Eawag:
Swiss Federal Institute of Aquatic Science and Technology

Sanitation Systems and Technologies

Part 2 : Treatment, Disposal and Resource Recovery

10th October 2024

Kayla Coppens
Eawag-Sandec
Kayla.coppens@eawag.ch

Today's lecturer:

Education:

PhD Env. Sciences (UniGE - Ongoing)

MSc Env. Sciences (UniGe)

BSc Biochemistry (USA-University of Wisconsin)

Experience:

Aneco

VaLoo

an eco
assainissement écologique

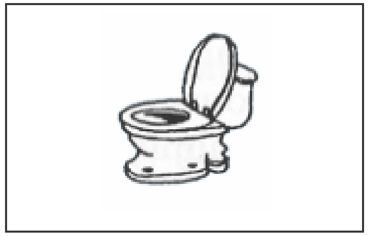
VaLoo
Circular Sanitation Network Switzerland
Réseau suisse pour un assainissement circulaire
Netzwerk für kreislauffähige Sanitärsysteme Schweiz

Rules of the game

- Put on your **creative** hats and your **logical** hats
- Answer each question – group discussion allowed
- Incentives for **Correct** answers or **Funny** answers

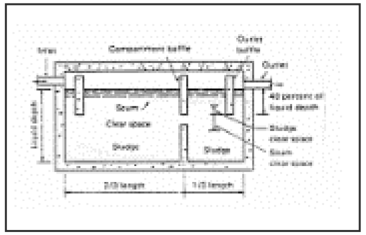
From last week:

User Interface



- Dry Toilet
- Urine Diverting Dry Toilet (UDDT)
- Urinal
- Pour Flush Toilet
- Cistern Flush Toilet
- Urine Diverting Flush Toilet

Collection and Storage / Treatment



- Urine Storage Tank / Container
- Single Pit
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- Double Ventilated Improved Pit (VIP)
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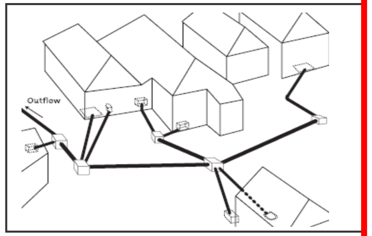
- Dehydr. Vaults
- Composting Chamber
- Septic Tank
- Etc.

Conveyance



- Jerry can / Tank
- Human-Powered Emptying and Transport
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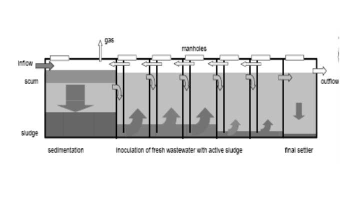
- Transfer Station (Holding Tank)

(Semi-) Centralised Treatment



- Anaerobic Baffled Reactor (ABR)
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- Waste Stabilization Ponds
- Aerated Pond
- Constructed Wetland
- Trickling Filter
- Activated Sludge
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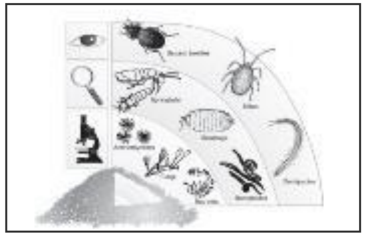
- Co-composting
- Biogas Reactor
- Etc.

Use and / or Disposal



- Fill and Cover / Arborloo
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- Soak Pit
- Leach Field
- Fish Pond
- Floating Plant Pond
- Water Disposal / Groundwater Recharge
- Surface Disposal
- Biogas Combust.

Today:

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User Interface

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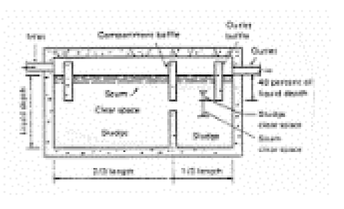
Storage



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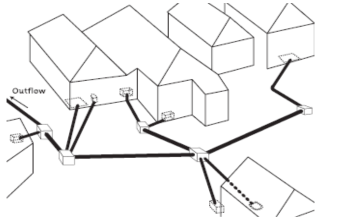

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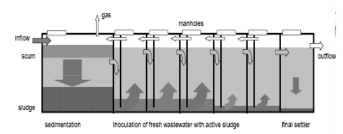

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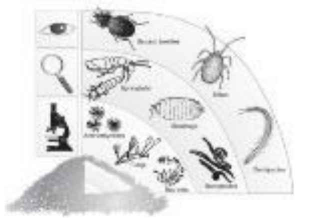

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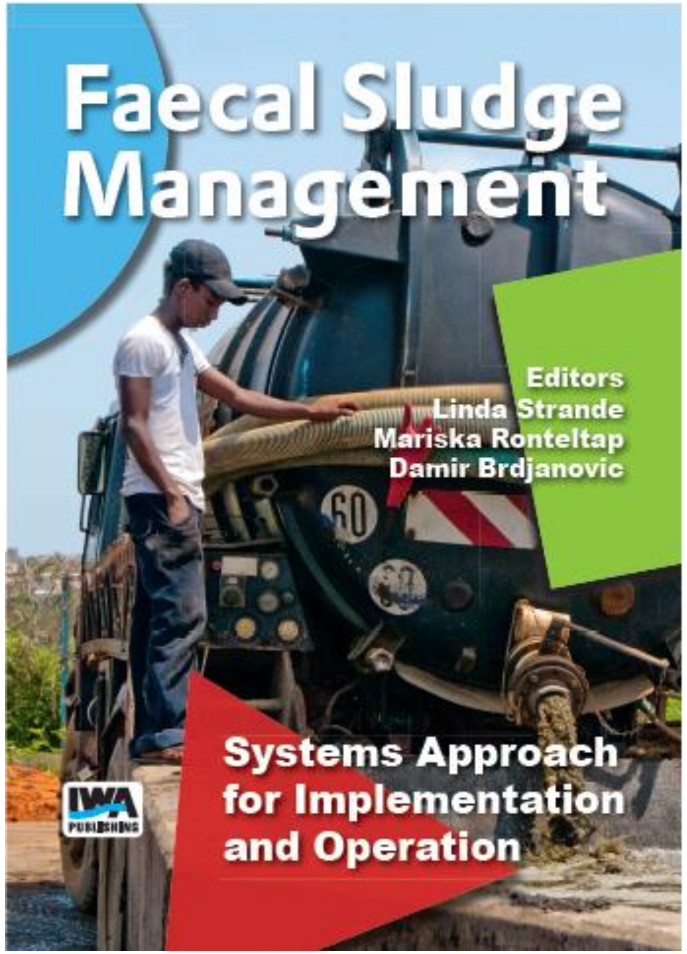
Learning objectives

- Understand and describe the difference between faecal sludge, wastewater and excreta
- Explain the Engineering Design Approach for faecal sludge management
- Be familiar with resource recovery products and treatment technologies associated with them
- Explain the treatment objectives of faecal sludge treatment and link them to treatment technologies.



www.sandec.ch/fsm_book

Terminology: What is faecal sludge?

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Environmental Science & Technology

Open Access

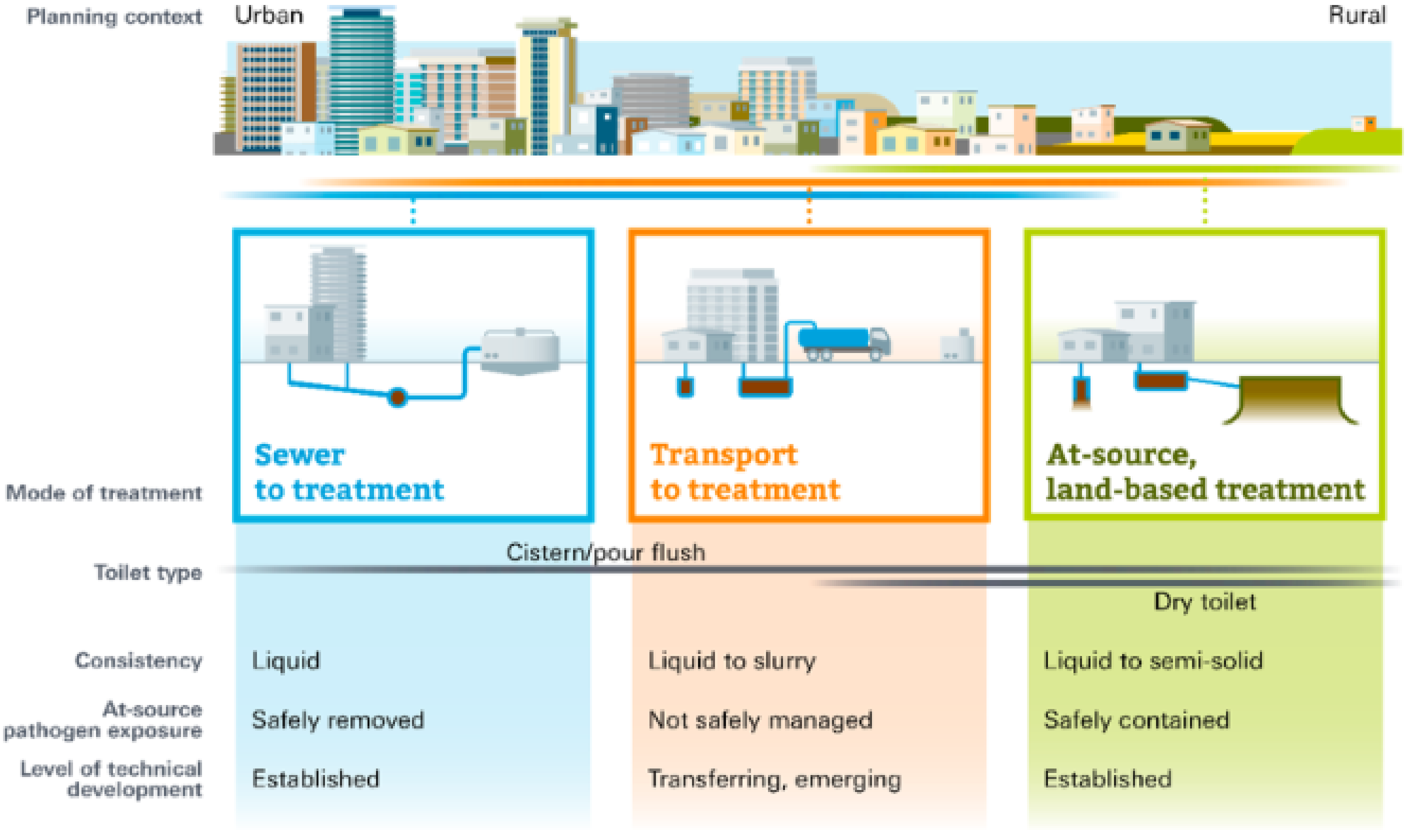
pubs.acs.org/est

Feature

Urban Sanitation: New Terminology for Globally Relevant Solutions?

Published as part of the Environmental Science & Technology virtual special issue "Accelerating Environmental Research to Achieve Sustainable Development Goals".

Linda Strande,* Barbara Evans, Marcos von Sperling, Jamie Bartram, Hidenori Harada, Anne Nakagiri, and Viet-Anh Nguyen



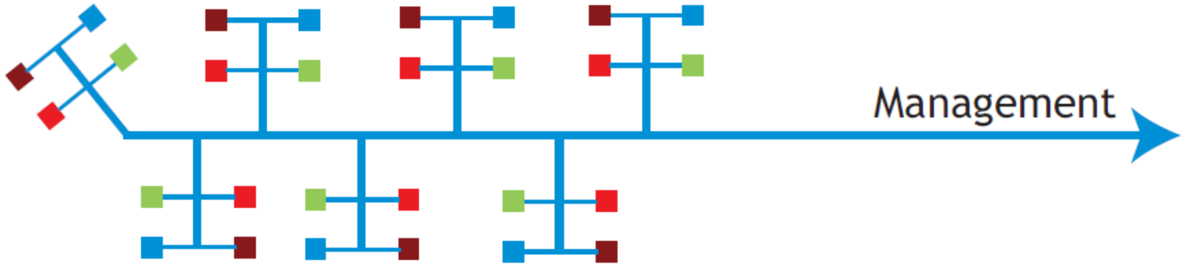
Terminology: What is faecal sludge?

EXCRETA ≠ FAECAL SLUDGE ≠ WASTEWATER

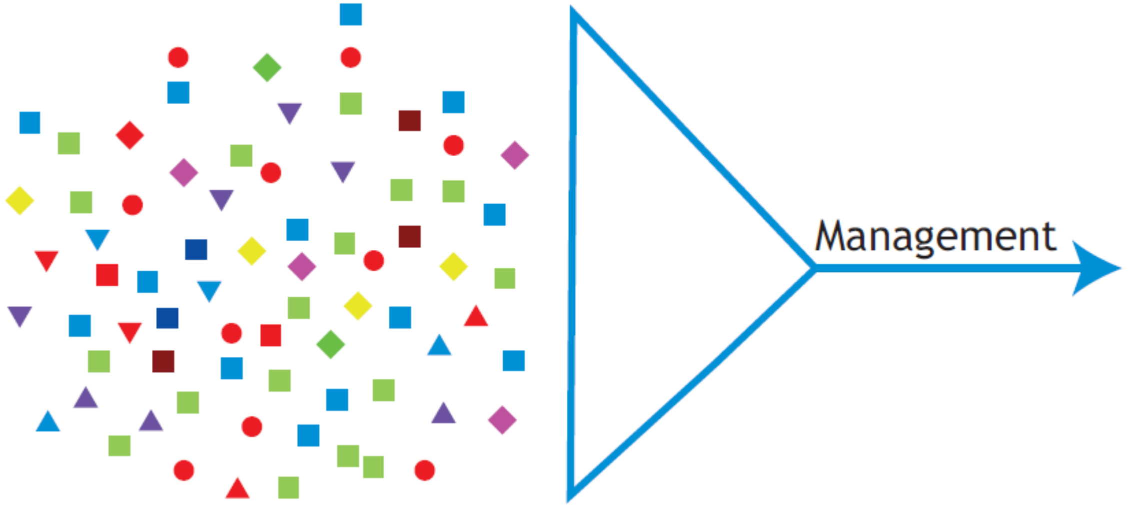
EXCRETA	FAECAL SLUDGE	WASTEWATER
=	=	=
URINE & FAECES	EXCRETA	EXCRETA
	+ ADDITIONAL INPUT	+ ADDITIONAL INPUT
	↓ ONSITE CONTAINMENT	↓ SEWER
	↓ COLLECTION	
	↓ TRANSPORTATION	
	↓ TREATMENT	↓ TREATMENT

Wastewater versus faecal sludge

Wastewater



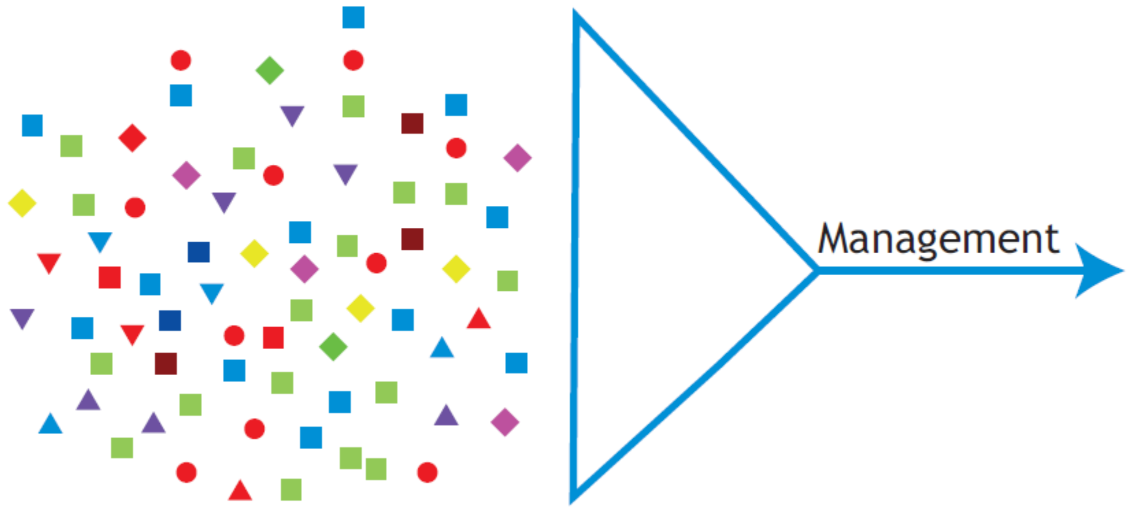
Faecal sludge



Characteristics of Faecal Sludge

Quantities and Qualities are highly variable

- Unknown information:
  - Collection & storage technology
  - Number of users connected
  - Time stored before arriving to treatment
- No homogenization during transport, as occurs in sewered systems. Sludge arrives batch-wise
- Varying infiltration rates – changing water content in faecal sludge
- Amount of greywater
- Emptying method
- Climate
- Other solid wastes



Treatment Technologies

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User Interface

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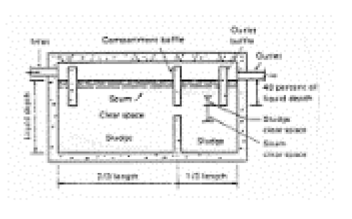
Storage



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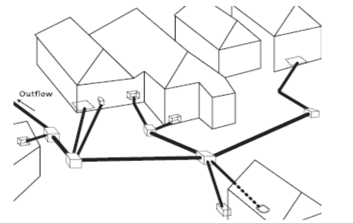

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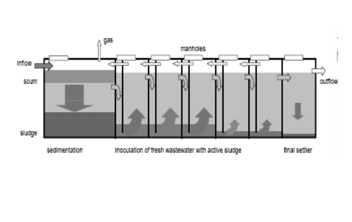

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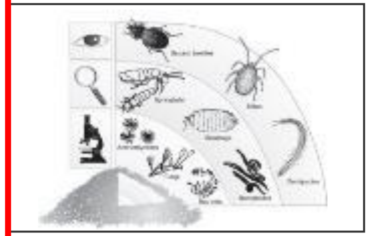

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Treatment Technologies

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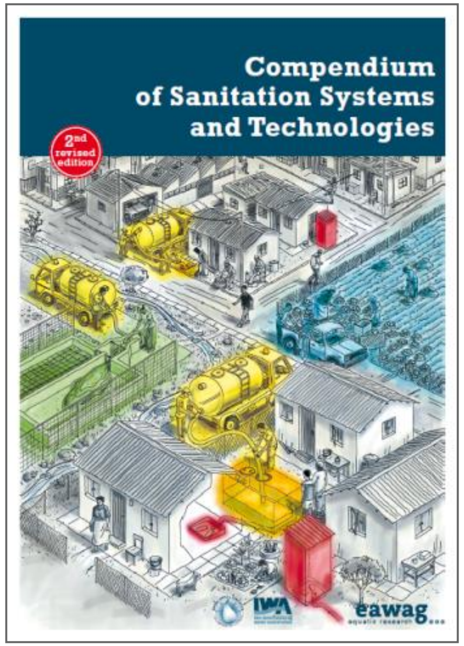
For Wastewater
- T.1 Settler
- T.2 Imhoff Tank
- T.3 Anaerobic Baffled Reactor (ABR)
- T.4 Anaerobic Filter
- T.5 Waste Stabilization Ponds (WSP)
- T.6 Aerated Pond
- T.7 Free-Water Surface Constructed Wetland
- T.8 Horizontal Subsurface Flow constructed Wetland
- T.9 Vertical Flow constructed Wetland
- T.10 Trickling filter
- T.11 Upflow Anaerobic Sludge blanket Reactor (UASB)
- T.12 Activated Sludge

For Fecal Sludge
- T.13 Sedimentations / Thickening Ponds
- T.14 Unplanted Drying Beds
- T.15 Planted Drying Beds
- T.16 Co-composting
- T.17 Biogas Reactor



Global relevance?

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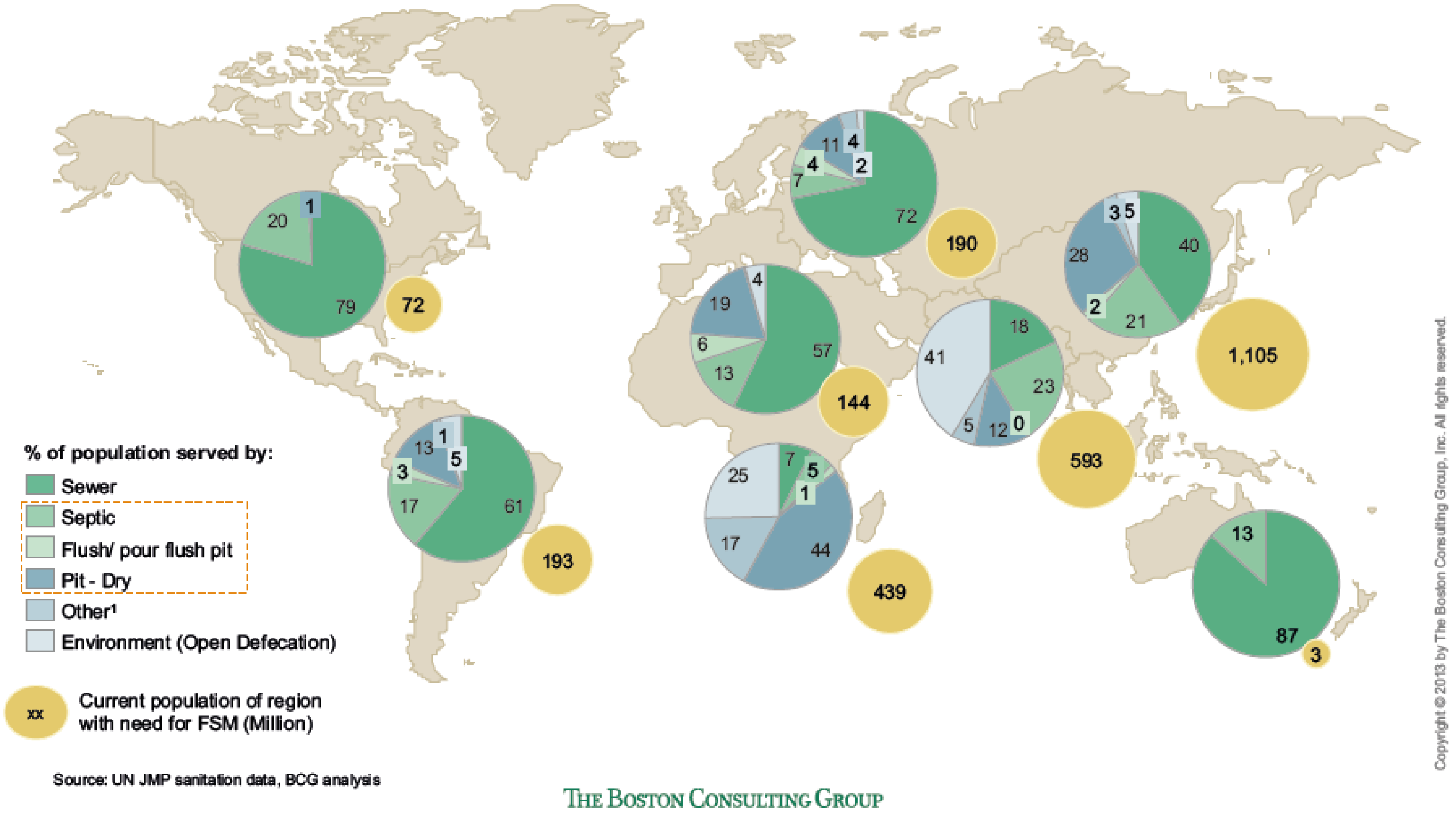
- Sanitation needs of 2.7 billion people worldwide are met by **onsite technologies**.
- Majority of onsite systems are not safely managed (61−72% in Africa, 62−68% in LAC, 100% in SE Asia, and 5−100% in W. Pacific)

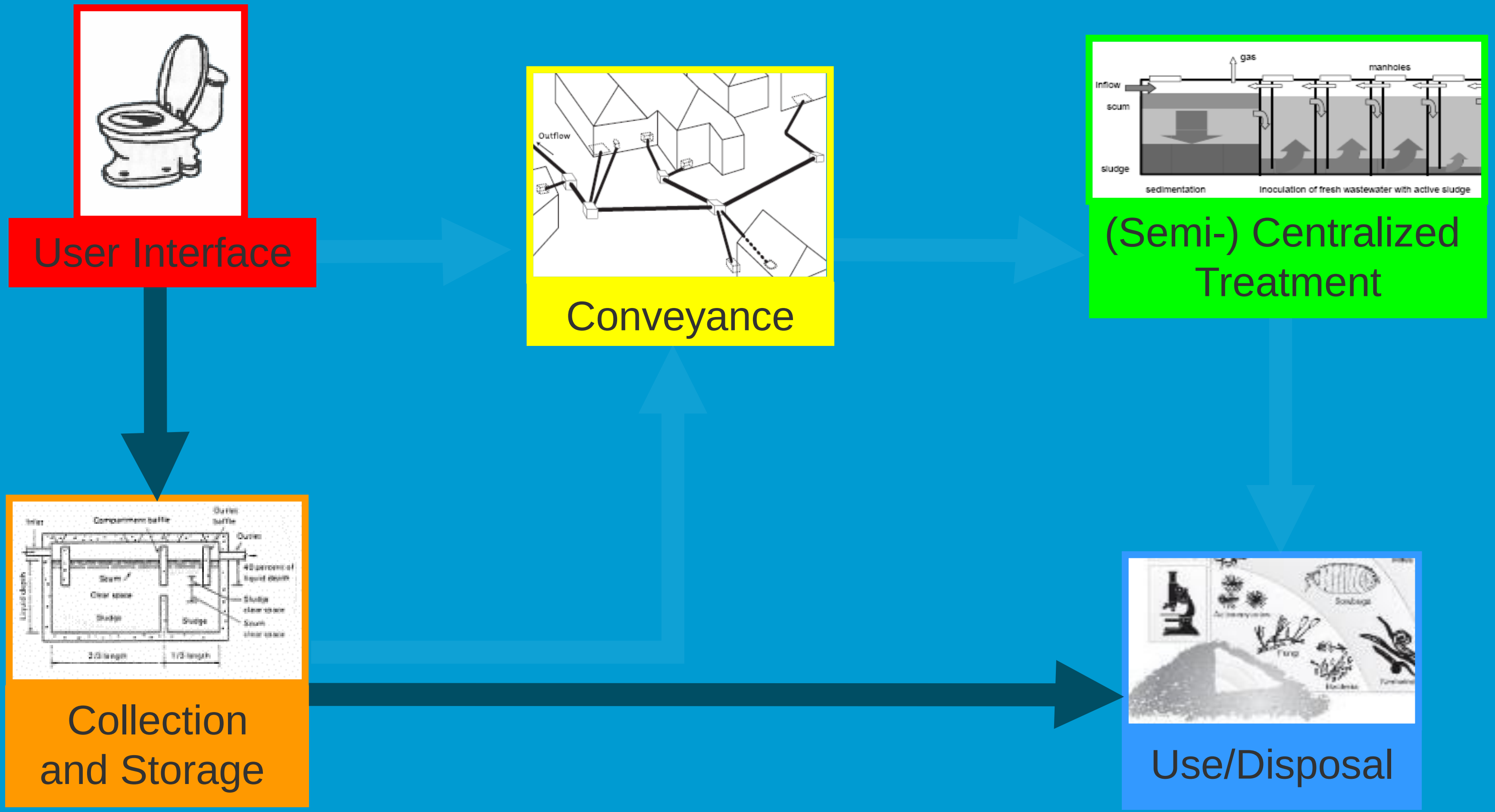


Cairns-Smith et al., 2014; Berendes et al., 2017

<u>Challenges pushing towards decentralized solutions</u>:

- Rapid urbanization & densification
- Expenses
- Resource Recovery

What happens when decentralized systems are not managed properly?



This shit is not working…

Yaoundé Cameroon

What happens when the pits are full?

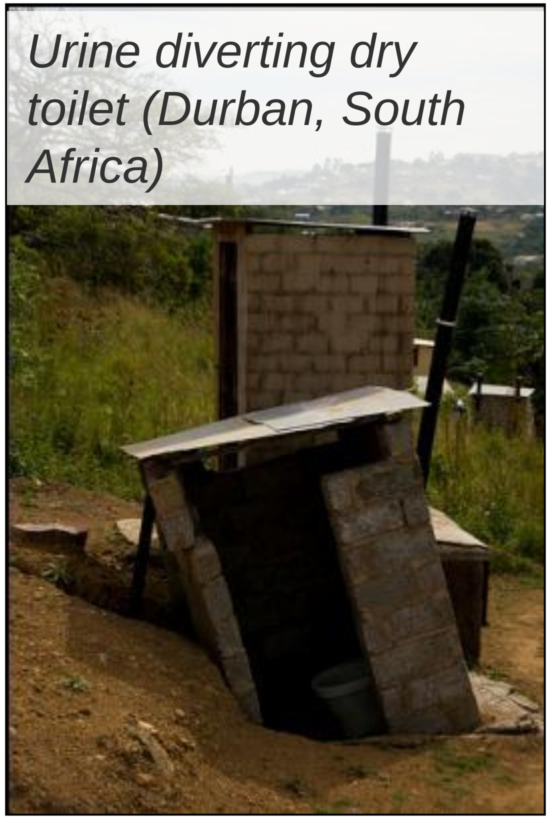
Dakar, Senegal

Accra, Ghana

Yaoundé, Cameroon

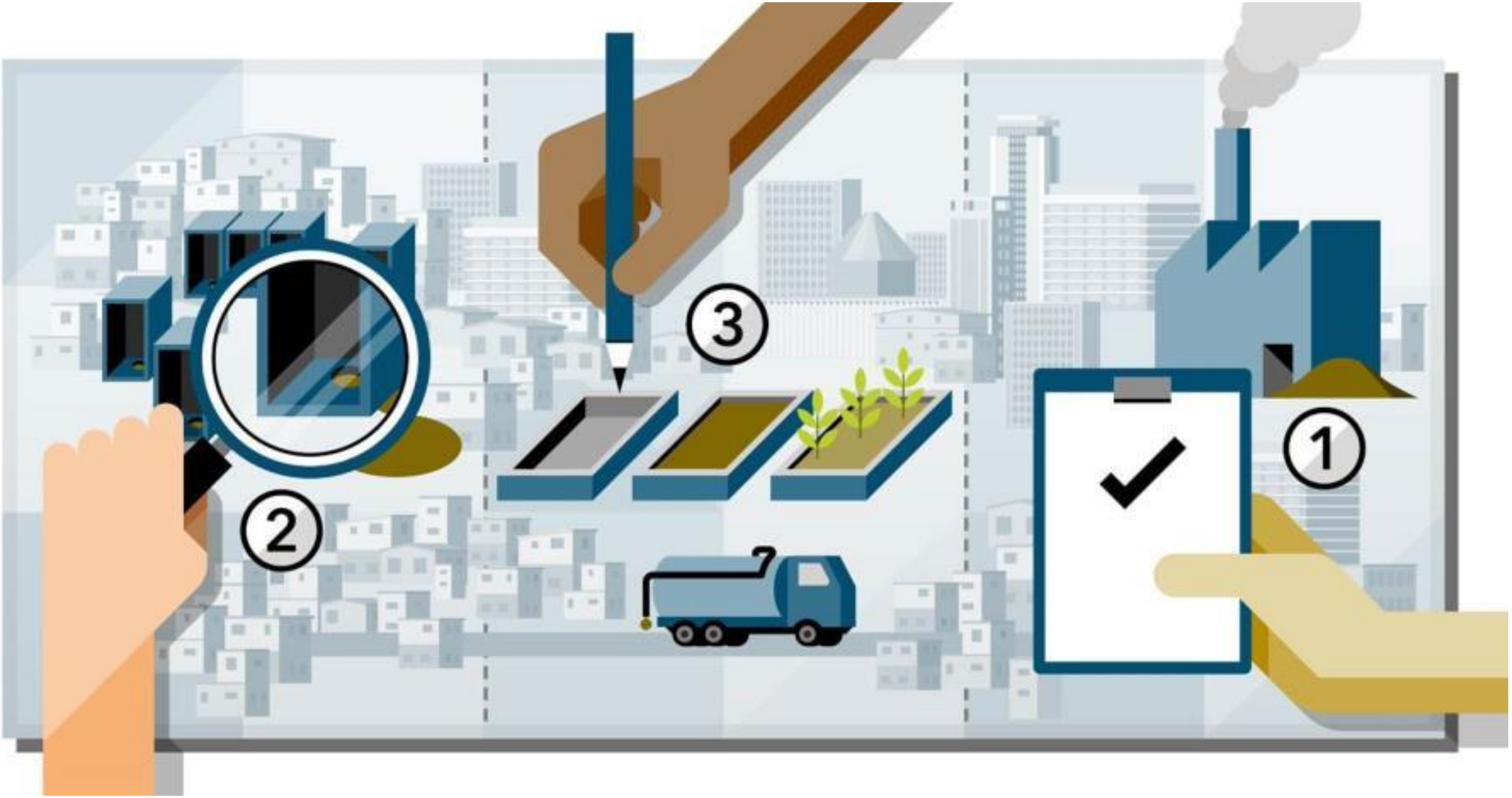

Septic tank (Dakar, Senegal)

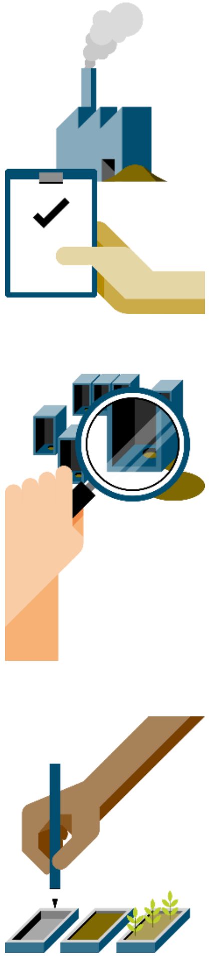
Public toilet (Accra, Ghana)



Urine diverting dry toilet (Durban, South Africa)

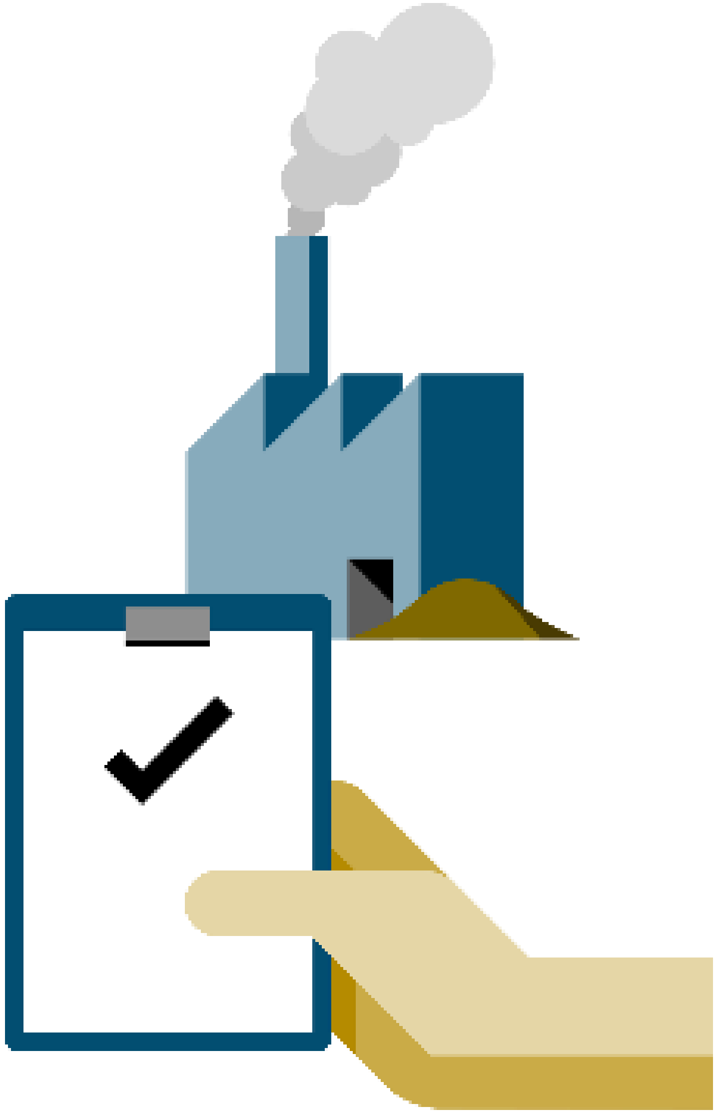
Engineering Design Approach



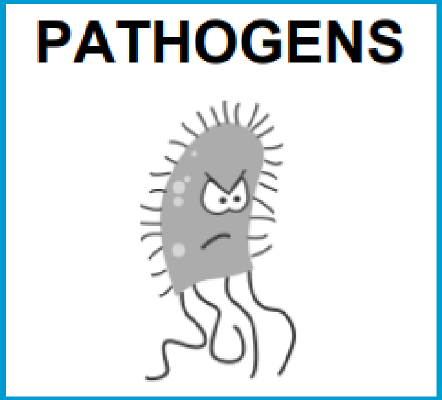


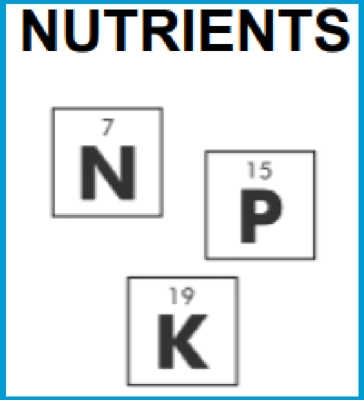
Engineering Design Approach

Step 1: Treatment objectives & Resource Recovery



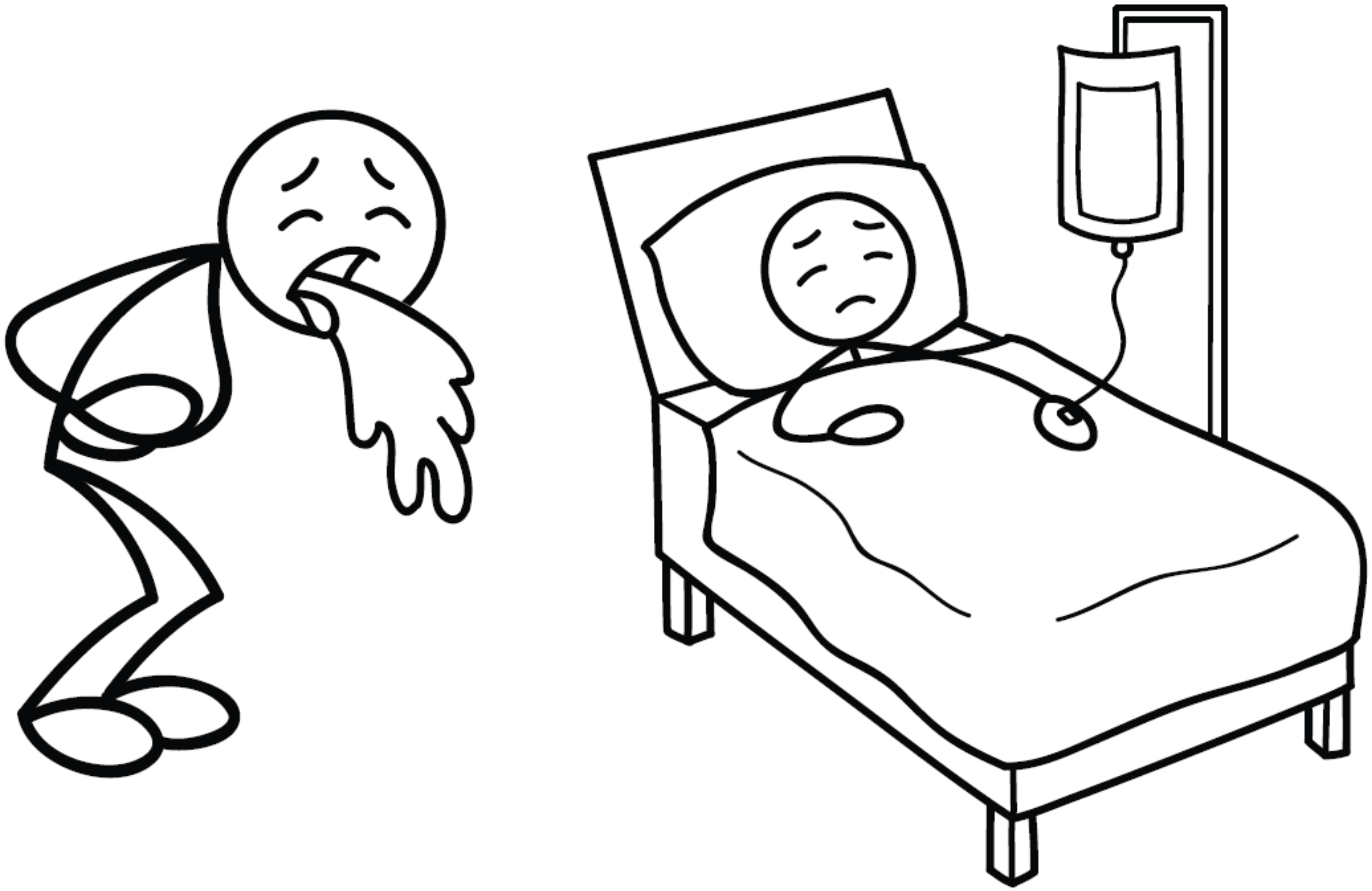
Treatment Objectives Activity





Treatment objectives

What component will make people sick?



Treatment objectives

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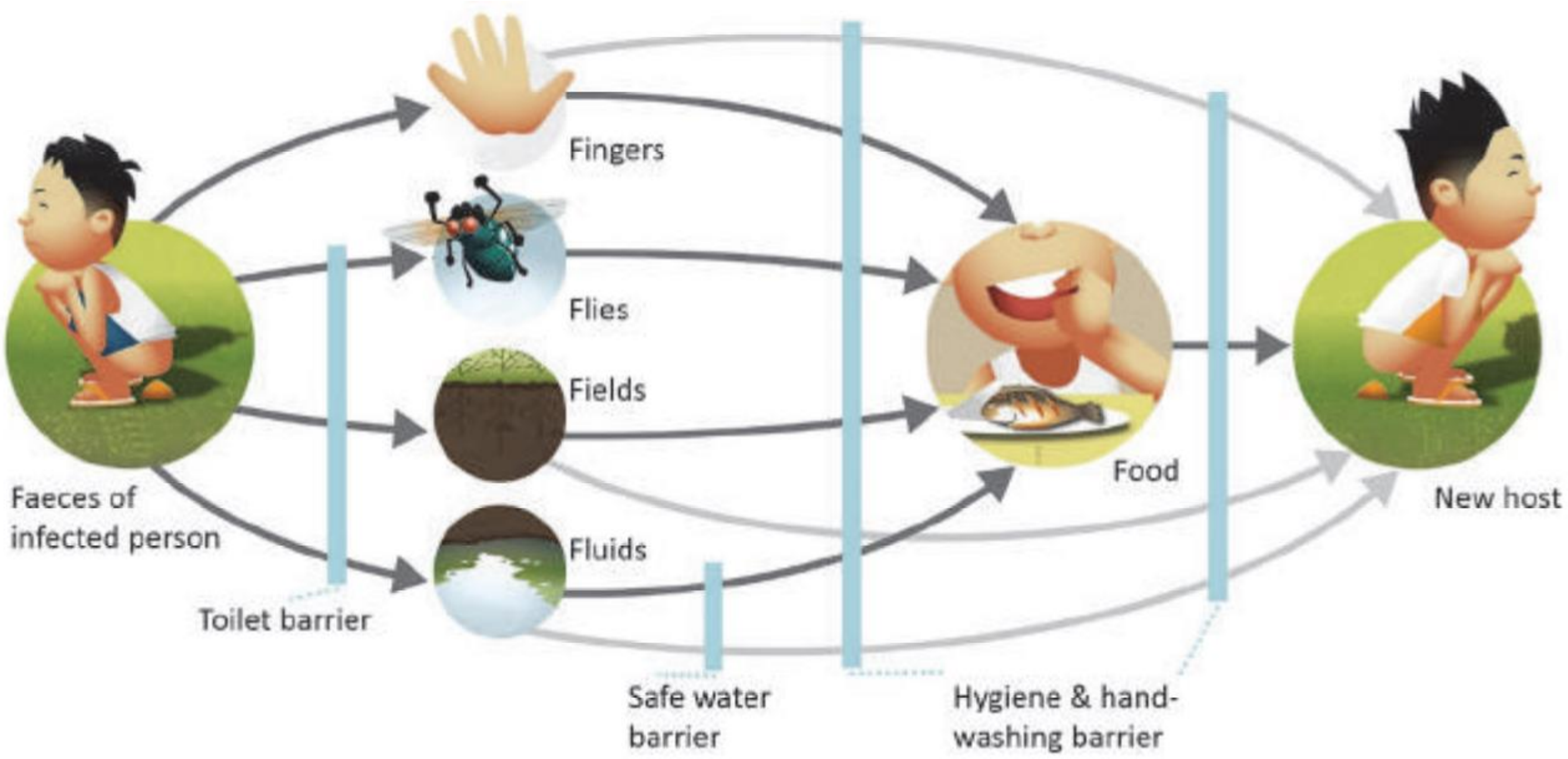
Transmission pathways of pathogens



Treatment objectives

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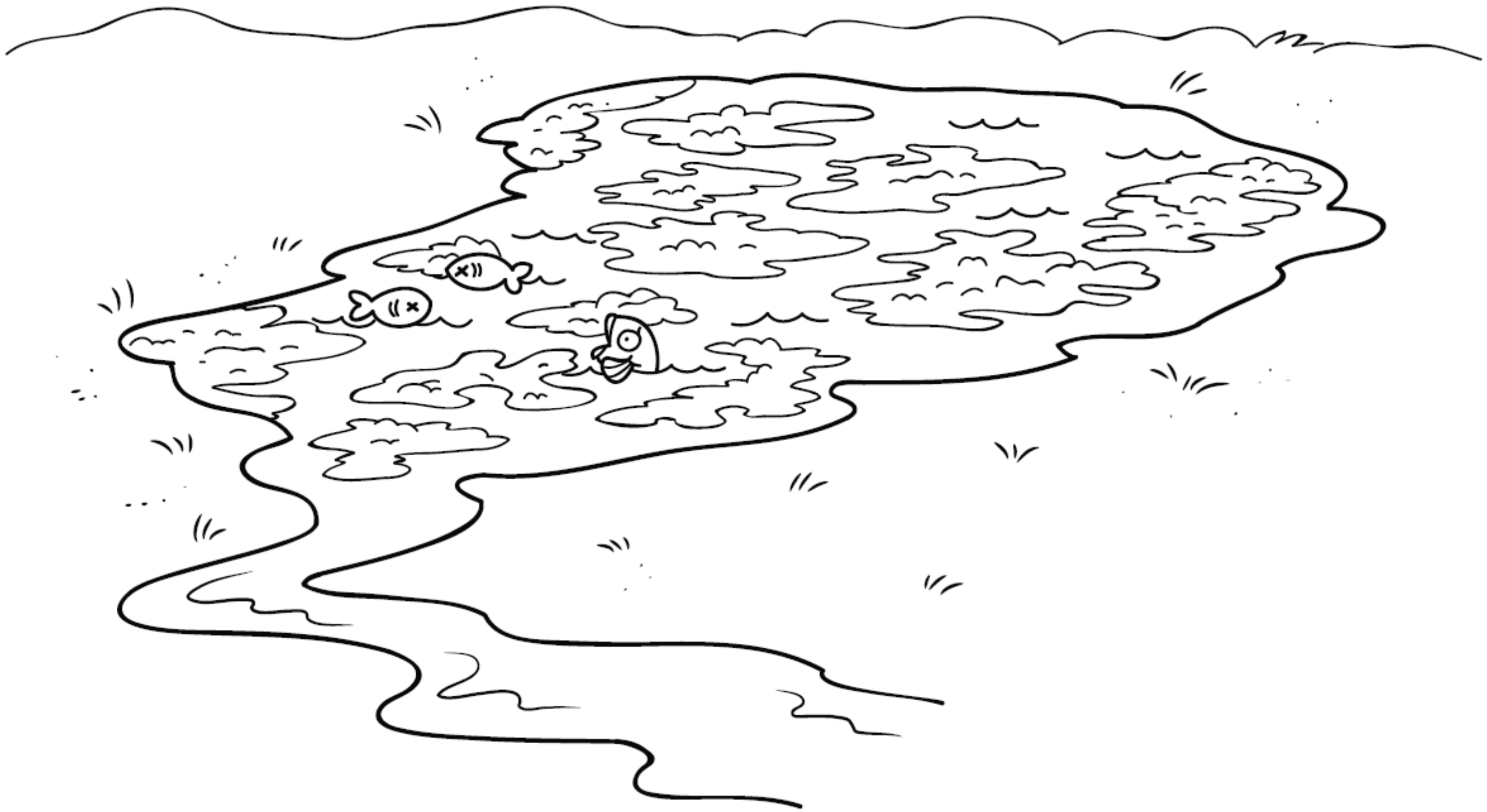
What component can cause eutrophication?



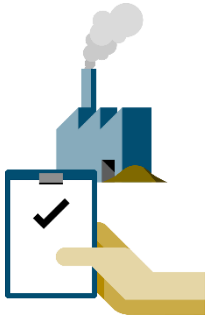
Treatment objectives

What component would make faecal sludge smell badly?

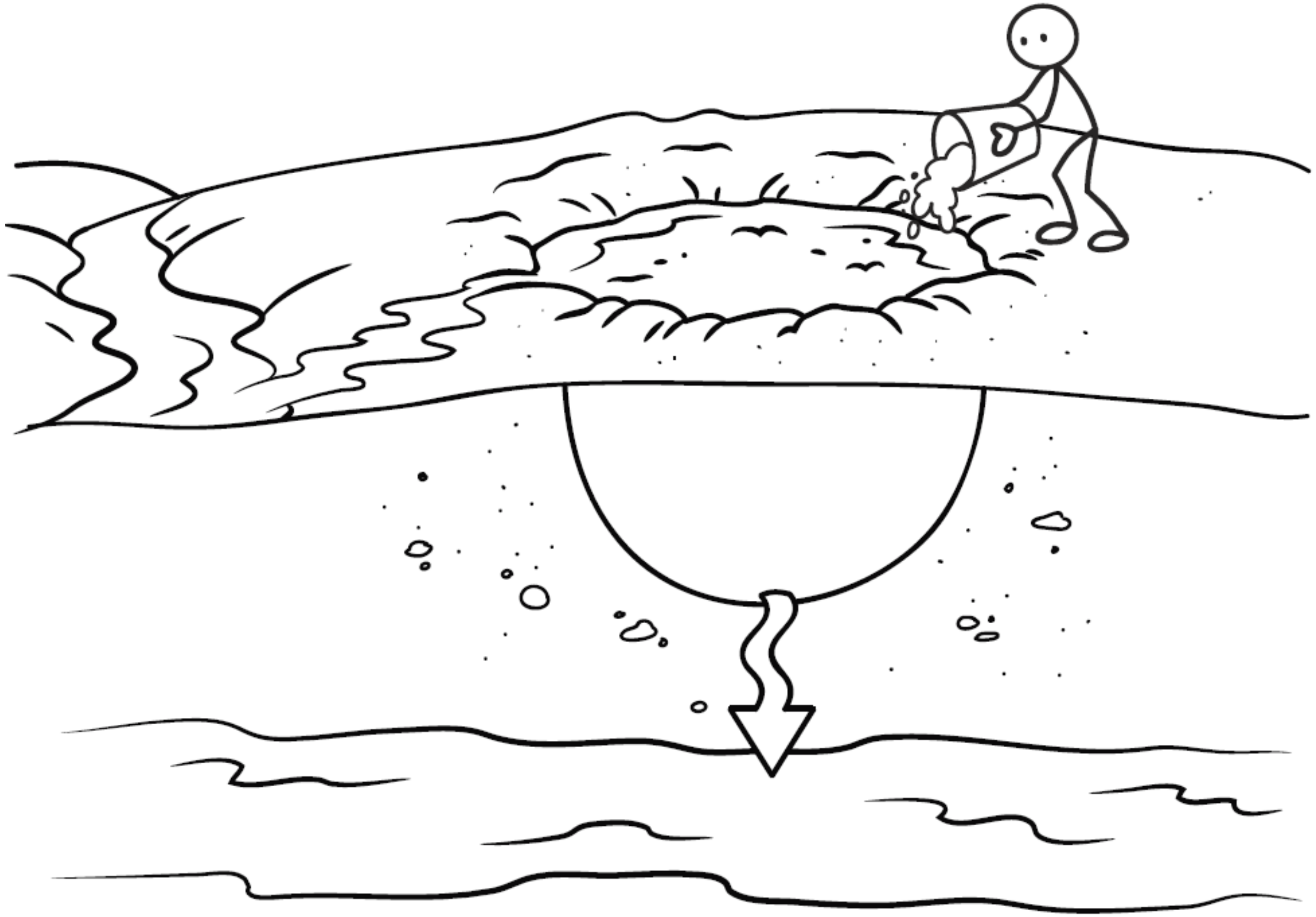
Treatment objectives

What component makes faecal sludge heavy and voluminous to manage?

Treatment objectives

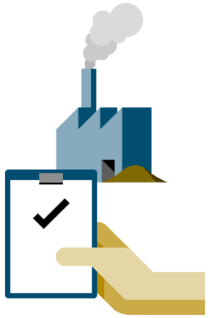


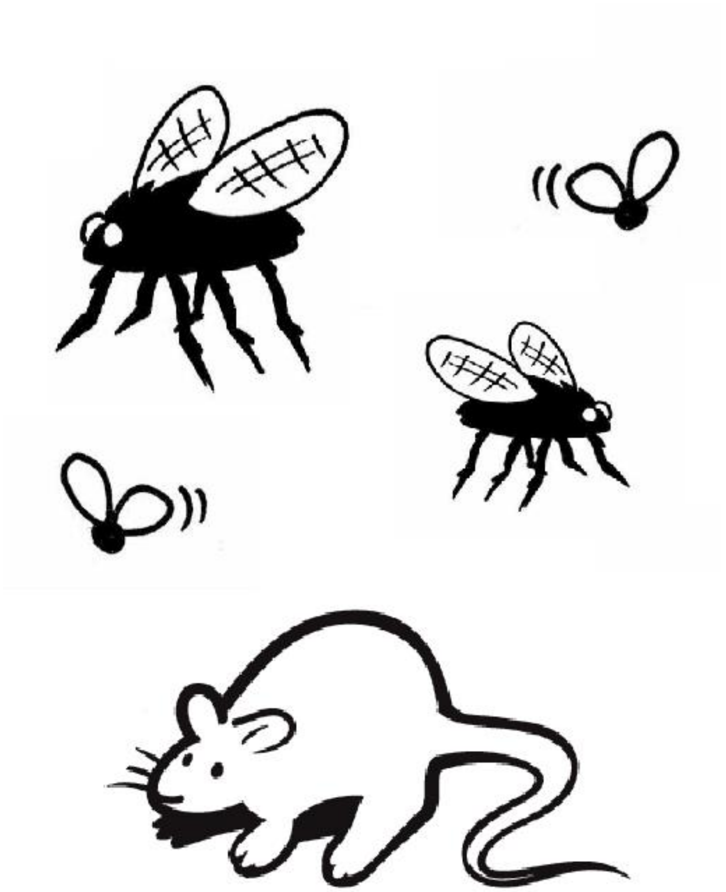
What component will increase the risk of water contamination?



Treatment objectives

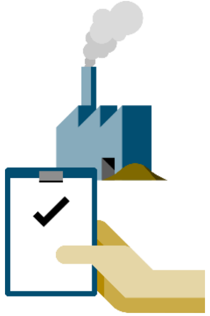
What component would attract vectors such as flies and rats?





Treatment objectives

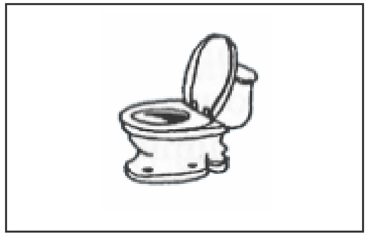
1. Pathogen inactivation
2. Stabilization
3. Dewatering
4. Nutrient management



The ultimate goal of faecal sludge management: protection of public and environmental health

Treatment Technologies

User Interface



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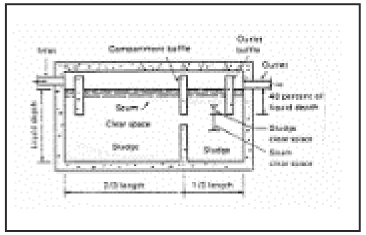

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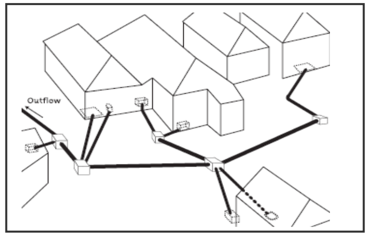

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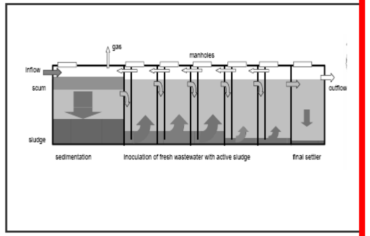

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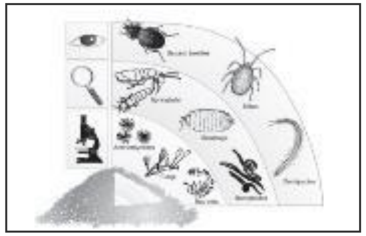

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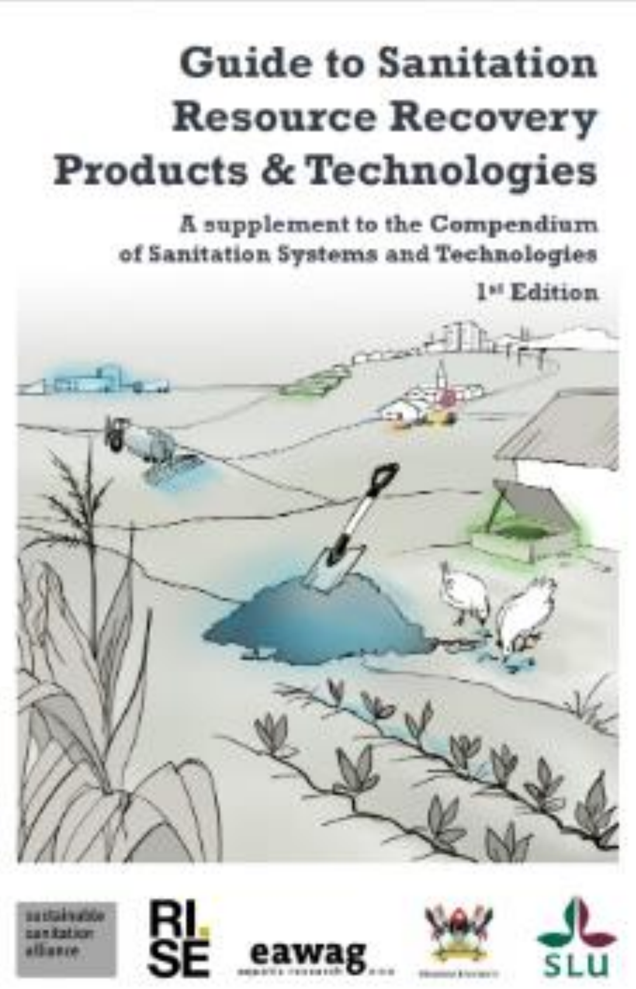
Guide to Sanitation Resource Recovery Products & Technologies

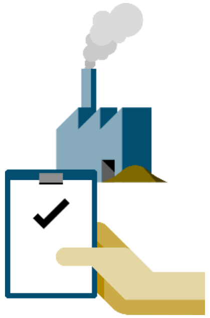
Part 1: Reuse Products

Part 2: Treatment Technologies for Resource Recovery

https://www.susana.org/en/knowledge-hub/resources-and-publications/library/details/4008#



Resource recovery options for faecal sludge



Resource	Treatment product	Product type
Energy	Solid fuel	Pellets, briquettes, powder
Energy	Gas fuel	Biogas
Energy	Electricity	Conversion of biogas, or gasification of solid fuel
Food	Protein	Black soldier flies, fish meal
Food	Animal fodder	Plants from drying beds, dried aquaculture plants
Food	Fish	Grown on effluent from faecal sludge treatment
Material	Building materials	Additive to bricks, road construction
Nutrients	Soil conditioner[1]	Compost, pellets, digestate, black soldier fly residual
Nutrients	Fertilizer[2]	Pellets, powder
Nutrients	Soil conditioner[3]	Untreated sludge, dewatered sludge from drying beds
Water, nutrients	Reclaimed water	Effluent from faecal sludge treatment

[1] With different levels of pathogen removal, based on enduse
[2] Addition of NPK to fulfill nutrient needs of a fertilizer
[3] No pathogen removal.

Designing for End-use / Resource Recovery

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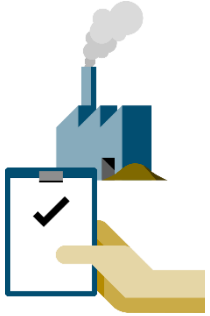
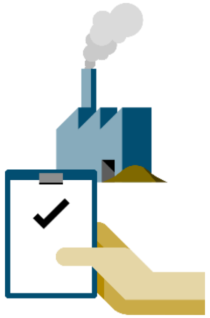


Factors influencing product production:

- Type, quality and costs of input material available
- Socio-cultural acceptance
- Local demands
- Legal aspects
- Availability of materials and equipment
- Availability of space
- Soil and groundwater characteristics
- Local knowledge and capacity

Designing for End-use / Resource Recovery



- No effluent standards / standards not enforced
- Revenues from FS treatment products could offset FS treatment costs
- Market for end products could help ensure sustainable operation
    - Markets for FS treatment end products are undeveloped

Resource recovery options for faecal sludge

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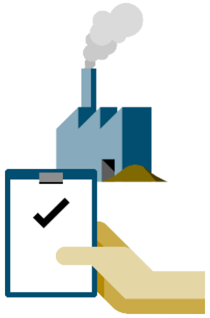

Resource	Treatment product	Product type
Energy	Solid fuel	Pellets, briquettes, powder
Energy	Gas fuel	Biogas
Energy	Electricity	Conversion of biogas, or gasification of solid fuel
Food	Protein	Black soldier flies, fish meal
Food	Animal fodder	Plants from drying beds, dried aquaculture plants
Food	Fish	Grown on effluent from faecal sludge treatment
Material	Building materials	Additive to bricks, road construction
Nutrients	Soil conditioner[1]	Compost, pellets, digestate, black soldier fly residual
Nutrients	Fertilizer[2]	Pellets, powder
Nutrients	Soil conditioner[3]	Untreated sludge, dewatered sludge from drying beds
Water, nutrients	Reclaimed water	Effluent from faecal sludge treatment

Trade-off of between energy potential and nutrient recovery

Resource recovery – Soil Conditioner

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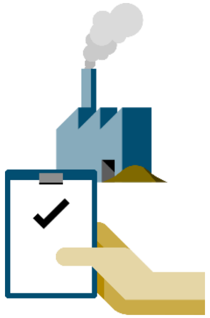
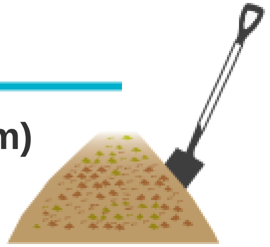


R.8 Dried Faeces

(D.3 in Compendium)

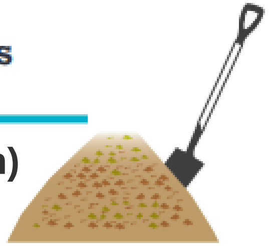
R.11 Compost

(D.4 in Compendium)

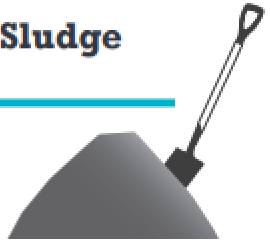


R.9 Pit Humus

(D.4 in Compendium)



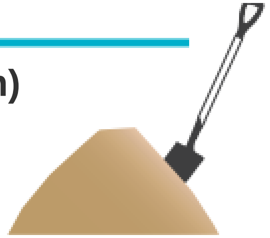
R.12 Ash from Sludge



R.14 Nutrient-Enriched Filter Material

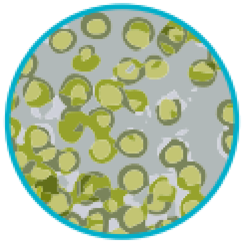
R.10 Dewatered Sludge

(D.5 in Compendium)



R.13 Biochar

R.15 Algae

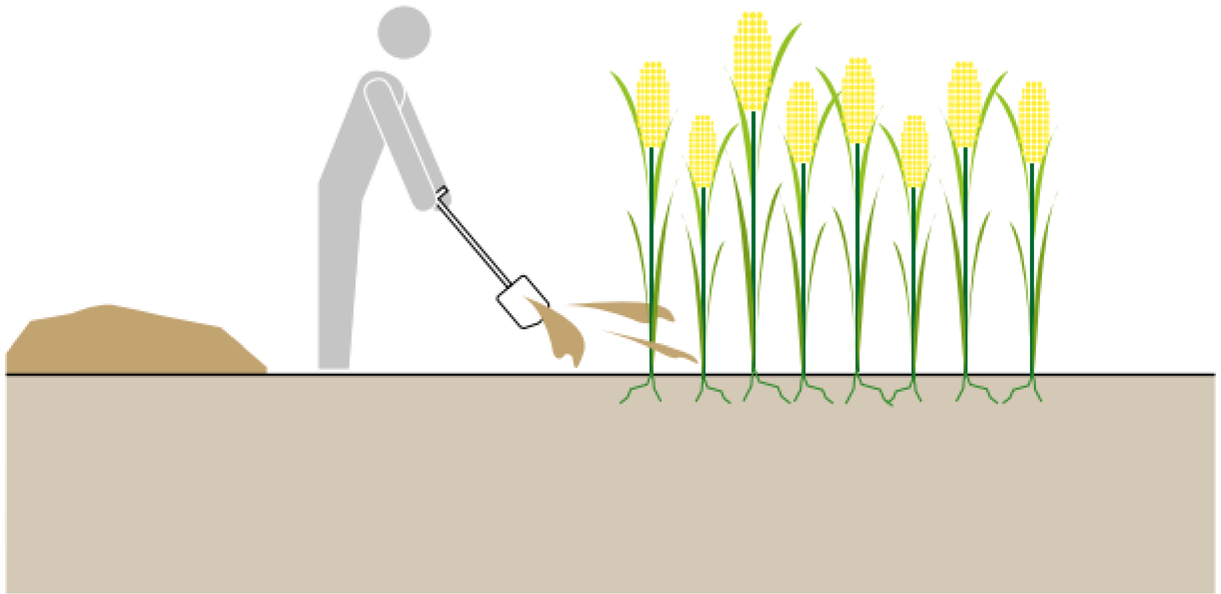


Resource recovery – Soil conditioner

D.4 **Application of Pit Humus and Compost**

Applicable to:
Systems 2, 3

Application Level:	**Management Level:**	**Inputs:** Pit Humus, Compost
★★ Household	★★ Household	**Outputs:** Biomass
★★ Neighbourhood	★★ Shared	
★ City	★ Public	



Advantages:

+ Improves structure of soil
+ Reduces chemical fertilizer needs
+ Low costs
+ Low risk of pathogen transmission

Disadvantages

– Long maturation times
– Low social acceptance in some areas

Resource recovery options for faecal sludge

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Resource	Treatment product	Product type
Energy	Solid fuel	Pellets, briquettes, powder
Energy	Gas fuel	Biogas
Energy	Electricity	Conversion of biogas, or gasification of solid fuel
Food	Protein	Black soldier flies, fish meal
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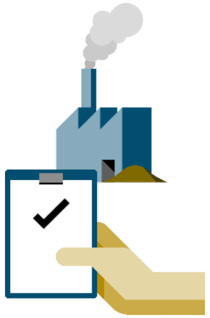
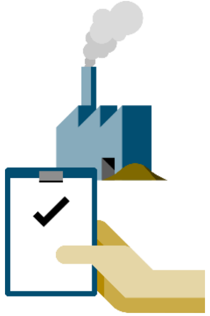
Water, nutrients	Reclaimed water	Effluent from faecal sludge treatment



Resource recovery – Solid fuels (Biofuels)



End products to be used as fuels:

Dried faecal sludge

Briquettes/pellets

Charcoal

Dewatering is Key!

Resource Recovery: Carbonized fuels

R.13 Biochar

Intended use:	Application level:		Treatment technologies:
Soil conditioner, Water purification, Energy production	*	Household	T.27 Carbonisation
	**	City	
Technical maturity:	**	Regional	
High	*	Global	

***Compiled by:** Swedish University of Agricultural Sciences (SLU)*

Advantages:

+ Can be used as a solid fuel (char) or soil conditioner (biochar)
+ Improves soil quality & structure
+ Carbon-neutral or carbon-negative

Disadvantages

– Dust during soil application
– Sorption of pesticides and herbicides
– Nitrogen loss

Resource recovery options for faecal sludge

Resource	Treatment product	Product type
Energy	Solid fuel	Pellets, briquettes, powder
Energy	Gas fuel	Biogas
Energy	Electricity	Conversion of biogas, or gasification of solid fuel
Food	Protein	Black soldier flies, fish meal
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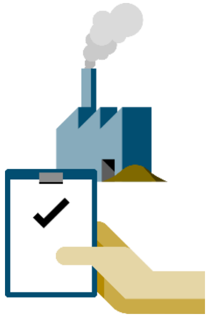
Water, nutrients	Reclaimed water	Effluent from faecal sludge treatment



Resource recovery – Gas Fuel

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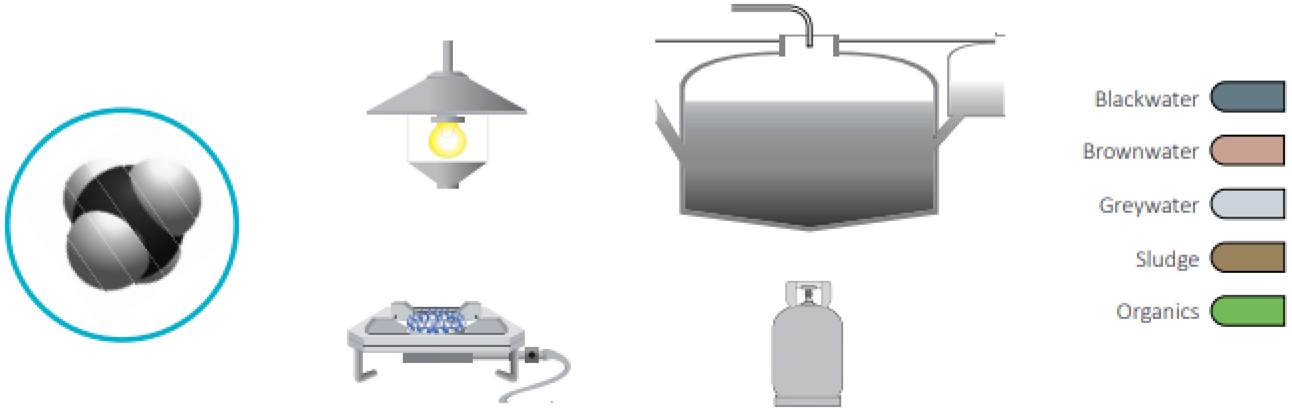
R.21 Biogas (D.13 in Compendium)

Intended use: Heat, Electricity, Vehicle fuel	**Application level:** ** Household ** City * Regional Global	**Treatment technologies:** (S.12 Biogas Reactor, T.11 Upflow Anaerobic Sludge Blanket Rector UASB, T.17 Biogas Reactor)
Technical maturity: High		



Compiled by: *Tilley et al. (2014) and Swedish University of Agricultural Sciences (SLU)*

Advantages:

+ Low-cost energy source from renewable ressources
+ Replaces fuel wood for cooking
+ Few operational skills and little maintenance required

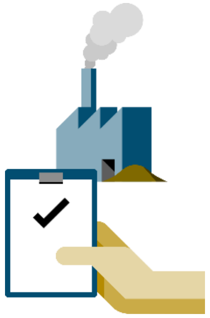
Disadvantages

– Low storage time, low energy density

– Biogas lamps have lower efficiency

– Leaked / unburned methane is a GHG emission

Resource recovery options for faecal sludge



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Water, nutrients	Reclaimed water	Effluent from faecal sludge treatment

Resource recovery – Animal Fodder

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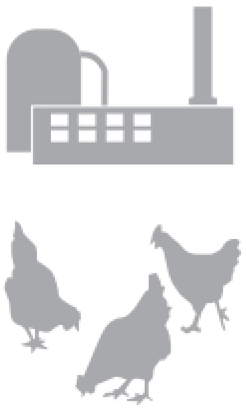
R.17 Black Soldier Fly Larvae

Intended use:	Application level:	Treatment technologies:
Biomass (e.g., animal fodder, biofuels), Industrial use	** Household ** City *** Regional * Global	T.21 Black Soldier Fly Composting
Technical maturity: Medium		



Faeces
Excreta
(+Dry cleansing material)
Sludge
Organics

***Compiled by:** Swedish University of Agricultural Sciences (SLU)*

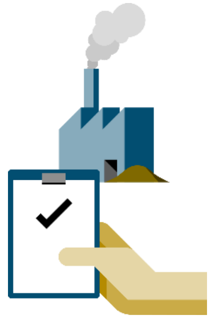
Advantages:

+ Good source of protein and oil in animal feed
+ Easily dried for longer storage (55-75% volume reduction)
+ Can also be used as biofuel
+ Pesticides and mycotoxins are not accumulated in BSFLStabilization of organic matter.

Disadvantages

– Solid residue not pathogen free.
– May alter meat products
– Stringent rules about insects
    - In Europe, cannot give animal by-products to BSFL and cannot give BSFL as feed to other animals

Resource recovery options for faecal sludge



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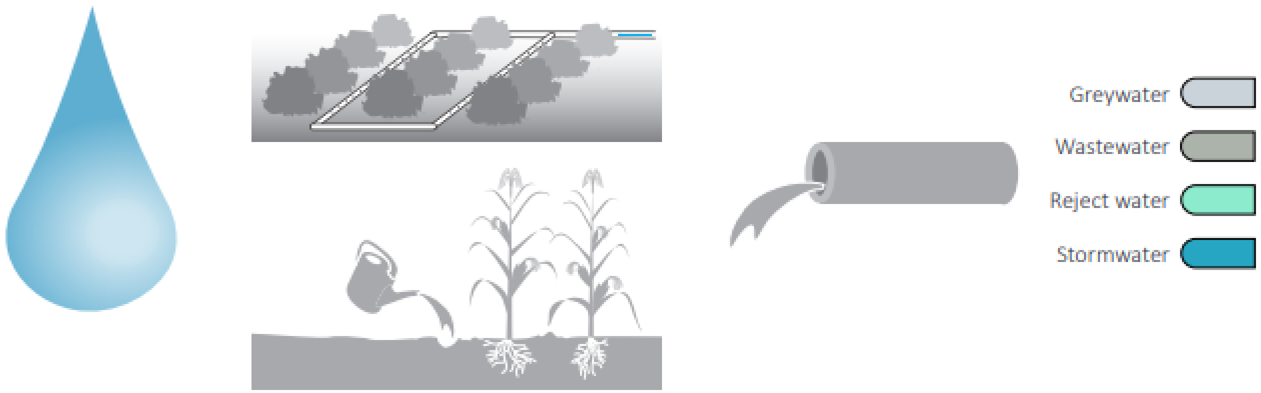
Nutrients	Soil conditioner[3]	Untreated sludge, dewatered sludge from drying beds
Water, nutrients	Reclaimed water	Effluent from faecal sludge treatment

Resource recovery – Reclaimed Water

R.19 Irrigation Water

Intended use:	Application level:	Treatment technologies:
Irrigation	*** Household ** City * Regional Global	All technologies that produce an effluent as an output
Technical maturity: High		



Compiled by: *Tilley et al. (2014) and Swedish University of Agricultural Sciences (SLU)*

Advantages:

+ Reduces depletion of groundwater and improves availability of drinking water
+ Low risk of pathogen transmission if water is properly treated
+ Low capital and operational costs depending on the design

Disadvantages

– Expert design and installation
– Drip irrigation normally required
– Risk of soil contamination
– Risk of groundwater contamination
– Social acceptance is low

Resource recovery – Reclaimed Water

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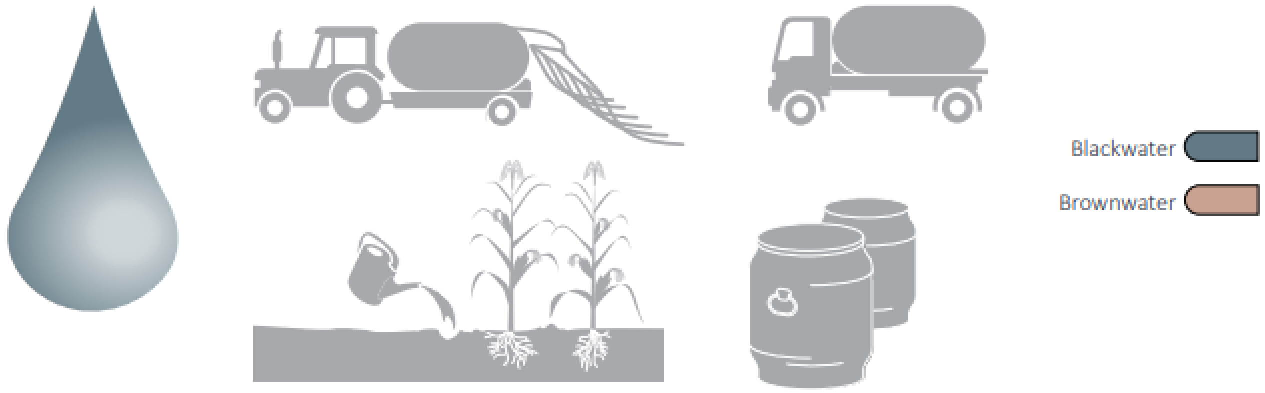
R.3 Sanitised Blackwater

Intended use:	Application level:	Treatment technologies:
Liquid fertiliser, Agricultural irrigation	** Household ** City ** Regional * Global	T.32 Ammonia Sanitisation/Urea Treatment, T.33 Lime Sanitisation
Technical maturity: High		



***Compiled by:** Swedish University of Agricultural Sciences (SLU)*

<u>Advantages:</u>

+ Reduces depletion of groundwater and improves availability of drinking water
+ **Reduced the need for fertilizer (*Fertigation*)**
+ Low risk of pathogen transmission if water is properly treated
+ Low capital and operational costs depending on the design

<u>Disadvantages</u>

– Expert design and installation

– Drip irrigation normally required

– Risk of soil contamination

– Risk of groundwater contamination

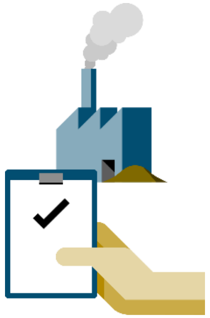
– Social acceptance is low

Designing for End-use / Resource Recovery

<u>Other potential resources:</u>

(from Guide to Sanitation Resource Recovery Products and Technologies)

- Urine
  - Stored (R.1)
  - Concentrated (R.2)
  - Dry (R.6)
  - Struvite (R.7)
- Digestate (R.4)
- Macrophytes (R.16)
- Worms (R.18)
- Aquaculture (R.20)



<u>End-uses without resource recovery:</u>

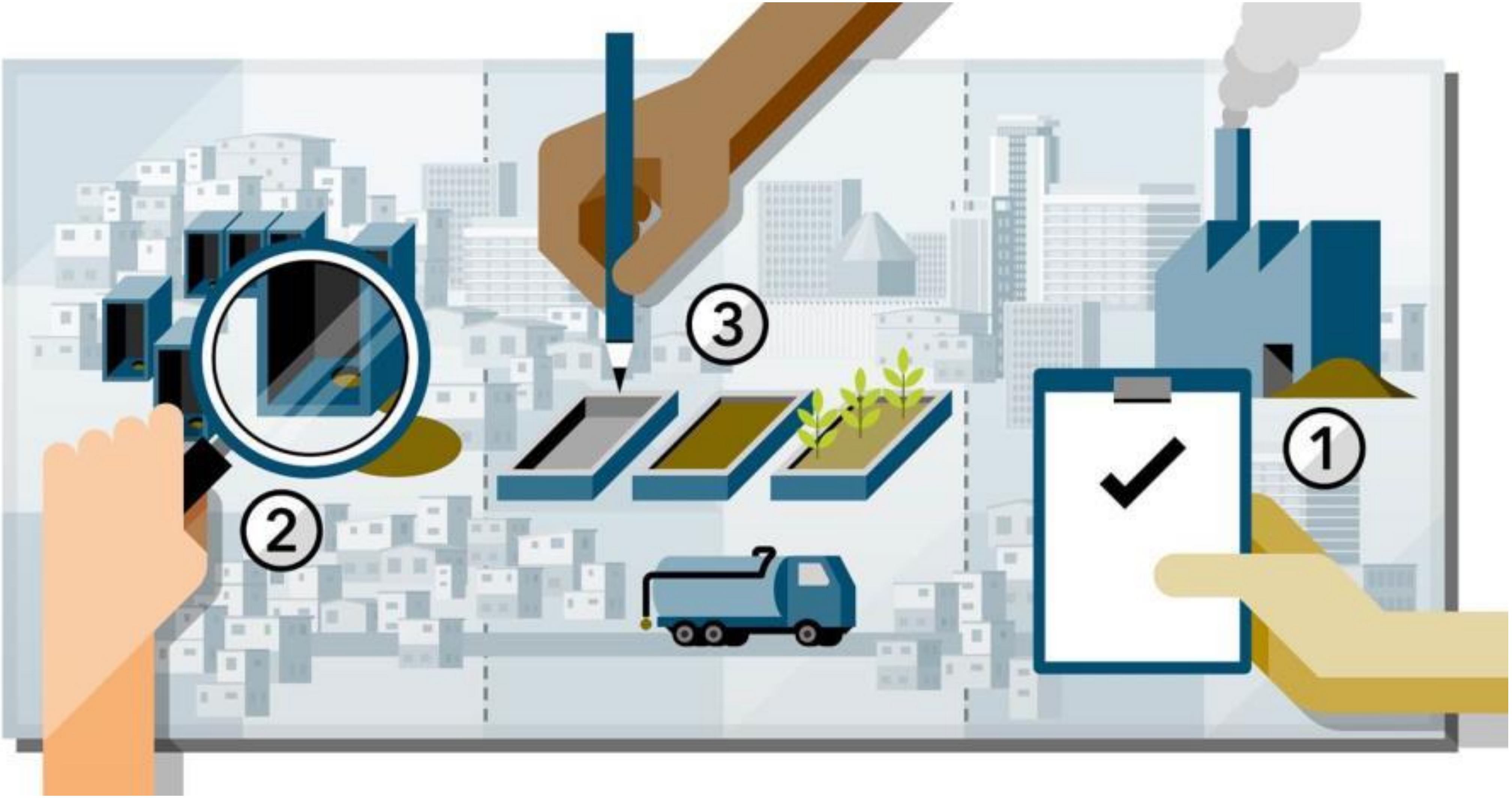
(from Compendium of Sanitation Systems and technologies)

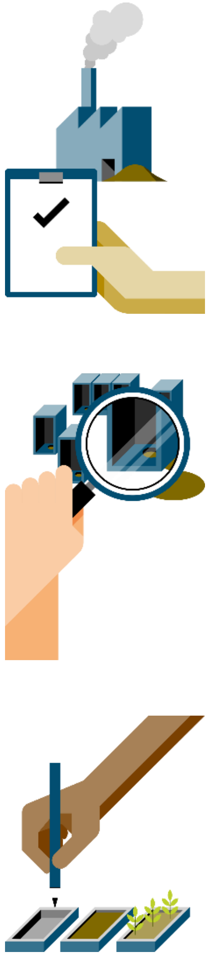
- Soak pit (D.7)
- Leach field (D.8)
- Water discharge (D.11)
- Surface disposal (D.12)

Questions ?

BREAK

Engineering Design Approach





Engineering Design Approach

Step 2: Quantification and characterization of influent sludge

Reminder:
Faecal Sludge is highly variable!

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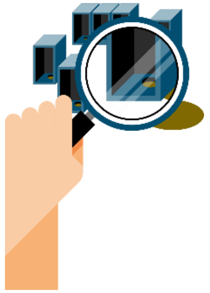
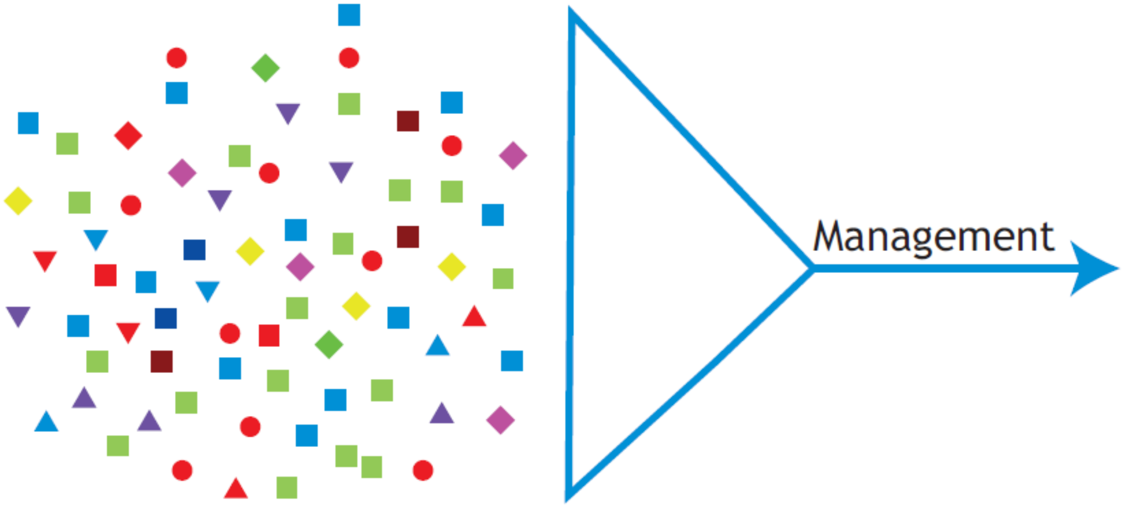
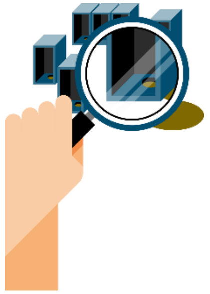




Variability of faecal sludge

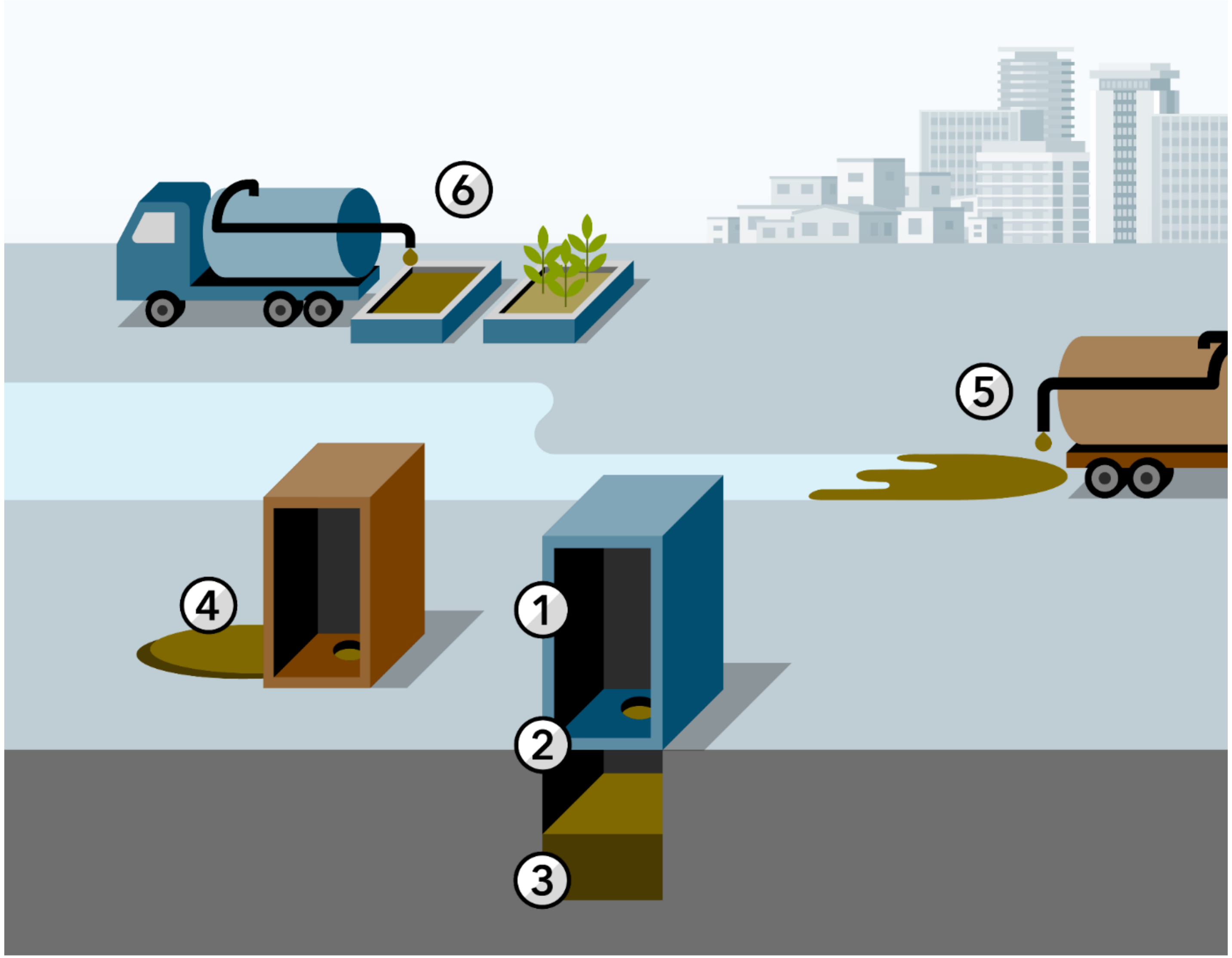


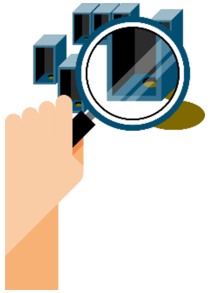
Faecal sludge characteristics (Quality)

	pH	TSS (mg/L)	tCOD (mg/L)	sCOD (mg/L)	NH_4-N (mg/L)	COD/N ratio	Alkalinity (mmol HCO_3^-/L)	Conductivity (mS/cm)
Fecal sludge	6.5-8	4,900-8,500	1,200-127,200	92-19,600	21-5,000	151/1 - 5/1	-	1.7-14.5
Fecal sludge supernatant	6.6-7.8	1-645	76-1,116	39-641	17-262	19/1-1/1.5	7.1-36.8	0.81-4.5
Primary effluent municipal wastewater	7-8	36-112	450-469	199-277	25-45	19/1-9/1	300-340	0.70-0.12

Data from Shaw et al. (2022), Verloo (2022), Ramanathan (2023), Strande et al. (2014), Ward et al. (2023), Ekama (2009), Veloz et al. (2022)

Quantities





1. Excreta produced
2. Faecal sludge produced
3. Faecal sludge accumulated
4. Faecal sludge emptied, but not collected
5. Faecal sludge collected, but not delivered to treatment plant
6. Faecal sludge treated

Q&Q

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Contents lists available at ScienceDirect

Journal of Environmental Management

journal homepage: www.elsevier.com/locate/jenvman

Research article

Methods to reliably estimate faecal sludge quantities and qualities for the design of treatment technologies and management solutions

Linda Strande[a,*], Lars Schoebitz[a], Fabian Bischoff[a], Daniel Ddiba[b], Francis Okello[b], Miriam Englund[a], Barbara J. Ward[a], Charles B. Niwagaba[b]

[a] Eawag: Swiss Federal Institute of Aquatic Science and Technology, Department of Sanitation, Water and Solid Waste for Development (Sandec), Überlandstrasse 133, 8600, Dübendorf, Switzerland

[b] Department of Civil and Environmental Engineering, College of Engineering, Design, Art and Technology (CEDAT), Makerere University, P.O. Box 7062, Kampala, Uganda

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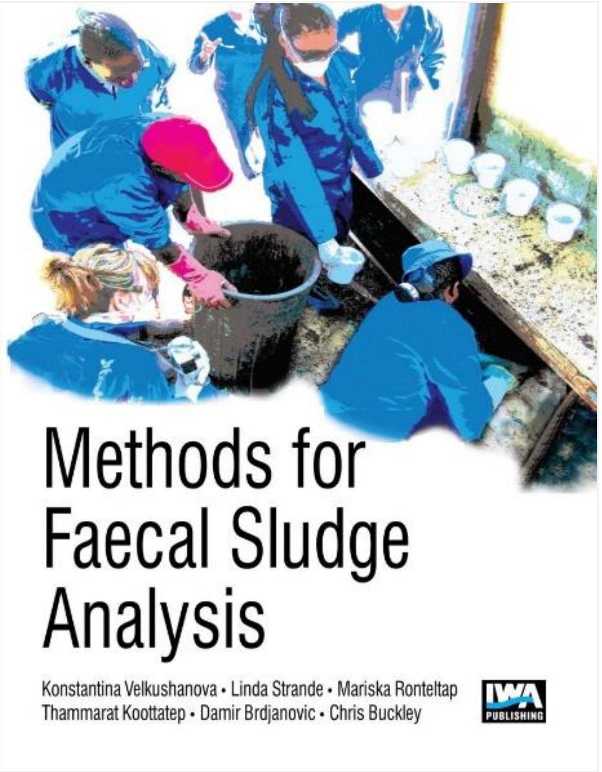
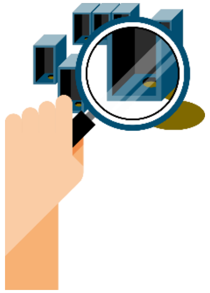
Research Paper

Methods for estimating quantities and qualities (Q&Q) of faecal sludge: field evaluation in Sircilla, India

Prerna Prasad, Nienke Andriessen, Anantha Moorthy, Amrita Das, Kayla Coppens, Rohini Pradeep and Linda Strande



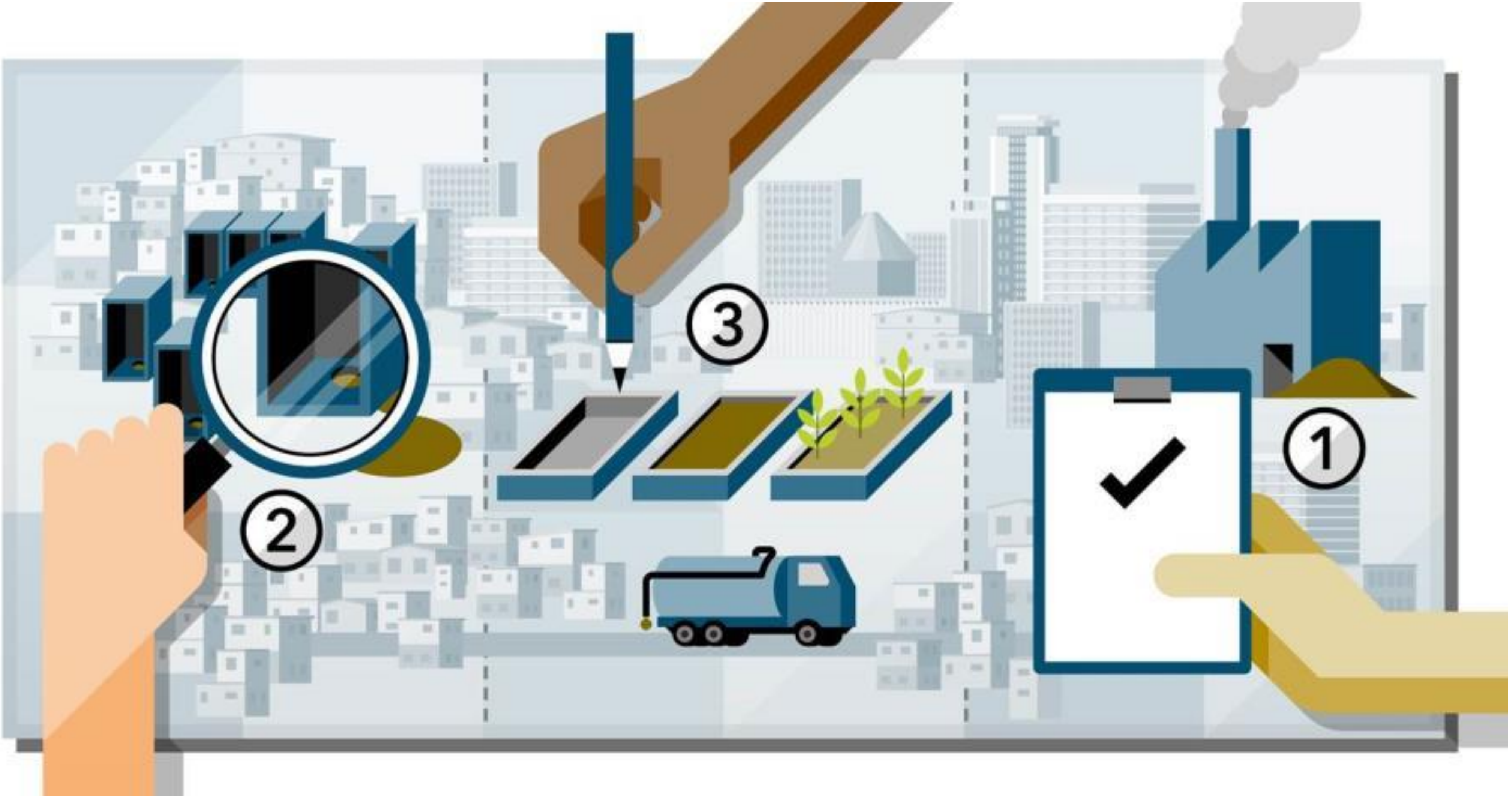
Massive Open Online Course (MOOC)

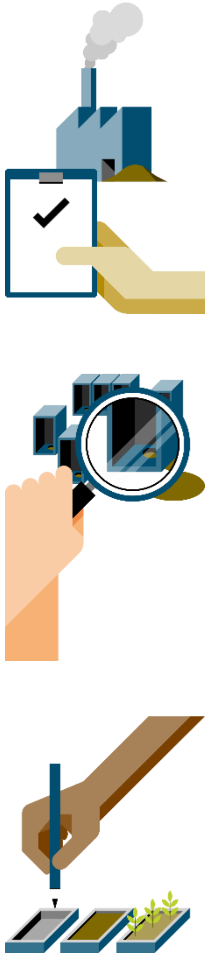


coursera.org/learn/faecalsludge

https://www.youtube.com/watch?v=J9GsW2mCKXM

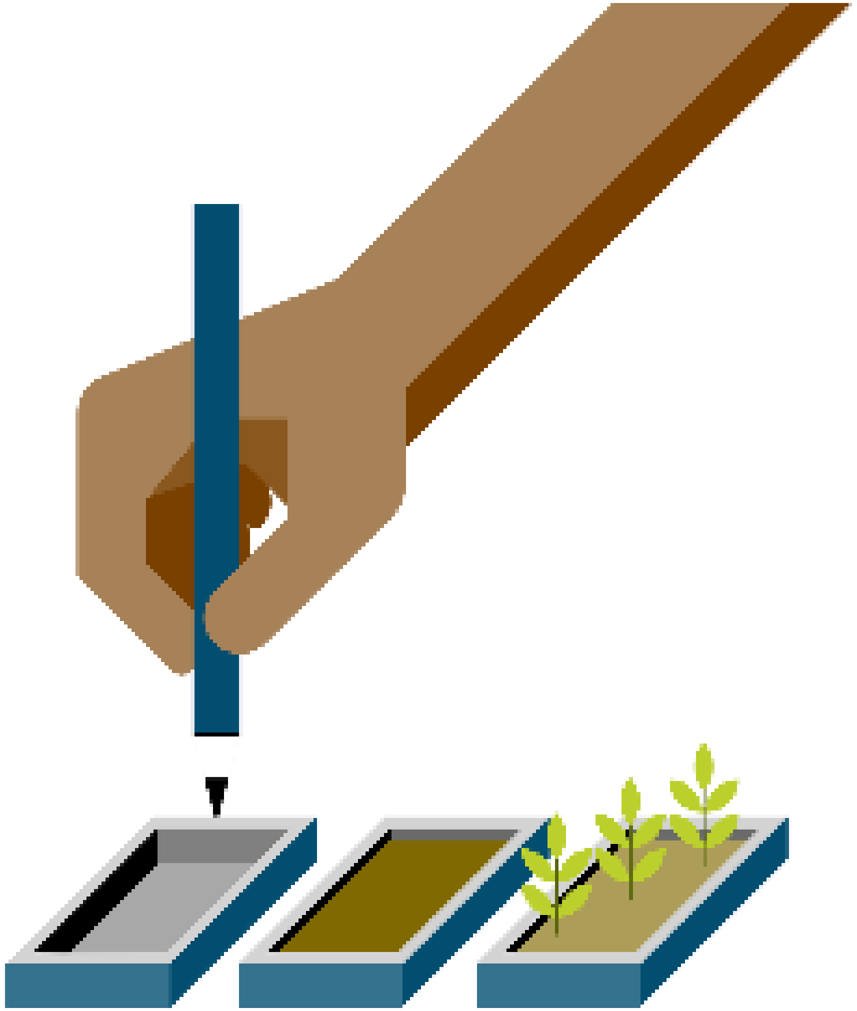
Engineering Design Approach





Engineering Design Approach

Step 3: Design of treatment technology



Treatment Technologies

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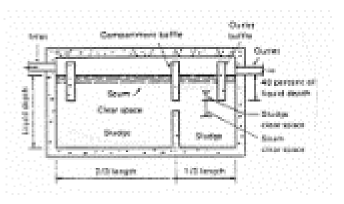
User Interface

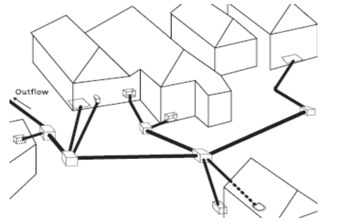
- Dry Toilet
- Urine Diverting Dry Toilet (UDDT)
- Urinal
- Pour Flush Toilet
- Cistern Flush Toilet
- Urine Diverting Flush Toilet

Storage



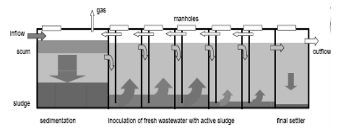
- Urine Storage Tank / Container
- Single Pit
- Single Ventilated Improved Pit (VIP)
- Double Ventilated Improved Pit (VIP)
- Fossa Alterna
- Twin Pits for Pour Flush
- Dehydr. Vaults
- Composting Chamber
- Septic Tank
- Etc.

Conveyance



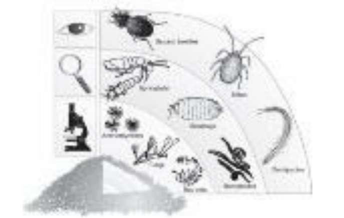
- Jerry can / Tank
- Human-Powered Emptying and Transport
- Motorized Emptying and Transport
- Simplified Sewer
- Solids-Free Sewer
- Conventional Gravity Sewer
- Transfer Station (Holding Tank)

(Semi-) Centralised Treatment



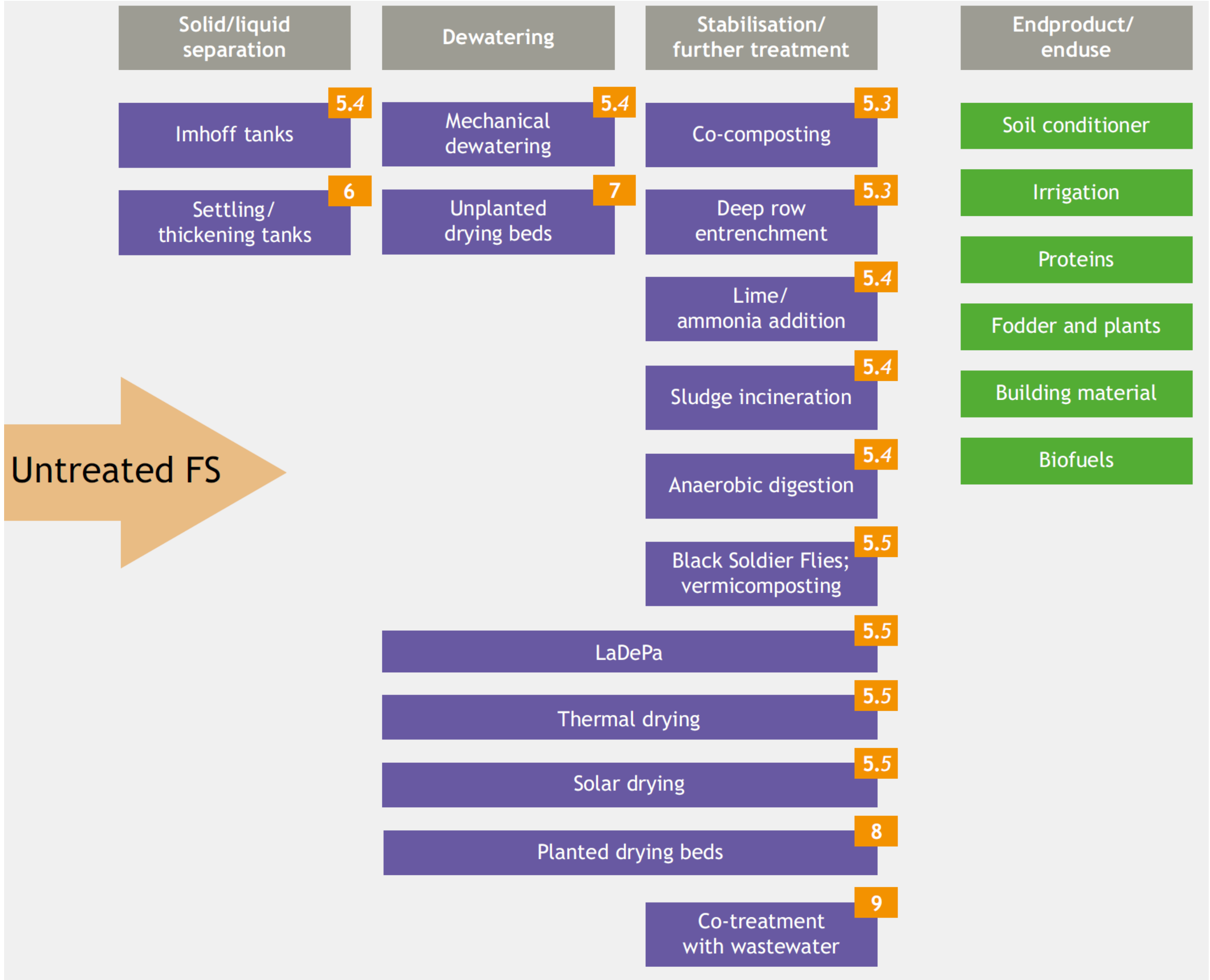
- Anaerobic Baffled Reactor (ABR)
- Anaerobic Filter
- Waste Stabilization Ponds
- Aerated Pond
- Constructed Wetland
- Trickling Filter
- Activated Sludge
- Drying Beds
- Co-composting
- Biogas Reactor
- Etc.

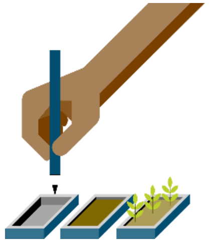
Use and / or Disposal



- Fill and Cover / Arborloo
- Applic. of Urine
- Application of Dehydr. Faeces / Compost/Sludge
- Irrigation
- Soak Pit
- Leach Field
- Fish Pond
- Floating Plant Pond
- Water Disposal / Groundwater Recharge
- Surface Disposal
- Biogas Combust.

Treatment technologies





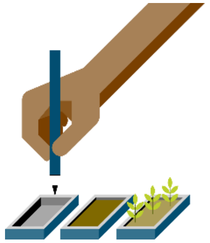
Treatment Technologies

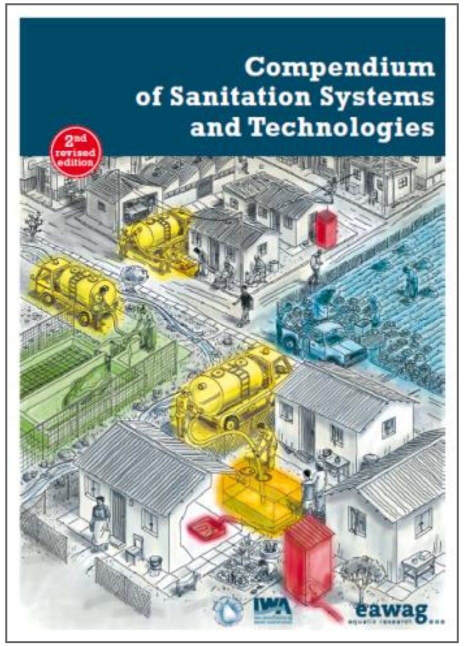
For Wastewater

- T.1 Settler
- T.2 Imhoff Tank
- T.3 Anaerobic Baffled Reactor (ABR)
- T.4 Anaerobic Filter
- T.5 Waste Stabilization Ponds (WSP)
- T.6 Aerated Pond
- T.7 Free-Water Surface Constructed Wetland
- T.8 Horizontal Subsurface Flow constructed Wetland
- T.9 Vertical Flow constructed Wetland
- T.10 Trickling filter
- T.11 Upflow Anaerobic Sludge blanket Reactor (UASB)
- T.12 Activated Sludge

For Fecal Sludge

- T.13 Sedimentations / Thickening Ponds
- T.14 Unplanted Drying Beds
- T.15 Planted Drying Beds
- T.16 Co-composting
- T.17 Biogas Reactor



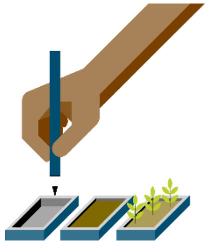


Guide to Sanitation Resource Recovery Products & Technologies

For Fecal Sludge

- T.20 Vermicomposting and Vermifiltration
- T.21 Black Soldier Fly Composting
- T.26 Incineration
- T.27 Carbonization
- T.28 Solar Drying

Treatment technologies



- **Pre-treatment**
  example: removal of oil, grease, sand or trash

- **Primary treatment:** solid-liquid separation (dewatering)
  example: a settling-thickening tank

- **Secondary treatment:** biological removal of organic matter, nutrients and remaining suspended solids
  example: anaerobic digestion

- **Post-treatment or tertiary treatment:** final polishing
  example: removal of remaining pathogens, nutrients or micropollutants

Level of development

- **Innovative:** New technologies that are still in the pilot phase and need more research before large scale implementation.

- **Transferring:** Have been used for wastewater treatment, and are in the process of being adapted for faecal sludge

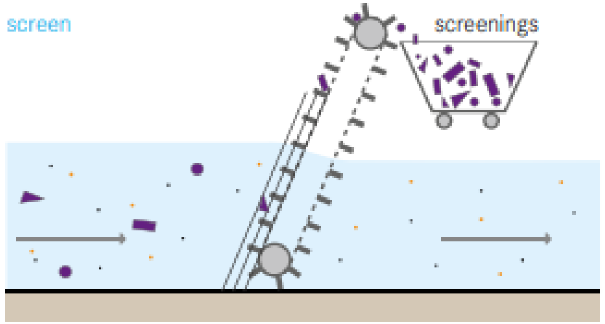
- **Established:** Are established technologies for treating faecal sludge

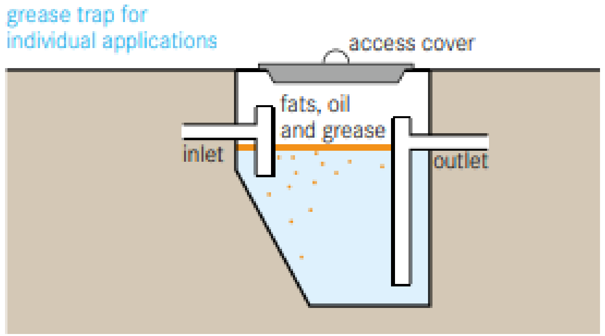
Pre-treatment

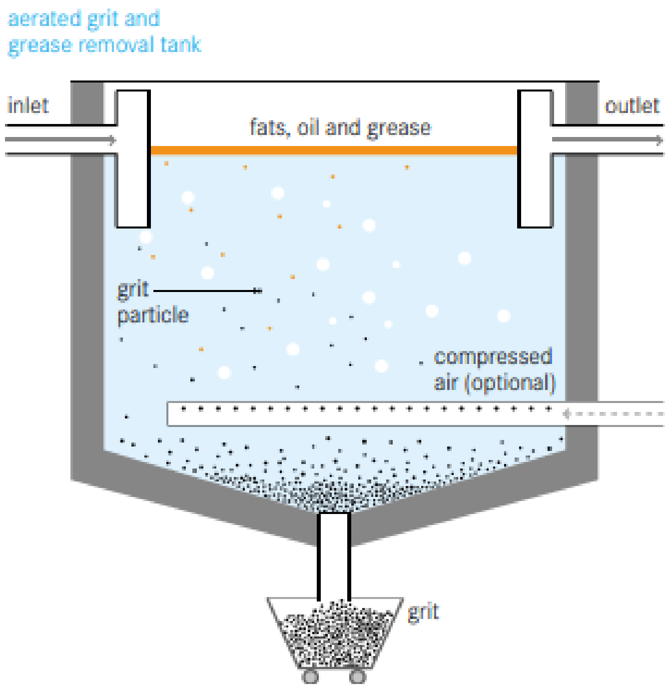
PRE **Pre-Treatment Technologies**

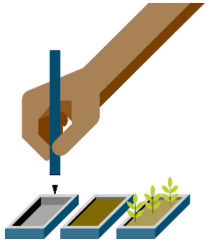
Applicable to: **Systems 1, 6-9**

Application Level:	Management Level:	Inputs / Outputs
Household	Household	**Inputs:** Blackwater, Brownwater, Greywater, Sludge
Neighbourhood	Shared	**Outputs:** Blackwater, Brownwater, Greywater, Sludge, Pre-Treatment Products
City	Public	









Advantages:

+ Relatively low capital and operating costs
+ Reduced risk of impairing subsequent Conveyance and/or Treatment technologies
+ Higher lifetime and durability of sanitation hardware

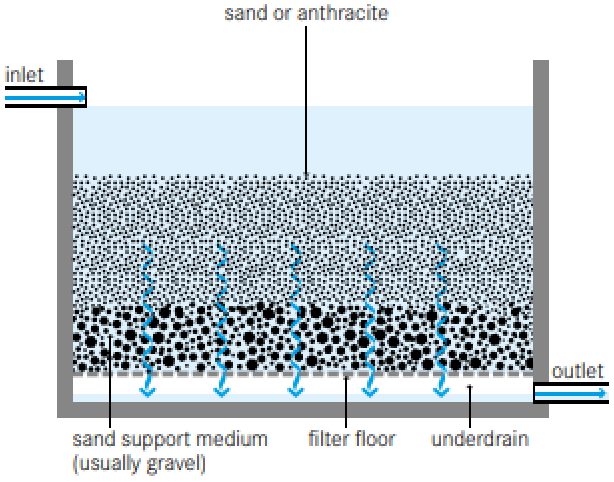
Disadvantages

- Frequent maintenance required
- The removal of solids and grease is not pleasant

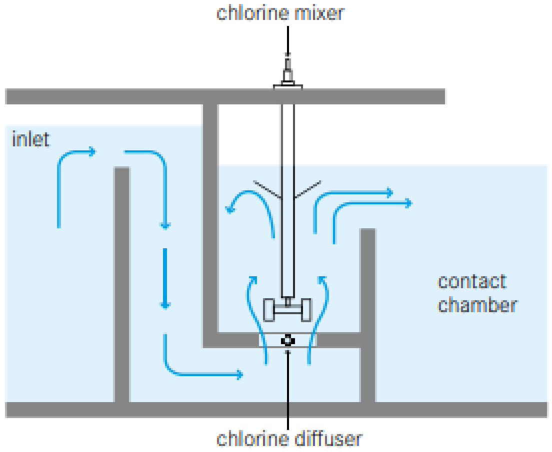
Tertiary Treatmetn & Disinfection

POST | **Tertiary Filtration and Disinfection** | Applicable to: **Systems 1, 6-9**

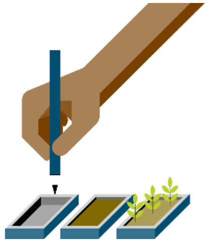
Application Level:	Management Level:	Inputs / Outputs
Household	Household	**Inputs:** Effluent
★ Neighbourhood	★ Shared	**Outputs:** Effluent
★★ City	★★ Public	



tertiary filtration (e.g., depth filtration)



disinfection (e.g., chlorination)



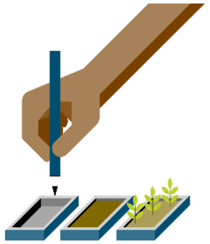
<u>Advantages:</u>

+ Additional removal of pathogens and/or chemical contaminants
+ Allows for direct reuse of treated wastewater

<u>Disadvantages</u>

- Skills, Technology, spare parts and materials may not be locally available
- High capital and operating costs
- May require constant source of electricity or chemicals
- Continuous monitoring
- Filter materials need regular maintenance
- Chlorination / Ozonation can form toxic by-products

Exercise: Treatment technologies



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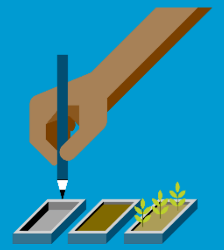
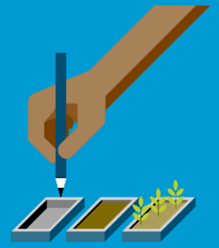


Treatment Technology Activity

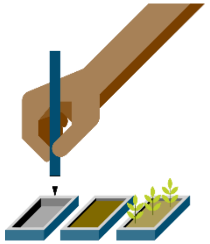


Treatment Technology Activity

Plenary

Treatment technologies - Summary

eawag
aquatic research

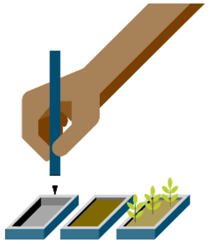


In general, often need several technologies in a particular order to effectively treat FS.

Examples:

- To compost sludge, it must first be dewatered
- Compost from vermicomposting cannot be directly applied to agricultural lands – first need to inactivate pathogens through co-composting
- For Briquettes, need to dewater and dry

Treatment technologies



Besides treatment objectives, treatment products and level of technology development, there are other factors which may influent the selection of treatment technologies

Photos from the field

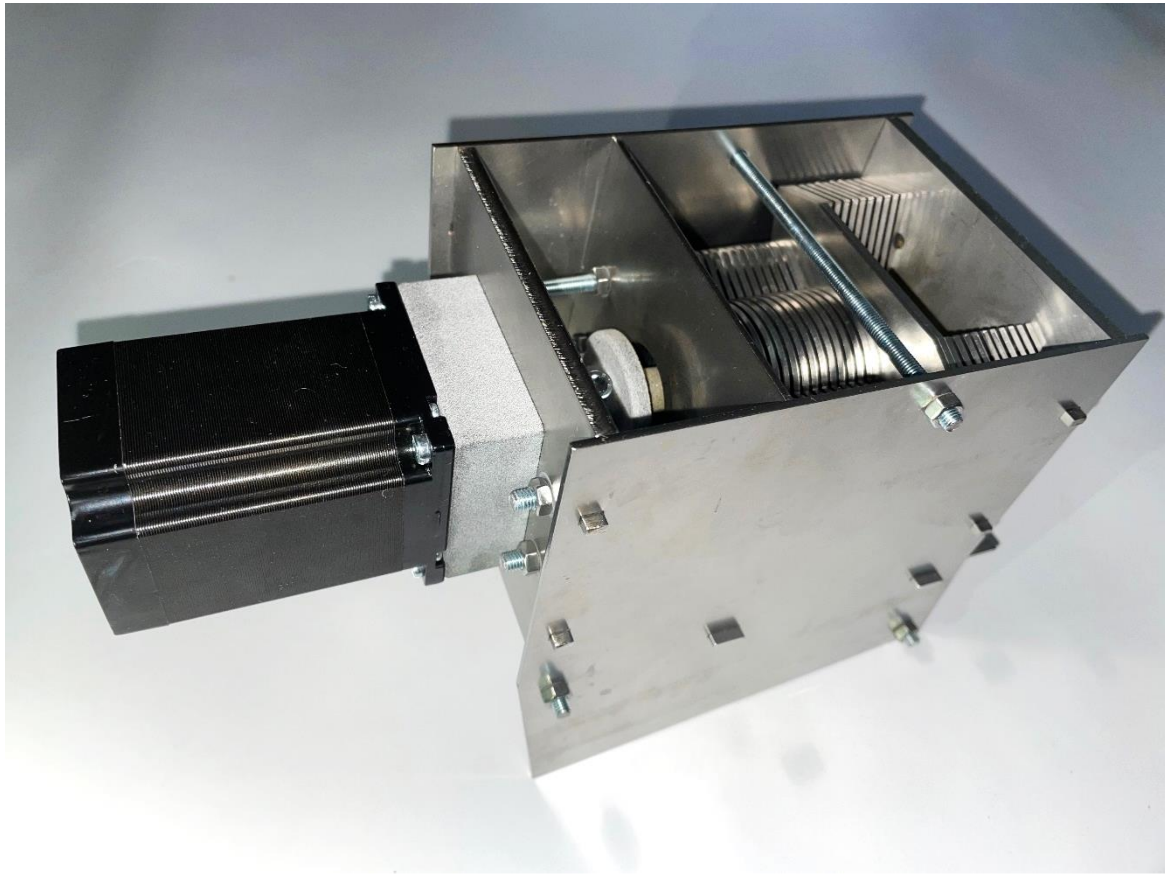
Settling-thickening tank

Unplanted drying beds

Planted drying beds

Co-composting

Mechanical dewatering

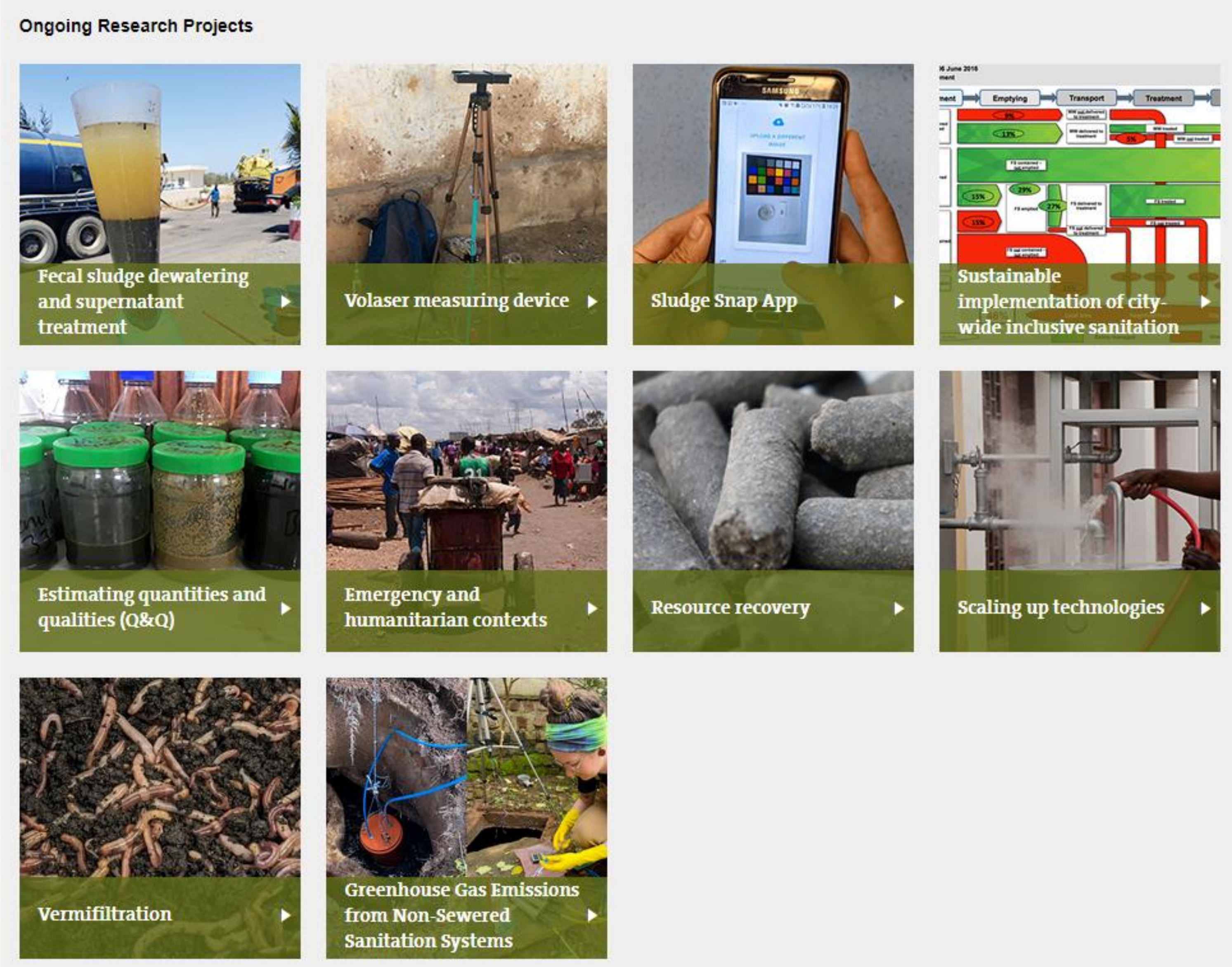


Waste stabilization ponds

For more information…

Management of Excreta, Wastewater and Sludge

eawag
aquatic research

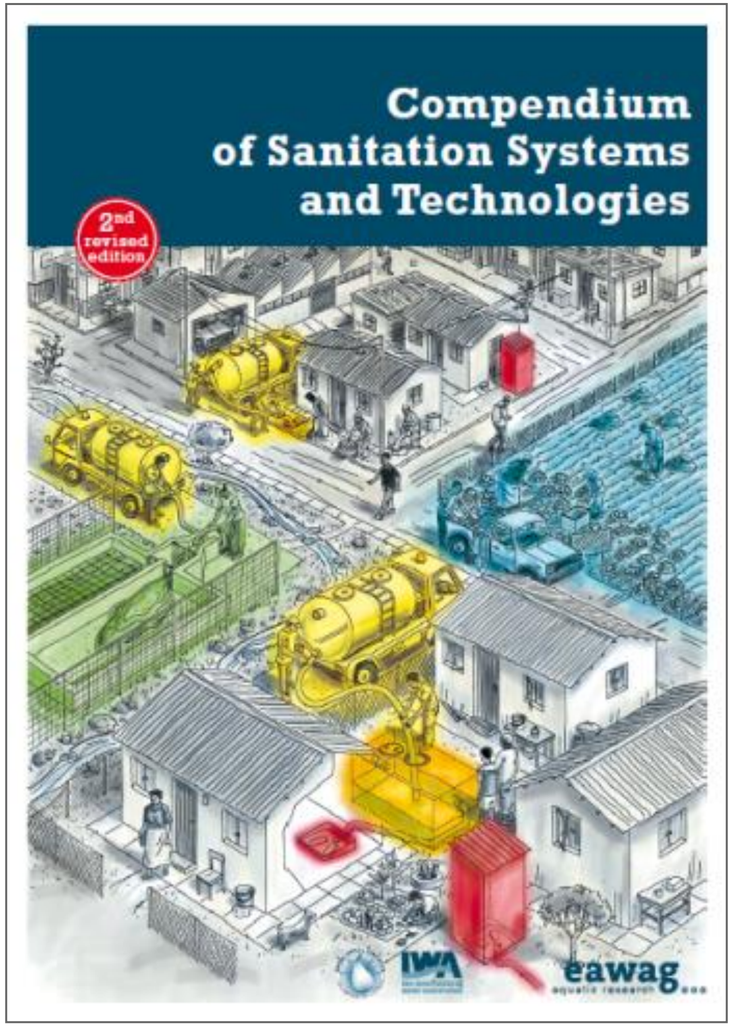


www.sandec.ch/mews

Useful Resource

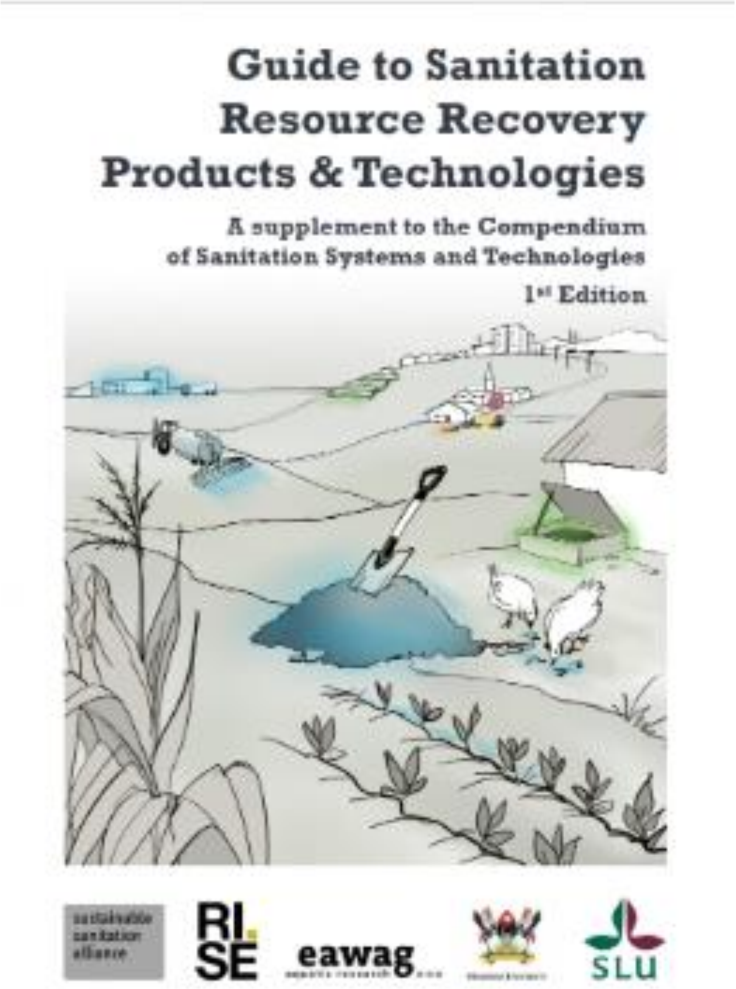
Compendium of Sanitation Systems and Technologies

sandec.ch/compendium



Guide to Sanitation Resource Recovery Products & Technologies

https://www.susana.org/en/knowledge-hub/resources-and-publications/library/details/4008#



Useful resource

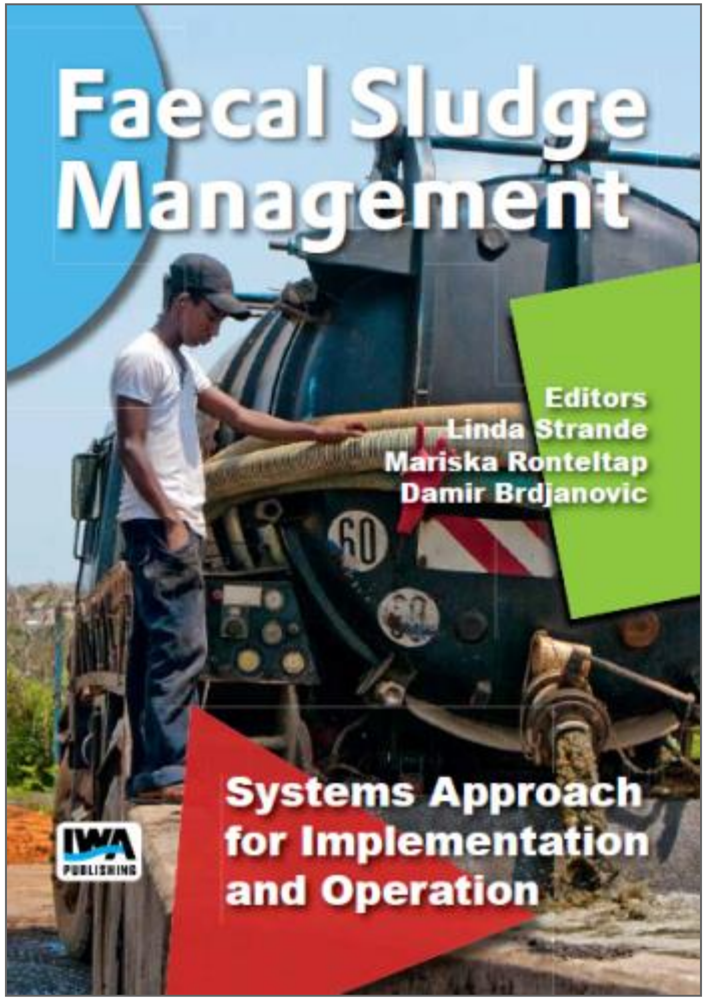
eawag
aquatic research

Overview of anything FSM

Including:

- Characteristics
- Treatment technologies
- Planning
- Enabling environment
- Systems approach

www.sandec.ch/fsm_book



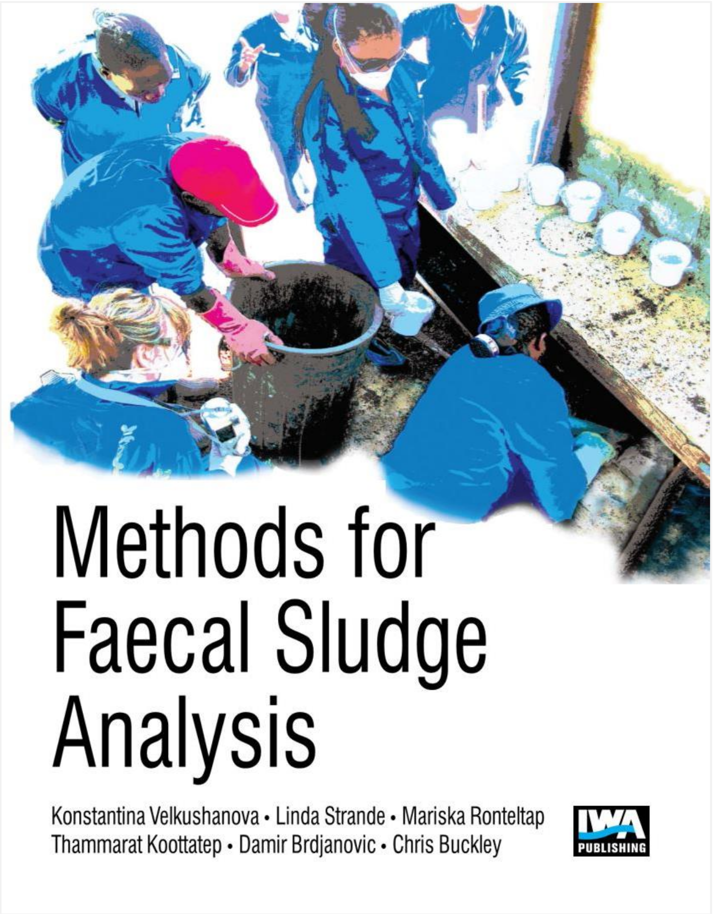
Useful resource

Guidelines for standard practices

Including:

- Background info on types of faecal sludge
- Methods for sample collection
- Health and safety procedures for handling
- Approach for estimating quantities & qualities on community to city-wide scale
- Laboratory methods for faecal sludge analysis

www.sandec.ch/fsm_methods



Thank you for your attention!