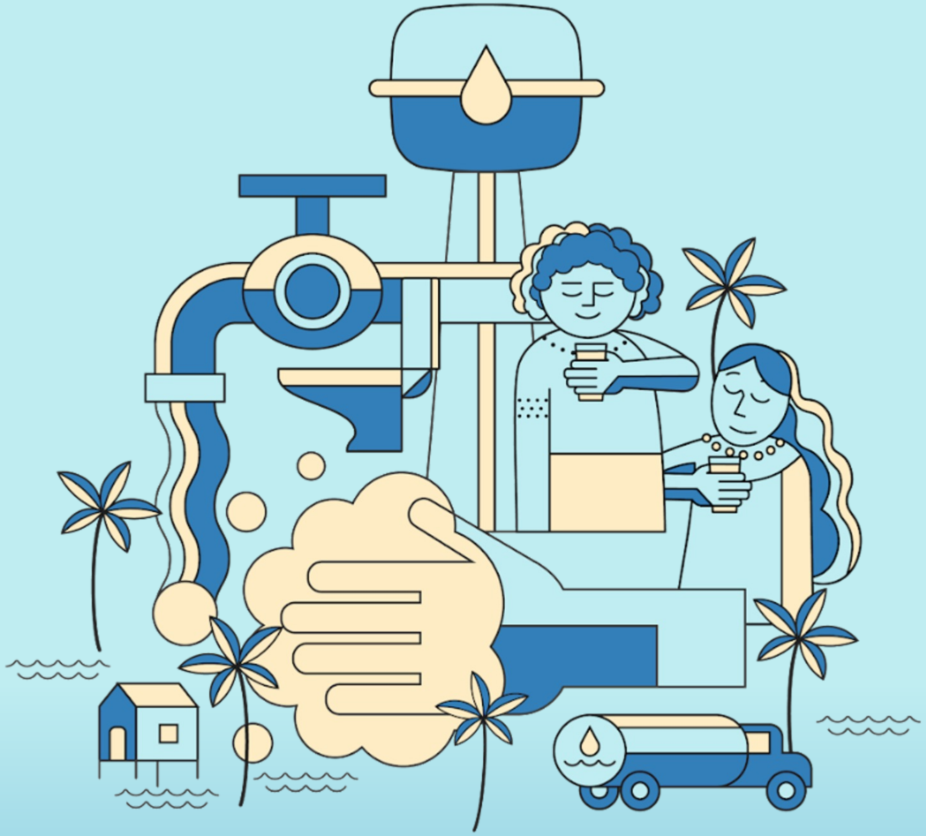
ADB Technical Assistance
Strengthening WASH in the Pacific

ADB

A 'Good enough guide' to sanitation in the Pacific

On-line training resources as delivered at the Water and WASH Futures Conference

17 February 2023



Trainers

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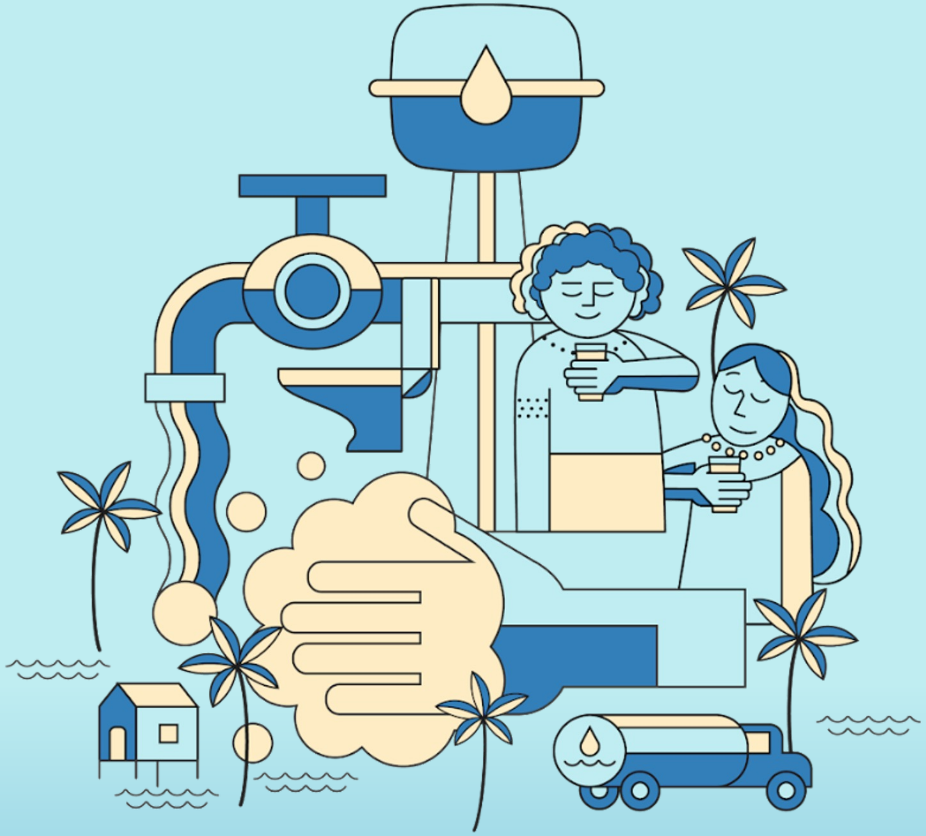
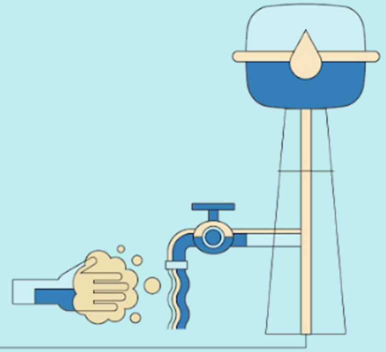


Learning objectives:

1. To understand the principles underpinning the dry (aerobic) and wet (anaerobic) processes for the containment and treatment of faecal waste.
2. To understand the principles underpinning the design of septic tanks & soakaways, wet & dry pit toilets, septage & sewage treatment plants.



Introduction:

- Context: What's unique about Pacific sanitation?
- Health impacts – chronic and acute

1. Understanding faecal exposure risks

- Faecal exposure pathways
- Groundwater safety and setback distances

2. Principles of septic tanks and soakaways

- Design, operation and maintenance
- Common failings

3. Principles of pit toilets

- Wet / anaerobic
- Dry / aerobic

4. Principles of septage / sewage treatment systems

- Design, operation and maintenance
- Common failings

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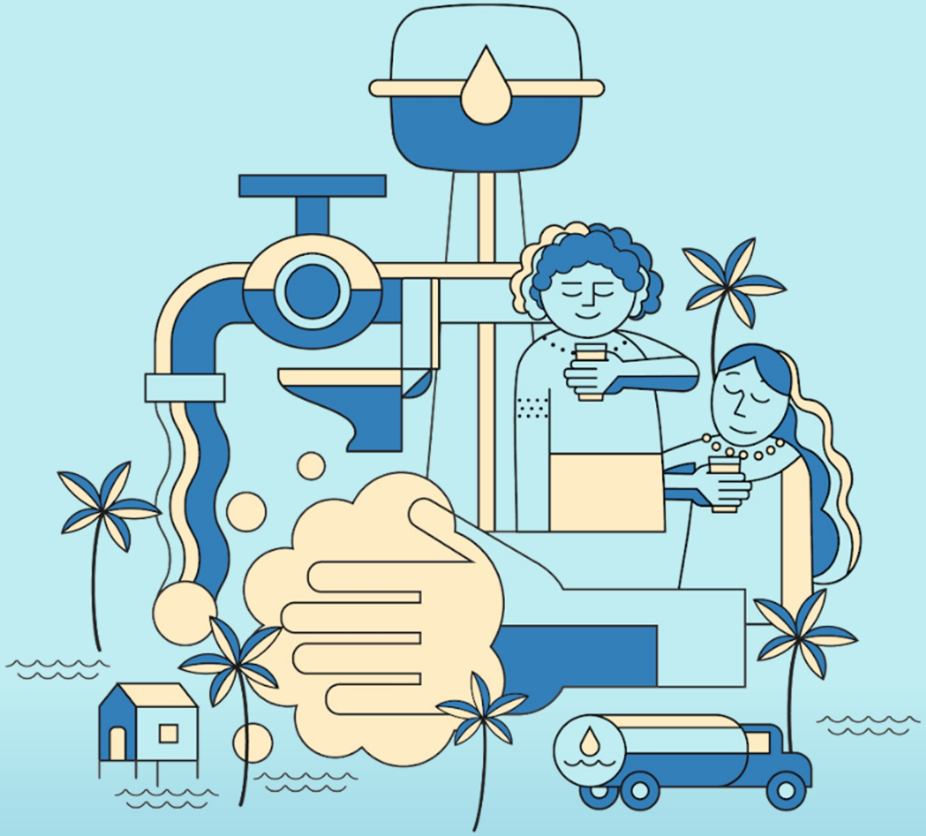
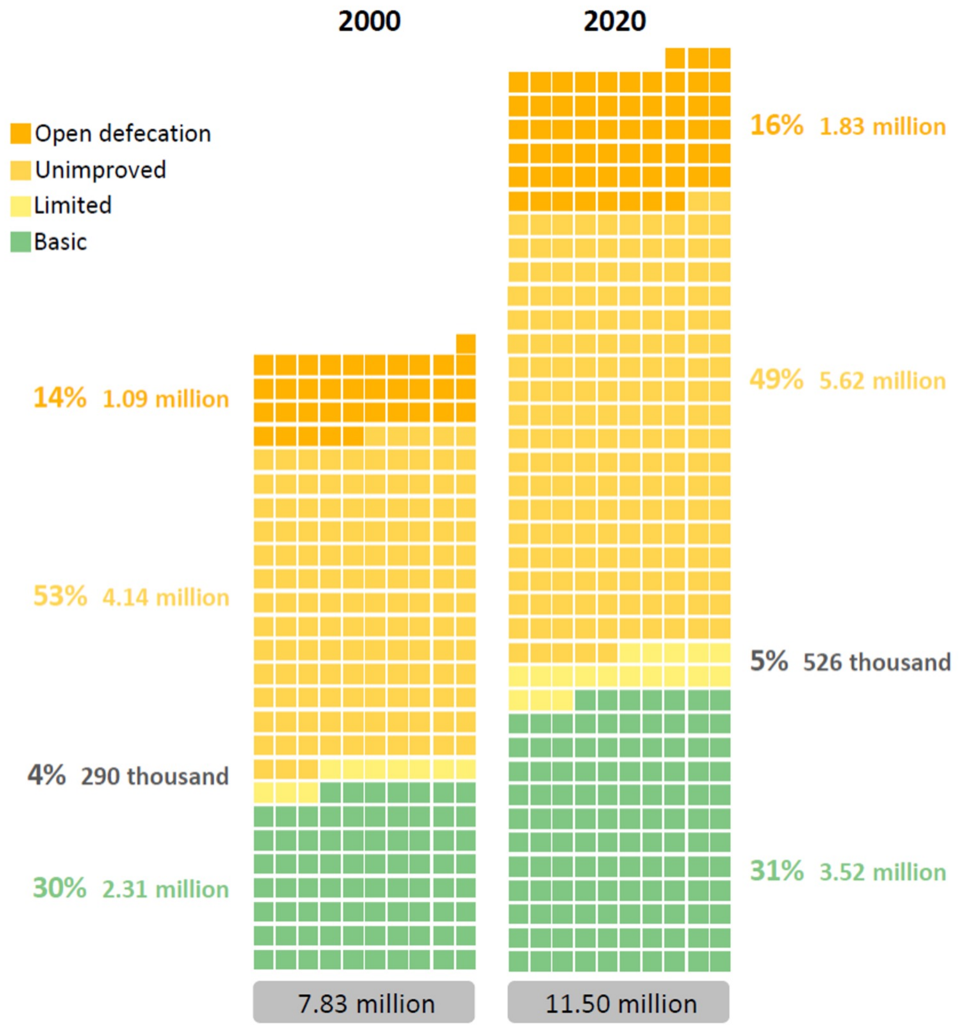
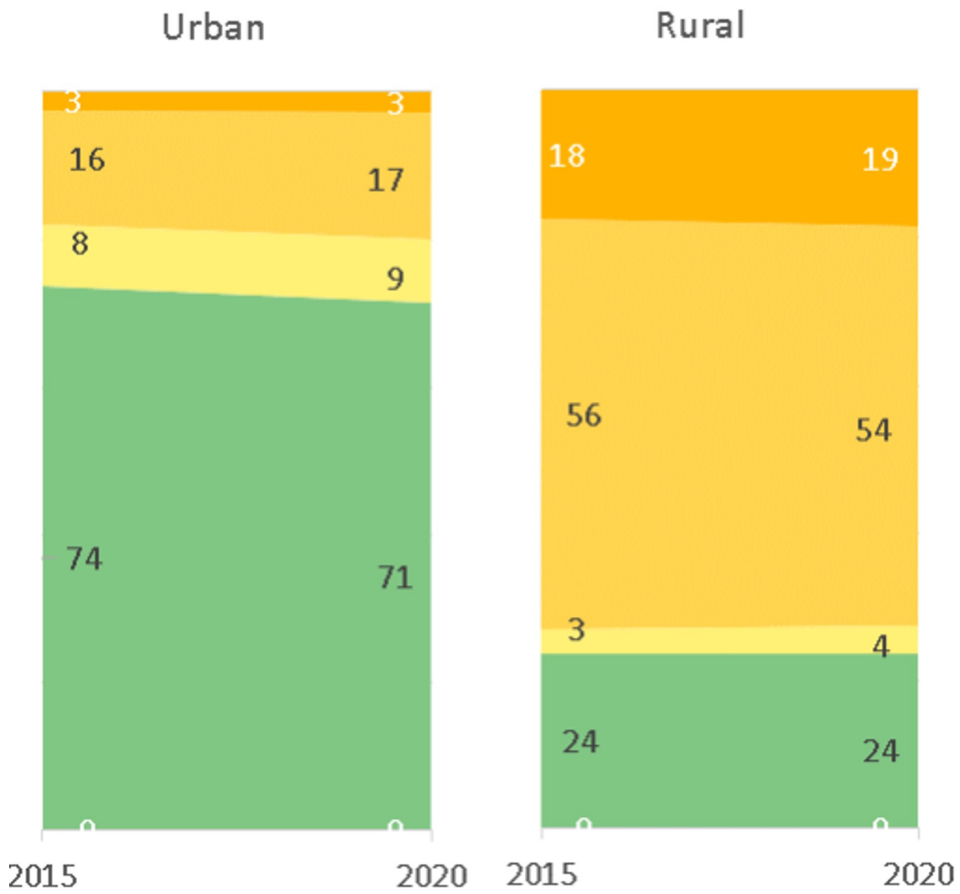
Introduction: Sanitation in the Pacific



Pacific Sanitation Context

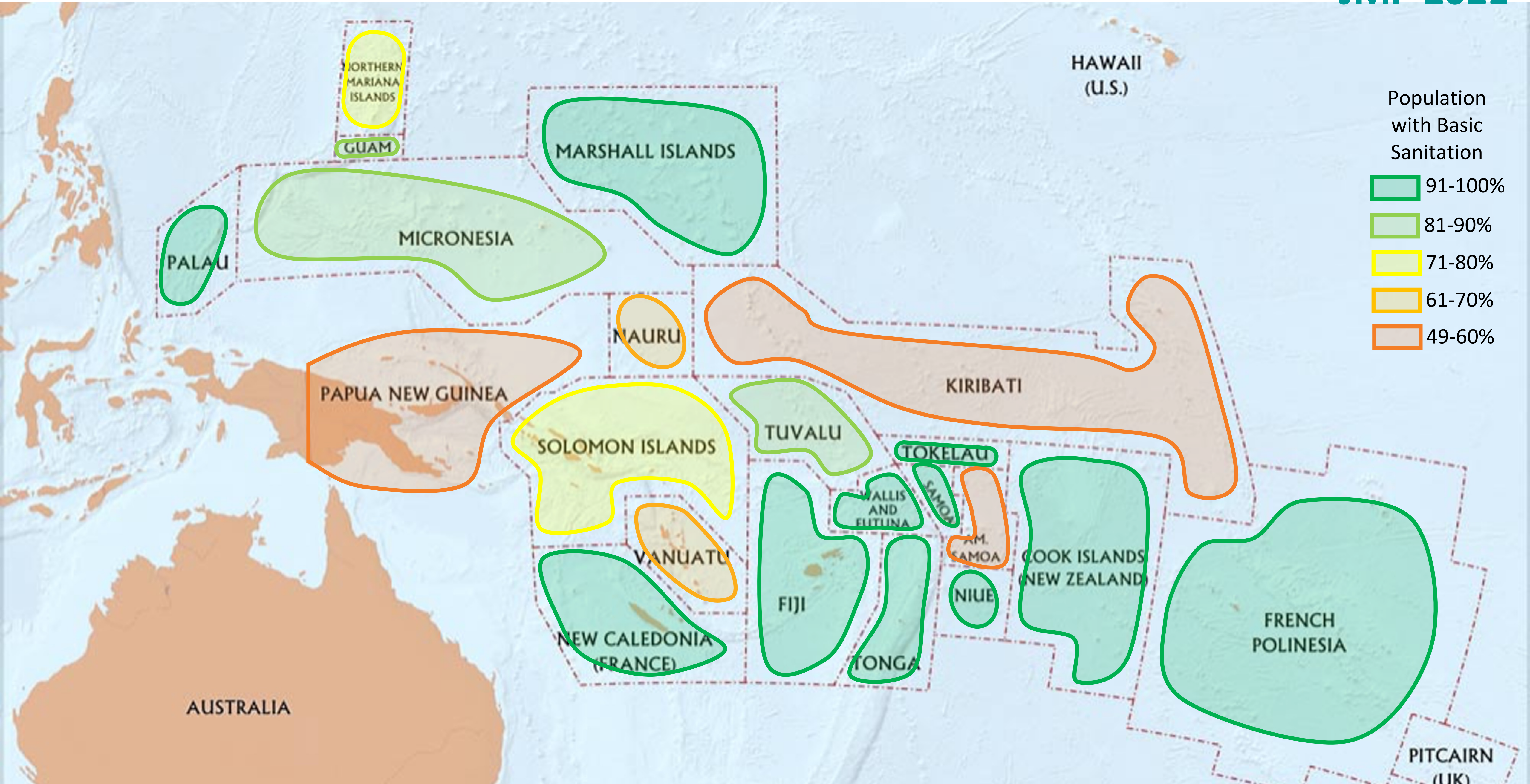


1.2m people gained access in last 20 years, but this did not keep up with population growth

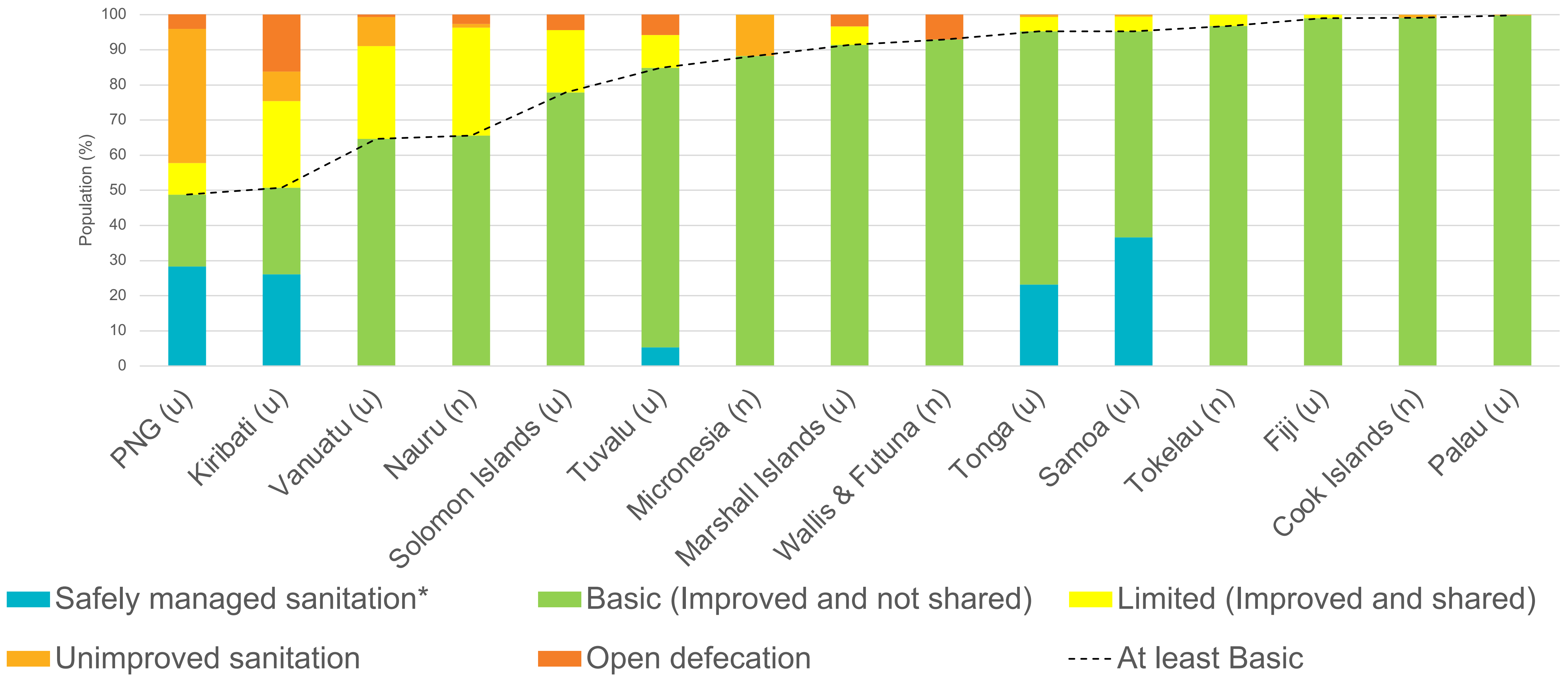


Inequities in access between urban and rural populations

Access to at least Basic Urban Sanitation Facilities JMP 2021

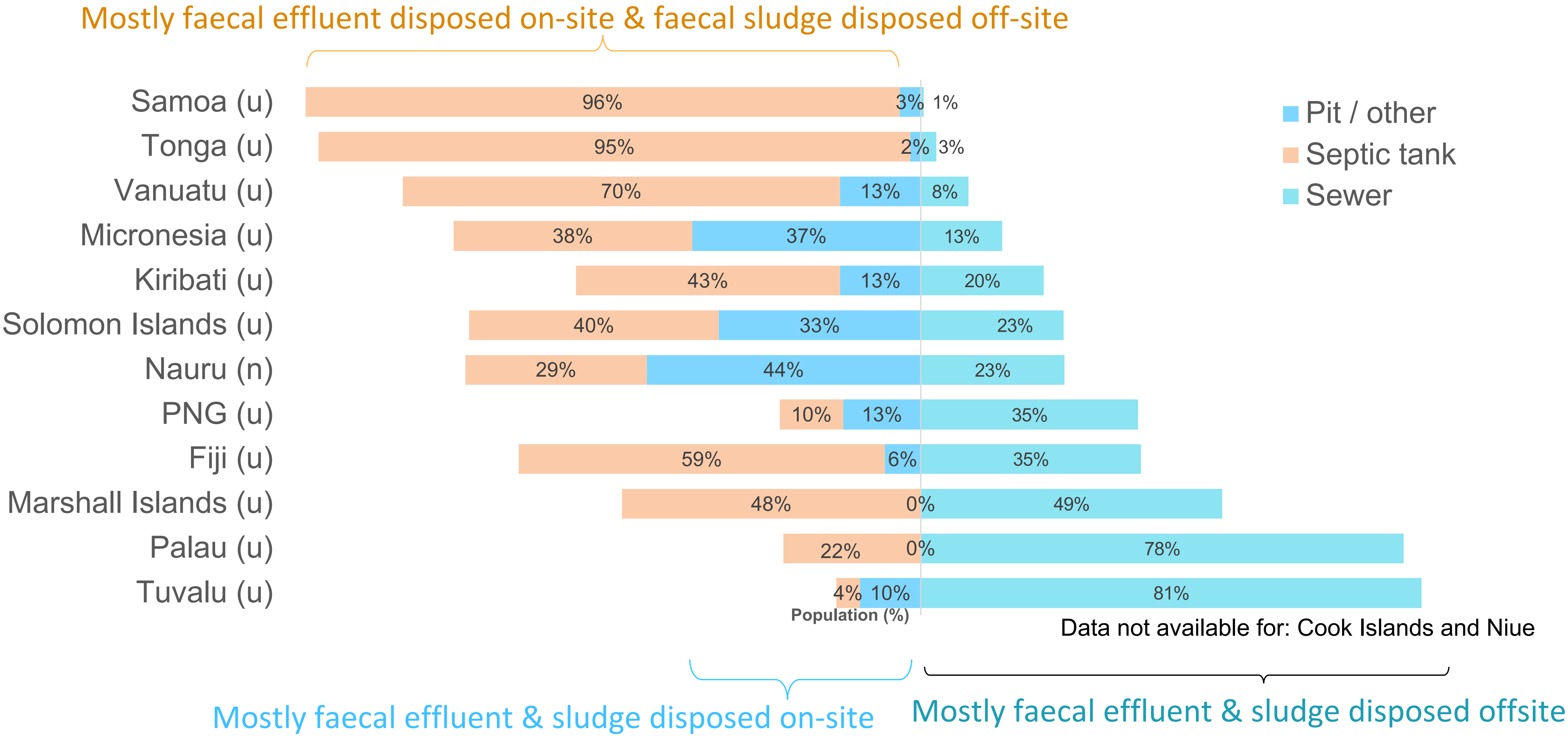


Pacific Access to Basic Urban Sanitation Facilities JMP 2021



(u) Urban data available (n) Only national data available

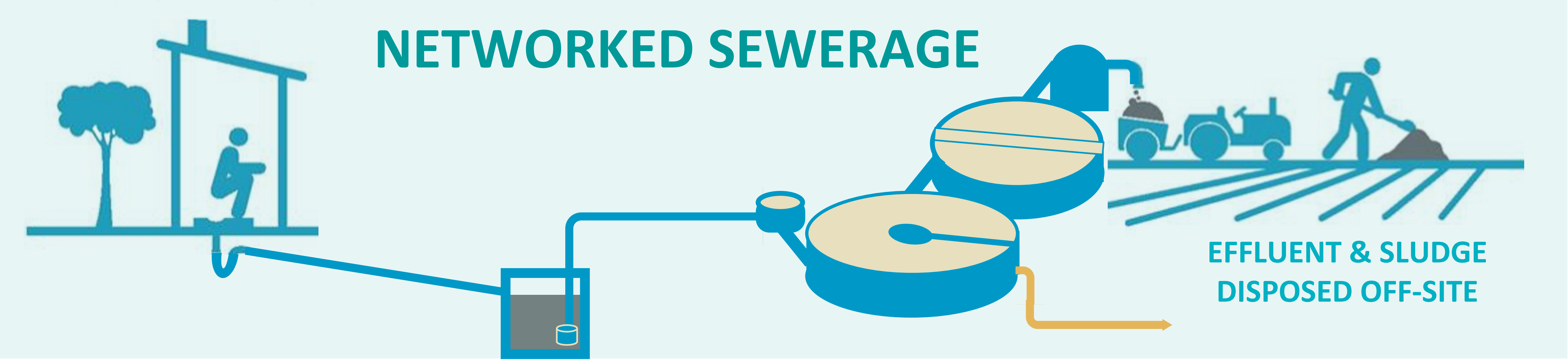
Faecal Sludge Management vs Sewerage Treatment in the Pacific



(u) Urban data available (n) Only national data available

Source: WHO/UNICEF JMP (2021)

Safely Managed Sanitation Elements



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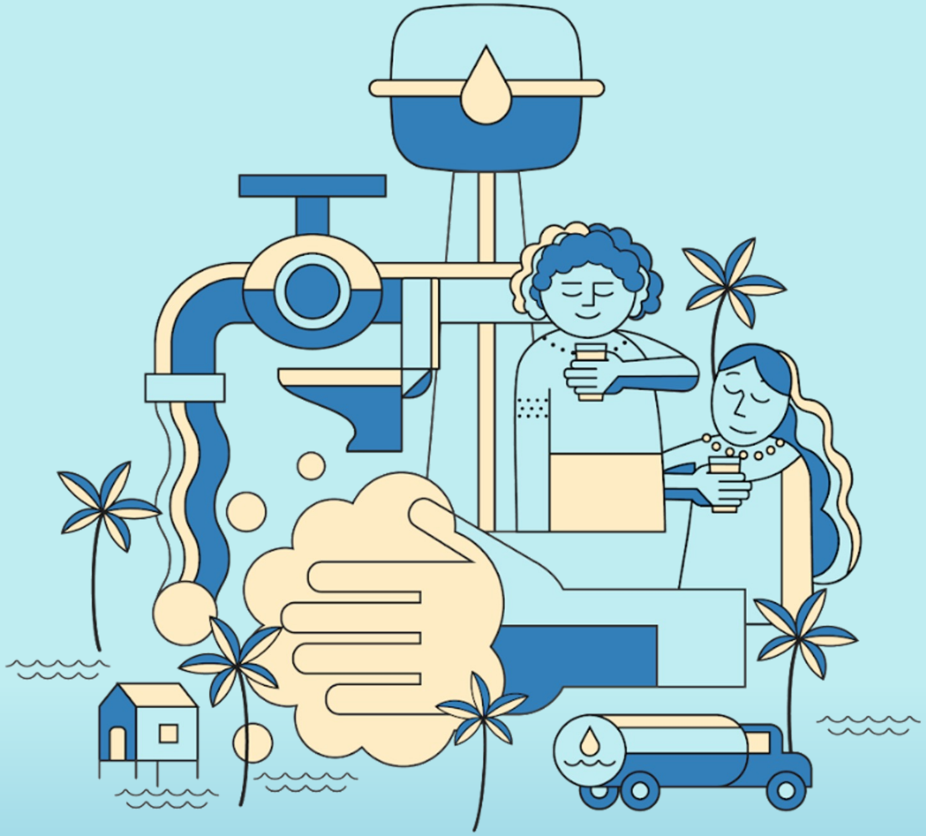
Introduction: What's unique to the Pacific ?



Pacific Island Countries

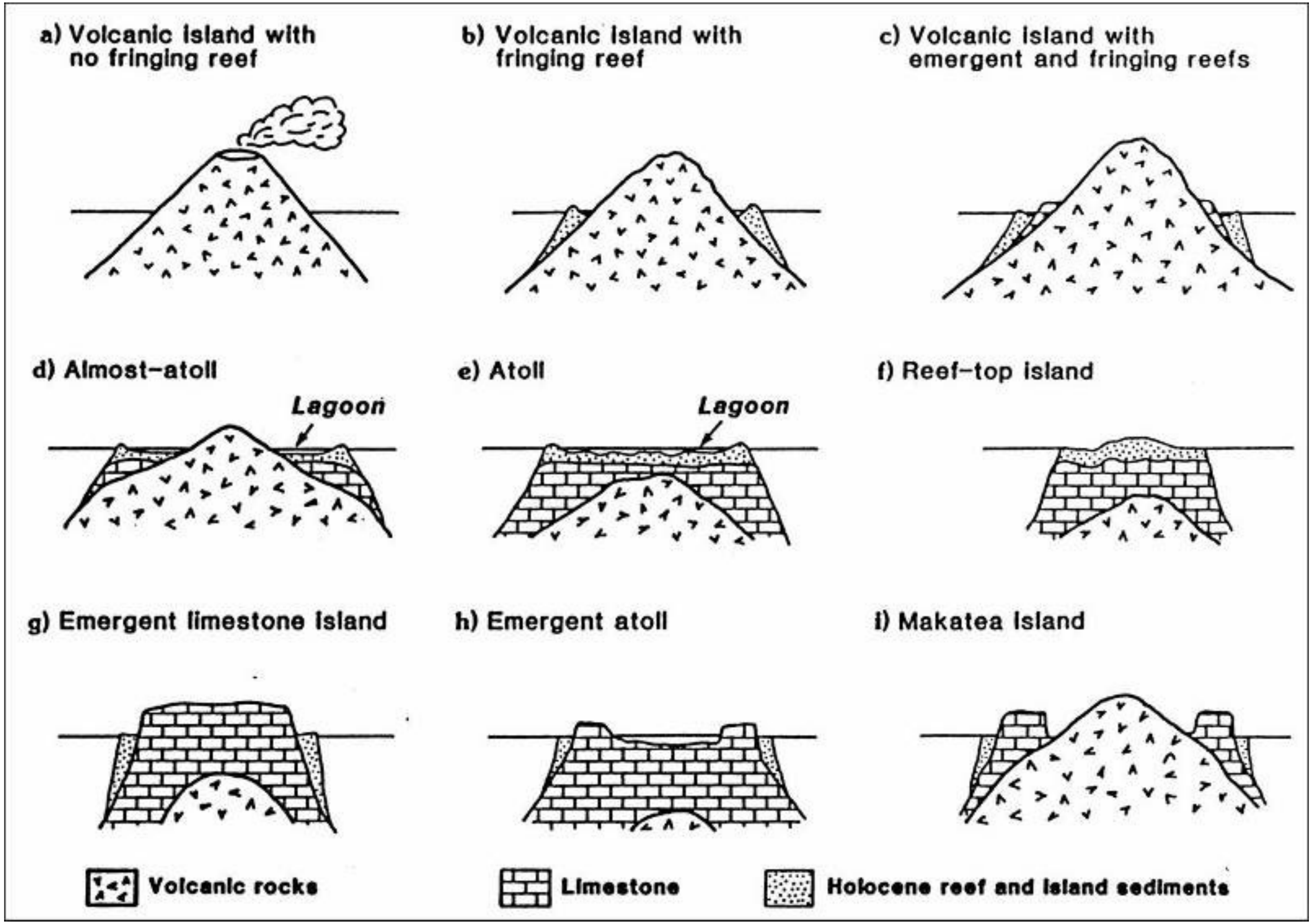
Large diversity

- **Physical nature of islands** (size, shape elevation, geology, etc)
- **Climate** (especially rainfall – very variable in space & time)
- **Hydrology & water resources availability**
- **Demography** (total population, population density, growth rate, % of urban and rural)
- **Culture**
- **Degree of economic development**
- **Degree of isolation**

Physical characteristics of Pacific Island Countries

Country	Total Land Area (km^2)	Number of islands or atolls	Island type according to geology
Cook Islands	237	15	Volcanic, limestone, atoll, mixed
Federated States of Micronesia	701	607	Volcanic, atoll, sand, mixed
Fiji	18,300	322	Volcanic, limestone, atoll, sand, mixed
Kiribati	811	33	Atolls & coral islands, one limestone island
Marshall Islands	181	34	Atolls & coral islands
Nauru	21	1	Limestone
Niue	259	1	Limestone
Palau	444	340	Volcanic, some with limestone
Papua New Guinea	463,000	Approx. 600	Volcanic, limestone, atoll, sand, mixed
Samoa	2,930	10	Volcanic
Solomon Islands	28,200	Approx. 1,000	Volcanic, limestone, atolls
Tonga	749	171	Volcanic, limestone, sand, mixed
Tuvalu	26	9	Atolls
Vanuatu	12,300	83	Volcanic with coastal sands & limestone

Geology



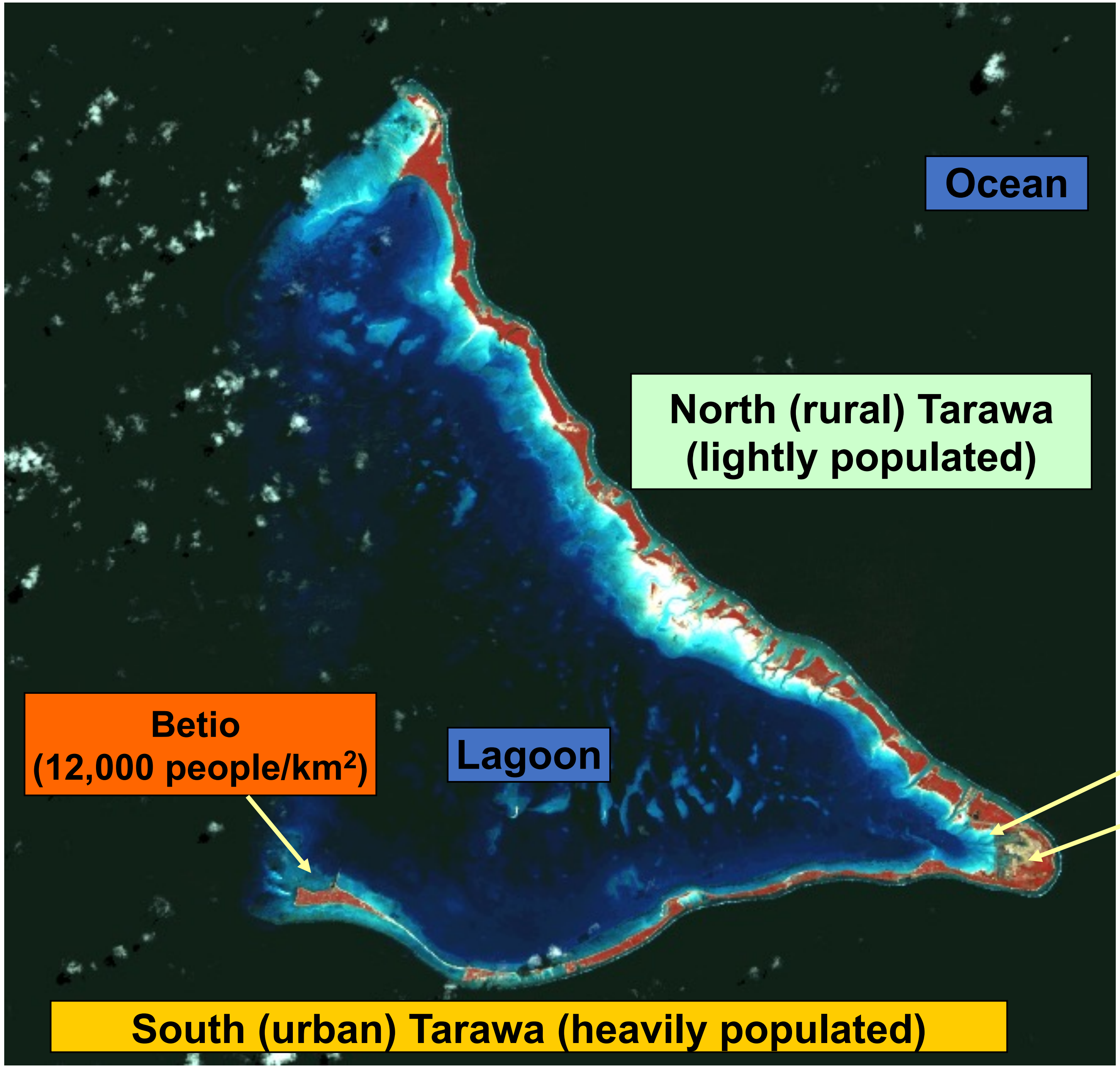
Examples of Volcanic, Limestone, Coral & Mixed Geology Islands

Population summary for Pacific Island Countries

Country	Population estimates, 2022	Average population density (people/km^2)	Population growth rate (%)	Urban population (%)	Rural population (%)
Cook Islands	15,400	65	0.4%	75%	25%
Federated States of Micronesia	106,000	151	0.2%	22%	78%
Fiji	902,000	49	0.4%	56%	44%
Kiribati	122,700	151	1.7%	53%	47%
Marshall Islands	54,400	301	-0.1%	74%	26%
Nauru	11,900	567	0.8%	100%	0%
Niue	1,530	6	-1.1%	36%	64%
Palau	18,000	41	0.1%	80%	20%
Papua New Guinea	9,310,000	20	2.1%	13%	87%
Samoa	201,000	69	0.6%	19%	81%
Solomon Islands	744,000	26	2.3%	19%	81%
Tonga	99,300	133	-0.3%	23%	77%
Tuvalu	10,800	415	0.9%	63%	37%
Vanuatu	308,000	25	2.2%	25%	75%
Total / Average	11,905,030			21%	79%

Tarawa atoll, Kiribati

High population density on South Tarawa



Buota

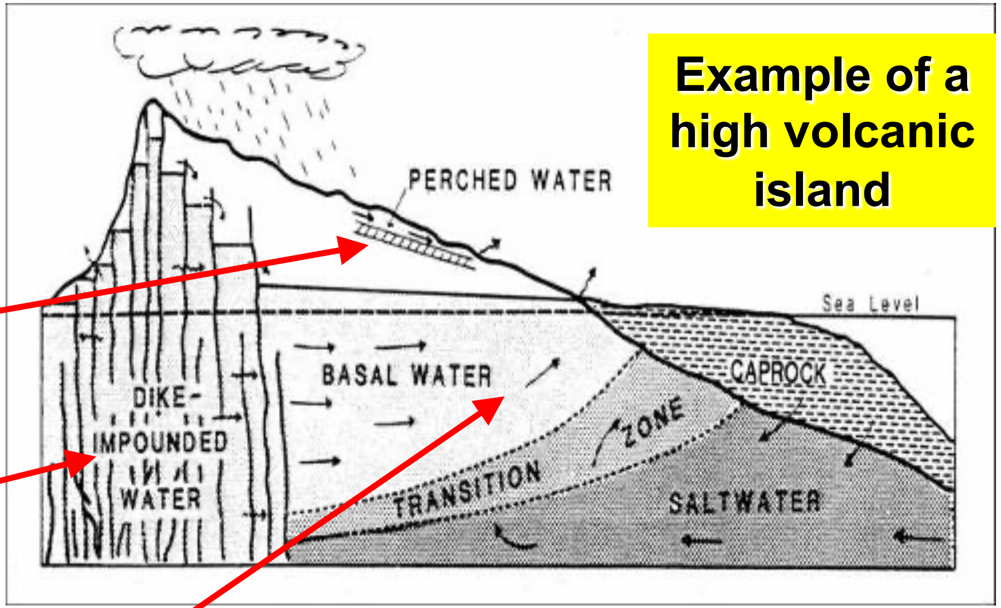
Bonriki

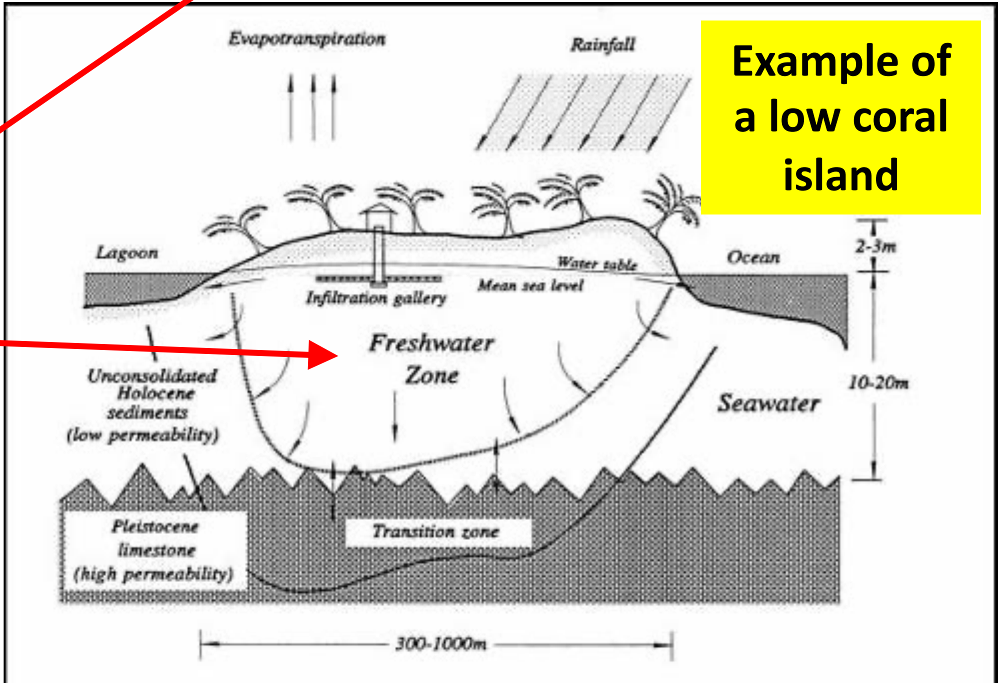
Main current sources of fresh groundwater for South Tarawa

Groundwater Resources

- **PERCHED AQUIFERS**
  (High Islands)
  - ♦ ***'HORIZONTAL'***
  - ♦ ***'VERTICAL'(Dyke-confined)***
- **BASAL AQUIFERS**
  (High & Low Islands)
  - ♦ ***COASTAL AQUIFERS***
  - ♦ ***'FRESHWATER LENSES'***

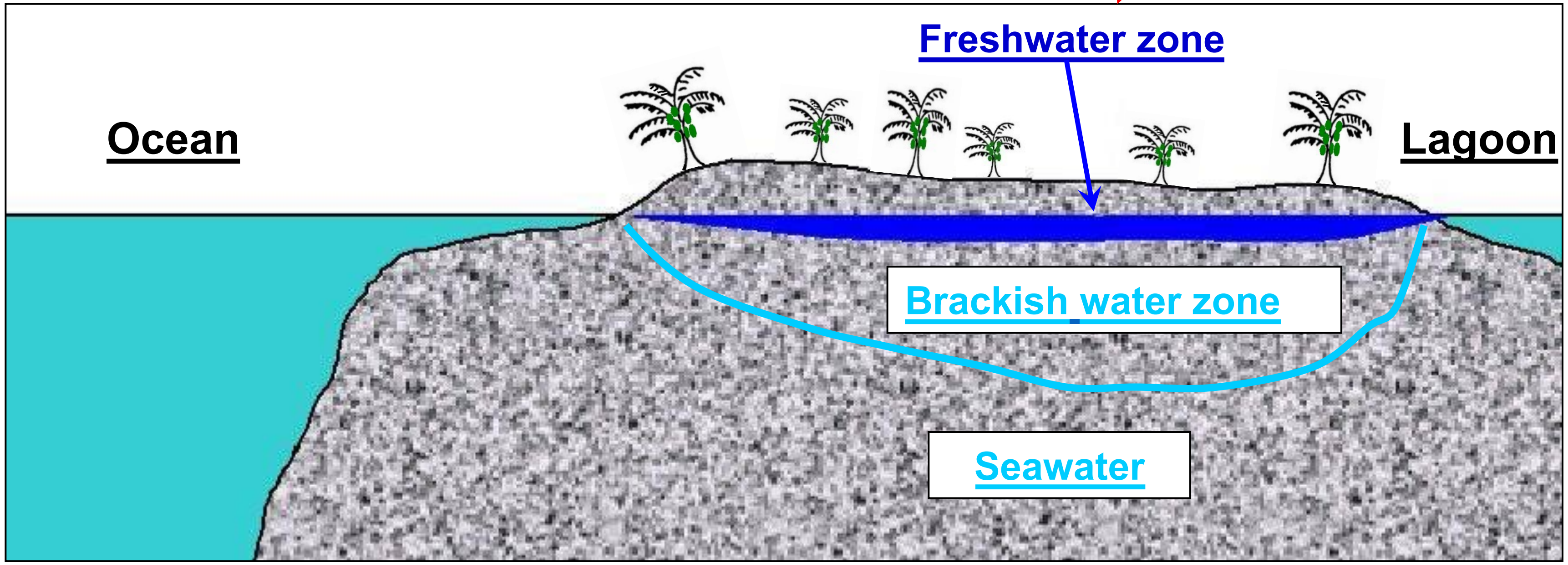
(Note: vertical scale is highly exaggerated)





Atoll Groundwater

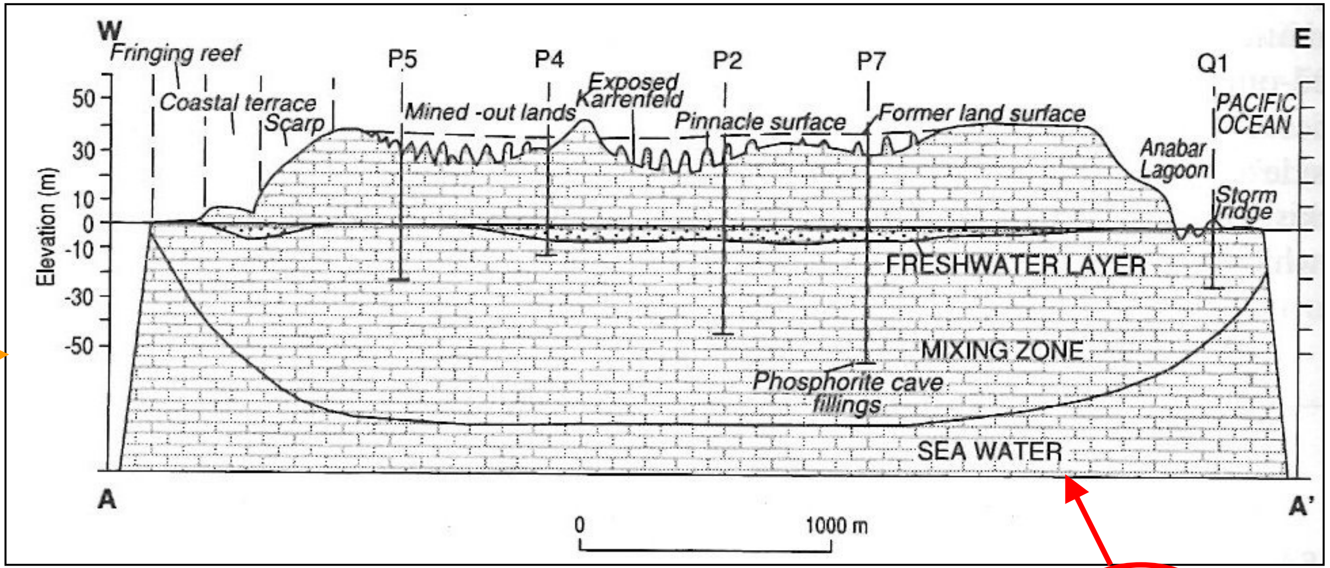
Freshwater lens drawn at more realistic scale

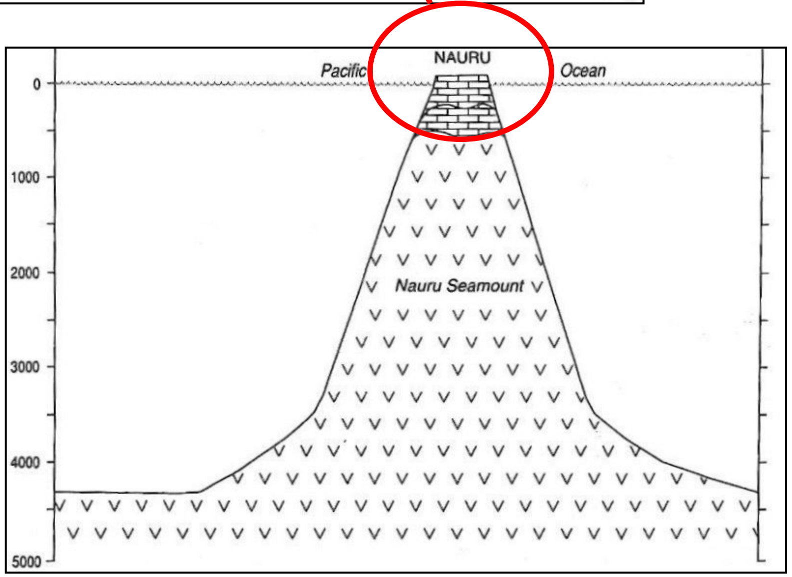


Groundwater Resources

(Limestone island – e.g. raised atoll of Nauru)

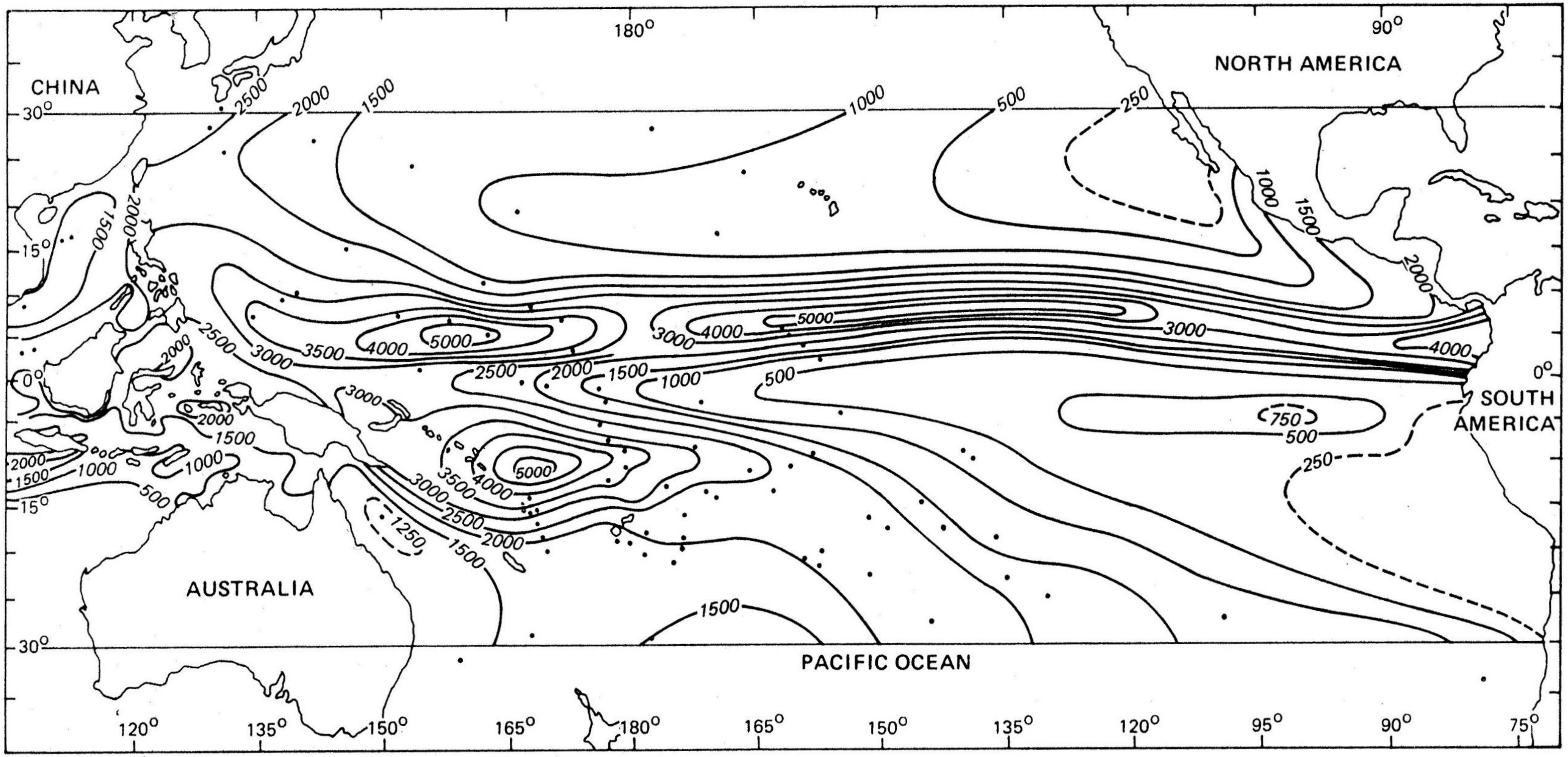
Cross section





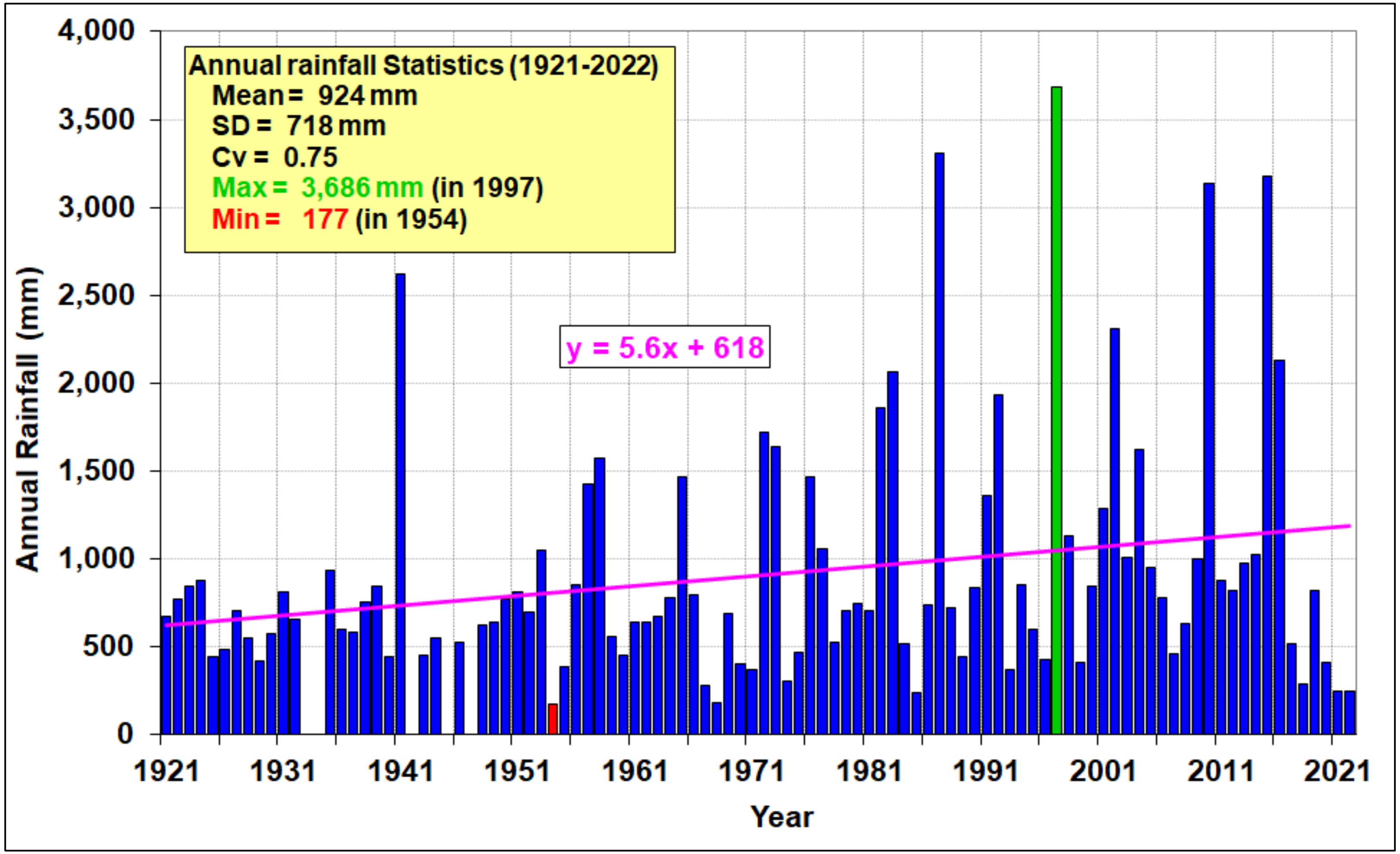
Source: Jacobson et al (1992). Geology & Hydrogeology of Nauru Island. in Vacher & Quinn, Geology & Hydrogeology of Carbonate Islands.

Mean annual rainfall at sea level in the Pacific Ocean



- **High average annual rainfall in west (up to 5,000mm)**
- **Low average annual rainfall in equatorial east (as low as 700mm)**
- **In mountain areas, annual rainfall can be close to 10,000mm**

High rainfall variability in some islands e.g. Kiritimati Island, Kiribati



- **Annual average rainfall = 924mm**
- **Highest annual rainfall = approx. 3,700mm,**
- **Lowest annual rainfall = approx. 180mm**
- **High & low rainfalls influenced by cycles of El Niño & La Niña episodes**

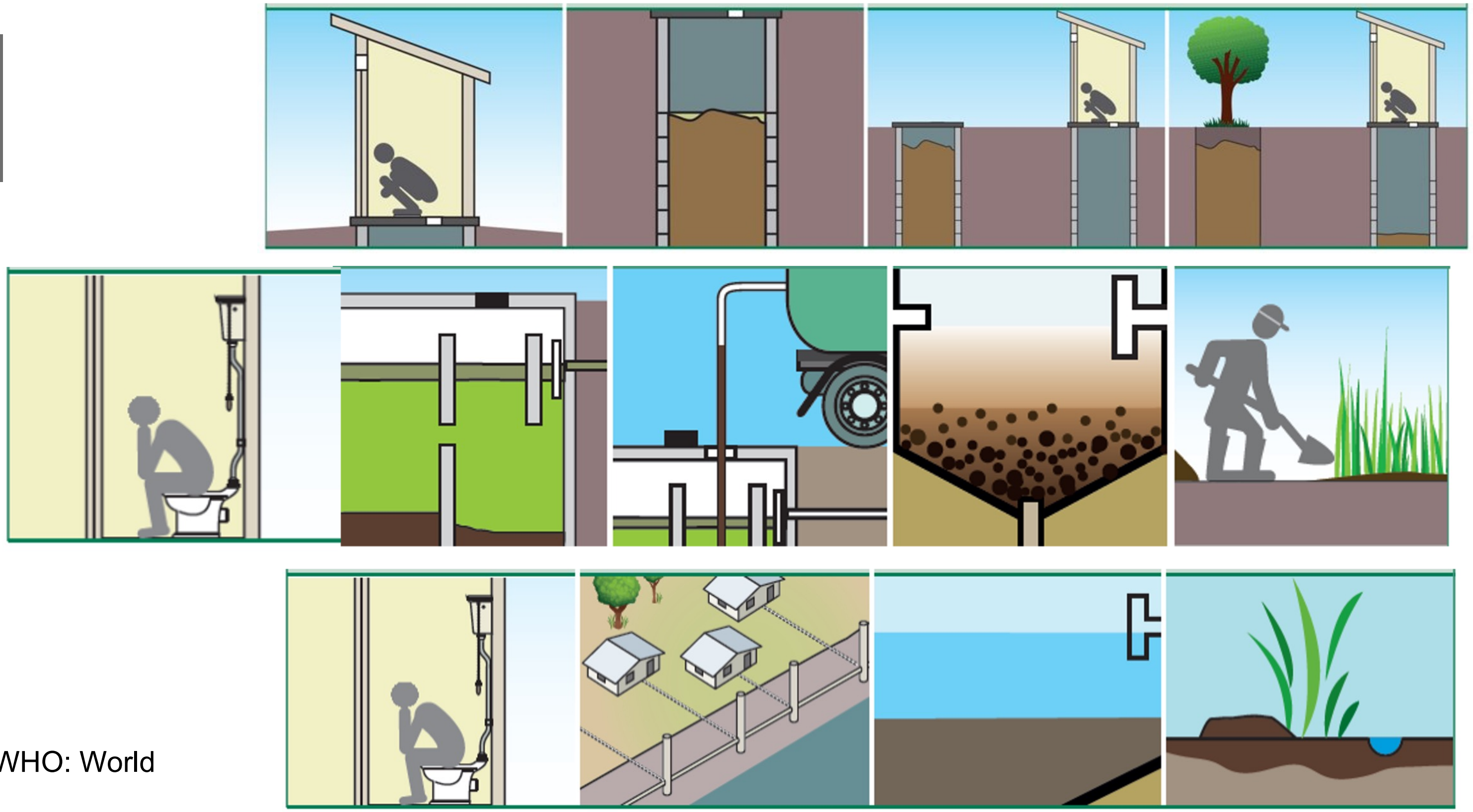
Safely managed sanitation should look like this…

TOILET/ CONTAINMENT › CONVEYANCE › TREATMENT › END USE/ DISPOSAL

Onsite sanitation systems (dry and low-flush)

Onsite sanitation systems with FSM and offsite treatment (septic tanks)

Offsite / conventional sewerage with offsite treatment



WHO. (2018). Guidelines on Sanitation and Health . WHO: World Health Organisation.

But in reality very often looks like this…

TOILET/ CONTAINMENT ❯ **CONVEYANCE** ❯ **TREATMENT** ❯ **END USE/ DISPOSAL**

Onsite sanitation systems (dry and low-flush)

Onsite sanitation systems with Faecal Sludge Management and offsite treatment (septic tanks)

Offsite / conventional sewerage with offsite treatment

WHO. (2018). Guidelines on Sanitation and Health . WHO: World Health Organisation.

And has these common problems…

	TOILET/ CONTAINMENT	CONVEYANCE	TREATMENT	END USE/ DISPOSAL
Onsite sanitation systems (dry and low-flush)	DIY designs Overflow to surface Poorly managed (odours etc) Insufficient holding time for treatment	Pits rarely emptied Unsafe practices Insufficient services	Lack of safe treatment facilities Dumping to environment	Rarely happens
Onsite sanitation systems with FSM and offsite treatment (septic tanks)	Poorly designed or no soakaway Rapid filling tanks	Limited pit emptying services	Lack of treatment facilities Dumping to envrionment	Reuse or disposal areas become anerobic
Offsite / conventional sewerage with offsite treatment	Blockages Misuse	Infrastructure regularly damaged / poorly maintained	Inadequate maintenance High Energy Costs	Uncontrolled discharge

What's unique to sanitation in the Pacific?

Context

Challenging environments:
- Atolls
- High population densities (e.g. South Tarawa, Funafuti, Ebeye)
- Peri-urban areas (Port Moresby, Suva, Honiara)
- Lack of market access

Culture and history

- Commonly a taboo topic
- Complex cultural and gendered beliefs affect use and siting
- History of 'handouts' and system failures

Sustainability

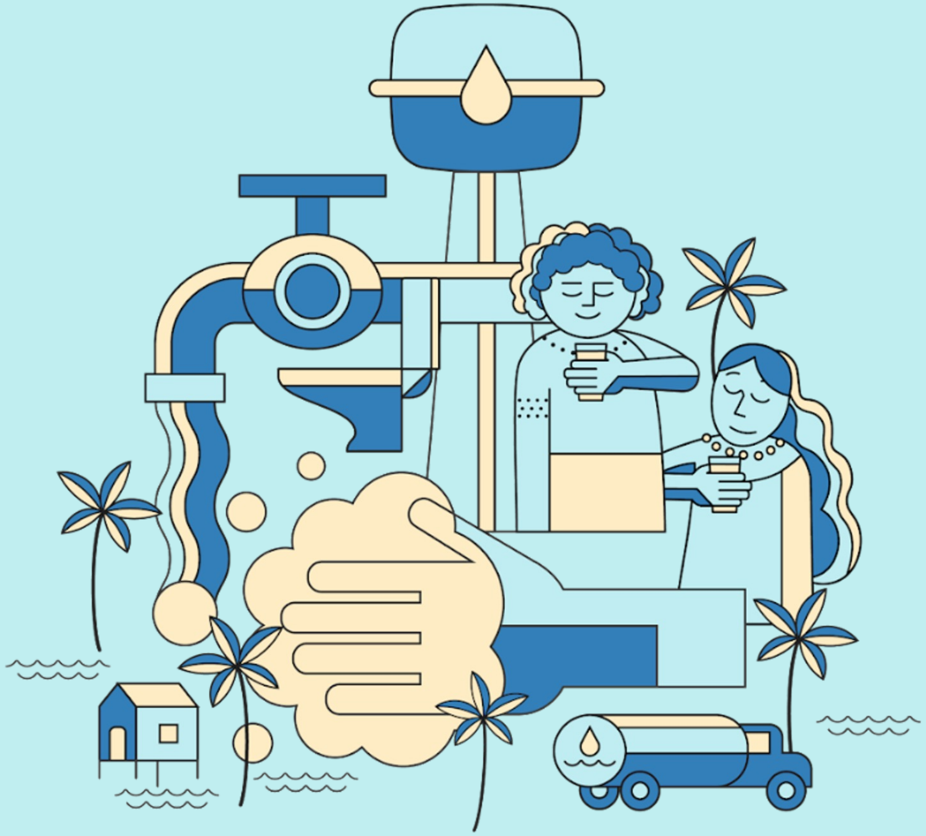
- Operations and maintenance under-supported
- Few safe disposal options
- Capacity constraints

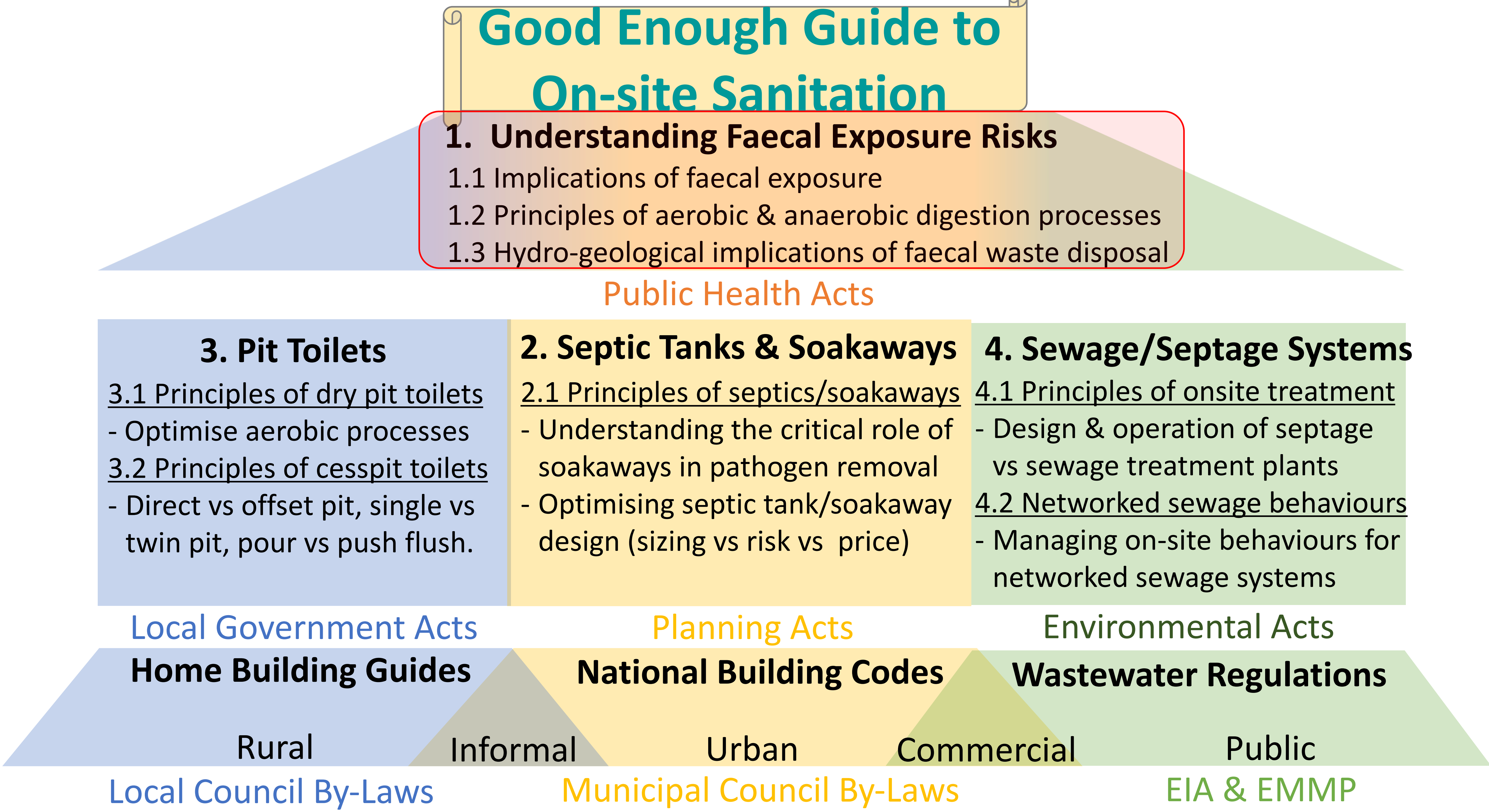
Common misunderstandings about sanitation in the Pacific

#	Common misunderstandings	Training topic
1	Faecal contamination of groundwater sources is primarily through the groundwater	1
2	Septic tanks significantly reduce the pathogens in faecal sludge and effluent	2
3	Septic tanks with soakaways are always a superior on-site option to cesspits	3
4	There is no problem operating dry pit toilets as wet pits	3
5	Mechanical sewage treatment plants always reduce the faecal exposure risks	4

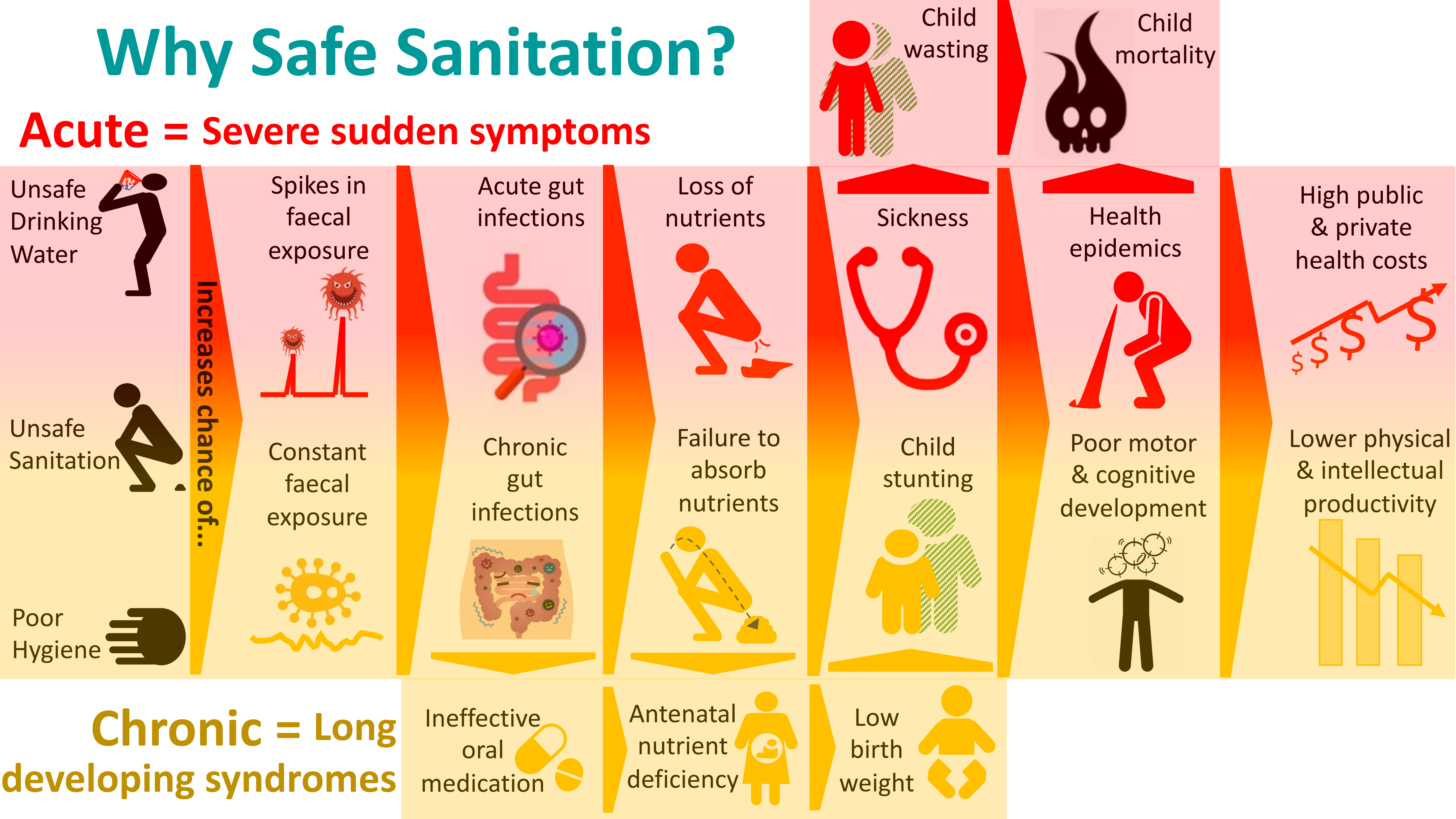
Topic 1: Understanding Faecal Exposure Risks

"The soil is our friend"



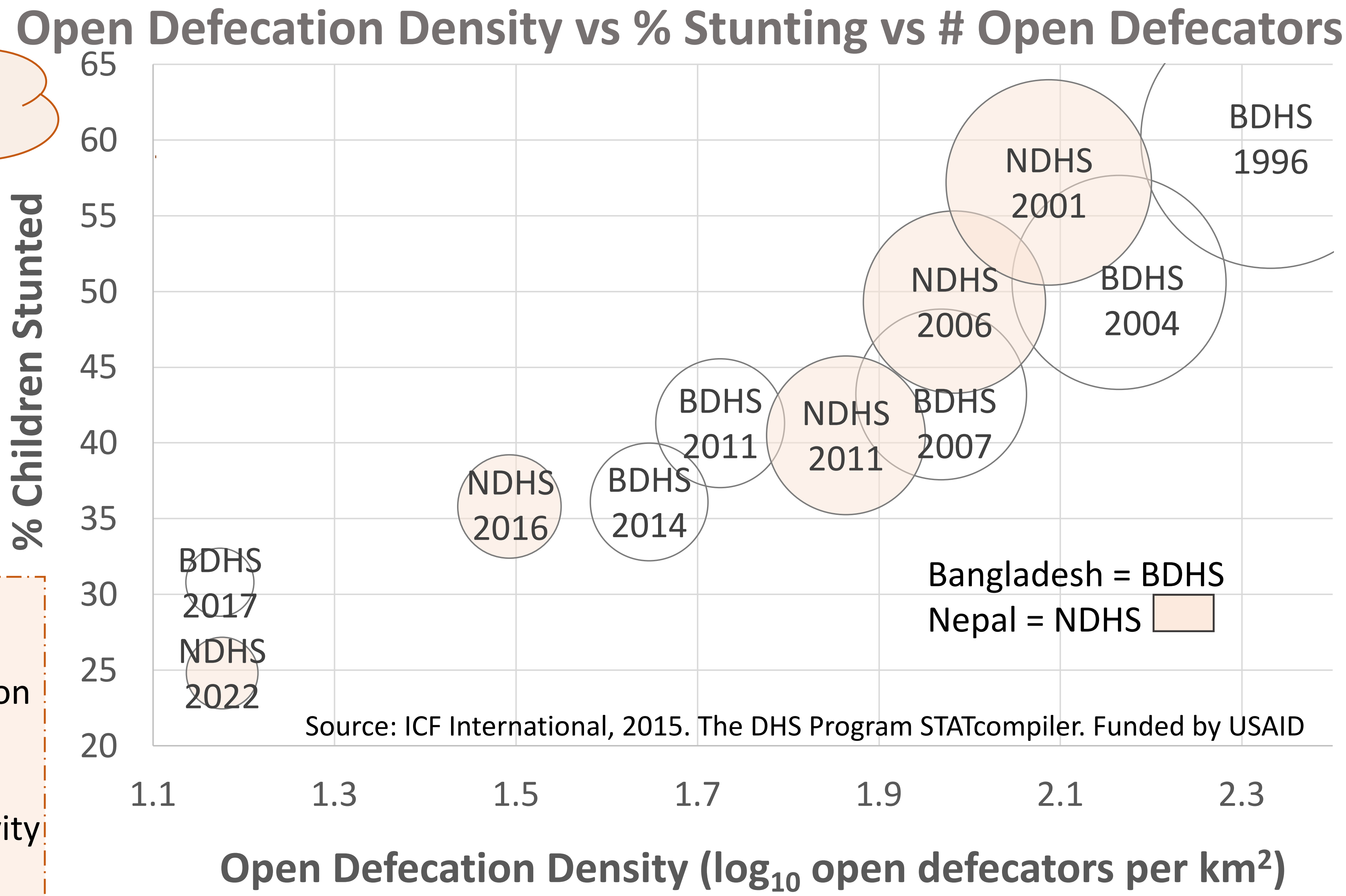


EIA = Environmental Impact Assessment; EMMP = Environmental Monitoring and Management Plan


Why Safe Sanitation?
Acute = Severe sudden symptoms
Child wasting
Child mortality
Unsafe Drinking Water
Unsafe Sanitation
Poor Hygiene
Increases chance of...
Spikes in faecal exposure
Constant faecal exposure
Acute gut infections
Chronic gut infections
Loss of nutrients
Failure to absorb nutrients
Sickness
Child stunting
Health epidemics
Poor motor & cognitive development
High public & private health costs
Lower physical & intellectual productivity
Chronic = Long developing syndromes
Ineffective oral medication
Antenatal nutrient deficiency
Low birth weight

Strong Correlation (OD Density ↓ ≈ Stunting ↓)

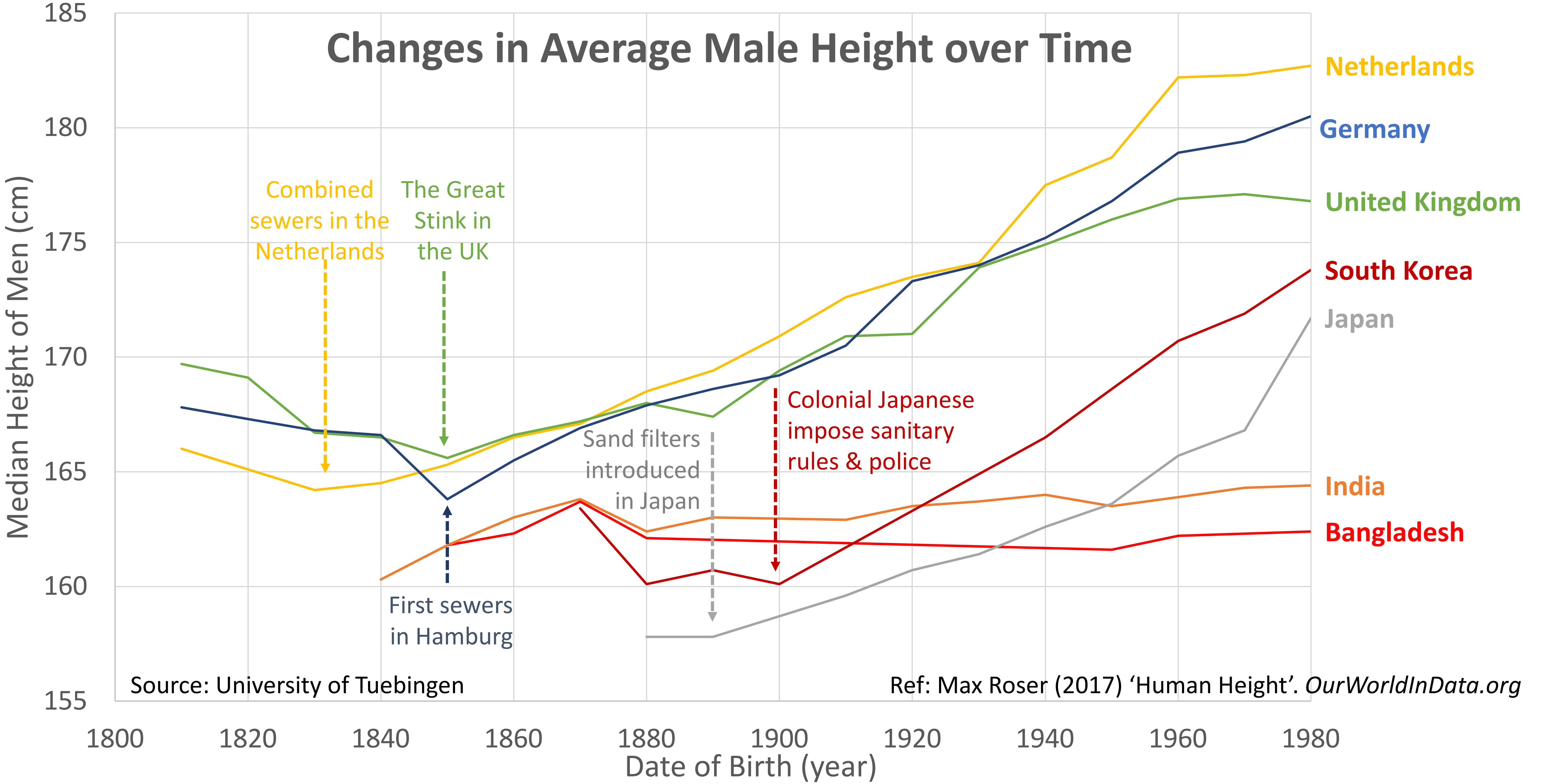
Stunting = children >2 standard deviations below normal height-for-age



Stunting: (or chronic under-nutrition) can result in:

- impaired cognitive function
- low physical capacity
- low human productivity, efficiency, economic activity
- Increased mortality risk

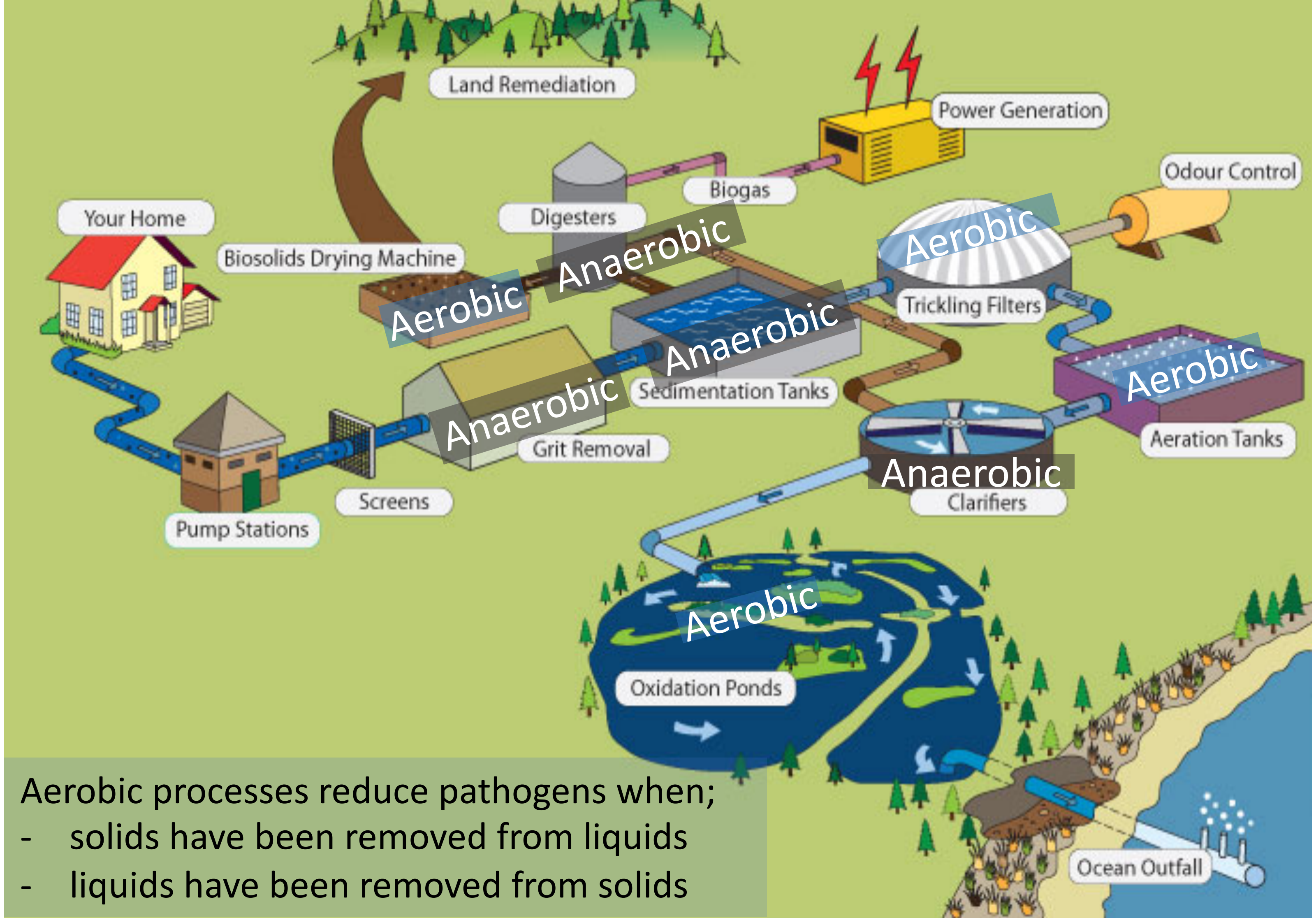
Men have Grown Taller with Sanitary Improvements



Sewage Treatment Processes

Faecal waste (solids & liquid) can be treated by anaerobic (no air) + aerobic (with air) processes:

- *Anaerobic digestion:* is more efficient in reducing the volume of solids (i.e. BoD & CoD) → **Environmental Health**
- *Aerobic digestion:* is more efficient in reducing pathogens (i.e. bacteria, viruses & parasites) → **Public Health**

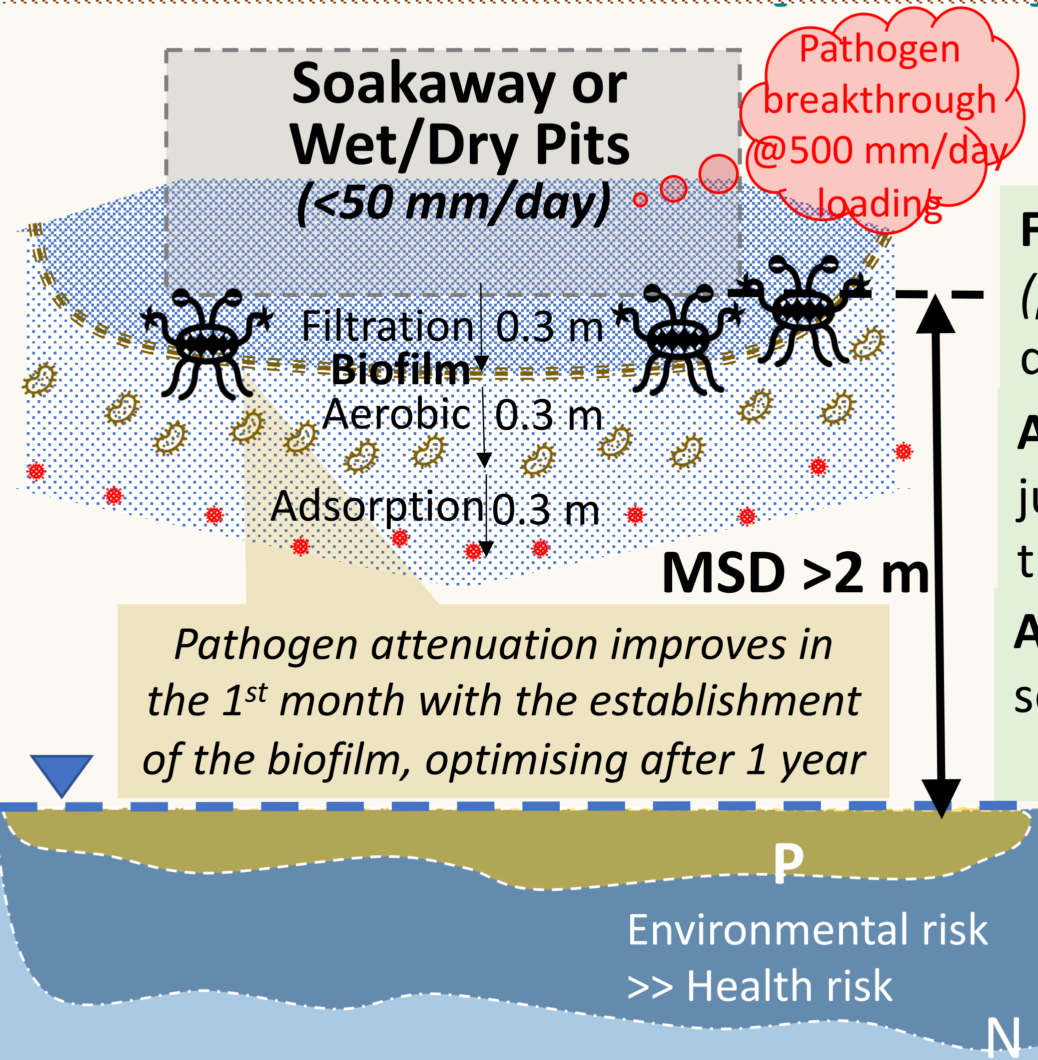


Aerobic processes reduce pathogens when;

- solids have been removed from liquids
- liquids have been removed from solids

Vertical Minimum Safe Distance (MSD)

The **survival time** of pathogens decreases:
- at higher ambient temperatures
- in drier soil with higher moisture holding capacity
- closer to the soil surface (more sun/air/evaporation)
- in soil rich in microflora but low in soluble organics



>99.99% attenuation

Filtration: by soil limits *parasite* *(protozoa & helminths)* transit due to their relatively large size

Aerobic organisms: in the soil just beyond the biofilm limit the transit of faecal *bacteria*

Adsorption: to the surface of the soil (esp. clay) limits *virus* transit

Source: Lewis WJ (1980)

Pathogens

Parasites (>10 um)
<1 year @ 20-30°C

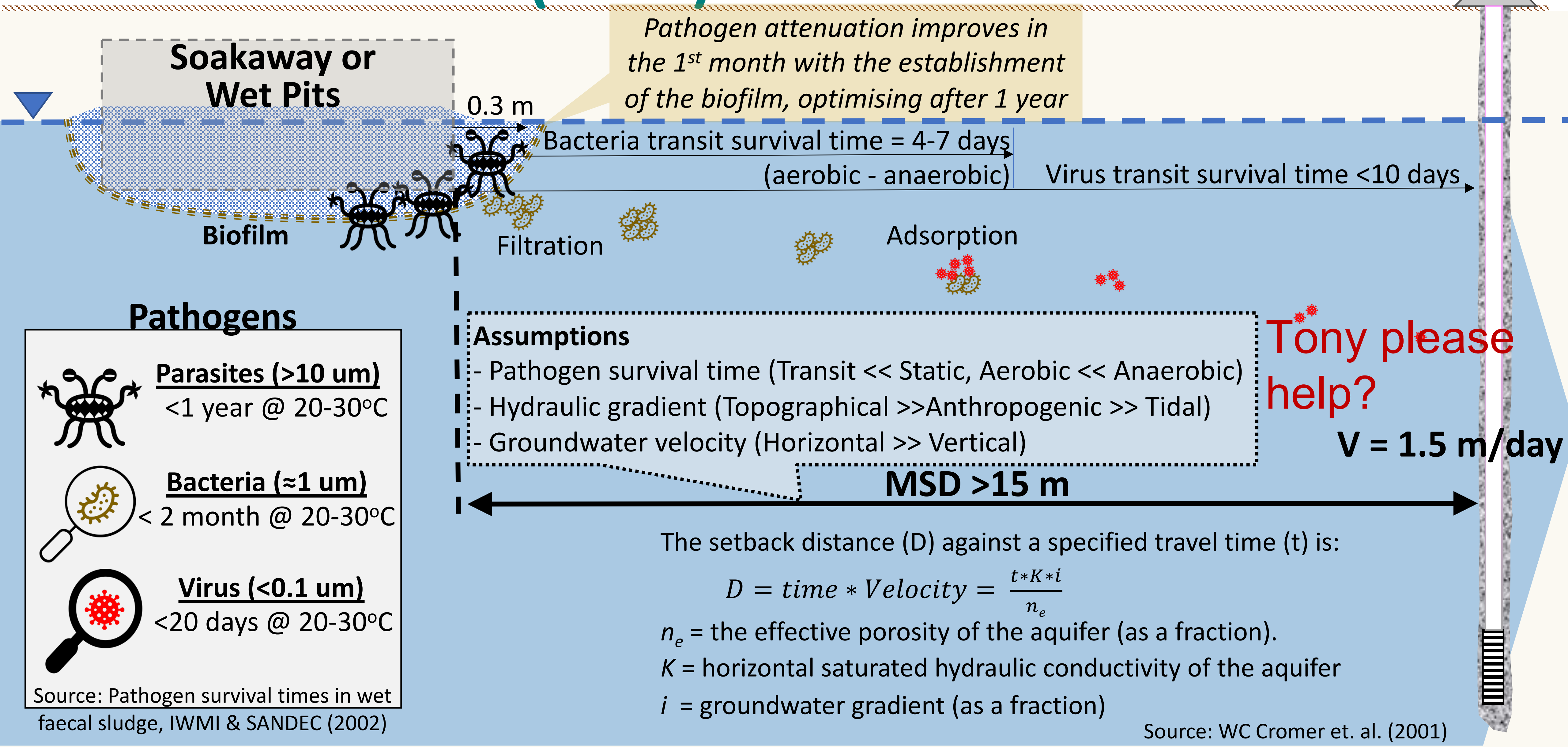
Bacteria (≈1 um)
<2 month @ 20-30°C

Virus (<0.1 um)
<20 days @ 20-30°C

Source: Pathogen survival times in wet faecal sludge, IWMI & SANDEC (2002)

The **migration** of pathogens decreases:
- in a saline environment
- in drier unsaturated soil
- in finer & more clay soil
- at lower hydraulic loading rates

Horizontal Minimum Safe Distance (MSD)



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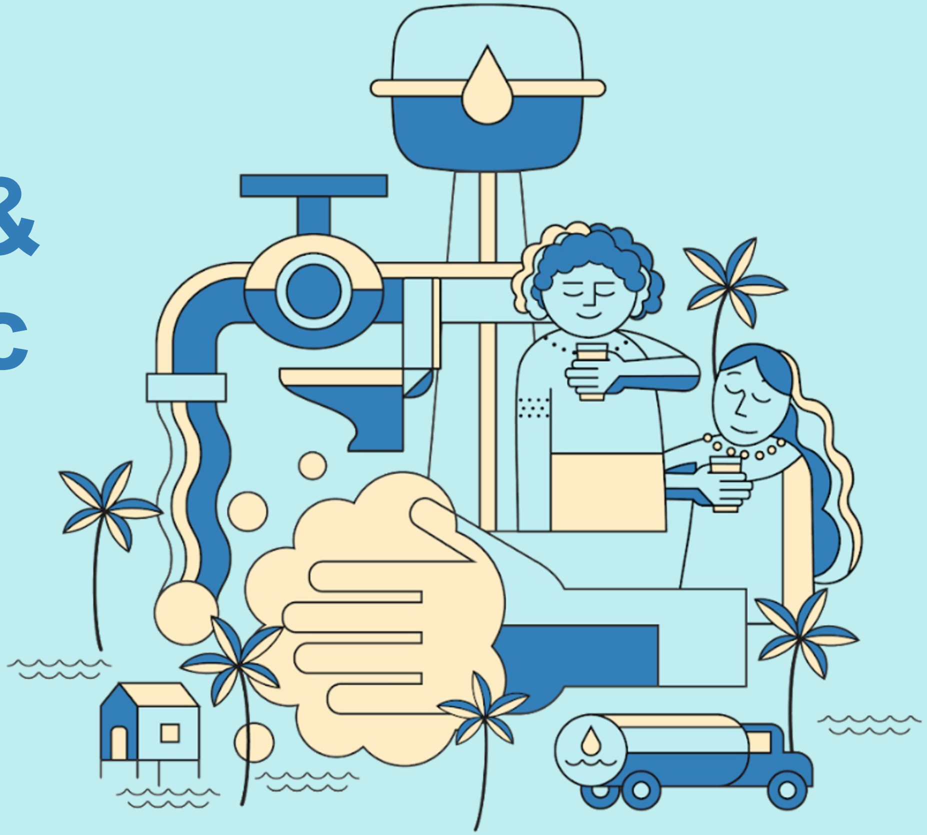
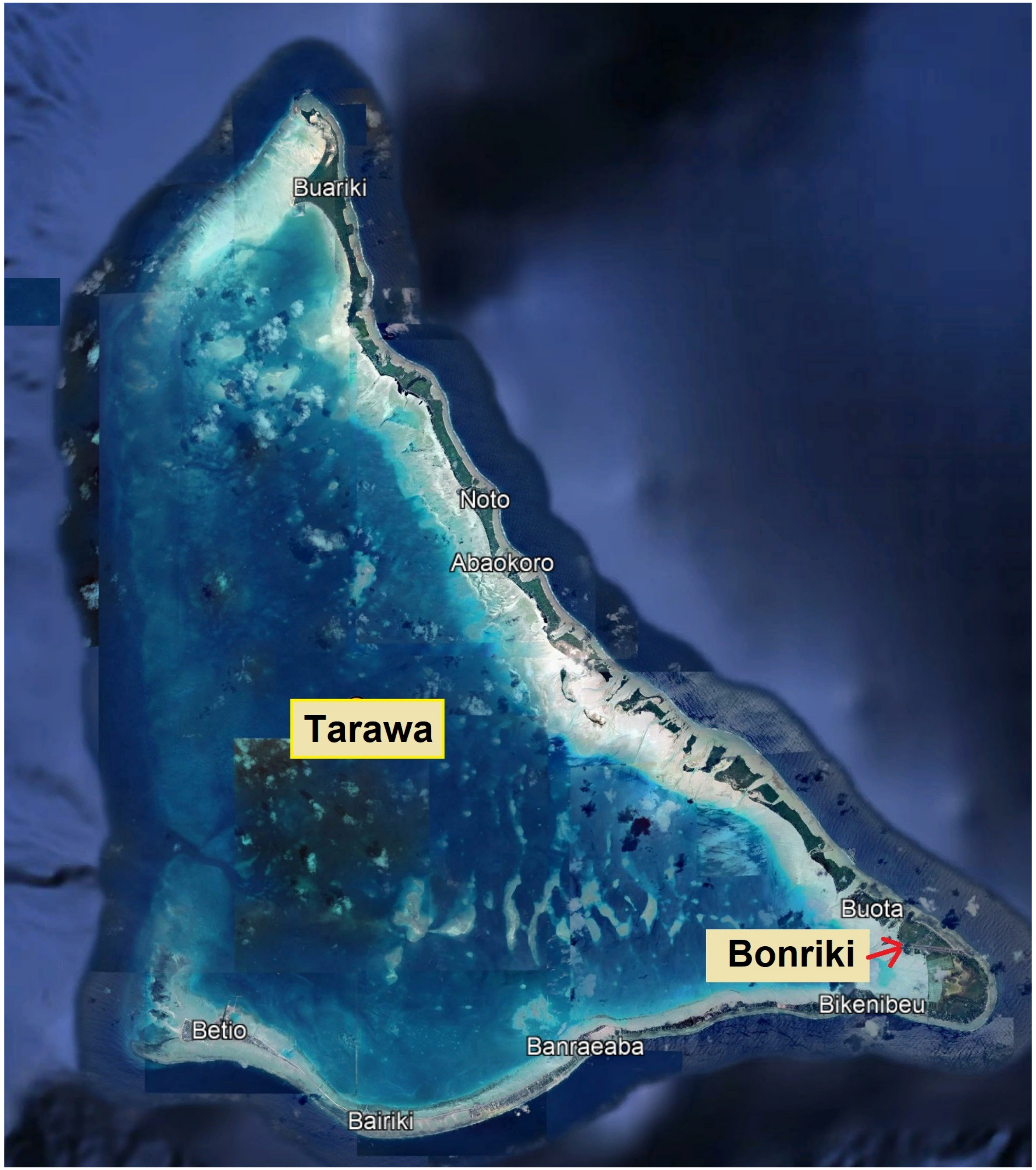
Groundwater profiles & velocities in the Pacific





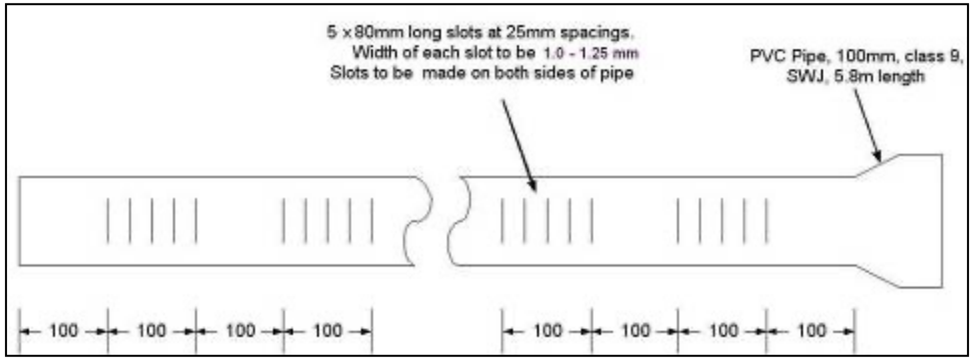
Example
Bonriki island, Tarawa atoll, Kiribati

- **Bonriki island & nearby Buota island are the main current sources of fresh groundwater for South Tarawa.**
- **Groundwater is pumped from freshwater lenses on these islands using infiltration galleries**
- **Groundwater is also extracted from village wells on the edge of the islands**

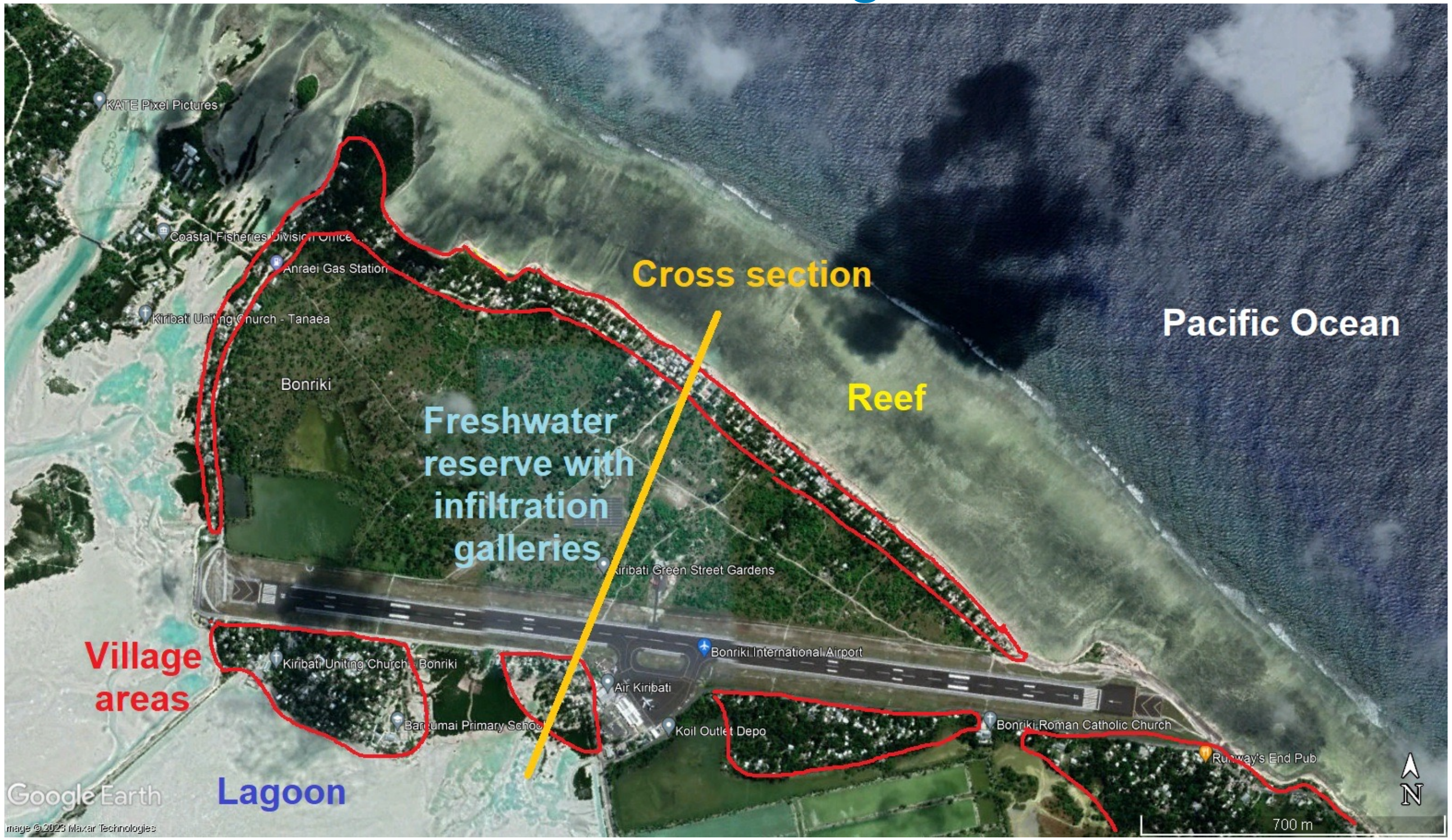
Bonriki island water reserve and village areas

Village areas around the edges of Bonriki have on-site sanitation

Gallery pump stations & pipes, Bonriki

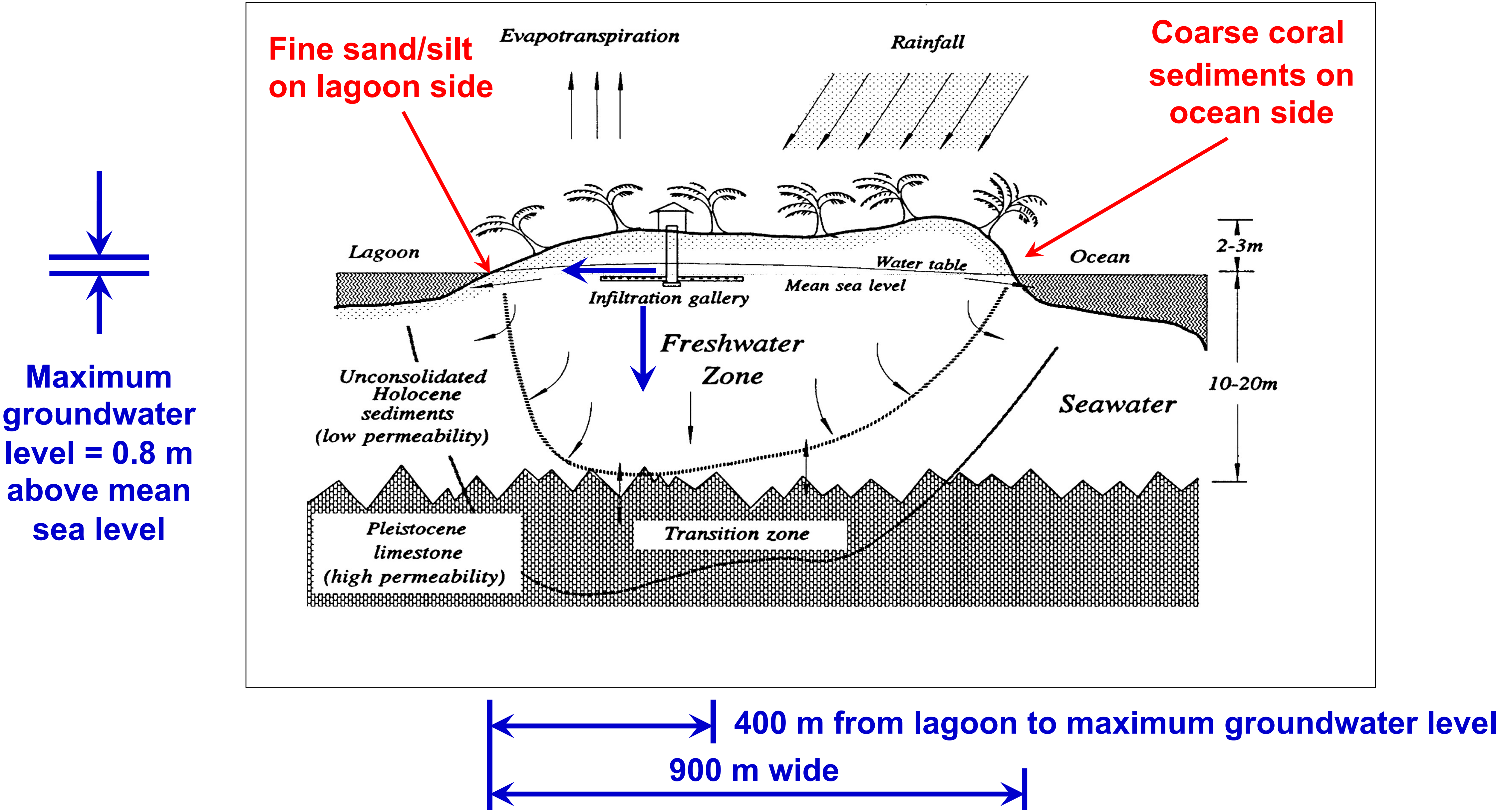


Bonriki island showing cross section through water reserve and village areas



- **Distance across island at cross section = 900m**
- **Maximum measured height of groundwater level above mean sea level = 0.8m at 400m from lagoon side**

Cross Section through Bonriki Freshwater Lens



Calculation of horizontal & vertical groundwater velocities for Bonriki

Calculation of horizontal and vertical velocities for Bonriki, Tarawa, Kiribati

1. Average horizontal velocity from near centre of freshwater lens to edge of island (V_h) = (k * i) / n_e

where

k (hydraulic conductivity or permeability) = **5 m/day** (from borehole measurements)

i (hydraulic gradient) = height of groundwater above mean sea level / distance from lagoon = 0.8 / 400 = **0.002**

n_e (effective porosity) = portion of total void space in a porous material (e.g. aquifer) that can transmit fluid = **0.3**

therefore **V_h = 33 mm/day**

Results using this velocity

Distance travelled in 10 days (probable Virus transit survival time) = **0.33 m**

Time taken to travel 15m ("Minimum Safe Distance") = **1.2 years**

Time taken to travel 400m (edge of lagoon) = **33 years**

2. Average vertical velocity from surface to base of freshwater lens (V_v) = average groundwater recharge rate

where average recharge = approximately 0.4 x average annual rainfall (2,000mm) = 800mm/year = **2.2mm/day**

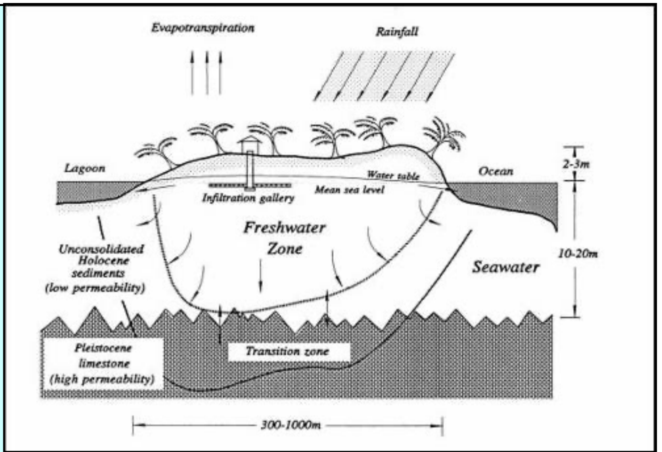
therefore **V_v = 2.2 mm/day**

Results using this velocity

Time taken to travel to the base of freshwater lens with average thickness of 10m and effective porosity of 0.3 = approx. **4 years.**

Hence, a molecule of water is more likely to mix with saline water in a vertical direction than a horizontal direction

Influences on groundwater level in small coral island e.g. Bonriki



(a) Natural influences

- **Due to sea level movements (mainly tides): 100 – 150mm**
  (twice daily highs & lows,
  approx. 5-10% of sea level movements)

- **Due to short term extreme rainfall: up to 1m**
  (influence over several days)

- **Due to longer-term rainfall changes during El Niño – La Nina cycles: 300 – 500mm**
  (influence over several years)

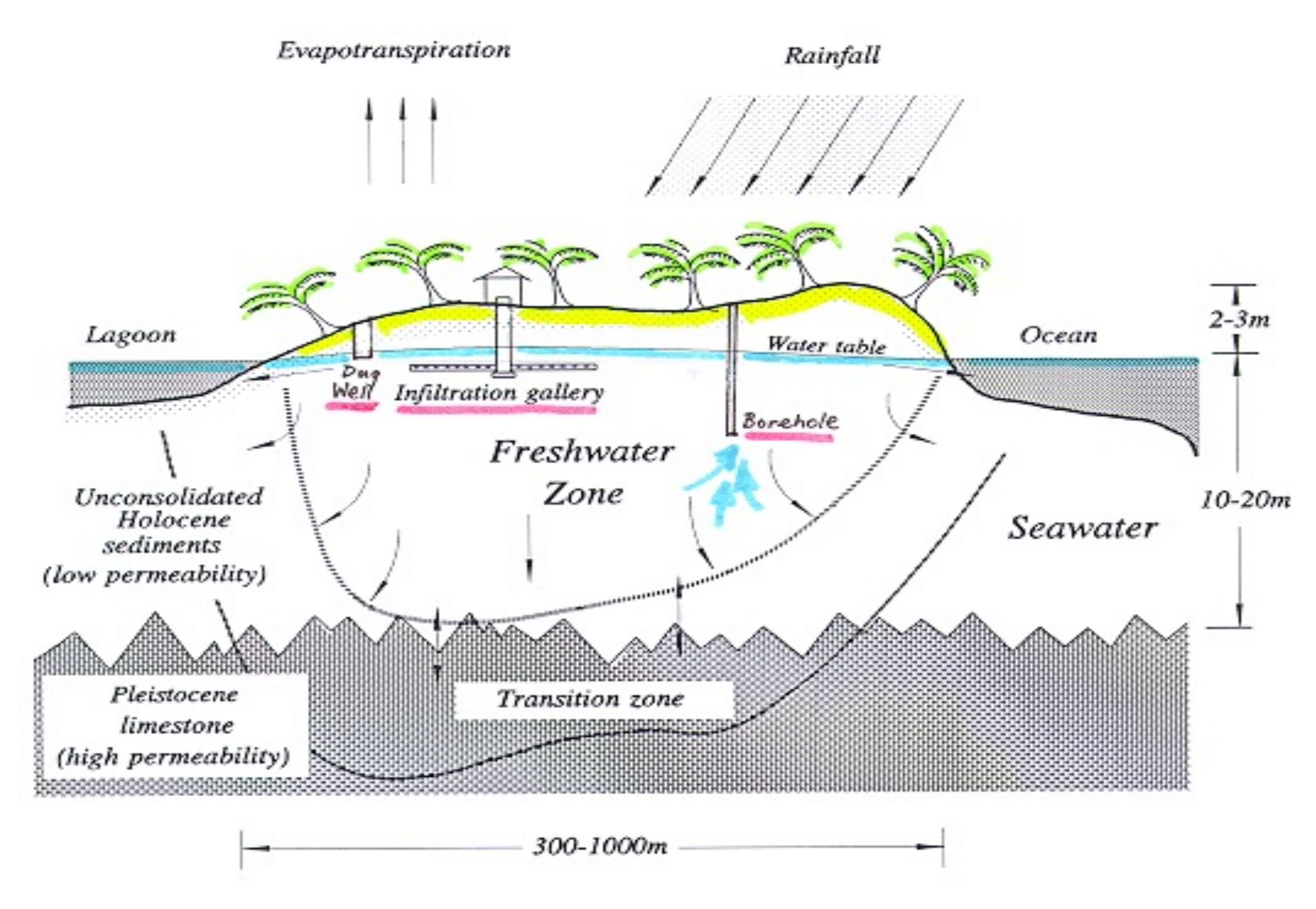
(b) Anthropogenic influences

- **Drawdown due to pumping from infiltration galleries (water reserve): 10 – 50mm**
  (continuous, minor compared with other influences)

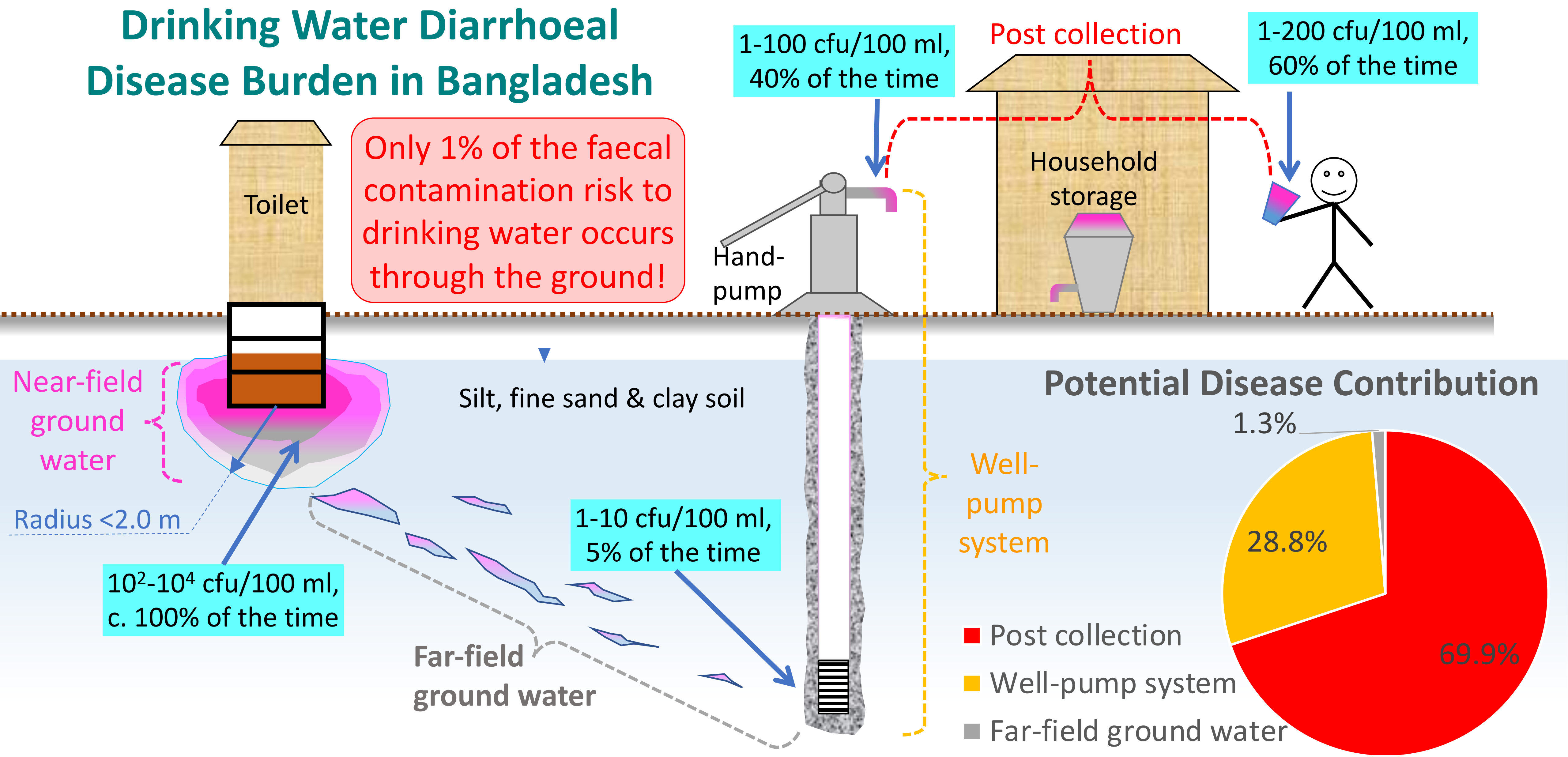
- **Drawdown due to pumping from wells (village areas): variable, can be up to 500mm**
  (intermittent, can be significant depending on capacity of pump)

Groundwater Pumping Systems – Anthropogenic Influences
(on small coral islands and coastal zones of high islands)

- **Dug wells** (if pumped, the groundwater drawdown can cause movement of contaminants towards the well and seawater intrusion from below)
- **Boreholes** (can cause significant seawater intrusion and are not recommended for small coral islands)
- **Infiltration galleries** (cause very small groundwater drawdowns and hence have insignificant impact on movement of contaminants and seawater intrusion)



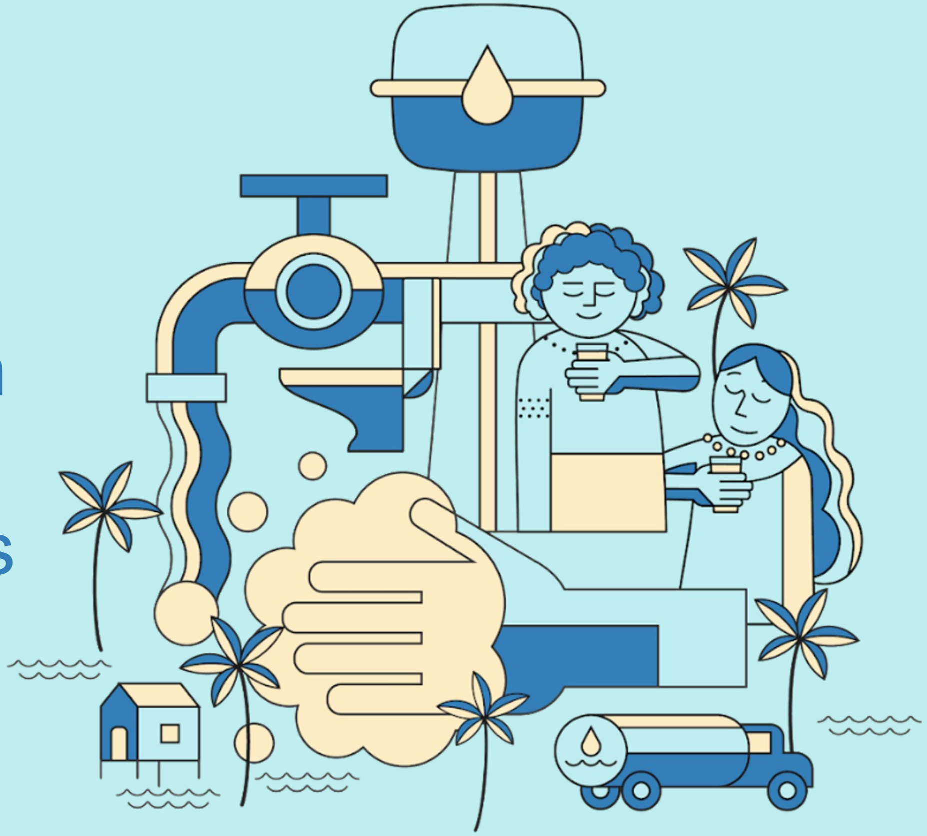
Misunderstanding #1: Faecal contamination of groundwater sources is primarily via the groundwater



Source: Ravenscroft P. et. al. (2017) Water Research https://www.sciencedirect.com/science/article/abs/pii/S004313541730622X

We still have many questions:

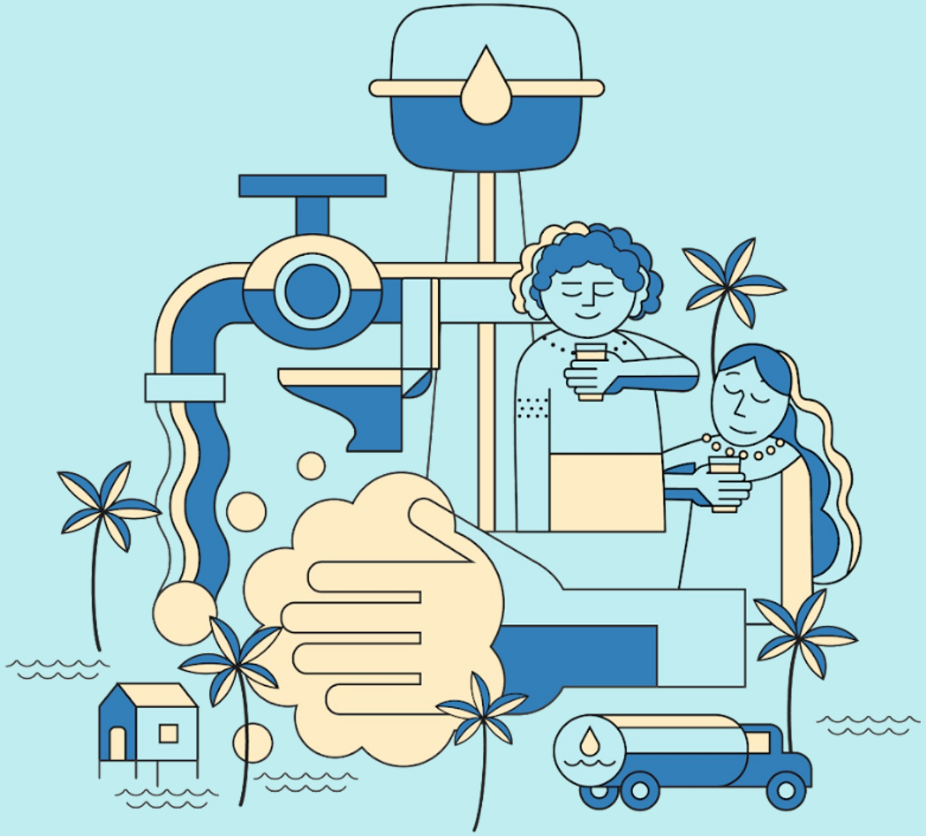
- What are the lateral groundwater velocities in different contexts?
- What is the transit survival time of pathogens in different soil conditions in the Pacific?
- How does the biofilm behave when pits are saline / flooded / shock loaded?



What about you?

Topic 2: Principles of Septic Tanks & Soakaways

“soakaway design is most important”



Good Enough Guide to On-site Sanitation

1. Understanding Faecal Exposure Risks

1.1 Implications of faecal exposure
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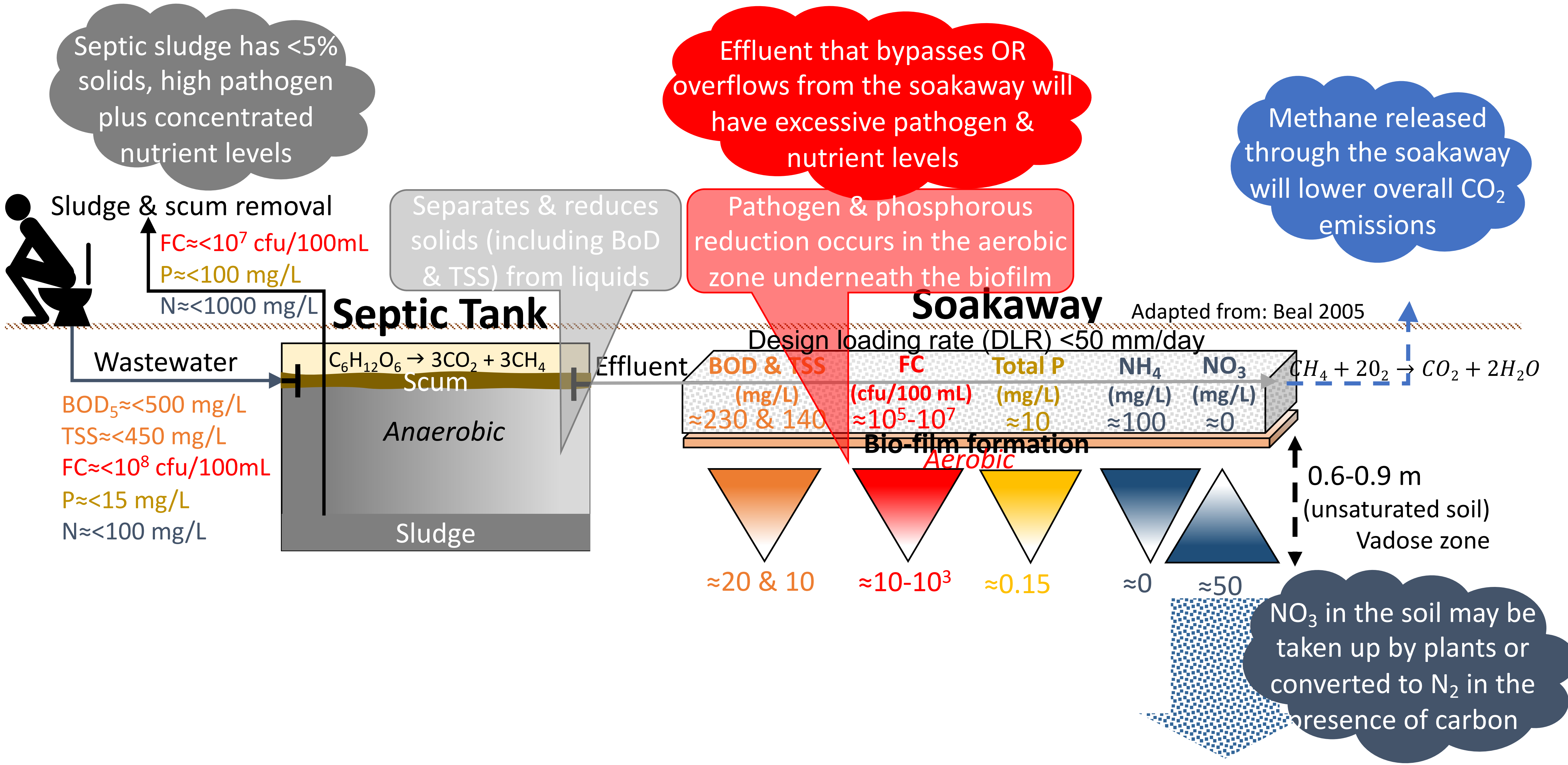
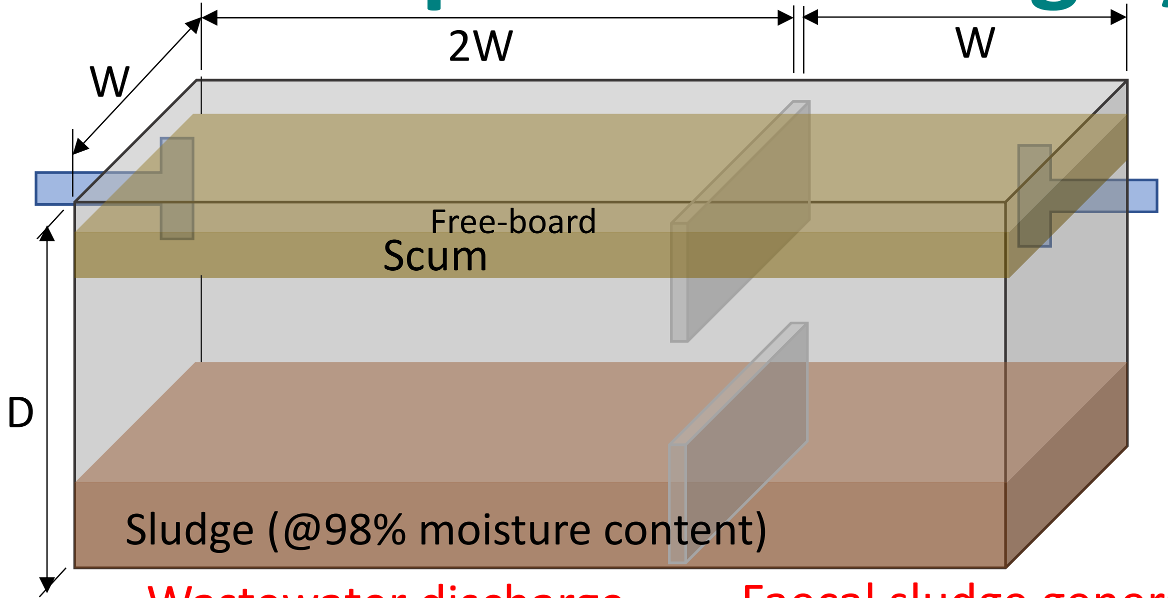
Misunderstanding #2: Septic tanks significantly reduce pathogen concentrations



Septic Tank Design / Sizing to AS 1547-2012



Based on a wastewater retention time of 24 hrs

Volume = Accumulation of Liquids + Solids + Free

Liquid Accumulation = # people * litres per capita per day
Solid Accumulation = # people * litres per capita per year
* # years between desludge
Freeboard = 10% of tank volume

Wastewater discharge is probably half this …

Faecal sludge generation @ 98% MC ??

For 96% MC, then AS/NZS 1547 implies 6-10 years fill-time

Sizing based on septic tank emptying every 3-5 years

RETENTION TIME	Effluent (lpcd)	People (#)	Liquid (litres)	Sludge (lpcy)	Empty (years)	Solids (litres)	Free (litres)	Total (litres)
Pour Flush Toilet	30	5	150	50	5	1250	140	1,540
	30	10	300	50	5	2500	280	3,080
Push Flush Toilet	50	5	250	50	4	1000	125	1,375
	50	10	500	50	4	2000	250	2,750
Black & Grey Water	150	5	750	80	5	2000	275	3,025
	150	10	1500	80	3	2400	390	4,290

1,500 litre tank for blackwater from a household of 5 people

3,000 litre tank for blackwater from a household of 10 people or black+grey water of 5 people

4,500 litre tank for black+grey water from a HH of 10 people

Why are Faecal Sludge Accumulation Rates Important?

Honiara City (Faecal Sludge @ 96% MC)

We know that there are **11 septage trucks** BUT we have no estimates of septage disposal!

The city has a population of 42,000 people with 23% connected to sewerage, 43% on septic tanks and 13% on offset pit toilets.

- **Sludge generation** = 100,000 * ((13% * 20 l/cap/yr) + (43% * 40 l/cap/yr)) / 1000 = 2,045 m3/year
- **# trucks req'd** = 2,045 m3/year / 52 wks per yr / 5 days per week / 3 loads per day / 3 cubic metres per load = 1 septage truck

Conclusion: The sludge trucks are primarily transporting effluent (with some sludge) without any significant reduction of pathogens.

Potential Cause: The dense silty soil does not have the capacity to absorb all of the grey + black water.

Investigation: Is blackwater plumbing separate from grey water? Can the sizing of soakaways be increased?

Dhaka City (Faecal Sludge @96% MC)

We know there are **<2 septage trucks** BUT we have no estimates of septage disposal!

The city has a population of 9 million people with 25% connected to sewerage, 50% on septic tanks and 25% on offset pit toilets

- **Sludge generation** = 9,000,000 * ((25% * 20 l/cap/yr) + (50% * 40 l/cap/yr)) / 1000 = 236,250 m3/year
- **# trucks req'd** = 236,250 m3/year / 52 wks per yr / 5 days per week / 3 loads per day / 3 cubic metres per load = 101 septage trucks

Conclusion: All the septic sludge from non-sewered areas is either piped, pumped or manually emptied into the stormwater drains.

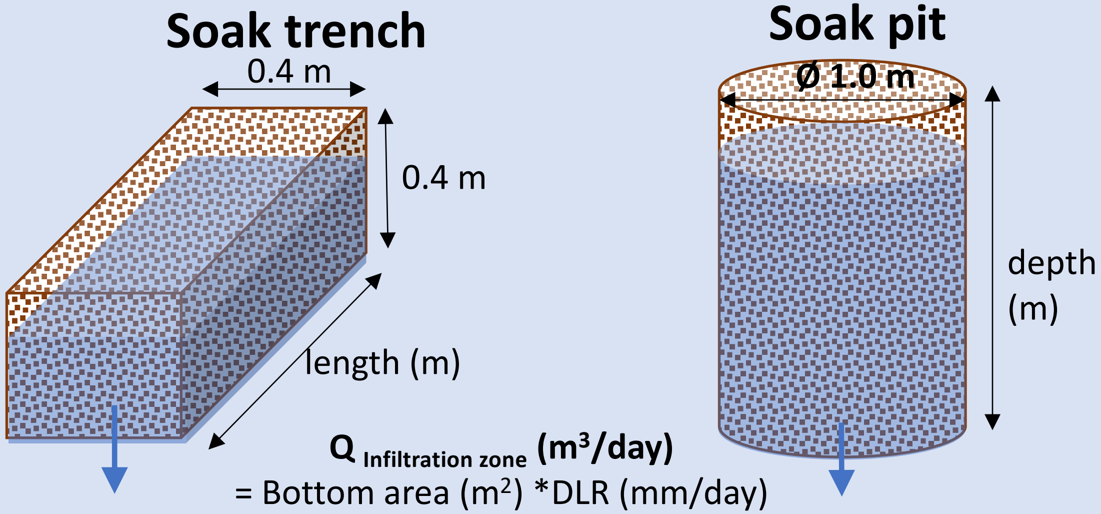
Potential Cause: The dense silty soil does not have the capacity to absorb all of the grey + black water.

Investigation: Can the stormwater be treated prior to the discharge into the waterways?

Soakaway Design & Sizing Approaches

Australian Standards: AS/NZS 1547:2012

Infiltration zone only (+ soil permeability for sidewalls)

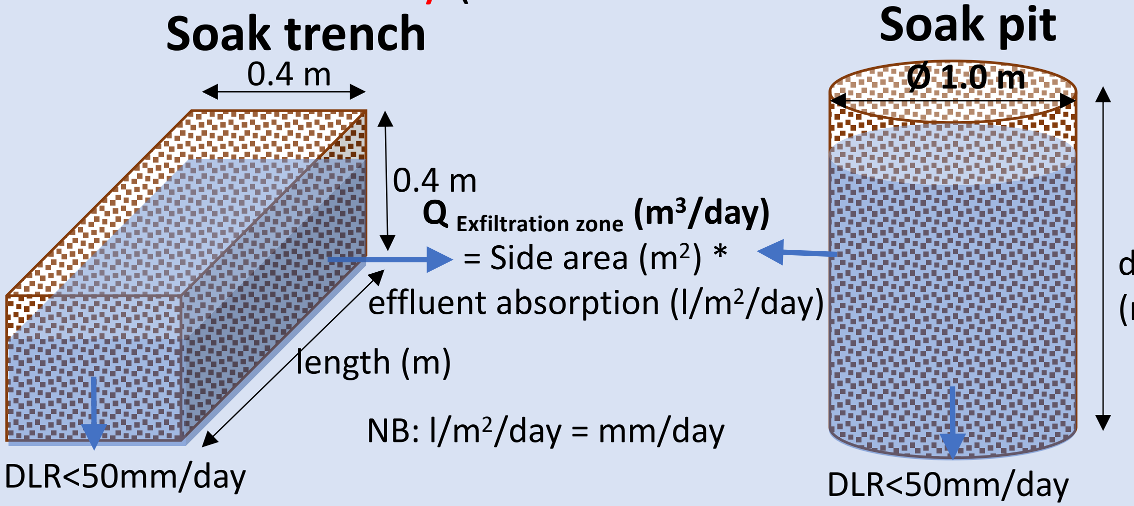


Biomat LTAR approaches a constant @1-10 mm/day. Allowing for exfiltration, the AS 1547 DLR ranges from 4-8 mm/day for silty soil (safe-max) to 20-35 mm/day for sandy gravel (safe-max).

RESULT = Very long trenches or lots of pits (depth is irrelevant)

British / Indian Standards

Exfiltration zone only (+ infiltration zone factor of safety)



Sizing on exfiltration only, the BS/IS ranges from 10 mm/day for silty soil to 100 mm/day for sandy gravel, BUT in porous soil the sizing is generally defined by <50 mm/day infiltration zone

RESULT = Shorter trenches (but DLR <50 mm/day defines the sizing of trenches in sandy soil or the number of pits)

DLR = design loading rate
LTAR = long term acceptance rate

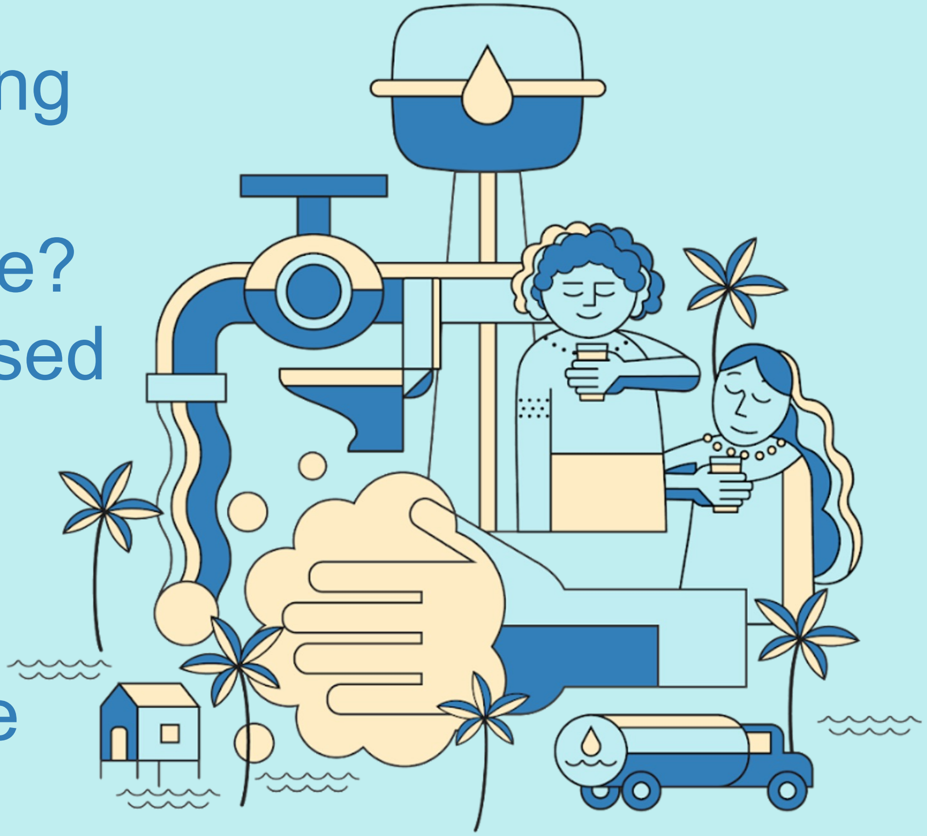
1m of soakaway (0.4m wide * 0.4m deep) per *'blackwater only'* user in unsaturated fine sand will prevent the surcharging of effluent to surface

- If blackwater + greywater users, the length should be tripled
- If proximate to drinking water sources, the length should be doubled
- In gravelly soil, the soakaway length can be halved

Optimising these two approaches when the use of groundwater for drinking is low

We still have many questions:

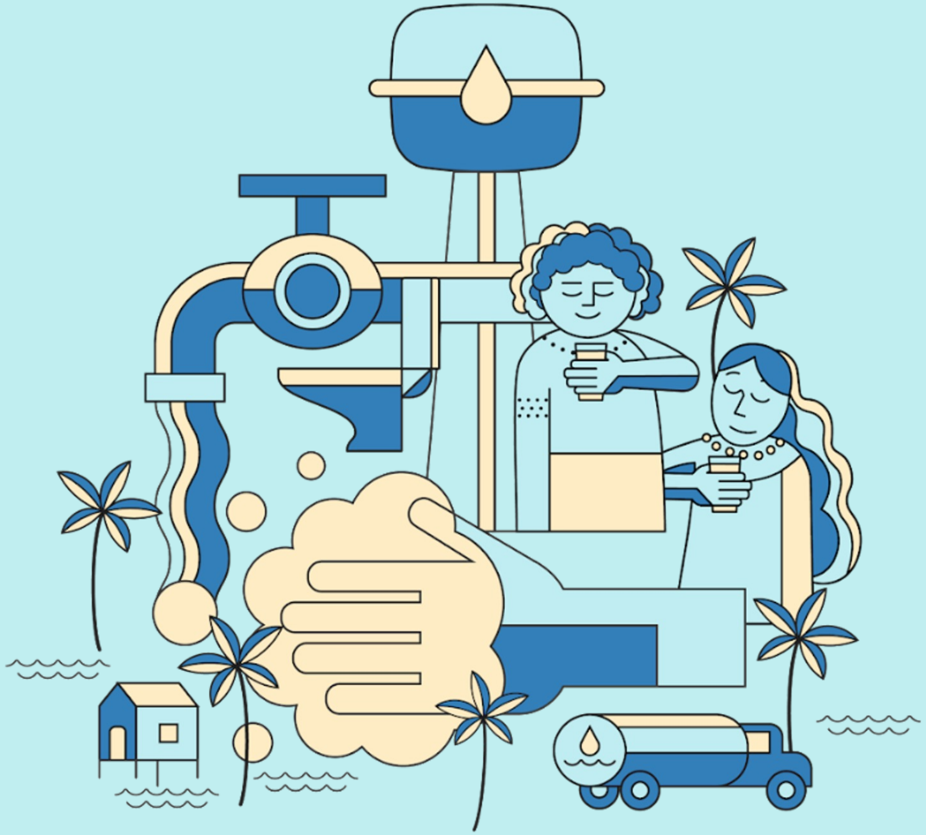
- What is the GHG reduction from venting methane through the soakaway?
- When do septic tanks need a vent pipe?
- What are the consequences of increased sludge density in septic tanks?
- How do we optimize the sizing of soakaways in the Pacific?
- What are the opportunities of separate blackwater & greywater plumbing?



But what about you?

Topic 3:
Principles of Pit Toilets

“knowing where aerobic processes are occuring”



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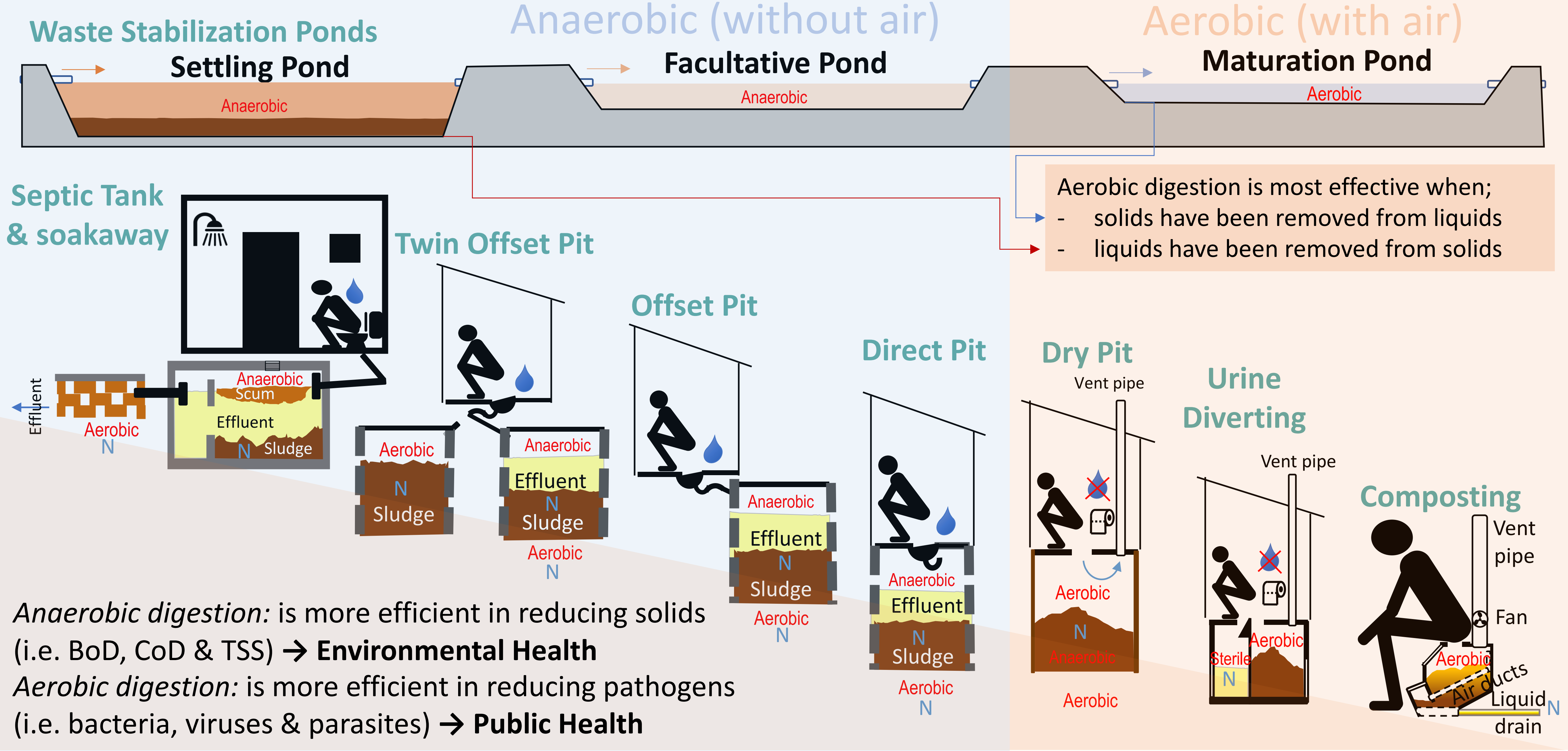
Two Different Biological Treatment Processes

Faecal waste is digested naturally by aerobic (with air) & anaerobic (without air) processes



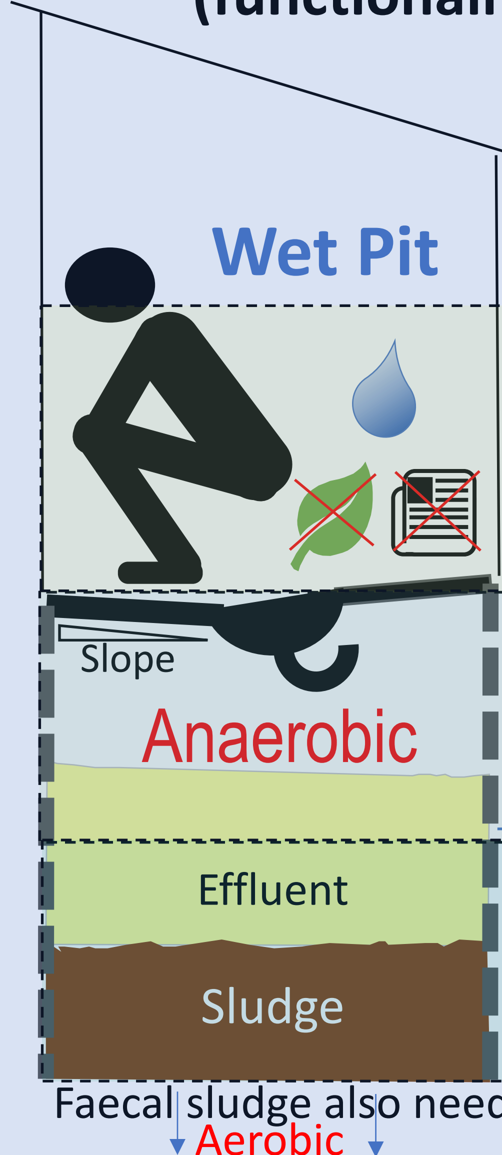
Anaerobic digestion: is more efficient in reducing solids (i.e. BoD, CoD & TSS) → **Environmental Health**

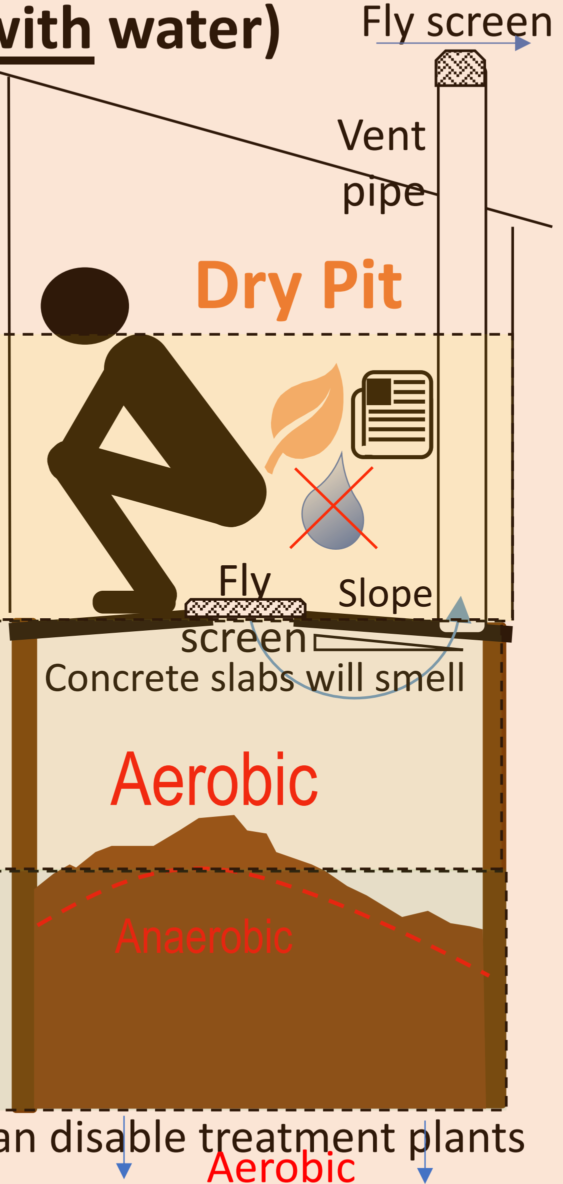
Aerobic digestion: is more efficient in reducing pathogens (i.e. bacteria, viruses & parasites) → **Public Health**

Wet & Dry Pit Toilets are Fundamentally Different

Water-seal Toilets are Anaerobic
(functionality fails without water)

Dry Pit Toilets are Aerobic
(functionality fails with water)

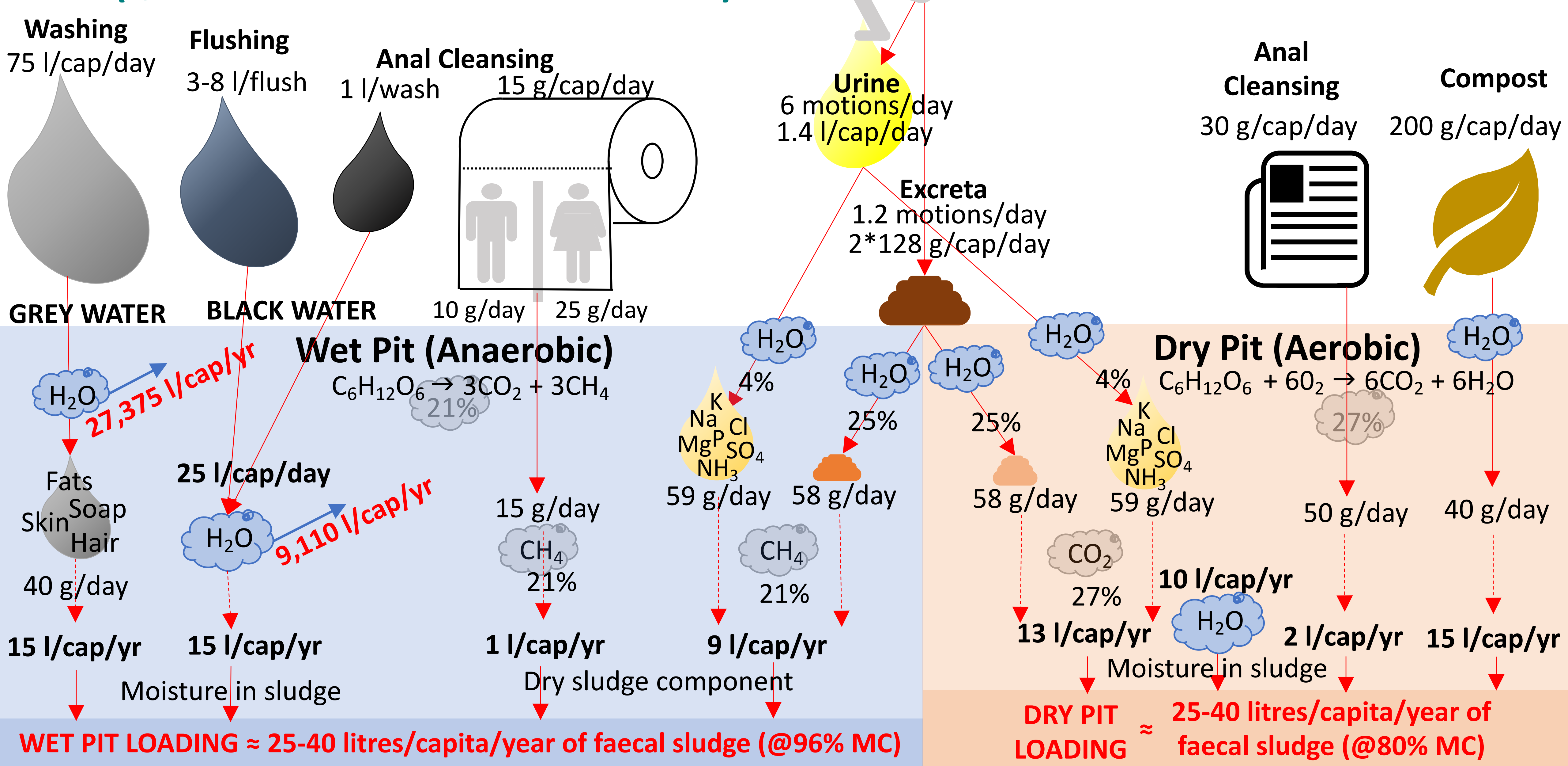




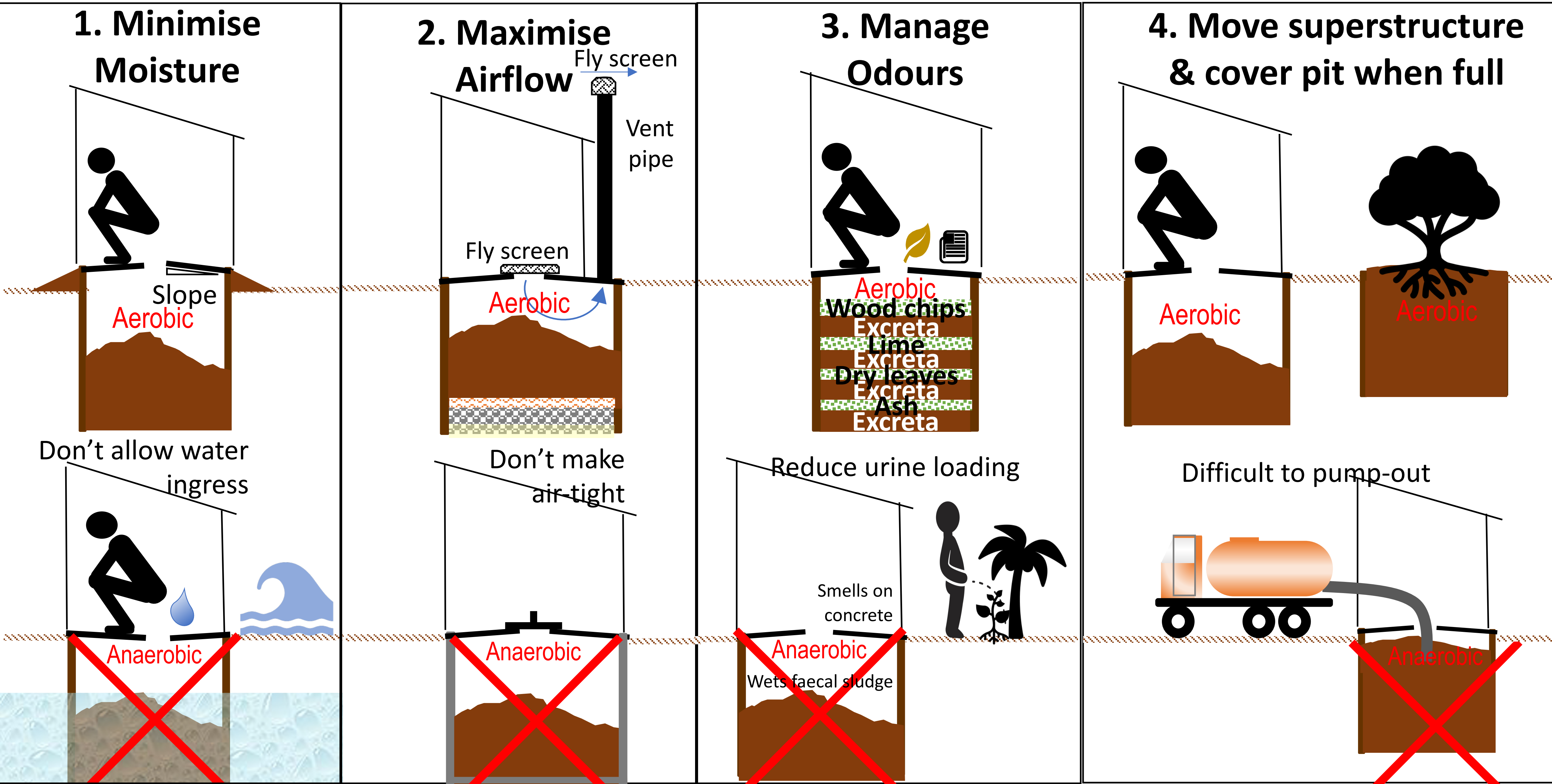
Water-seal (Wet Pit)		Dry Pit
MANAGE MOISTURE: Inclusion of grey water & poor percolation will increase pit fill rates		MINIMISE MOISTURE: Separate urinals & adding ash or dry compost will improve operation
Can use water, toilet paper or tissues. Leaves, newspaper, pads or rocks will block toilets.	**Anal Cleansing**	Can use toilet paper, tissues, newspaper, leaves, rocks or mud. No water permitted.
Use if the rainfall is high & modify if water table is high. Should not use if access to water is unreliable.	**Environment**	Must be kept dry. Can add ash or leaves. Should not use if water table is high.
Can be pumped, transported & dried. Pit contents can NOT be safe.	**Faecal Sludge Management**	Cannot be pumped. If dry, pit contents MAY be safe. Cover & dig new pit
Faecal sludge also needs to be exposed to aerobic processes		Dry faecal sludge is concentrated. Can disable treatment plants

Faecal Sludge Loading Rates
(@ twice AS1547:2012 densities)

Source: Still D. & Foxon K. (2012) *Tackling the Challenges of Full Pit Latrines.* Water Research Commission, South Africa
Reed, B. (2004) *Low-Cost Sanitation,* WEDC
Rose, C. (2016) *The Characterization of Feces & Urine*



Optimizing Dry Pit Toilet Operation & Maintenance



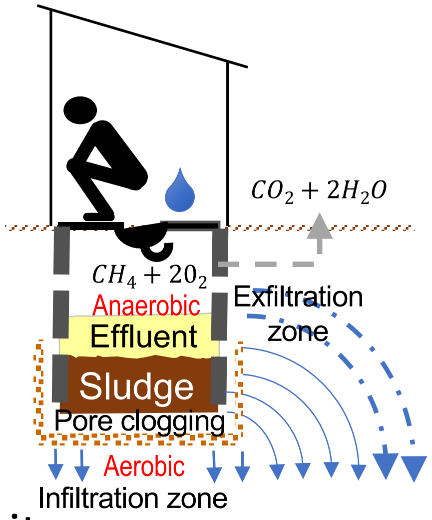
Optimizing Wet Pit Toilet Operation & Maintenance

1. What is a cesspit?

A cesspit is a combined septic tank & soakaway BUT cesspits:

- do not always operate full
- cannot accommodate fats, oils & grease

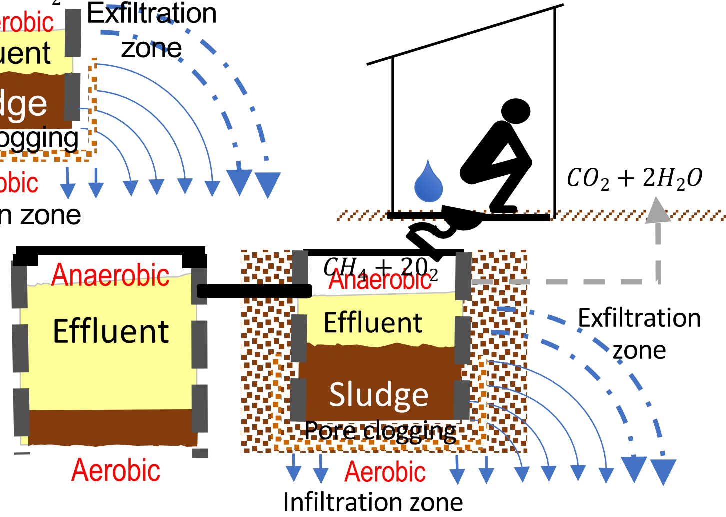
Cesspits MUST be 'blackwater' only



2. What happens if cesspits fill prematurely?

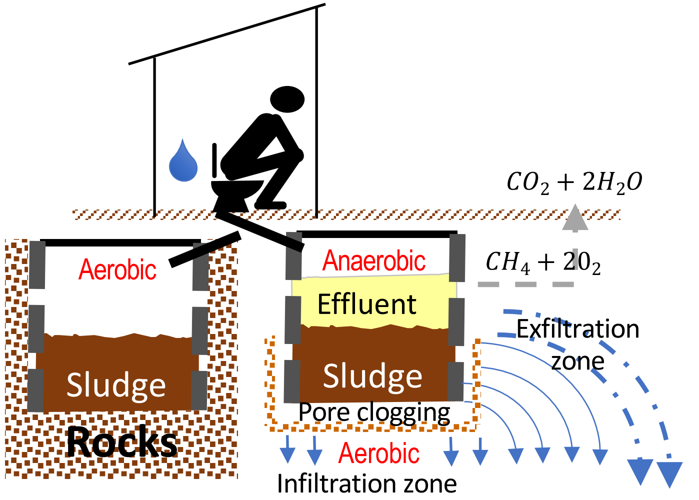
The effluent absorption area can be increased by placing rocks around the pit.

The effluent absorption area & sludge holding capacity can be increased by adding more pits in series.



3. How can cesspits be emptied?

Adding a second pit in parallel enables 'the duty' pit to be taken 'off-line' to rest for at least a year before being emptied



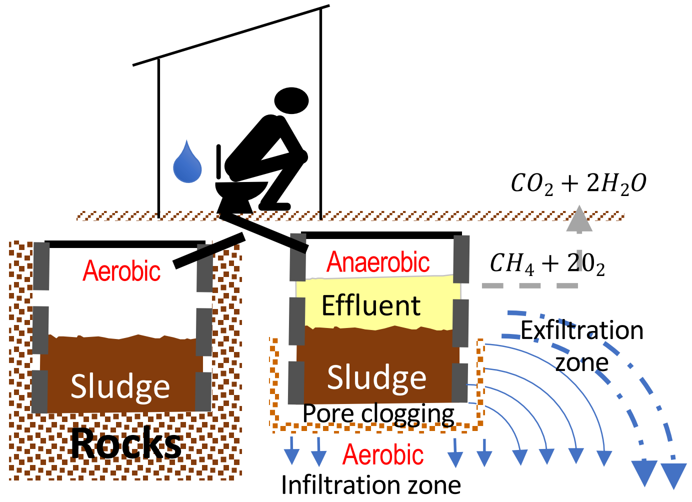
4. Why do cesspits fill so slowly?

The moisture content of sludge in efficient cesspits is 80% (20% solids), while the moisture content of sludge in septic tanks is 98% (2% solids).

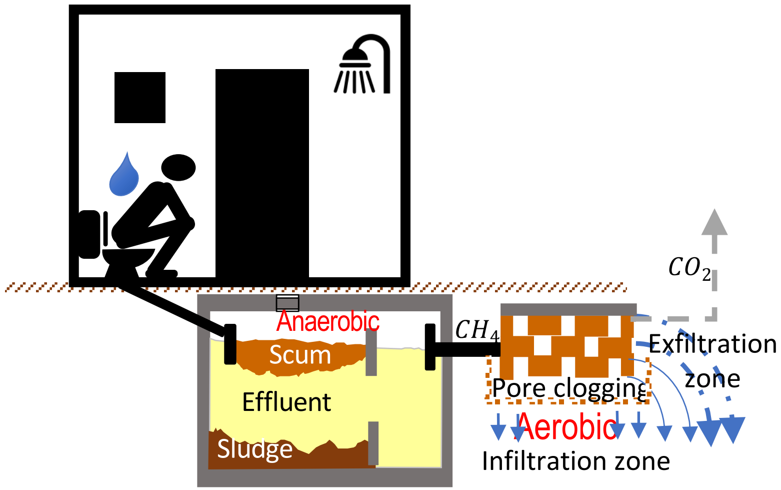
- Cesspits will take 10 times longer to fill than a septic of a given volume

Misunderstanding #3: Septic tanks are always superior to Cesspits

Offset Cesspit Toilet



Septic with soakaway



Advantages of Cesspits

- Septic tank sludge fill rates (50-80 lpcy @ 98% moisture content) are ≈10 times faster than cesspit fill rates (5 lpcy @ 80% moisture)
- Modular cesspits with an expanded effluent absorption area can be adapted to suit most soil conditions
- Cesspits offer multiple options for resting, switching or emptying when they fill-up, as compared to septic tanks that must be pumped out
- Cesspits are therefore ≈10 times cheaper than septic tanks with soakaways to install and maintain

Advantages of Septic Tanks & soakaways

- Septic tanks can treat all wastewater, as compared to cesspits that cannot accommodate grey wastewater (fats, oil and grease)
- Septic tanks contain nutrients in the sludge & effluent to potentially be removed, as compared to cesspits that will leach nutrients
- Septic tanks enable the effluent treatment mechanism to be designed and sized to suit the requirements for pathogen and/or nutrient removal, as compared to cesspits where the sludge storage volume tends to define the effluent infiltration area / type

Misunderstanding #4: It is okay to run dry pits in a wet state

Pit Toilet (wet)

>3 times the GHG emissions per capita

Pit Toilet (dry)

MANAGE MOISTURE (wet): Need to keep it wet or it smells awful

MINIMISE MOISTURE (dry): Separate urinals & adding ash or dry compost will improve operation

Pit Toilet (wet)		Pit Toilet (dry)
Can use anything for anal cleansing.	**Anal Cleansing**	Can use toilet paper, tissues, newspaper, leaves, rocks or mud. No water permitted.
Can use in high or low water table. Can even use if access to water is unreliable.	**Environment**	Must be kept dry. Can add ash or leaves. Should not use if water table is high.
Can be pumped, transported & dried. Pit contents can NOT be safe.	**Faecal Sludge Management**	Cannot be pumped. If dry, pit contents MAY be safe. Cover & dig new pit

Wet State

$C_6H_{12}O_6 \rightarrow 3CO_2 + 3CH_4$

Anaerobic

Aerobic

Effluent

Sludge

Dry State

Fly screen

Vent pipe

Fly screen

Slope

Concrete slabs will smell

$C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O$

Aerobic

Anaerobic

Faecal sludge also needs to be exposed to aerobic processes

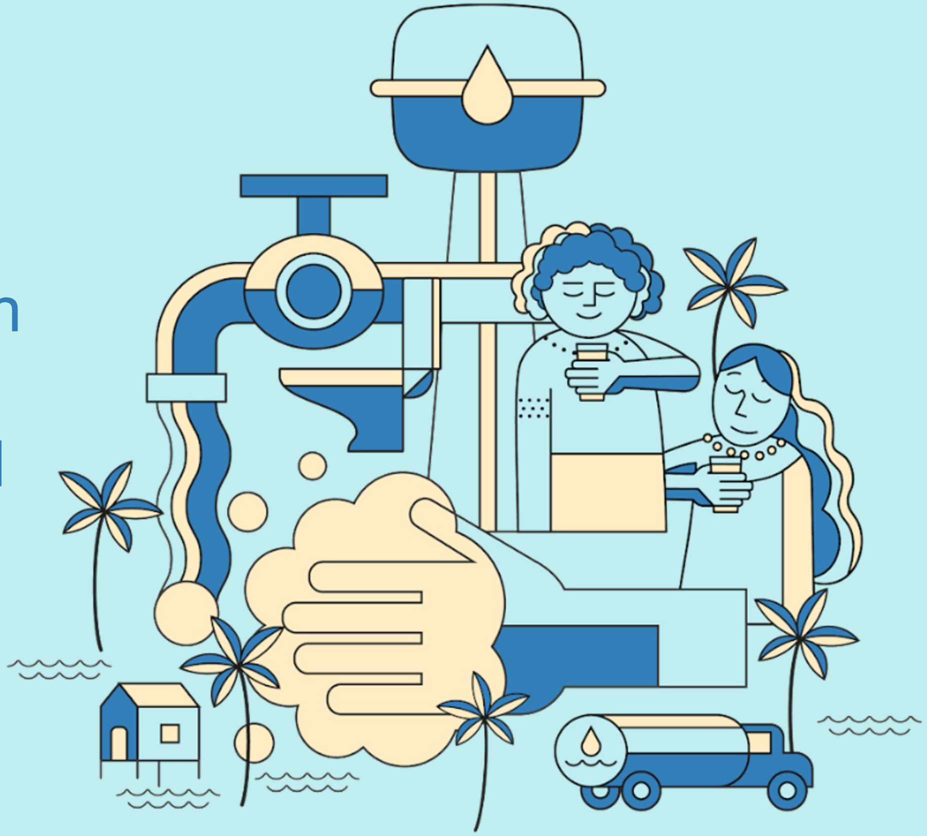
Aerobic

Dry faecal sludge is concentrated. Can disable treatment plants

Aerobic

We still have many questions:

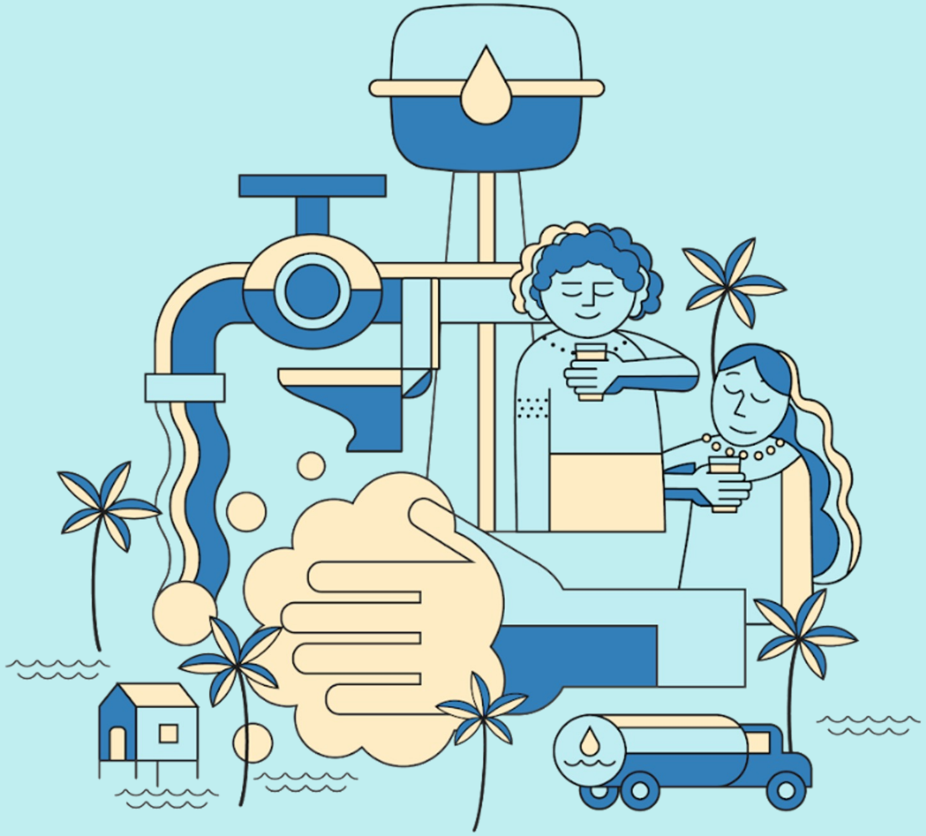
- What are the implications (risks) of running dry pit toilets in an anaerobic state?
- Is the SaTo pan a dry or a wet pit option?
- Can waterseal toilets be designed to function when the cesspit/septic is submerged?
- What are the factors that affect the assumed faecal sludge densities in
    - dry pits (i.e. 40% solids)
    - cess pits (i.e. 20% solids)
    - septic tanks (i.e. 2-4% solids)



What about you?

Topic 4:
Principles of septage / sewage treatment plants

"Rewards vs risks of complex technologies"



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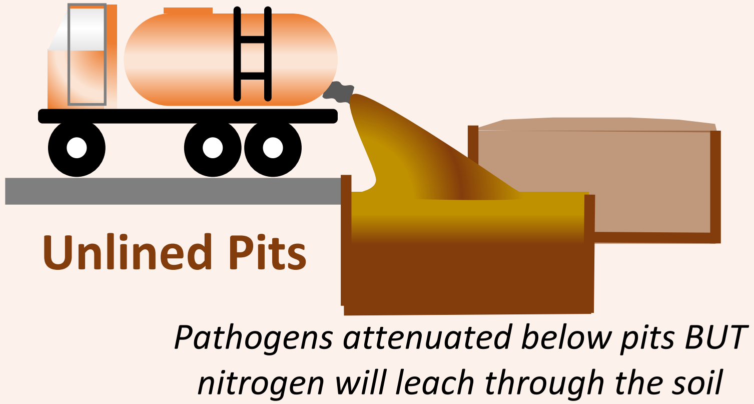
Passive Septage Treatment Plants

Septage plant treatment options are primarily driven by choices in the management of nutrient risks

1) Nitrogen leaches to the environment

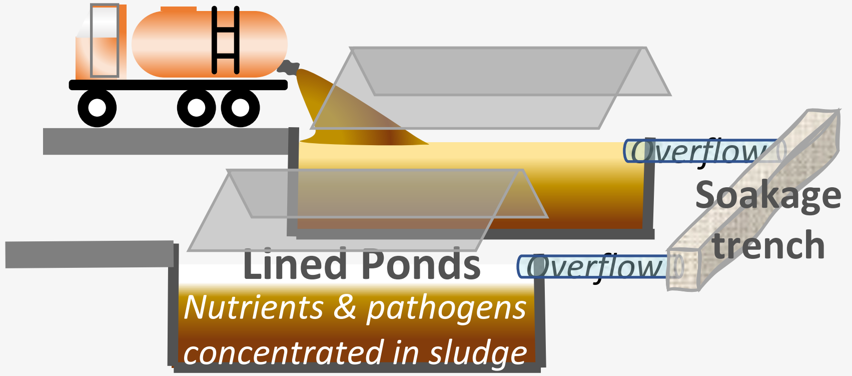


Sizing (=smallish)
- Pit volume to hold dry sludge (60% moisture)
- Pit area sized to facilitate effluent leaching
- Pits designed to limit moisture ingress

Maintenance (= minimal)
- Mound ground over the pits when full

Feasibility
- When septage tanker trucks are bringing sludge from toilets with well functioning soakaways (i.e. moisture content <96%)
- Where the nutrient risks are low (or carbon exists in an anoxic zone below the pit)

2) Nitrogen concentrated in the sludge

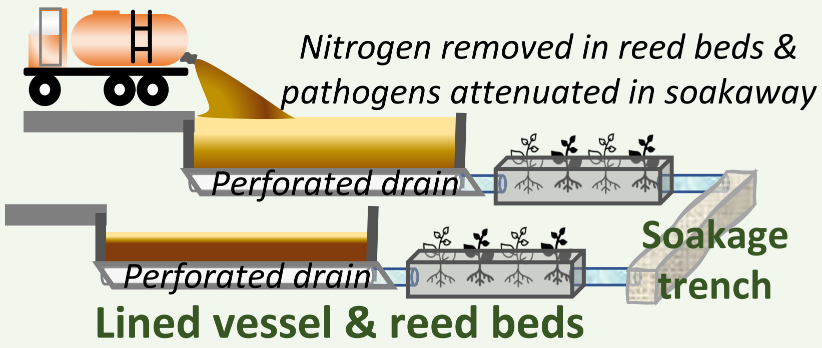


Sizing (=large)
- Pond volume sized to hold wet sludge (95% moisture) & soakaway to dissipate excess liquid
- Efficiently deployed in low rainfall areas or fitted with covers in high rainfall areas

Maintenance (=medium)
- Rest ponds when full … dig-out sludge, turn into the soil and wait before re-using.

Feasibility
- When there is demand for septage sludge as a 'nutrient rich' soil conditioner.
- Where the nutrient risks are moderate

3) Nitrogen concentrated in the effluent



Sizing (=medium)
- Vessel sized to hold moist sludge (80% moisture) & soakaway to dissipate all liquid
- Vessel could also be an Imhoff tank or anaerobic baffled reactor or similar

Maintenance (=high)
- Dig out sludge when full & turn into soil
- Gravel in reed beds needs to be replaced

Feasibility
- When moisture ingress is likely to be high
- When the nutrient contamination risks to the environment are considered to be high

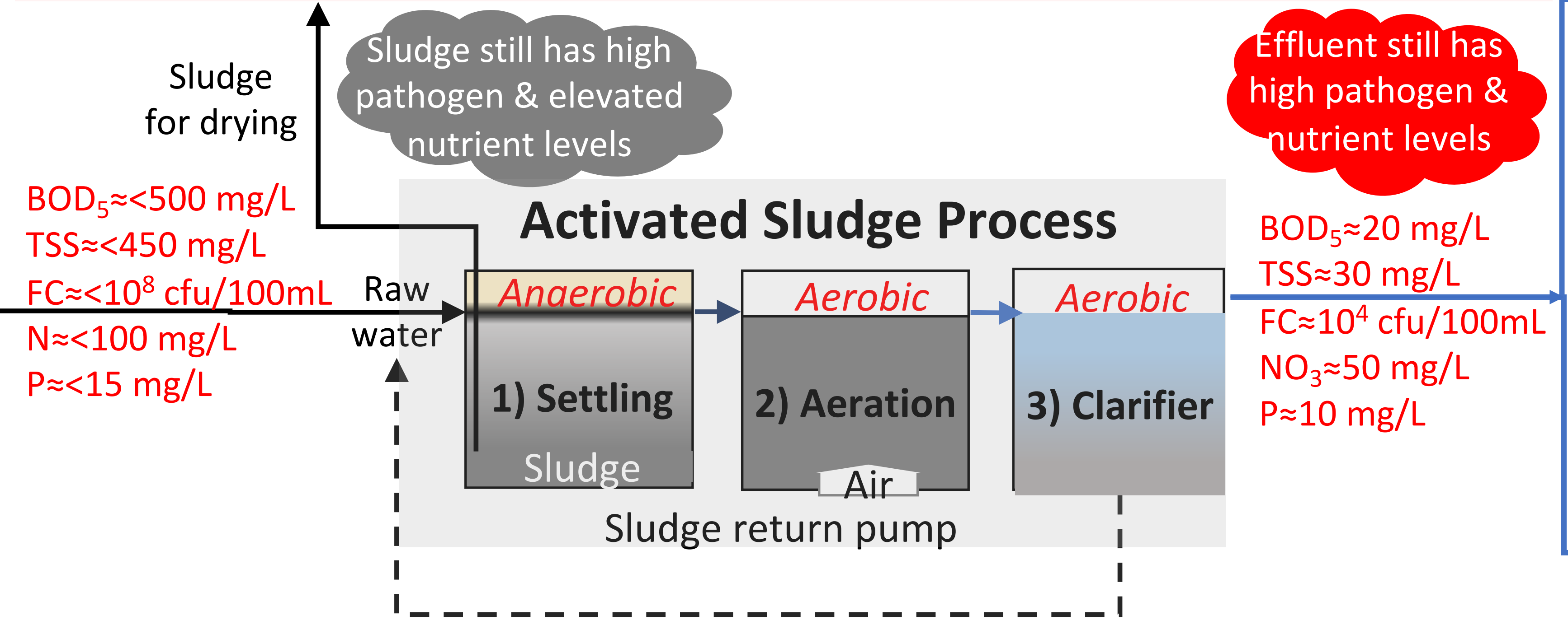
Package Sewage Treatment Plants On-site STPs

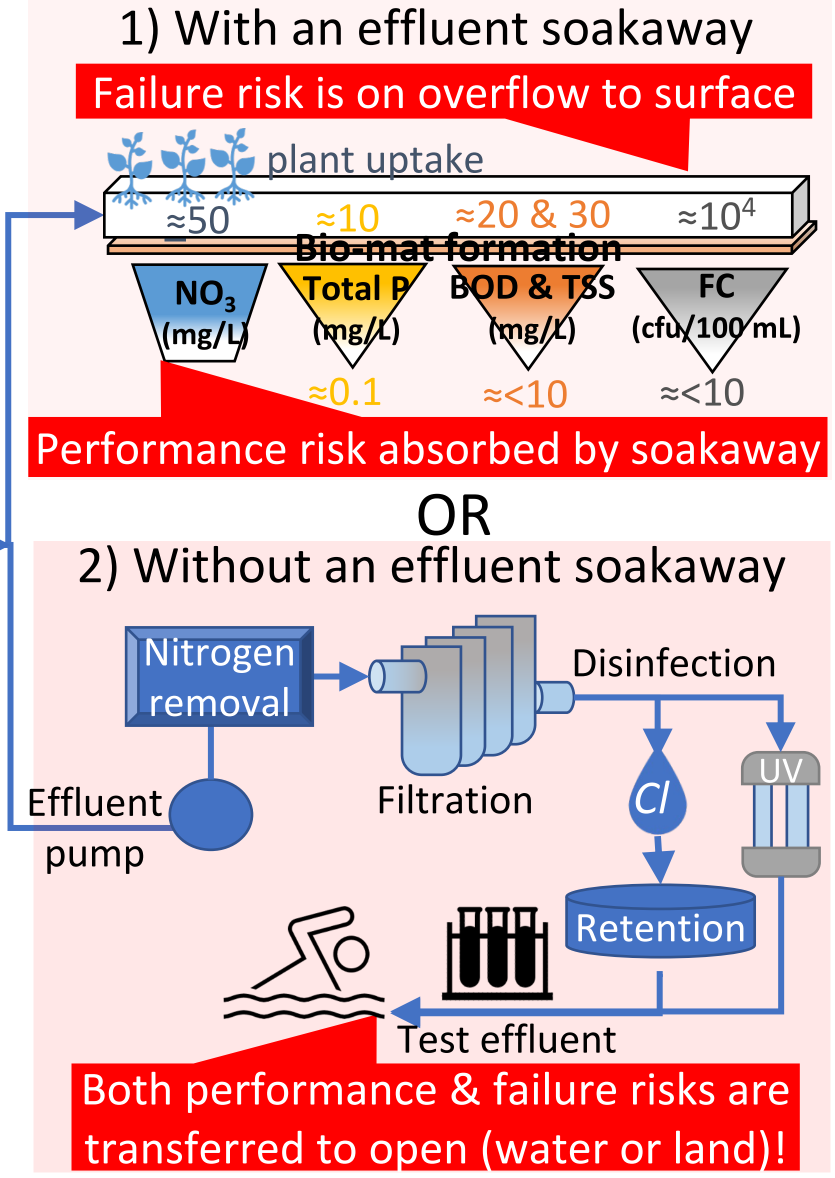
There are numerous package STPs on the market deploying an activated sludge treatment process BUT the regulatory requirements depending on whether or not they are fitted:

1) STP discharges effluent to a soakaway = lower performance <u>yet</u> lower failure risks

The lower BoD and TSS of effluent results in a thinner bio-mat with greater pathogen attenuation capacity. Nitrogen removal can be facilitated by plant uptake or a carbon source in the soakaway.

NB: Although effluent testing is NOT required, routine maintenance & emptying is necessary





2) Discharges effluent to open = higher performance yet higher failure risks

In order to achieve the required pathogen concentration levels, the activated sludge process must be followed by filtration and disinfection prior to the release to open. Nitrogen can also be removed by an effluent return to facilitate exposure to naturally occurring carbon in the sewage.

NB: Routine testing, maintenance & emptying is necessary to manage the risks of failure

Sewerage (on-site behaviours)

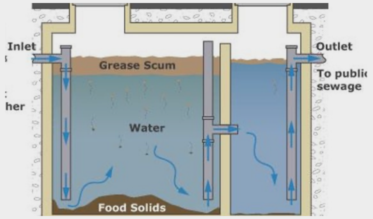
Minimizing the ingress of water and non-biodegradable materials will improve the efficiency and reduce the costs of the collection, transfer and treatment of wastewater. Improving residential and commercial user behaviour can improve the performance of the sewerage system.

1. Minimise Fats, Oil & Grease Discharges to Sewers

Fats, oil & grease can combine with detergents to form solid white cakes (fatbergs) that can block sewerage lines.

- Educate households to dispose of oil/grease with their solid waste
- Install grease traps in all commercial food processing industries
- Introduce the recycling of food oil as bio-diesel

Passive grease traps



Commercial (500-1000 litres)

Household (45 litres)

2. Prevent Non-Biodegradable Waste Entering Sewers

Foreign materials that enter sewers during construction, operation and maintenance can cause equipment failures. Educate households NOT to flush condoms, cotton buds, tampons, menstrual pads, wet wipes, nappies, dental floss

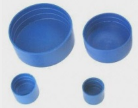






- Train builders to seal sewerage pipes during maintenance to limit the entry of sand, thread tape, pipe caps, building waste, tree roots





- Educate street sweeper & septage truck operators NOT to sweep sand or dump foreign objects into sewers

3. Reduce water percentage in the sewerage system

The transfer and treatment of sewage can be improved by reducing the percentage of clean water in the sewerage.

- Educate all users to eliminate rain/storm water from sewers
- Incentivise all consumers to reduce water wastage
- Eliminate crossovers between sewerage and stormwater systems

4. Reduce contaminants entering the sewers

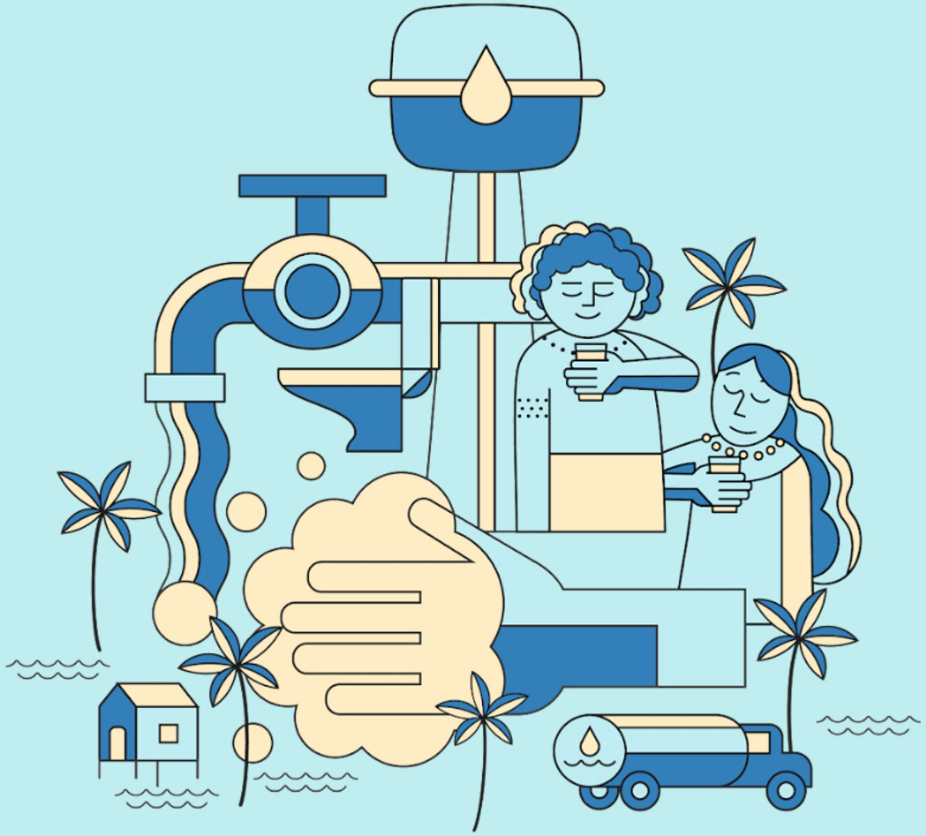
A sewerage system cannot manage all wastewater.

- Educate all users to minimise solid/chemical discharges to sewers
- Require all commercial users to obtain a ‘trade waste permit’
- Require the pre-treatment or prohibit the discharge of some wastewater to sewers

We still have many questions:

- Is nitrogen density loading the key trigger to move away from soil-based systems?
- Is it worth monitoring the quality of effluent discharged from STPs to soakaways?
- What are the relative inundation risks of onsite sanitation vs networked options

What about you?



ADB

Lessons

#	Common misunderstandings	Lesson
1	Faecal contamination of groundwater sources is primarily through the ground	Faecal contamination of groundwater sources is primarily via the surface
2	Septic tanks significantly reduce the pathogens in faecal sludge and effluent	Most of the pathogens are neutralized in the soil underneath the soakaway (aerobic digestion)
3	Septic tanks with soakaways are always a superior on-site option to cesspits	Cesspits offer a superior service to septic tanks with soakaways for many ‘blackwater only’ uses
4	There is no problem operating dry pit toilets as wet pits	Running dry pit toilets in a wet state is sub-optimal in reducing smell, emissions & pathogen removal.
5	Mechanical sewage treatment plants always reduce the faecal exposure risks	Mechanical sewage treatment plants often carry higher risks of failure

Malo! Vinaka! Thank you!

Please complete the feedback form