Eawag
Swiss Federal Institute of Aquatic Science and Technology

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Sanitation Systems and Technologies

Philippe Reymond – Eawag-Sandec

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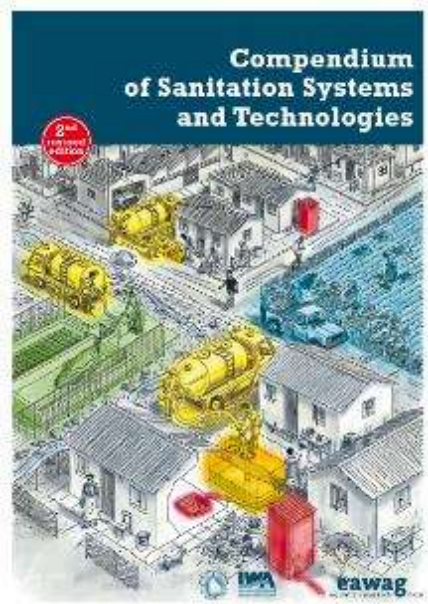
Sanitary Engineering for Development, EPFL, 2025

About me

- EPFL – Environmental Science & Engineering Master 2008
- Work at or close to Eawag-Sandec since 2008: **www.sandec.ch**
- Member of the WASH expert group of the Swiss Humanitarian Aid (SHA)
- Deployed for 3 years at **UNHCR, Geneva Technical Hub**, as a sanitation specialist
- Past sanitation consultant at Vuna Ltd.
- Board member of VaLoo, the Swiss Circular Network for Circular Sanitation

About me


Compendium
of Sanitation Systems
and Technologies
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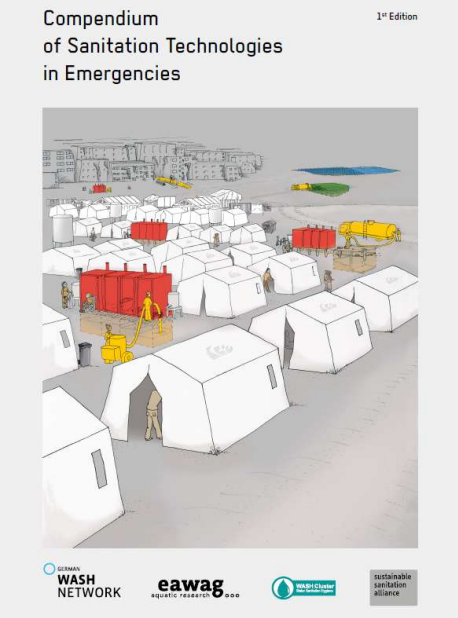
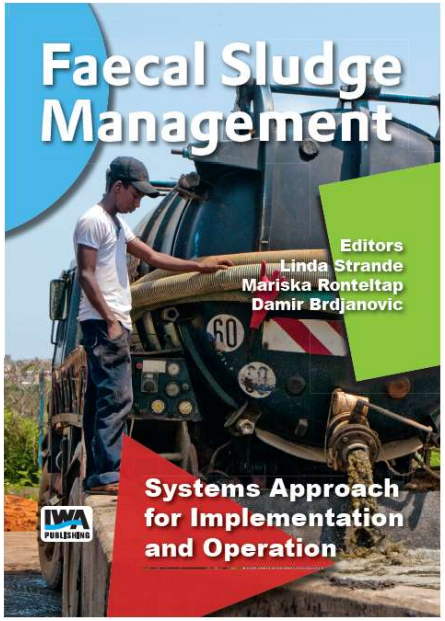

Compendium
of Sanitation Technologies
in Emergencies
1st Edition
WASH
NETWORK
eawag


Faecal Sludge
Management
Editors
Linda Strande
Mariska Ronteltap
Damir Brdjanovic
Systems Approach
for Implementation
and Operation
IWA
PUBLISHING

Learning objectives

- Learn how to use the Compendium of Sanitation Systems and Technologies
- Understand the concepts of functional groups and sanitation systems
- Be able to compare several technologies for each functional group of the sanitation service chain

Compendium of Sanitation Systems and Technologies

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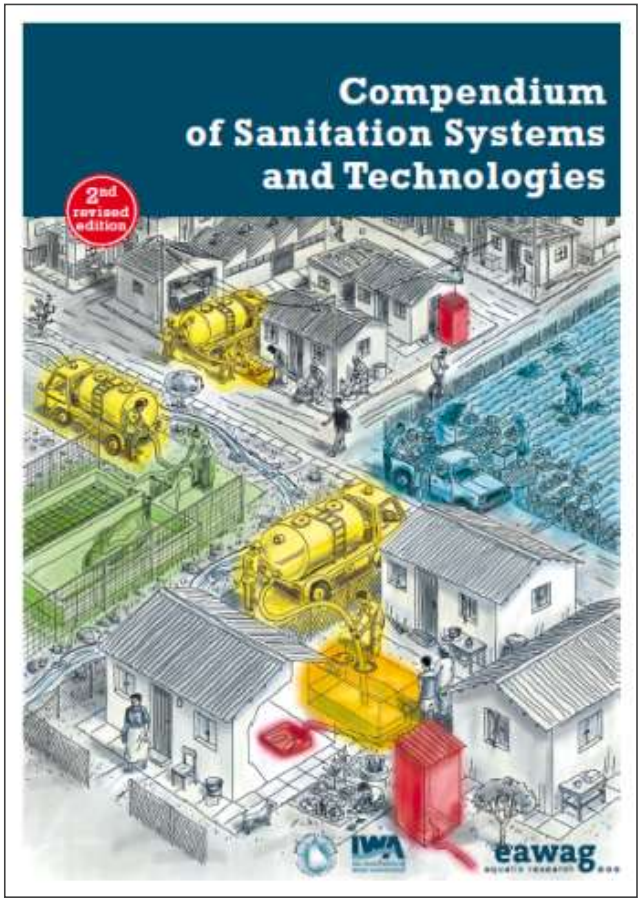
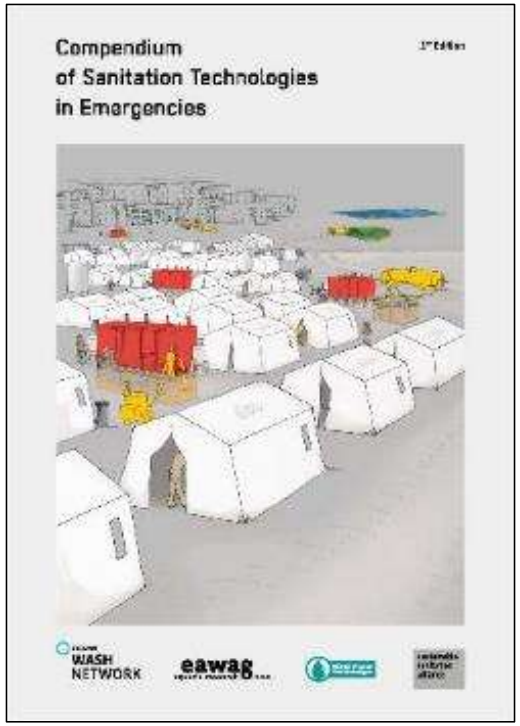
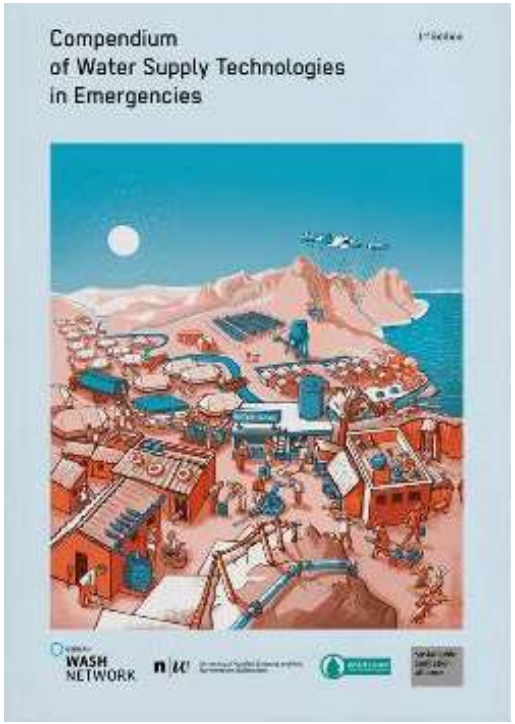
sandec.ch/compendium



Compendiums of WASH in Emergencies





A tool for WASH planning

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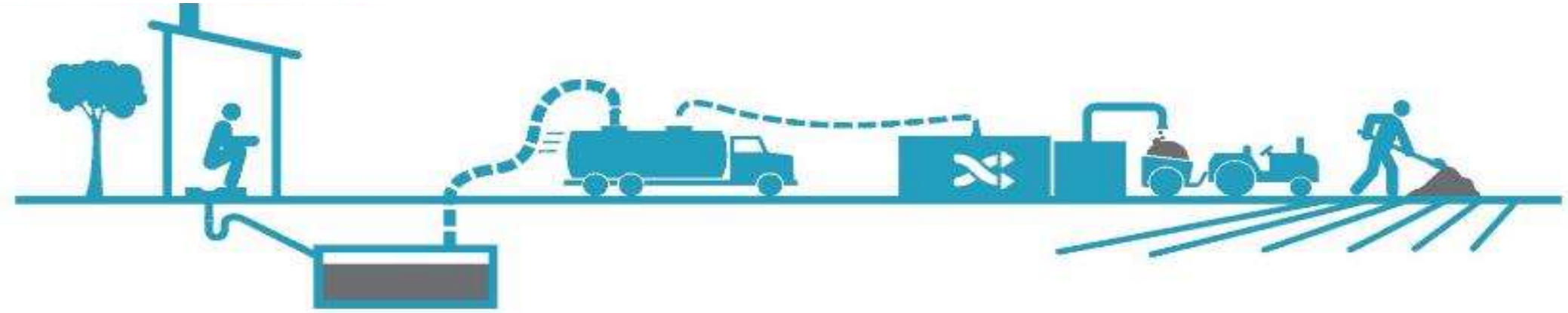
The Compendium follows the sanitation service chain

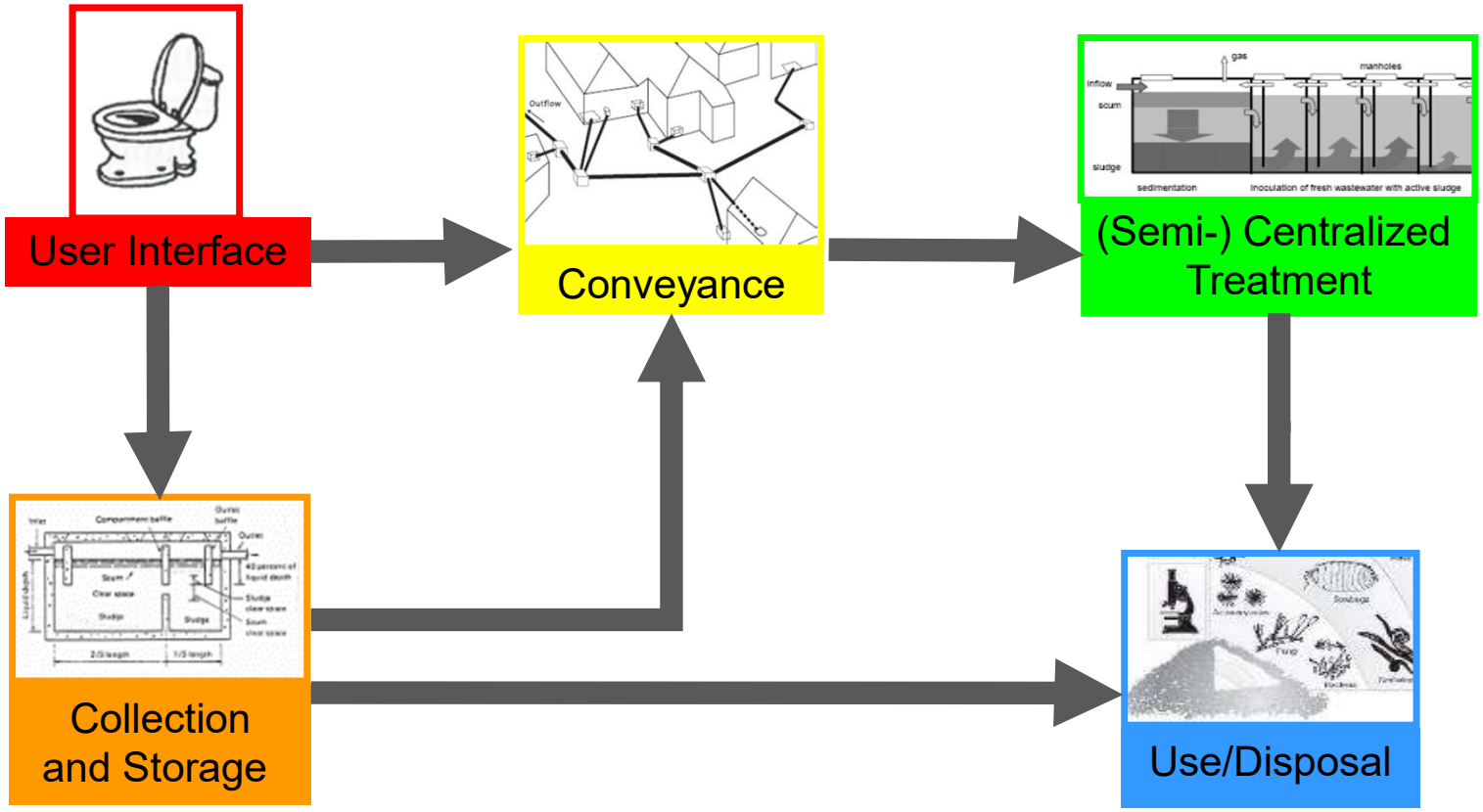
A system's approach to understand the various stages of the services and infrastructure required.



USER INTERFACE > COLLECTION & STORAGE > CONVEYANCE > TREATMENT > REUSE & DISPOSAL

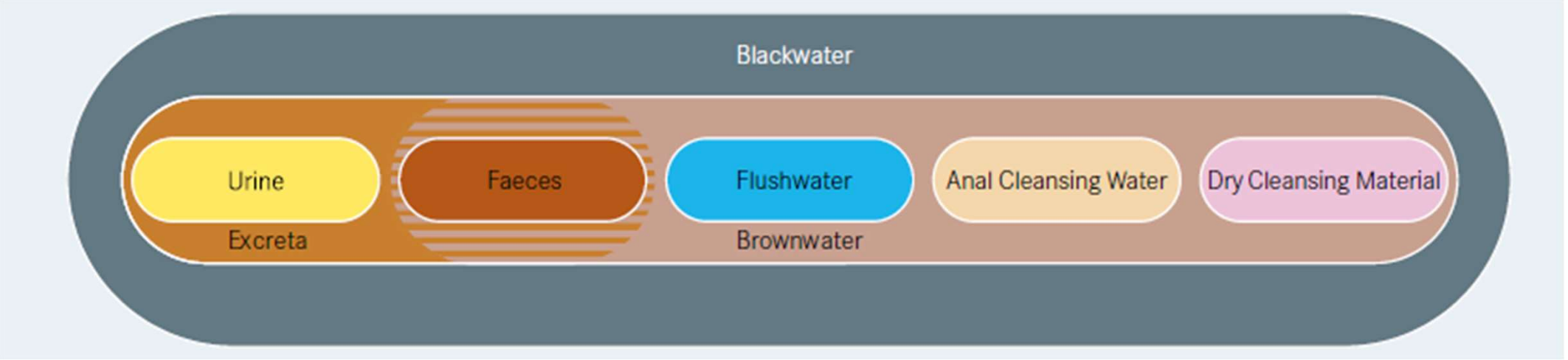
The Systems approach

Five functional groups



What are waste streams we have to manage?

Let's start with user interface levels



Overview of Functional Groups and Sanitation

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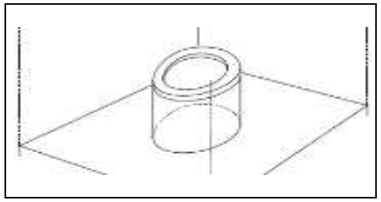
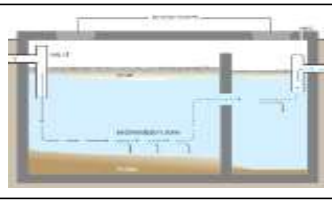
Technologies

User Interface



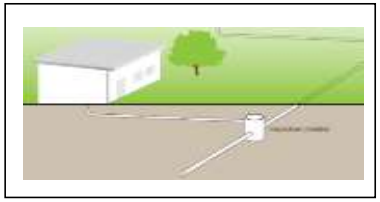
- Dry Toilet
- Urine Diverting Dry Toilet (UDDT)
- Urinal
- Pour Flush Toilet
- Cistern Flush Toilet
- Urine Diverting Flush Toilet

Collection and Storage / Treatment



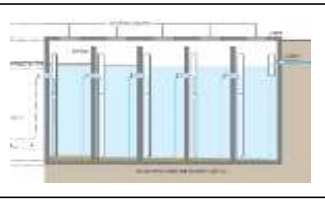
- Urine Storage Tank / Container
- Single Pit
- Single Ventilated Improved Pit (VIP)
- Double Ventilated Improved Pit (VIP)
- Fossa Alterna
- Twin Pits for Pour Flush
- Dehydr. Vaults
- Composting Chamber
- Septic Tank
- Etc.

Conveyance



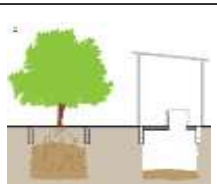
- Jerry can / Tank
- Human-Powered Emptying and Transport
- Motorized Emptying and Transport
- Simplified Sewer
- Solids-Free Sewer
- Conventional Gravity Sewer
- Transfer Station (Holding Tank)

(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.

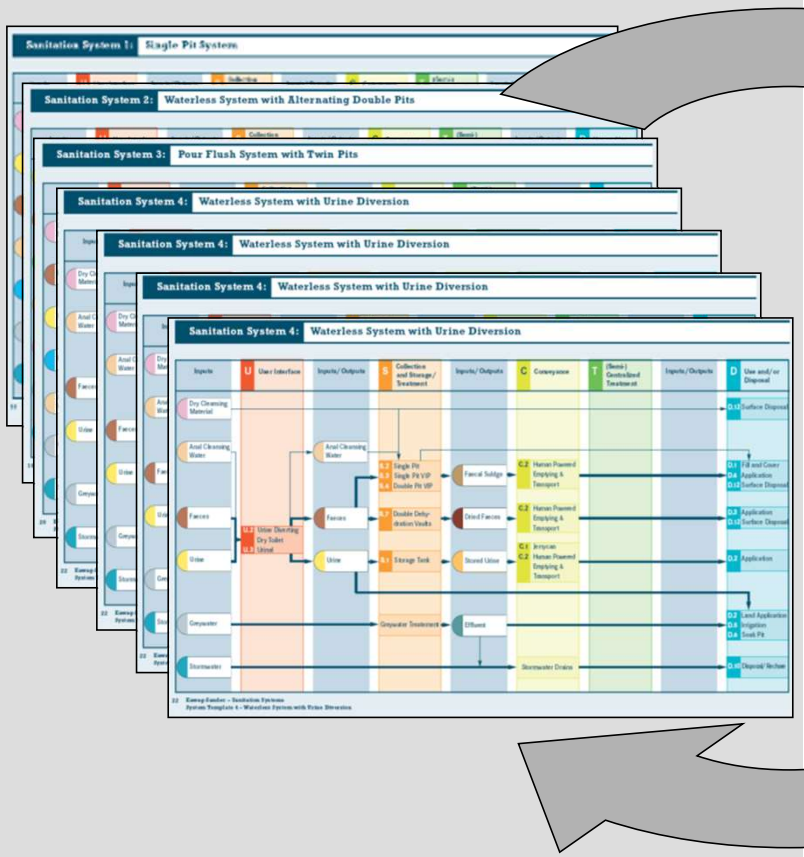
Use and / or Disposal



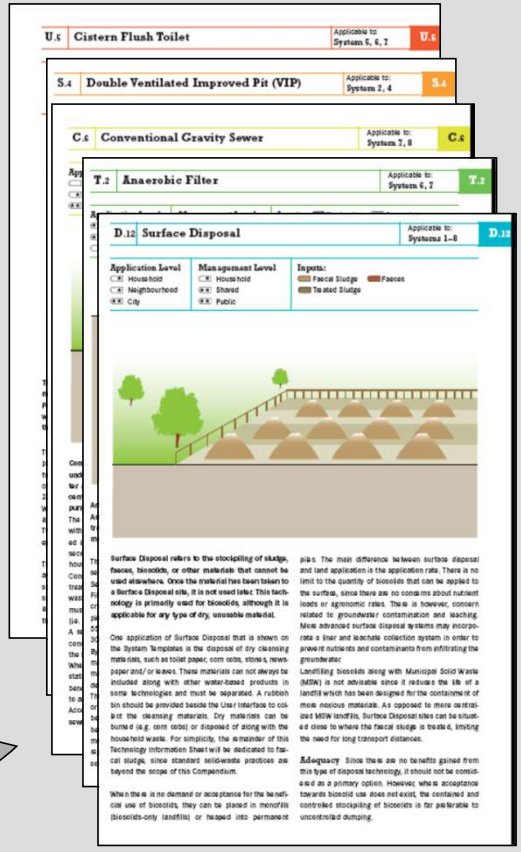
- Fill and Cover / Arborloo
- Applic. of Urine
- Application of Dehydr. Faeces / Compost/Sludge
- Irrigation
- Soak Pit
- Leach Field
- Fish Pond
- Floating Plant Pond
- Water Disposal / Groundwater Recharge
- Surface Disposal
- Biogas Combust.

How is the Compendium organised?

Part 1:
Sanitation System Templates



Part 2:
Technology Information Sheets

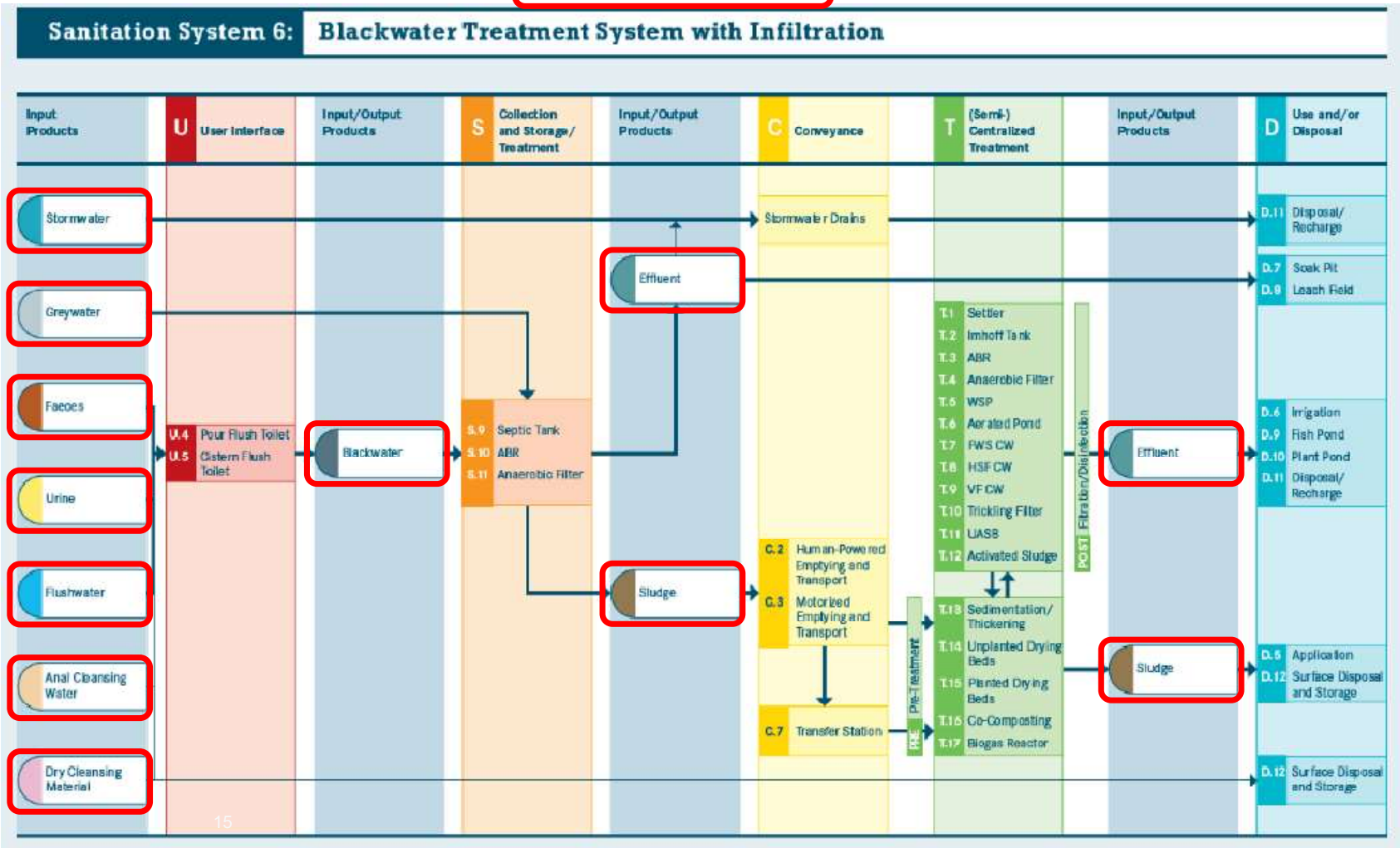


Part I: Sanitation System Templates

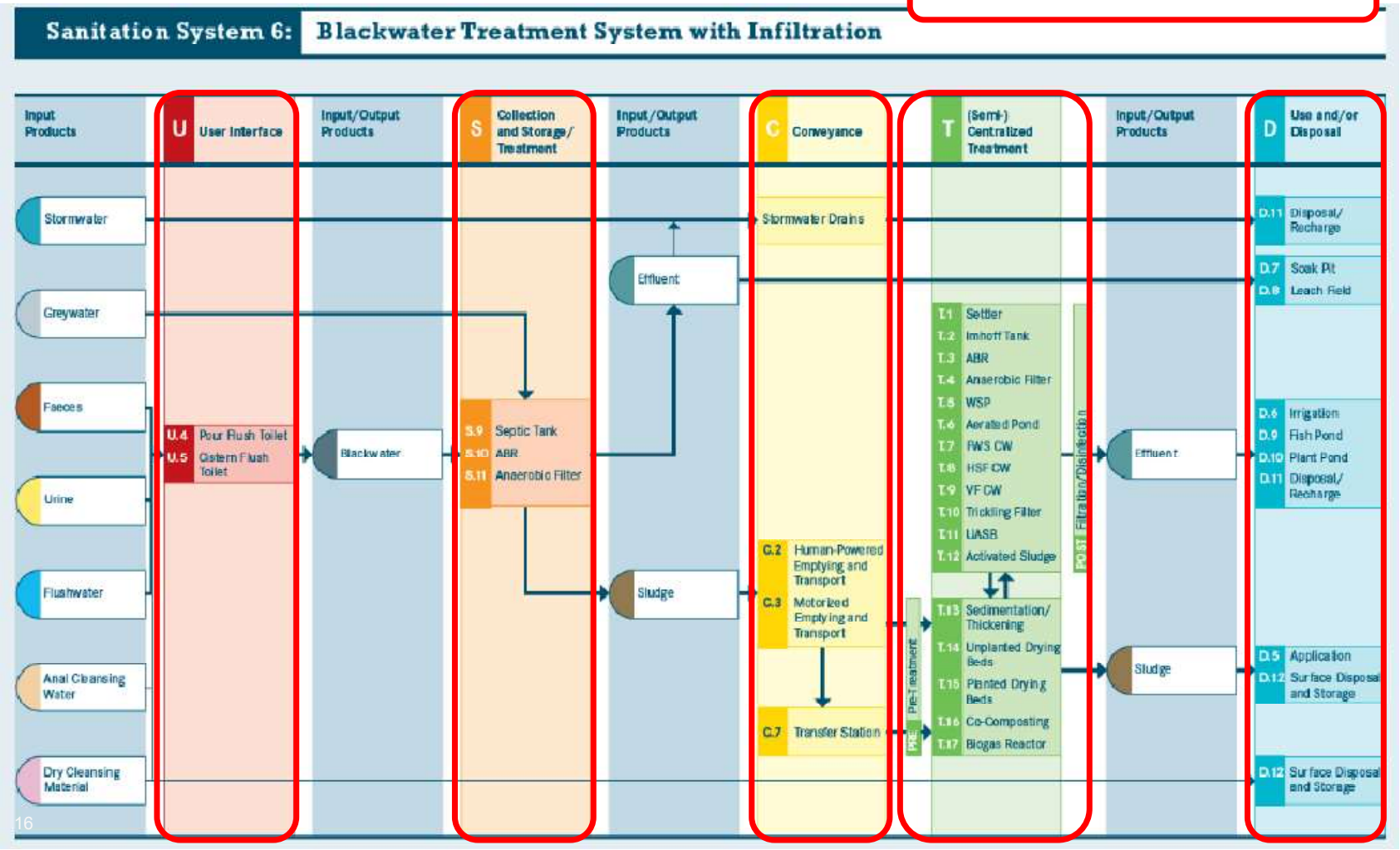
9 most common sanitation systems described

System 1:	Single Pit System
System 2:	Waterless Pit System without Sludge Production
System 3:	Pour Flush Pit System without Sludge Production
System 4:	Waterless System with Urine Diversion
System 5:	Biogas System
System 6:	Blackwater Treatment System with Infiltration
System 7:	Blackwater Treatment System with Effluent Transport
System 8:	Blackwater Transport to (Semi-) Centralized Treatment System
System 9:	Sewerage System with Urine Diversion

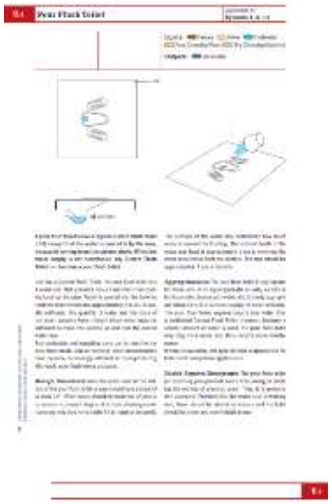
Products

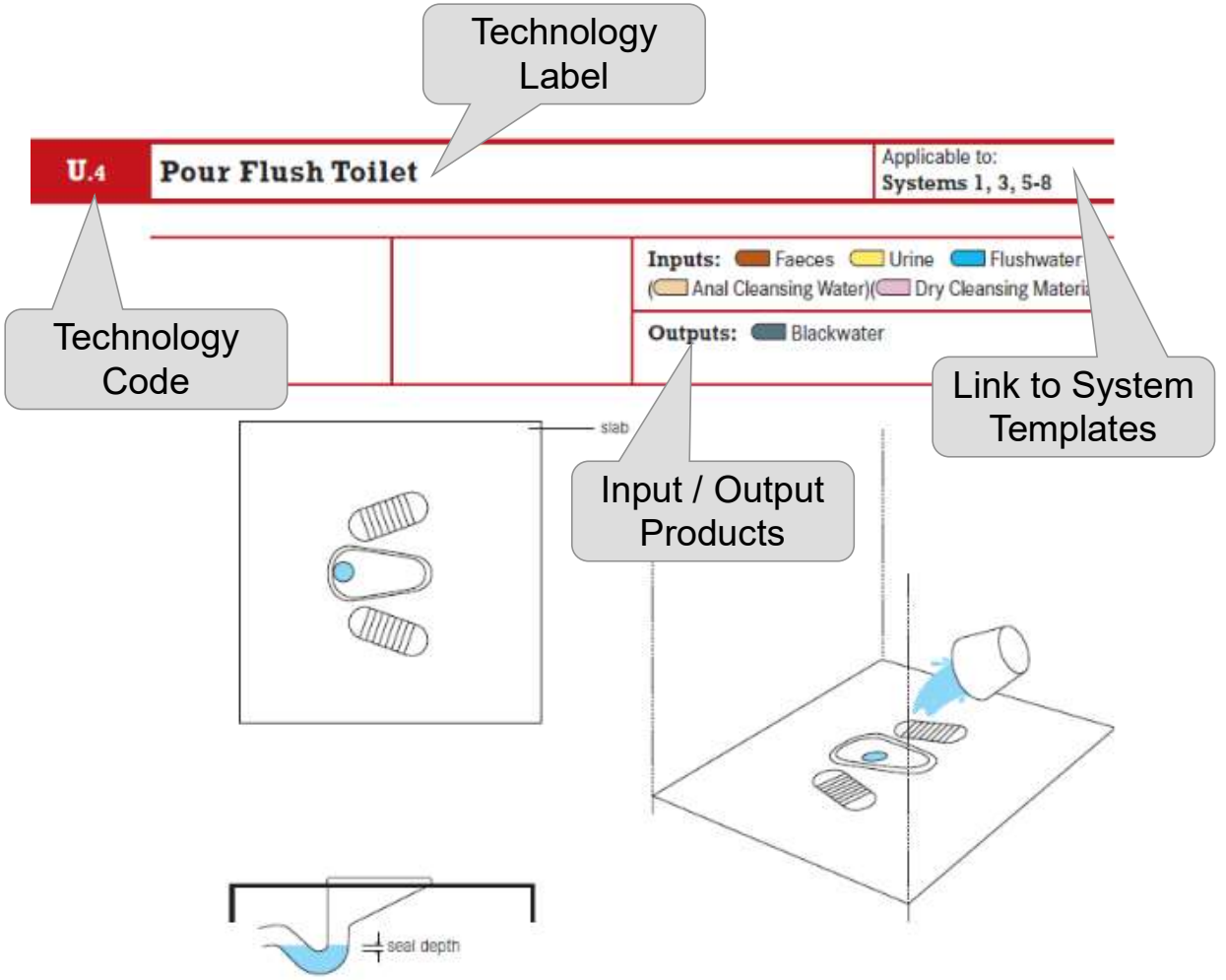

Sanitation System 6: Blackwater Treatment System with Infiltration
Input Products
U User Interface
Input/Output Products
S Collection and Storage/ Treatment
Input/Output Products
C Conveyance
T (Semi-) Centralized Treatment
Input/Output Products
D Use and/or Disposal
Stormwater
Greywater
Faeces
Urine
Flushwater
Anal Cleansing Water
Dry Cleansing Material
U.4 Pour Flush Toilet
U.5 Cistern Flush Toilet
Blackwater
S.9 Septic Tank
S.10 ABR
S.11 Anaerobic Filter
Effluent
Sludge
Stormwater Drains
C.2 Human-Powered Emptying and Transport
C.3 Motorized Emptying and Transport
C.7 Transfer Station
Pre-Treatment
T.1 Settler
T.2 Imhoff Tank
T.3 ABR
T.4 Anaerobic Filter
T.5 WSP
T.6 Aerated Pond
T.7 FWS CW
T.8 HSF CW
T.9 VF CW
T.10 Trickling Filter
T.11 UASB
T.12 Activated Sludge
T.13 Sedimentation/ Thickening
T.14 Unplanted Drying Beds
T.15 Planted Drying Beds
T.16 Co-Composting
T.17 Biogas Reactor
POST Filtration/Disinfection
Effluent
Sludge
D.11 Disposal/ Recharge
D.7 Soak Pit
D.8 Leach Field
D.6 Irrigation
D.9 Fish Pond
D.10 Plant Pond
D.11 Disposal/ Recharge
D.5 Application
D.12 Surface Disposal and Storage
D.12 Surface Disposal and Storage
15

Functional Groups



Part II: Technology Information Sheets





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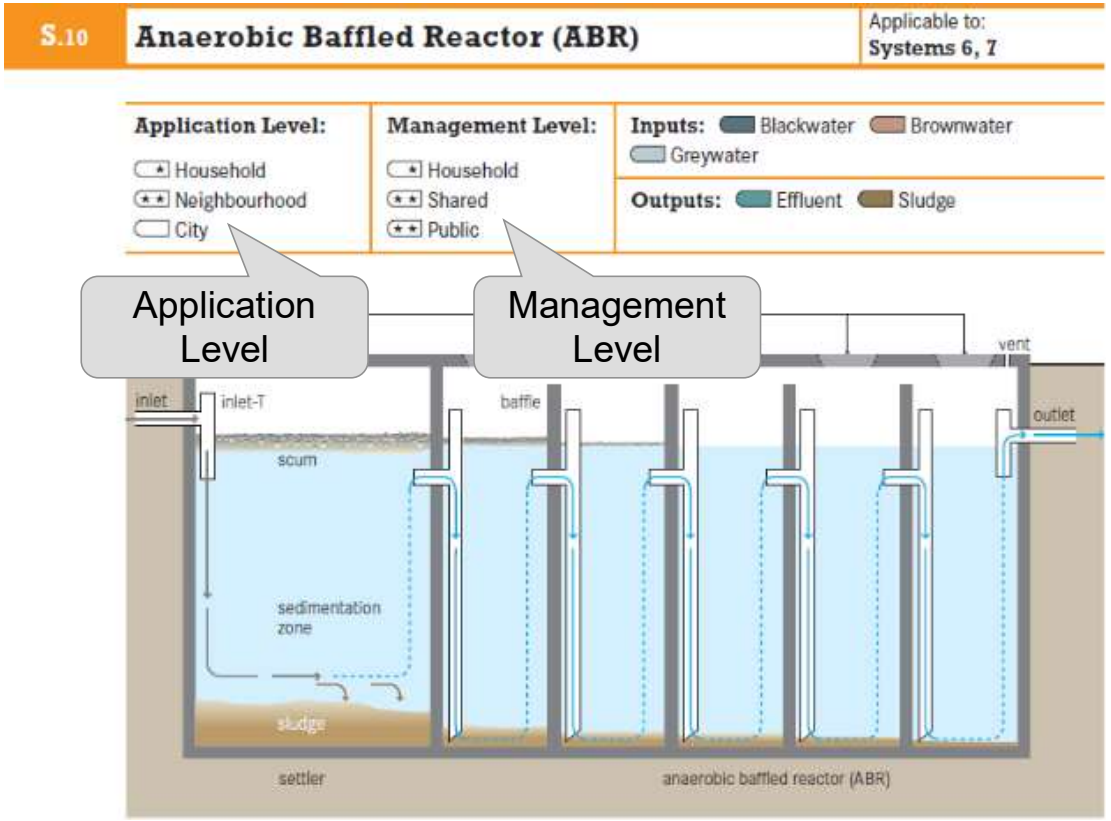

Why is the Biogas Reactor shown 2x: S.12 and T.17?

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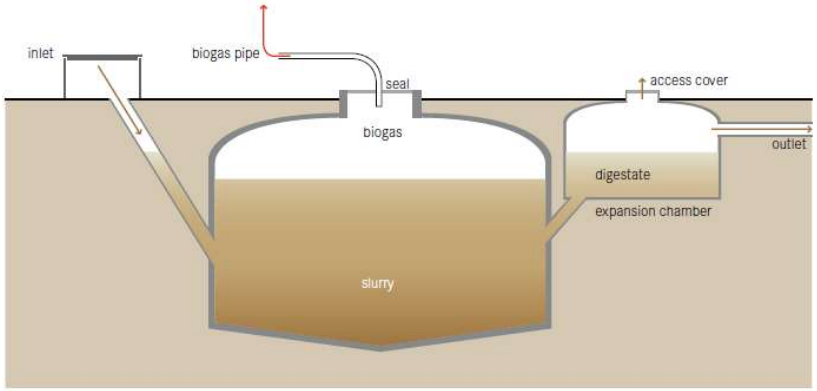
S.12 Biogas Reactor — Applicable to: **System 5**

Application Level:	Management Level:	Inputs: Sludge, Blackwater, Brownwater, Organics
★★ Household	★★ Household	Outputs: Sludge, Biogas
★★ Neighbourhood	★★ Shared	
★★ City	★★ Public	



A biogas reactor or anaerobic digester is an anaerobic treatment technology that produces (a) a digested slurry (digestate) that can be used as a fertilizer and (b) biogas that can be used for energy. Biogas is a mix of methane, carbon dioxide and other trace gases which can be converted to heat, electricity or light.

exerts a pressure and displaces the slurry upward into an expansion chamber. When the gas is removed, the slurry flows back into the reactor. The pressure can be used to transport the biogas through pipes. In a floating dome reactor, the dome rises and falls with the production and withdrawal of gas. Alternatively, it can expand (like a balloon). To minimize distribution losses,

T.17 Biogas Reactor — Applicable to: **Systems 1, 6-9**

Application Level:	Management Level:	Inputs: Sludge, Blackwater, Brownwater, Organics
★★ Household	★★ Household	Outputs: Sludge, Biogas
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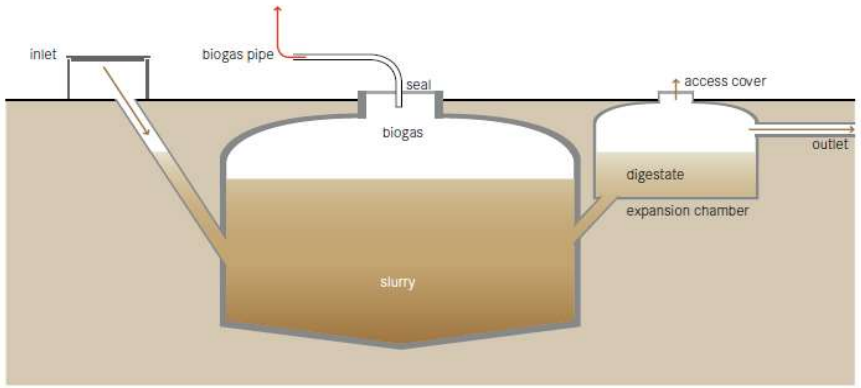
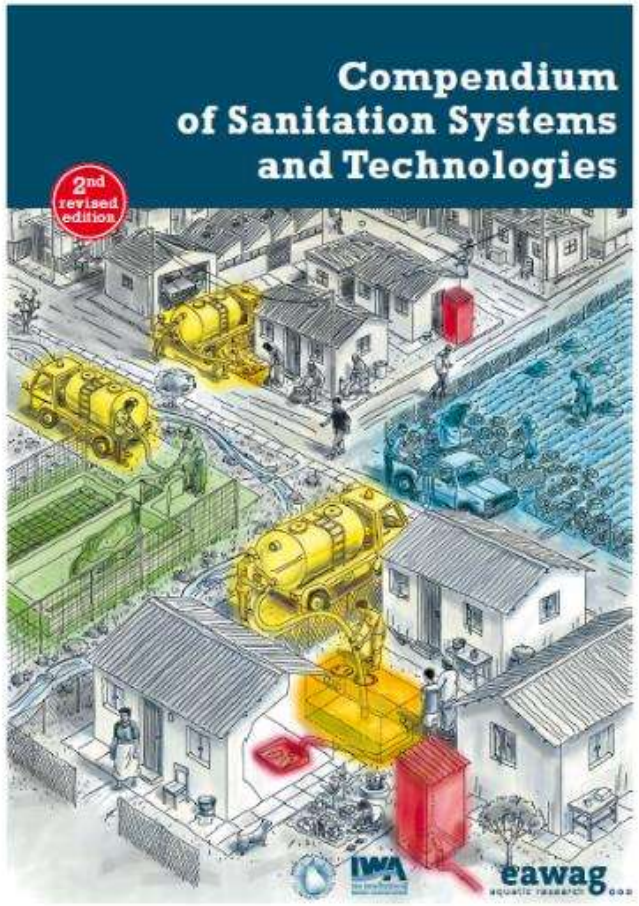


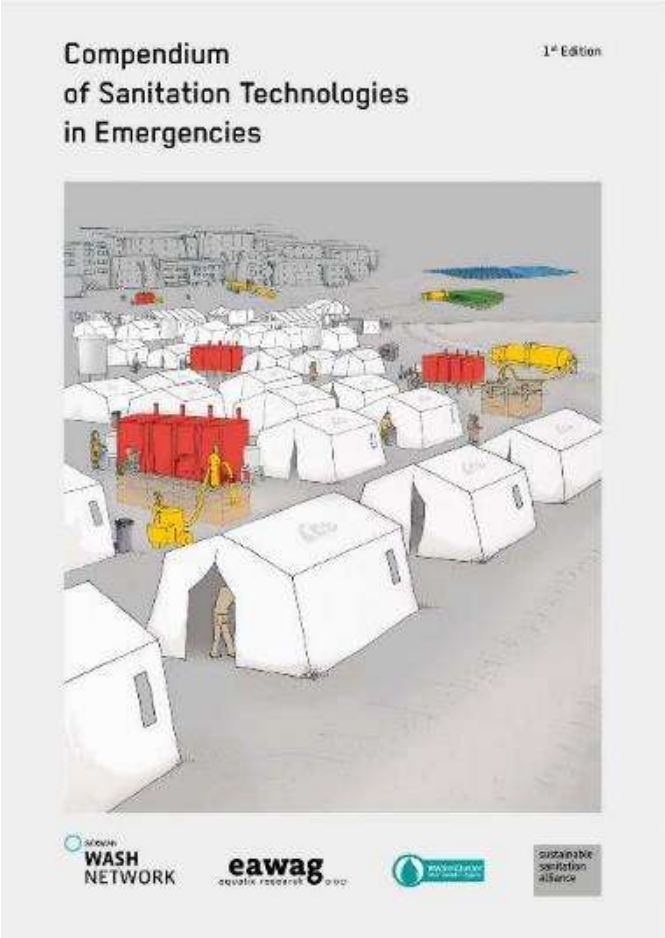
The Compendium of Sanitation Systems and Technologies



- 2nd ed also in French, Arabic, Russian and Spanish
- 1st edition also available in Vietnamese, Nepali and North Korean

www.sandec.ch/compendium

Compendium of Sanitation Technologies in Emergencies



- Available also in French, Arabic and Ukrainian
- 44 technologies adapted from the original Compendium
- 17 new technologies
- 13 cross cutting topics
- **An online platform!** *(also in Spanish)*

www.emersan-compendium.org

Sanitation Technologies in Emergencies

SANITATION TECHNOLOGIES X-CUTTING ISSUES GLOSSARY FAQ CASE STUDIES WATCHLIST

← Emergency WASH FR EN

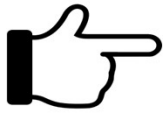
Reliable planning of sanitation service chain solutions in emergencies

The eCompendium is a comprehensive and well-structured online capacity development and decision support tool that allows real time filtering and configuration of entire sanitation service chain solutions in emergency settings. It provides detailed information on key decision criteria for all tried and tested emergency sanitation technologies, information on cross-cutting issues and available case studies, relevant to come up with informed sanitation technology decisions in emergencies.

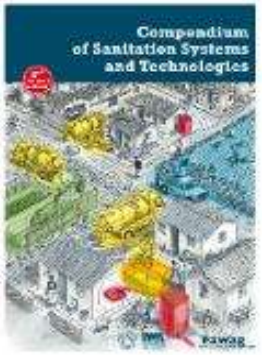
SEE HOW IT WORKS START NOW

What the Emersan Compendium does NOT provide you with

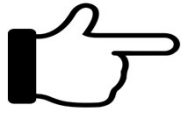
- Sanitation system templates



For that, refer to the original Compendium



- Detailed designs

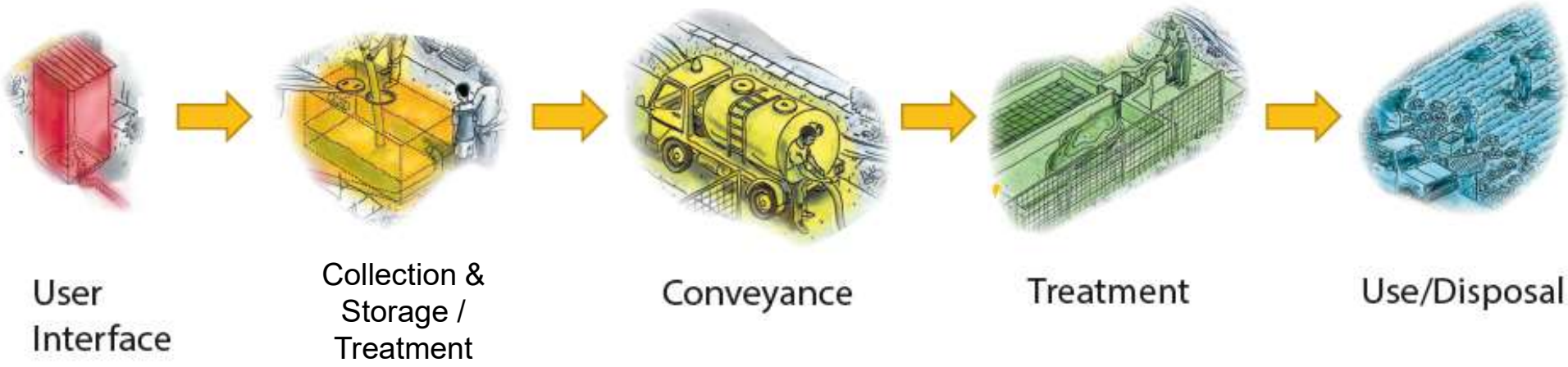


Each organisation has its own set of detailed designs. Check for example: **wash.unhcr.org**

- Ready-to-go solutions

Every context is different and should be handled case-by-case

The sanitation service chain as a basis



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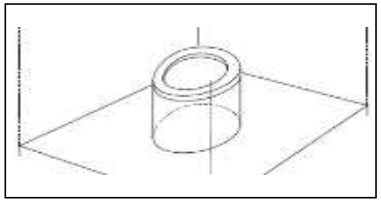
User Interface



- Dry Toilet
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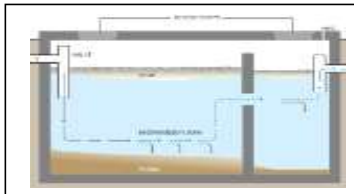
- Urine Diverting Flush Toilet

Collection and Storage / Treatment



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- Septic Tank
- Etc.

Conveyance

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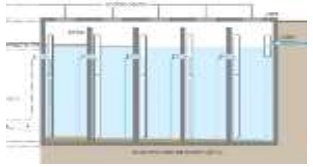
(Semi-) Centralised Treatment



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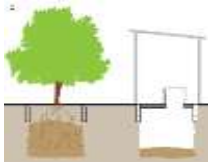
- Biogas Reactor
- Etc.

Use and / or Disposal



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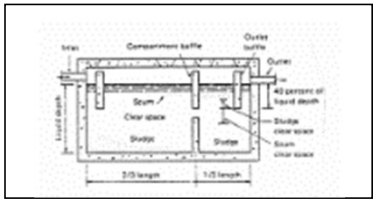

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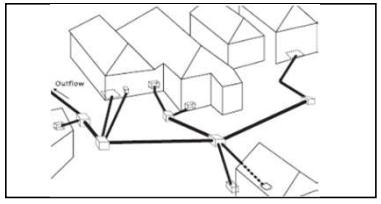

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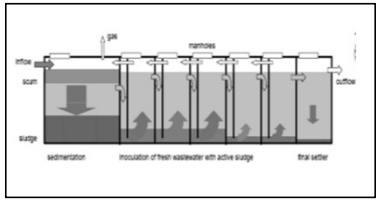

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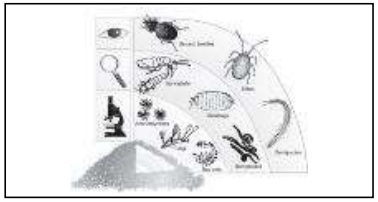

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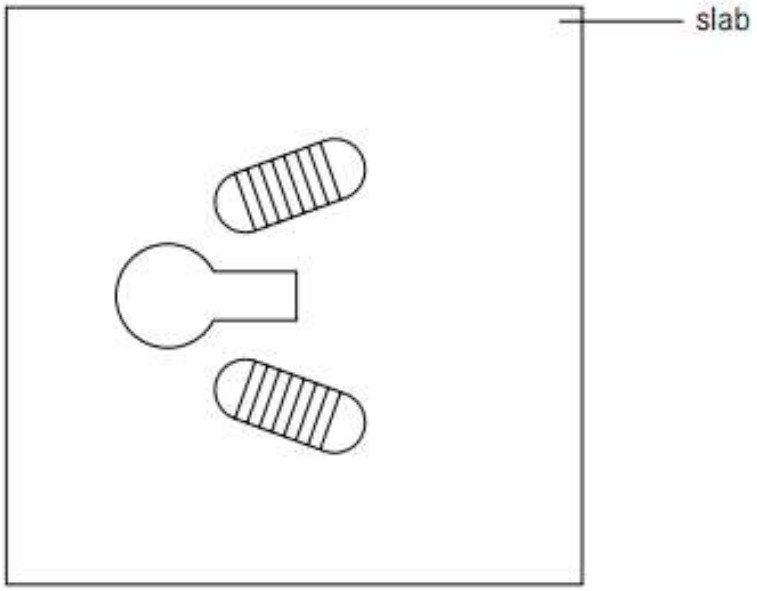
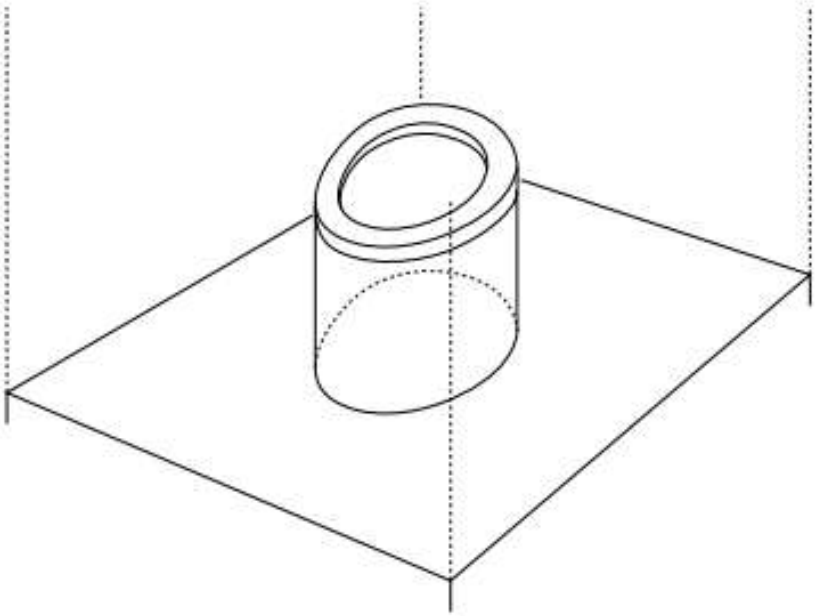
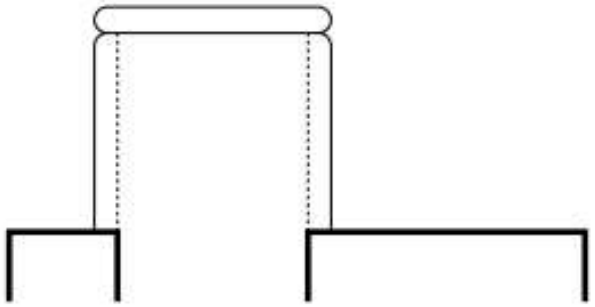
Dry toilets



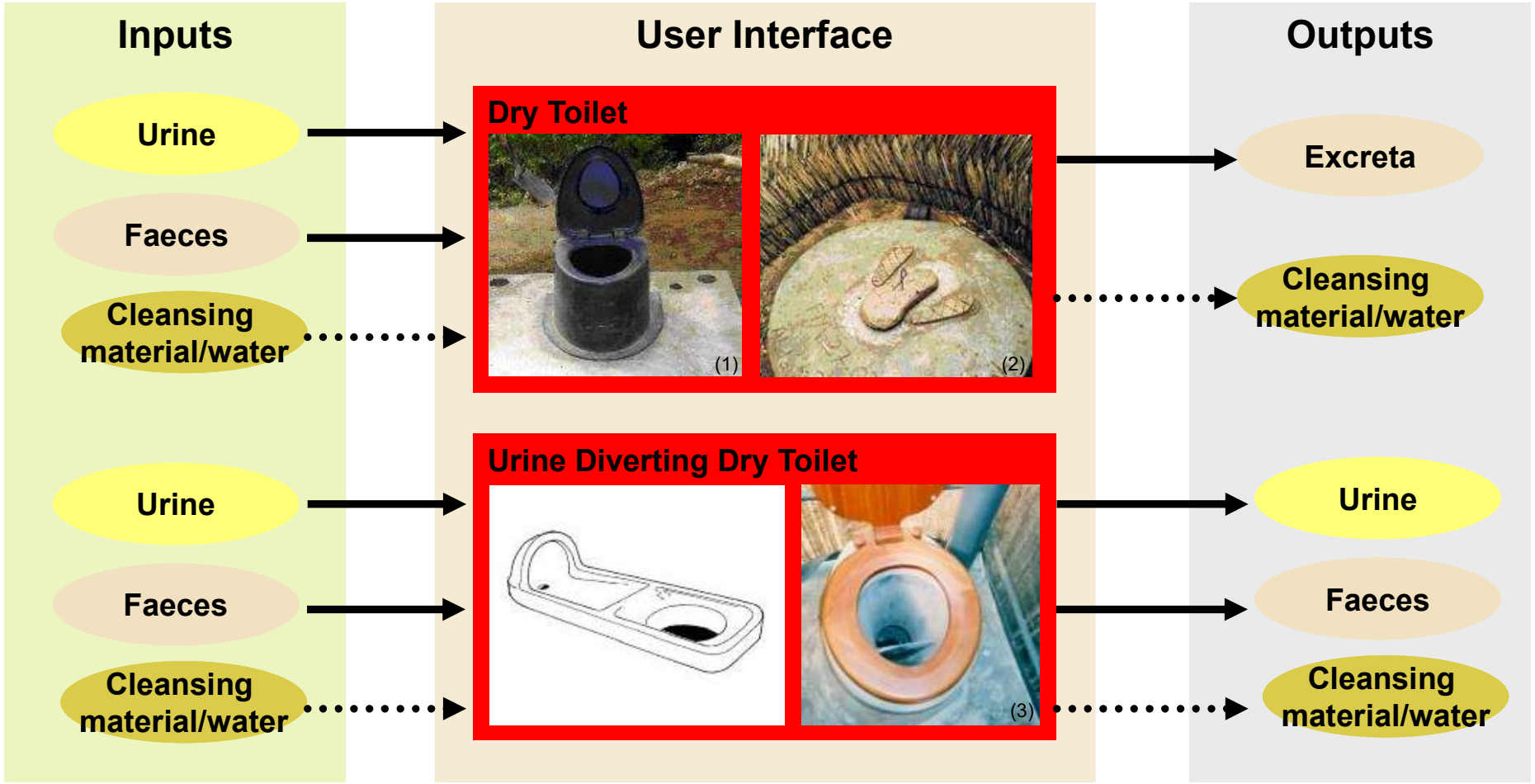
option 1





option 2

Waterless (Dry) User Interface Technologies



Dry toilets

Dry toilets

Pros and cons

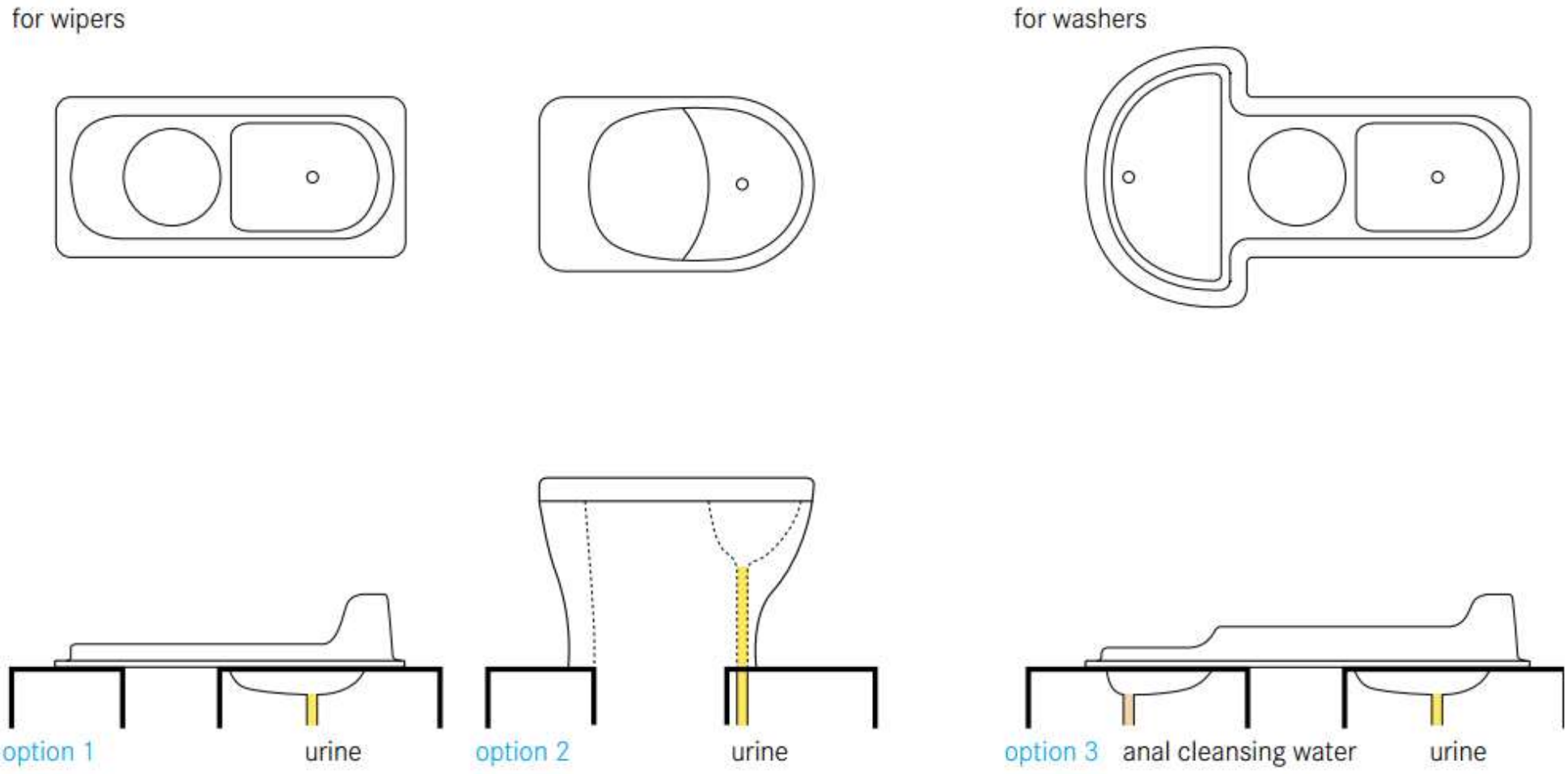
ADVANTAGES

- Does not require a constant source of water
- Can be built and repaired with locally available materials
- Low capital and operating costs
- Suitable for all types of users (sitters, squatters, washers, wipers)

CONSTRAINTS

- Odours are normally noticeable (even if the vault or pit used to collect excreta is equipped with a vent pipe)
- The excreta pile is visible, except where a deep pit is used
- Vectors such as flies are hard to control unless fly traps and appropriate covers are used

Urine-diverting dry toilet (UDDT)



Urine-diverting dry toilet (UDDT)

Pros and cons

ADVANTAGES

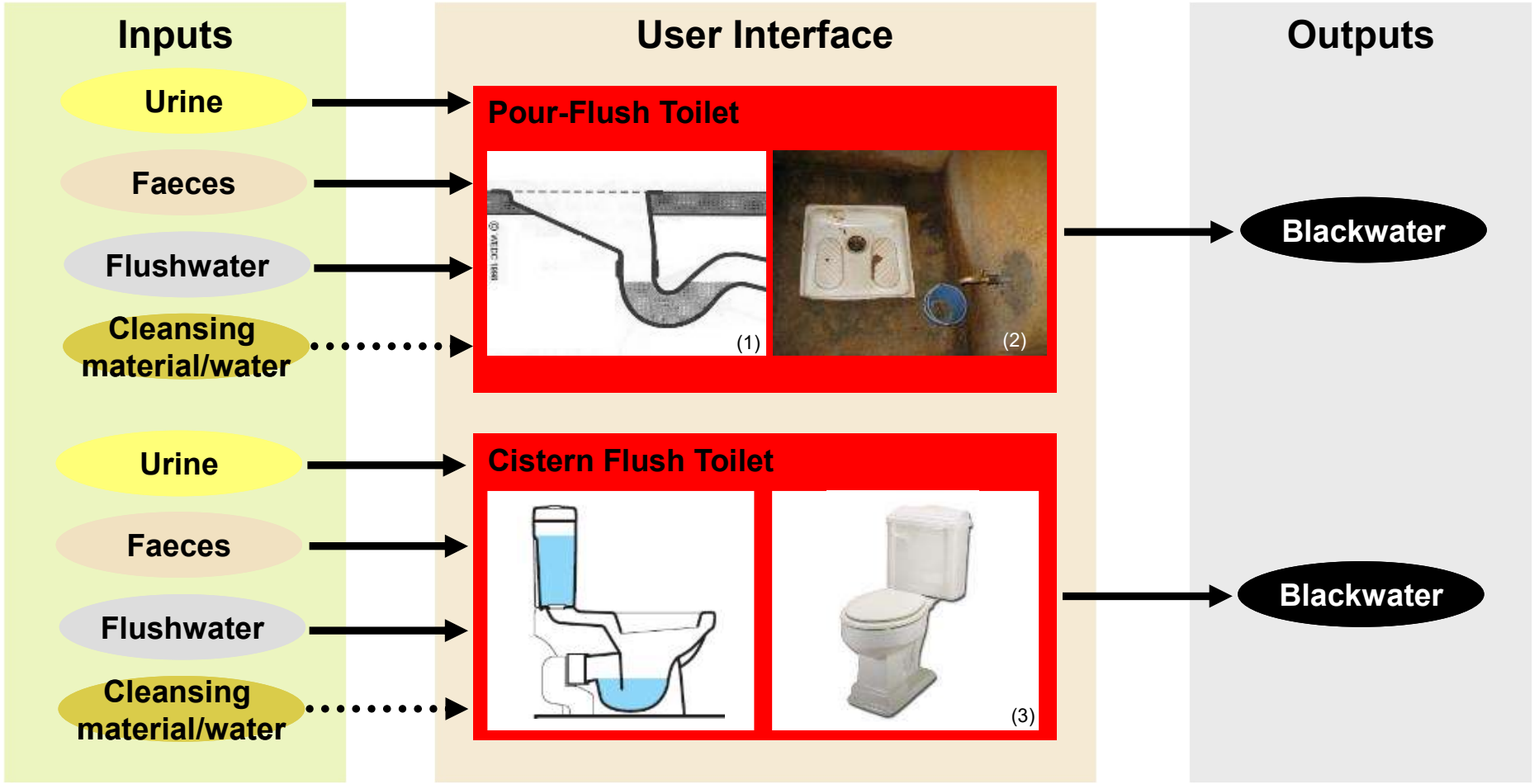
- Does not require a constant source of water
- No real problems with flies or odours if used and maintained correctly
- Can be built and repaired with locally available materials
- Low capital and operating costs
- Suitable for all types of users (sitters, squatters, washers, wipers)

CONSTRAINTS

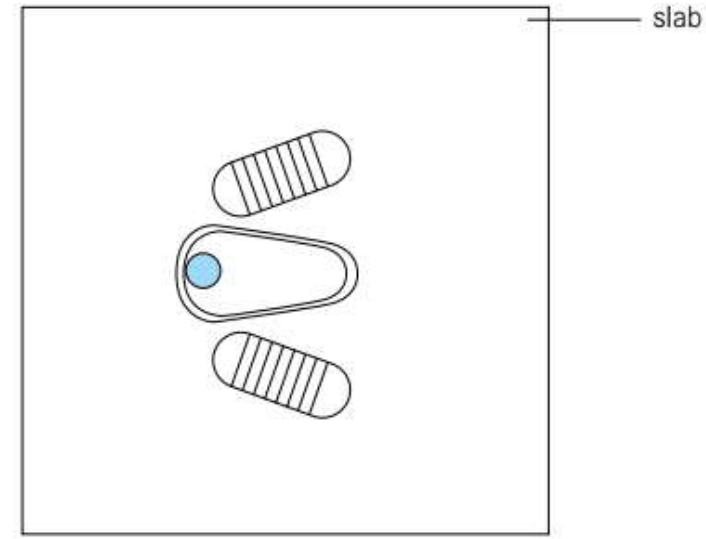
- Prefabricated models not available everywhere
- Requires training and acceptance to be used correctly
- Is prone to misuse and clogging with faeces
- The excreta pile is visible
- Men usually require a separate Urinal for optimum collection of urine

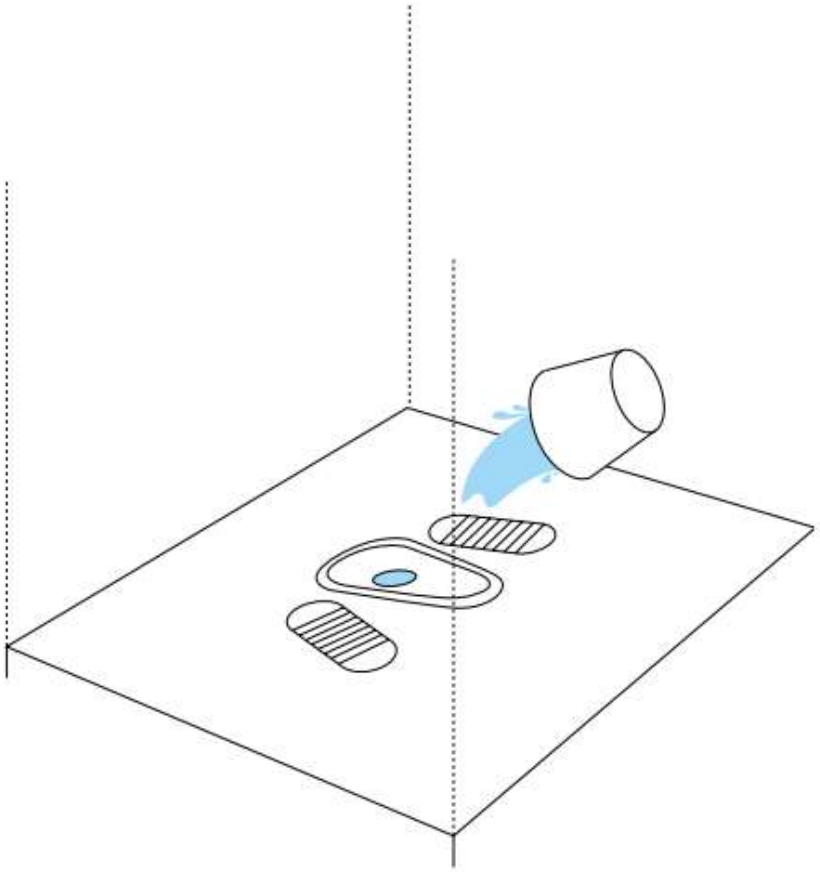
Urine-diverting dry toilet (UDDT)

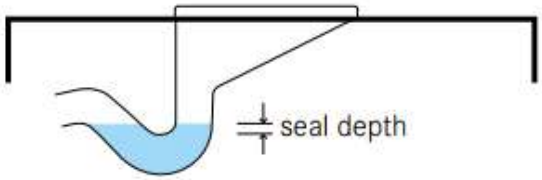
Water-Based User Interface Technologies



Pour Flush Toilet







Pour Flush Toilet

Pros and cons

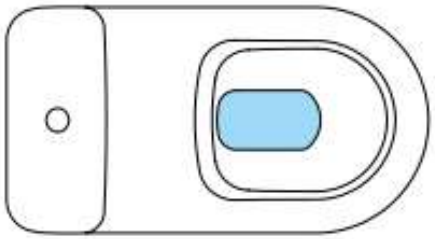
ADVANTAGES

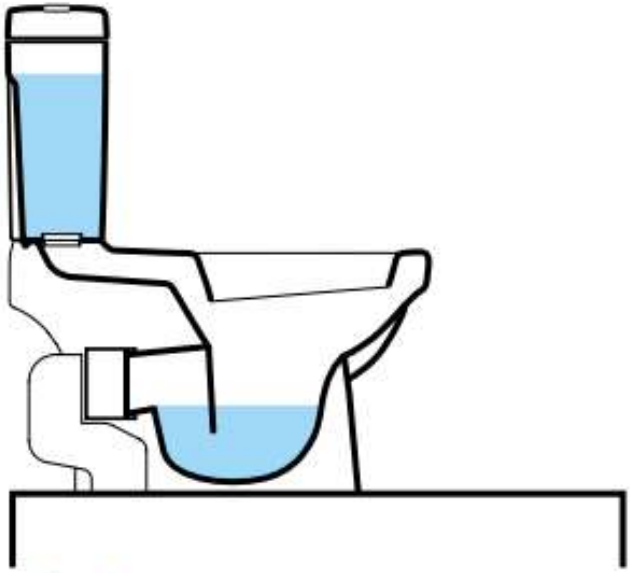
- The water seal effectively prevents odours
- The excreta of one user are flushed away before the next user arrives
- Suitable for all types of users (sitters, squatters, washers, wipers)
- Low capital costs; operating costs depend on the price of water

CONSTRAINTS

- Requires a constant source of water (can be recycled water and/or collected rainwater)
- Requires materials and skills for production that are not available everywhere
- Coarse dry cleansing materials may clog the water seal

Cistern Flush Toilet





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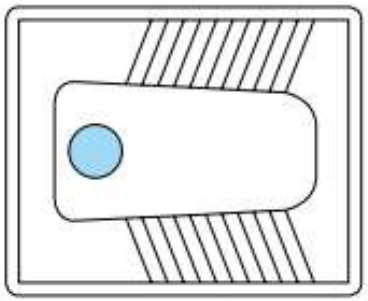
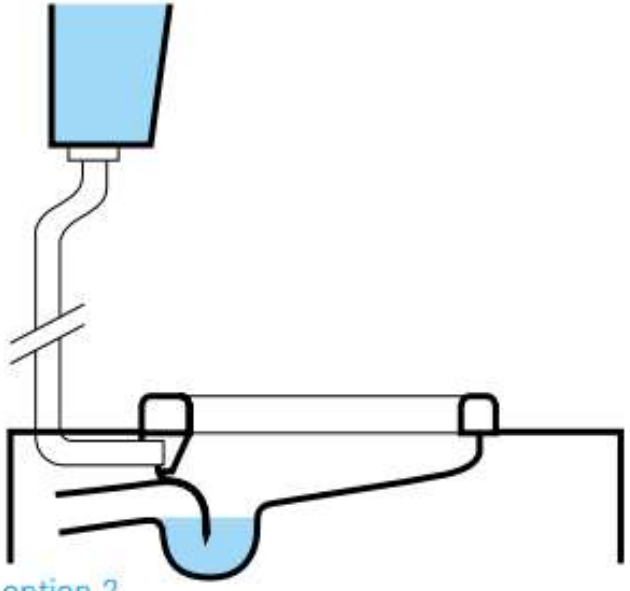
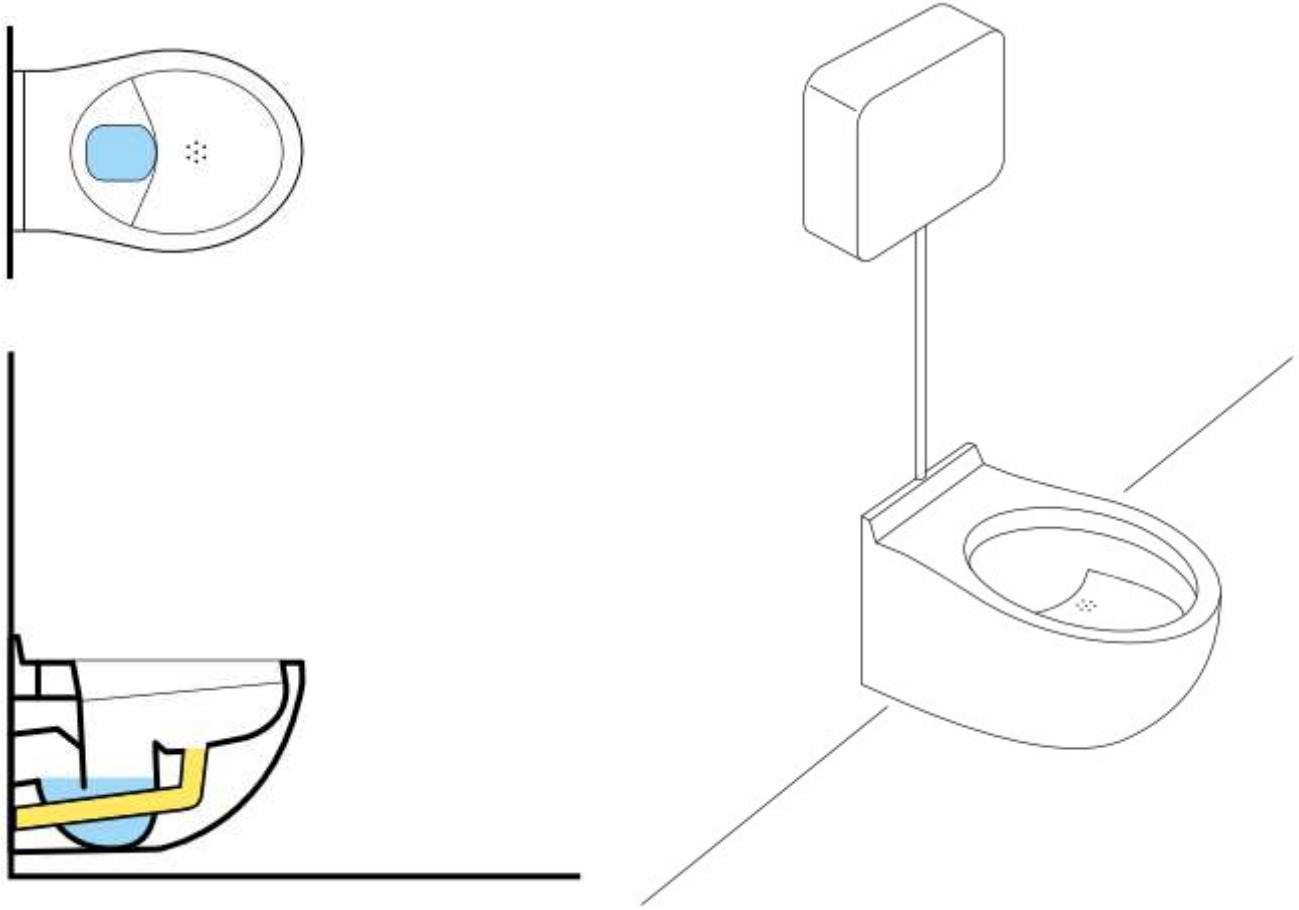




option 2

Urine-diverting flush toilet (UDFT)



Urine-diverting flush toilet (UDFT)

Pros and cons

ADVANTAGES

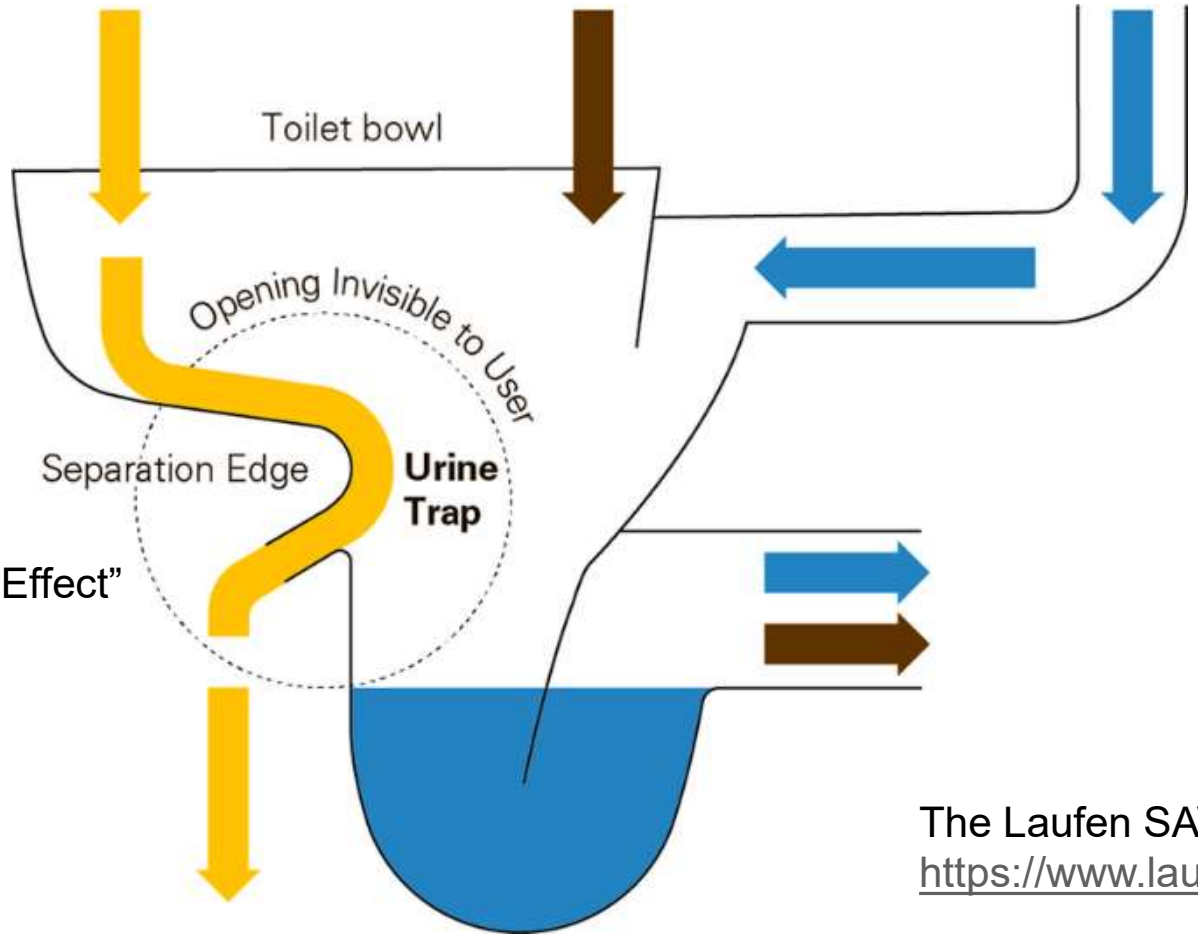
- Requires less water than a traditional Cistern Flush Toilet
- No real problems with odours if used correctly
- Looks like, and can be used almost like, a Cistern Flush Toilet

CONSTRAINTS

- Limited availability; cannot be built or repaired locally
- High capital costs; operating costs depend on parts and maintenance
- Labour-intensive maintenance
- Requires training and acceptance to be used correctly
- Is prone to misuse and clogging
- Requires a constant source of water
- Men usually require a separate Urinal for optimum collection of urine

Urine-diverting flush toilet (UDFT)

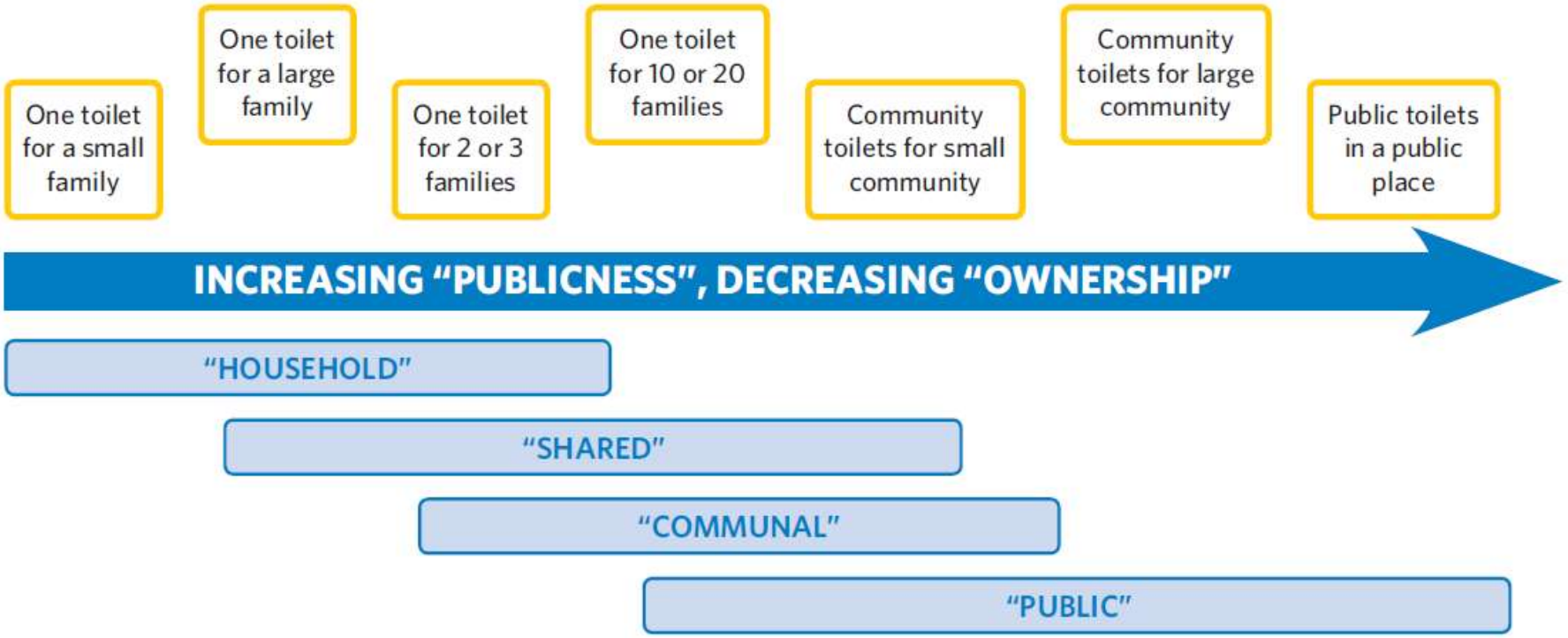
A recent innovation by EOOS



"Tea Pot Effect"

The Laufen SAVE Toilet:
https://www.laufen.com/save

Toilet Options for Urban Areas



How to choose the right user interface

- Flush water availability
- Habits and preferences of the users
- Local availability of materials
- Compatibility with the subsequent Collection and Storage/Treatment or Conveyance technology
- Special needs of user groups

What can go wrong?

Bad piping

Non-intuitive design

Poor ventilation design

Door interfering

Difficult to clean

Construction quality and supervision

Interior layout

Low-quality materials

Inclusive design

- People have different needs at different times in their lives, based on factors like:

  - ✓ Age
  - ✓ Occupation
  - ✓ Location
  - ✓ Health
  - ✓ Physical ability
  - ✓ Mental state
  - ✓ Sex and gender

Technical Considerations for Accessible Toilets

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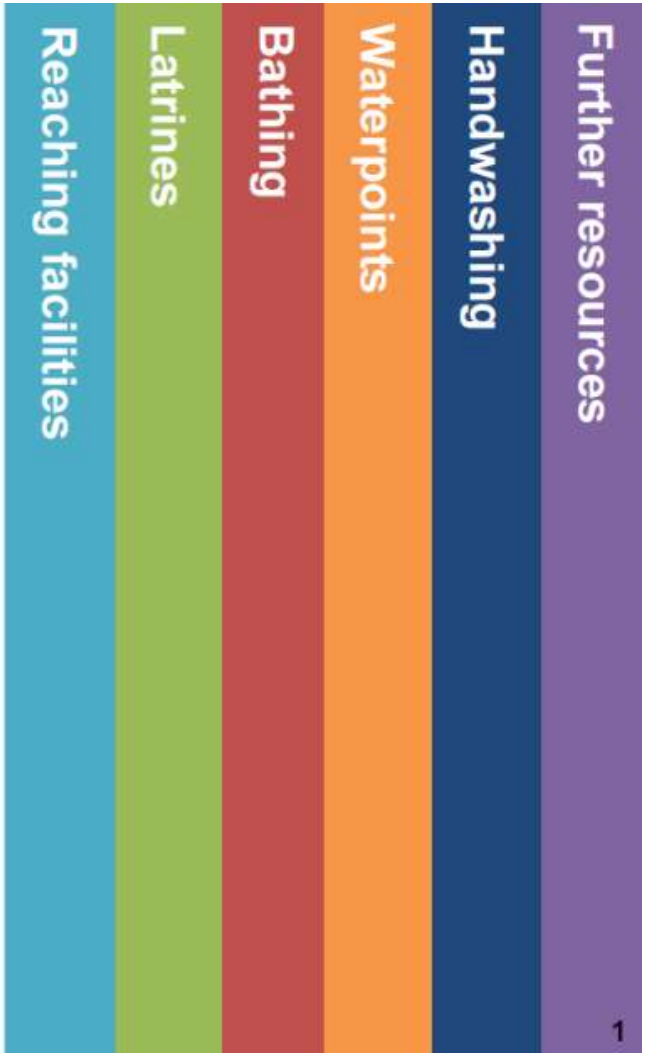
Compendium of accessible WASH technologies

Hazel Jones and Jane Wilbur (2014)

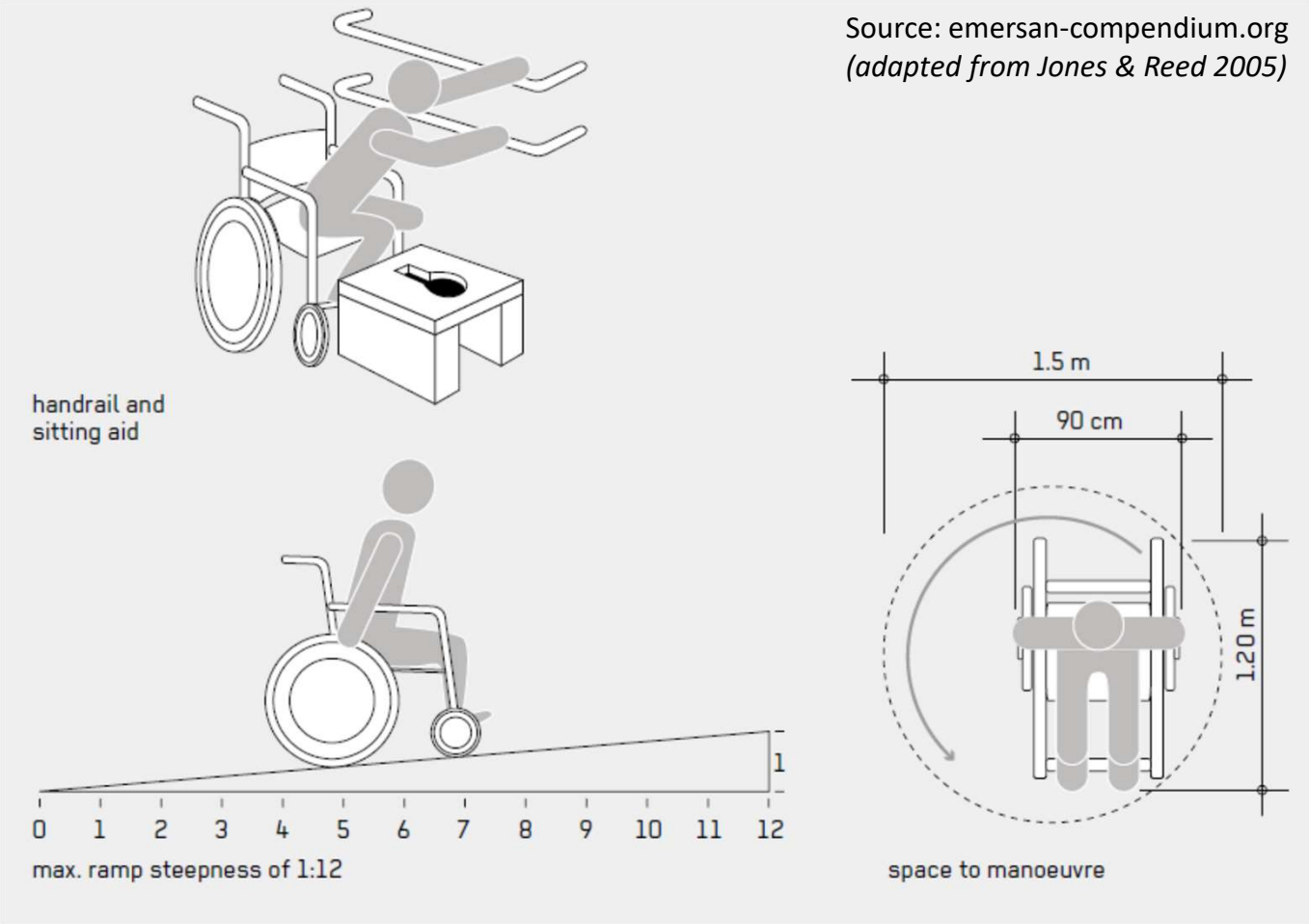


WEDC

WaterAid

share
Sanitation and Hygiene Applied Research for Equity

Inclusive design and equitable design



Source: emersan-compendium.org
(adapted from Jones & Reed 2005)

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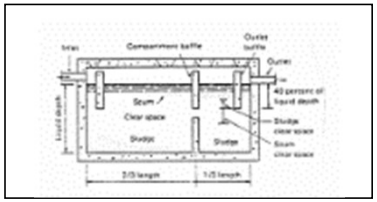
User Interface

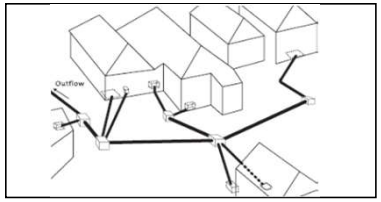
- Dry Toilet
- Urine Diverting Dry Toilet (UDDT)
- Urinal
- Pour Flush Toilet
- Cistern Flush Toilet
- Urine Diverting Flush Toilet

Collection and Storage / Treatment



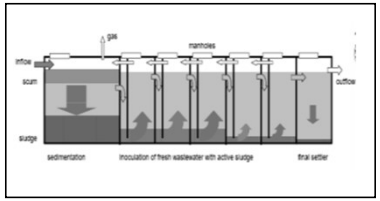
- Urine Storage
- Tank / Container
- Single Pit
- Single Ventilated Improved Pit (VIP)
- Double Ventilated Improved Pit (VIP)
- Fossa Alterna
- Twin Pits for Pour Flush
- Dehydr. Vaults
- Composting Chamber
- Septic Tank
- Etc.

Conveyance



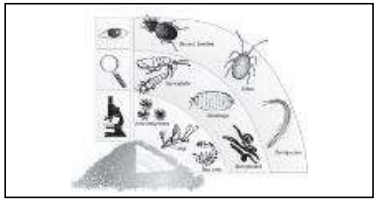
- Jerry can / Tank
- Human-Powered Emptying and Transport
- Motorized Emptying and Transport
- Simplified Sewer
- Solids-Free Sewer
- Conventional Gravity Sewer
- Transfer Station (Holding Tank)
- Sewer Discharge Station

(Semi-) Centralised Treatment



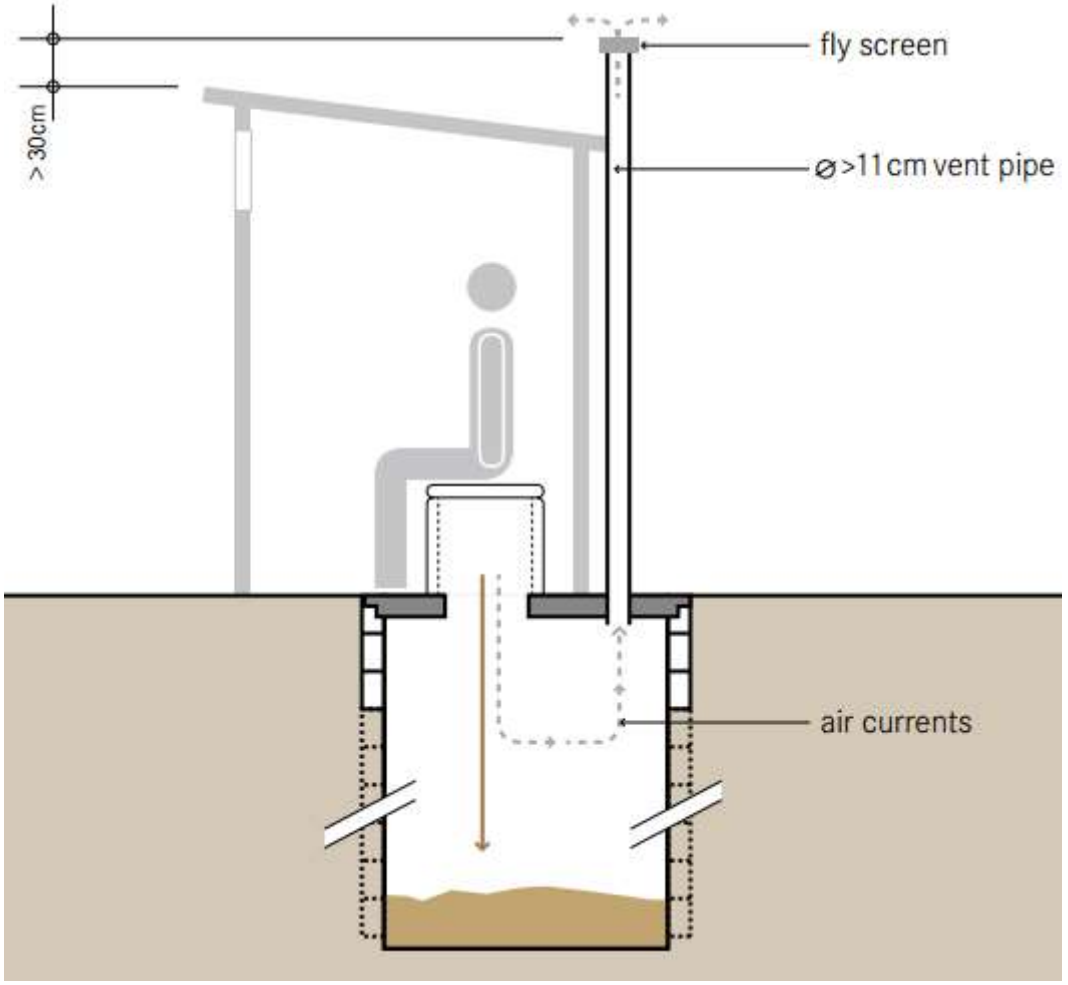
- Anaerobic Baffled Reactor (ABR)
- Anaerobic Filter
- Waste Stabilization Ponds
- Aerated Pond
- Constructed Wetland
- Trickling Filter
- Activated Sludge
- Drying Beds
- Co-composting
- Anaerobic Biogas Reactor
- Etc.

Use and / or Disposal



- Fill and Cover / Arborloo
- Applic. of Urine
- Application of Dehydr. Faeces / Compost
- Irrigation
- Soak Pit
- Leach Field
- Aquaculture
- Floating Plant Pond
- Water Disposal / Groundwater Recharge
- Land application
- Surface Disposal

Ventilated Improved Pit Latrine (VIP)



Ventilated Improved Pit Latrine (VIP)

Pros and cons

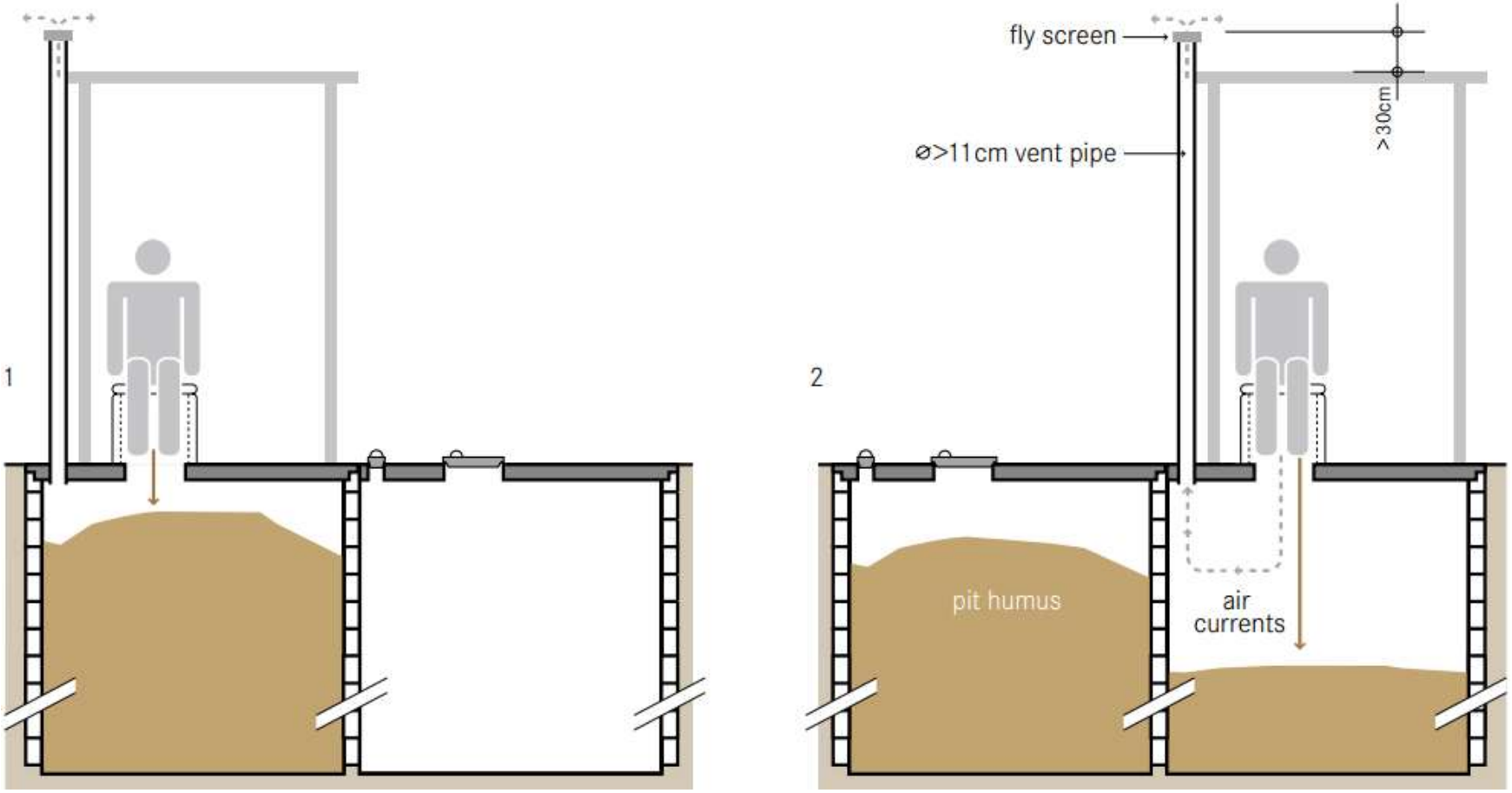
ADVANTAGES

- Flies and odours are significantly reduced (compared to non-ventilated pits)
- Can be built and repaired with locally available materials
- Low (but variable) capital costs depending on materials and pit depth
- Small land area required

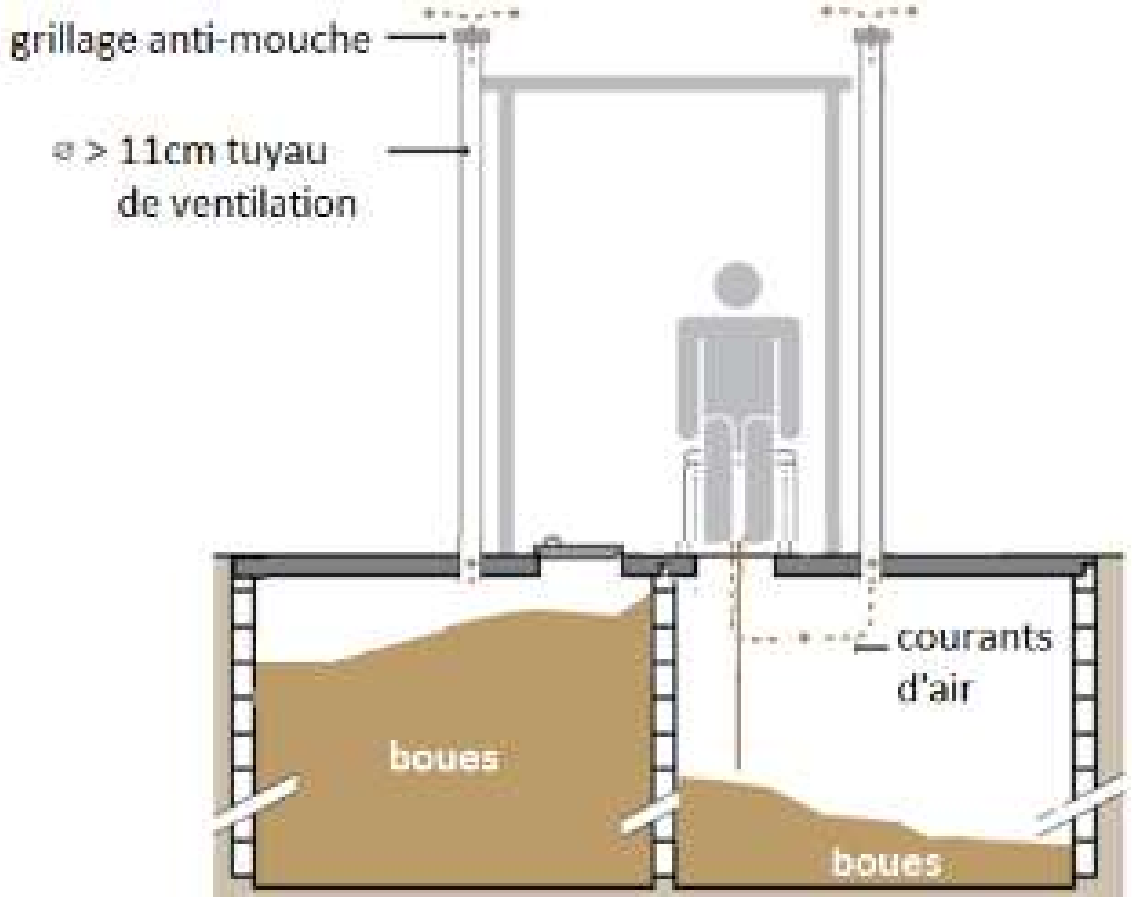
CONSTRAINTS

- Low reduction in BOD and pathogens with possible contamination of groundwater
- Costs to empty may be significant compared to capital costs
- Sludge requires secondary treatment and/or appropriate discharge

Double Ventilated Improved Pit Latrine (VIP)



Double Ventilated Improved Pit Latrine (VIP)



Double Ventilated Improved Pit Latrine (VIP)

Pros and cons

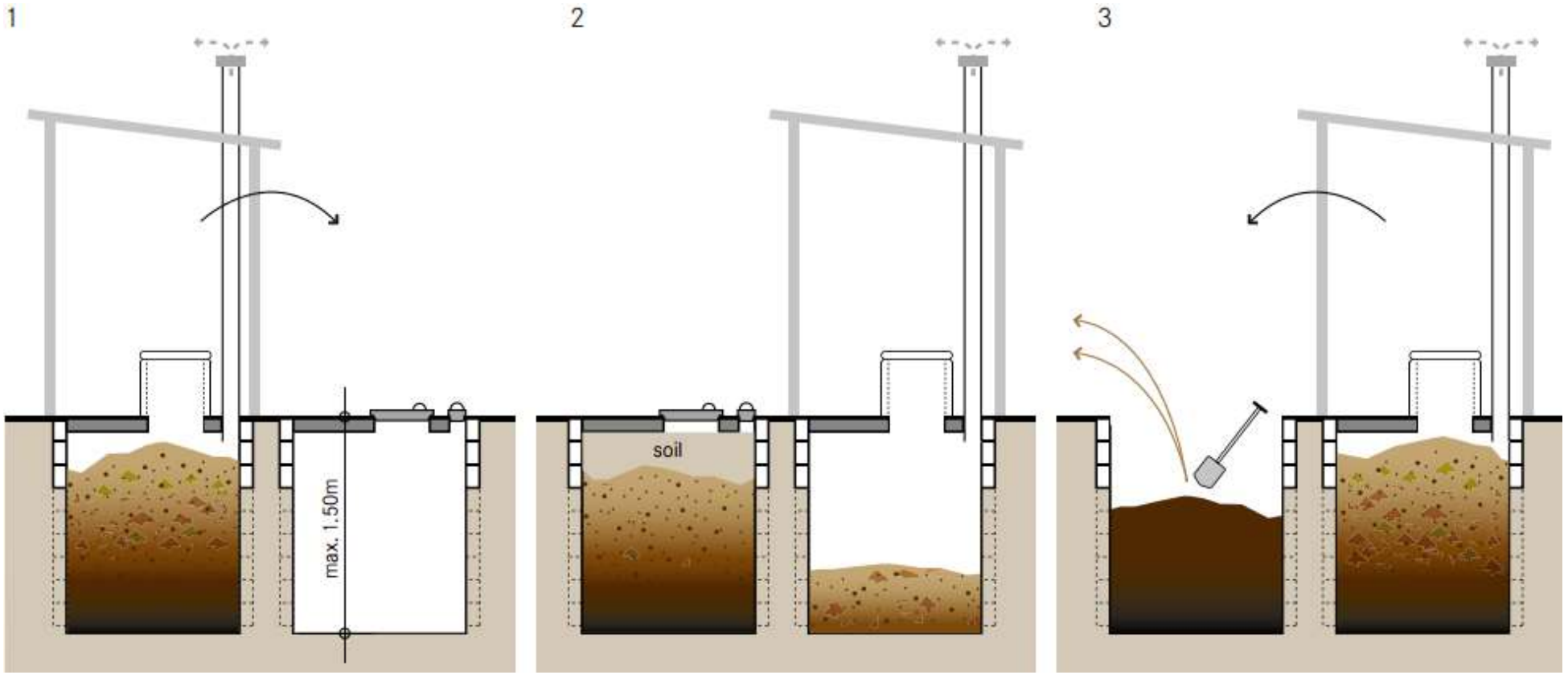
ADVANTAGES

- Longer life than Single VIP (indefinite if maintained properly)
- Excavation of humus is easier than faecal sludge
- Significant reduction in pathogens
- Potential for use of stored faecal material as soil conditioner
- Flies and odours are significantly reduced (compared to non-ventilated pits)
- Can be built and repaired with locally available materials

CONSTRAINTS

- Manual removal of humus is required
- Possible contamination of groundwater
- Higher capital costs than Single VIP; but reduced operating costs if self-emptied

Fossa Alterna



Fossa Alterna

Pros and cons

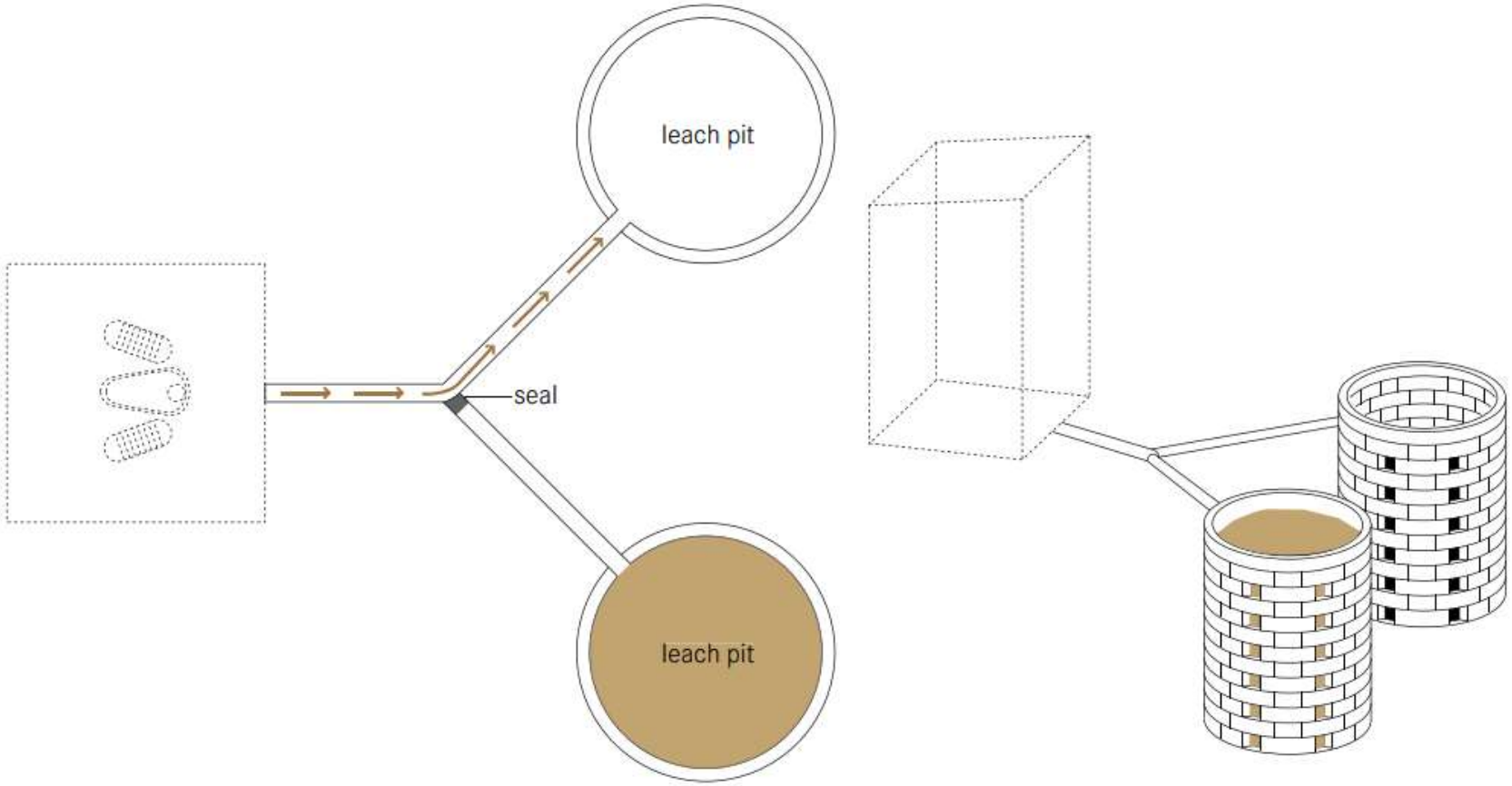
ADVANTAGES

- Because double pits are used alternately, their life is virtually unlimited
- Excavation of humus is easier than faecal sludge
- Significant reduction in pathogens
- Generates nutrient-rich humus with good potential for use as soil conditioner
- Flies and odours are significantly reduced (compared to non-ventilated pits)
- Can be built and repaired with locally available materials
- Low (but variable) capital costs depending on materials; no or low operating costs if self-emptied

CONSTRAINTS

- Requires constant source of cover material
- Manual removal of humus is required
- Garbage may ruin end-use opportunities of the product

Pour-flush system with twin-pits



Pour-flush system with twin-pits

Pros and cons

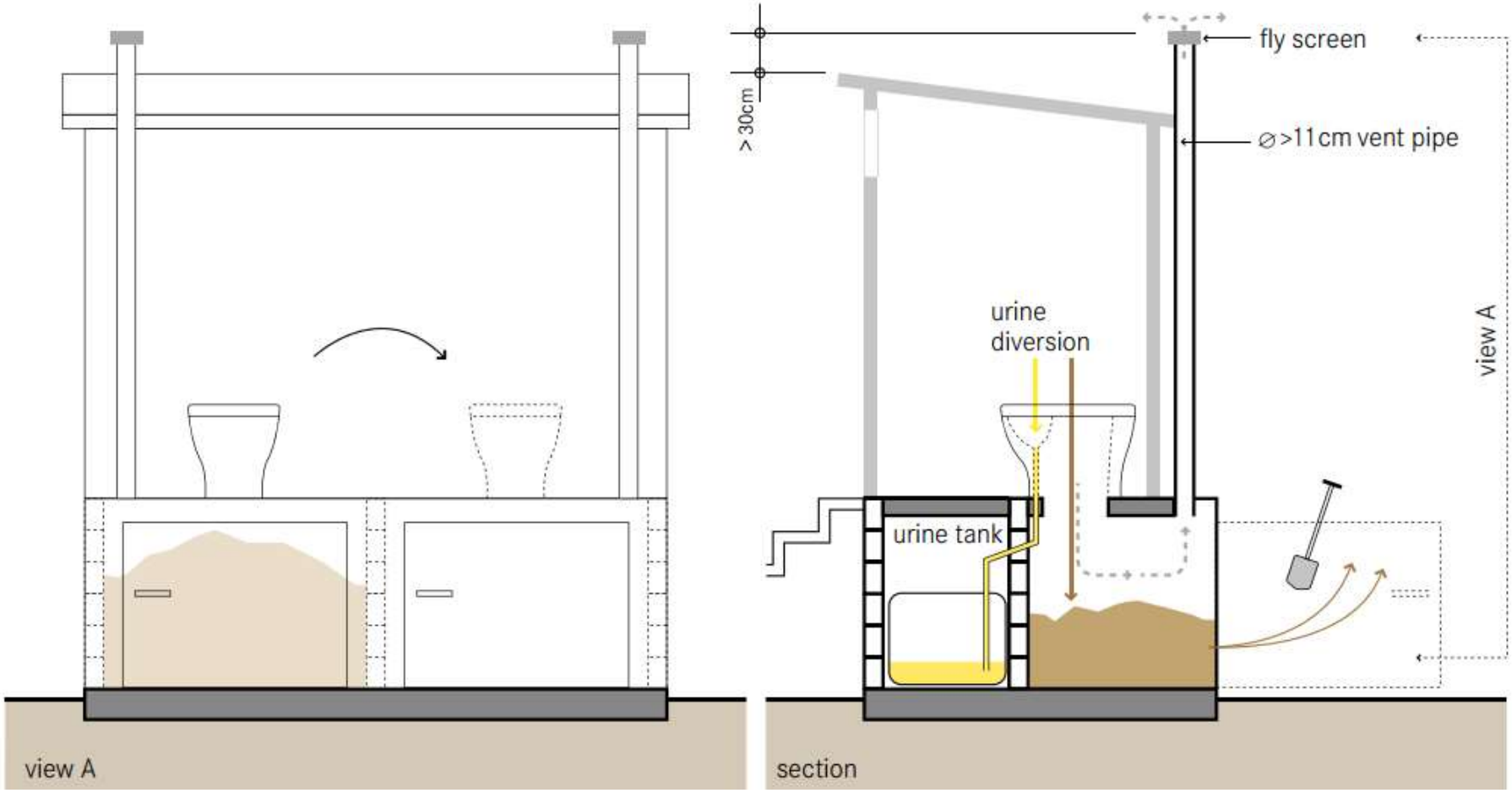
ADVANTAGES

- Because double pits are used alternately, their life is virtually unlimited
- Excavation of humus is easier than faecal sludge
- Significant reduction in pathogens
- Potential for use of stored faecal material as soil conditioner
- Flies and odours are significantly reduced (compared to pits without a water seal)
- Can be built and repaired with locally available materials
- Low (but variable) capital costs depending on materials; no or low operating costs if self-emptied
- Small land area required

CONSTRAINTS

- Manual removal of humus is required
- Clogging is frequent when bulky cleansing materials are used
- Higher risk of groundwater contamination due to more leachate than with waterless systems

Dehydration vaults (for UDDTS)



Dehydration vaults (for UDDTS)

Pros and cons

ADVANTAGES

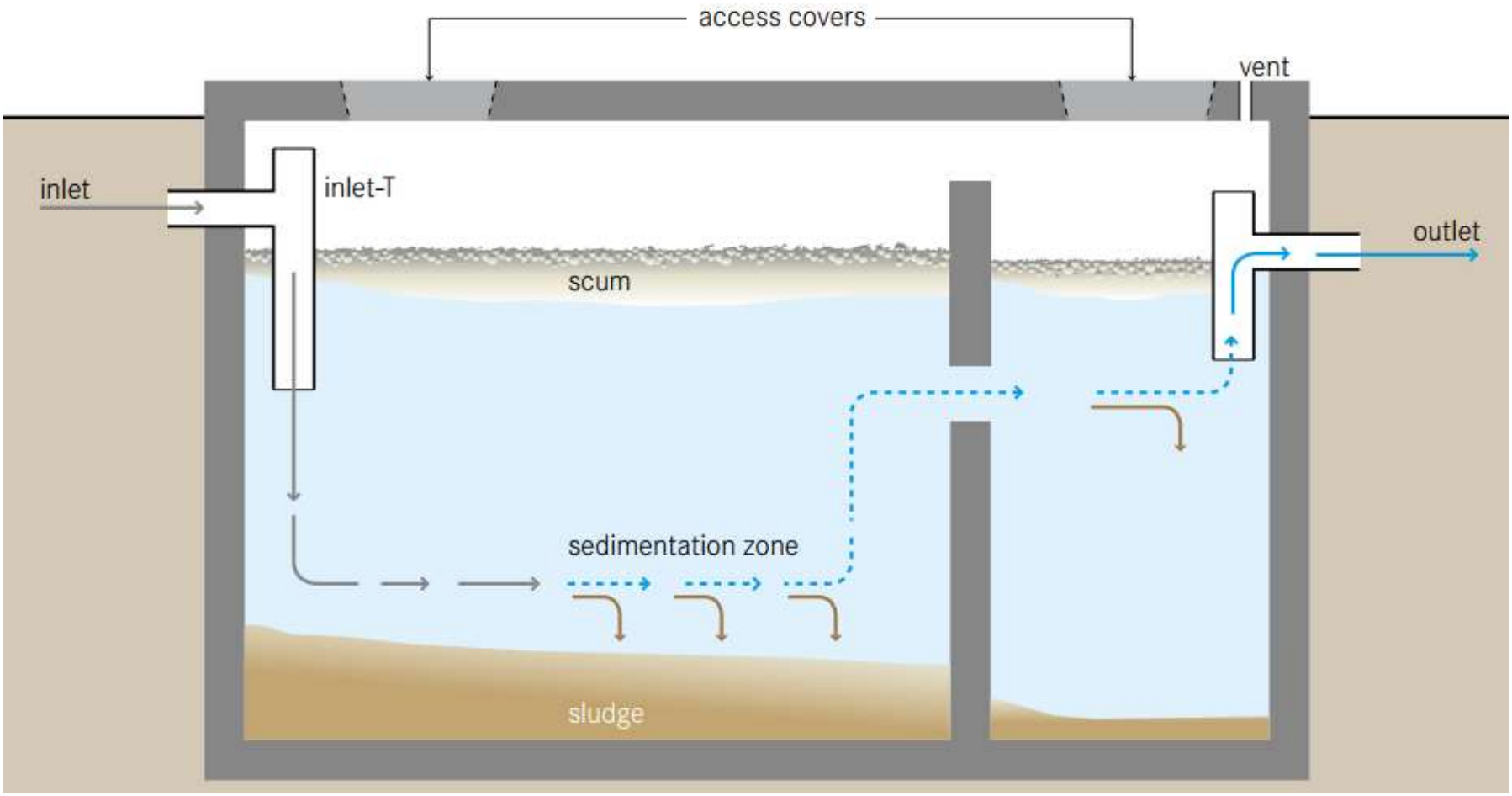
- Because double vaults are used alternately, their life is virtually unlimited
- Significant reduction in pathogens
- Potential for use of dried faeces as soil conditioner
- No real problems with flies or odours if used and maintained correctly (i.e., kept dry)
- Can be built and repaired with locally available materials
- Suitable for rocky and/or flood prone areas or where the groundwater table is high
- Low (but variable) capital costs depending on materials; no or low operating costs if self-emptied

CONSTRAINTS

- Requires training and acceptance to be used correctly
- Requires constant source of cover material
- Manual removal of dried faeces is required

Dehydration vaults (for UDDTS)

Septic tank


access covers
vent
inlet
inlet-T
outlet
scum
sedimentation zone
sludge

Septic tank

Pros and cons

ADVANTAGES

- Simple and robust technology
- No electrical energy is required
- Low operating costs
- Long service life
- Small land area required (can be built underground)

CONSTRAINTS

- Low reduction in pathogens, solids and organics
- Regular desludging must be ensured
- Effluent and sludge require further treatment and/or appropriate discharge

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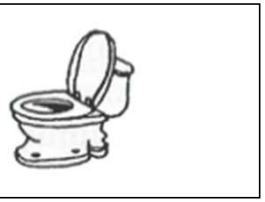
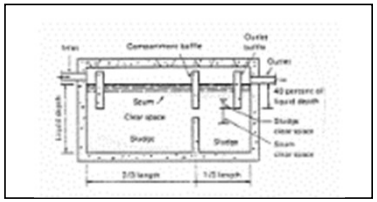
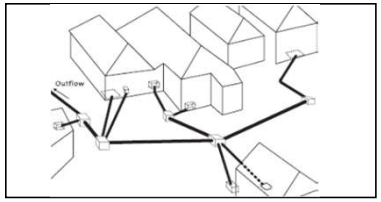
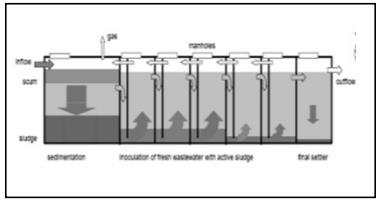
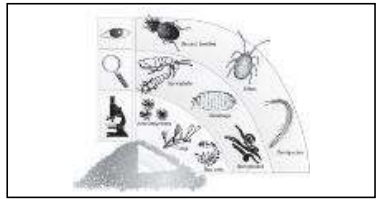
User Interface	Collection and Storage / Treatment	Conveyance	(Semi-) Centralised Treatment	Use and / or Disposal
				
○ Dry Toilet ○ Urine Diverting Dry Toilet (UDDT) ○ Urinal ○ Pour Flush Toilet ○ Cistern Flush ○ Toilet ○ Urine Diverting ○ Flush Toilet	○ Urine Storage ○ Tank / Container ○ Single Pit ○ Single Ventilated ○ Improved Pit (VIP) ○ Double Ventilated ○ Improved Pit (VIP) ○ Fossa Alterna ○ Twin Pits for ○ Pour Flush ○ Dehydr. Vaults ○ Composting ○ Chamber ○ Septic Tank ○ Etc.	○ Jerry can / Tank ○ Human-Powered Emptying and Transport ○ Motorized Emptying and Transport ○ Simplified Sewer ○ Solids-Free Sewer ○ Conventional Gravity Sewer ○ Transfer Station (Holding Tank) ○ Sewer Discharge Station	○ Anaerobic Baffled Reactor (ABR) ○ Anaerobic Filter ○ Waste Stabilization Ponds ○ Aerated Pond ○ Constructed Wetland ○ Trickling Filter ○ Activated Sludge ○ Drying Beds ○ Co-composting ○ Anaerobic Biogas Reactor ○ Etc.	○ Fill and Cover / Arborloo ○ Applic. of Urine ○ Application of Dehydr. Faeces / Compost ○ Irrigation ○ Soak Pit ○ Leach Field ○ Aquaculture ○ Floating Plant Pond ○ Water Disposal / Groundwater Recharge ○ Land application ○ Surface Disposal

Two categories of conveyance / transport systems

- Sewered (e.g. pipes)
- Non-sewered (e.g. containers)

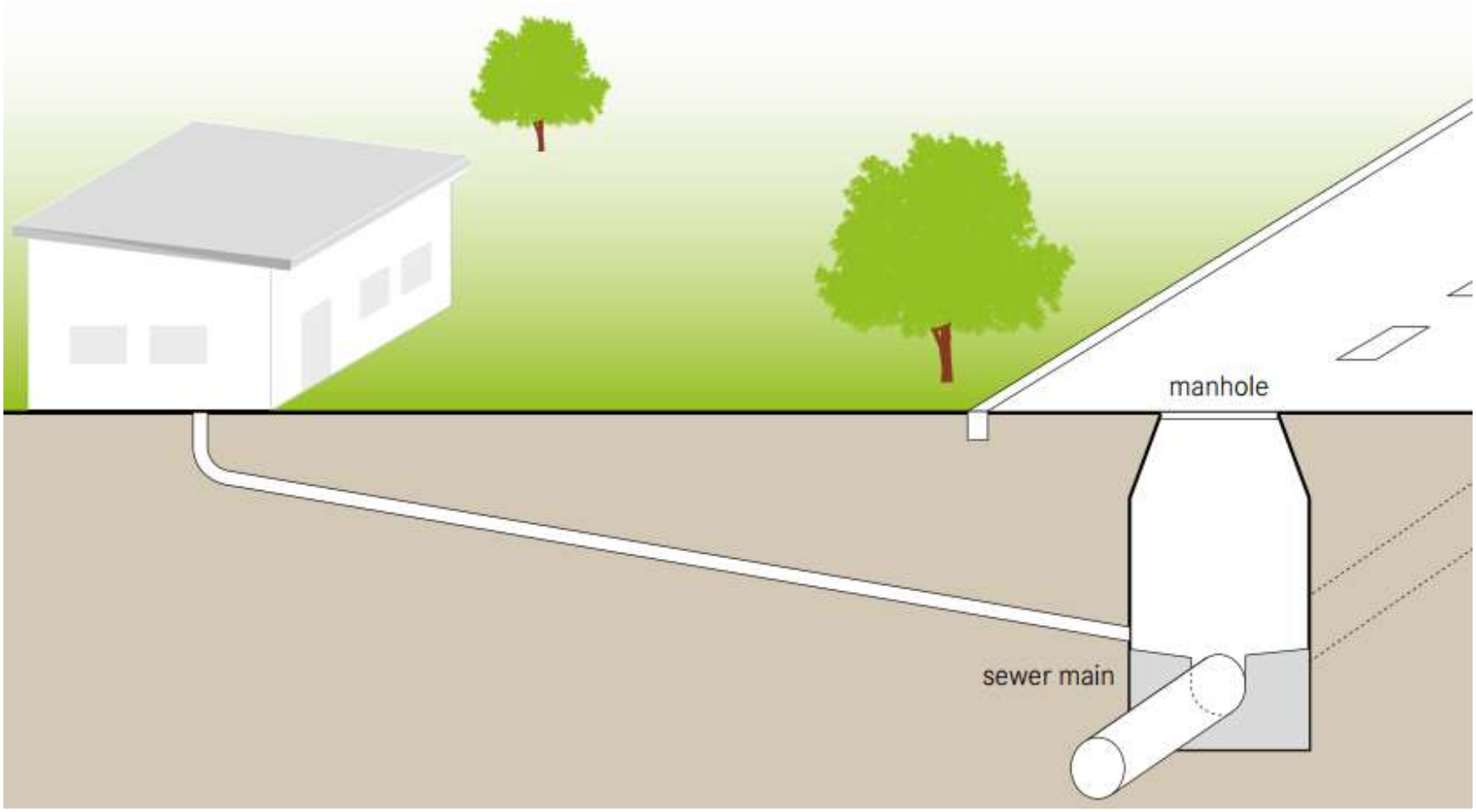
What needs to be transported:

- Blackwater
- Greywater
- Sludge
- Urine
- Dried faeces
- Pit humus
- Etc.

Sewer systems

- Simplified / shallow / condominial sewer
- Solids-free / settled / small-bore sewer
- Conventional gravity sewer

Conventional gravity sewers



Conventional gravity sewers

Pros and cons

What % of sanitation CAPEX are for sewers?

ADVANTAGES

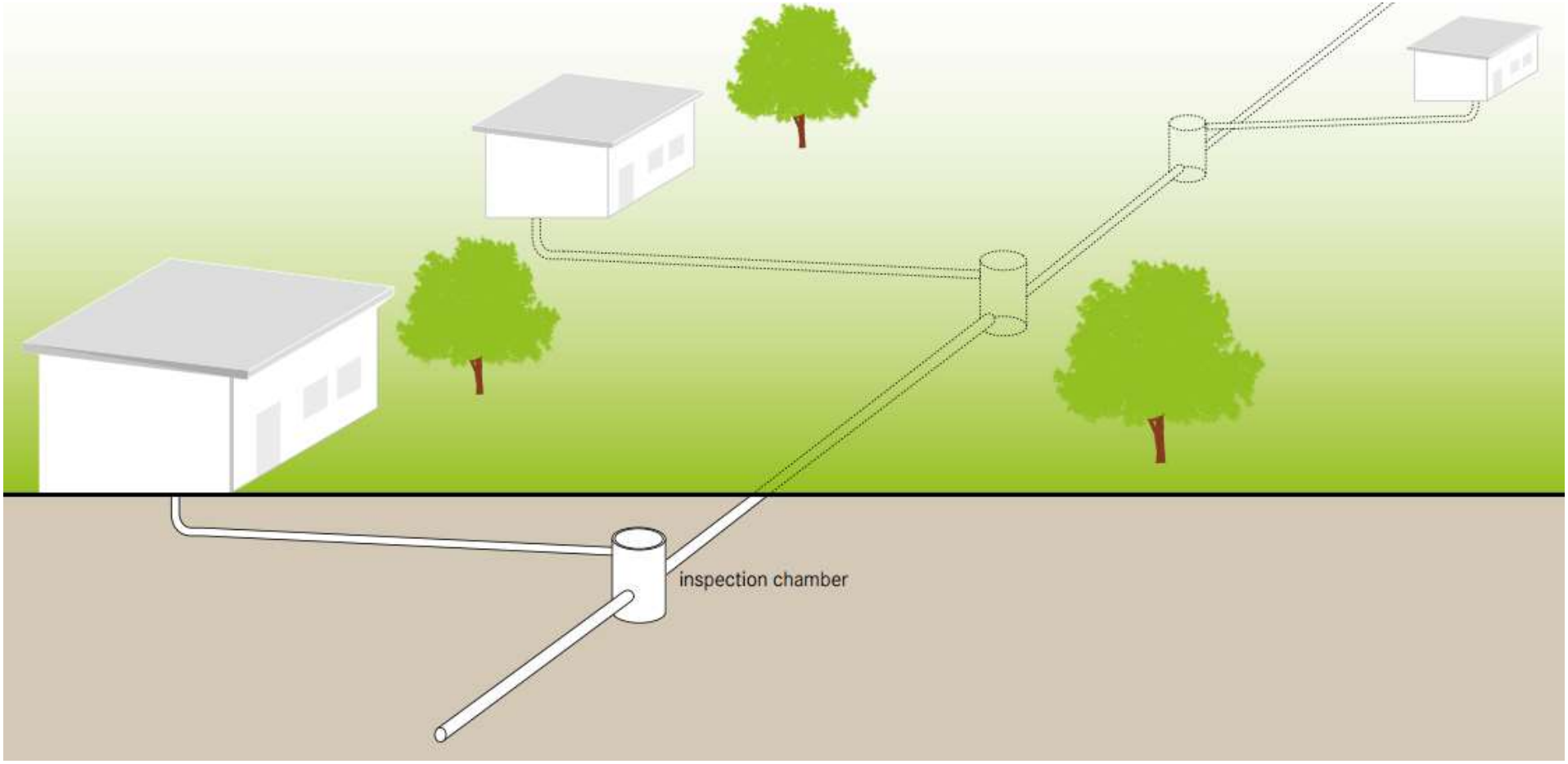
- Less maintenance compared to Simplified and Solids-Free Sewers
- Greywater and possibly stormwater can be managed concurrently
- Can handle grit and other solids, as well as large volumes of flow

CONSTRAINTS

- Very high capital costs; high operation and maintenance costs
- A minimum velocity must be maintained to prevent the deposition of solids in the sewer
- Requires deep excavations
- Difficult and costly to extend as a community changes and grows
- Requires expert design, construction and maintenance
- Leakages pose a risk of wastewater exfiltration and groundwater infiltration and are difficult to identify

Conventional sewers
Nile Delta, Egypt

Simplified / shallow / condominial sewer



Simplified / shallow / condominial sewer

Pros and cons

ADVANTAGES

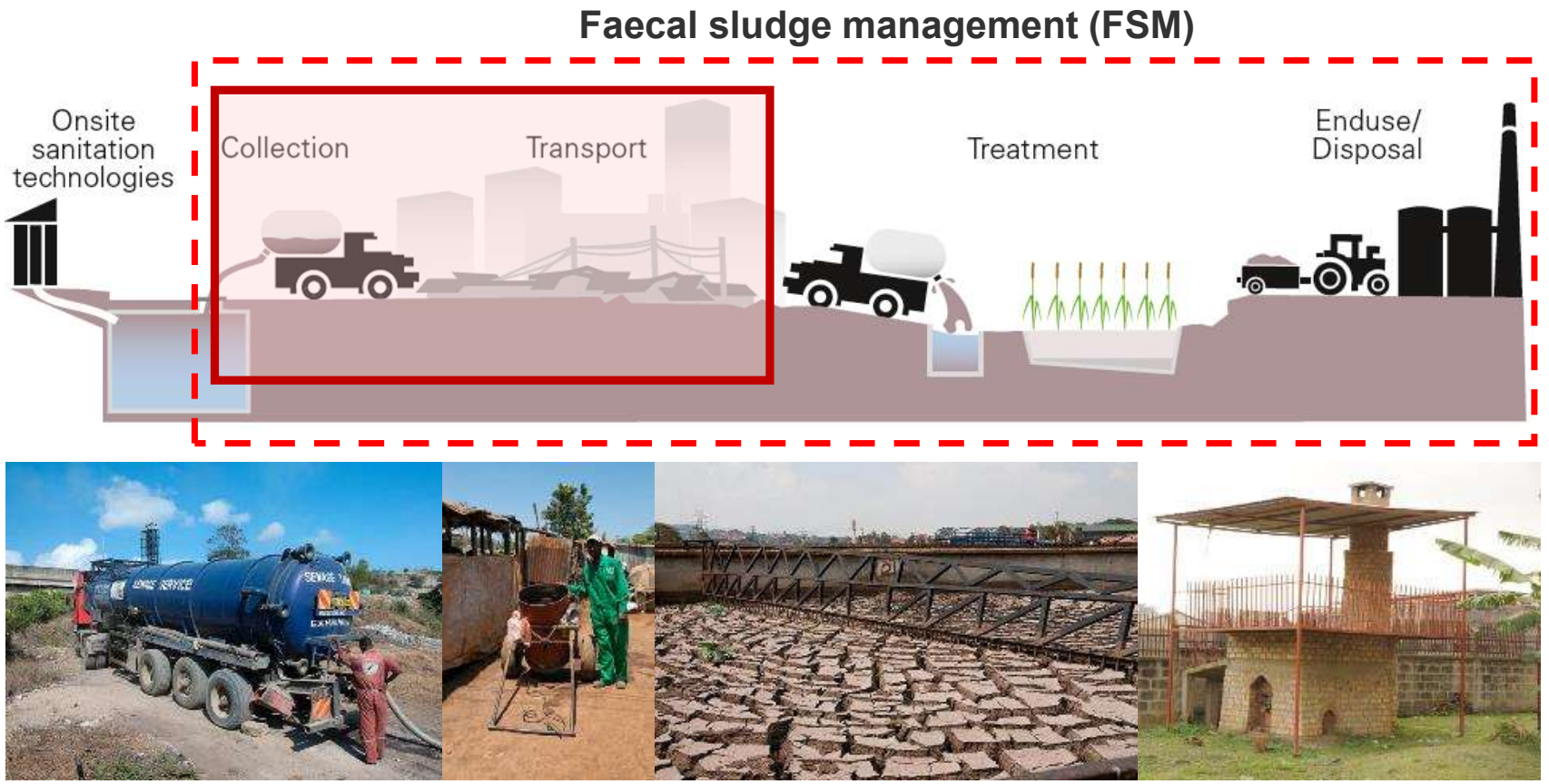
- Can be laid at a shallower depth and flatter gradient than Conventional Sewers
- Lower capital costs than Conventional Sewers; low operating costs
- Can be extended as a community grows
- Greywater can be managed concurrently
- Does not require onsite primary treatment units

CONSTRAINTS

- Requires repairs and removals of blockages more frequently than a Conventional Gravity Sewer
- Requires expert design and construction
- Leakages pose a risk of wastewater exfiltration and groundwater infiltration and are difficult to identify

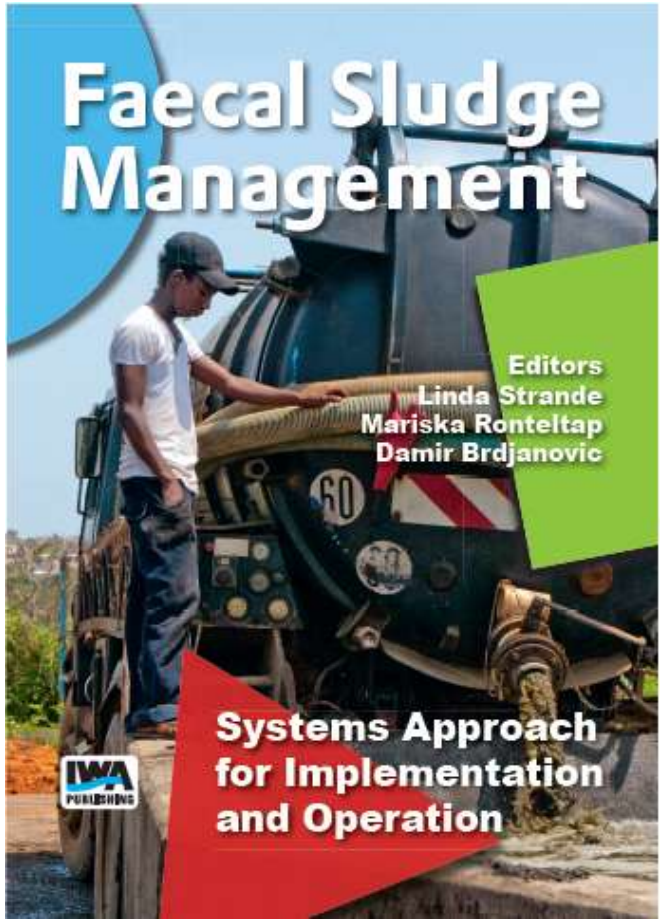
What happens when the pit is full?

Faecal Sludge Management (FSM) Service Chain



Non-sewered transport

sandec.ch/fsm_book



What is faecal sludge?

Faecal sludge (FS) *is …*

the raw or partially digested,

semisolid or slurry

resulting from collection or storage of combinations of excreta and blackwater, with or without greywater

that accumulates in onsite sanitation technologies.

What happens when the pit is full?

a. Overflowing

b. Manual emptying

c. Mechanical emptying

Collection and transport services are usually provided

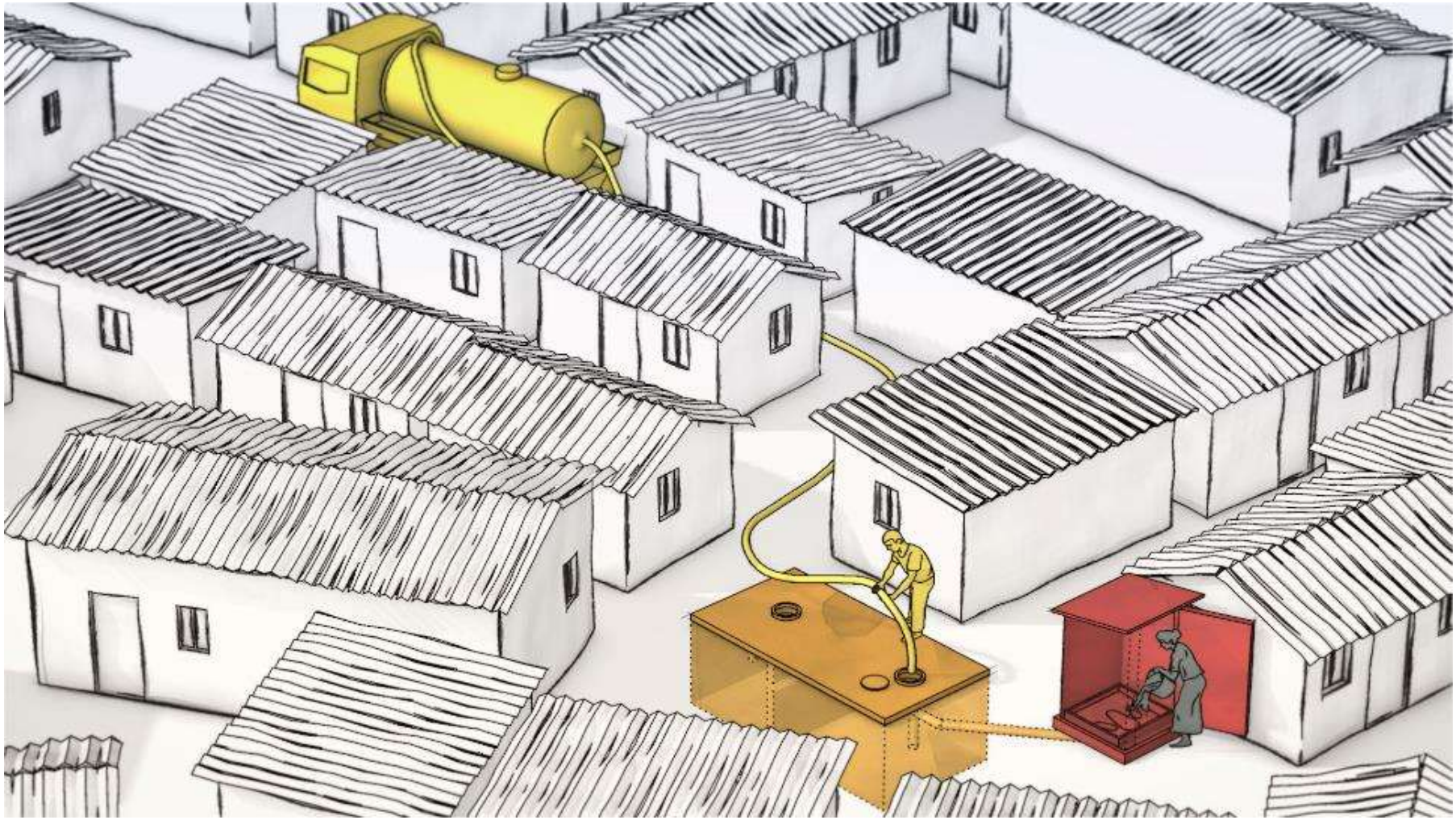
by the private sector

Manual latrine emptying

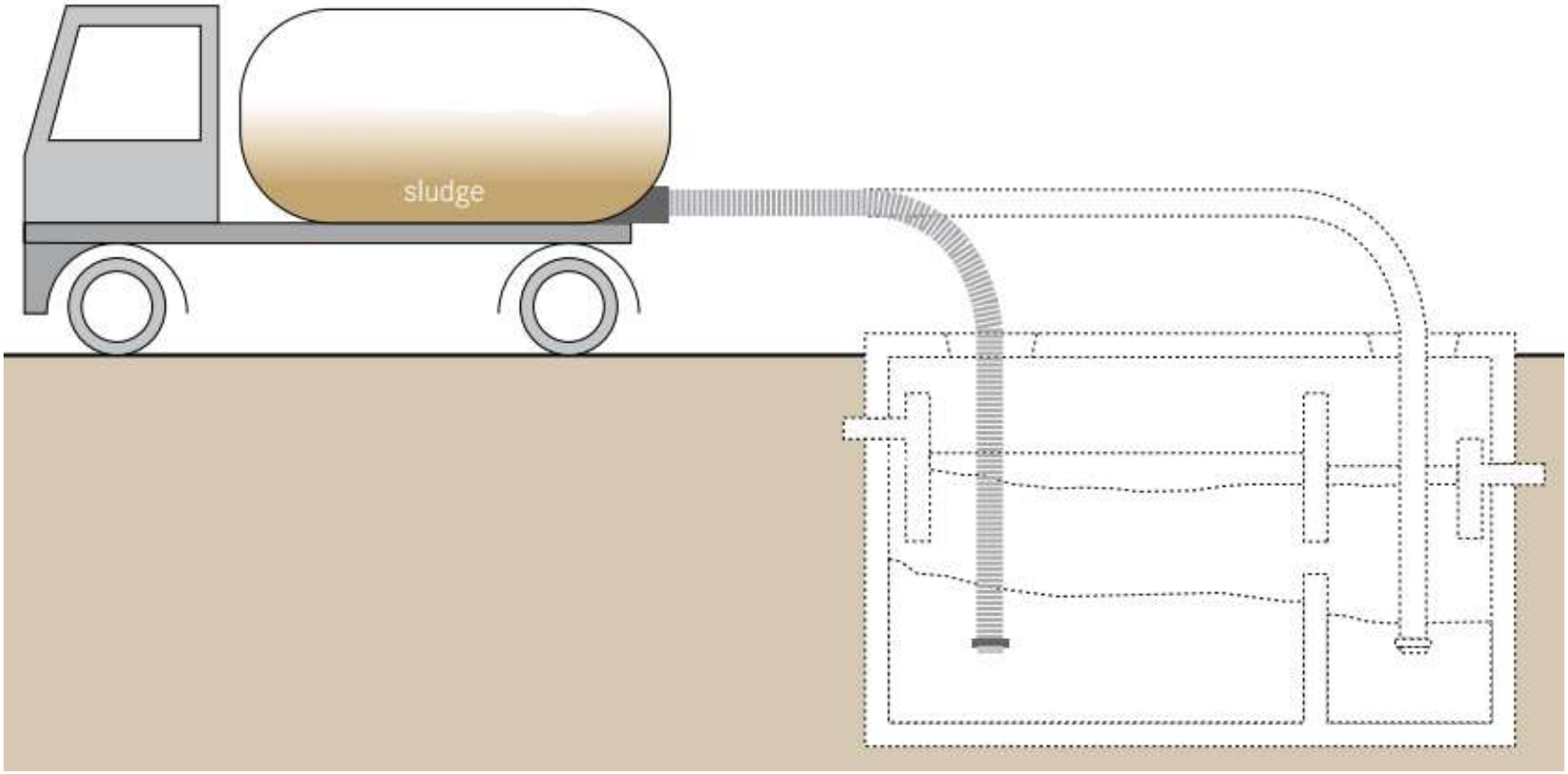
Usually occurs when:

- Trucks cannot access
- Trucks cannot pump
- Households cannot afford the service

Motorized emptying



Motorized Emptying and Transport



Motorized Emptying

Motorized Emptying

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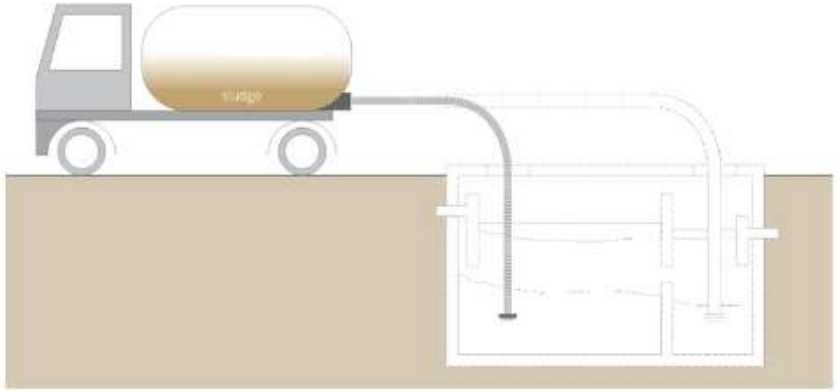
Vacutug

Motorized emptying

Pros and cons

ADVANTAGES

- Fast and efficient
- Minimizes health risks



CONSTRAINTS

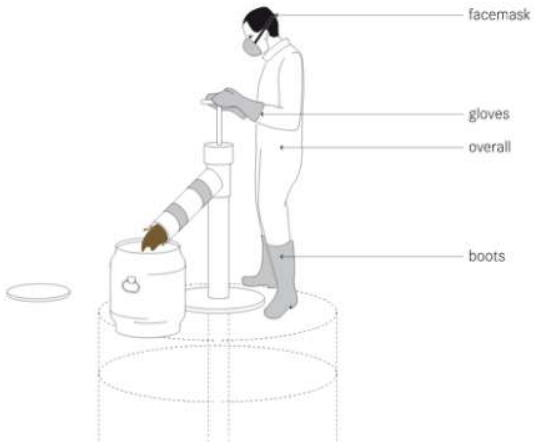
- High O&M and capital cost (passed to customer)
- Cannot pump thick dried sludge (manual removal)
- Garbage in pits may block the hose
- Pumps usually only suck to a depth of 2-3 m
- May have difficulties with access
- Spare parts often lacking

… vs. Manual emptying

Pros and cons

ADVANTAGES

- Low-cost operation and maintenance
- Accessibility
- Maintenance skills and spare parts available



CONSTRAINTS

- Limited efficiency
- Time consuming
- Health hazard for workers
- Spillage and bad odours
- Difficult and unpleasant work
- Requires a disposal point nearby (<0.5 km)

A Gulper
Kibera, Nairobi, Kenya

FS collection and transport

Hybrid of manual and mechanical collection & transport

FS collection and transport

Challenges

Limited road access

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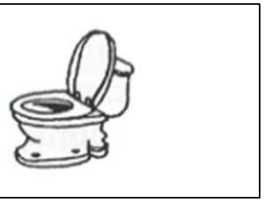
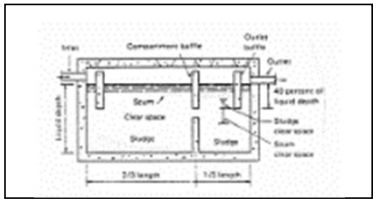
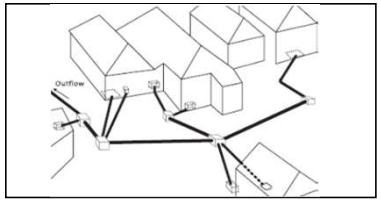
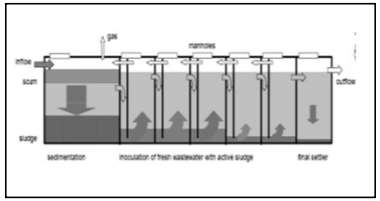
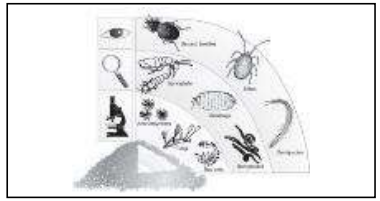
User Interface	Collection and Storage / Treatment	Conveyance	(Semi-) Centralised Treatment	Use and / or Disposal
				
○ Dry Toilet ○ Urine Diverting Dry Toilet (UDDT) ○ Urinal ○ Pour Flush Toilet ○ Cistern Flush ○ Toilet ○ Urine Diverting ○ Flush Toilet	○ Urine Storage ○ Tank / Container ○ Single Pit ○ Single Ventilated ○ Improved Pit (VIP) ○ Double Ventilated ○ Improved Pit (VIP) ○ Fossa Alterna ○ Twin Pits for ○ Pour Flush ○ Dehydr. Vaults ○ Composting ○ Chamber ○ Septic Tank ○ Etc.	○ Jerry can / Tank ○ Human-Powered Emptying and Transport ○ Motorized Emptying and Transport ○ Simplified Sewer ○ Solids-Free Sewer ○ Conventional Gravity Sewer ○ Transfer Station (Holding Tank) ○ Sewer Discharge Station	○ Imhoff Tank ○ Anaerobic Baffled Reactor ○ Anaerobic Filter ○ Trickling Filter ○ Waste Stabilization Ponds ○ Finishing Pond ○ Constructed Wetland ○ Co-composting ○ etc.	○ Fill and Cover / Arborloo ○ Applic. of Urine ○ Application of Dehydr. Faeces / Compost ○ Irrigation ○ Soak Pit ○ Leach Field ○ Aquaculture ○ Floating Plant Pond ○ Water Disposal / Groundwater Recharge ○ Land application ○ Surface Disposal

Treatment technologies

- **Pre-treatment**

  example: removal of oil, grease, sand or trash

- **Primary treatment**: liquid-solid separation

  example: a settler

- **Secondary treatment**: removal of organic matter and suspended solids

  example: activated sludge

- **Post-treatment or tertiary treatment**: final polishing

  example: removal of remaining pathogens, nutrients or micropollutants

Treatment technologies

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AEROBIC

= **with** the presence of oxgen

… aerobic treatment / digestion

… with aerobic / facultative bacteria

… large amount of sludge

e.g. compost, activated sludge, maturation pond, constructed wetlands

ANAEROBIC

= **without** the presence of oxgen

… anaerobic treatment / digestion

… with anaerobic / facultative bacteria

… low amount of sludge

… with production of biogas (methane + CO_2)

e.g. septic tank, ABR, biogas digester, anaerobic pond

Pre-treatment

Goals:

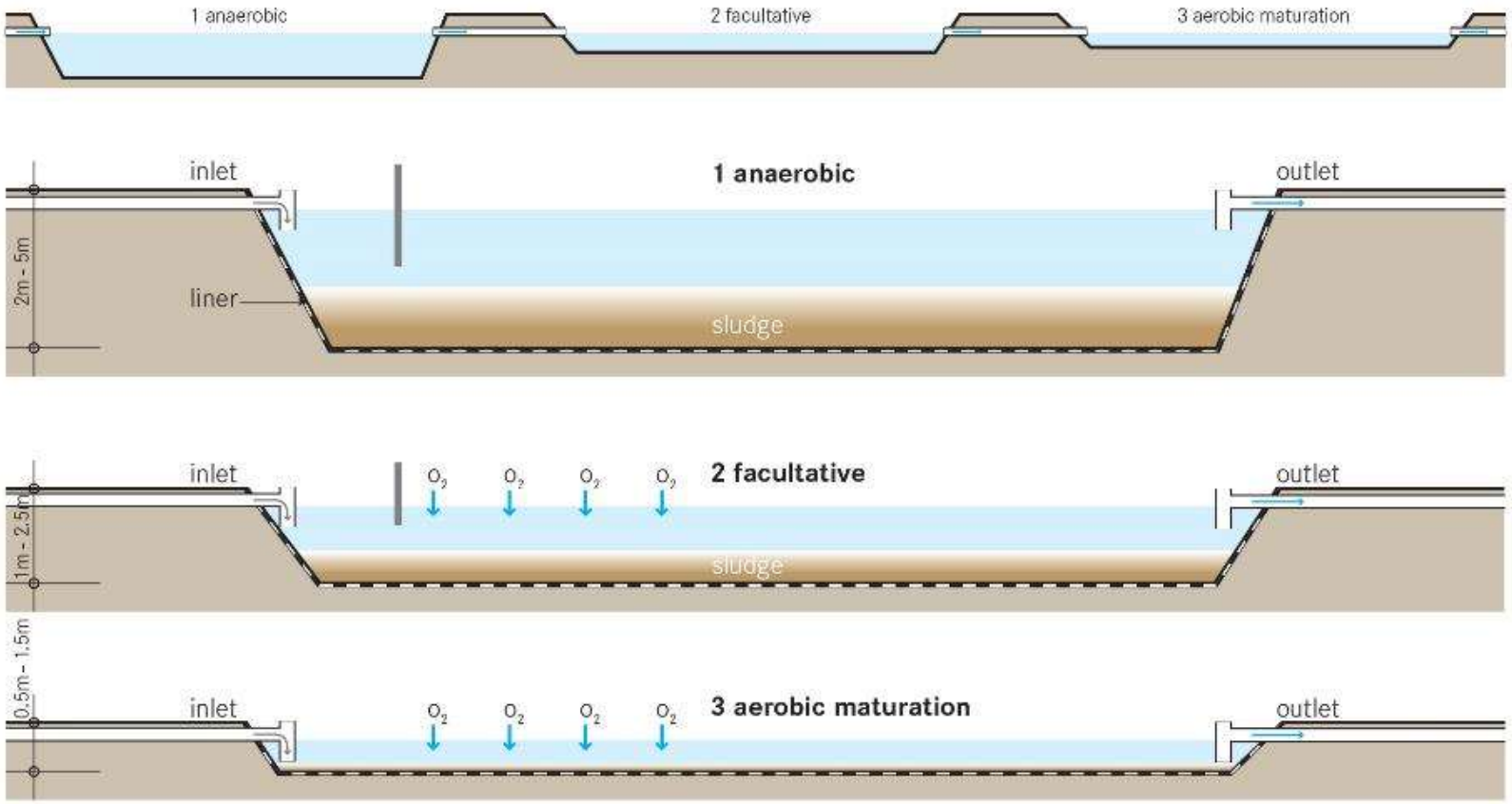
- Prevent the accumulation of solids in further stages and avoid blockages.
- Reduce abrasion of mechanical parts and extend the life of sanitation infrastructure.

Based on physical removal mechanisms:

- Screening (coarse solids/trash removal)
- Flotation (grease removal)
- Settling (grit and sand removal)

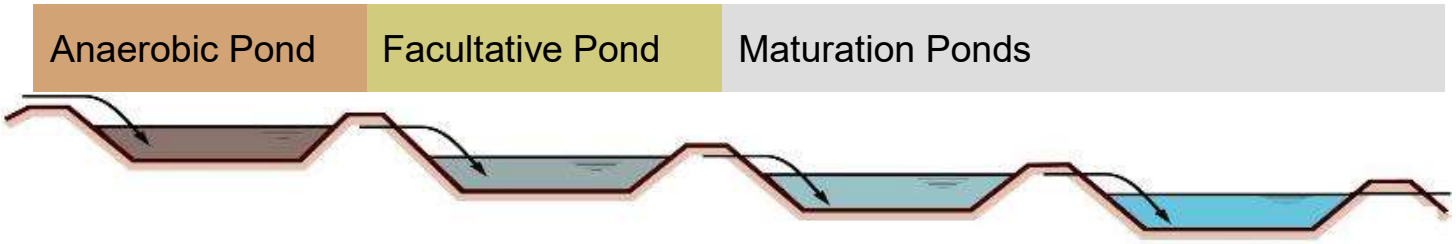
Waste stabilisation ponds
Cuenca, Ecuador, ETAPA

Waste Stabilisation Ponds (WSP)



Waste Stabilisation Ponds

A pond-system comprises:
- anaerobic sedimentation ponds,
- alternating facultative (anoxic) ponds and
- several maturation ponds (post-treatment aerobic)



Design	Deep (2-5m) and highly loaded but rather small area	Shallow (<1.5m) but large → Oxygen supply (algae, wind, artificial aeration)	Shallow (<1m) but large area
Flow	Hydraulic retention time: 1 to 3 days	Hydraulic retention time: 10 to 20 days	Hydraulic retention time: 10 days
Function	Sedimentation and anaerobic stabilisation of sludge (BOD reduction 40-50%) → **settling**	Aerobic degradation of suspended and dissolved matter (BOD reduction 50-70%) → **degradation**	Final sedimentation of suspended solids, bacteria mass and pathogens → **hygienization**

Waste Stabilisation Ponds

Pros and cons

ADVANTAGES

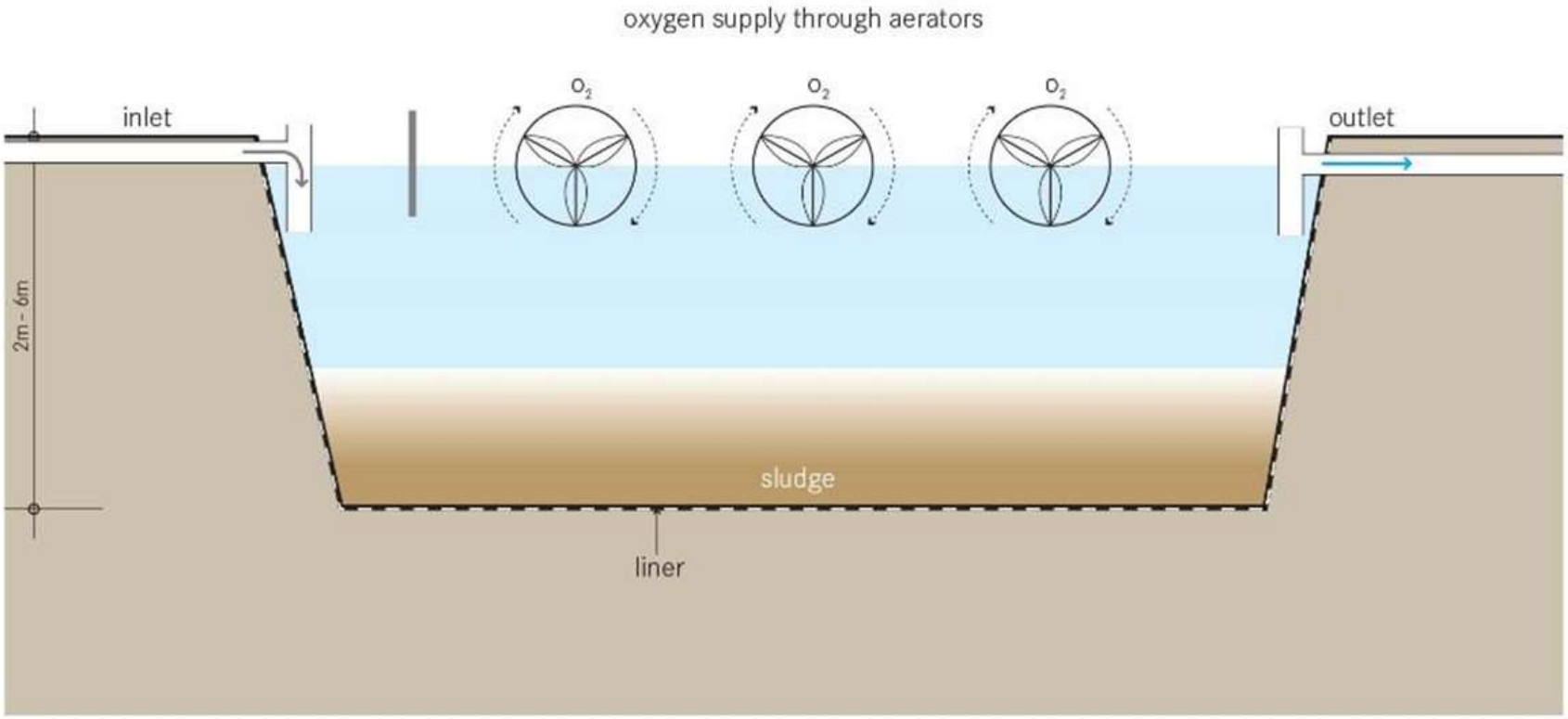
- Can treat high strength wastewater to high quality effluent
- Generally reliable and good functioning
- Very inexpensive compared to other centralized options

CONSTRAINTS

- Requires a lot of space
- Potential for bad odours if poorly designed
- Requires expert design and supervision (especially to avoid short-circuiting)
- Not always appropriate for colder climates

⇒ Ideal for developing countries **if enough space and supervision available**

Aerated Pond



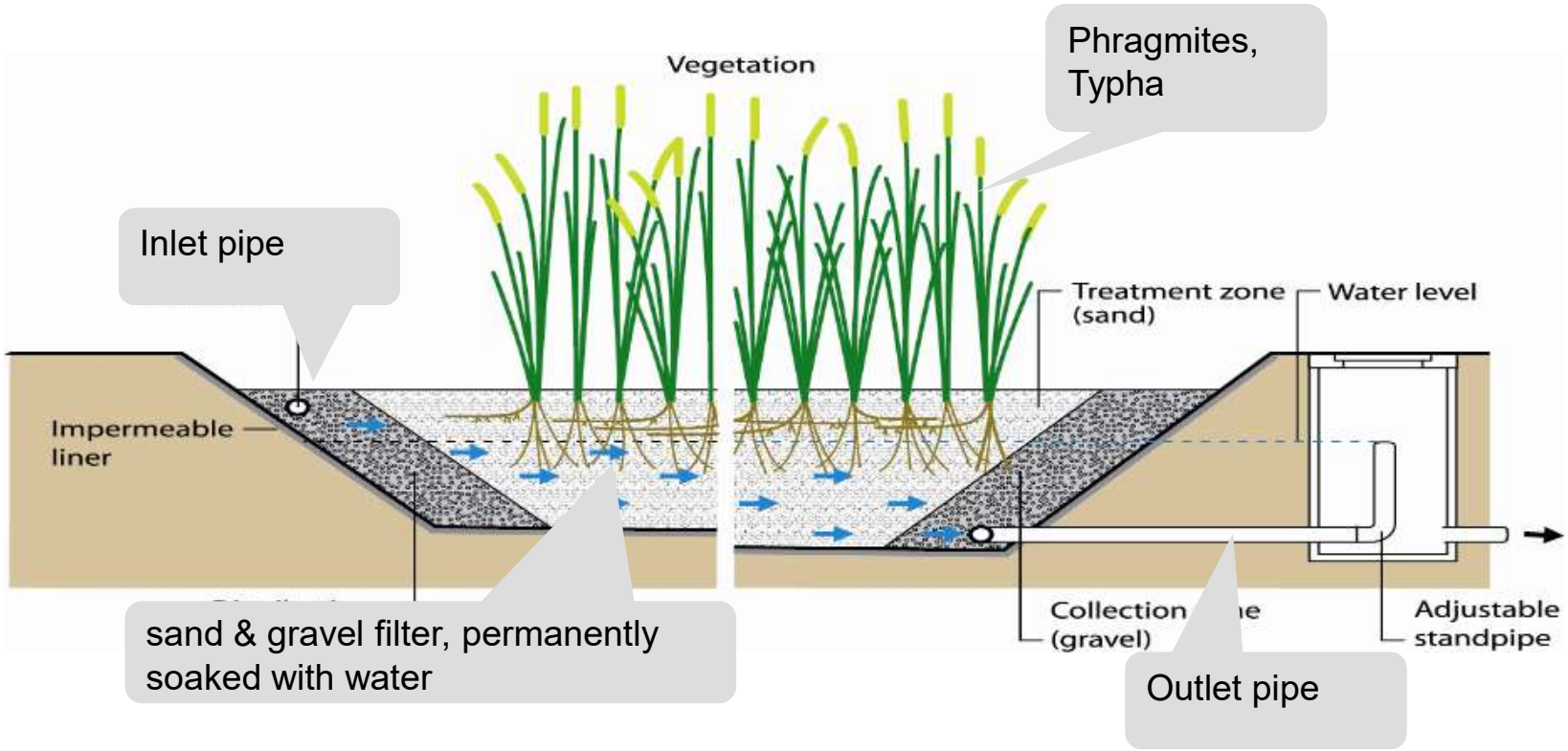
Vertical flow constructed wetland for a small community

Birmoos, Switzerland – BICON AG

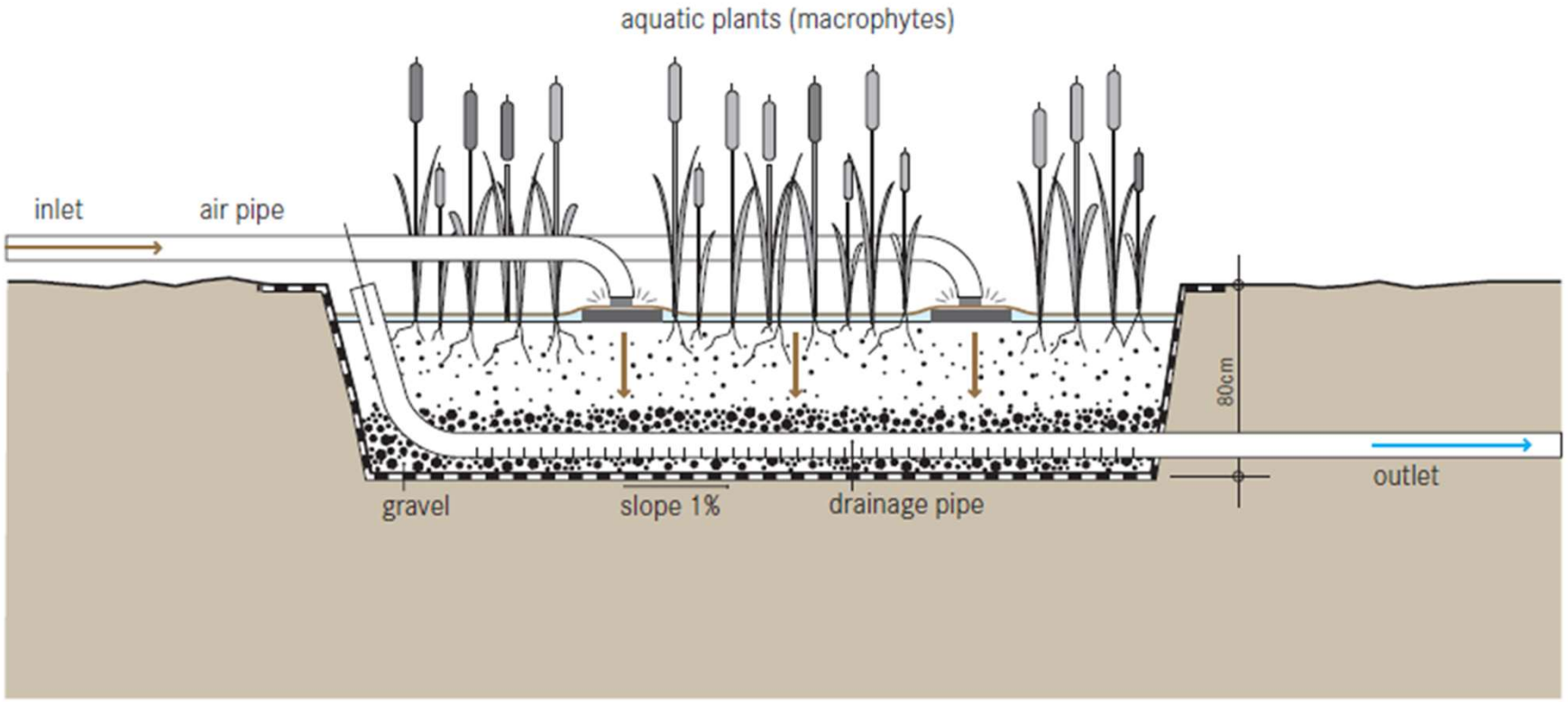
Constructed wetlands

Horizontal Subsurface Flow Constructed Wetland

→ For treatment of (pre-settled) domestic or industrial WW
(COD < 500mg/l and low solids)



Vertical Flow Constructed Wetland



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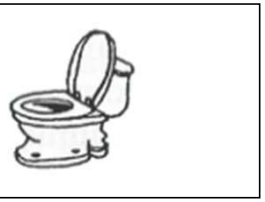
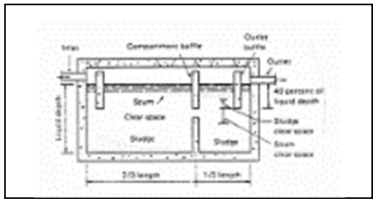
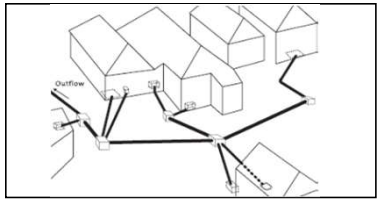
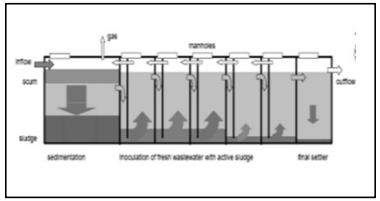
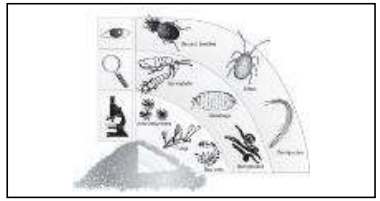
User Interface	Collection and Storage / Treatment	Conveyance	(Semi-) Centralised Treatment	Use and / or Disposal
				
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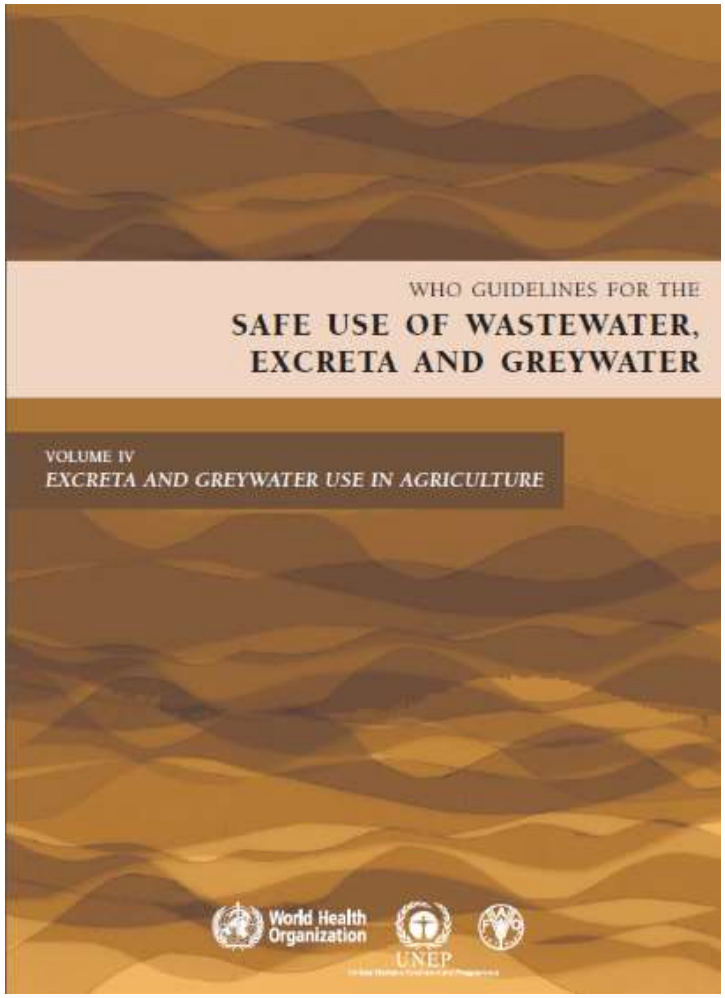
Benefitial enduses

- Irrigation
- Urine as fertilizer
- Compost as soil amendment and fertilizer
- Biogas – CH_4
- Humified or dried sludge
- Forage
- Fish (Aquaculture)
- Ornamental plants
- Fuel

Enduse and disposal

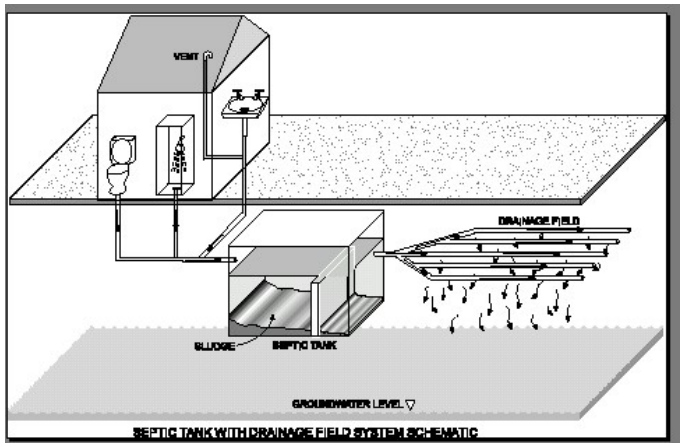
- Multi-barrier approach (WHO guidelines)
- Health protection measures
- Evaluation of who is exposed and how
- Adequate monitoring and oversight



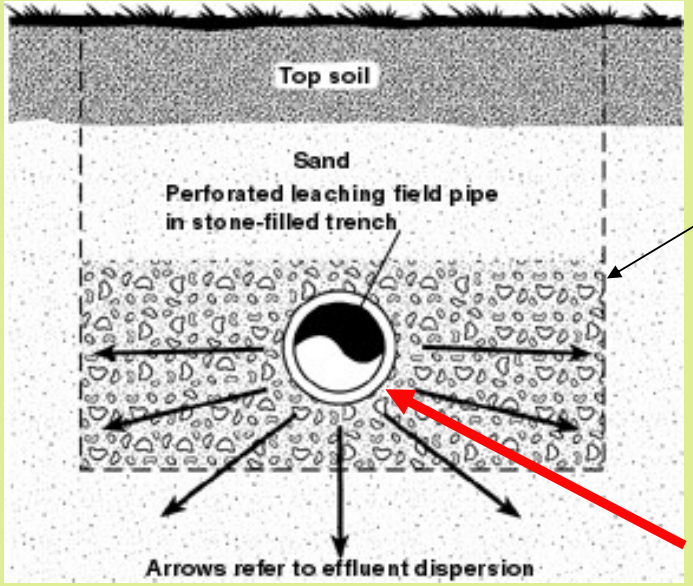
Wastewater disposal: Leaching Fields

System of trenches that is used to dissipate the effluent from a septic tank

→ for discharge of non-solid septic tank effluent



\+ little maintenance required
\- Space and skills required !



sand and/or topsoil

fabric, to prevent plugging of pipe

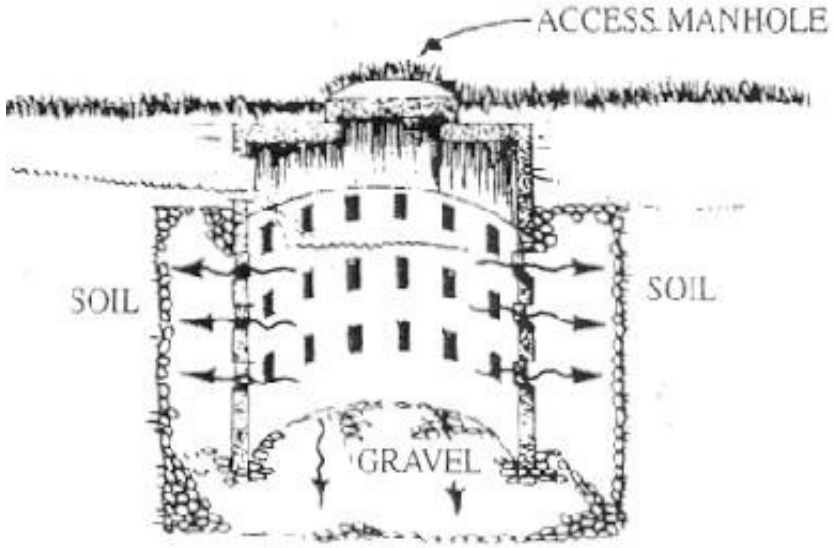
clean rock

perforated distribution pipe

Wastewater disposal: Soak Pits

= covered, porous-walled chamber that allows water to slowly soak into the ground.

→ for non-solid septic tank effluent (clogging!)



+ simple and cheap
+ little space required

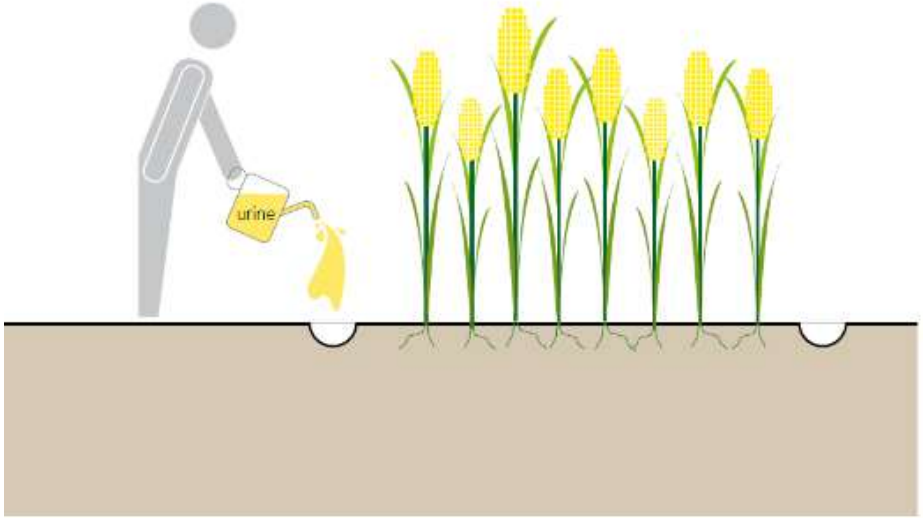
- not adequate for shallow ground water table (>1.5 m)
- not adequate in clay or rocky soils

Between 1.5 and 4 m deep

Valorisation of urine

Application of stored urine

About 88% N, 61% P and 74% potassium excreted by the body is in urine.



Note: stored urine should not be applied directly to plants because of high pH and concentrated form.

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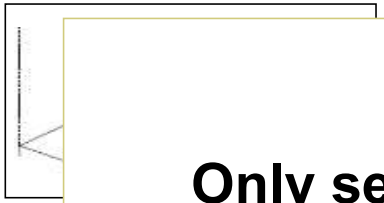
User Interface	Collection and Storage / Treatment	Conveyance	(Semi-) Centralised Treatment	Use and / or Disposal
				
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Remember:

Only selected combinations of technologies result in functional systems!

Sanitation System: Empty Template (Enter Title)

Input Products	U User Interface	Input/Output Products	S Collection and Storage/ Treatment	Input/Output Products	C Conveyance	T (Semi-) Centralized Treatment	Input/Output Products	D Use and/or Disposal

Disclaimer: This sanitation system was created using Eawag's Sanitation System Drawing Tool (Version 1). The user of this tool alone is responsible for the correctness and completeness of this system.

If you want to learn more…

massive open online course

MOOC series "Sanitation, Water and Solid Waste for Development"

MOOC I:
Introduction to Household Water Treatment and Safe Storage

Dr. Richard Johnston &
Dr. Sara Marks

MOOC II:
Planning & Design of Sanitation Systems and Technologies

Dr. Christoph Lüthi

MOOC III:
Municipal Solid Waste Management in Developing Countries

Dr. Christian Zurbrügg

MOOC IV:
Faecal Sludge Management

Dr. Linda Strande

More information: www.eawag.ch/mooc

Target groups: sector professionals, students and local government staff

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aquatic research

Questions or remarks ?

THANKS FOR YOUR ATTENTION !

philippe.reymond@eawag.ch