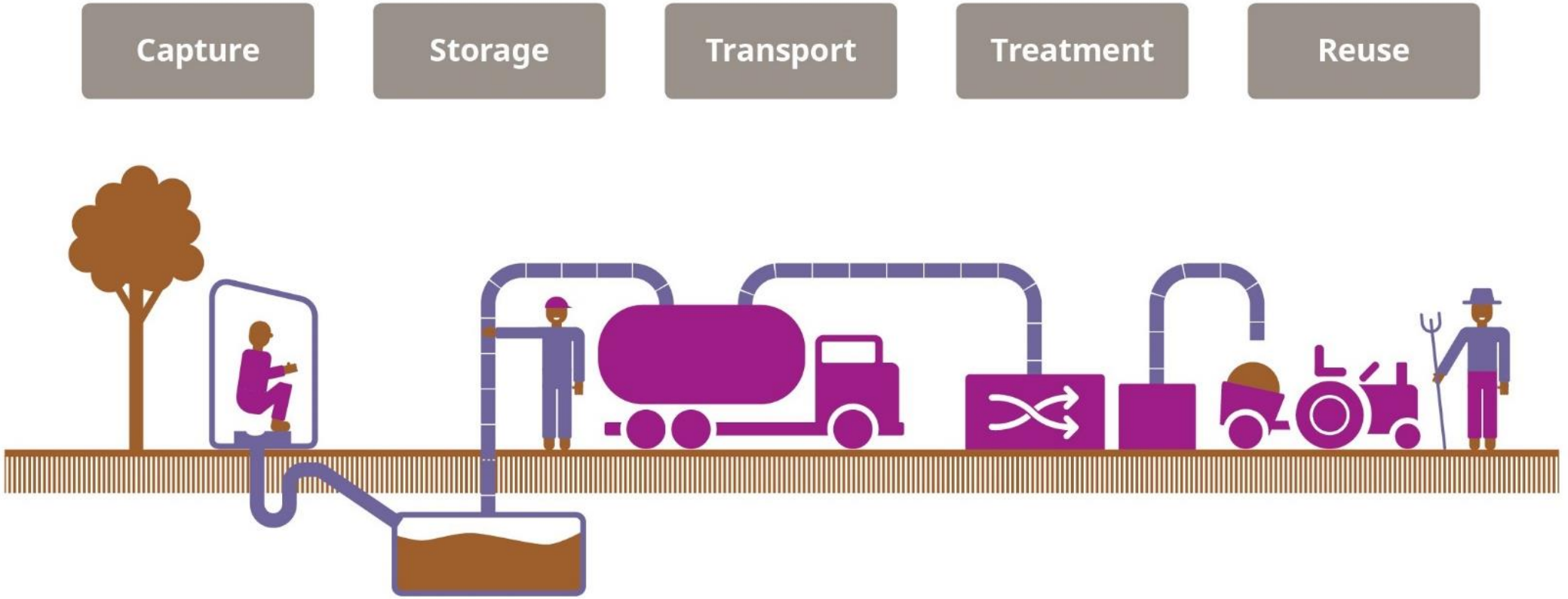
2.5 Billion
have access to

Where are we today on the SDG's track

Figure 4: Annualised net benefits of achieving universal services 2021–2040 (USD billions)

Note: The area of each circle corresponds with the magnitude of annualised net benefits from 2021–2040.
Source: Vivid Economics

Sanitation service chain- non-sewered sanitation

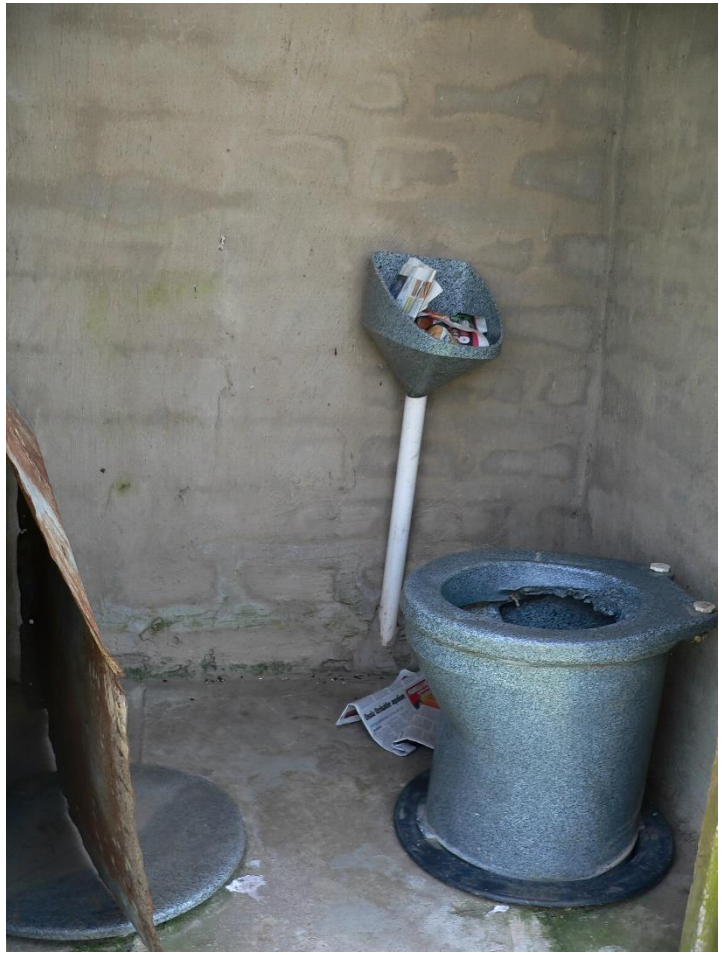


Household OSS and superstructures – VIP's (South Africa)

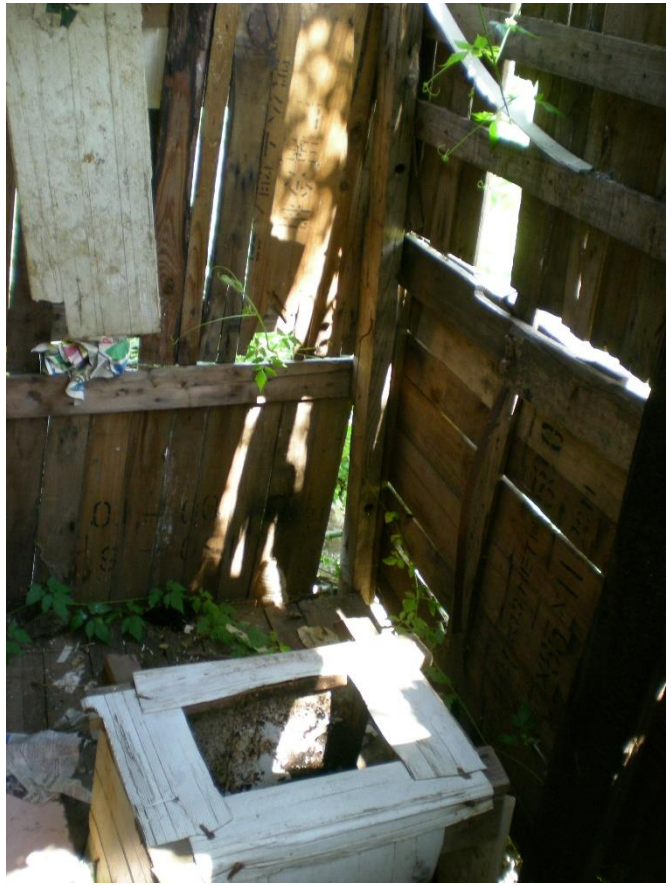
Household OSS and superstructures – VIP's (South Africa)

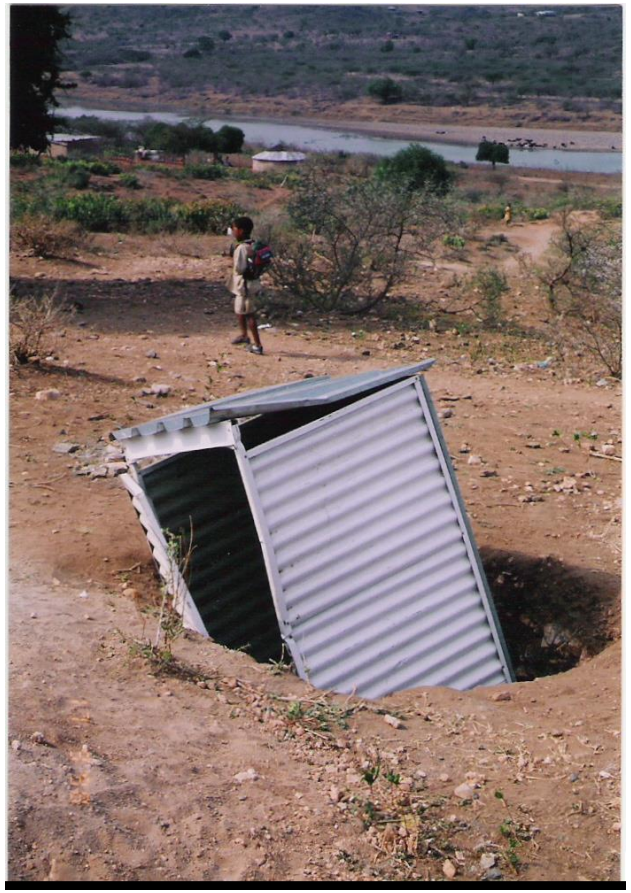
Household OSS and superstructures – UDDT's (South Africa)

Household OSS and superstructures – VIP's (South Africa)

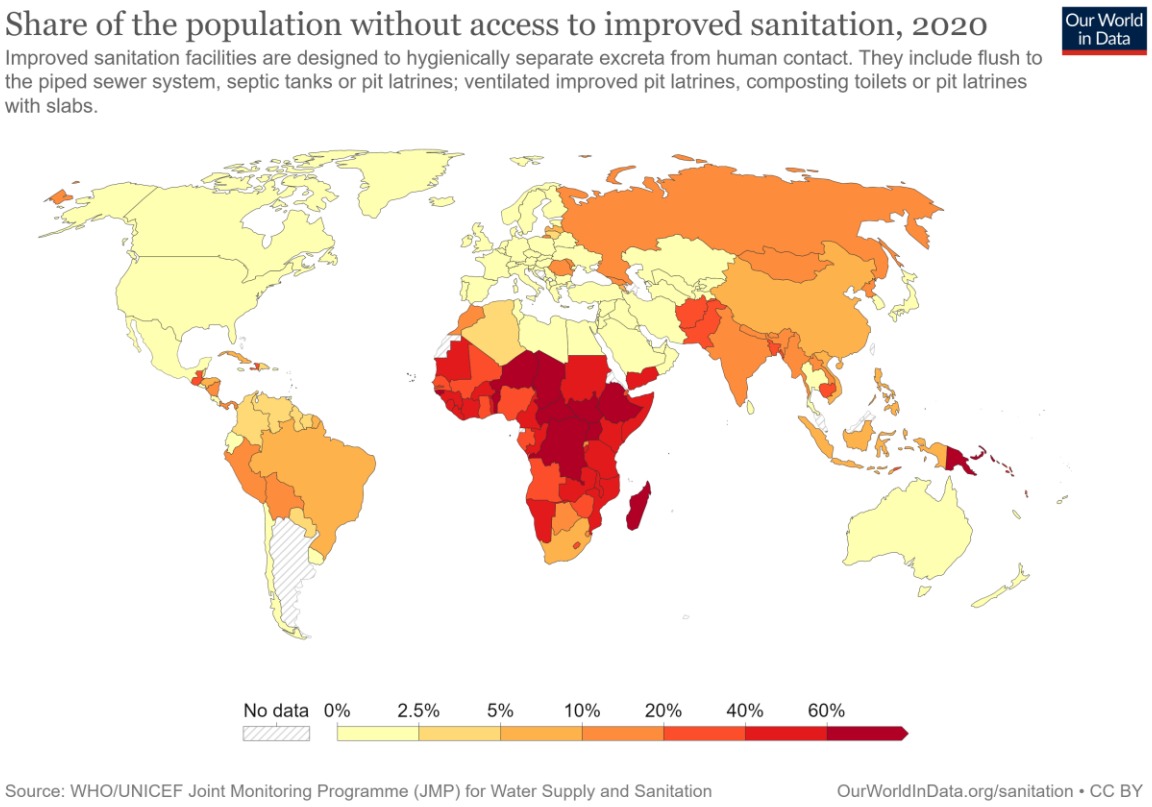


Household OSS and superstructures – unimproved pit latrines

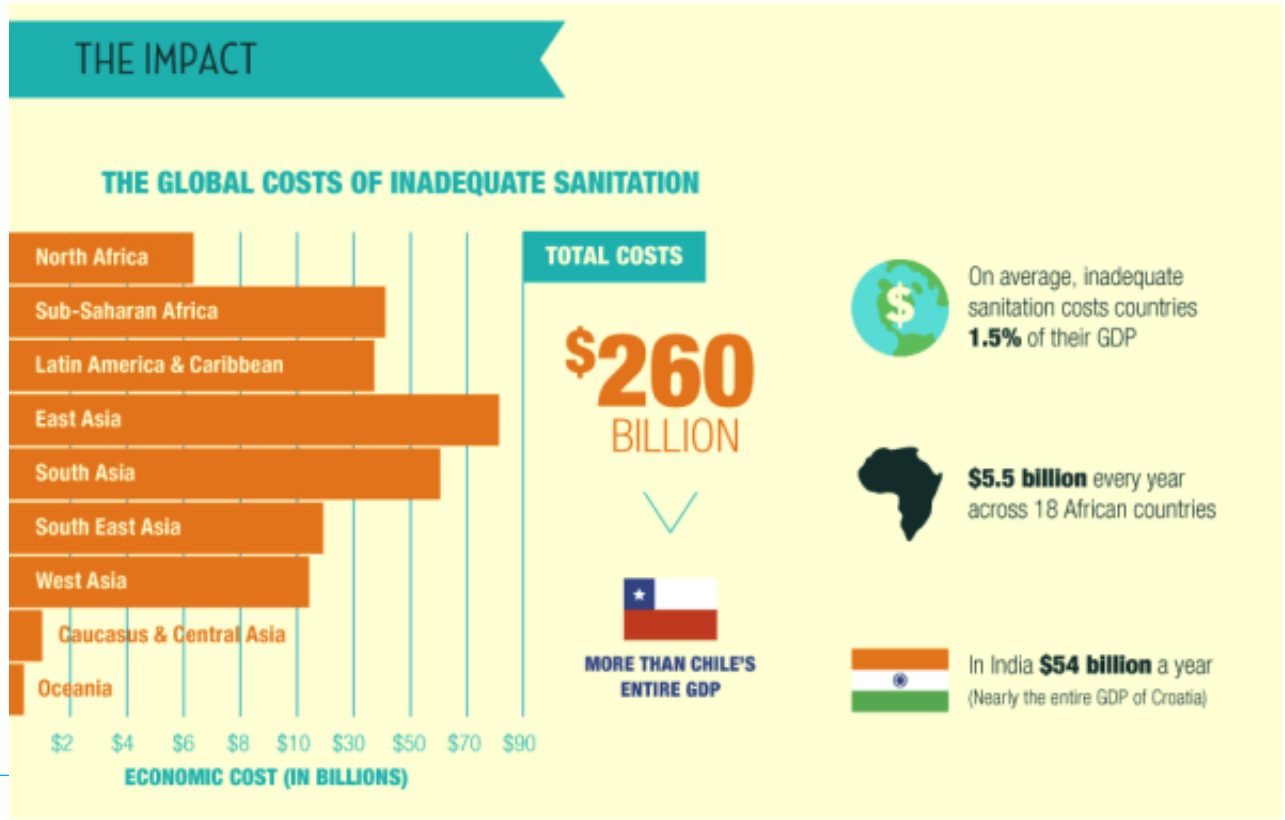




Who uses safely managed sanitation worldwide?

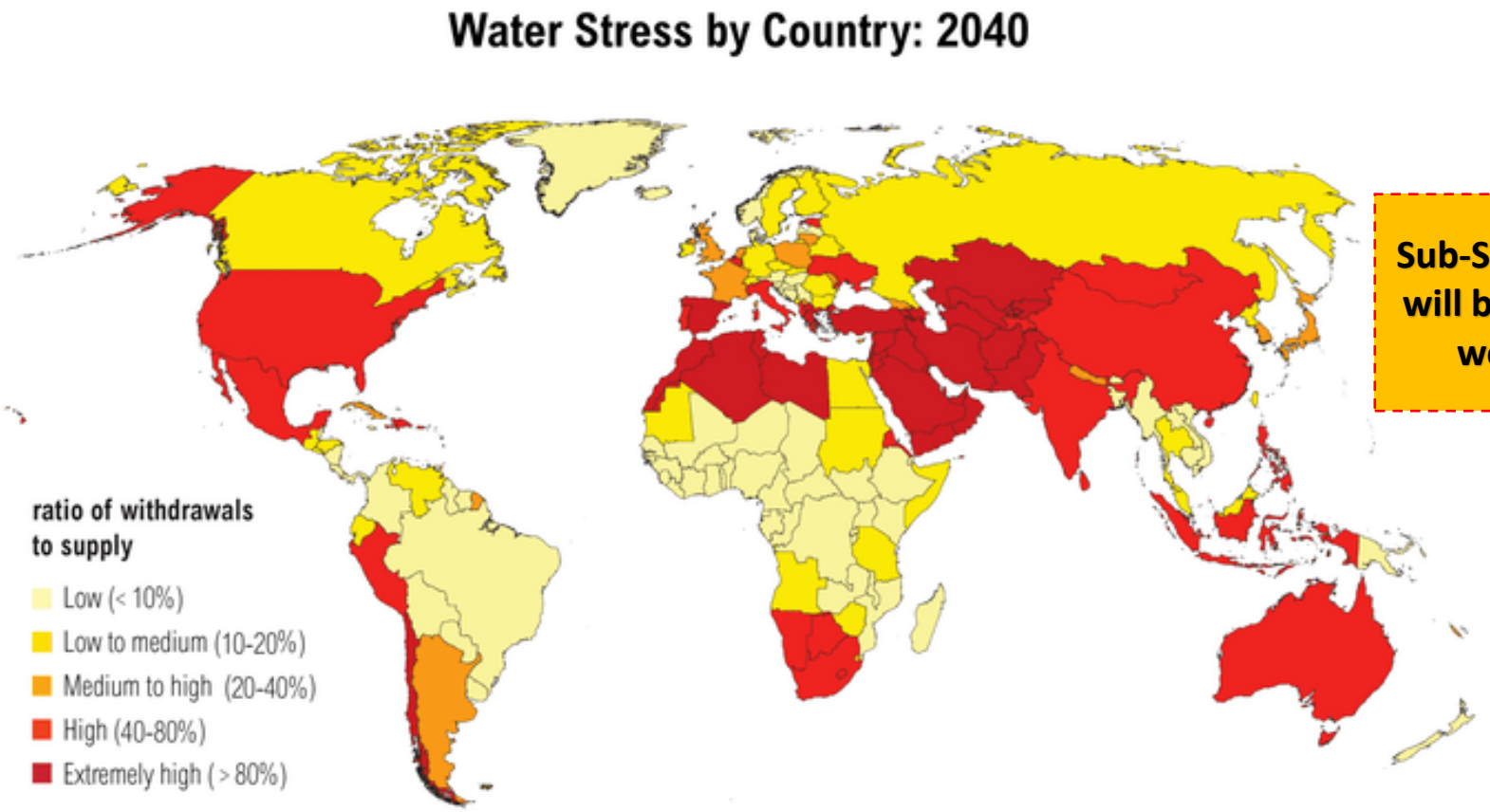


On-site sanitation (pit latrines, cesspools, septic tank systems and other on-site containments) was used by 43% of the global population in 2020 and their use is increasing more rapidly than sewer connections (JMP, 2021)



https://www.fastcompany.com

Water scarcity + urbanization ≠ centralized wastewater treatment
Not a universal solution

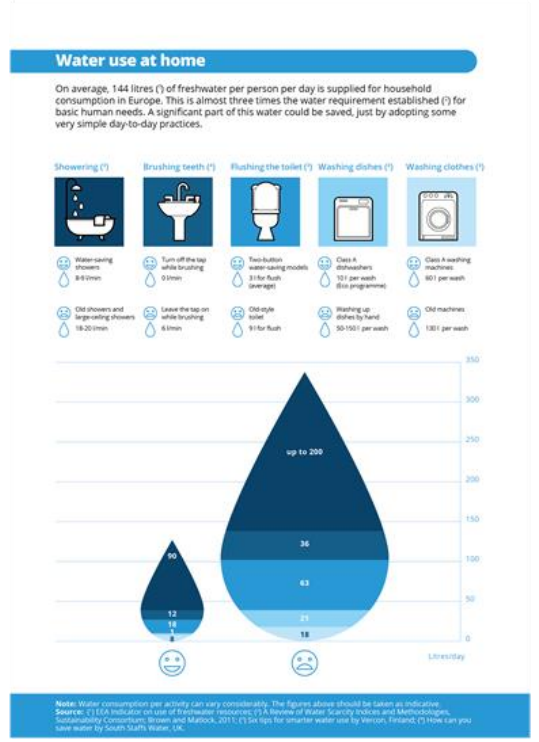


NOTE: Projections are based on a business-as-usual scenario using SSP2 and RCP8.5.

For more: ow.ly/RiWop

WORLD RESOURCES INSTITUTE

Sub-Saharan Africa & Asia will be home to 2/3rds of world's population



THE UNACHIEVABLE "DREAM" FOR MANY COUNTRIES

Example: Cape Town, South Africa

DAY ZERO 29 | 04 | 2018 THE DAY THE TAPS WILL BE TURNED OFF

Day Zero is based on the previous week's daily consumption average of 641 Ml/day. Only if all Capetonians reduce their daily use down to 87 litres or less, and the City implements the necessary projects, will we avoid Day Zero. To find out what you can do, visit www.capetown.gov.za/thinkwater

Our next update will be 9 January 2018.

THE CITY

The City's progress on securing alternative water sources.

50%

Cape Town Harbour (Desalination)	50%
Strandfontein (Desalination)	52%
Monwabisi (Desalination)	58%

THE DAMS

Combined level of dams supplying the city. For more info click here

32%

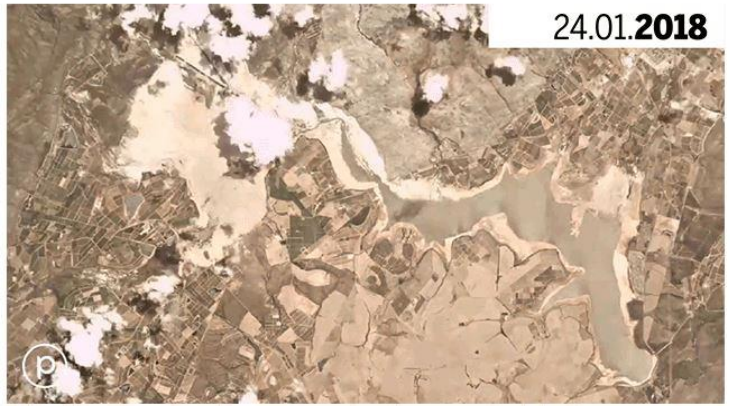
WEEKLY TREND - 1%

CAPETONIANS

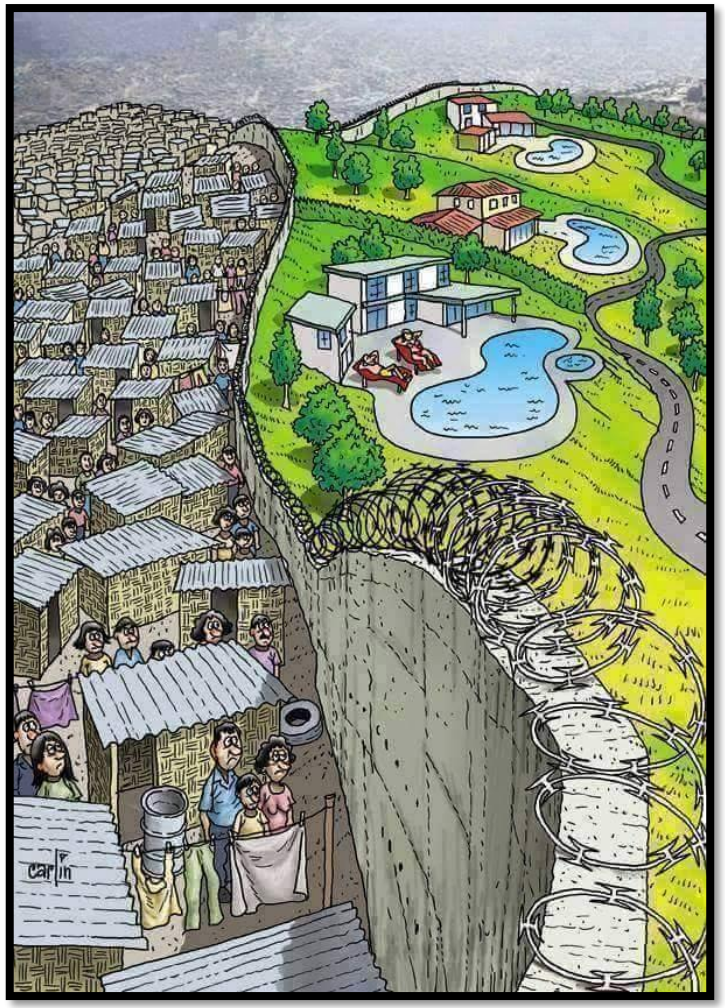
Percentage of residents using 87l or less per day.

34%

WEEKLY TREND - 3%



Our realities in urban settings



Another challenge

You Probably Don't Want To Know About Haiti's Sewage Problems

JULY 29, 2017 · 7:00 AM ET

HEARD ON WEEKEND EDITION SATURDAY

Rebecca Hersher

5-Minute Listen + PLAYLIST

People dump trash and raw sewage into canals that run through Port-au-Prince, Haiti. When it rains, the canals overflow and flood poor neighborhoods.

John W. Poole/NPR

https://www.npr.org/sections/goatsandsoda/2017/07/29/537945957/you-probably-dont-want-to-know-about-haitis-sewage-problems

Damaged sewer system puts people in Zomba City at risk of Cholera

Oct 27, 2022 Raphael Likaka Health 0

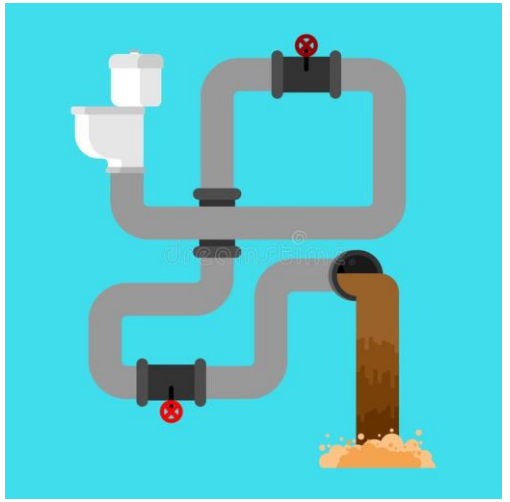
People along Likangala River at Kazembe, Chilupsya and Chikanda in the City of Zomba are at risk of suffering from Cholera because the sewer system in the city is damaged and fecal matters are spilling into the river.

Village Headman Kazembe told Malawi24 that most people along the Likangala River draw water for domestic use hence the risk.

https://malawi24.com/2022/10/27/damaged-sewer-system-puts-people-in-zomba-city-at-risk-of-cholera/

Some critical thoughts

- We flush 6-8 L drinking potable water every time we go to the loo!
- …to move 0.5 L urine or 200 g faeces all the way through the sewer system
- We use energy and valuable resources to transport it all the way to a WWTP…
- … and then treat it and discharge it at a minimum standard level back to water bodies
- Then we take the water from the water bodies and invest energy and resources to treat it to a drinking water level…
- And the cycle continues…



Excreta Facts and Figures

	Units	Urine	Faeces	Toilet paper	Excreta (urine + faeces)
wet mass	kg/person.y	550	51	8.9	**610**
dry mass	kg/person.y	21	11	8.5	**40**
nitrogen	kg/person.y	4	0.55		**4.5**
phosphorus	kg/person.y	0.36	0.18		**0.55**

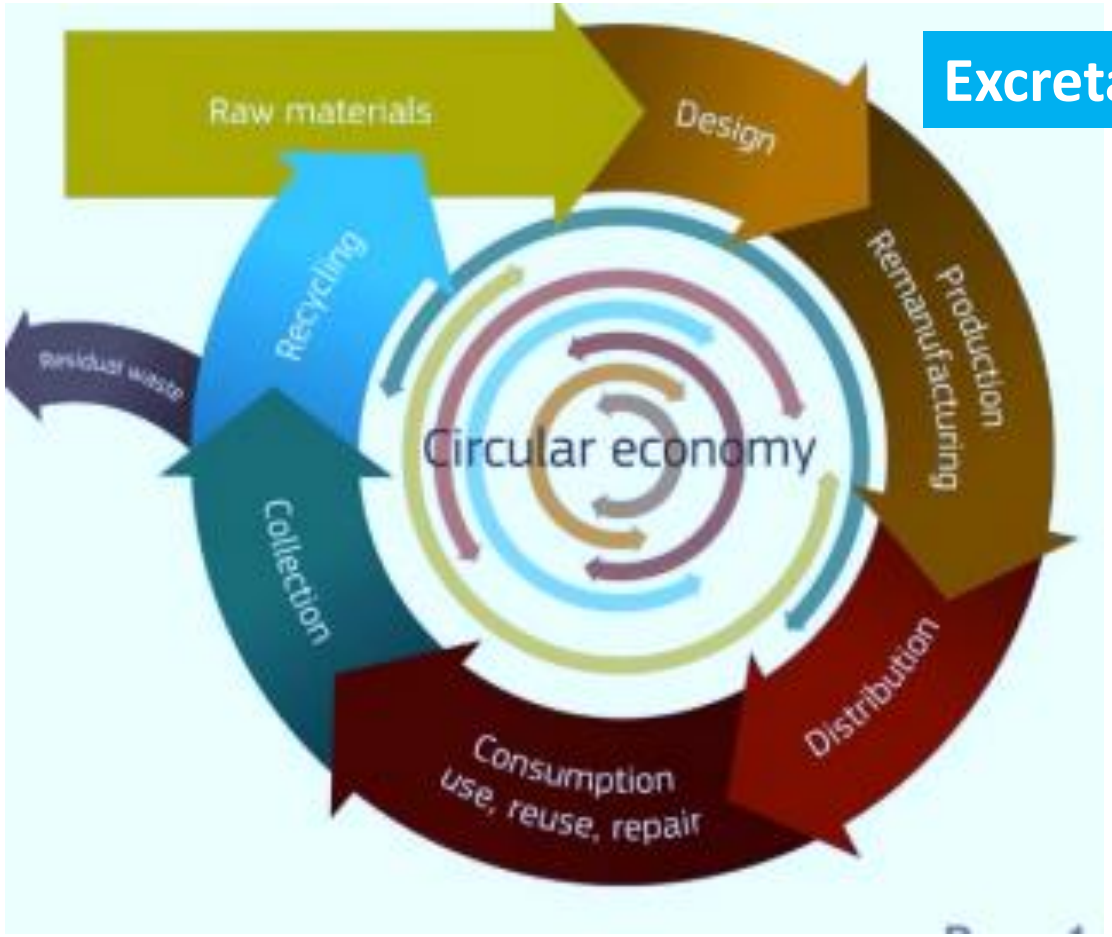
	Units	Excreta (urine + faeces)	Black water + Flush water
wet mass	kg/person.y	610	**18,000**
dry mass	kg/person.y	40	**40**
nitrogen	kg/person.y	4.5	**4.5**
phosphorus	kg/person.y	0.5	**0.5**

The most nutrients are in the urine

The most pathogens are in the faeces

Vinnerås et al. 2006

Can we look at a more sustainable way of managing our excreta?



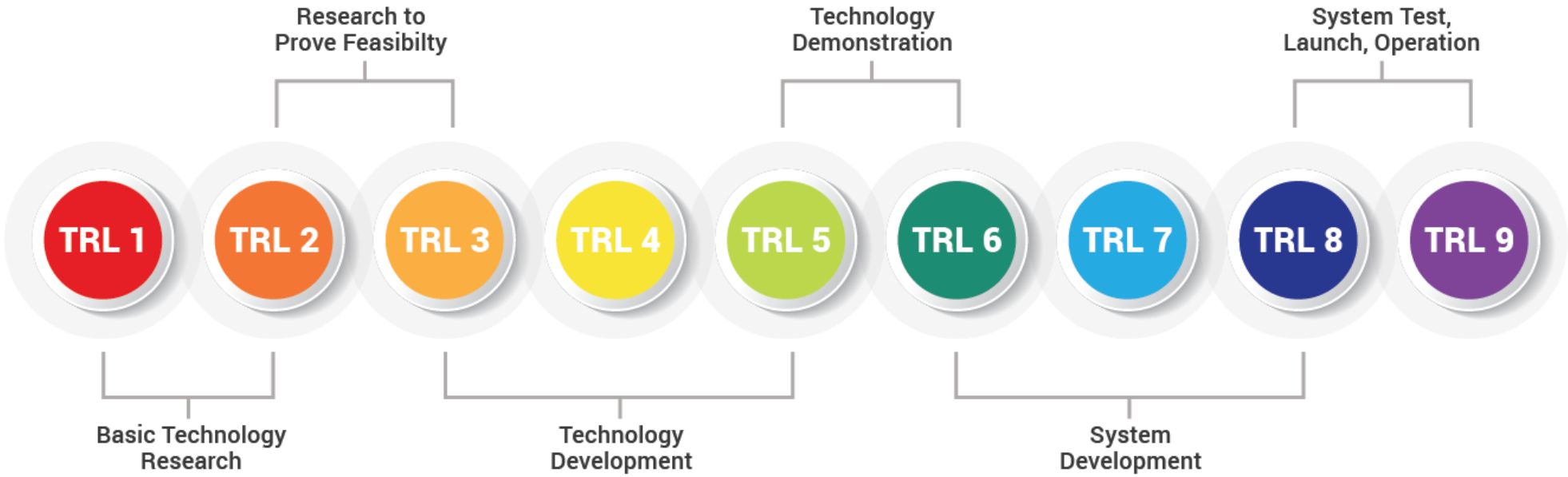
Excreta is a resource, not a waste!

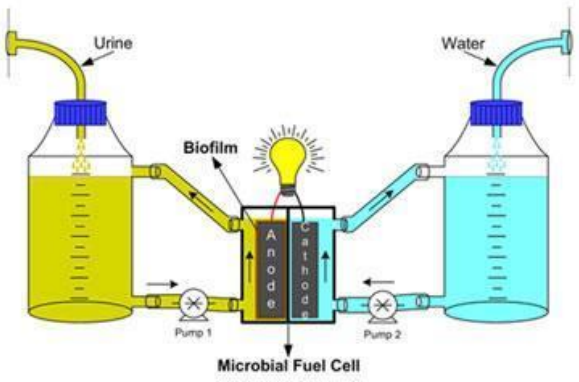
Innovative non-sewered sanitation systems (“Reinvented toilets”)

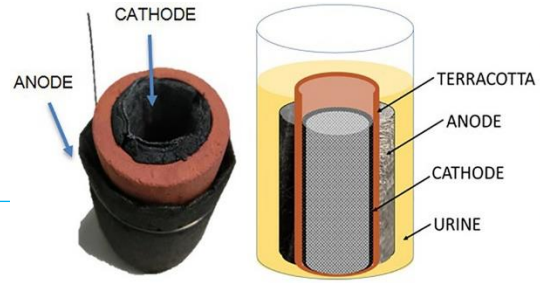
- Eliminate germs from human waste
- Recover energy, clean water and nutrients
- Operate ‘off the grid’
- Low life cycle costs
- Modular with hygienic interface

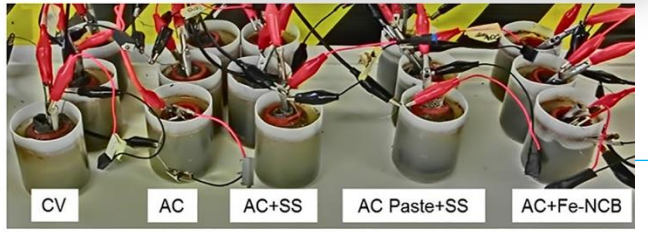
https://www.gatesfoundation.org/What-We-Do/Global-Growth-and-Opportunity/Water-Sanitation-and-Hygiene/Reinvent-the-Toilet-Challenge

Technology readiness level

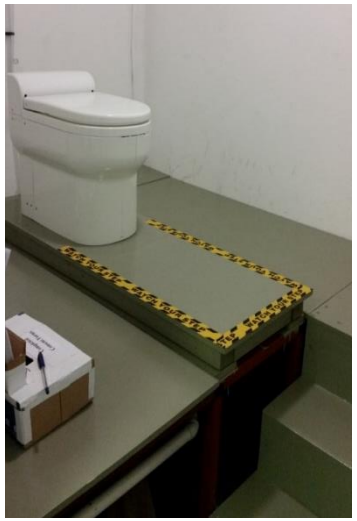




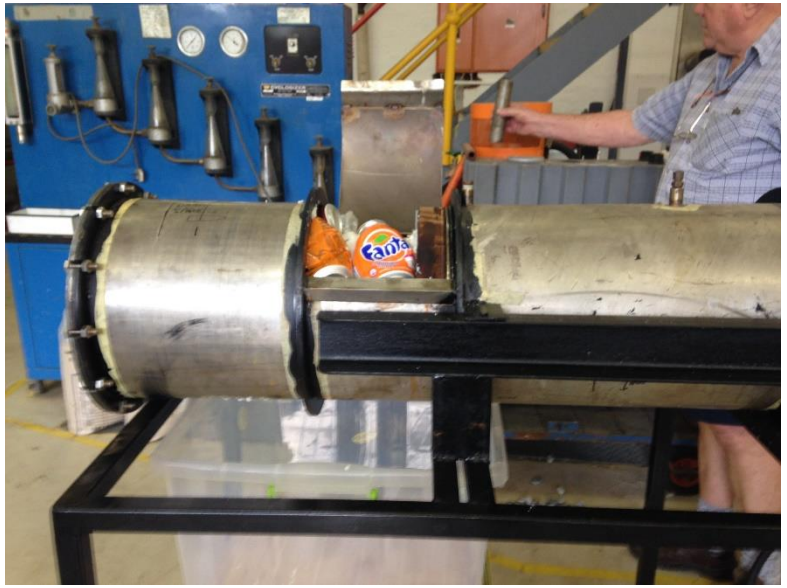




FIELD AND LABORATORY TESTING



SOLID WASTE SEPARATION FROM FS USING A SIMULANT



The Recipe for Fake Poop

Share 1385 Tweet Share Pin it

Chris Higgins

In partnership with: BILL & MELINDA GATES foundation

IMAGE CREDIT: © BILL & MELINDA GATES FOUNDATION

LIKE US ON FACEBOOK Like 1,545,188 people like this. Be the first of your friends.

Researchers around the world are working to reinvent the toilet, bringing toilets to the 2.5 billion people worldwide who don't have a safe place to relieve themselves. But there's a slightly gross problem—how do you test a toilet in a sanitary and, ahem, *repeatable* way?

Enter "fake poop," my preferred term for what scientists call "synthetic sludge simulant." Yes, this is a material meant to simulate fecal matter, and it has to have properties very similar to real fecal matter—minus all the pathogens, odors, and grossness. For this year's Reinvent the Toilet Fair, a new recipe was developed by the Pollution Research Group at the University of KwaZulu-Natal, South Africa. Their recipe was inspired by a research paper on simulated fecal

Methods for Faecal Sludge Analysis book

- Published in 2021 (8 chapters)
- Open access through IWA Publisher
- Funded by the BMGF
- Consolidates decades of knowledge on methods for sampling and analysis of faecal sludge
- Target audience: laboratory personnel, practitioners, researchers, students, NSS technological developers
- 50+ authors, contributors & reviewers
- Collaborative effort and partnership

Global Partnership of Laboratories for Faecal Sludge Analysis

IHE DELFT Institute for Water Education under the auspices of UNESCO

eawag aquatic research

UNESCO IHE DELFT

Schweizerische Eidgenossensc
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Swiss Agency for Developmen
and Cooperation SDC

ASIAN INSTITUTE OF TECHNOLOGY 1959

GLOBAL SANITATION GRADUATE SCHOOL

IHE DELFT Institute for Water Education under the auspices of UNESCO

UNIVERSITY OF KWAZULU-NATAL INYUVESI YAKWAZULU-NATALI

eawag aquatic research

AIT Asian Institute of Technology

CHARACTERISATION OF FAECAL SLUDGE & DATA GENERATION

Analysis / Teaching / Experimentation			CASS		eawag	IHE DELFT
PARAMETERS						
Helminths – number and viability	■	■	■	■	■	■
E. coli, total coliforms, coliforms	■	■	■	■	■	■
Organic matter (COD, BOD, TOC)	■	■	■		■	■
Solids (TS, VS, TSS, VSS, moisture)	■	■	■	■	■	■
Nutrients (nitrogen: total / nitrate / nitrite / ammonium) and phosphate: total / orthophosphate)	■	■	■	■	■	■
Ions (selective cations / anions)	■		■	■	■	■
Heavy metals	■		■	■	■	■
Osmotic pressure	■				■	
Respirometric tests	■				■	■
Calorific value	■	■	■		■	■
Thermal conductivity	■					
Heat capacity	■					
VFA	■			■	■	■
Pyrolysis / combustion	■				■	■
Drying energy potential	■					■
Particle size distribution	■		■		■	
Rheology properties (shear strength / viscosity)	■				■	■
EQUIPMENT						
Specialist microbiology laboratory	■	■	■	■	■	■
Rheometer	■				■	■
Differential scanning calorimeter / thermogravimetric analysis	■					■
Calorimeter	■	■	■		■	■
Spectrophotometer	■	■	■	■	■	■
Moisture balance and analyser	■		■		■	
Penetrometer	■					
Particle size analyser	■		■		■	
Thermal conductivity analyser	■					
Chloride analyser	■				■	
Osmometer	■				■	
Gas chromatograph	■			■	■	■
Respirometer	■				■	■
Microwave plasma / atomic emission spectrometer	■				■	

Methods for Faecal Sludge Analysis

IWA PUBLISHING

Konstantina Velkushanova • Linda Strande • Mariska Ronteltap
Thammarat Koottatep • Damir Brdjanovic • Chris Buckley

Global Partnership of Laboratories for Faecal Sludge Analysis — MEMBER

IHE DELFT Institute for Water Education

Velkushanova, K., Strande, L., Ronteltap, M., Koottatep, T., Brdjanovic, D., Buckley, C. (eds.) (2021). *Methods for Faecal Sludge Analysis.* IWA Publishing: London, UK

CHARACTERISATION OF FAECAL SLUDGE & DATA GENERATION

■ Analysis
■ Teaching
■ Experimentation

PARAMETERS					
Helminths – number and viability		■	■	■	■
E. coli, total coliforms, coliforms	■	■	■	■	■
Organic matter (COD, BOD, TOC)	■	■	■		■
Solids (TS, VS, TSS, VSS, moisture)	■	■	■	■	■
Nutrients (nitrogen: total / nitrate / nitrite / ammonium) and phosphate: total / orthophosphate)	■	■	■	■	■
Ions (selective cations / anions)	■				■
Heavy metals	■		■	■	■
Osmotic pressure	■				■
Respirometric tests	■				
Calorific value	■		■		
Thermal conductivity					
Heat capacity					
VFA	■	■			■
Pyrolysis / combustion	■				
Drying energy potential	■				
Particle size distribution	■		■		
Rheology properties (shear strength / viscosity)	■		■		■
EQUIPMENT					
Specialist microbiology laboratory	■	■	■	■	■
Rheometer	■				
Differential scanning calorimeter / thermogravimetric analysis	■				
Calorimeter	■		■		
Spectrophotometer	■	■	■	■	■
Moisture balance and analyser	■	■	■		
Penetrometer					
Particle size analyser	■				
Thermal conductivity analyser					
Chloride analyser	■	■			
Osmometer					
Gas chromatograph	■		■		■
Respirometer	■				
Microwave plasma / atomic emission spectrometer	■				

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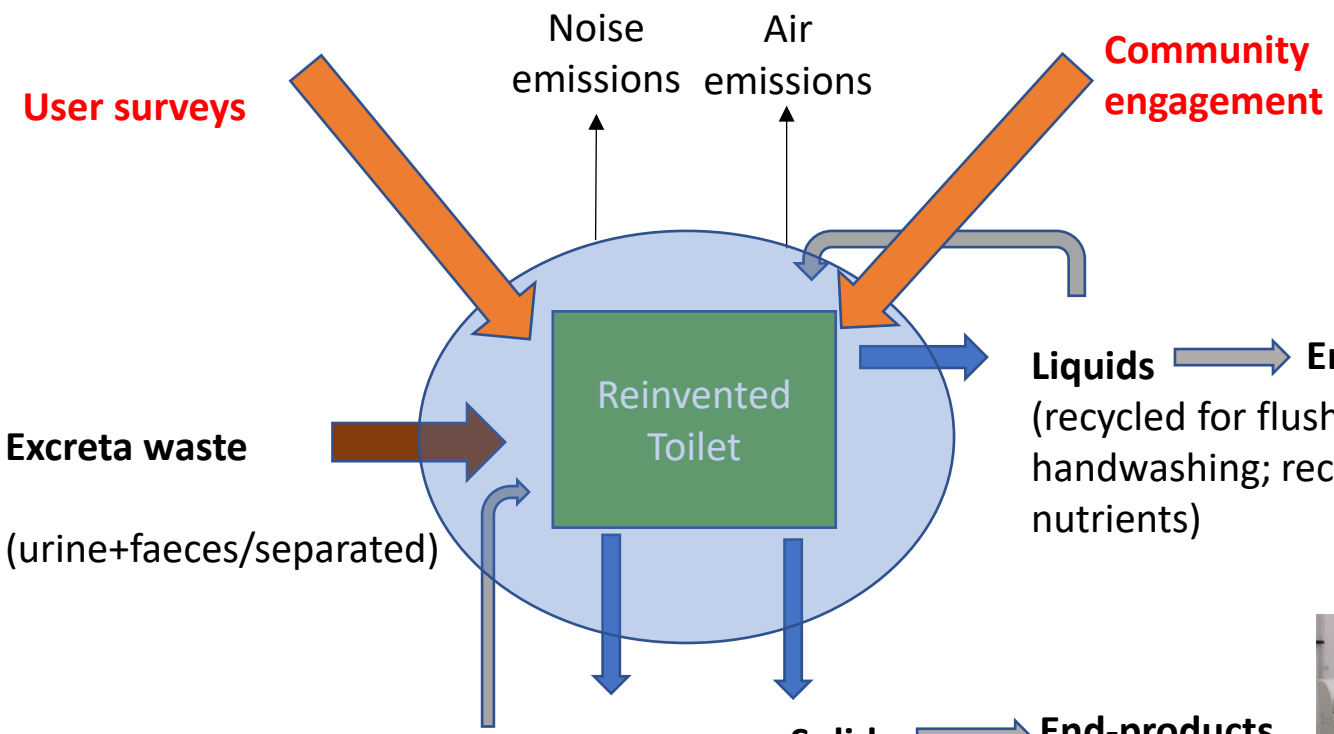
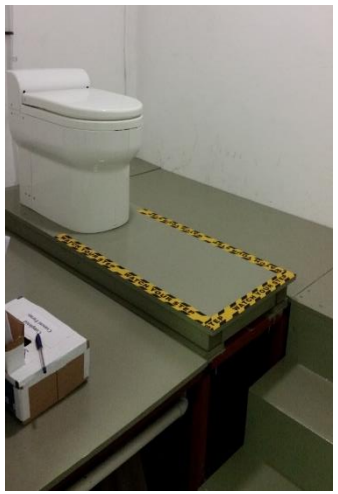
While the book was in progress

Sample collection and characterization in Zambia

ENGINEERING FIELD TESTING PLATFORM (DURBAN)





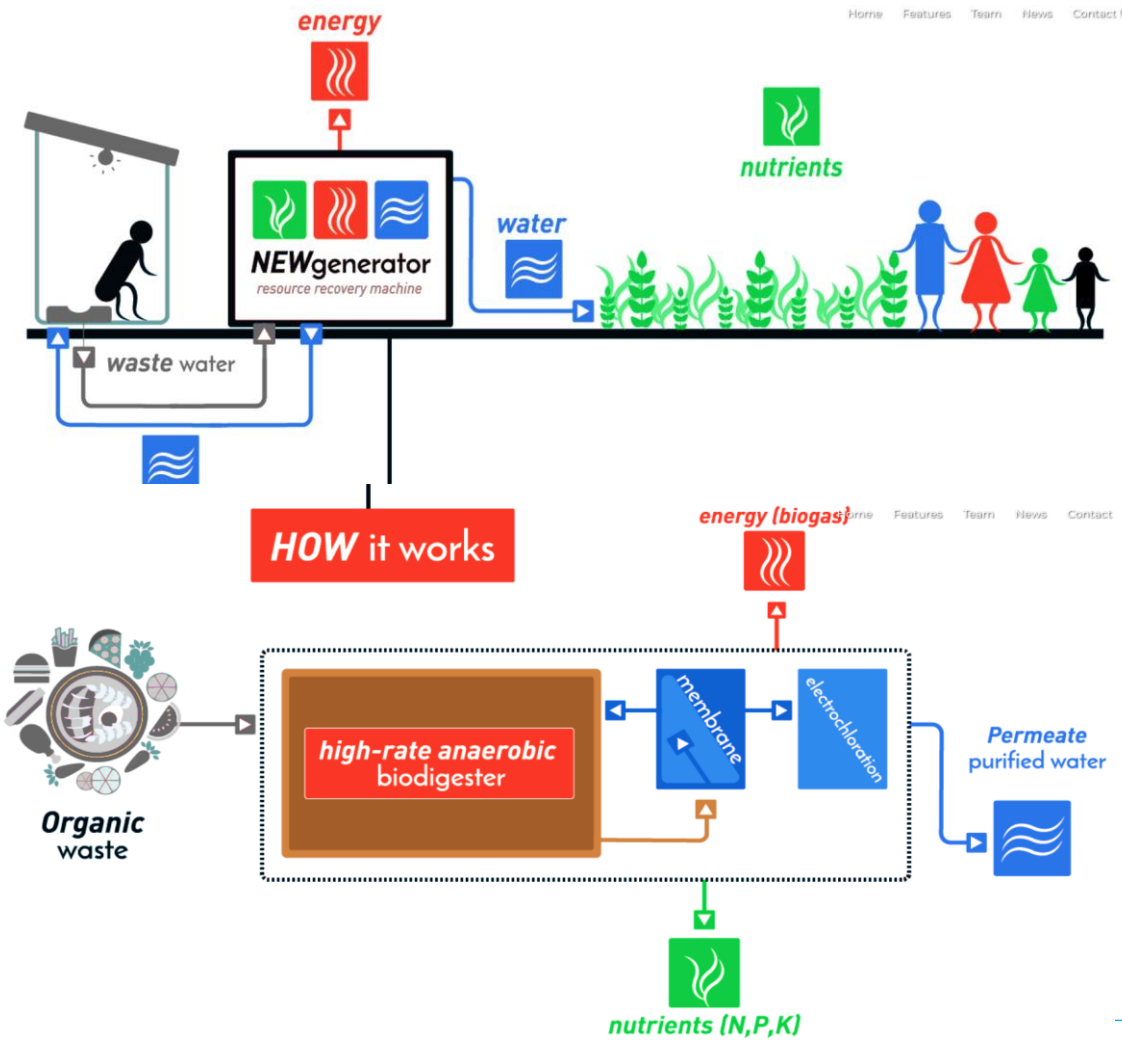
In partnership with:
Cranfield University – Nanomembrane Toilet ; University of South Florida – New Generator Toilet; Duke centre for WASH-AID
Yixing Eco-Sanitary Manifacture - EcoSan Toilet; Janicki Industries – Firelight Toilet ; EOOS – Source Separation Toilet Interface;
UWE – Bristol – Urinetricity Microbial Fuel Cell; Eawag – Blue Diversion Toilet; Swansea; Biomass Controls ; Natural synergies; SLU

ECO-SAN: OFF-GRID BLACKWATER RECYCLING YIXING ECO-SANITARY MANUFACTURE CO.,LTD

- Toilet block + wastewater treatment system
- Treats toilet wastewater only and recycles for toilet flushing
- Current unit serves 250 people/day
- Biological pre-treatment + electrochemical oxidation
- Solar powered
- Modifications needed to make it more suitable for South African context and O&M/robustness issues to resolve before commercial roll-out in SA. Additional handwashing solution needed.
- Has operated in recycling mode in SA
- Currently operating at informal settlement & school

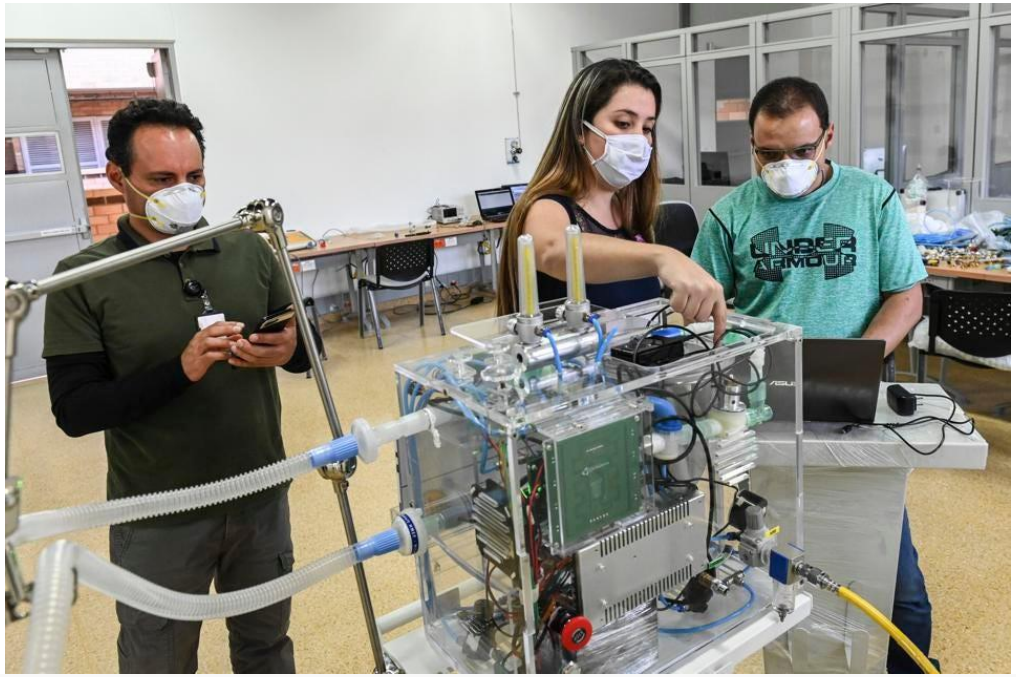
https://www.susana.org/en/knowledge-hub/projects/database/details/390

An example of innovative community NSS system



Liquid Processing; Solids Processing;
Power System (https://sanitation.ansi.org)

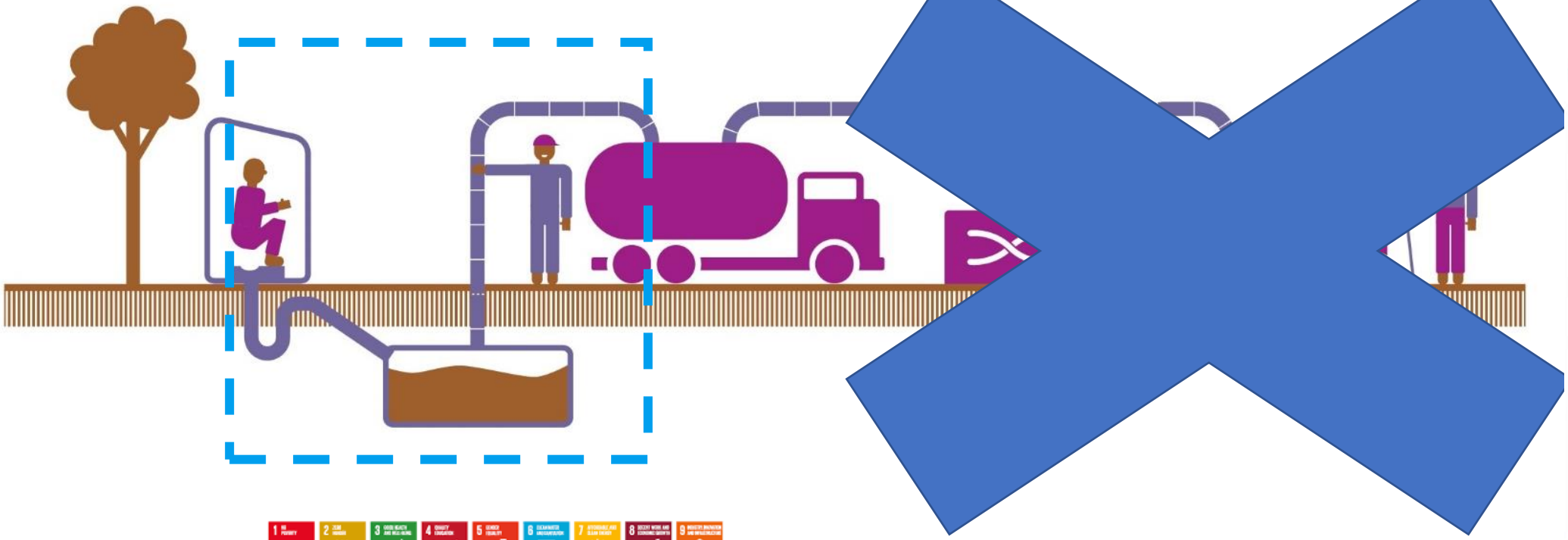
G2RT – GEORGIA TECH

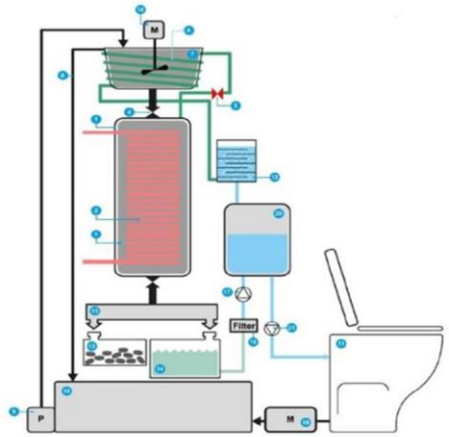


Source: https://yeelab.gatech.edu/g2rt/

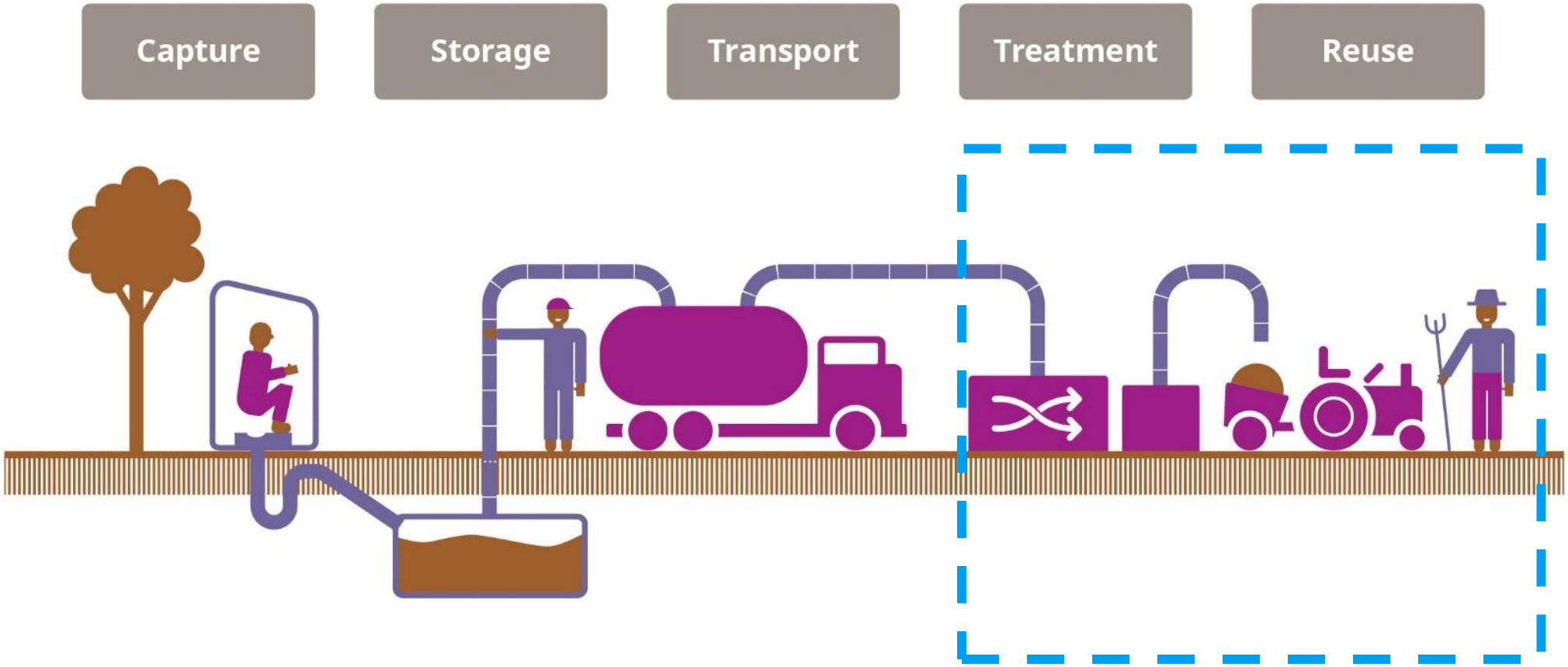
How does innovation help to achieve SDG's?

Capture | Storage | Transport | Treatment | Reuse

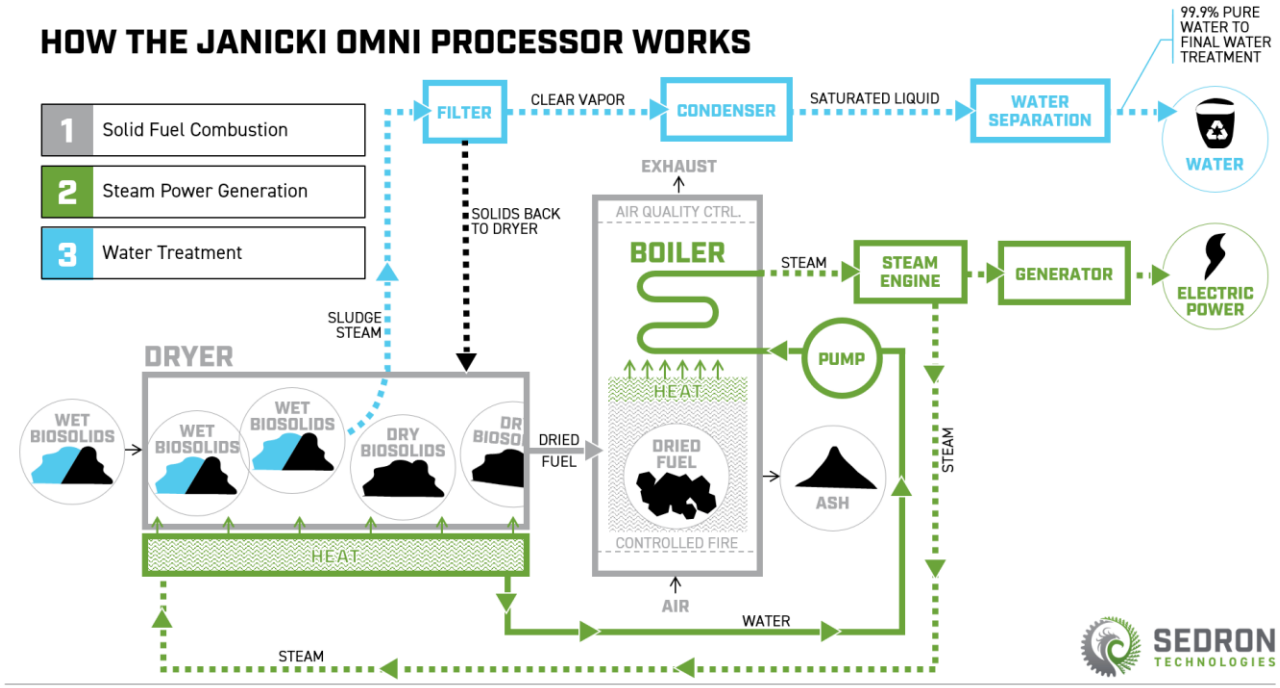




How does innovation help to achieve SDG's?



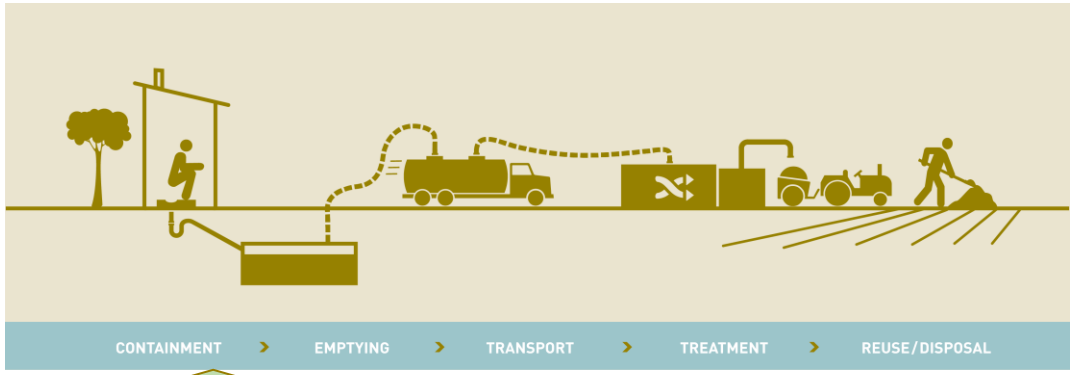
- Treatment of large quantities of faecal sludge
- Closed loop
- Energy recovery
- Pure water
- Ash

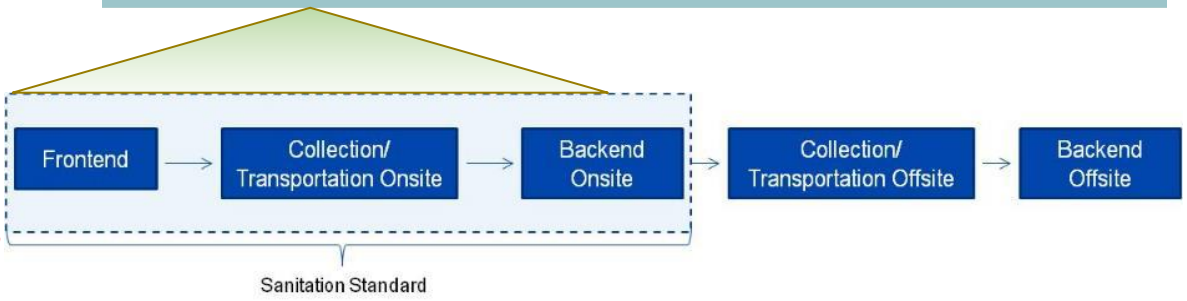


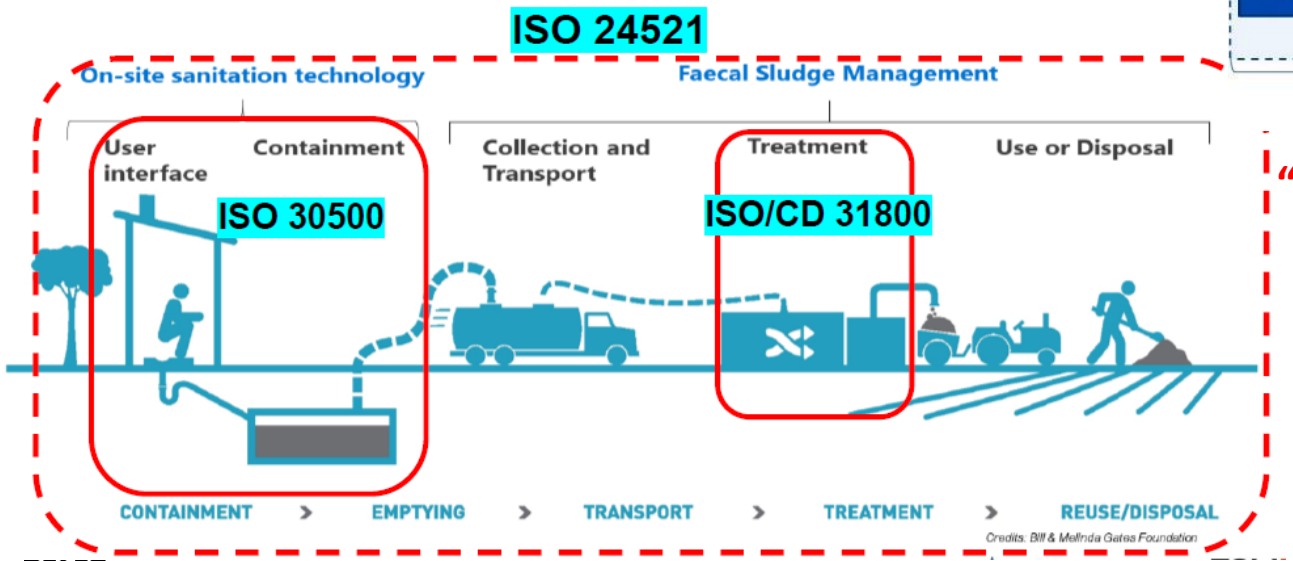
https://www.sedron.com

Means of implementation for SDG 6: Standards for sanitation technologies and services

- ISO 30500: Non-sewered sanitation systems - Prefabricated integrated treatment units - General safety and performance requirements for design and testing
- ISO 31800: Community scale resource oriented sanitation treatment systems







"…to boost global health in places without sewers"

SUSTAINABLE DEVELOPMENT GOALS

This standard contributes to the following Sustainable Development Goals:

1 3 4 5 6 8 9 10 11 14 15

Lüthi and Narayan, 2019

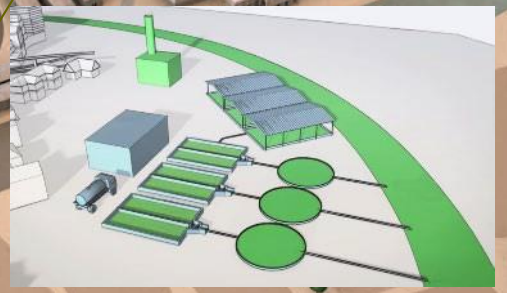
Context specific solutions needed

- Centralised systems where economy of scale works.
- Decentralised systems in areas dictated by topography, population density, and fund availability
- Fecal Sludge Management in outer areas where access is an issue. Eg- slums, and peri urban regions

Equity in service

Inclusive Planning

Conxtextual solutions



Environmental and social justice

Citywide Inclusive Sanitation (CIWS) brings various evolved thinking of urban sanitation under one umbrella

eawag aquatic research

Lüthi and Narayan, 2019

QUESTIONS?

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