Talking Crap

Exploring Ecological Sanitation for a Sustainable World

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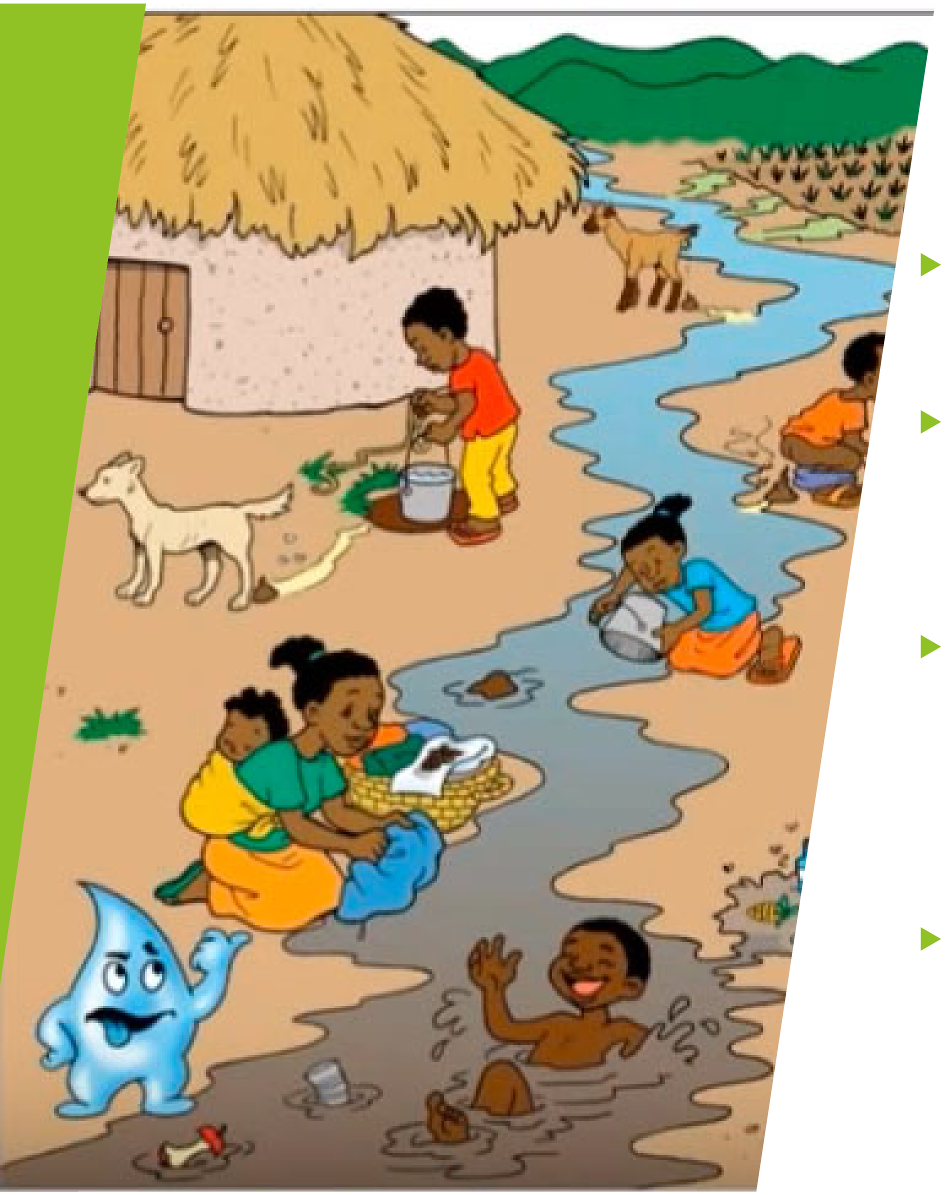
Me

- **UK**
- **Sociology** and **social policy**
- Forestry and arboriculture; **tree surgeon**
- TEFL in **Thailand**
- Sustainable **construction** in the UK, low energy homes – **passive houses**
- MSc **Sustainability and adaptation in the built environment**; took an interest in applying theories to **Thai context**, local building materials, ecosystem services, water treatment, research looked at low energy home design– eliminating the need for AC
- **CVBT**, community development, climate adapted affordable housing, appropriate technology
- Given my **background**, this workshop has an unsurprising **focus** on **sustainability and adaptation in the built environment**!

Contents:
the journey I’d like to take you on today!

The world of WASH and even just sanitation is huge and very complex but I hope to scratch the surface in the following areas:

- Introduction to sanitation
- A critical appraisal of current practices
- The need for a shift in sanitation systems and our attitudes towards human excreta
- An introduction to some natural treatment methods/systems and their benefits
- Implementation of such technology and our role as community development practitioners
- Summary
- Questions/additions/discussions



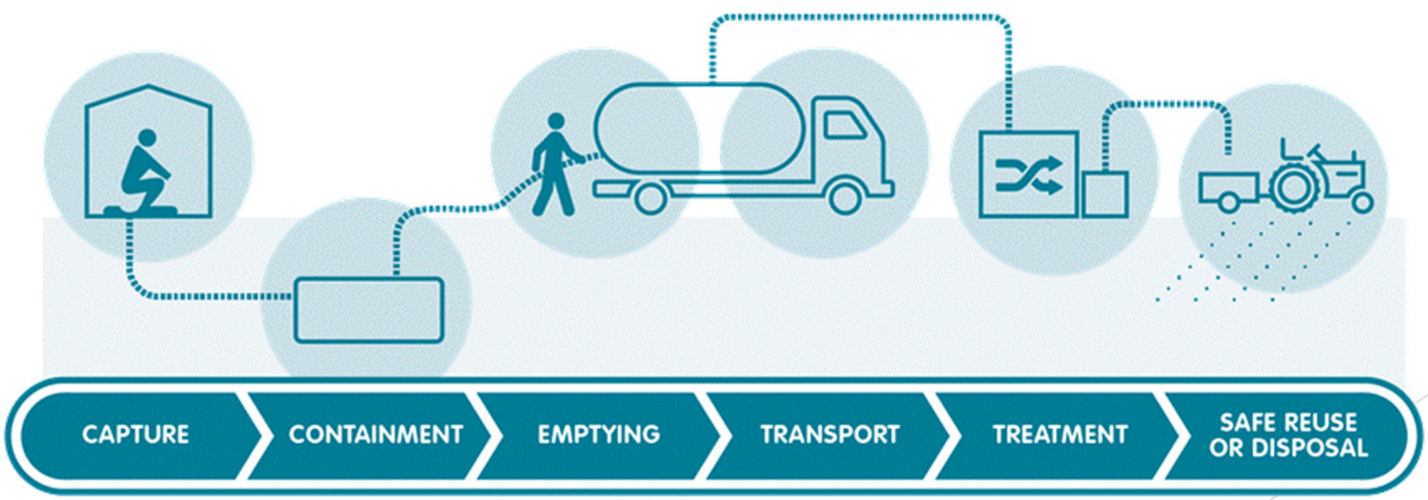
Sanitation

- The role of sanitation is to **protect** and **promote human health** by providing a clean environment and **breaking the cycle of disease**
- The **scope** of this workshop is to look more specifically at the **technologies we as practitioners could implement** and **promote** that manage **human excreta**, particularly from a **sustainability perspective**.
- These can and should ideally be part of a **broader 'environmental' sanitation approach** that includes all aspects of human health and well being – human and animal excreta management, domestic wastewater management, storm water drainage, solid waste management, vector control and safe water supply
- These aspects are **interconnected** and so a broad, **community wide perspective** is ultimately needed to raise standards across the board. Consider household AND networked technologies.

Source: Centre for Affordable Water and Sanitation Technology

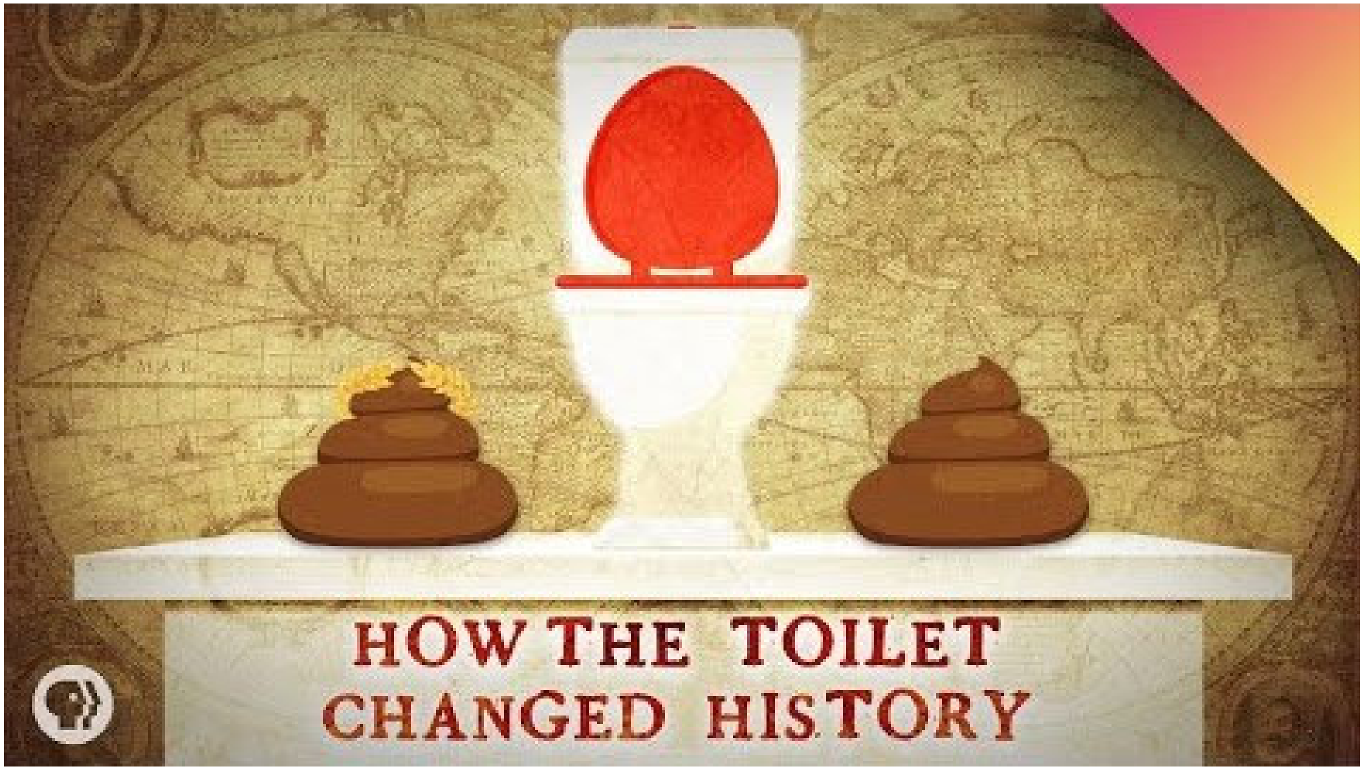
Academic medical/technical perspective; successful sanitation system?

- It should **reduce pathogens** in the environment and **opportunities for pathogen contact**.
- This should in turn **directly reduce the transmission** of excreta related diseases whilst passively control methods of **indirect transmission** (mosquitoes, flies, rats etc.)
- **The sanitation chain** goes **beyond the toilet** itself to the **safe management of excreta at every stage** of the chain, inappropriate or inadequate methodology at any one stage can **“break”** the chain and render the whole **system ineffective**



Source: Centre for Affordable Water and Sanitation Technology

Let’s get up to speed on the global sanitation situation and the current paradigm of human “waste”



Source: Bill and Melinda Gates Foundation

Global sanitation situation and the current paradigm of human "waste"

- We will critique this video as the presentation continues but firstly some **helpful facts** to remember;
- We **need sanitation systems**; ~130g poop per person per day X ~7.5 billion people on earth
- **1 in 3 (~2.4 billion)** people are **without a toilet** (13% open defecation)
- Many **dangerous diseases** can be transmitted from human excreta; 100,000 deaths a year from dysentery, cholera, typhoid, parasites etc.
- 800,000 children under 5 still die from diarrhoea every year (more than AIDS or maleria)
- Estimates put the **economic cost** of poor sanitation at $60 billion as a result of illness, loss of income and loss of life, **women** are disproportionately affected.
- Traditionally people used **water systems** like rivers to get rid of their excrement
- In 1775 Alexander Cummings modified earlier **flushing designs** (John Harrington's Ajax device, 1500s) to block sewer gas and **popularise this tech**
- 1854 Dr John Snow **identifies contaminated water** as the cause of cholera epidemic, London enclosed its sewers and diverted them downstream of the city
- Over the next 100 years sewage treatment plants and toilet paper was developed ... Welcome to the "**modern sanitation system**"!
- In many **cultures it remains a taboo subject** making addressing these issues difficult to address

So, according to the video, we have a global population that can be divided along the lines of who has access to adequate sanitation and who doesn’t

Let’s have a look at the situation and the sanitation chain and its consequences for *those without*

And then let's have a look at those with the sanitation chain of the system advocated in the video and its consequences

Those without access to safely managed sanitation services

World Health Organisation (2017):

- **2.0 billion people** still do not have basic sanitation facilities such as toilets or latrines.
- ***What does this mean for their sanitation chains and management of excreta?***
- Of these, 673 million still **defecate in the open**, for example in street gutters, behind bushes or into open bodies of water.
- ***A broken/inadequate sanitation chain means …***
- At least 10% of the world's population is thought to consume food irrigated by wastewater.
- The **transmission of diseases** such as cholera, diarrhoea, dysentery, hepatitis A, typhoid and polio and transmitted whilst stunting of growth is exacerbated
- **Additional negative impacts** include a reduction in human well-being, social and economic development due to impacts such as anxiety, risk of sexual assault, and lost educational opportunities

Gandhi – *"sanitation is more important than independence"*

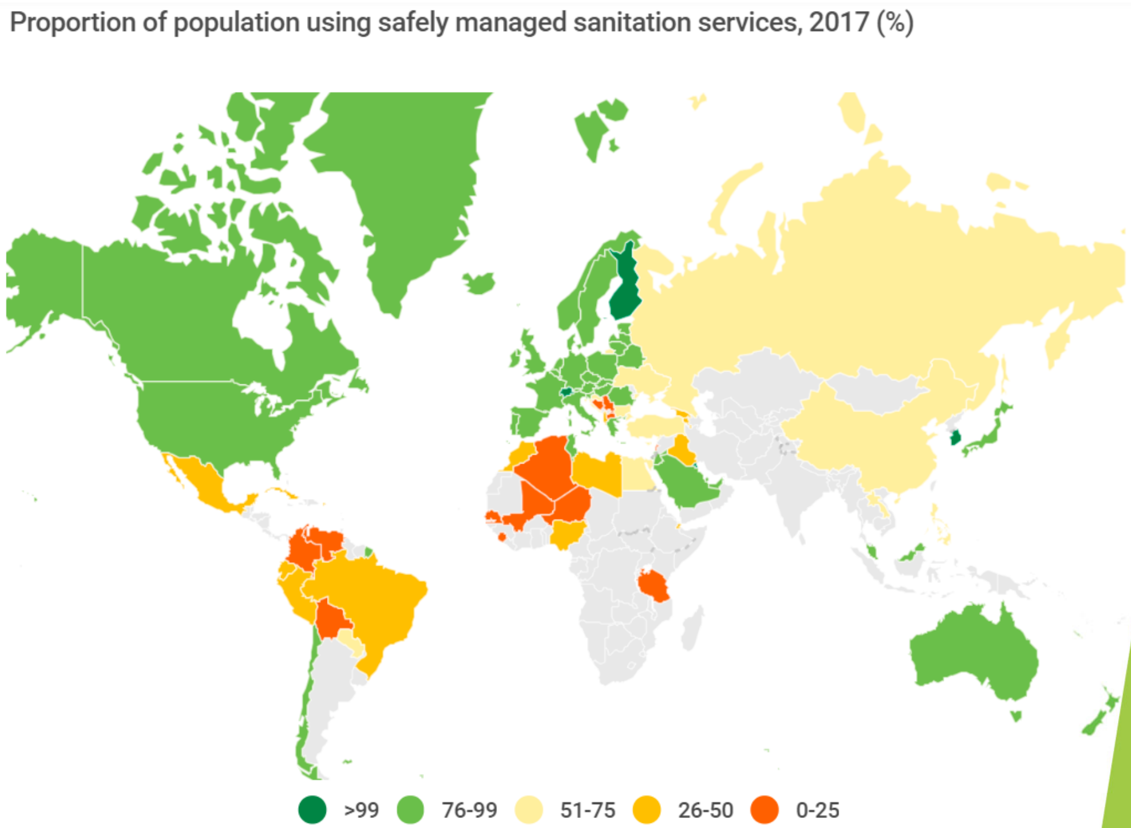
Recognition of the need to improve the situation

- In 2010 the **UN** General Assembly recognized safe access to sanitation (alongside clean drinking water) as a human right, codifying adequate and equitable sanitation for all in **Sustainable Development Goal 6.2**
- This is being tracked with the indicator of **“safely managed sanitation services”** – the use of a private sanitation facility from which excreta are safely treated in situ or transported and treated off-site
- **Benefits of improved sanitation** go beyond reducing disease; promote dignity and safety, promote school attendance (particularly among women and girls)

Source: World Health Organization, Sanitation

Those with access to safely managed sanitation services?

- Definition; serviced by "safe" sanitation chains from use to disposal. Commonly this means a flush toilet and sewers or septic tanks.
- **Distributed unequally**; access to safely managed sanitation systems is disproportionately high in Europe, North America, Australia and New Zealand.
- "…large disparities in access still exist. Almost all developed countries have achieved universal access, but sanitation coverage varies widely in developing countries."
- Slowly access is growing; "Since 2000, 2.1 billion people have gained access to basic sanitation, such as flush toilets or latrine with a slab which are not shared with other households"



Source: UNICEF

Flush Toilet Sanitation Systems

Emerging over the last 160 years, the **flush toilet** and its associated sewage systems has come to be seen as the **'modern' toilet system**.

Usually linked by **pipe** to **local sewers** or into a **septic tank**, sewer systems were once just released untreated sewage downstream but now are connected to a network of **filtration** and **treatment systems**.

Flush Toilet Sanitation Systems; **Sewage**, Primary Treatment

Firstly, sewers have **a network of grills** to catch larger objects and prevent them from entering the Sewage Treatment Plants (STPs).

↓

Then sewage enters a **settling tank or "grit chamber"** where heavy solids like sand and gravel settle to the bottom.

↓

It then passes through a further **mechanical screen** to remove other non-dispersable flushables; paper towels, wet wipes etc.

Primary Clarifier; circular basin slows down sewage, allowing heavier organic solids fall to the bottom (and be removed to be transferred to a digester, sludge press or drying bed) whilst also skimming the top for floating fats, oils and grease (also for the digester).

Aeration basin; air is added to foster an efficient environment for aerobic microorganisms to consume organic matter. It is now known as activated sludge, looks like dark mud, and is rich with active bacteria and protozoans that are breaking down the oxygen rich water and its organic contents.

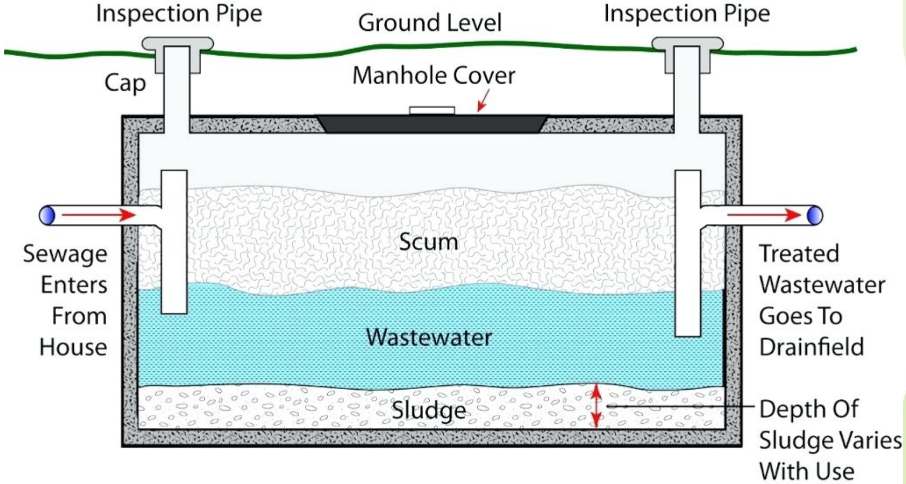
Secondary clarifier and sedimentation basin: last chance to remove heavy stuff and pump it to the digester.

Digester; an anaerobic environment (like a septic tank) where bacteria can break down sludge, reducing the volume, odours and disease-causing organisms. Drying beds can also be used at this stage.

Leftover solid material from this process is called **biosolids or treated sewage sludge**. This was once put into landfill. Now, in some areas, it is being used in agriculture as fertilizer or compost.

Tertiary Treatment

- **Wastewater** at this stage still needs to be **disinfected** before it is **discharged** or **reused**.
- This is commonly done by **chlorination**, introduced as a gas or salt to break down bacteria's cell membranes and kills them.
- This gives the water a bad taste and can also be dangerous for organisms in the water bodies that receive the treated water. Therefore the last step is **de-chlorination** using sulphur dioxide to turn chlorine compounds into chlorine ions, making the water less toxic.
- Less common wastewater disinfection can now also be done with **UV** (UV light physically mutates/degrades DNA of pathogens) or **wetlands** (using plants to improve aeration, hydraulic flow and microbial diversity) and **sand filters** (biofilters that primarily rely on aerobic microorganisms for the biodegradation of pollutants and pathogens).



Schematic of a Septic Tank

Septic Systems

- **Anaerobic digestion** of sewage is effective in breaking down human excreta and eliminating pathogens.
- Black ("foul waste") and grey water (drains, sinks, showers) flows into **holding tank** in which **anaerobic bacteria** break solids down into liquids and a greasy fatty residue (over about two days) – this is **"primary treatment"** (not yet fully treated).
- Insoluble particles will sink to the bottom in the form of sludge, whilst the fats form a layer at the top.
- The tank is then either pumped for the wastewater (having been **broken down by bacteria by about 40%**) or released in a **drainage field** where the bacteria continue to break down the pathogens whilst the soil acts as a **biofilter** and **aerobic bacteria** also help with the breaking down process.
- The rate of the **accumulation of sludge** is usually faster than decomposition and therefore must be periodically removed with a vacuum truck.

Some factors worth considering; environmental and community development perspective?

- A reliance on ***water*** as the medium in which to collect/store, transport, treat and dispose of human excreta through a network of tanks, pipes, treatment works and reservoirs.
- In these cases our excreta are **combined** with other hazardous material (industrial, medical, chemical and all manner of household waste) in a waterborne waste stream we call ***sewage***.
- London has a ***37,000-mile network of sewers***, New York has 6,000 miles and Paris 1,500 miles.
- The picture on the left shows a 210ft “fatberg” in a sewer in the UK under the small town of Sidmouth. Made of household waste (fat, oil, wet wipes etc), requires excavation with high pressure jets, shovels and pickaxes
- **Vulnerability**, **resilience**, **economic viability**, **infrastructure**, **ecological sustainability** and **regulation** in the face of ***urbanisation*** and ***climate change***?

Sources: npr.org, WHO

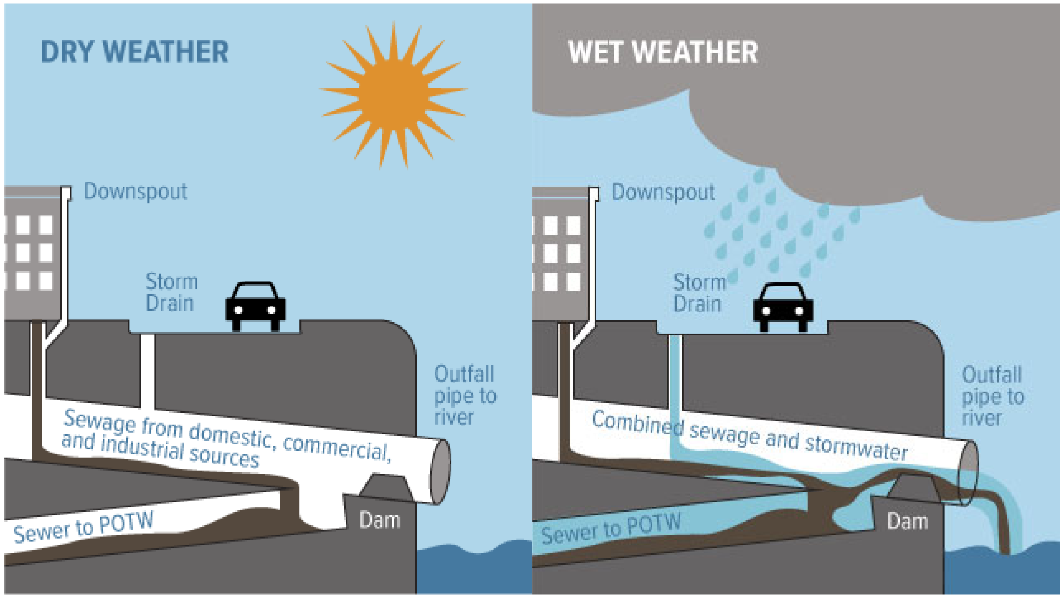
Is this really sanitary? Is this really sustainable? Is it really appropriate to be advocating this technology?

Some major issues:

- Pollution and contamination
- Water use
- Soil fertility
- Energy use
- Costs (financial, social etc.)

Pollution and contamination

- Sewer systems are **vulnerable** throughout the sanitation chain; they **require difficult and dangerous maintenance**, can be **overwhelmed by extreme** weather events and are **difficult and expensive to expand** when capacity is reached. These problems can lead to **pollution and contamination** as the 'containment' and 'transport' elements of the **sanitation chain are broken.**



- This illustration shows how as little as **4mm of rain** can overwhelm **combined city sewers**, causing the **discharge of sewage mixed with rainwater** into **open water sources** in the city
- India Today (13/06/2019): **"801 workers died cleaning sewers in country since 1993"**, mostly from suffocation, 34,859 manual 'scavengers' still operate around the country today

Sources: Jersey Waterworks, India Today

Water Scarcity

71% of the surface of the earth is water, and at a global level **we can't "run out of water"** because of the **water cycle.**

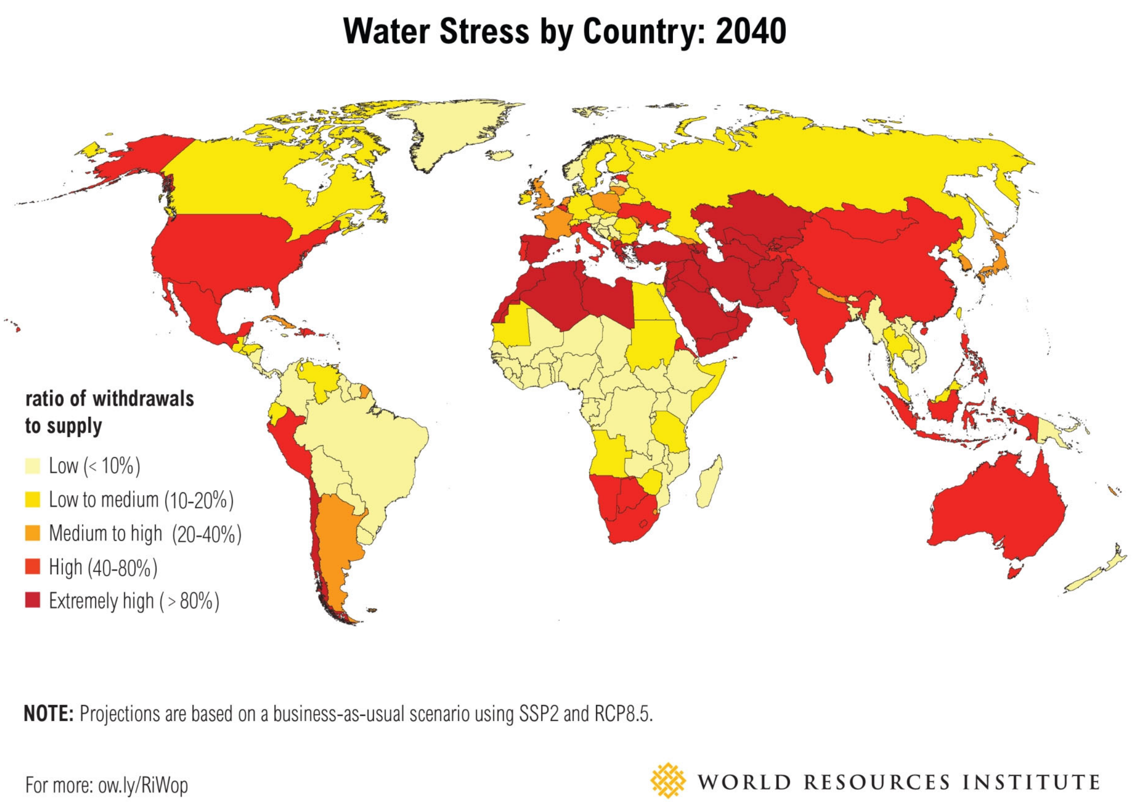
It's not a question of how much there is but **how much is accessible** to us; **97% of liquid on earth saltwater**, unfit for consumption or agriculture.

Of the remaining 3%, 2% is frozen in ice caps or glaciers. **1% is spread across rivers, lakes, underground aquifers, ground ice and permafrost** and this is what is being **rapidly depleted** by humans and **replenished much more slowly** by rain and snowfall.

This limited supply is **not distributed equally** around the world; climates, geography and water use patterns mean that **over 50% of the global population already faces extreme water scarcity for at least 1 month a year** and current estimates predict that **by 2040 up to 20 more countries could be experiencing water shortages** as their water **supplies are extracted** faster than they can be replenished.

Finite underground reservoirs are being extracted when more accessible sources can't meet the demand. As a result **21/37 of these major underground reservoirs are on track to be irreversibly emptied** if our current usage continues.

- The earth isn’t running out of water but we are **depleting the resources we rely on at an unsustainable pace**. Although **far less than agriculture** and slightly less than industry, **household water consumption** still **accounts for 3.6% of humanities water consumption**.
- On the scale of **water poor communities** in which we may be working the savings could however be **significant**, consider **similarities of water stress** map and **sanitation map**:



- On average, toilet **flushing is the single highest use of water** in a home (31% of overall consumption).
- The average person flushes the toilet **five times a day**.
- Depending on the water efficiency of the toilet, an average flush can range between **13.6 – 6 litres of water**.
- The common recommended intake of water per day for us to remain **healthy** is **~2 litres**.
- Introducing a sanitation system that is reliant on a supply of water will **increase the vulnerability** of the population to climate change and extreme weather events.

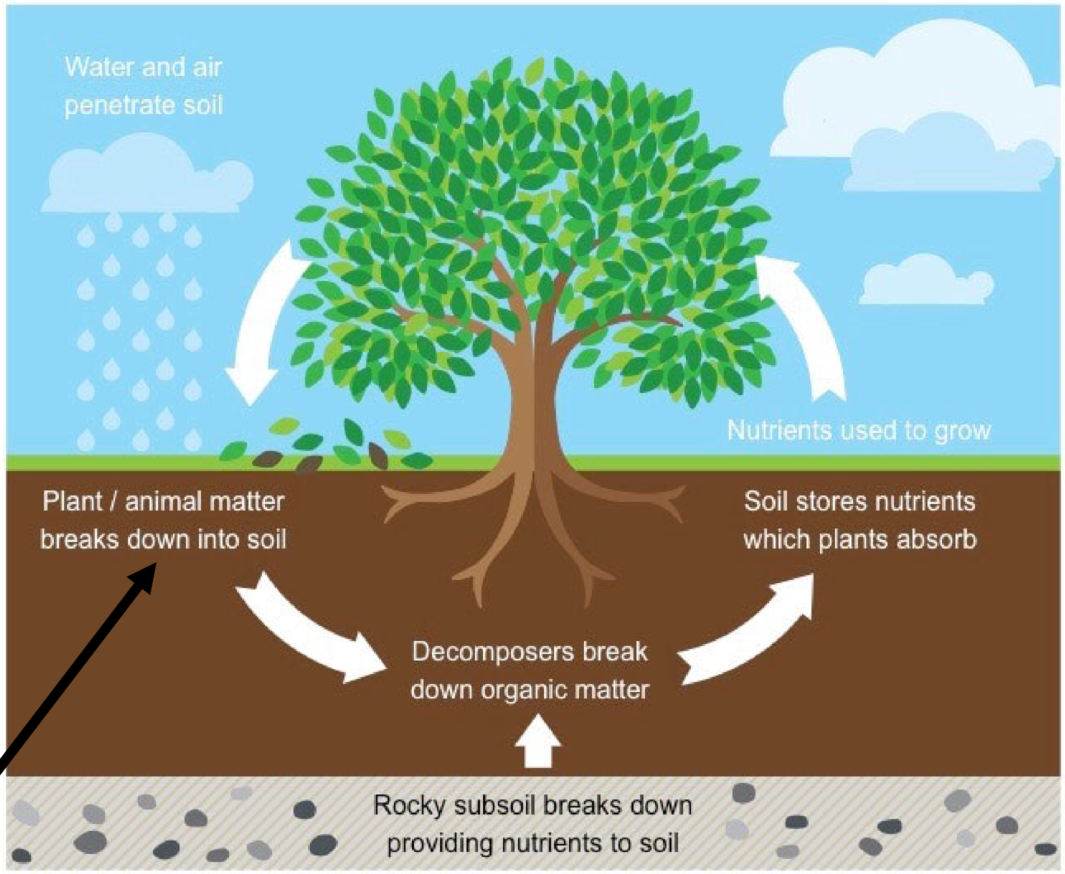
Source: Home Water Works

Soil fertility

- Currently, excessive use of **pesticides** and the **extractive and destructive** nature of industrial agriculture which relies on **chemical heavy farming techniques** and **deforestation** are **destroying the fertility** of the worlds soil.
- The UN has warned that soils around the world are heading for exhaustion and depletion, there are an estimated **60 harvests** left before they are **too barren to feed the planet**. **UK** environment secretary Michael Gove, said we have **30-40 years** from the fundamental eradication of soil fertility and “**no country can withstand the loss of its soil**”.
- Without new approaches, the amount to **productive arable land per person** will be **a quarter** of the level in **2050** that it was in **1960** (growing population and soil degradation).

Sources: The Guardian, Science Direct

- **Plant production** and **nutrient cycling** are two of the **key function** of farmed soils. **Decomposition** by soil organisms **liberates carbon and nutrients** from complex **organic materials**, putting them back into **circulation** so they are **available to plants** and other **organisms**.
- Rather than **recycling the nutrients** of unwanted organic materials, modern agriculture has become dominated by **chemically manufactured fertilizers**. This manufacturing process is associated with **low efficiency**, high **environmental pollution** and **inadequate control** measures.
- In addition, nutrients such as **phosphorus** have **no substitute** and **cannot be synthesized**, meaning it must be **extracted** from the earth's **finite** resources. Some sources are claiming we have already reached **'peak phosphorus'**. Unlike other non-renewables, it is reusable … in fact **we excrete enough to meet ¼ of the current global demand**, 60% of which is in our urine.
- **Flush toilets** as they are currently used are **preventing** most of these **nutrients** from re-entering the nutrient cycle.



Sources: The Guardian, Science Direct, NPR

Energy use and carbon footprint of water/wastewater management

Water and **energy** are two **interrelated resources**, reliant on each other and therefore **vulnerable** to **fluctuations** in the availability of one another.

Therefore, as the global population grows, and we seek to **provide access** to water/wastewater treatment services we must **be aware of the energy demand** our systems incur

The **embodied energy of water supply systems** in a region is related to **population**, **land use patterns** and **water sources** and should be calculated as a supporting tool for **decision making** and **planning**

There is a potential to mitigate energy use in water/wastewater systems by recovering resources in the wastewater treatment process

The embodied energy of water depends on the supply (e.g. surface water vs groundwater and their respective plumbing requirements) but then also on the required treatment (already partially filtered groundwater vs desalination process)

Studies have suggested that by using integrated resource recovery (energy, nutrient and water) in the treatment process the total direct operational energy of the treatment plant can be offset. However, the total embodied energy of the STP cannot be offset, making carbon neutrality unfeasible.

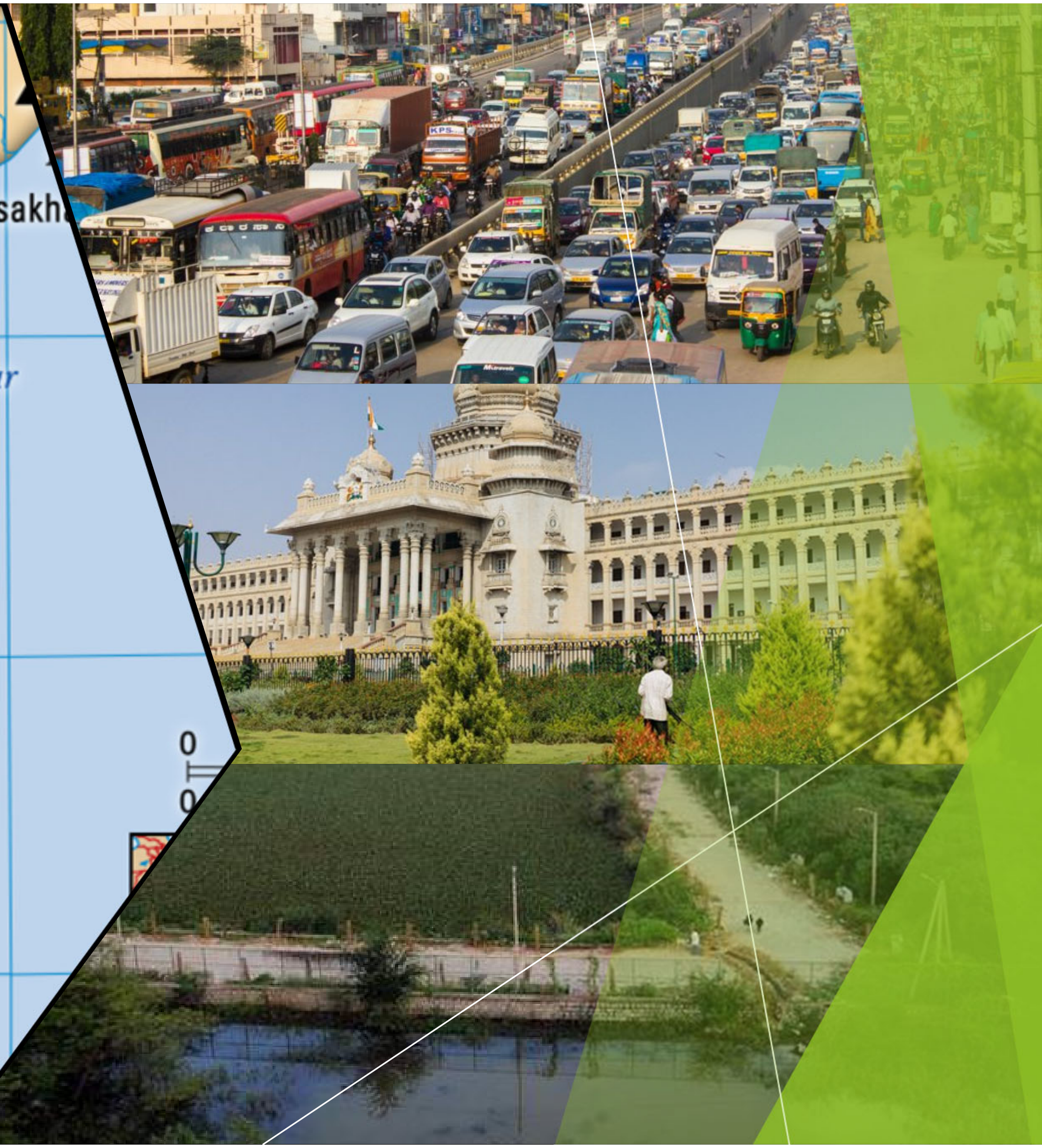
Source: Water's Dependence on Energy: Analysis of Embodied Energy in Water and Wastewater Systems

Cost

- The **financial costs** to cities for **construction** and **maintenance** of **infrastructure**
- The **financial costs** for **operation** and **maintenance** of the **toilet system**
- The **financial** and **environmental** cost of the **water** to the household, city and state
- The **social cost** of time spent **collecting water**, often specifically a role assigned to **women**
- We must be **aware** that an **affordable technology** in region may be not only unaffordable in another **context** but wholly **damaging** financially, socially and environmentally

Source: Water Aid

Case study; Bangalore/Bengaluru, India



The capital of Karnataka, it was once famous for **beautiful lakes and wetlands** which were constructed in the sixteenth century to meet the drinking water, irrigation and fishing needs of the community. They also provided the **ecosystem services** or replenishing groundwater resources, prevented flooding, and arresting sediment loads.

Known as India's "Silicon City" it has a big IT industry and is an international air hub. It is experiencing "unprecedented urbanisation and sprawl"; land use analyses show a 584% growth in built-up area over the last four decades, a 66% decline in vegetation and 74% decline in water bodies.

The estimated population is now 12.476 million over an area of 709 km^2, population forecast to more than double by 2050

Sources: India Water Portal, Geospatial world, India Population 2018, The New Silk Roads

- **Rapid growth and urbanisation** = extraordinary strain on infrastructure and resources = encroachment and the discharge of sewage and industrial effluents.
- Having outgrown the capacity of its sewage system, a **grey market of faecal sludge management for septic tanks and sewage cleaning** appeared that dumps sewage along the sides of streets and lakes, **unregulated** by civic bodies.
- More than **90% of it's lakes are polluted or encroached**; "Abused, polluted, encroached and vanishing". Of **105 lakes** in the city surveyed for their physiochemical characteristics, only **four seemed to be in a good condition**. These four differed only because they had been **restored and taken care of by local residents**
- Illegal sewage dumping and badly-functioning STPs; whilst there are **24 STPs in the city**, **none treat wastewater according to the norms prescribed by the Central Pollution Control Board**. Journalists found that **chlorination and dichlorination processes** - essential to ensure nitrates are removed to produce clear water, were **not present**.
- Researchers showed that the **largest and oldest STPs in Bangalore** have near **zero impact on the wastewater** they treat.
- The **sanitation chain broke down**; no sewage **connections** to many **homes** within the city limits**, open drains** carrying industrial effluents and garbage, **power outages at STPs**, and inadequate implementation of **regulations** mandated by the state.
- Sustained flows of **untreated sewage, industrial effluents** and the **dumping of solid wastes** and **building debris** fed the lakes. **Fish deaths**, **foam formation** and **fire** were all found.
- One ethnography of the faecal sludge management sector fond that **lower socio-economic classes** handled the sewage from the upper classes.
- One academic study cited **poor governance**, lack of a sense of **belonging** and poor **regulation** as three primary causes.
- Although **regulations** surrounding adequate STP exists and is a part of the planning process of new buildings, reports suggested they were simply **turned off or improperly used** once buildings were occupied.
- The **costs** and **knowledge** regarding sustainable disposal of sewage would be beyond most households

Sources: India Water Portal, Wetlands: treasure of Bangalore, The Hindu Digital, The News Minute

“Toxic foam; a cocktail of chemicals and sewage with a pungent odor and causes irritation to skin”

Sources: The Guardian

“Bellandur lake, the city’s largest body of water covered in a thick layer of vegetation, burns for hours”

Sources: The Guardian

“Dead fish washed up on the banks of Ulsoor Lake”

Sources: The Guardian

However … from dumping ground to oasis

- **Kyalasanahalli Lake**, a 36-acre water body near Anekal, **Bangalore** was “restored in 45 days”
- The lake had dried and villagers were using it as a dumping ground.
- Mechanical engineer Anand Malligavad designed and executed a **rehabilitation procedure**
- With the help of a **community elder**, he reached out to the local community (400 houses), **spreading awareness** and then conducted the work with a volunteer force
- Hired trucks to move earth into islands across the lake.
- Fruit bearing trees, native plants, flowers and nesting areas were established on these islands.
- Two canals fed by the **stormwater** drain were **diverted** 1.8km away and the September rain brought water and life to the lake which had “been dead for 35 years”
- The surrounding areas were **rehabilitated** with the planting of grasses and plants to prevent erosion
- To avoid the emptying of the lake 186 **borewells** around the lake were created and recharged to be used by local farmers for irrigation

Source: The Better India

What are the lessons from this?

- An **extreme case** but it is **illustrative** of the **wider challenges** of **urban growth** and it's impacts on **economic**, **demographic** and **political stability** in the region
- A combination of **urban slums without any sanitation** and the **failure of civic infrastructure** to maintain **adequate sanitation systems** in the face of a **growing population**
- The negative environmental impact of both **inadequate sanitation** and **unregulated sanitation chains**
- **Exacerbating inequality**, the underprivileged handle and live amongst the sewage of the wealthy whilst their interests are not represented politically, further decreasing their quality of life and opportunities
- The unique challenge presented by the **rapid urban migration** we are witnessing across the developing world, particularly in Asia
- A situation arose where **disposing of sewage safely** was **cost prohibitive**
- Massive **damage** to the **environment** and **human population**
- The report on the damage to the wetlands specifically argued there is a need for good **governance systems**, conducting **capacity studies**, documenting **biodiversity** in areas, a **holistic approach** in **conservation** and management of ecosystems, effective **judicial systems** and better **education** and information access for the public, encouraging local **community involvement**.

Source: The New Silk Roads

So … the problem(s) for us as environmentally concerned sanitation practitioners

1. There is an **urgent need** for toilets/sanitation where people **don't have them**. Impractical, unaffordable, unsustainable infrastructure required for flush toilet + sewer technology.

2. Adapting the current sanitation infrastructure to meet the demands of rapid urban migration and climate change. Current systems don't have the capacity to deal with contemporary issues and are not being regulated properly.

3. However, there is hope!

Even in crisis situations like Bangalore, **communities** can come together in the face of overwhelming odds to provide services whilst restoring and protect their own environment.

As part of **SDG #6**, safe sanitation is on the global development agenda.

So, how's it going across the AP region? … ☹

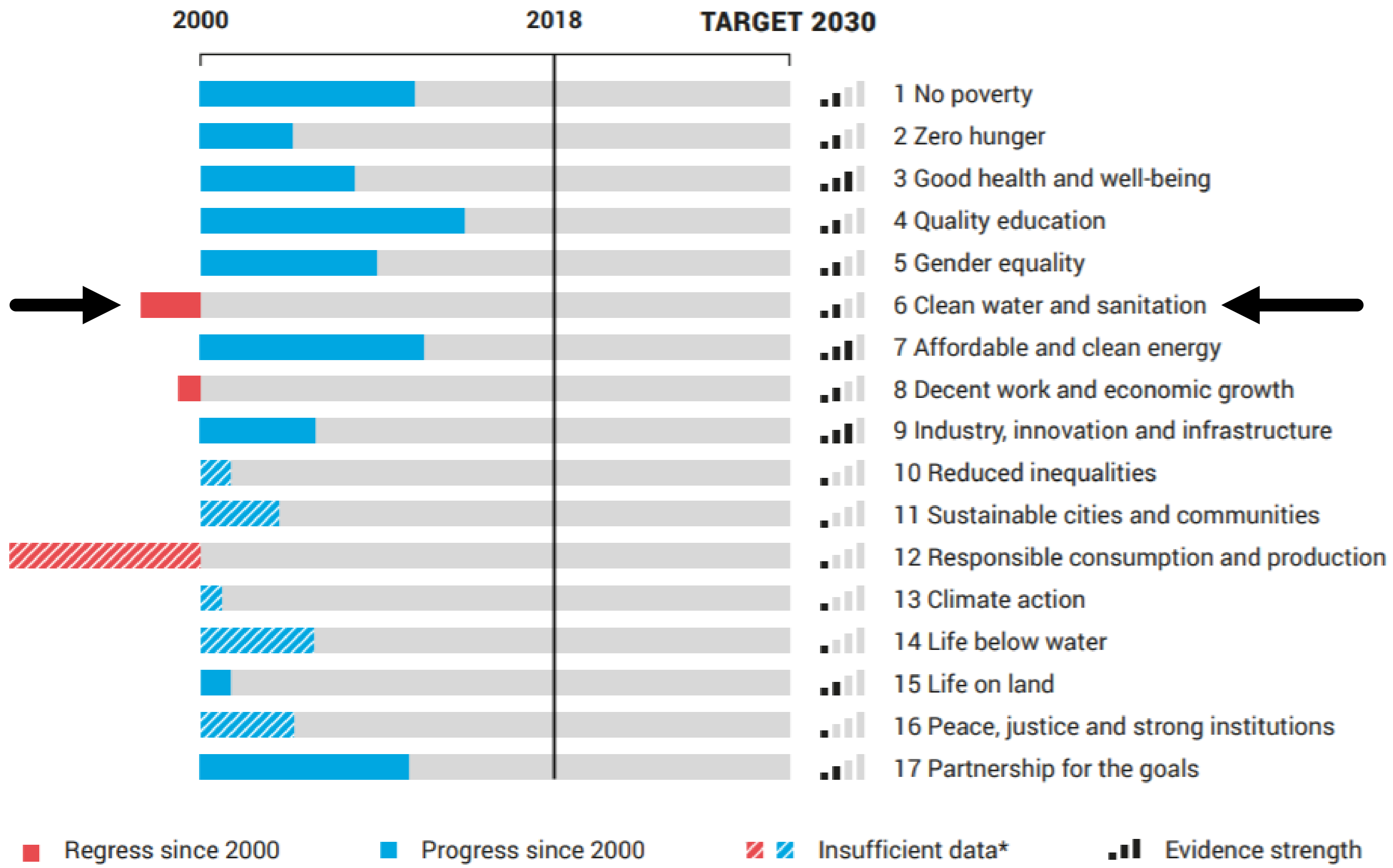


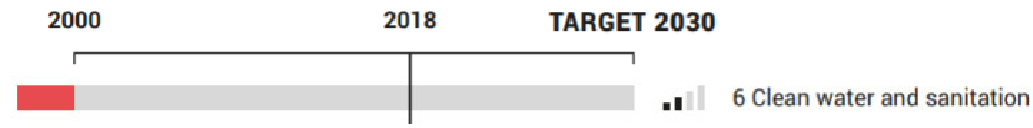
Figure 1 – Snapshot of SDG progress in 2018: Asia-Pacific region

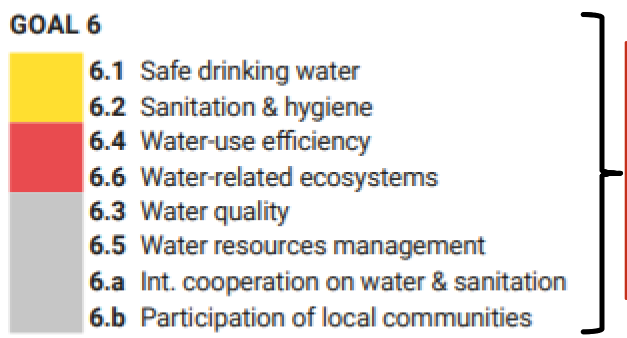
"The Asia-Pacific region will likely **miss all Goals by 2030** at the current pace of progress."

"Asia-Pacific's progress is going in **the wrong direction** for consumption, production, **water, sanitation**, decent work and economic growth."

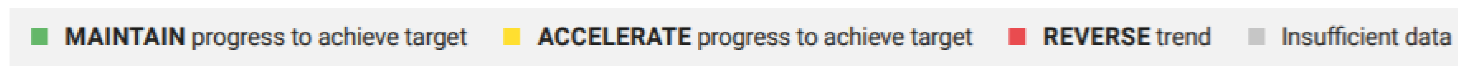
Source: Asia and the Pacific SDG Progress Report 2019, Part I: Asia-Pacific SDG progress

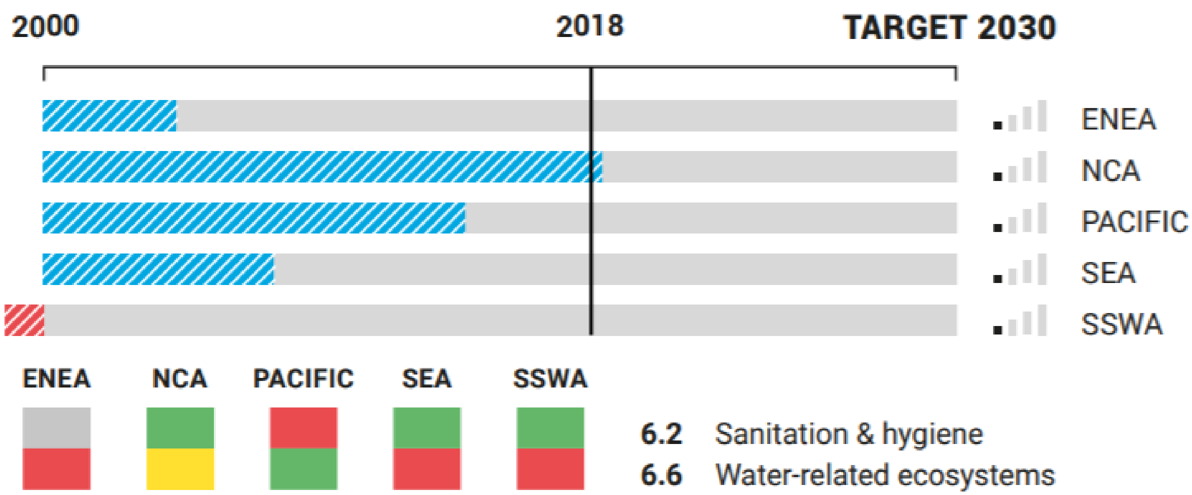
Not as bad as it seems?





This breakdown of the targets that constitute SDG 6 shows that actually **sanitation and hygiene are not the targets that are reversing the progress of this goal**, although they **must be accelerated** if the 2030 target is to be achieved



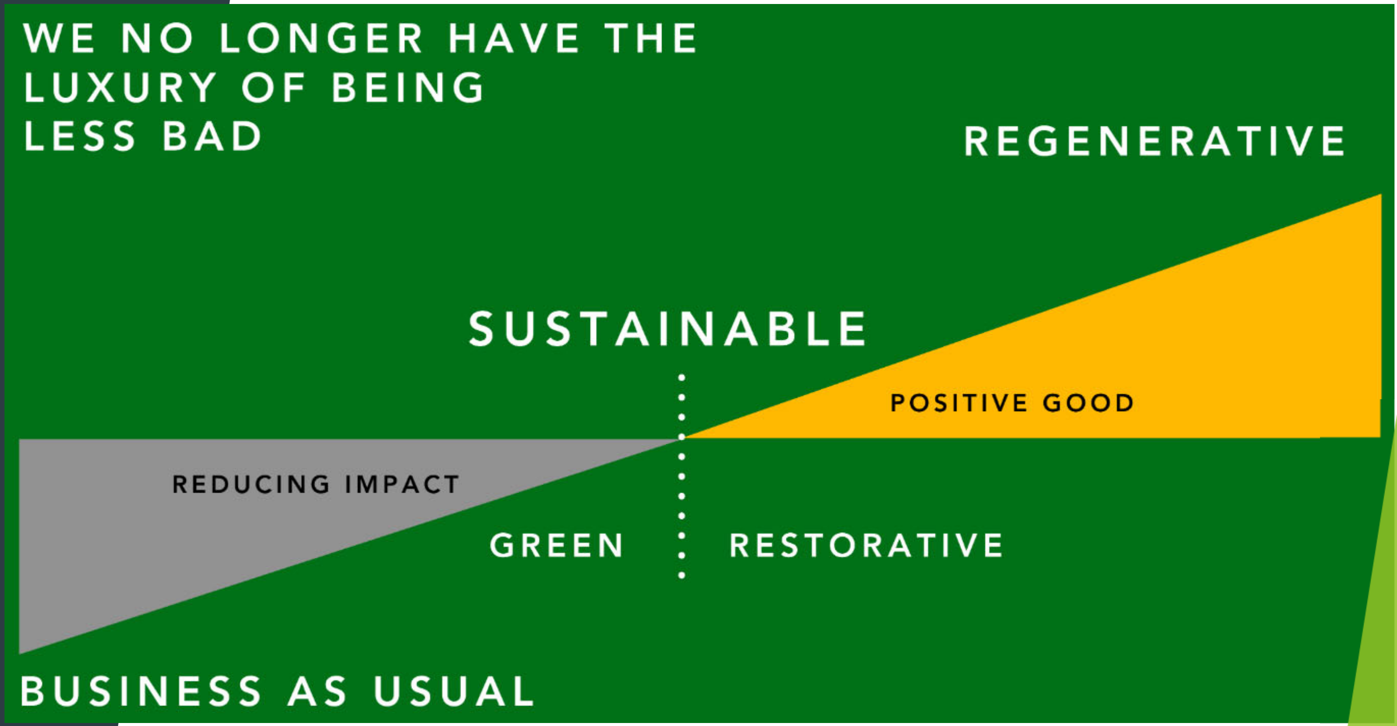


At the sub regional level, although data availability is limited, only South and South-West Asia has regressed overall whilst it has in fact **increased access to safely managed sanitation services** (measured by the practice of open defecation). The **Pacific region** however is showing a **reverse trend** in this area

Figure 16 – Goal 6 dashboard by subregion

How can we make progress in the *right* direction?

- I've tried to get across the extent to which **"business as usual"** in the world of sanitation, even where it is comparatively safe, still **has a substantial negative environmental impact** and **unsuitability** in much of the region
- Introducing or imposing inappropriate systems could potentially do more harm than good
- BAU (open defecation, pit latrines, flush toilet sewage and septic systems)
- Green (low water flush systems, adding biosolids back to arable land)
- Sustainable (?)
- Regenerative (?)
- Maybe we should revise our 19th century technology and our 19th century mindset? Particularly surrounding the idea of "waste"



Keep this graph in mind as we move forward to look at other technologies

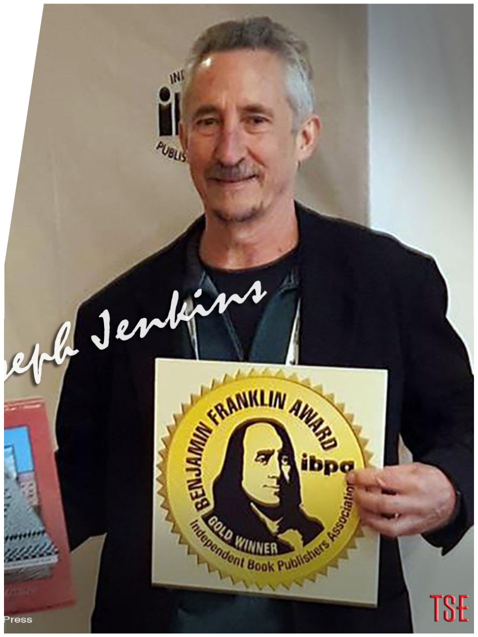
Image source: fairsnape.com

We've mostly looked at the **problems** so far, lets get **positive** and look at some **solutions**!!

The **flush toilet** was just **one piece of Victorian technology** that managed to **appeal** to the **sensibilities** of the age …

- An **alternative** piece of **contemporaneous technology** used **earth** rather than water as the **medium** in which to capture excreta in order to halt the cholera epidemics
- In **1859** a clergyman called **Henry Moule** developed the system on the left
- Looking similar to the cistern in a flush system, a **hopper** above the bucket contained the **earth** which was released with the handle after each use to **cover** ones excreta
- Moule also realised that once left to **decompose** in the earth for 3-4 weeks the excrement was odourless and an **excellent fertilizer** for root vegetables
- The **"earth closet" competed briefly** with the **"water closet"** for the **Victorian's loyalty** but the **upper classes** sided with the flush systems and that **set the trend** …

Source: Stephen Fry's Victorian Secrets

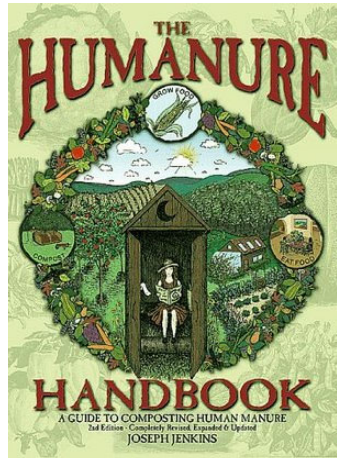


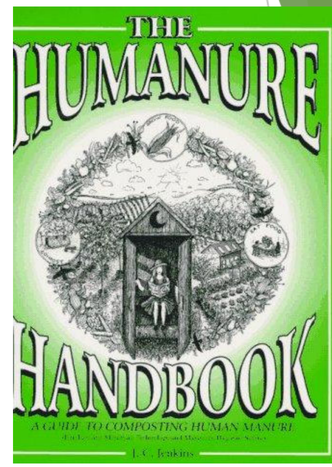
Loveable Loo EcoPotty

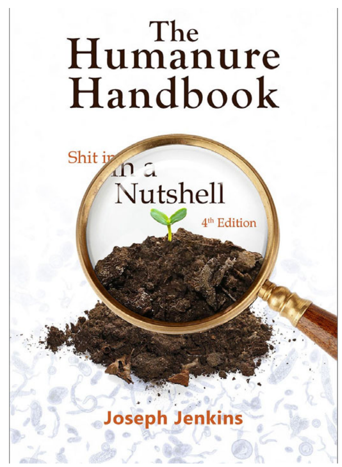
Joseph Jenkins, the modern-day Henry Moule?

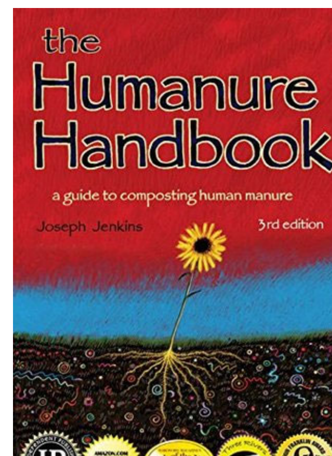
The Humanure Handbook

- Introduction and guide to **composting human-manure** (excreta … and any other biological material!)
- Particularly focused on **shifting** the readers **mindset** away from a flush toilet system
- Now on it’s **4^{th} edition**
- Began life as Joe’s **MSc Science in Sustainable Systems thesis** in the early 90s
- **Self-published** and it became a hit
- **Composting** is the answer for an environmentally friendly **sanitation chain**, alleviating the need for “water, plumbing, pipes, vents, drains, electricity, or urine separation”
- He takes the same **ancient ideas** (and those we saw more recently in Henry Moule’s system) and provides a **modern biological and ecological foundation** from which to advocate what is a very **mechanically simple system**









Lots **of resources** available (pdf of the book, instruction manuals, FAQs, YouTube instructional videos, social media feeds etc.) on: https://humanurehandbook.com/

A *new* understanding of "waste"?

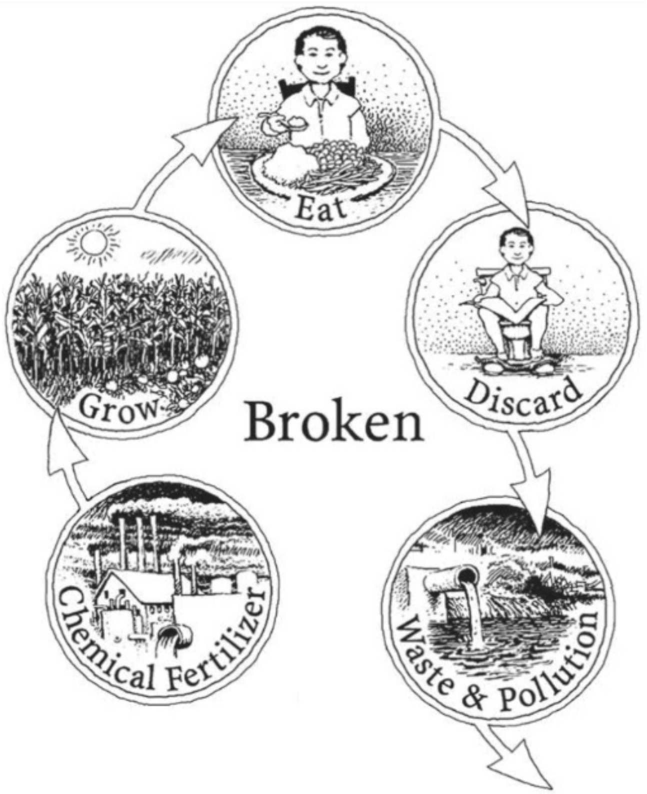
- *"Americans each year produce **3.63 billion pounds** of valuable **agricultural nutrients** just by **relieving themselves in a toilet**. Almost all of it is **discarded** into the **environment** as a **waste** material or a **pollutant**, or as Dr. King puts it, "poured **into the seas**, **lakes** or **rivers** and into the **underground waters**."*
- We must **recognize** our **dependence** on the **ecosystem** we call the **Earth** and try to "**harmonize**" with it, one way of doing this is by **eliminating organic *waste*** through **recycling**.
- The human **population** is constantly **increasing** whilst **available agricultural land** is **not**; it is **essential** therefore that **farming practices** leave us with land **more fertile** with each harvest
- **Not new**; many cultures have understood **human excrement** as a **natural resource** for **thousands of years**; "we [industrialised **West**] produced **waste and pollution**; they produced **soil nutrients** and **food**"

Source: Humanure Handbook 4th ed

The Human Nutrient Cycle

- The **modern sanitation chain** of flush toilet systems is built on a 19th Century **"waste"** mindset prevalent since the industrial revolution viewing **excreta** as a **toxic material** that must be **removed** from our environment
- However, human and animal excreta are natural, **organic** and **potentially beneficial products** of the digestive process that, through effective **recycling**, become **valuable agricultural resources**.
- Fundamental to sustainable agriculture is the **return** of **organic residues** to the **soil** from which crops are produced. Widely practiced with **animal manure** and the principles apply to humanure too.
- **Grow food** using **nutrients** from the **soil** → we **eat** and **digest it** → we **collect** and **process the organic residues** (**SANITATION**) → **return** the material back to the **soil**, enriching it and **allowing the cycle to continue indefinitely**
- If we **discard organic materials** as "waste" we **break** the human nutrient **cycle**, **depleting** the **nutrients** of our productive **soils**. This creates **unsustainable "extractive" systems** reliant on the **addition** of chemical fertilizers
- **Geoff Lawton** – "You are **never sustainable** … unless you are **creating more soil** than you are **using** to [grow] produce. You must be creating soil as you produce your food"

Source: The Humanure Handbook



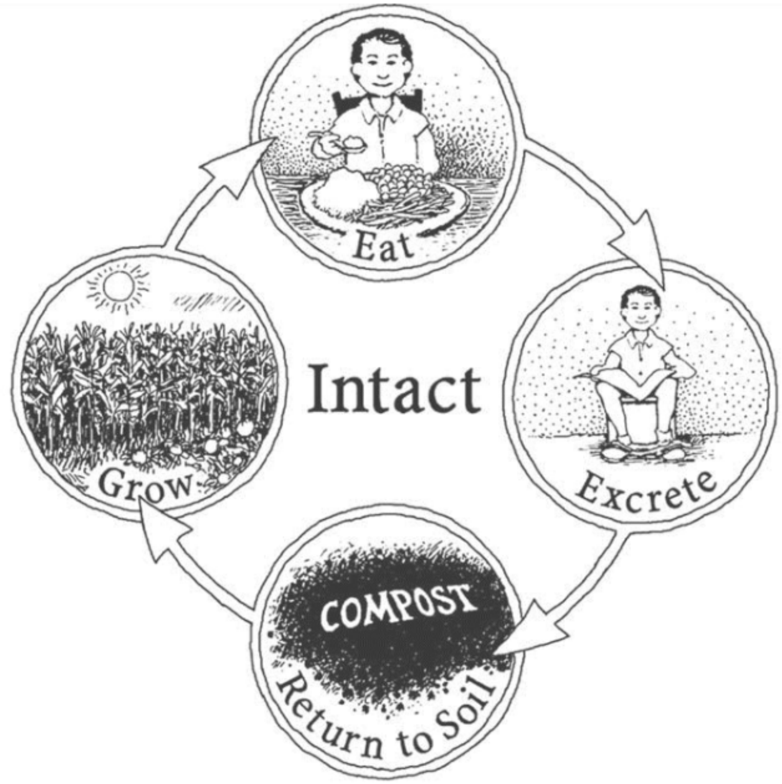
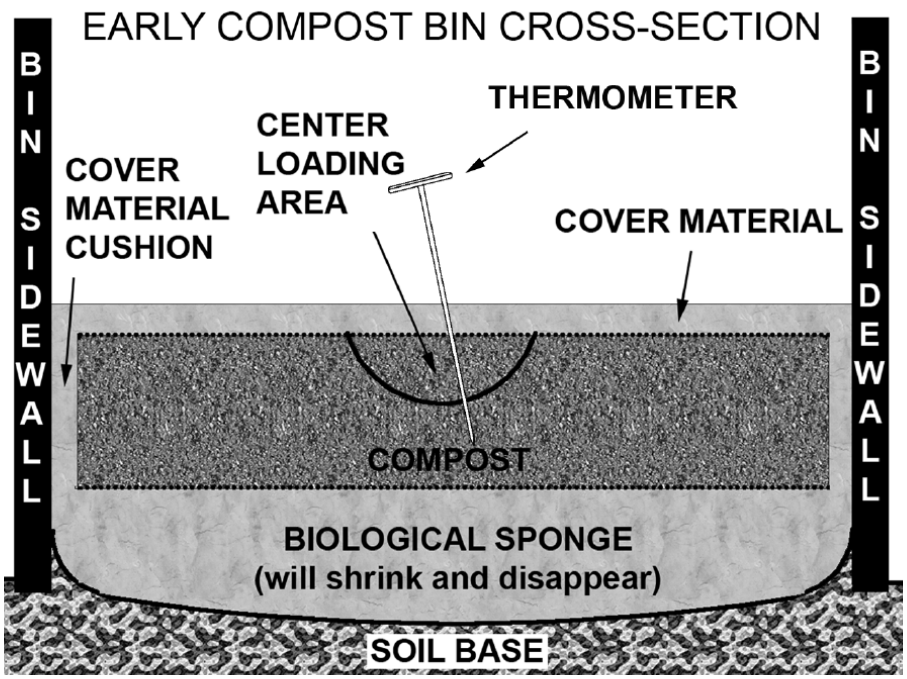
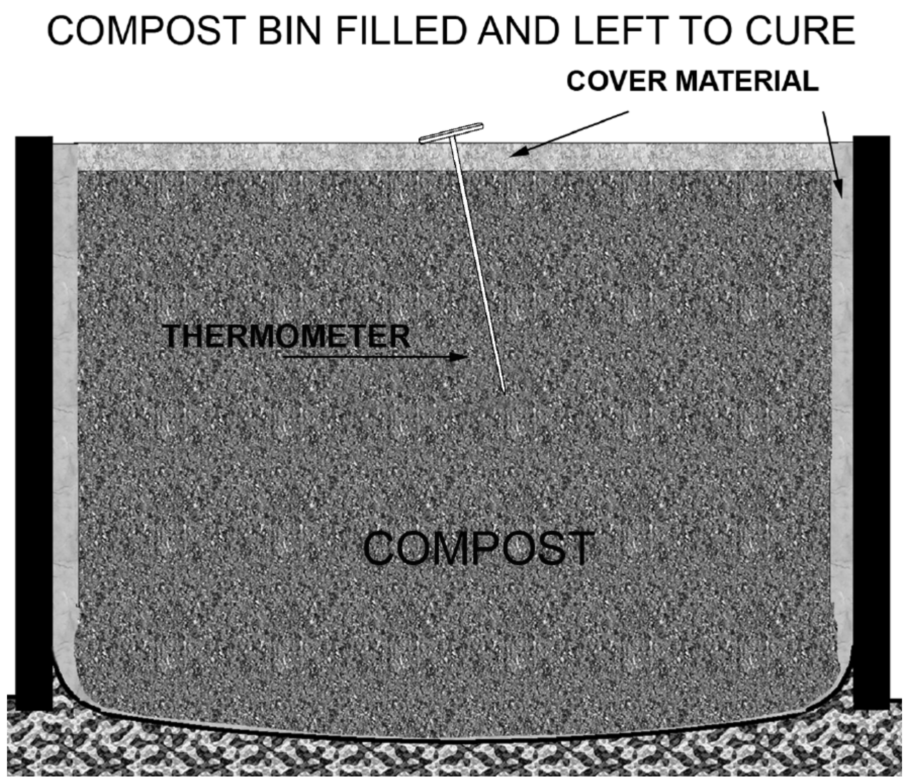


Image source: The Humanure Handbook 3rd edition

The sanitation chain

- All “**toilet material**” is captured with a moist carbon based “**cover material**” (added after each use) in an **appropriately sized** (portability, number of users, schedule) **receptacle** (above is a 20 litre bucket – capable of capturing ~1 weeks’ worth of material from an average adult).
- **Location** should be as private, comfortable as required and with adequate access for removal. When properly used, no odours are released so this can be beside for those with mobility issues.
- When full, containers can be **covered** and can be set aside or immediately emptied directly **into** the **centre** of a **compost bin**. They should then be cleaned and returned.
- Compost bins contain **all** the **organic material** from the **household** vertically **above ground** in a way that **animals can’t get into** them. They should be **sized** so that it takes **a year** to fill them. They should be **on soil** and **lined** with a “**biological sponge**” (any carbon based material) that like the **cover material** is added on top of each **deposited container**.





The materials for the **biological sponge** and cover material can be dry or moist and do not have to be fine particles unlike that inside the toilet. **Straw** is perfect, **hay** is good as are **grasses**, **weeds**, **leaves** etc.

Image source: The Humanure Handbook 4th edition

- Once **full**, **cover** the pile with the cover material and leave it completely **undisturbed** for **~1 year** (**9 months** in a **tropical climate**) to let it fully **age** and **cure**. **Immature compost** is **phytotoxic** (will kill plants) and so must be avoided.
- If unsure, **maturity** can be **tested** by **growing seeds** in a sample of the compost (pumpkin or cucumber work well) and by using a **thermometer** to make sure the **internal temperature** has returned to the **ambient temperature** outside of the pile.
- During this **retention time** the final **decomposition** of the **organic material** is taking place, a process often dominated by fungal organisms and larger organisms like earthworms. This environment is alien for **human disease causing organisms** and as a result such pathogens are **killed** during the composting process. Finished compost is **not "sterile"** but is **sanitary**; it should be teeming with **beneficial microorganisms** that **don't pose a threat** to **human health**.
- Looking and smelling like rich, dark, moist **garden soil**, the **finished compost** can be used **on top** of the soil like a **mulch** or **dug into the soil** for better root access. It can also be **buried in holes** where trees and shrubs are to be **planted**.

Source: Humanure Compost Toilet System Condensed Instruction Manual

The “*Contained*” Composting Process

- **Compost** is comprised of **piled organic materials.**
- By definition it has **three components**; **human management**, the **generation** of **internal biological heat**, and the **presence of oxygen** for the organisms that proliferate inside it.
- Once piled, **ever present aerobic microbes** within the organic materials start to **consume them**, **generating internal biological heat** until everything has been **converted** into **compost.**
- Unlike vermicomposting, this **thermophilic composting** process has the advantage that the **high temperatures kill** the **organisms** that **cause human diseases** which are adapted to live at **human body temperature**; **compost** that stays at **50°C** for **24 hours** will be safe to use to **grow food.**

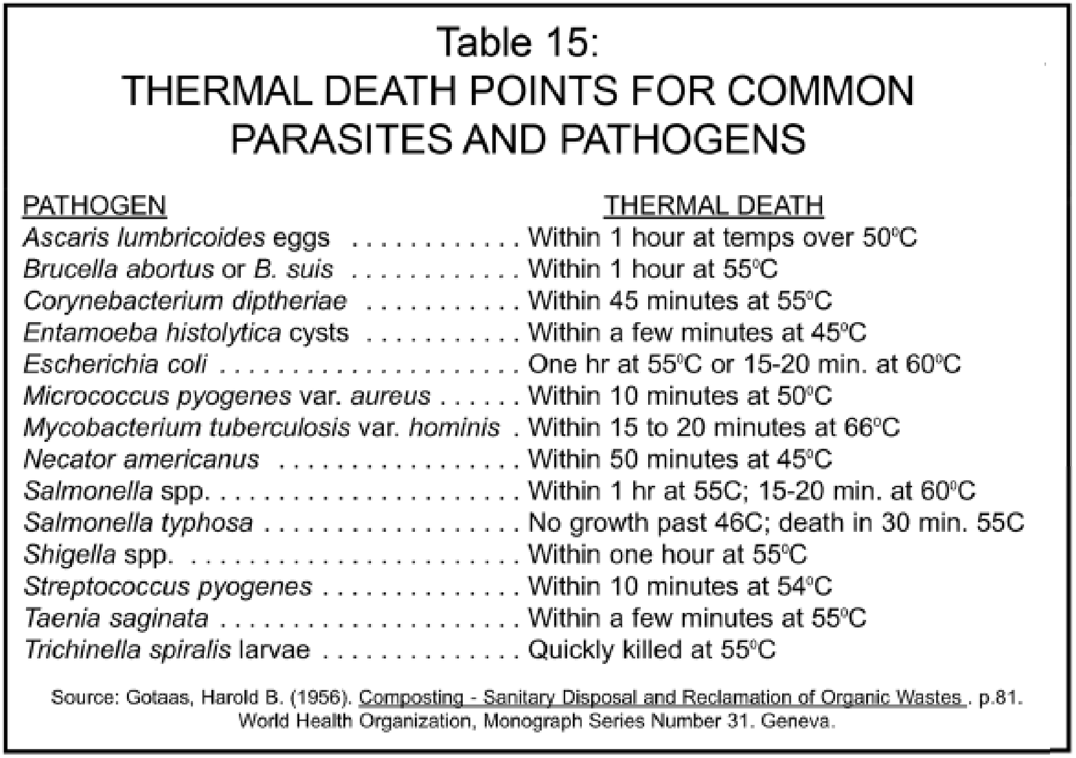


Table 15:
THERMAL DEATH POINTS FOR COMMON PARASITES AND PATHOGENS

PATHOGEN	THERMAL DEATH
Ascaris lumbricoides eggs	Within 1 hour at temps over 50°C
Brucella abortus or *B. suis*	Within 1 hour at 55°C
Corynebacterium diptheriae	Within 45 minutes at 55°C
Entamoeba histolytica cysts	Within a few minutes at 45°C
Escherichia coli	One hr at 55°C or 15-20 min. at 60°C
Micrococcus pyogenes var. *aureus*	Within 10 minutes at 50°C
Mycobacterium tuberculosis var. *hominis*	Within 15 to 20 minutes at 66°C
Necator americanus	Within 50 minutes at 45°C
Salmonella spp.	Within 1 hr at 55C; 15-20 min. at 60°C
Salmonella typhosa	No growth past 46C; death in 30 min. 55C
Shigella spp.	Within one hour at 55°C
Streptococcus pyogenes	Within 10 minutes at 54°C
Taenia saginata	Within a few minutes at 55°C
Trichinella spiralis larvae	Quickly killed at 55°C

Source: Gotaas, Harold B. (1956). Composting - Sanitary Disposal and Reclamation of Organic Wastes, p.81. World Health Organization, Monograph Series Number 31. Geneva.

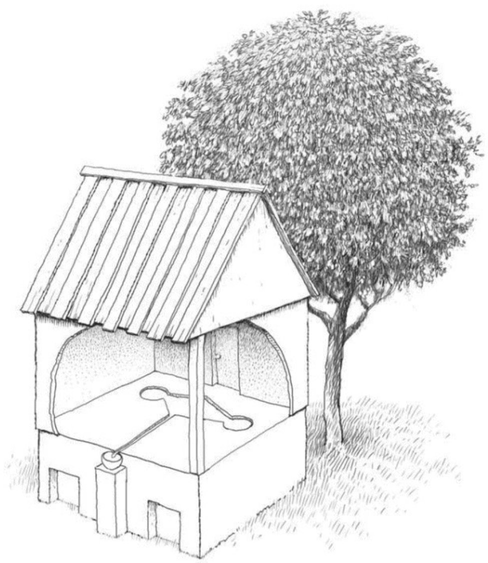
Source: The Humanure Handbook

- “**Composting** is a **science** *and* an **art**” – the goal is **to recycle organic material** in an **odour-free**, **nuisance-free**, **environmentally safe** and **hygienically effective** manner, this always requires some **management**.
- Combined with a toilet system it is simple but requires **management** (emptying and cleaning receptacles, supplying cover materials, managing the compost pile) – it is recommended that **the manager** of the system is a **stakeholder** in the quality of the **compost**.
- Under the “***contained compost***” methodology previously outlined the compost is **never** left in an **open**, exposed pile; rather it is always collected in bins and always.
- Proper **cover materials** in adequate **quantities** are essential to the process for the toilet and bin, providing a **biofilter** against **odour** and **flies**. They should have a basic **carbon content**/plant cellulose material (will burn when dry), **fine** enough **texture** for **bacteria** to deal with them and can be **damp** but not wet. Examples are **sugarcane bagasse**, **sawdust** and **rice husk** or hulls.
- This **prevents odour**, the **accumulation of insects** and removes the **need to stir or turn**. It **maximises volume** to **surface ratios**, **maximising** the **internal heat** of the pile and subjecting all **areas** to the **raised internal temperatures**.

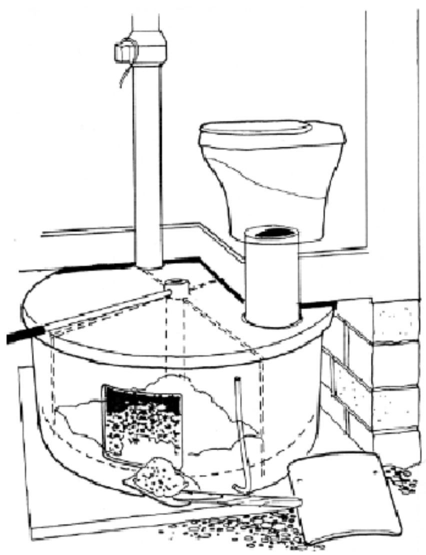
Source: The Humanure Handbook

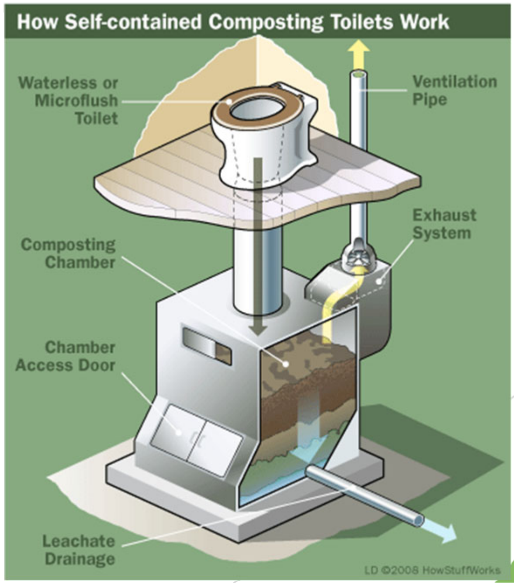
Variations on the compost toilet system

- Many people will **not use** a compost toilet if they have to do anything **related to the contents**.
- As a result, many homemade and commercial composting toilets **integrate composting chambers** into the system allowing the **organic material** to **be directly deposited** without the need for transportation or handling until the composting process has been finished.
- Without **"centre-feeding"** the pile the contents will compost at a **lower temperature** but **research suggests** a few months retention in **just about any composting toilet** will result in the **deaths** of nearly all **human pathogens**

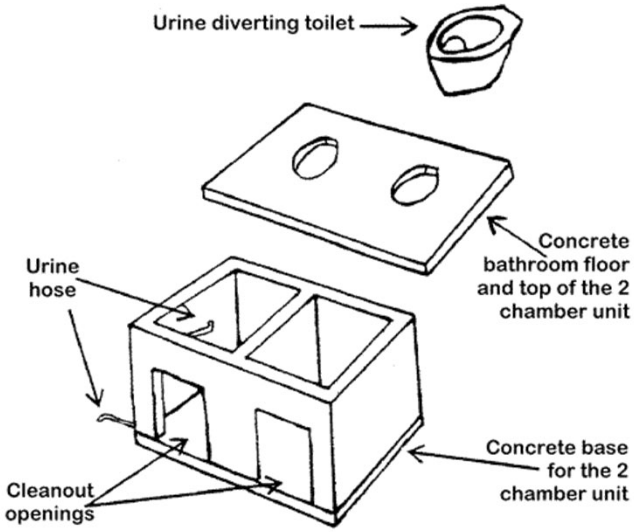


Vietnamese Double Vault





Source: The Humanure Handbook



- **Urine diversion** ("dry toilets") is also a common variation, **dehydrating** the organic matter to **reduce** size and weight whilst also **reducing nitrogen** and **odour** of the collected material. A raw **urine/faeces blend** may be **too high in nitrogen** to allow for effective **composting** meaning the collected material **remains wet** and **becomes odorous**.
- However, this can be **addressed** by simply **adding** more **carbon cover material** (such as sawdust) to dilute the mix rather than removing urine.
- It should be noted that those designs which **dehydrate** the organic material rob the organic mass of **moisture** and **heat** and therefore **discourage thermophilic composting.** Even **passive**, **low temperature composting** will eventually yield a relatively **pathogen-free compost** after a period of time

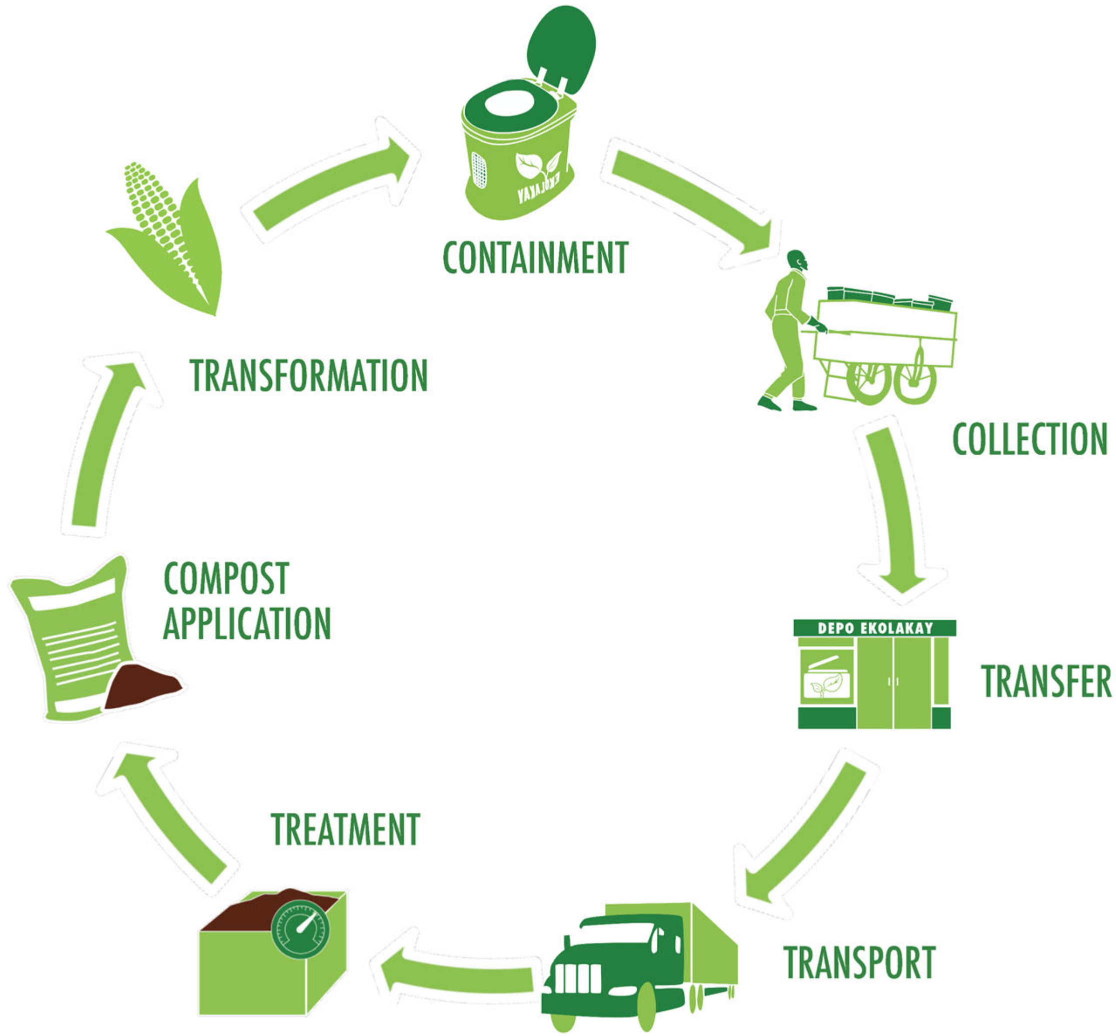
Source: The Humanure Handbook

Case Study: SOIL, Haiti

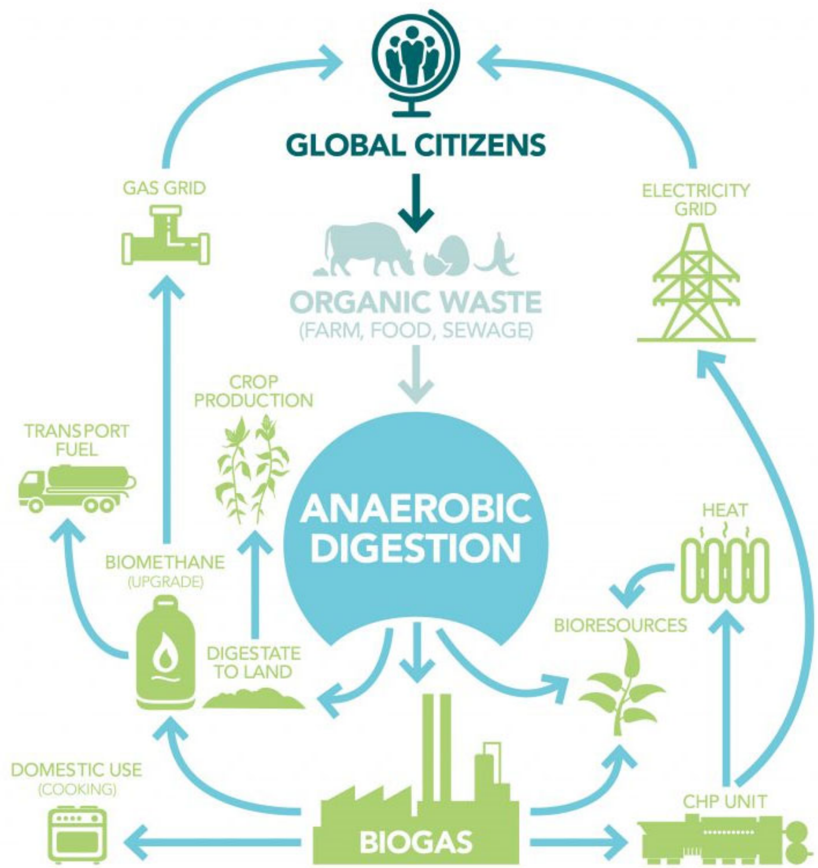
- In **Haiti**, **only 30%** of the population has **access** to **improved sanitation** and **less than 1%** of **wastes** are **safely treated**, which has fuelled one of the largest **cholera epidemics** in recent global history.
- Aquatic ecosystems are becoming increasingly **polluted** by **human waste**, soil **nutrients** are rapidly **declining** due to **erosion** and **intensive agricultural** practices, leading to a **loss** of **biodiversity**, **vulnerability** to **climate-related risks**, **reduced** agricultural **production**, **poverty**, and **malnutrition**.
- *"SOIL are a non-profit R&D organization working in Haiti to implement sustainable and cost effective solutions to the sanitation crisis"*

Source: SOIL, OurSoil.org

- **SOIL** is using the **compost toilet** to turn the **sanitation chain** into a **sanitation circle**
- **Toilets** are **provided** and “waste” is then **collected** by SOIL who **compost it** and **sell it**, using the **proceeds** to **support agriculture**, **reforestation** and other **climate change mitigation** efforts in Haiti.
- It is interesting in it’s efforts to **centralise** the **treatment stage** of the sanitation chain to and apply it in an **urban context**.
- **6,500 people** now have access toilets through SOIL’s growing **urban sanitation service**
- **510 tons** of waste **transformed** into **agricultural grade compost** last year



Source: SOIL



Sources: World Biogas Association, American Biogas Council

Excreta and energy production?

- **Thermophilic composting** turns potentially harmful **organic materials** into **nutrient rich**, agriculturally **valuable compost.**
- However, an **additional** way in which human excreta can be **recycled** into a **valuable resource** occurs under **anaerobic** conditions when broken down by **methanogenic bacteria cultures** to **produce biogas.**
- Like composting, it is a **natural process**, turns a "waste" material into a **resource**, is well suited to **rural infrastructure** and can be used to **diversify rural income streams** and can even operate in **conjunction** with **composting operations.**
- As an **energy source** biogas is an already **established fuel** used to produce **heat**, **electricity**, combined **heat and power**, **pipeline quality biomethane** and **transportation fuel.**
- Compared to other sources of renewable energy it is **not intermittent.**
- Compared to fossil fuels it **burns cleaner** and the **distributed** nature of its **generation** means **lower transmission/transportation costs**, higher **reliability** and **less price fluctuation**

Sanitation chain of a biogas system

- **Organic material** is **captured** and **delivered** to the **biodigester system** (as with compost, this could be a diverse range of materials or a self contained system built for one)
- Material is **broken down** in the digester using a natural biological process under controlled conditions (**airtight tank** in which **naturally occurring microorganisms** digest the organic matter, continually **producing biogas** and **digestate** according to the supply)
- **Digested material** is **processed**; solid and liquid digestate is high in nitrogen, phosphorus, potassium and organic carbon and can therefore be easily processed into **fertilizer**, **compost** or **soil amendments** as required
- Simultaneously, the **raw biogas** is **processed**; **typically water**, **carbon dioxide** and other **trace compounds** are removed leaving mostly **methane** (the level of processing varies depending on the end use)
- The processed digestate and biogas can then be distributed and **used as intended** (nutrients returned to the land and gas burned for energy), domestically or commercially depending on the scale

Some further considerations

- **Digestate** is **not** completely **safe**! Similar to a **septic tank**, the anaerobic digestion process creates an environment where the population of **pathogens** are out competed by non-infectious microorganisms, **reducing** but not entirely eliminating them
- A number of **pre**, **synchronous** and **post treatment methods** to complete the **removal of pathogens** have been developed including **pasteurization** to 70˚C (usually done as early as possible and can be done using waste steam, passive solar heating, or direct combustion of biogas), **extended retention** (very long retention times have been shown to destroy virtually all pathogens; 90 days in hot climates, 150+ in cold), and familiar **tertiary treatments** – **UV**, **wetlands** and **composting**
- As with thermophilic composting, **temperature is important** to the speed and efficiency of digestion. **Methanogens** are **mesophilic** meaning ~**36˚C is optimal** (consider climate)
- Various **different designs** for toilets to **capture the biological material** have been devised, some **waterless**, some **water saving**, some in a **closed loop system** (see ECOSTP)
- A **methanogenic inoculum** (small amount of methane producing microorganisms taken from a pure culture to start a new culture) is **necessary** to initially 'activate' or 'seed' the biodigester and **start producing biogas**, this can come naturally from animal manure in the form of slurry or diluted manure or from the anaerobic sediment of a water body.
- Once **activated**, the **biodigester** should start **producing biogas** almost **immediately** although the **quantity** and **quality** depends on several factors including the **waste**, type and quantity of **inoculum**, **climatic conditions** and characteristics of the **digester** (size, mixing etc.). Some systems claim biogas **production** as soon as **7-10 days**
- This is a technology that does **better at scale**, both **economically** in terms of the initial cost of construction/technology (more expensive than a 20 litre bucket and toilet seat!), maintenance (minimal but necessary), and **biologically** (domestically worthwhile for fuel with 50 kg of manure per day, ~3 cows, several households etc.)
- It therefore lends itself to **community projects** or densely populated areas. It would be particularly **environmentally beneficial** in a setting where the biogas could **offset firewood** as a fuel source, thereby producing **less GHGs** in combustion and mitigating the rate of **deforestation**

Sources: Researchgate, Appropedia

Case Study: Cyangugu Central Prison, Rwanda

- Following the war and genocide in 1994 prisons across the country became **severely overcrowded** (over five times the planned population)
- This created an **unsustainable** use of **firewood** for cooking and rendered **the sanitation facilities inoperative** to the point of serious **health risks** to the prisoners and general public through **air pollution** + **contaminated soil** and **water**
- Between 2001 and 2002 the KIST (Kigali Institute of Science, Technology and Management) set up a pilot **biogas project**, successfully **addressing** the problems of **sanitation**, **fuel**, and **manure** for **food crops** and **woodlots**
- By treating **toilet material** from the **entire prison**, **275 m^3 of biogas** was generated daily, **halving** the demand for **firewood**, creating enough **bio digestate** to be safely **applied across the farm** and **ending** the use of **open buckets** for toilets

Source: Energypedia

Implementation strategies

- **Technical solutions** are purely **academic** without appropriate **implementation** within the community/household
- Across the world of development, studies have shown the **importance** of **user participation** and **agency** – it's the same in the world of emergency shelter, affordable housing etc. **Community agency** must be **prioritised**!
- **Key factors** during **implementation** identified as influencing the **long term sustainability** of **WASH projects** are; **community participation**, **management**, **ownership**, **operation** and **maintenance**
- Communities should be **consulted** to **assess** the **demand** for a new sanitation system → a range of feasible **options** should be **presented** → basic **willingness to pay** survey including initial and O&M costs → **preferred technology** can be matched with **affordability** to select a system → **management system** established (community only, community/private mix etc.) → **action plan** (time frame, activities, key participants etc.)
- Follow up surveys?

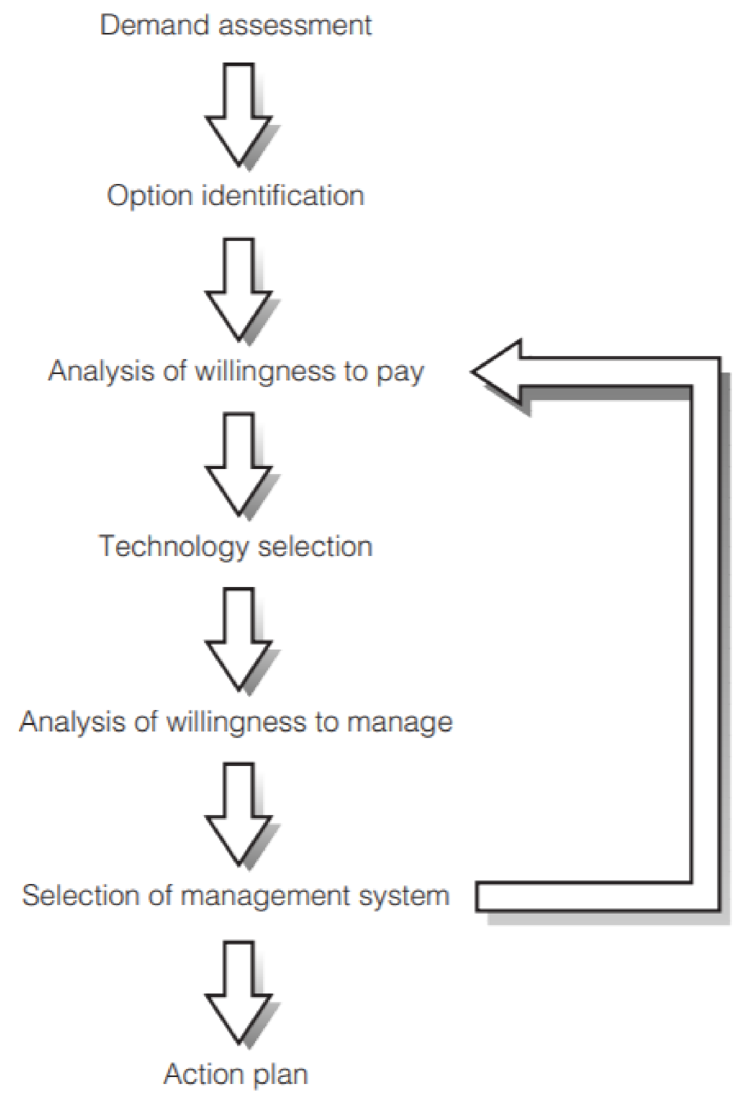
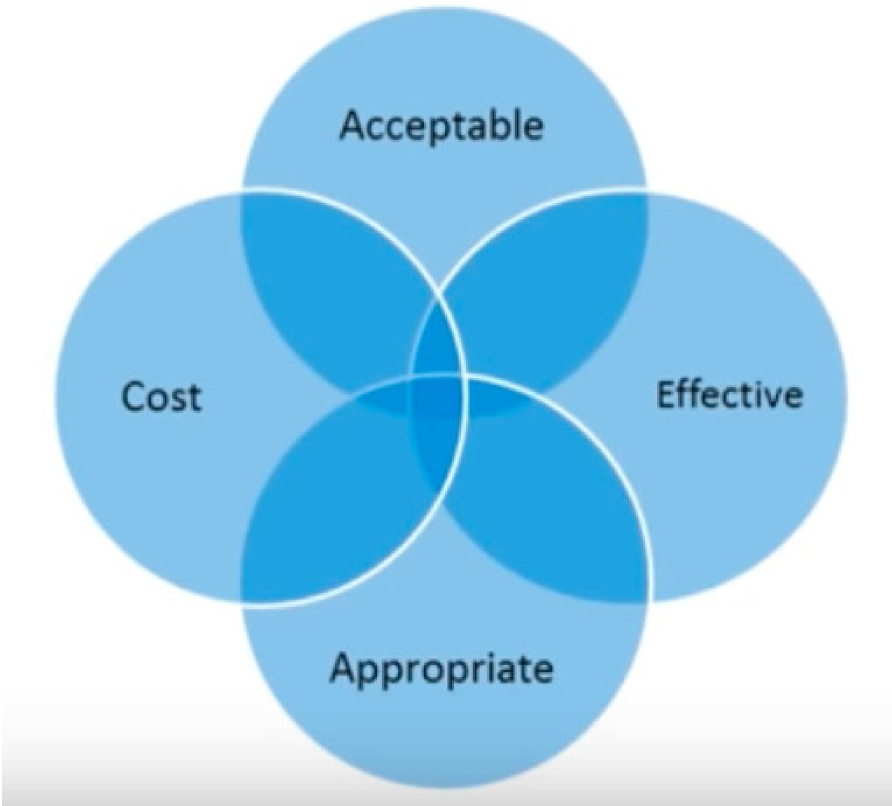


Figure 4.2. Social steps towards sustainability

Source: Harvey and Reed (2004) Rural Water Supply in Africa

As practitioners working *WITH* communities how can we best design/select an ecological sanitation system?

- **CAWST criteria** for housing water treatment system, I think just as **applicable** for **sanitation systems**:
- **Appropriateness** – how well does the technology fit into people's daily lives? Local availability of materials and expertise, time/schedules of users, operation and maintenance, lifespan, scale, usefulness of produce
- **Efficacy** – how well does the technology perform? Safe and usable in this context, if the system requires ongoing management can this be guaranteed?
- **Cost** – What are the costs for the user and object? Initial, operational, end of life costs, future proofing – will it still be cost effective in 5-10 years (growing population/brain drain)
- **Acceptability** – what will people think of the technology? A familiarity with local culture, religion and attitudes towards sanitation, ease of use, privacy, safety, odour, appearance, cultural and social considerations, reputation, desirability, marketability



Source: Centre for Affordable Water and Sanitation Technology

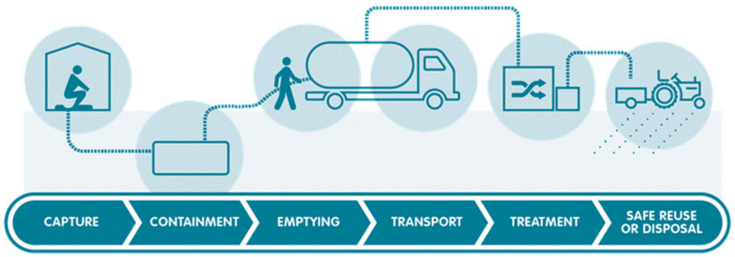
Case Study; CVBT (Deborah + Geoffrey) in China

- Urine diverting DCT design the "Vietnamese Double Vault" shown earlier but using our own ICEBs
- Geoffrey built several at his home and at the Center
- Existing sanitation situation = no sanitation chain – segregated but open sludge
- On a visit with EWB family expressed their own need for a new toilet
- Users were interviewed first, design was formulated including gender segregation
- Constructed and finished by end users with help from local community
- Follow-up interviews showed a pride in acquired skills as well as an affinity with the new technology

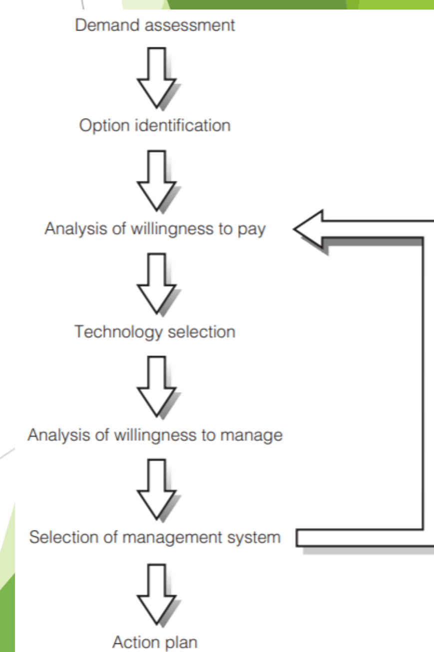
Wider considerations

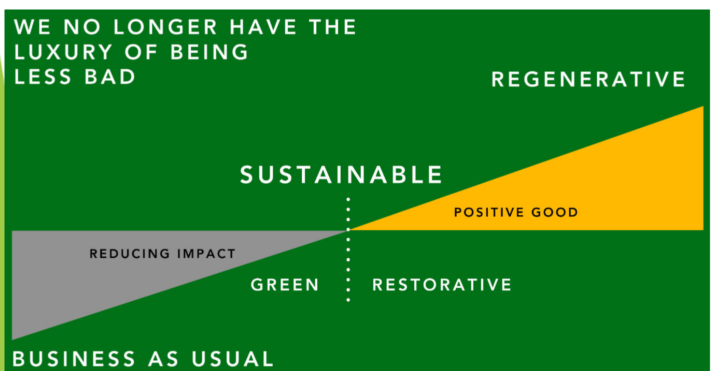
- In addition to these methods of implementation there are **wider considerations** regarding ecological sanitation technology
- Although there are good reasons for **targeting interventions** where there are already sanitation crises, we shouldn't **"ghettoise"** this technology, by **voluntarily adopting** it over less sustainable technology we **prevent stigmatisation**, **promote environmental causes** and awareness, **provide proof of concept** and **receive the benefits**!
- Beyond this there is a case to be made for **targeting 'low hanging fruit'** (maximum impact, minimum expenditure) but it is **important** that we **recognise** these **opportunities** in **MEDCs** and **LEDCs alike**, consider the pictures on the left
- Lastly, what is the **future of ecological sanitation**? Are we still **waiting** for the **magic bullet**, a **technology** so affordable, widely applicable and environmentally friendly that it will solve the current crisis (see **Bill Gates** and his **megabucks**)? Or does the **technology already exist** and it's a case of facilitating **widespread adoption**???

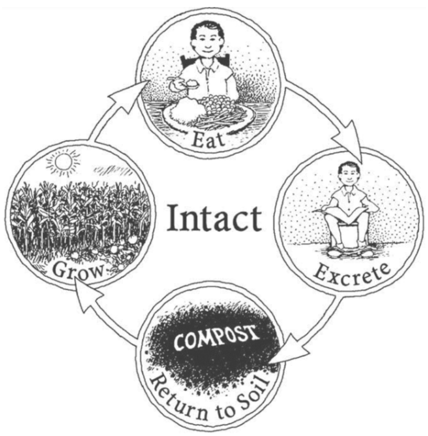
Summary

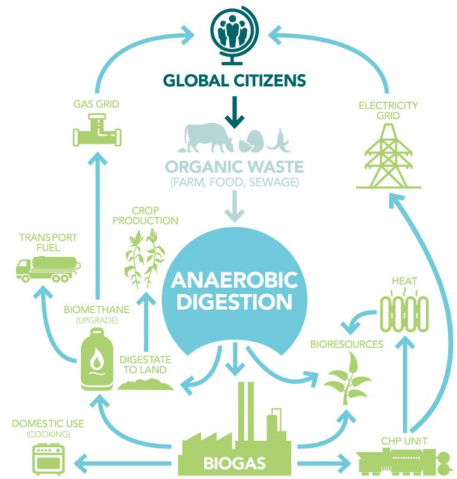

CAPTURE
CONTAINMENT
EMPTYING
TRANSPORT
TREATMENT
SAFE REUSE OR DISPOSAL


6
CLEAN WATER AND SANITATION


Demand assessment
Option identification
Analysis of willingness to pay
Technology selection
Analysis of willingness to manage
Selection of management system
Action plan


WE NO LONGER HAVE THE LUXURY OF BEING LESS BAD
REGENERATIVE
SUSTAINABLE
POSITIVE GOOD
REDUCING IMPACT
GREEN
RESTORATIVE
BUSINESS AS USUAL


Eat
Intact
Excrete
Grow
COMPOST
Return to Soil


GLOBAL CITIZENS
GAS GRID
ELECTRICITY GRID
ORGANIC WASTE
(FARM, FOOD, SEWAGE)
TRANSPORT FUEL
CROP PRODUCTION
ANAEROBIC DIGESTION
HEAT
BIOMETHANE
(UPGRADE)
DIGESTATE TO LAND
BIORESOURCES
DOMESTIC USE
(COOKING)
CHP UNIT
BIOGAS

Resources

- **CAWST** (Centre for Affordable Water and Sanitation Technology): provides resources to develop the capacity of practitioners (field workers, community members), education and training, consultation and support etc. resources.cawst.org
- Please see the **Humanure Handbook** for a ton more information on everything from the biology of **composting** to the **human microbiome**, 4th edition is heavily revised so worth a read even if you've read previous editions!
- **Google** all the case studies for loads more detail and information:
- **Bangalore** water restoration, **SOIL Haiti**, **Cyangugu Prison** and **ECO STP** etc. etc. etc.
- See individual slides for further references

Scalability?

Examples in your own work?

Questions/additions/discussions?

Issues?

Implementation?

Variations on these technologies?

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