INTEGRATED WASTEWATER AND SEPTAGE MANAGEMENT

Training of Trainers (ToT) Module

SCBP
Sanitation Capacity Building Platform

Part B: Presentation Slide

ECOSAN SERVICES FOUNDATION

NIUA
National Institute of Urban Affairs

INTEGRATED WASTEWATER AND SEPTAGE MANAGEMENT

Presentation Slides

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Sustainable Sanitation and Water Management Tool Box

CONTACT

CONTENTS

Integrated Wastewater and Septage Management (IWSM)

An Advanced Training Module

AGENDA

Time duration	Session Title
Day 1: Sustainable Sanitation and Water Management, Designing of Sanitation Systems	
9.30 am-10.00 am	Registration
10.00 am-10.45 am	Introduction, setting ground rules! Understanding expectations, aims and objectives.
10.45 am-11.00 am	*Coffee Break*
11.00 am –11.45 am	Water and Sanitation
11.45 am – 1.00 pm	Sustainable Sanitation and Water Management (SSWM)
1.00 pm - 2.00 pm	Lunch
2.00 pm- 3.15 pm	SSWM Group work: Define boundaries, identify sanitation components of your system/city
3.15 pm- 3.30 pm	Coffee Break
3.30 pm- 4.30 pm	Designing of Sanitation System

Time duration	Session Title
Day 2: Sanitation Systems and Technologies, Wastewater Treatment Technologies, Non-Technical Aspects	
10.00 am - 11.00 am	Sanitation Systems and Technologies
11.00 am - 11.15 am	Coffee Break
11.15 am - 12.30 pm	Wastewater Treatment Technologies
12.30 pm – 13.00 pm	Group Work: Conceptualising Wastewater Treatment Systems
1.00 pm - 2.00 pm	Lunch
2.00 pm – 3.15 pm	Non-Technical Aspects
3.15 pm - 3.30 pm	Coffee Break
3.30 pm – 16.30 pm	Group Work: Stakeholders Analysis

Time duration	Session Title
Day 3: Need of Faecal Sludge and Septage Management, Planning Process of FSSM, Financing of FSSM Planning Process,	
10.00 am -10.45 am	Need of Faecal Sludge and Septage Management
10.45 am -11.00 pm	Coffee Break
11.00 am- 12.15 pm	Faecal Sludge and Septage Management (FSSM) Planning Process
12.15 pm- 1.00 pm	Financing of Faecal Sludge and Septage Management (FSSM)
1.00 pm- 2.00 pm	Lunch
2.00 pm- 3.00 pm	Group Work: FSSM Planning Process
3.00 pm- 3.15 pm	Coffee Break
3.15 pm- 3.45 pm	Wrap-up and Feedback Session

Module

1 WATER AND SANITATION

Contents

- Introduction to environmental health
- Water supply and environmental sanitation
- Resource and waste streams
- Urban challenges

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1.1.1 Introduction to Environmental Health

Definition

- Field of science that studies how the environment influences human health and disease.
- Environment in this context is;
  - air, water and soil
  - the physical, chemical, biological and social features of our surroundings.

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Environmental Health is the field of science that studies how the environment influences human health and disease. "Environment," in this context, means things in the natural environment like air, water and soil, and also all the physical, chemical, biological and social features of our surroundings.

Good health presupposes that the water we drink, the air we breathe and the food we eat are free from contaminants and pathogens, and that facilities, services and hygienic behaviour provide for a clean environment in which to live, with measures to break the cycle of disease and contamination. Health is best protected by safeguarding the environment by pollution prevention and provision of an environmental service to each household or community.
Individual health benefits from enough clean and safe drinking water. This can be attained by clean water sources or reliable water treatment. Community health can only be reached if waste is collected, recycled, treated or disposed of in a sanitary manner.

Environmental health

To achieve the objectives one must;

- Maintain a natural environment free from undue hazards
- Ensure a built environment free from undue hazards
- Provide essential environmental services to households and communities

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Anyone changing the natural or built environment has an impact on environmental health. To achieve good environmental health, one should

- maintain a natural environment free from undue hazards,
- ensure a built environment free from undue hazards
- Provide essential environmental services to households and communities in order to achieve good individual and community health.

Natural and built environment

Source: Sandec Training Tool

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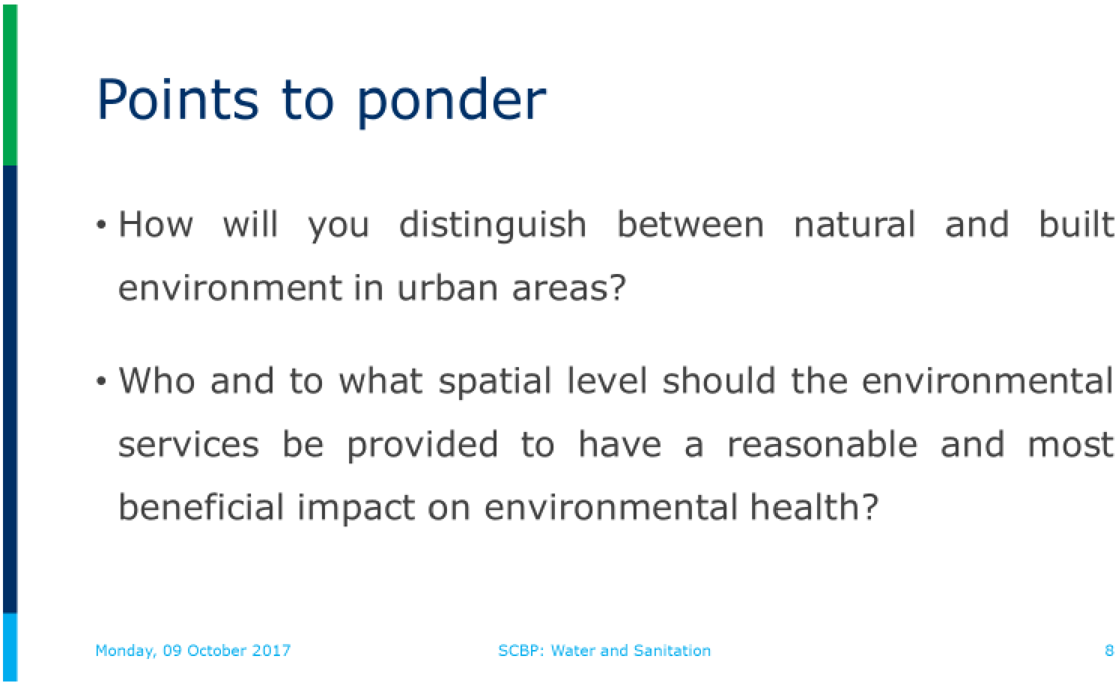
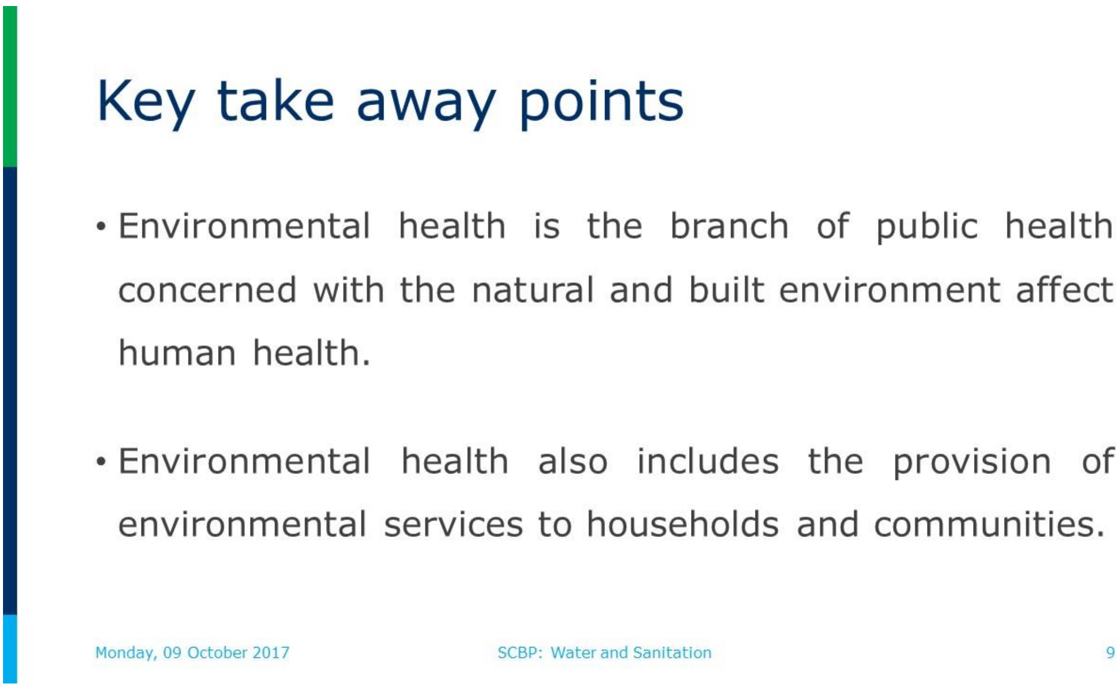
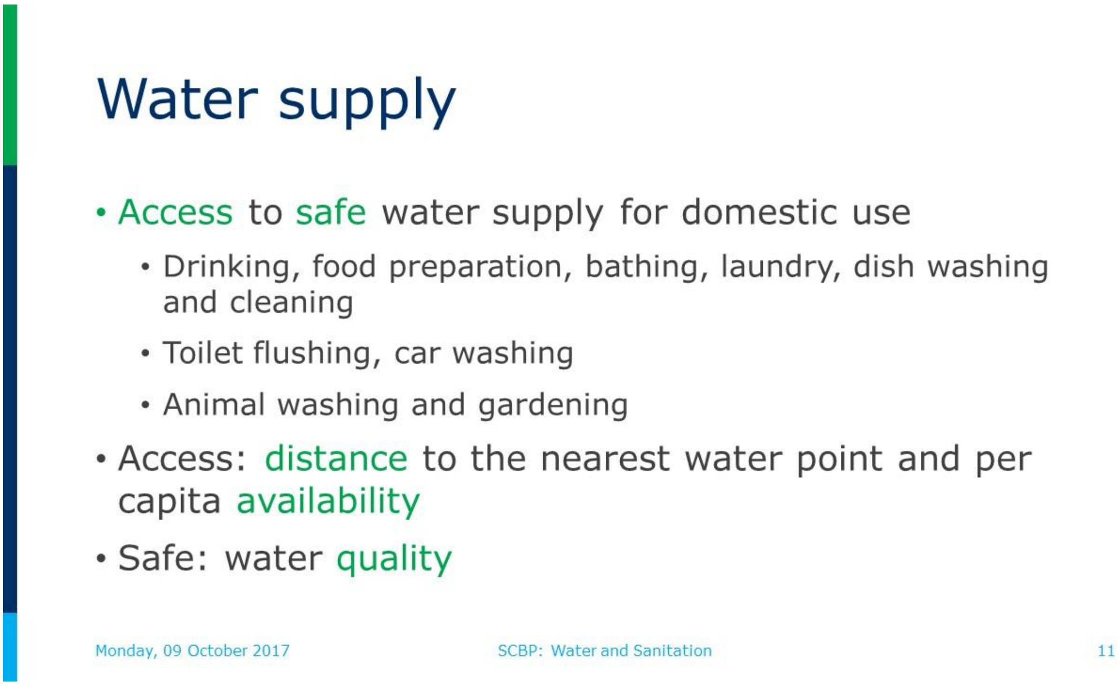
The natural and built environment with its natural resources water, air and soil (blue); all services and facilities required to keep the environment clean and protect health (green). Our focus is on water supply and environmental sanitation services, facilities and human behaviour (inside yellow line).





Environmental health has two key components- natural and built environment. Both these components are likely to affect the human health in a good or bad way. It is our responsibilities to respect and protect the environmental health. For this it is important to provide necessary environmental services to households and communities.

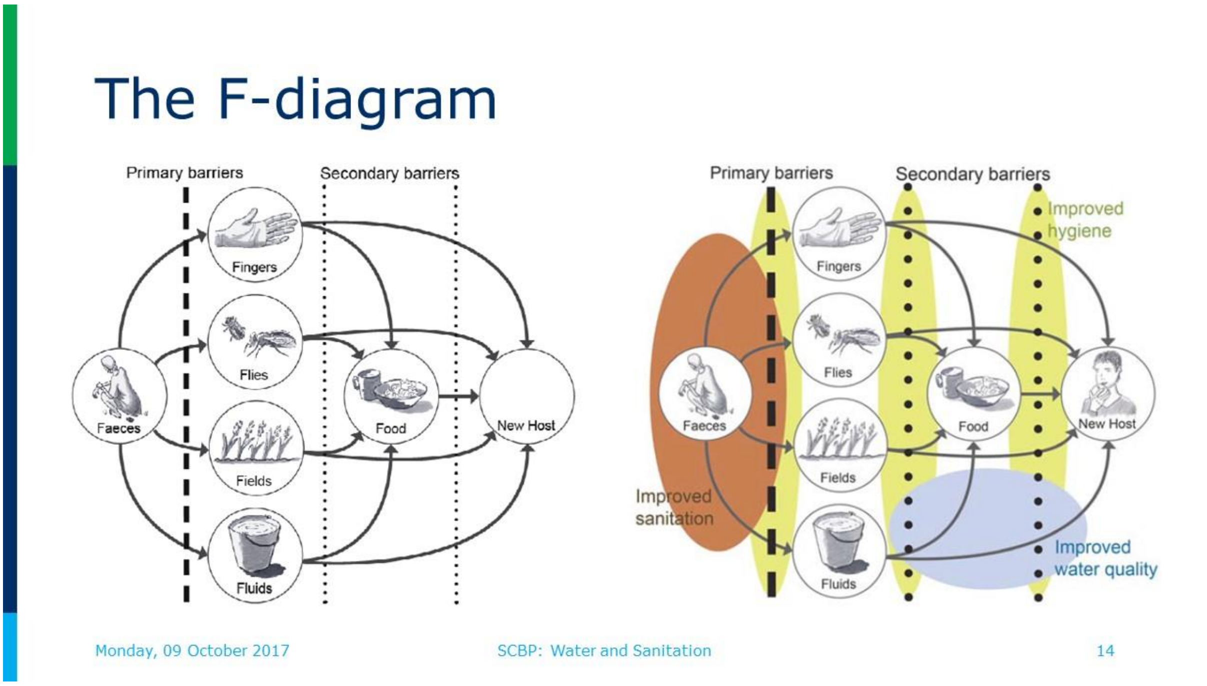
1.1.2 Water Supply and Environmental Sanitation



Water is one of the basic need for human being to survive. History tells us that the empires and civilisations which flourished were set on the banks of major rivers of the world. Water has three main consumers, Agriculture-Domestic and Industrial. In domestic a person uses water for various purposes like drinking, cooking, bathing, laundry, toilet flushing, cleaning etc. WHO and UNICEF recommends 20 lpcd from a source within one km of the user's dwelling.

There are many possible definitions of sanitation. Sanitation mean the safe management of human excreta and wastewater. It therefore includes both the ‘hardware’ (e.g. latrines and sewers) and the ‘software’ (regulation, hygiene promotion) needed to reduce faecal-oral disease transmission. It encompasses potential reuse, ultimate disposal of human excreta or discharge of wastewater.

Environmental sanitation aims at improving the quality of life of the individuals and at contributing to social development. This includes disposal or hygienic management of liquid and solid human waste, control of disease vectors and provision of washing facilities for personal and domestic hygiene. Environmental sanitation comprises both behaviour and facilities to form a hygienic environment.



Most diseases associated with water supply and sanitation, such as diarrhoea, are spread by pathogens (disease-causing organisms) found in human excreta (faeces and urine). The faecal-oral mechanism, in which some of the faeces of an infected individual are transmitted to the mouth of a new host through one of a variety of routes, is by far the most significant transmission mechanism. This mechanism works through a variety of routes, as shown by the so-called "F Diagram". Primary interventions with the greatest impact on health often relate to the management of faeces at the household level. This is because (a) a large percentage of hygiene-related activity takes place in or close to the home and (b) first steps to improving hygienic practices are often easiest to implement at the household level. Secondary barriers are hygiene practices preventing faecal pathogens, which have entered the environment via stools or on hands, from multiplying and reaching new hosts. Secondary barriers thus include washing hands before preparing food or eating, and preparing, cooking, storing, and re-heating food in such a way as to avoid pathogen survival and multiplication.

Environmental sanitation

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The water supply and sanitation provide the necessary barrier between the pollutants, natural - built environment and humans. The waste and resource sub-systems of water and environmental sanitation (yellow); the natural environment (blue); the built environment (pink).

1.1.3 Resource and Waste Systems

Sanitation planning

- Cities are engines of economic & social development
- Urban development relies on good infrastructure and reliable service provision
- Sanitation systems are only considered partially!
- Failures or unsustainable solutions put huge financial burden on ULBs.

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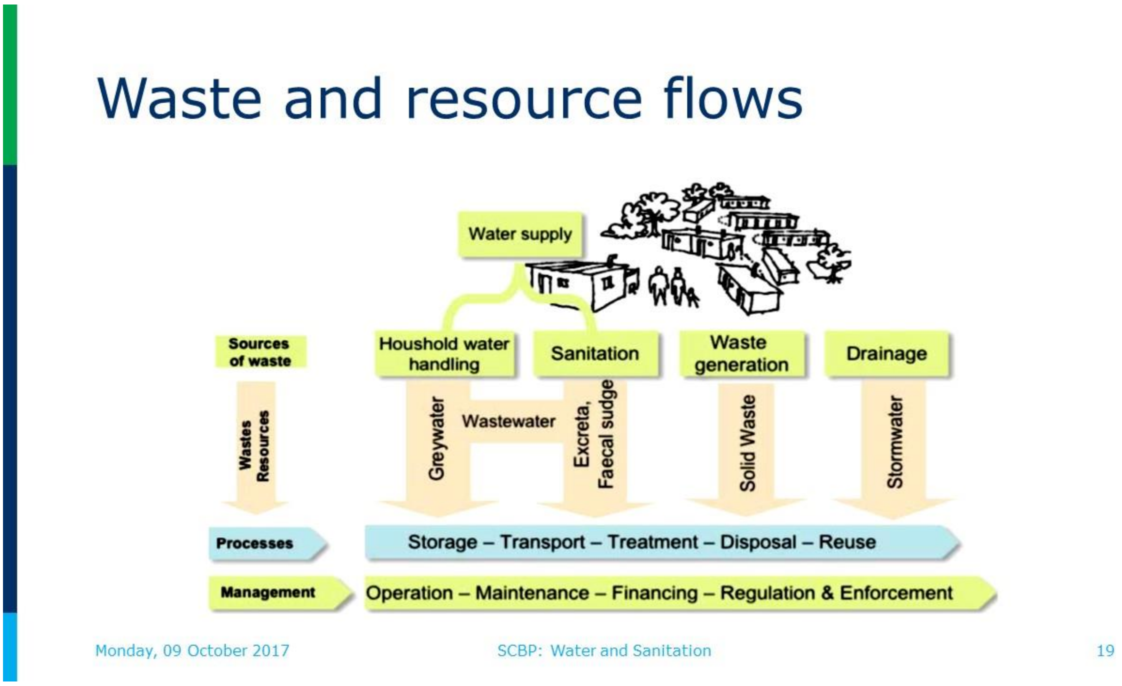
Cities, as engines of economic growth and social development, require large quantities of natural resources to meet the inhabitants' economic and social needs. Good infrastructure and reliable service provision are keys to a sustained urban development. To respond to the lack of sanitation infrastructure affecting especially the urban poor, many governments, development agencies and NGOs have launched programmes to provide the poor and vulnerable population with sanitation options.

The sanitation systems are often only considered partially. For example, on-site based sanitation solutions (latrine or septic tank-based) frequently do not include excreta and faecal sludge emptying, transport or treatment services and facilities. Additionally, local business opportunities, as well as demand and potential use of waste resources, such as water, nitrogen or biosolids, are given little attention. Failures or unsustainable solutions put huge financial burden on municipalities.

In cities of developing countries, large amounts of excreta and faecal sludge collect in on-site sanitation facilities, such as private or public latrines, and septic tanks. As opposed to industrialised countries, where excreta is disposed of via cistern-water flush toilets, city-wide sewerage systems and central wastewater treatment plants, all of which are widespread technologies in industrialised countries but unaffordable or inappropriate in developing countries. If faecal sludge is collected at all from on-site sanitation technologies, they are most often disposed of in an uncontrolled manner without prior treatment, thus, posing severe health risks and polluting the environment.

If treatment facilities are available in larger cities, haulage distances or the time required for transport due to traffic congestions may be prohibitive for efficient sludge emptying services. Within city boundaries, land is often highly valued and may thus not be available for waste treatment. This will consequently lead to nearest possible uncontrolled dumping, be it on open grounds, into drainage ditches, water courses or into the sea.



The figure shows the sources of waste in the household and neighbourhood (green) and the waste and resource flows (brown). All waste and resource flows require an integrated management (green) within a settlement: regulatory system and its enforcement, as well as operation and maintenance for safe transport, treatment, safe disposal, and/or reuse (blue).

What needs to change is our thoughts. We should regard waste as resources to develop an integrated view point.

In India we call a wastewater treatment facility as STP, however in Singapore where fresh water is very limited they call it water reclamation facility.

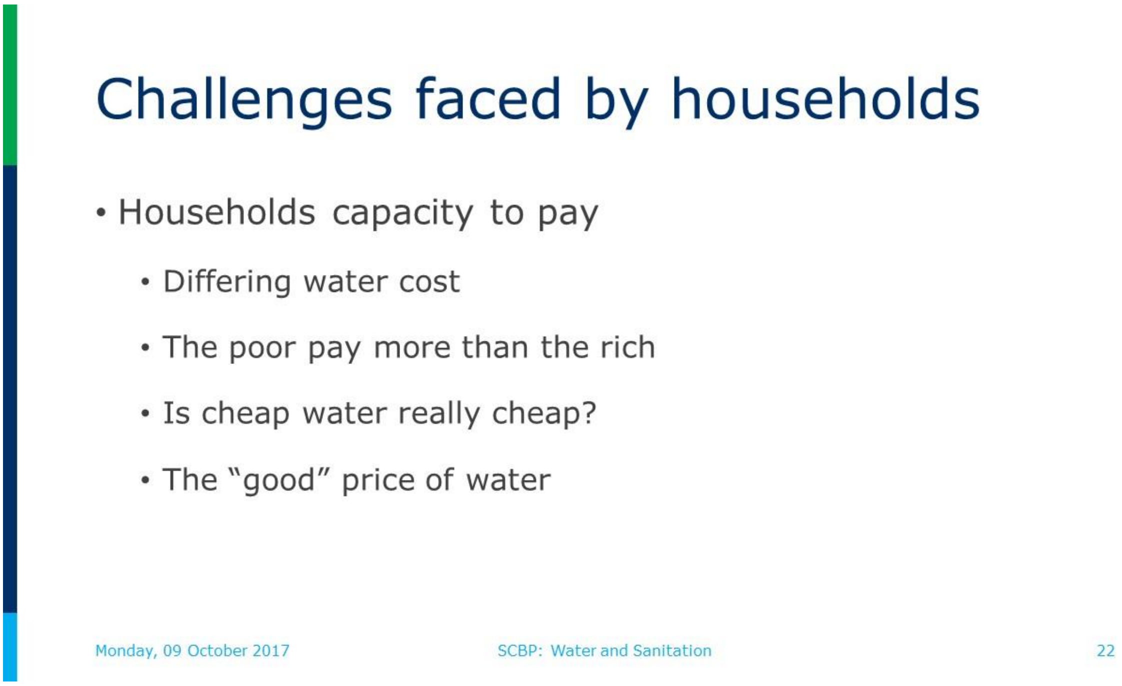
1.1.4 Urban Challenges

Factors leading to deficiencies in water and sanitation can be found on every level – from local to international. The causes for the inadequacies are thus proximate (household/local), contributory (city & town) or underlying (global/international).

1/4–2/3 of the urban population lives in slums (informal or illegal settlements). Many public or private official water and sanitation providers do not operate in illegal settlements. Moving from illegal to legal status is complicated and expensive. House plots don't have formal addresses and clear demarcations. Hence it is difficult for the ULBs to give individual connections to the households in illegal settlements. The transition of illegal to legal requires agreement of several different agencies. The ULBs also lack qualified manpower such as lawyers and surveyors for such purpose.

Planning, funding, implementing, operating, and maintaining water and sanitation systems require qualified skills and expertise in different disciplinary fields. Since illegal settlements lack regular plot layouts, access roads, solid waste collection, the tasks are far more complex than in regulated settlements.

House-owners tend to resist improvements requiring investments, and tenants do not wish to invest in properties they do not own.



Urban low-income households

- Lack of house connections, public
- Lack of house connections, public taps are located far away, queues are long etc.
- Water from vendors is expensive, so used only for cooking and drinking.
- Water and sanitation expenditure: up to 10% of total income is used for good quality water and another per cent for public toilets!
- Many households cannot afford" Clean" water, so poor water quality is used.

Is cheap water really cheap? It is difficult to differentiate between the provision costs (or prices charged) and the inadequacies of provision as these are interrelated.

The "good" price of water. There is an obvious justification for seeking cost recovery when improving water and sanitation provision as improved provision can pay for itself, i.e. the quality of provision can be maintained without any constraints on expanding provision.

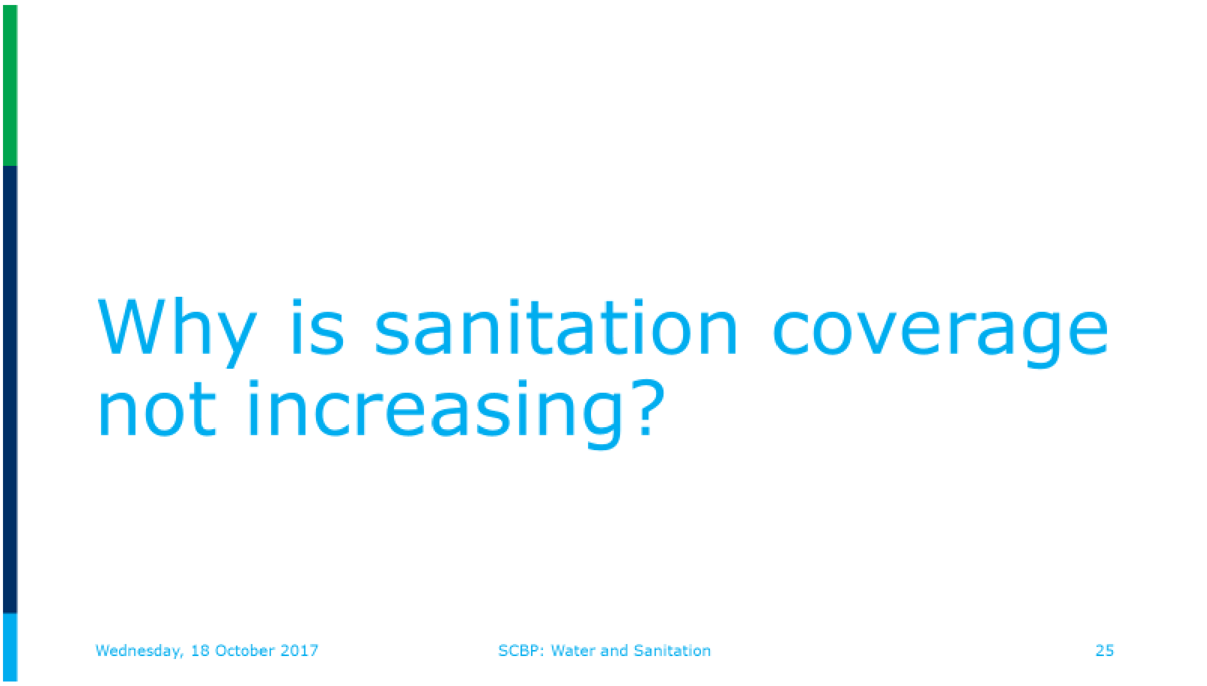
Conflict of objectives

- To reach financial sustainability, costs should be recovered for water and sanitation provision.
- To protect health and the environment, it is necessary to reach the poorest.

The WHO/UNICEF Assessment identified cost recovery and inadequate operation and maintenance as two of the main constraints on the development of water supply and sanitation – both largely a consequence of the weakness or incapacity of water and sanitation agencies. The spatial distribution of the population has always been a key factor on the policy agenda of governments. The governments of developing countries have often expressed concern about their inability to provide basic services for their rapidly growing urban populations, including safe drinking water, sanitation, affordable housing, and public transport.

Small-city problems (< 500,000)

- Weak governments.
- No official water and sanitation utilities/institutions.
- No professional staff.
- Neglected by governments and donors.
- The management gap occurs because the large towns are not big enough to make top down/centralization approach economical or bottom up/decentralization approach manageable due to lack of resources.



Points to be discussed

- Insufficient awareness and priority setting
- Inadequate institutional framework
- Inadequate legislation and policy
- Inappropriate financing schemes
- Capacity and expertise

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Thank you...

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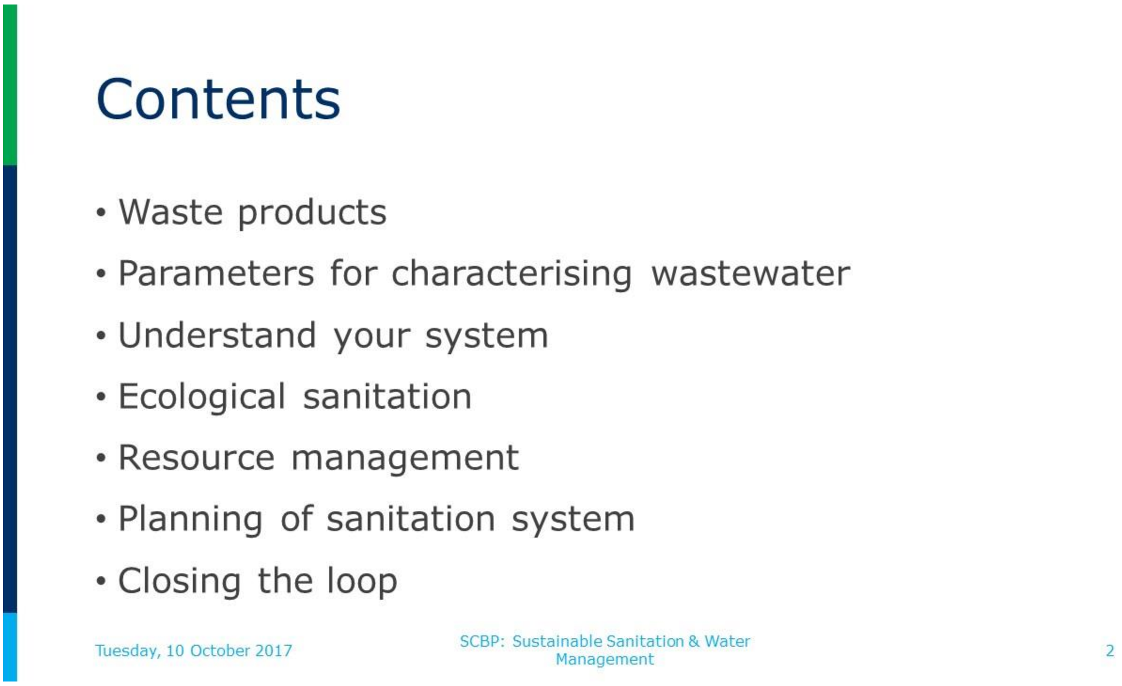
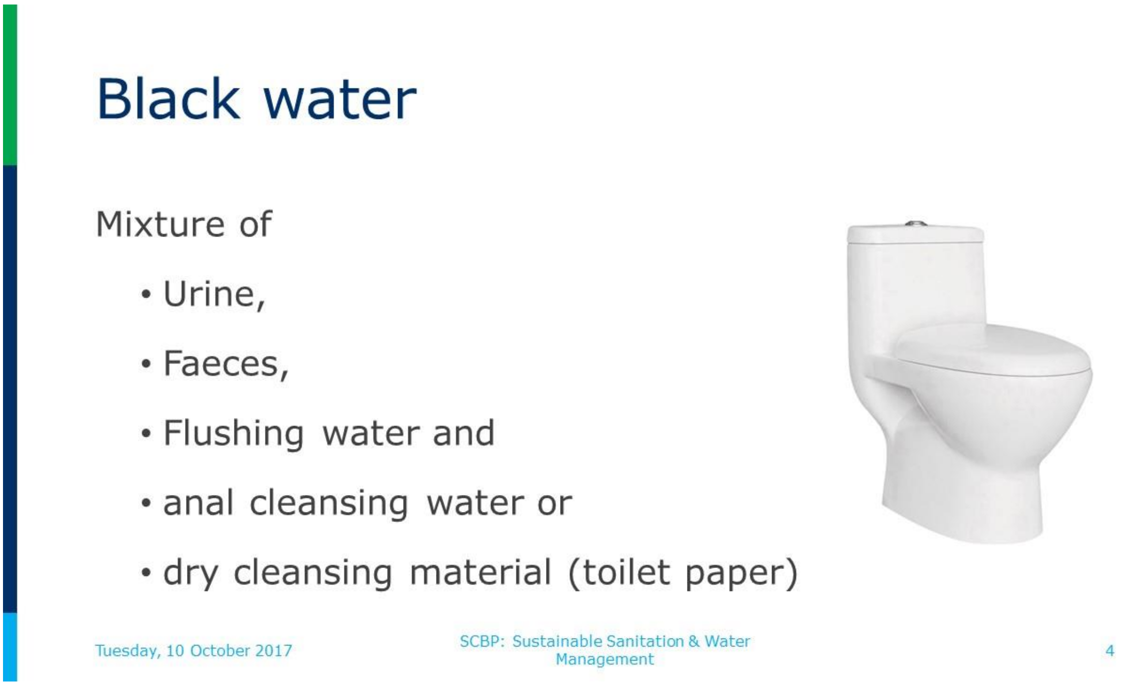
2 SUSTAINABLE SANITATION AND WATER MANAGEMENT

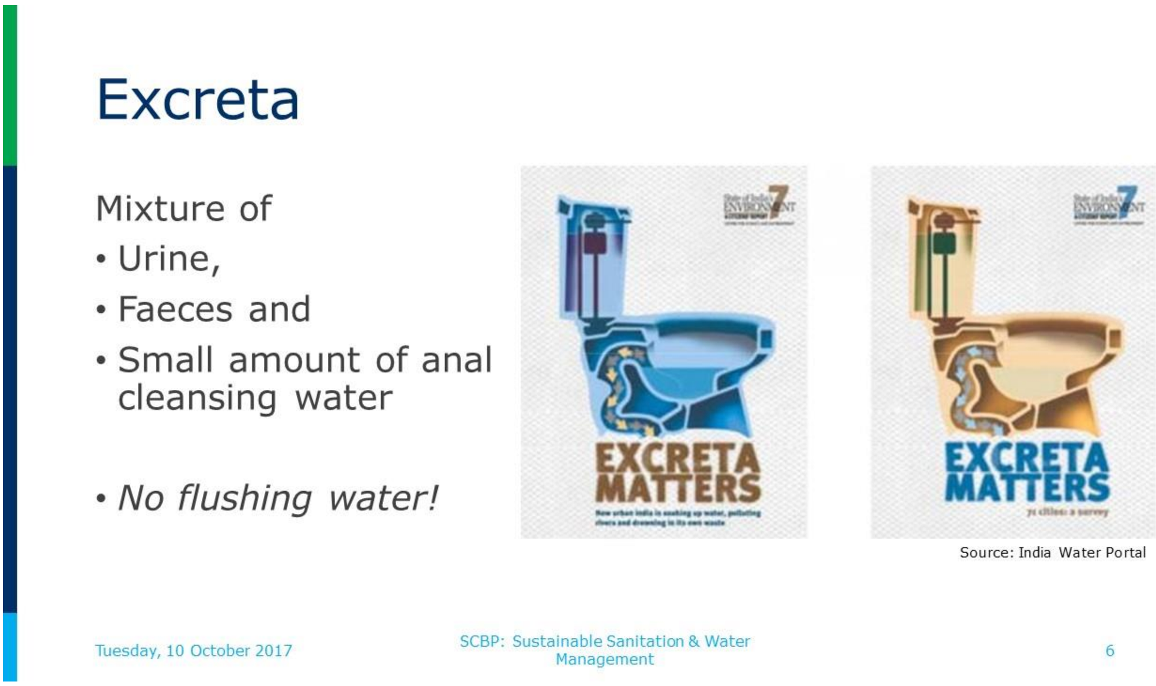


2.1.1 Waste Products



Blackwater is the mixture of urine, faeces and flushing water along with anal cleansing water (if anal cleansing is practised) or dry cleansing material (e.g. toilet paper).

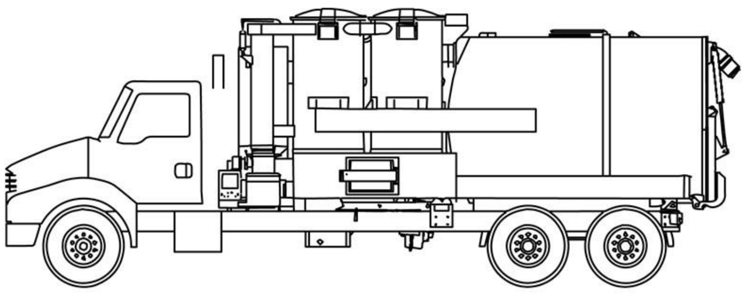
Greywater is used water generated through bathing, hand-washing, cooking or laundry. It is sometimes mixed or treated along with blackwater.



Excreta is the mixture of urine and faeces not mixed with any flushing water (although small amounts of anal cleansing water may be included).

Faecal sludge

Undigested or partially digested slurry or solid resulting from storage of blackwater or excreta.



Source: Martin Engineering

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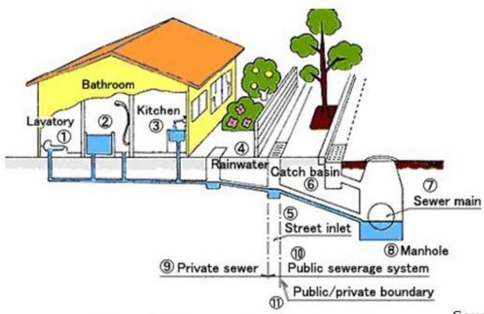
Faecal sludge is the general term for the undigested or partially digested slurry or solid resulting from the storage or treatment of blackwater or excreta.

Domestic wastewater

It includes all kind of liquid waste generated at household level (blackwater and greywater). However it usually does not include storm water.



Source: Eawag, Sandec

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Domestic wastewater comprises all sources of liquid household waste: blackwater and greywater. However, it generally does not include stormwater.

Stormwater

- Runoff from house roofs, paved areas and roads during rainfall event.
- Water from catchment of a stream or river upstream of a community settlement.

Source: Protect Every Drop

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Stormwater in a community settlement is runoff from house roofs, paved areas and roads during rainfall events. It also includes water from the catchment of a stream or river upstream of a community settlement.

2.1.2 Parameters to Characterise Wastewater

Solids

- TS: Total Solids & TSS: Total Suspended Solids
- Suspended solids- bigger than 0.2µm
- Settleable and colloidal solids
- 70% organic solids; 30% inorganic solids

Turbidity and organic solids deplete the oxygen in the water body and prevent light from penetrating.

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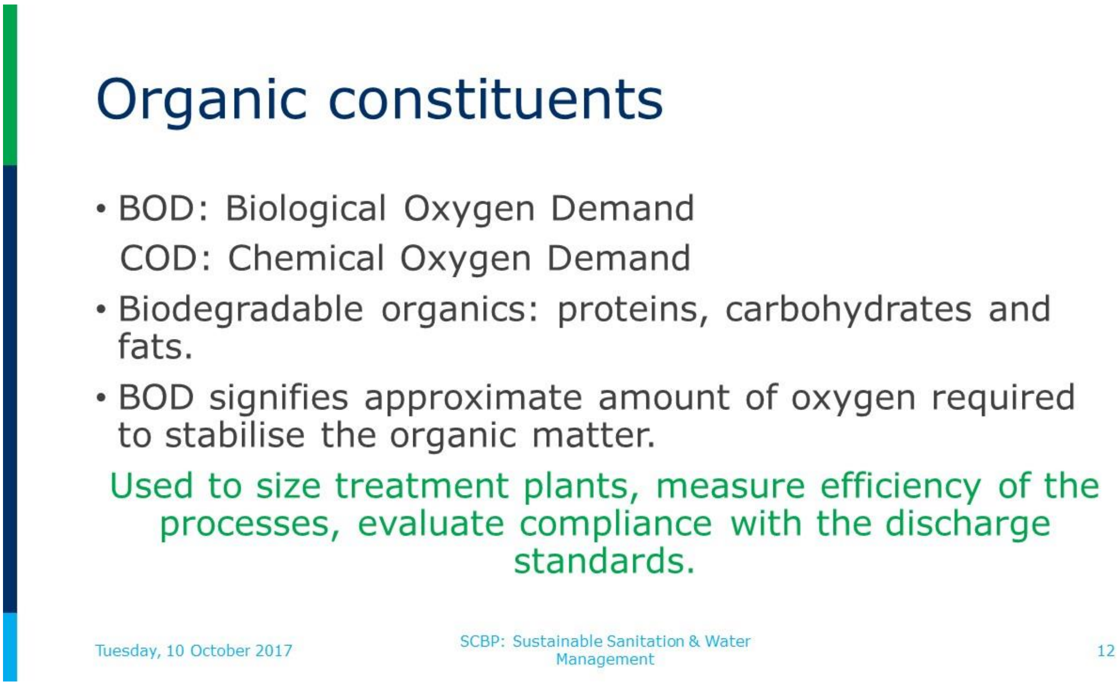
Suspended solids are those solids that do not pass through a 0.2-um filter. About 70 % of those solids are organic and 30 % are inorganic. The inorganic fraction is mostly sand and grit that settles to form an inorganic sludge layer. Total suspended solids comprise both settle able solids and colloidal solids. Settleable solids will settle in an Imhoff cone within one hour, while colloidal solids (which are not dissolved) will not settle in this period.

Suspended solids are easily removed through settling and/or filtration. However, if untreated wastewater with a high suspended solids content is discharged into the environment, turbidity and the organic content of the solids can deplete oxygen from the receiving water body and prevent light from penetrating.



Biodegradable organics are composed mainly of proteins, carbohydrates and fats. If discharged untreated into the environment, their biological stabilisation can lead to the depletion of natural oxygen and development of septic conditions.

BOD test results can be used to assess the approximate quantity of oxygen required for biological stabilisation of the organic matter present, which in turn, can be used to determine the size of wastewater treatment facilities, to measure the efficiency of some treatment processes and to evaluate compliance with wastewater discharge permits.

Nutrients

- TN: Total Nitrogen; TP: Total Phosphorus
- Also known as bio stimulants.
- Essential for growth of micro organisms, plants and animals.
- In aquatic environment – growth of undesired aquatic life.
- On land – leads to groundwater pollution

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Nitrogen and phosphorus, also known as nutrients or bio stimulants, are essential for the growth of microorganisms, plants and animals. When discharged into the aquatic environment, these nutrients can lead to the growth of undesirable aquatic life, which rob the water of dissolved oxygen. When discharged in excessive amounts on land, they can also lead to groundwater pollution.

Pathogens

- TC (MPN): Total Coliform; FC (MPN): Faecal Coliform
- Communicable diseases can be transmitted.
- Specific monitoring organisms is tested
  - to gauge the plant operation and
  - suitability for reuse.

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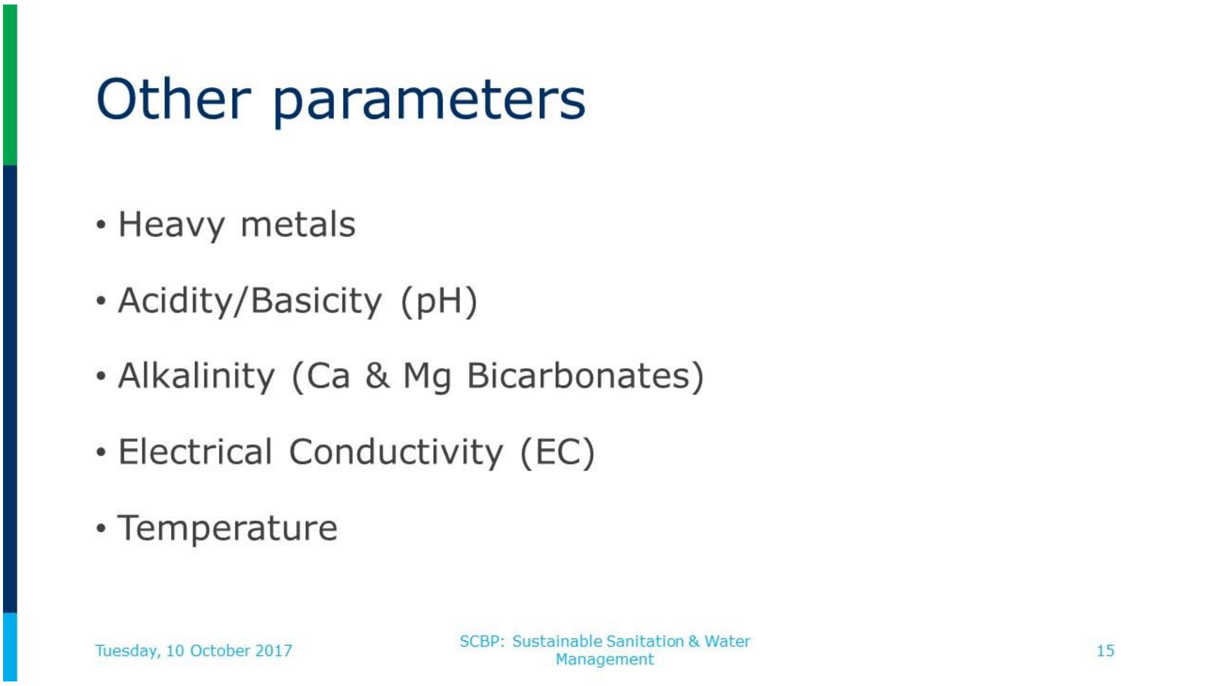
Communicable diseases can be transmitted by pathogenic organisms present in wastewater. The presence of specific monitoring organisms is tested to gauge plant operation and the potential for reuse.

Coliform bacteria include genera that originate in faeces (e.g. *Escherichia*) as well as genera not of faecal origin (e.g. *Enterobacter*, *Klebsiella*, *Citrobacter*). The assay is intended to be an indicator of faecal contamination; more specifically of *E. coli* which is an indicator microorganism for other pathogens that may be present in faeces. Presence of faecal coliforms in water may not be directly harmful and does not necessarily indicate the presence of faeces.



Heavy metals are usually added to wastewater by commercial and industrial activities and may have to be removed if the wastewater is to be reused.

The concentration range suitable for the existence of most biological life is quite narrow (typically 6 to 9). Wastewater with an extreme concentration of hydrogen ions is difficult to treat biologically.

Alkalinity in wastewater results from the presence of calcium, magnesium, sodium, potassium, carbonates and bicarbonates, and ammonia hydroxides. Alkalinity in wastewater buffers (controls) changes in pH caused by the addition of acids.

The measured EC value is used as a surrogate measure of total dissolved solids (TDS) concentration. The salinity (i.e. 'saltiness') of treated wastewater used for irrigation is also determined by measuring its electric conductivity.

The wastewater temperature is commonly higher than that of local water supplies. Temperature has an effect on chemical reactions, reaction rates, aquatic life, and the suitability for beneficial uses. Furthermore, oxygen is less soluble in warm than in cold water.

2.1.3 Ecological Sanitation

- ✓ EcoSan – is not just a toilet interface!
- ✓ The concept of EcoSan is resource recovery and reuse oriented.
- ✓ It is a concept that is characterized by desire to safely close the loop.

Characteristic comparison

	Total	Grey water	Urine	Faeces
Volume (L/cap.yr)	25,000-100,000	**25,000-100,000**	500	50
Nitrogen (kg/cap.yr)	2.0-4.0	5%	**85%**	10%
Phosphorus (kg/cap.yr)	0.3-0.8	10%	**60%**	30%
Potassium(kg/cap.yr)	1.4-2.0	34%	**54%**	12%
COD (kg/cap.yr)	30	**41%**	12%	**47%**
Faecal coliform (per 100 mL)	-	**10^4-10^6**	0	**10^7-10^9**

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Greywater is a reflection of household activities, its main characteristics strongly depend on factors such as cultural habits, living standard, household demography, type of household chemicals used etc. Greywater is the least contaminated type of wastewater which needs very less degree of treatment.

The concentration of nutrients in the excreted urine depends on the nutrient and liquid intake, the level of personal activity and climatic conditions. In its pure form, it is sterile and quite rich in nutrients.

From a risk perspective, exposure to untreated faeces is always considered unsafe on account of the high levels of pathogens whose prevalence is dependent on the given population.

Potential risks and benefits

	Greywater	Urine	Faeces
Chemical contaminants	Fats, oils and toxic substances (org. compounds, chlorides, metals)	Micro contaminants (e.g. hormones & antibiotics)	Micro contaminants (e.g. heavy metals)
Biological contaminants	Pathogens (bacteria, viruses, helminths, protozoa)	Almost sterile (if not cross contaminated by faeces)	Pathogens (bacteria, viruses, helminths, protozoa)
Value	Reuse potential (for irrigation or municipal and non potable domestic use)	Nutrients (N, K and P) Ideal fertilizer	Good soil conditioner but only little nutrients.

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Greywater, urine and faeces have distinct characteristics. When dealing with waste products, it is important to account for their value and potential risks.

Sanitation and the Nexus

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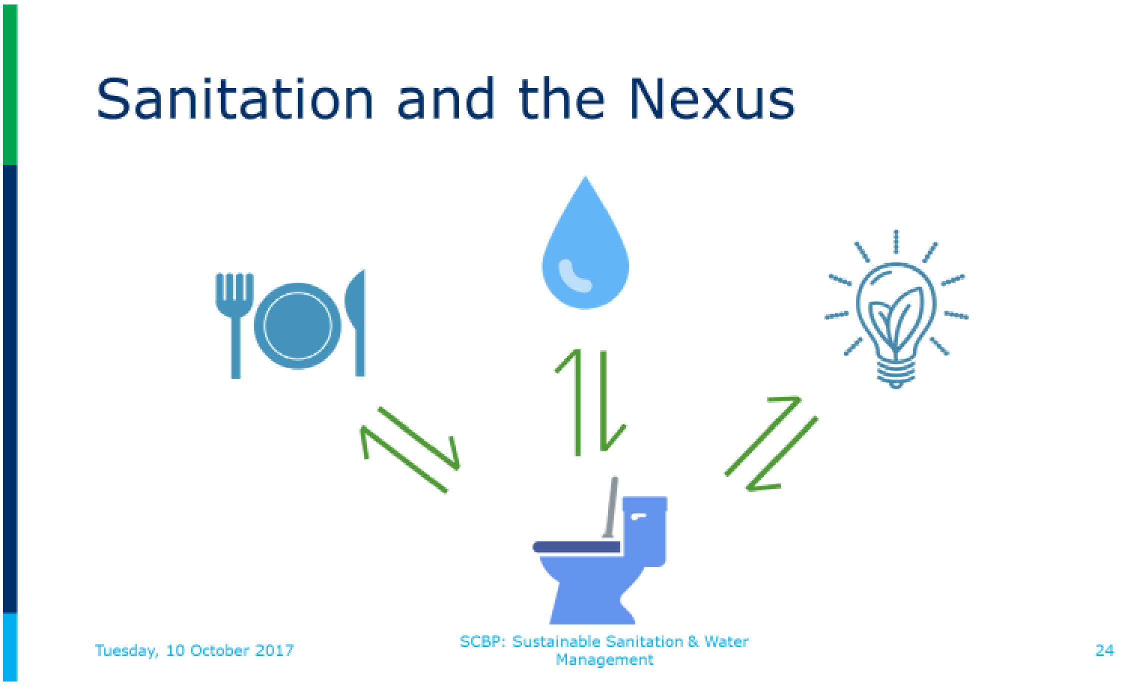
Sanitation and wastewater treatment are closely interlinked with the given nexus. If the sanitation system is sustainable and productive, the benefits are not only for public health but for water, energy and food security are enormous. Sustainable and productive sanitation systems save water and energy, contribute to renewable energy security (biogas), and contribute to food security through decentralised and cost-efficient provision of fertiliser, soil conditioner or nutrient rich irrigation water.

Further reading: https://www.water-energy-food.org/news/2011-09-19-nexus-blog-sanitation-and-the-nexus/

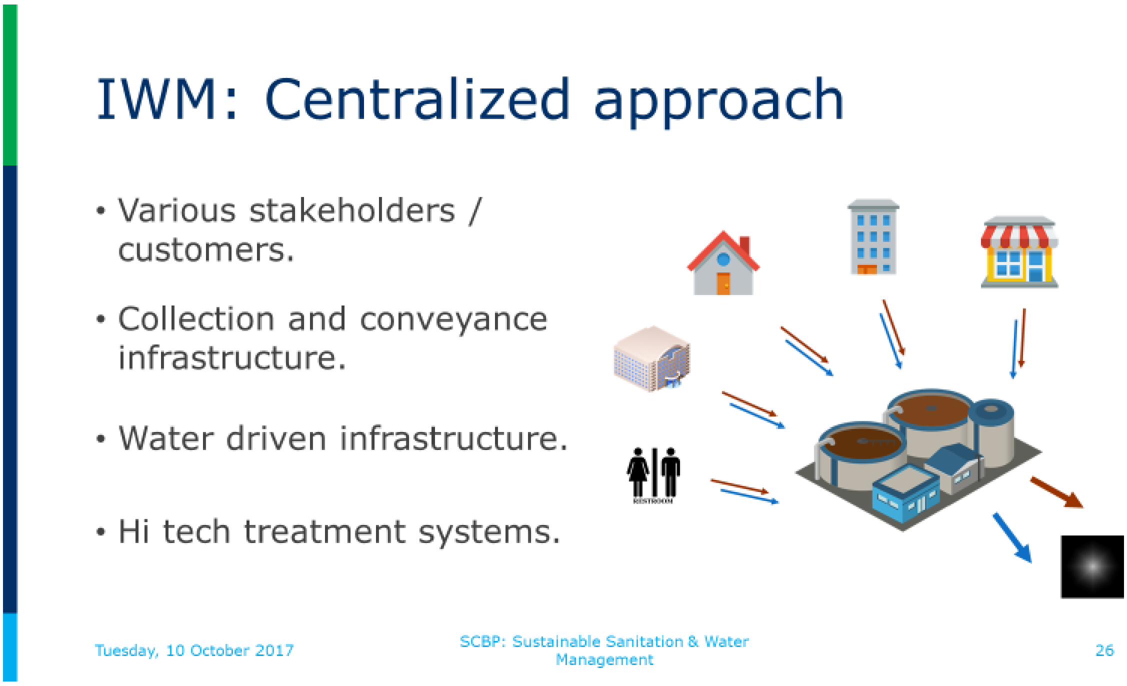


A toilet might need little water to flush but sanitation includes many other water-dependent processes such as the hygiene practice of hand washing with safe drinking water. Insufficient sanitation practices — such as the lack of containment of faecal matter and the inadequate treatment of wastewater — pose direct risks to drinking water sources and to public health. Legislators need to both recognise the benefits of using treated wastewater, as well as assure its safety through better regulation and the provision of incentives to ensure adequate treatment and re-use according to the WHO guidelines (2006).

The use of treated sanitation products — urine and faeces — as fertilisers can help mitigate poverty and malnutrition, and improve the trade balance of countries importing chemical fertilisers, especially in respect of phosphate fertiliser, a non-renewable resource. Food security can be increased with a fertiliser that is readily available for all at very little cost, regardless of infrastructure and economic resources. Safe handling of urine and faeces including treatment and sanitisation before use according to the WHO guidelines (2006) is a key component of sustainable sanitation as well as sustainable crop production.

High energy demand is required for conventional sanitation systems, especially for aerobic wastewater treatment targeting nitrogen (N2) removal. A tremendous amount of energy is required to re-capture N2 from the air to produce chemical fertilisers. Firstly, the heat of the wastewater can be re-gained. Secondly, energy in the form of biogas can be gained through anaerobic digestion — a process already applied in large scale plants in industrialized countries, using the sewage sludge at the "end of the pipe". The energy yields would be even higher if anaerobic systems were applied at the source, for example through pour flush biogas toilets, and UASB treatment of wastewater.

2.1.4 Resource Management



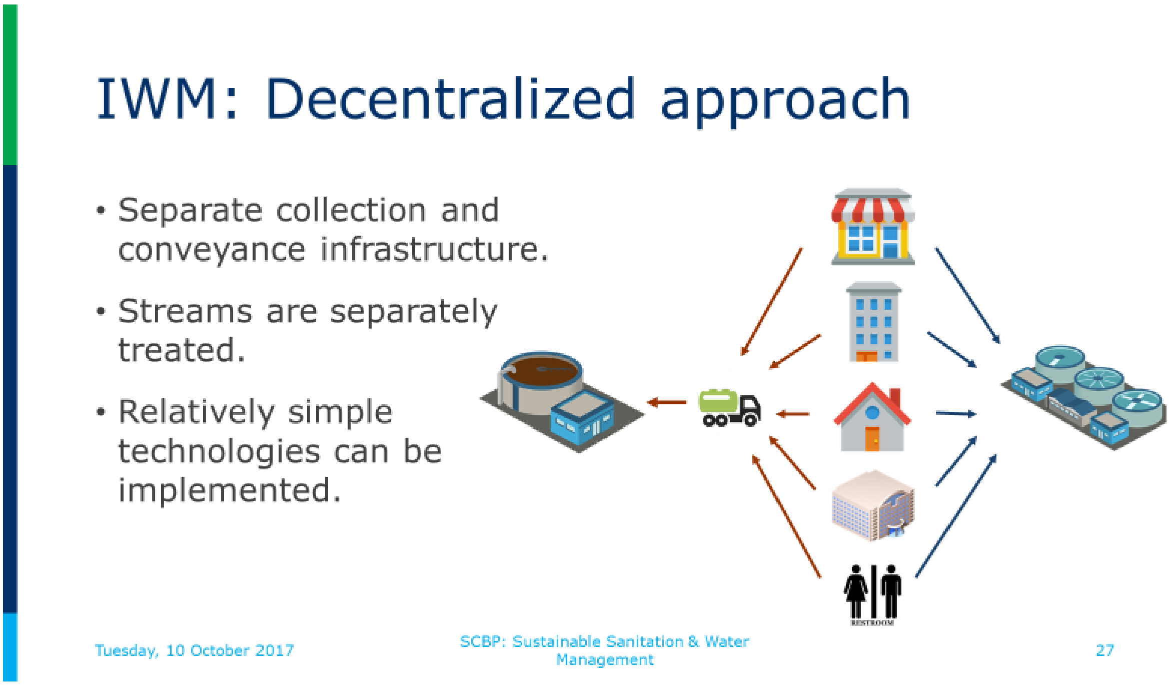
Faecal sludge is mixed with water to facilitate conveyance to the hi-tech wastewater treatment.

Here the water and sludge are separated and treated water is disposed/reused.

Sludge treatment is usually not the highest priority and is disposed unhygienically.

Minimum interference from stakeholders ensures smoother operation.

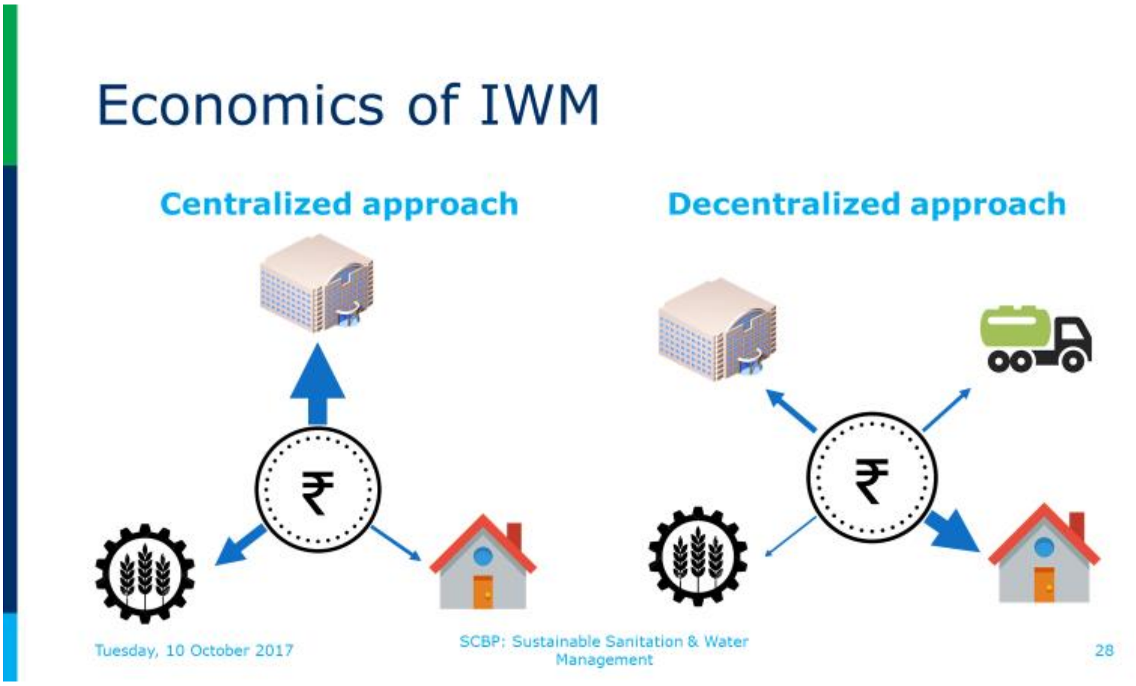
Management and monitoring of system is easier however resource such as (water, electricity, skilled manpower and expertise) are not easily available.



Sludge and water is separated at source. Collection and conveyance infrastructure is smaller and simpler to implement.

PPP model can be effectively implemented in this approach.

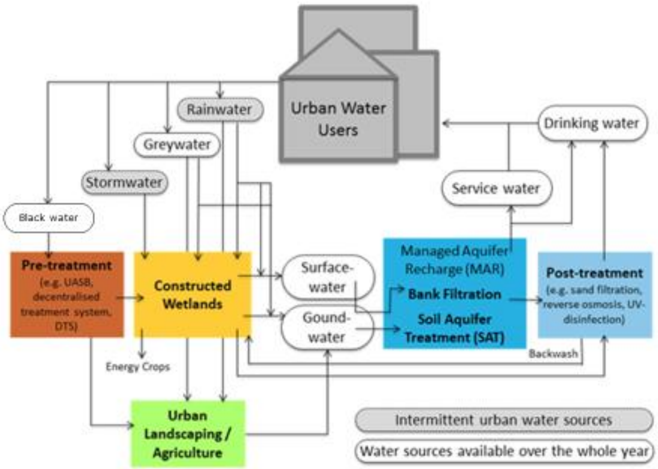
Here maximum stakeholder interaction happens. Multi-level management is required and hence it is complex. Monitoring needs to be done at multiple points and hence environmental protection cannot be guaranteed.



In a centralized approach, the ULB has to bear the capital and O&M cost of the infrastructure. However, taking into consideration the efficiency of collection of taxes in Indian cities, maintaining the infrastructure and providing services to the masses becomes more of a burden.

On the contrary, in a decentralizes approach (depending on the selected sanitation system) the household (who is the consumer of the services) bears most of the cost. Since private service providers in terms of collection – transport and treatment are available, the costs get distributed among different stakeholders.

Multi barrier approach



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The multi barrier approach focusses more on integration of natural water treatment technologies in the urban scape. These technologies treat perennial and intermittent water sources with special emphasis on resource recovery and reuse.

The approach was successfully demonstrated through Indo-EU project called NaWaTech.

2.1.5 Planning of Sanitation Systems

Key determinants for planning

- Settlement: population size and density of a settlement.
- Physiographical parameters: soil type, topography, altitude, terrain and groundwater table.
- Land availability and social acceptance

Design of sewers, gradient of network, pumping requirements, technology options, construction techniques and associated costs

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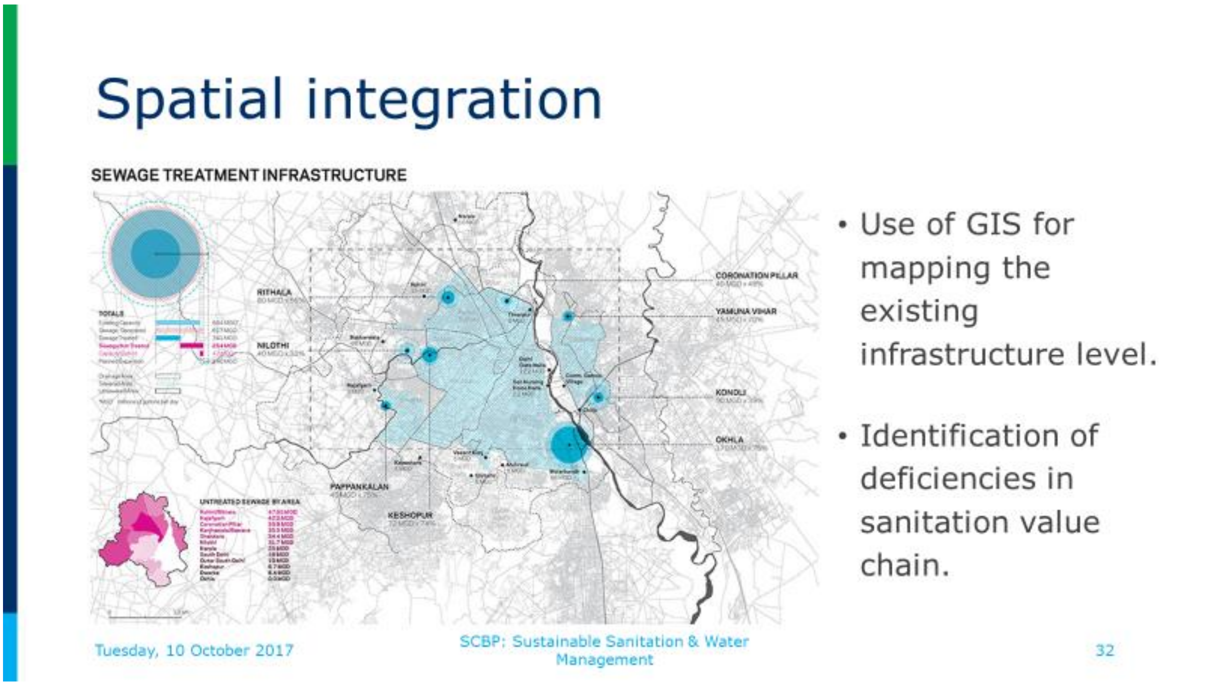
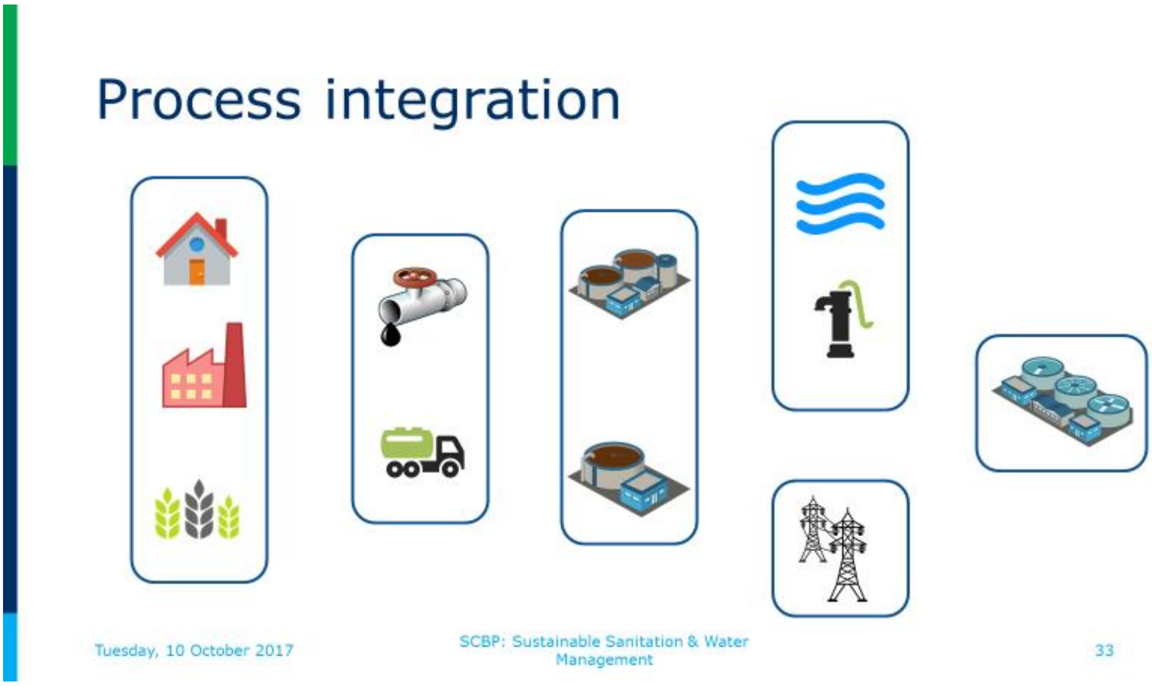
Example of Kochi: In the case of Kochi, although centralized approach was logically the most favourable, the high ground table influenced the construction techniques and associated costs. Hence Kochi had to adopt decentralized approach in the form of septage management. Kochi has India’s first working Septage Management Plant.



The cities should integrate the new added areas to the municipal limits / urban agglomerations & newly developed areas (eg. due to change in master plan) within the municipal limits, with the proposed system.

Tools such as GIS helps to visualize the reach of the services and compare it with growth of the city. This helps to identify the section of the city which needs immediate attentions in terms of infrastructure. Such tools help to have planning and implementations in different phases.



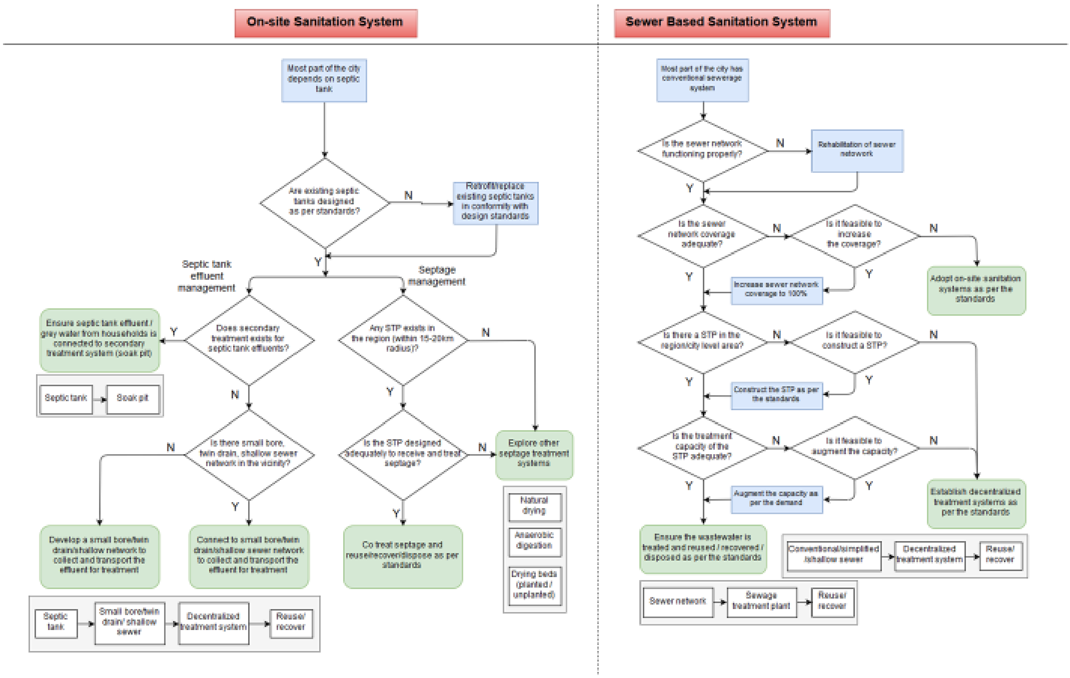
Demand management | Collection and conveyance | WTP, STP and FSTP | Water resources | Energy |

Importance should be given to how the cities are maturing not only with respect to its growth but also the sanitation infrastructure.

Integration of the newly proposed infrastructure should be proposed with existing infrastructure.

Need analysis should be done for replacing, retrofitting or refurbishment of existing system before implementing new systems and process.

Logic diagram



A logical approach needs to be defined keeping in mind the local natural and built environment. Such logical framework is specific to area and needs to be altered or adopted from place to place.

The logic diagram like these, helps to identify gaps in the sanitation chain and thereby zero down on the suitable options to complete the sanitation value chain.

Reuse aspects

- IWM has strong linkage with resource recovery & reuse.
- Reuse is a demand driven process.
- Quality and quantity of the treated effluents plays important part!
- Affordability of the treated effluents.
- Equilibrium needs to achieved between conveyance infrastructure and cost of the treated effluent.

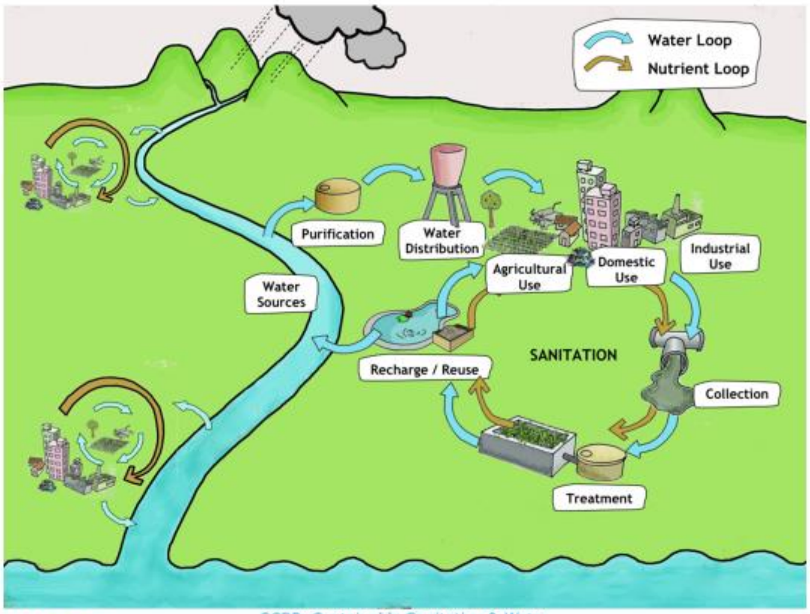
With enough political will and the creation of adequate incentives for businesses and policy makers alike, sustainable and productive sanitation can be a major contributing factor to the achievement of greener economies, fostering job creation and poverty reduction along the whole sanitation, wastewater treatment and re-use chain.

Tadipatri is a town which is known for its cement industries. Cement production is a water intensive process and hence requirement of water is huge. In case of Tadipatri, this requirement is planned to be fulfilled using the treated effluent of from a centralized STP. The industry is going to bear the cost of the conveyance infrastructure. A centralised STP facilitates easy one point of source for the industry.

Mancherial is a town in Telangana, where an organised planned layout for residential complexes called Hi Tech Colony has been developed. The colony is already having community septic tank, however looking at the degradation of the lake near by the municipal corporation wants to upgrade the treatment facility. Doing this will provide effluent of good quality which can be reused for non-potable purposes inside the colony. However, there is very little interest in people to pay for reclaimed water.

Tirupati's case is similar to tadipatri, but as the industries and other relevant stakeholders are located far from the existing STP, the conveyance of treated effluent is costly.

2.1.6 Closing the Loop



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It is very important to identify the water and nutrient pathway in the local system. After identifying the pathway, all the issues and problems needs to be identified and root cause of each needs to be realised.

Only after understanding the system dynamics in depth, it is possible to plan and implement sustainable solutions which will help to close the water and nutrient loop. It is only through closing the loops (water and nutrient) that sustainability of water and sanitation system can be achieved.

Key take away...

- HYBRID options – maximum coverage in collection and treatment.
- Policies and regulations should focus on reuse of end products!
- Private sector can play very important role in decentralization of sanitation systems.
- Decentralized approach – supplementary to – centralized approach.

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Opting for fragmenting the urban scape based on decision making criteria results into mix into hybrid options where decentralization and centralization co-exists! Only this can ensure maximum coverage in collection and treatment of solids and liquids.

Septage management is demand driven and hence policies should focus on promoting reuse of end products. There is strict implementation of regulations on septage management along with reuse of treated effluents in agriculture and industries.

State government should encourage sanipreneurs to start small medium enterprises so that sanitation services can reach to the last denominator.

Decentralization and conventional approach are supplementary to each other in developing countries like India.

3 SANITATION SYSTEMS AND TECHNOLOGIES

Contents

- Sanitation and its objectives
- Functional groups
- Sanitation systems
- Emergency sanitation infrastructure

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3.1.1 Sanitation and its Objectives

Definition

- An intervention involving behaviour and facilities aiming at interrupting the disease cycle (faecal-oral disease transmission).
- Safe management of excreta.
- Hardware (toilets & sewers)
- Software (regulations & hygiene promotion)
- Access to basic vs. access to improved

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There are numerous definitions of sanitation. The word sanitation alone is taken to mean the safe management of human excreta. It therefore includes both the hardware (e. g. latrines and sewers) and the software (regulation, hygiene promotion) needed to reduce faecal-oral disease transmission. It also encompasses the reuse and ultimate disposal of human excreta.

Improved technologies: Connection to a public sewer, Connection to a septic system, Pour-flush latrine, Ventilated improved pit latrine (VIP)

Unimproved technologies: Bucket latrines, Public latrines, Open latrines

It should keep disease-carrying waste and insects away from people, both at the site of the toilet, in nearby homes and in the neighbouring environment.

Avoid air, soil, water pollution, return nutrients/resources to the soil, and conserve water and energy.

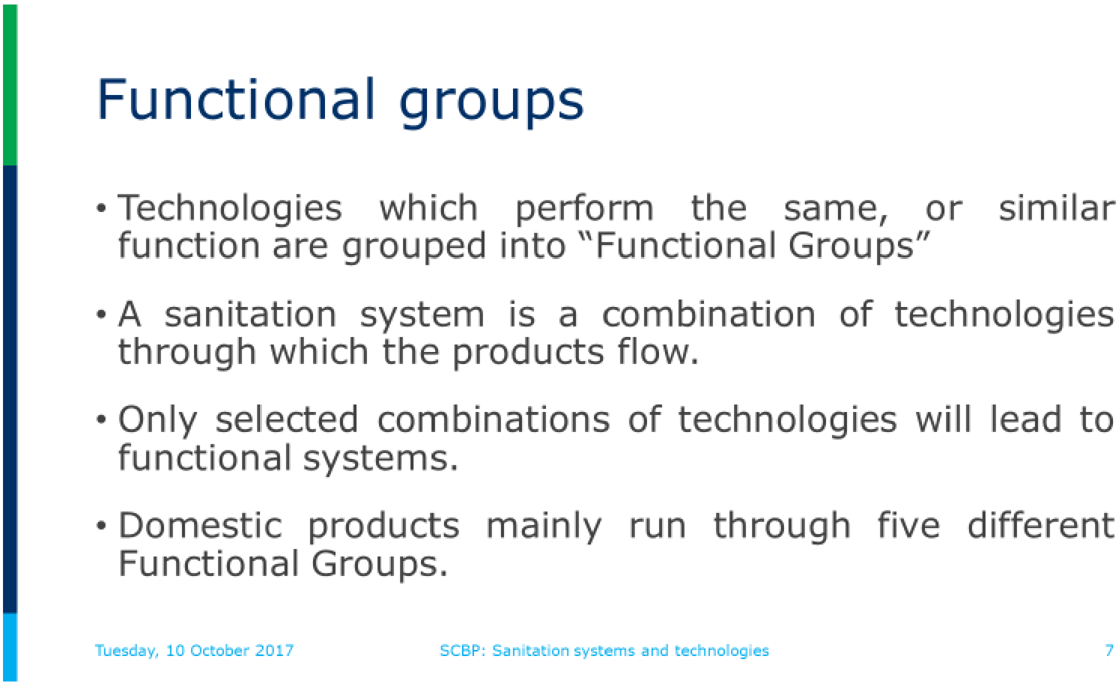
The system must be operational with locally available resources (human and material). Where technical skills are limited, simple technologies should be favoured.

Total costs (including capital, operational, maintenance costs) must be within the users' ability to pay.

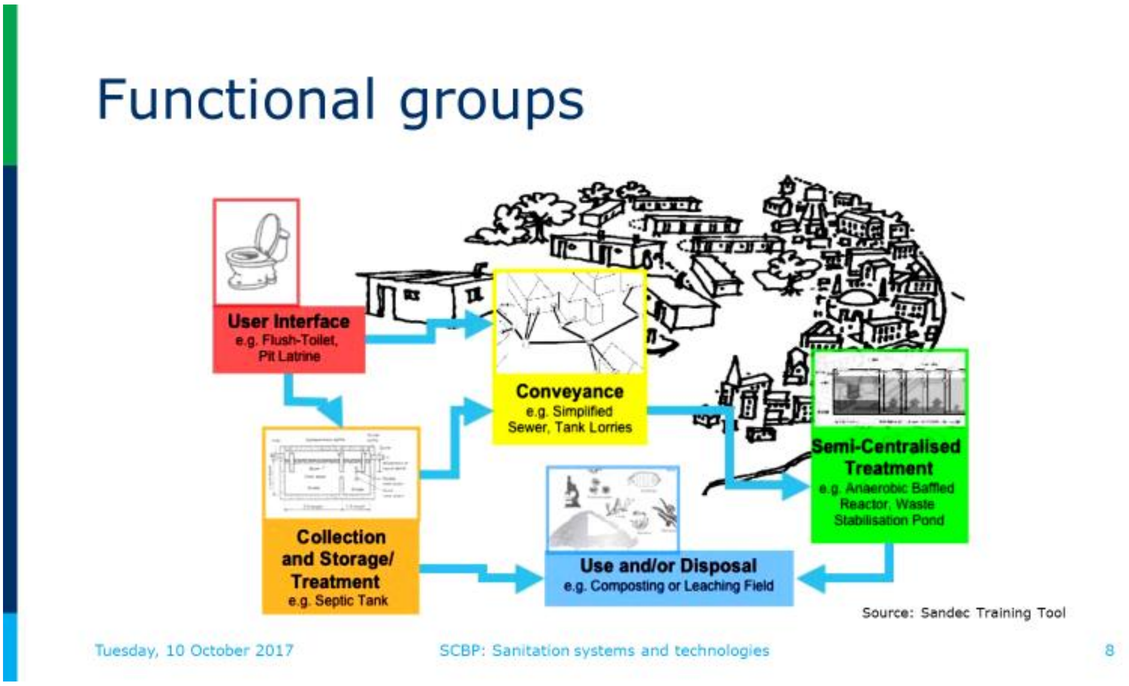
It should be adapted to local customs, beliefs and desires.

It should address the health needs of children, adults, men, and women.

3.1.2 Functional Groups



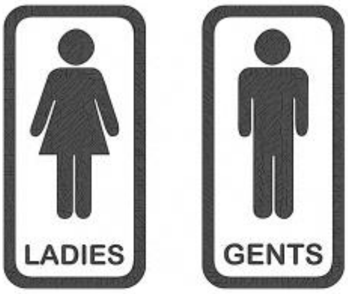
Various technologies which perform the same or similar type of function are called as Functional Groups. When different technologies from different functional groups are clubbed together, a sanitation system is made. Careful selection of the technologies needs to be done to make the sanitation system functional. A sanitation system should consider all the products generated and all the Functional Groups these products are subjected to prior to being suitably disposed of. Domestic products mainly run through five different Functional Groups, which form together a system.



All sanitation systems start with User Interface. From this the product either goes to Collection and Storage/Treatment group or to Conveyance. This mainly depends on whether there is adequate supply of water available for water based system.

After conveyance the products flow in the Centralised Treatment function group, where the products are treated before moving on to Use/Disposal group. The product though Collection and Storage/Treatment also end up into Use/Disposal functional group.

Depending on the system, not every Functional Group is required.



User interface

Functional group

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User interface

- The type of toilet, pedestal, pan or urinal the user comes in contact with.
- It is the place where water is introduced in the system.
- Determines the final composition of the product.
- The choice of user interface is often dependent on the availability of water.

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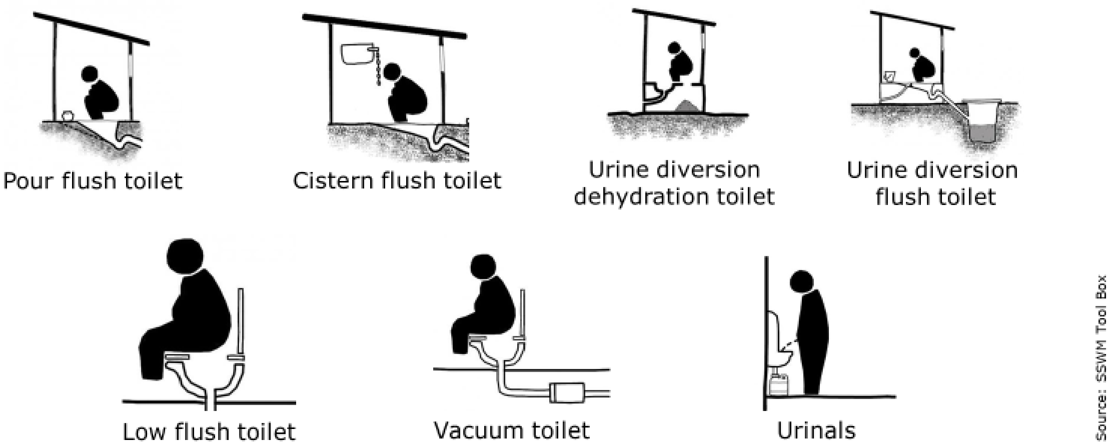
User interface describes the type of toilet, pedestal, pan or urinal the user comes in contact with. User interface also determines the final composition of the product, as it is the place where water is introduced in the system. Thus, the choice of user interface is often dependent on the availability of water.

User interface



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Technical and physical criteria

- Availability of space (especially in case of urban poor)
- Ground condition (rock, sandy, loam)
- Groundwater level and contamination (coastal towns and cities having sandy strata)
- Water availability (small towns and emerging cities)
- Climate (temperature, rainfall, sunlight)

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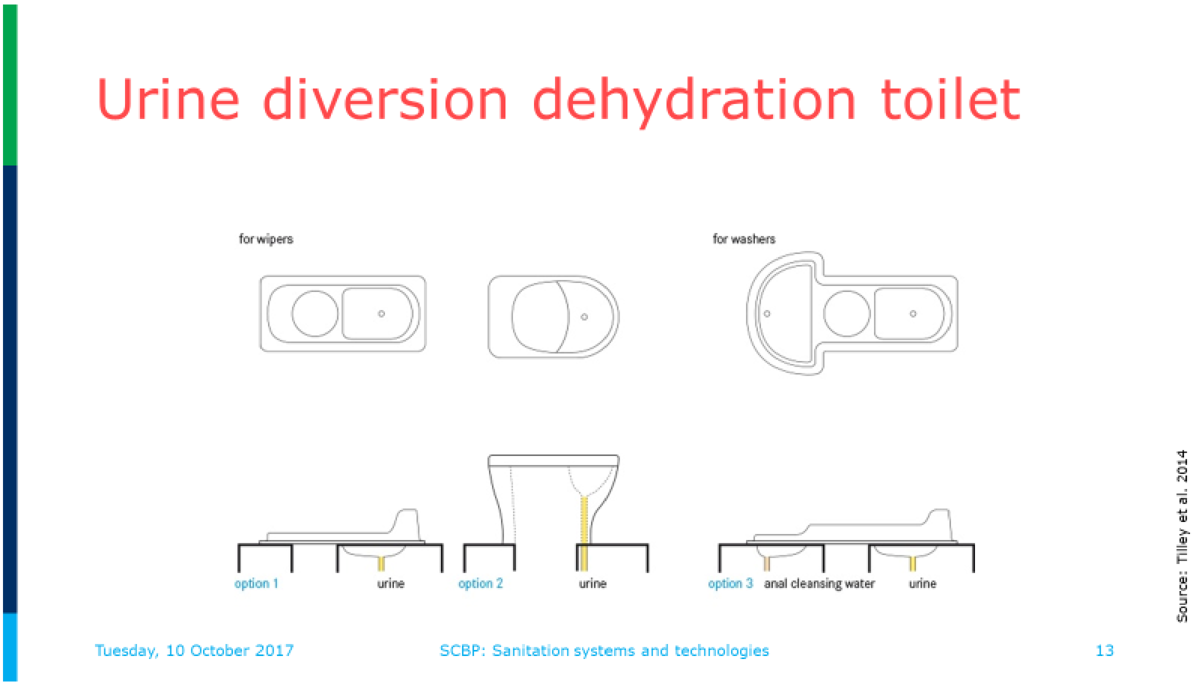
Selection of user interface depends on the following six technical and physical criteria;

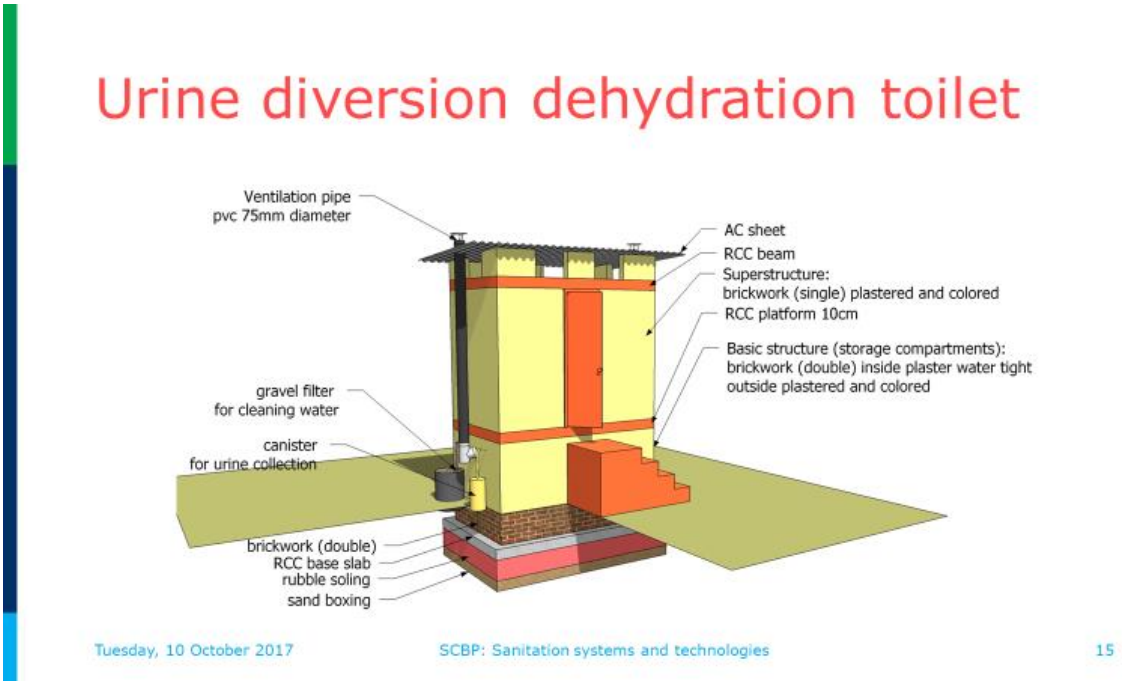
1. Availability of space 2. Ground condition 3. Groundwater level and contamination 4. Water availability 5. Climate



A urine diverting dry toilet (UDDT) is a toilet operating without water and separating the liquid (urine) from the solid (faeces) fraction. In a UDDT toilet, urine is collected and drained from the front area of the toilet, while faeces fall through a large chute (hole) in the back of the toilet.

It is important for the two sections of the toilet to be well separated so that a) urine does not splash down into the 'dry' area of the toilet and b) faeces do not fall into and clog the urine collection area in the front.

Depending on user preference, either a pedestal or a squat slab can be built/used to separate urine from faeces.



Suitability

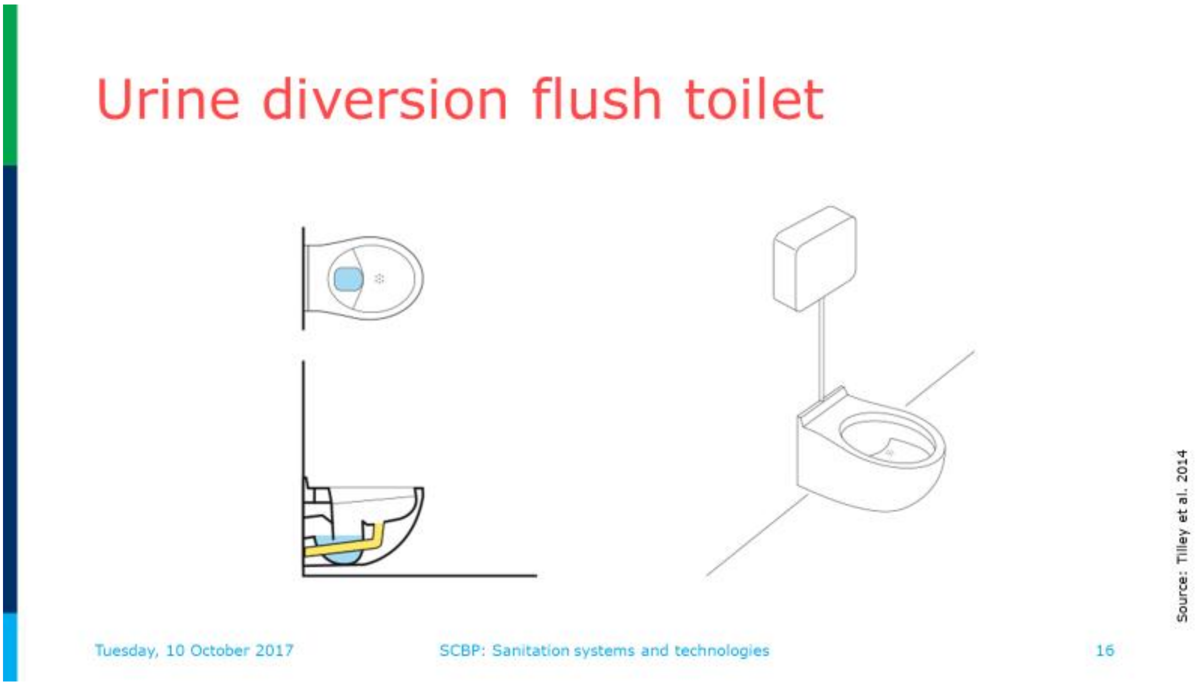
The dry toilet is quite simple to design and build and can be altered to suit the needs of specific populations (i. e. small children, people who prefer to squat etc.).

Health Aspects/Acceptance

The UDDT is not intuitive or immediately obvious to all users. Users may at first be hesitant to use it, and mistakes (e. g. faeces in the urine bowl) may also deter others from accepting this type of toilet. Education and demonstration projects are essential in achieving good acceptance among users.

Maintenance

A UDDT is slightly more difficult to keep clean than other toilets due to its lack of water and need to separate the solid from the liquid fraction. Since it forms part of a dry system, water should not be poured down the toilet, although the seat and the inner bowls should be wiped with a damp cloth. Metals should be avoided, as they tend to rust in the presence of urine.



Urine diversion flush toilets enables the user to segregate urine for reuse and the black water from the toilet can be collected in a decentralised treatment system.

Urine diversion flush toilet

Source: dubbletten.nu; gustavsberg.com; stman.se; rroevac.de

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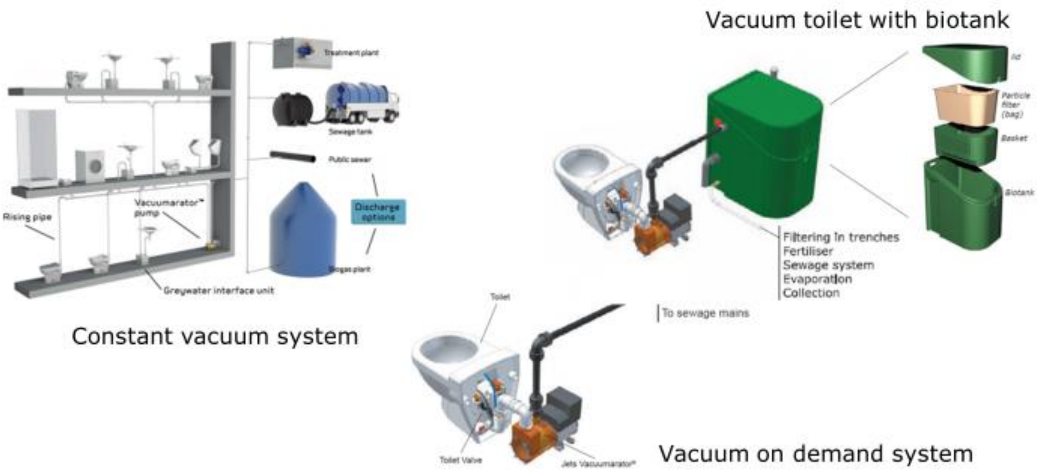
Vacuum toilet



Source: Jets Group (2005 & 2009)

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Vacuum toilets are flush toilets that use suction for the removal of faeces and urine resulting in a minimal requirement of water (0.5 to 1.5 litres). Vacuum toilets provide the same level of comfort as traditional flush toilets and they help saving costs due to the minimised amount of flush water. Due to the fact that the effluent has a high organic matter content, vacuum toilets are specifically adapted for the use in combination with separate greywater and blackwater treatment; or aerobic digestion treatment for biogas production. Vacuum toilet systems are applicable both in large and small buildings, trains, ships and airplanes.

Collection & storage/treatment

Functional group

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Collection & Storage/Treatment

- The ways of collecting and storing products generated at the user interface.
- Storage often also performs some level of treatment.
- The units are connected to soakaway zone or conveyance system for discharge of liquid.
- The units have to be regularly emptied for solids.

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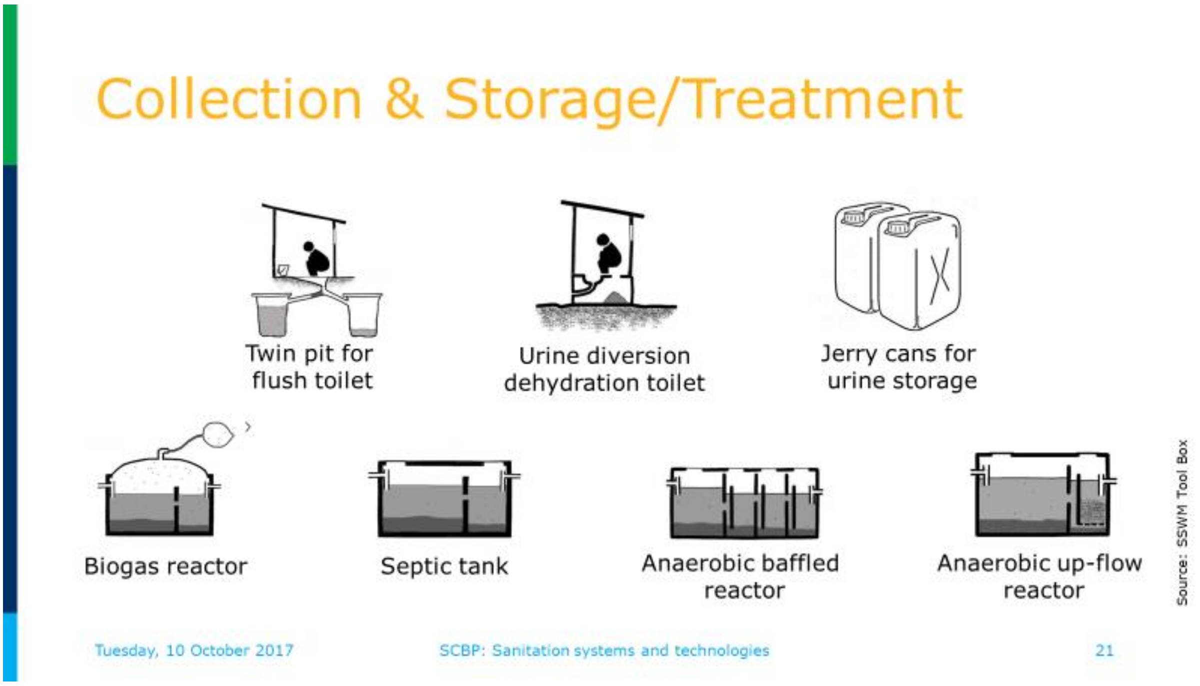
The technologies which are used for the collection and storage of the products generated at the user interface. In the case of extended storage, some treatment may be provided, though it is generally minimal and dependent on storage time.

All the units have to be either connected to conveyance or use/disposal function group for liquid effluent and to conveyance to solids.

All the units need to be emptied regularly (depending on the design criteria) for solids. These solids in turn need to be treated or processed before use/disposal.



Technical and physical criteria

- Ground condition
    - Soil and strata (percolation and cost of construction)
- Groundwater level and contamination
    - Cross contamination (pathogens)
- Climate
    - Temperature (degree of treatment) and rainfall (percolation rate)

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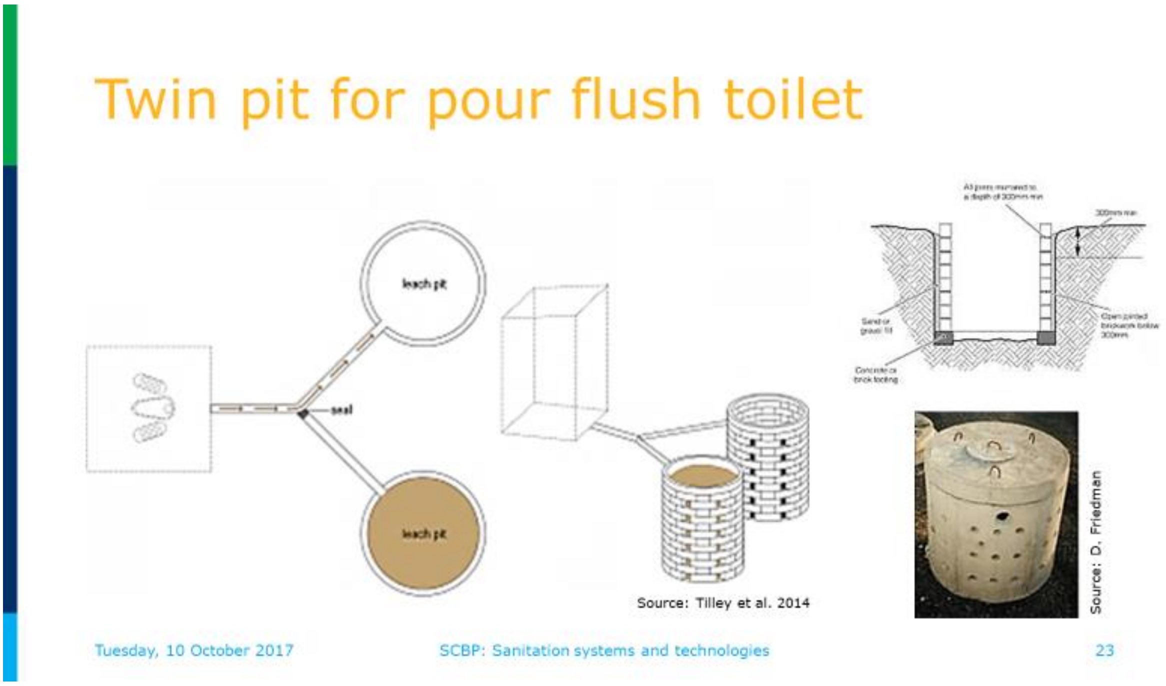
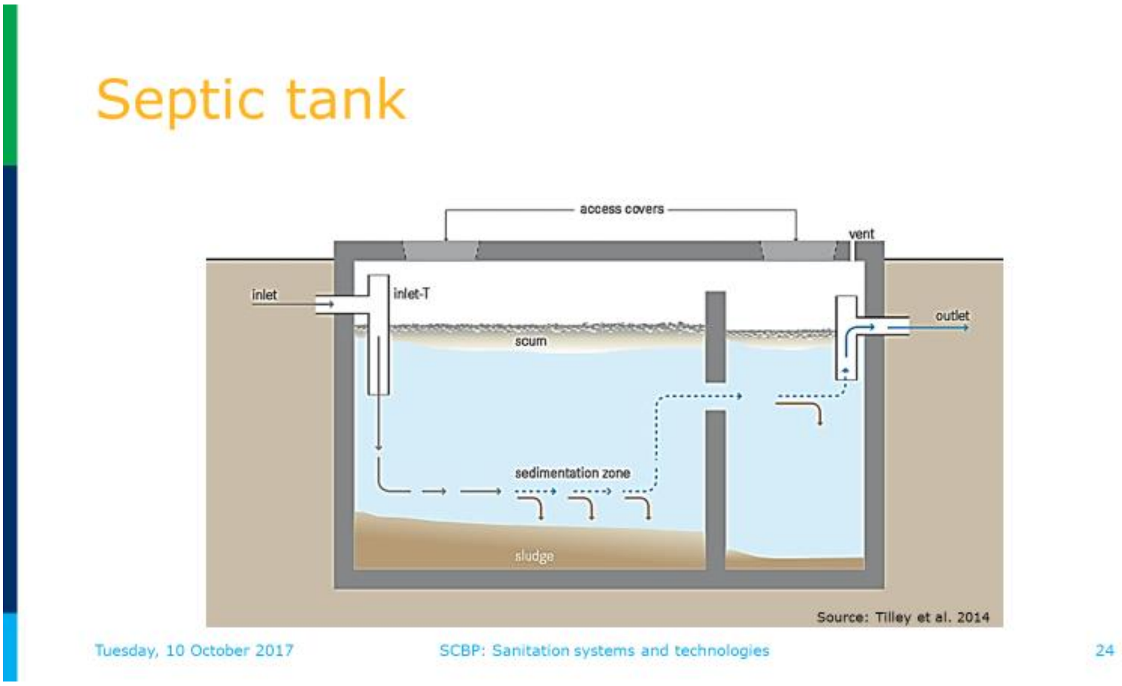
The technical and physical criteria for choosing appropriate collection, storage and treatment technology are as follows;

1. Ground condition 2. Groundwater level and contamination 3. Climate.



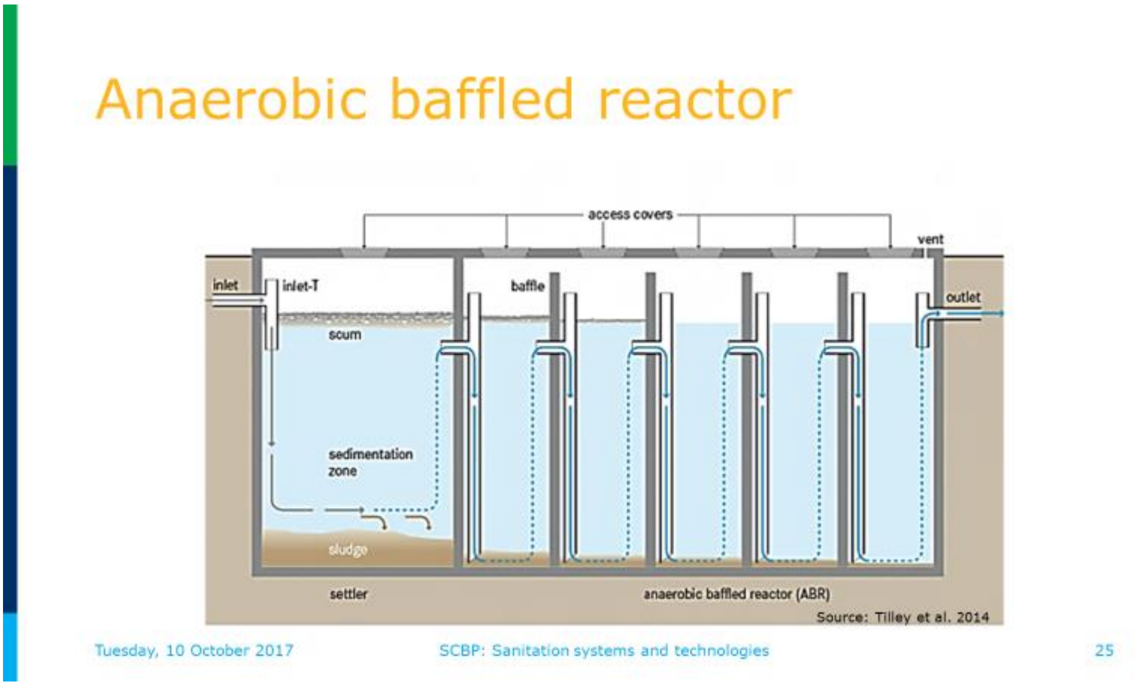
This technology consists of two alternating pits connected to a pour flush toilet. The blackwater (and in some cases greywater) is collected in the pits and allowed to slowly infiltrate into the surrounding soil. Over time, the solids are sufficiently dewatered and can be manually removed with a shovel and reused on-site, much like compost, to improve soil fertility and fertilise crops. Although most pathogens are filtered during soil infiltration or die-off with time and distance, there remains a risk of groundwater pollution, particularly in densely populated areas or in areas with a high groundwater table.

Further reading: http://www.sswm.info/category/implementation-tools/wastewater-treatment/hardware/site-storage-and-treatments/twin-pits



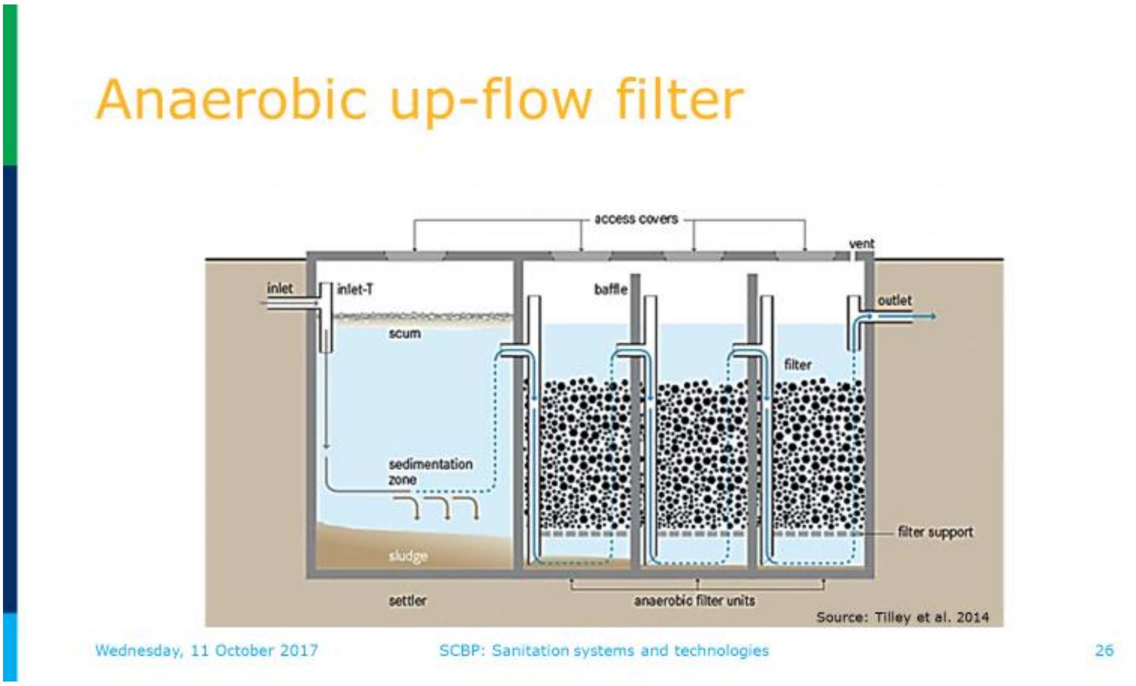
A septic tank is a watertight chamber made of brick work, concrete, fibreglass, PVC or plastic, through which blackwater from cistern or pour-flush toilets and greywater through a pipe from inside a building or an outside toilet flows for primary treatment. Settling and anaerobic processes reduce solids and organics, but the treatment is only moderate. Effluent is infiltrated into the ground or transported via a sewer to a (semi-)centralised treatment plant. Accumulating faecal sludge needs to be dug out the chamber regularly and correctly disposed of.

Further reading: http://www.sswm.info/category/implementation-tools/wastewater-treatment/hardware/site-storage-and-treatments/septic-tank



An anaerobic baffled reactor (ABR) is an improved Septic Tank with a series of baffles under which the grey-, black- or the industrial wastewater is forced to flow under and offer the baffles from the inlet to the outlet. The increased contact time with the active biomass (sludge) results in improved treatment. ABRs are robust and can treat a wide range of wastewater, but both remaining sludge and effluents still need further treatment in order to be reused or discharged properly.

Further reading: http://www.sswm.info/category/implementation-tools/wastewater-treatment/hardware/site-storage-and-treatments/anaerobic-ba



An anaerobic filter is a fixed-bed biological reactor with one or more filtration chambers in series. As wastewater flows through the filter, particles are trapped and organic matter is degraded by the active biomass that is attached to the surface of the filter material. Anaerobic filters are widely used as secondary treatment in household black- or greywater systems and improve the solid removal compared to septic tanks or anaerobic baffled reactors. Since anaerobic filters work by anaerobic digestion, they can be designed as anaerobic digesters to recover the produced biogas.

Further reading: http://www.sswm.info/category/implementation-tools/wastewater-treatment/hardware/site-storage-and-treatments/anaerobic-fi

Conveyance

Functional group

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Conveyance

- The way in which products are moved from one process to another.
- Products may need to be moved in various ways to reach the required process.
- The longest and most important gap lies between user interface and treatment stage.

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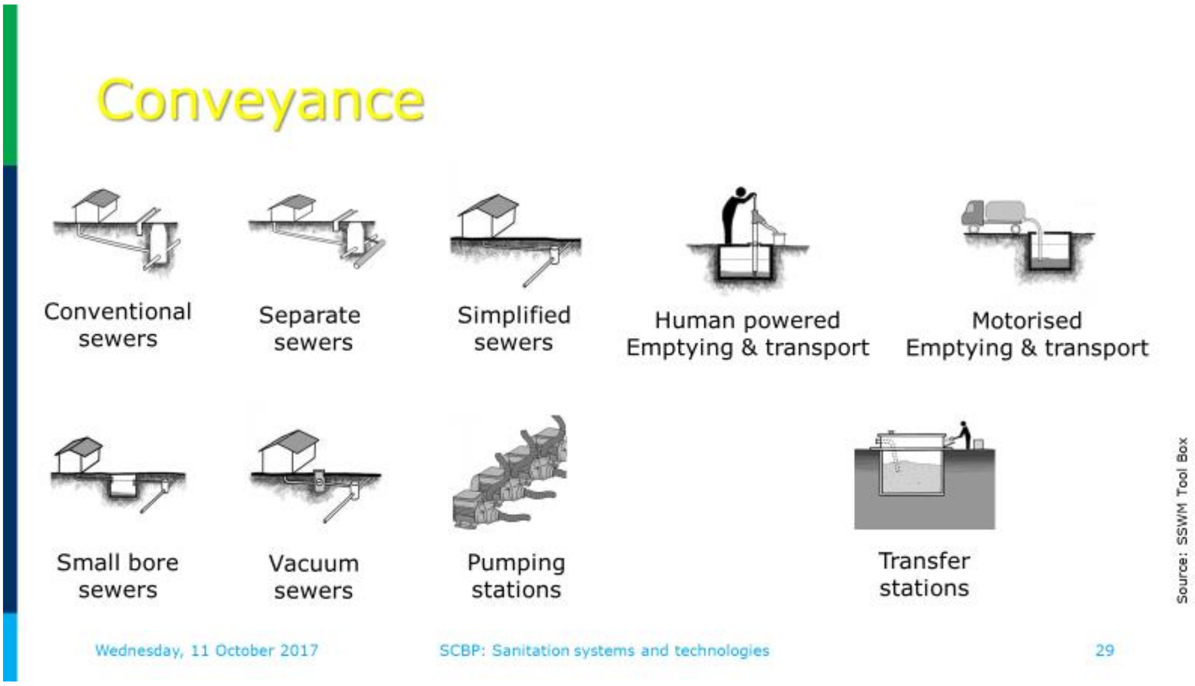
Conveyance describes the way in which products are moved from one process to another. Although products may need to be moved in various ways to reach the required process, the longest and most important gap lies between on-site storage and (semi-) centralised treatment. For the sake of simplicity, conveyance is thus limited to moving products at this point.



Technical and physical criteria

- Water availability
  - Centralized, decentralized and choice of conveyance
- Ground condition
  - Rocky and high water table increases cost of construction
- Groundwater level and contamination
  - Choice of conveyance

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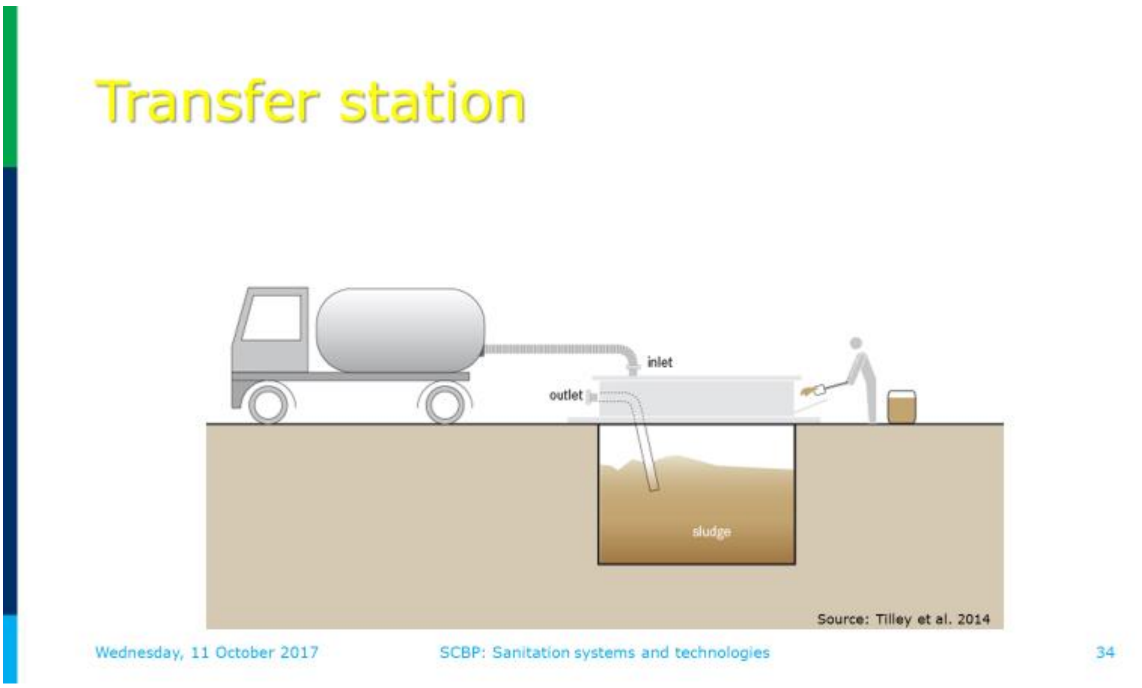
The technical and physical criteria for choosing appropriate conveyance technology/system are as follows; 1. Water availability, 2. Ground condition, 3. Ground water level and contamination.

Human-powered emptying and transport refers to the different ways in which people can manually empty and/or transport sludge and solid products generated in on-site sanitation facilities. It can be done by using buckets and shovels, or by manually operated pumps specially designed for faecal sludge. The advantages of manual emptying include the generation of income, low costs and the availability of tools, little or no requirement of electric energy. The large disadvantage that inheres manual emptying is the high health risk.

Further reading: http://www.sswm.info/category/implementation-tools/wastewater-collection/hardware/cartage/human-powered-emptying-and-tran

Manual sludge pumps like the Pooh Pump or the Gulper are relatively new inventions and have shown promise as being low-cost, effective solutions for sludge emptying where, because of access, safety or economics, other sludge emptying techniques are not possible. Sludge hand pumps work on the same concept as water hand pumps: the bottom of the pipe is lowered into the pit/tank while the operator remains at the surface. As the operator pushes and pulls the handle, the sludge is pumped up and is then discharged through the discharge spout. The sludge can be collected in barrels, bags or carts, and removed from the site with little danger to the operator. Hand pumps can be locally made with steel rods and valves in a PVC casing.

Motorized emptying and transport refers to a vehicle equipped with a motorized pump and a storage tank for emptying and transporting faecal sludge septage and urine. Humans are required to operate the pump and manoeuvre the hose, but sludge is not manually lifted or transported (see also human powered and transport. Motorised emptying and transport, is fast and generally efficient. Moreover, it can generate local jobs. But large streets are required for the trucks to pass, thick or dried material cannot be pumped and garbage in pits may block the hose. Moreover, capital costs are high and spare parts may be not available locally.



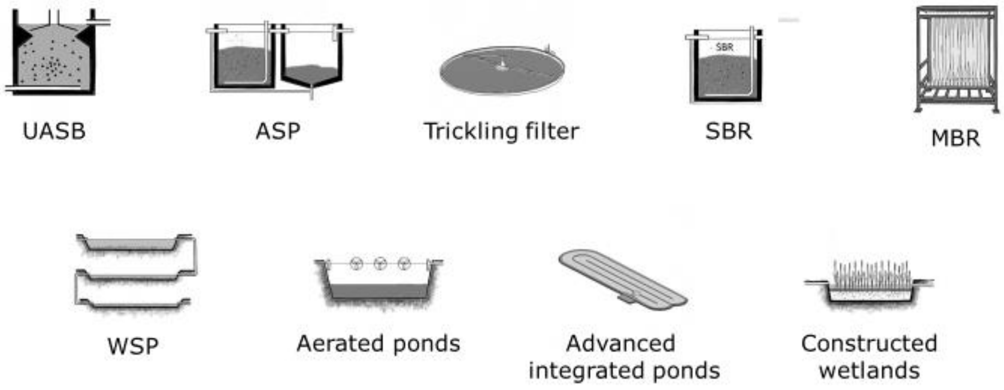
Sludge and septage emptied from on-site sanitation systems need to be transferred to (semi-)centralised infrastructures for further treatment. Transfer stations or underground holding tanks act as intermediate dumping points for faecal sludge and septage when it cannot be easily transported to a (Semi-) Centralized Treatment facility. A vacuum truck is required to empty transfer stations when they are full. Sewer discharge stations are similar to transfer stations, but instead of simply being a holding tank, the stations are directly connected to the sewer transporting the sludge to a (semi-) centralised treatment facility. Transfer stations reduce transport distance, may encourage more community-level emptying solutions and prevent illegal dumping. The moderate capital costs may be offset with access permits and the construction and maintenance can create local income. However, expert design and construction supervision are necessary.

Further reading: http://www.sswm.info/category/implementation-tools/wastewater-collection/hardware/sewers/transfer-stations

Semi-Centralised Treatment

- Are larger in size.
- Require a greater inflow.
- More skilled operation.
- WSP, Aerated lagoons, ASP, SBR, MBBR, FBR, UASB, Anaerobic treatment, Constructed wetlands etc.

Semi-Centralised Treatment



Source: SSWM Tool Box

Technical and physical criteria

- Availability of space and other resources (Choice of technology)
- Climate (Temperature affects rate of reactions)
- Ground condition (Flood prone area)
- Groundwater level and contamination (Cross contamination from tanks underground)

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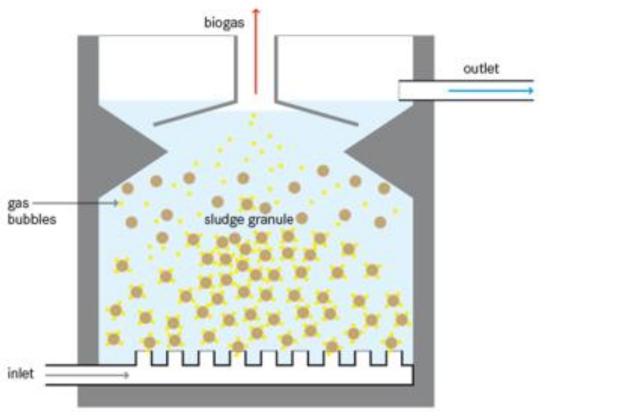
The technical and physical criteria for choosing appropriate technology for treatment are as follows; 1. Climate, 2. Availability of space, 3. Ground condition, 4. Ground water level and contamination.

UASB Reactor



Source: Tilley et al. 2008

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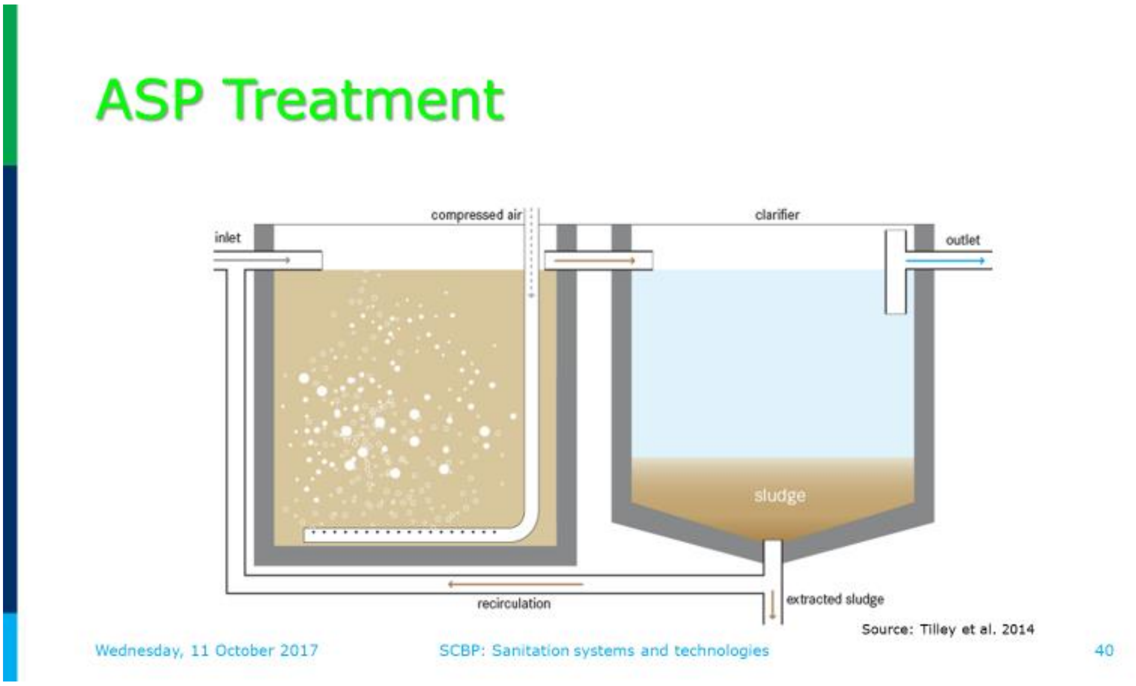
The upflow anaerobic sludge blanket reactor (UASB) is a single tank process in an anaerobic centralised or decentralised industrial wastewater or blackwater treatment system achieving high removal of organic pollutants. Wastewater enters the reactor from the bottom, and flows upward. A suspended sludge blanket filters and treats the wastewater as the wastewater flows through it. Bacteria living in the sludge break down organic matter by anaerobic digestion, transforming it into biogas. Solids are also retained by a filtration effect of the blanket. The upflow regime and the motion of the gas bubbles allow mixing without mechanical assistance. Baffles at the top of the reactor allow gases to escape and prevent an outflow of the sludge blanket. As all aerobic treatments, UASB require a post-treatment to remove pathogens, but due to a low removal of nutrients, the effluent water as well as the stabilised sludge can be used in agriculture.

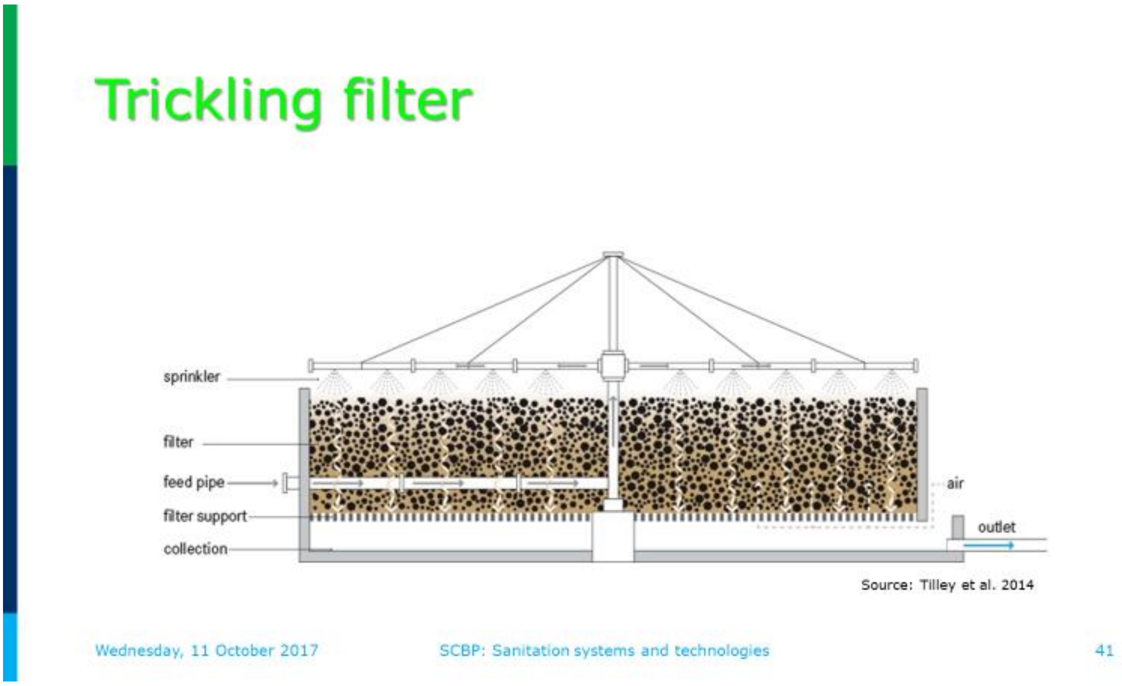
Further reading: http://www.sswm.info/category/implementation-tools/wastewater-treatment/hardware/semi-centralised-wastewater-treatments/u



An activated sludge process refers to a multi-chamber reactor unit that makes use of highly concentrated microorganisms to degrade organics and remove nutrients from wastewater to produce a high-quality effluent. To maintain aerobic conditions and to keep the activated sludge suspended, a continuous and well-timed supply of oxygen is required.

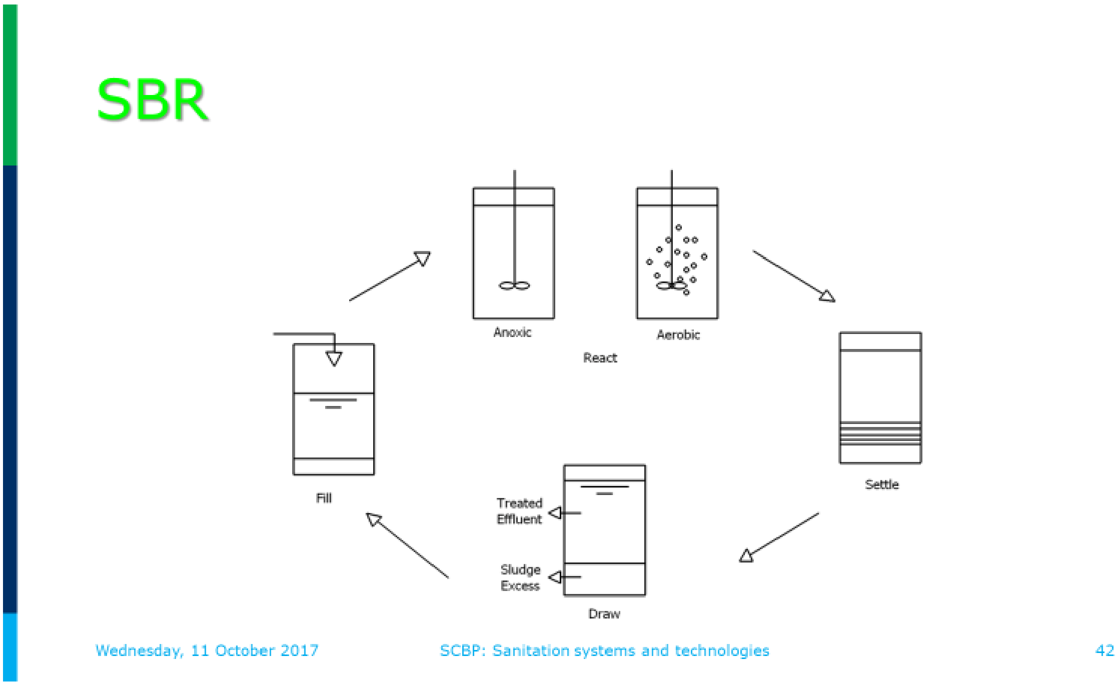
Activated sludge consists of flocs of bacteria, which are suspended and mixed with wastewater in an aerated tank. The bacteria use the organic pollutants to grow and transform it to energy, water, CO2 and new cell material. Activated sludge systems are suspended-growth type and are used in conventional high-tech wastewater treatment plants to treat almost every wastewater influent as long as it is biodegradable. A physical pre-treatment unit, a post-settling unit (a clarifier) from which active sludge is re-circulated to the aerated tank, and excess sludge treatment, are compulsory for appropriate treatment. The process is highly mechanised and thus mainly adapted for centralised systems where energy, mechanical spare parts and skilled labour are available. Provided the reactor is well operated, a very good removal of organics and suspended solids can be achieved, though pathogen removal is low.

Further reading: http://www.sswm.info/category/implementation-tools/wastewater-treatment/hardware/semi-centralised-wastewater-treatments-3



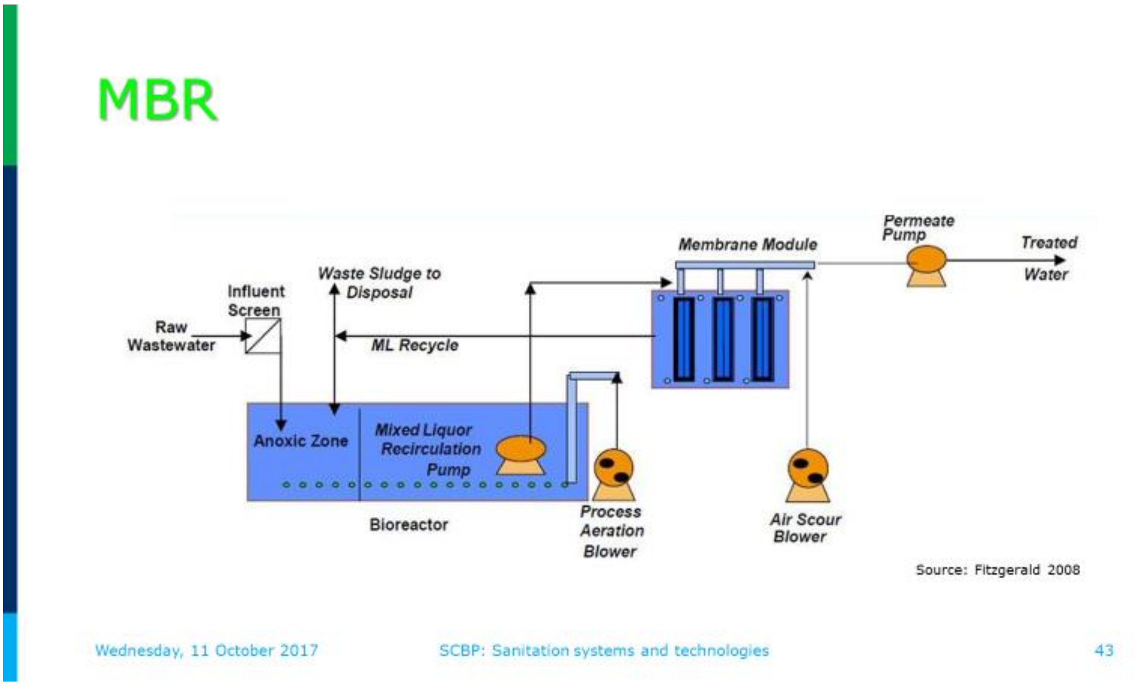
A trickling filter, also called trickling biofilter, biofilter, biological filter and biological trickling filter, is a fixed-bed, biological reactor that operates under (mostly) aerobic conditions. Pre-settled wastewater is continuously 'trickled' or sprayed over the filter. As the water migrates through the pores of the filter, organics are aerobically degraded by the biofilm covering the filter material.

Further reading: http://www.sswm.info/content/trickling-filter

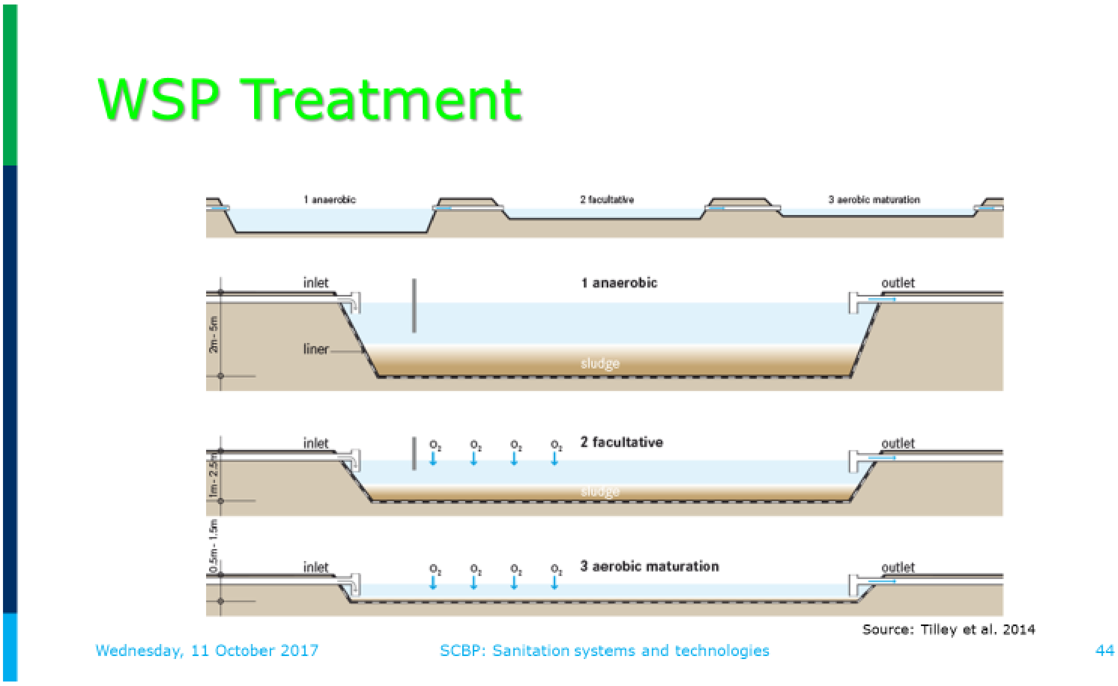


Activated sludge reactors are aerobic suspended-growth type processes. Large amounts of injected oxygen allow maintaining aerobic conditions and optimally mixing the active biomass with the wastewater to be treated. Activated sludge systems are highly efficient for organic matter and nutrient removal, though pathogen removal is low. In the view of reuse of the effluent in agriculture, it is not beneficial to remove all nutrients while standards for pathogen removal are barely met.

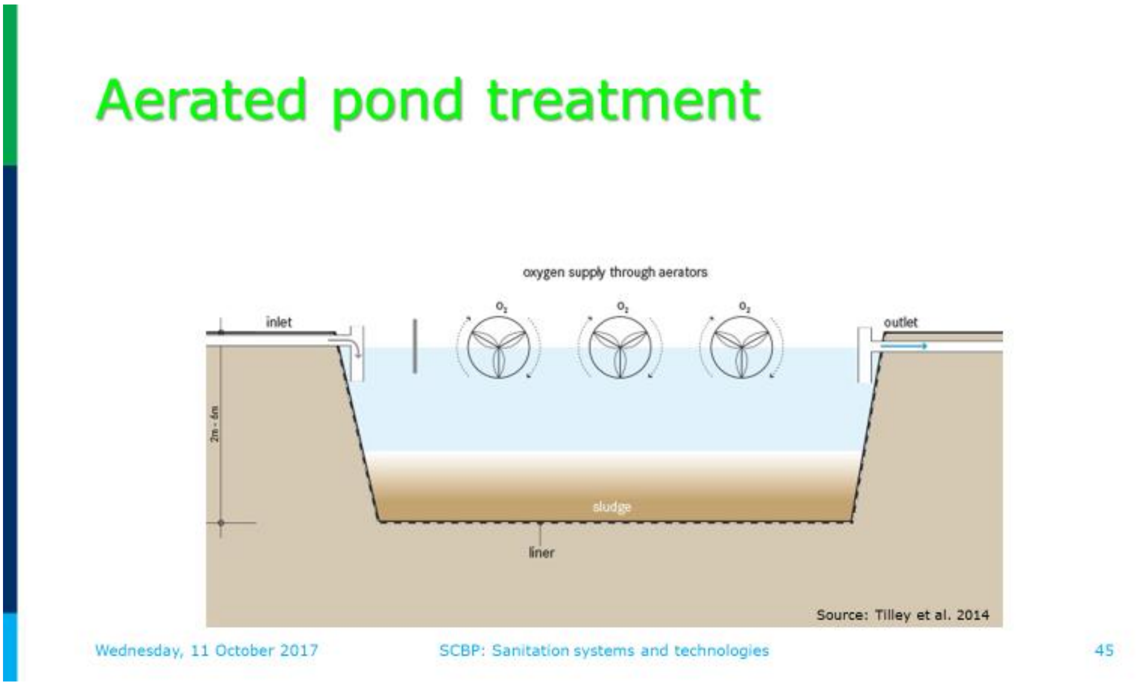
Further reading: http://www.sswm.info/category/step-nawatech/m1-nawatech-basics/appropriate-technologies/appropriate-technologies/conten-8



Membrane Bioreactors (MBR) are treatment processes, which integrate a perm-selective or semi-permeable membrane with a biological process (JUDD 2011). It is the combination of a membrane process like microfiltration or ultrafiltration with a suspended growth bioreactor, and is now widely used for municipal and industrial wastewater treatment with plant sizes up to 80’000 population equivalents. Due to it being a very technical solution; it needs expert design and skilled workers. Furthermore, it is a costly but efficient treatment possibility. With the MBR technology, it is possible to upgrade old wastewater plants.

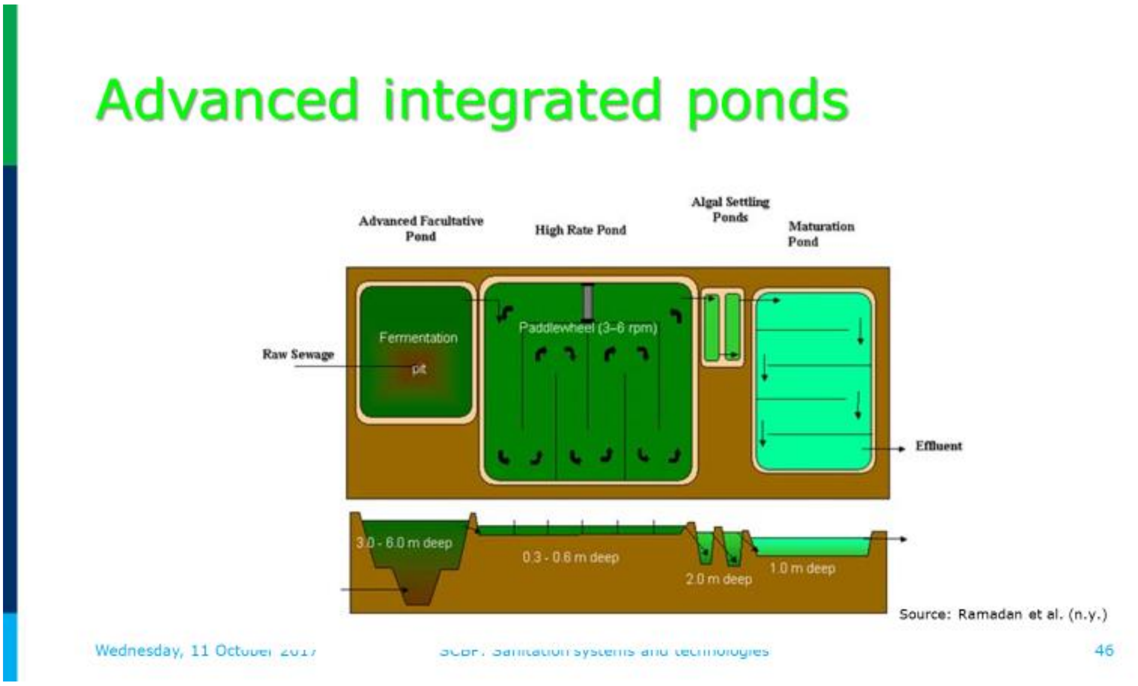


Waste or Wastewater Stabilization Ponds (WSPs) are large, man-made water bodies in which blackwater, greywater or faecal sludge are treated by natural occurring processes and the influence of solar light, wind, microorganisms and algae. The ponds can be used individually, or linked in a series for improved treatment. There are three types of ponds, (1) anaerobic, (2) facultative and (3) aerobic (maturation), each with different treatment and design characteristics. WSPs are low-cost for O&M and BOD and pathogen removal is high. However, large surface areas and expert design are required. The effluent still contains nutrients (e.g. N and P) and is therefore appropriate for the reuse in agriculture, but not for direct recharge in surface waters.

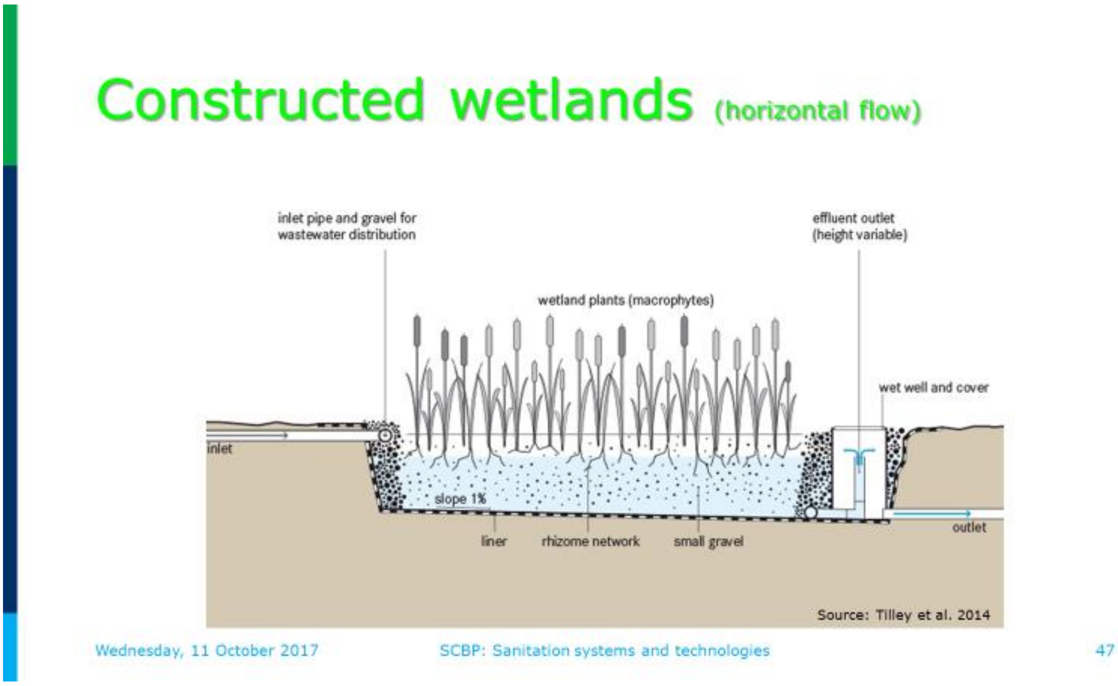


An aerated pond is a large, mixed aerobic reactor similar to facultative ponds in waste stabilization pond systems, with the difference that natural oxygenation is enhanced. Mechanical aerators provide oxygen and keep the aerobic organisms suspended and mixed with water to achieve a high rate of organic degradation. As natural oxygenation is enhanced, ponds can be deeper (thus smaller in surface) and are suited also for colder climates compared. There are two types of aerated ponds: common aerated lagoons (enhanced facultative ponds) and completely mixed aerated ponds are in essence activated sludge systems without sludge. The effluent of aerated ponds may be reused or used for recharge, but settled sludge requires a further treatment or correct disposal.

Further reading: http://www.sswm.info/category/implementation-tools/wastewater-treatment/hardware/semi-centralised-wastewater-treatments-0

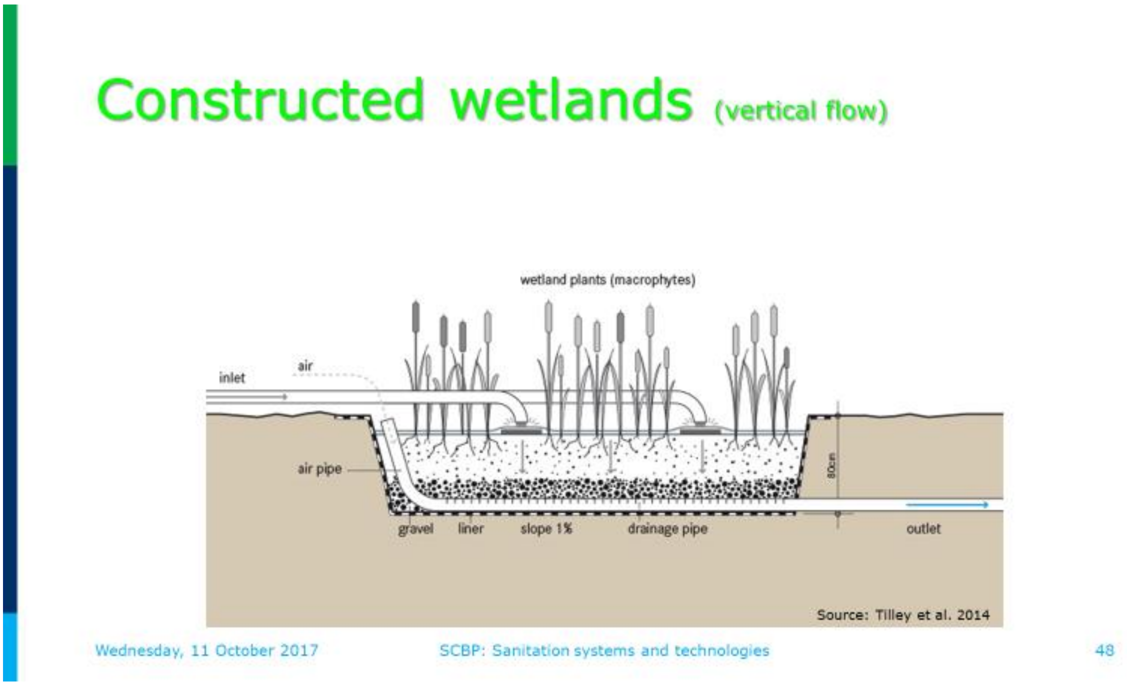


Advanced integrated wastewater pond systems (AIWPS), advanced integrated pond systems (AIPS) or advanced integrated ponds (AIPs) are an adaptation of waste stabilisation ponds (WSPs) systems based on a series of four advanced ponds: (1) An advanced facultative pond (AFP) containing a digester pit, which functions much like an anaerobic pond; (2) a high rate pond (HRP) covered with algae, similar to the facultative pond, which provide oxygen to aerobic bacteria for BOD oxidation and take up nutrients and further organics; (3) an algal settling pond (ASP); (4) and finally a maturation pond (MP) for solar disinfection and pathogen abatement. The effluent from the MP can be reused for agri- or aquaculture and the nutrient rich algae can be applied as fertilizer or used as animal feed.



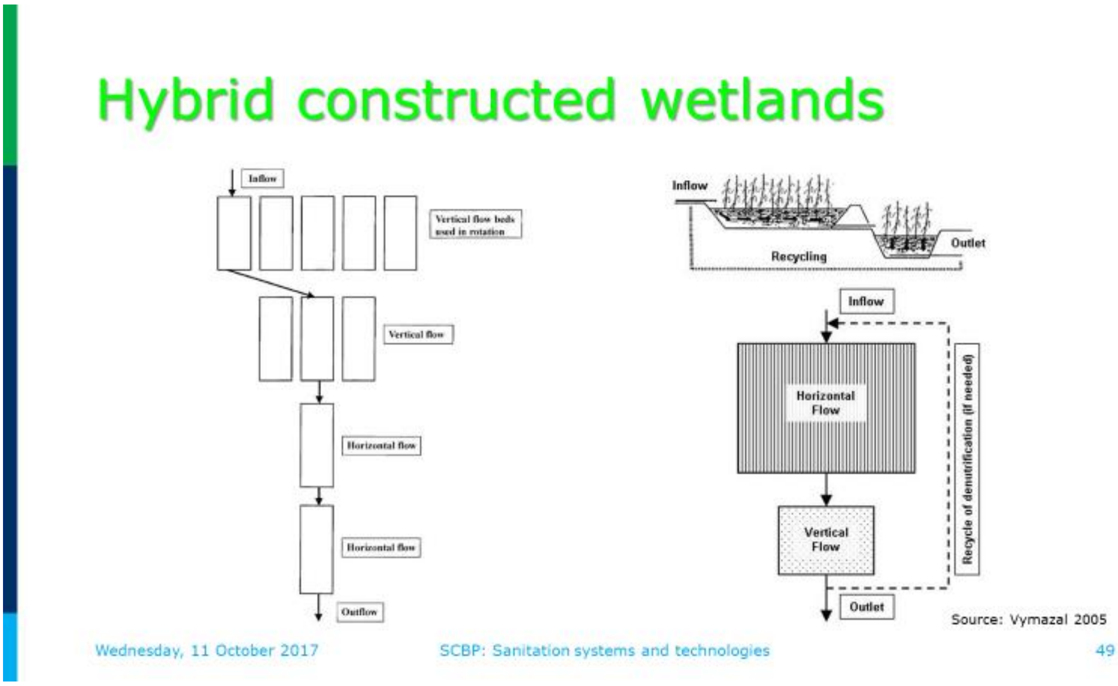
A horizontal subsurface flow constructed wetland (horizontal subsurface flow CW) is a large gravel and sand-filled basin that is planted with wetland vegetation. It is used for secondary or tertiary treatment of wastewater (e.g. greywater or blackwater). Solids are removed in a primary treatment (e.g. in a septic tank or imhoff tank). As wastewater flows horizontally through the basin, the filter material filters out particles and microorganisms degrade the organics. The effluent of a well-functioning constructed wetland can be used for irrigation and aquaculture or safely been discharged to receiving water bodies. Design and implementation requires expert knowledge. Horizontal flow CW are relatively inexpensive to build where land is affordable and can be maintained by the local community as no high-tech spare parts, electrical energy or chemicals are required.

Further reading: http://www.sswm.info/category/implementation-tools/wastewater-treatment/hardware/semi-centralised-wastewater-treatments/h



A vertical flow constructed wetland (vertical flow CW) is a planted filter bed for secondary or tertiary treatment of wastewater (e.g. greywater or blackwater) that is drained at the bottom. Pre-treated Wastewater (e.g. from a septic tank or an Imhoff tank) is poured or dosed onto the surface from above using a mechanical dosing system. The water flows vertically down through the filter matrix to the bottom of the basin where it is collected in a drainage pipe. The water is treated by a combination of biological and physical processes. The filtered water of a well-functioning constructed wetland can be used for irrigation, aquaculture, groundwater recharge or is discharged in surface water. To design a vertical flow constructed wetland, expert knowledge is recommended. They are relatively inexpensive to build where land is affordable and can be maintained by the local community. The important difference between a vertical and horizontal wetland is not simply the direction of the flow path, but rather the aerobic conditions.

Further reading: http://www.sswm.info/category/implementation-tools/wastewater-treatment/hardware/semi-centralised-wastewater-treatments/v



Different types of constructed wetlands can be combined in order to achieve a higher treatment efficiency by using the advantages of individual systems. Most hybrid constructed wetlands combine vertical filter and horizontal filter stages. The vertical- horizontal filter system was originally designed in the late 1950s and the early 1960s but the use of hybrid systems was very limited. In the 1980s hybrid constructed wetlands were built in France and United Kingdom. At present, hybrid constructed wetlands are in operation in many countries around the world. They need expert design, but they can be built mostly with locally available material and the community can be trained for operation and maintenance. The effluent can be used for e.g. irrigation and aquaculture or safely be discharged to receiving water bodies.

Further reading: http://www.sswm.info/category/implementation-tools/wastewater-treatment/hardware/semi-centralised-wastewater-treatments-2

Use and/or disposal

Functional group

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Use and/or disposal

- The ways in which products are ultimately returned to the soil, either as harmless substances or useful resources.
- Products can also be re-introduced into the system as new products.
- Products - Dehydrated faeces, Sterilized urine, Treated wastewater, Treated sludge

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Use and/or disposal refers to the ways in which products are ultimately returned to the soil, either as harmless substances or useful resources. Furthermore, products can also be re-introduced into the system as new products. A typical example is the use of partially treated greywater used for toilet flushing.

Agriculture: The dried faecal matter is used as soil conditioner in agriculture. The soil conditioner improves the texture of the soil and helps to increase the moisture retention capacity of the soil. The sterile urine after disinfection is used as fertilizer in the agriculture. Urine as a liquid fertilizer contains high amount of nitrates and phosphates which can reduce the consumption of inorganic fertilizers.

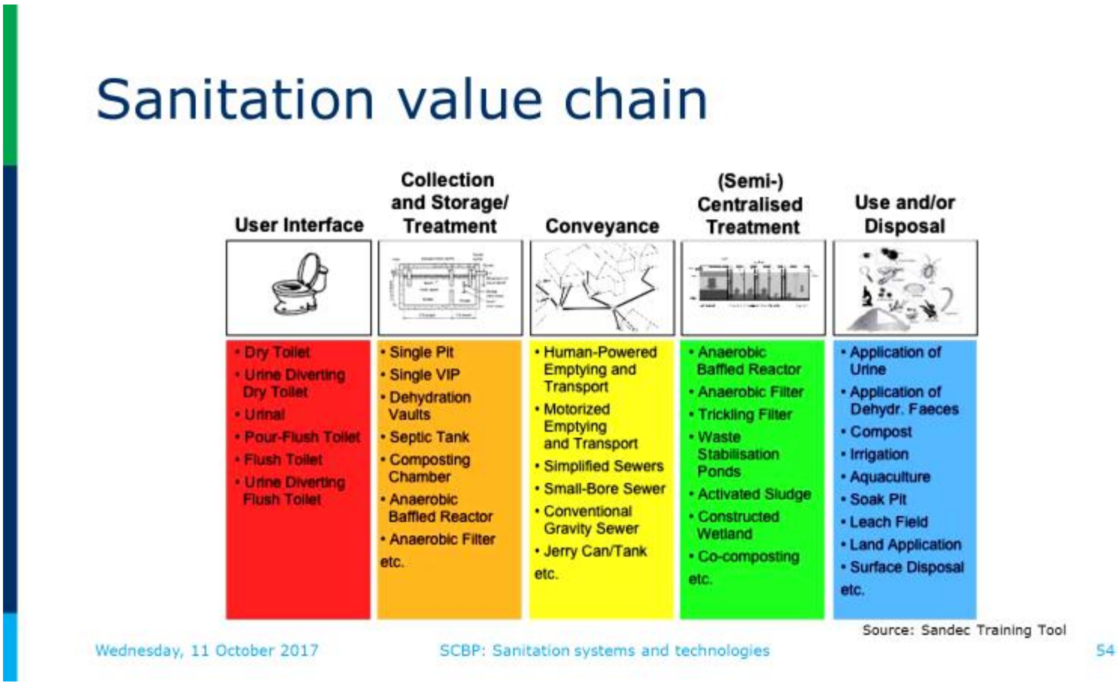
Aquaculture: The term aquaculture refers to the controlled cultivation of aquatic plants and animals by making use of various types of wastewater as a source for nutrients and/or warm temperatures for plants and fish to grow. Fish can be grown in ponds that receive effluent or sludge where they can feed on algae and other organisms that grow in the nutrient-rich water. The fish, thereby, remove the nutrients from the wastewater and are eventually harvested for consumption. You can also read the description of plant aquacultures.

Recharge or disposal: This can be done is several ways. The most common way is to have a leach field of soak pit. However, there are other ways like soil aquifer treatment, short crop rotation which are popular in other countries and utilize the treated wastewater in most sophisticated way.

Energy products from sludge: The sludge can be processed to make solid or liquid fuel depending on treatment process used. The biogas generated through anaerobic digestion can be directly used as liquid fuel or alternatively converted into electricity. Dried sludge can also be used as solid fuel in furnaces or brick kiln due to its high calorific value.

Further reading: http://www.sswm.info/category/implementation-tools/reuse-and-recharge

3.1.3 Sanitation Systems



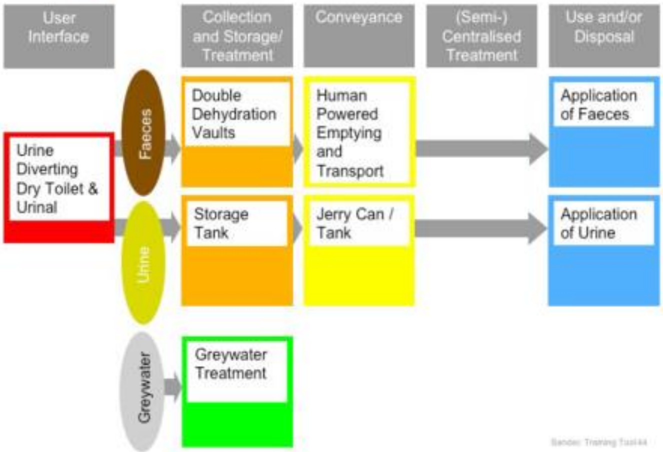
A sanitation system has to manage all the waste products generated.

Waste products should be processed from "from cradle to grave".

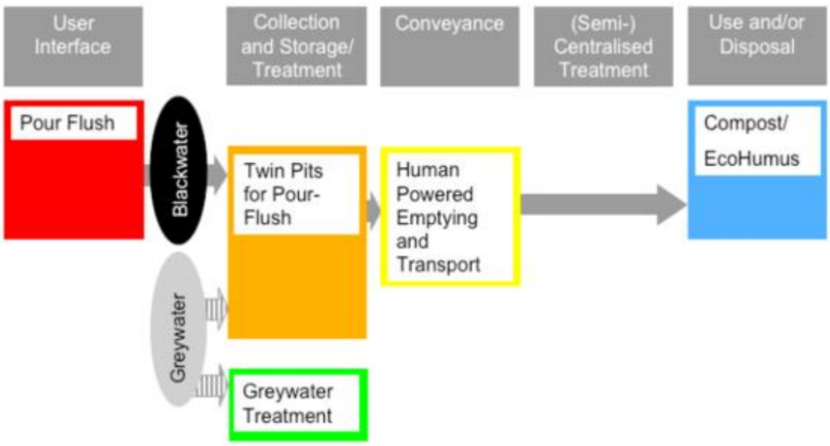
Appropriate systems and technologies have to be identified based on technical, social, economic, and resource aspects.

The most site-specific system option has to be selected on a case-to-case basis.

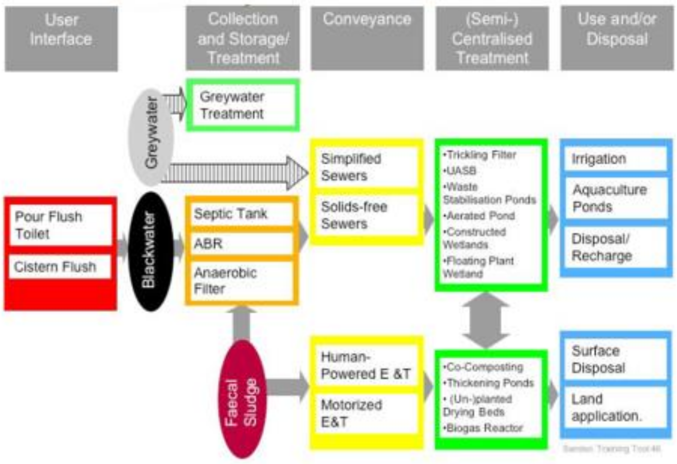
Case 1
Waterless system with urine diversion



Case 2
Water based, alternating double pit



Case 3
Water based, small bore system



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3.1.4 Emergency Sanitation Infrastructure

Emergency sanitation

- Aim is to minimize faecal oral transmission of disease.
  - Away from water sources,
  - Away from cultivated fields.
- Immediate sanitation measures and technologies are available that would otherwise not be recommended in normal situations.
- The technologies and service coverage is then improved incrementally step by step.

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Where indiscriminate open defecation is practised, the first step in excreta disposal is to provide designated defecation sites and remove the scattered faeces. It is essential to minimise the spread of faecal-oral disease. Faeces can be covered with lime and should be removed to a safe disposal site such as a pit. Workers must be provided with appropriate tools and protective clothing.

The population must be discouraged from defecating in or close to streams, ponds, any other water source or on cultivated fields.

Structures dealing with excreta will have to be provided. Since it is generally not possible to construct adequate structures in sufficient numbers straight away, the situation has to be improved gradually.

Implementation of sanitation structures (in order of low preference (easily installed) to high preference (more demanding to install):

Open defecation fields:

Advantages: Implemented rapidly, Minimal resources required, Minimises indiscriminate open defecation

Disadvantages: Lack of user privacy, Considerable space required, Difficult to manage, Potential for cross-contamination of users, More suitable for hot dry climates

Trench defecation:

Advantages: Implemented rapidly, Faeces can be covered easily with soil

Disadvantages: Limited privacy, Short life-span, Considerable space required

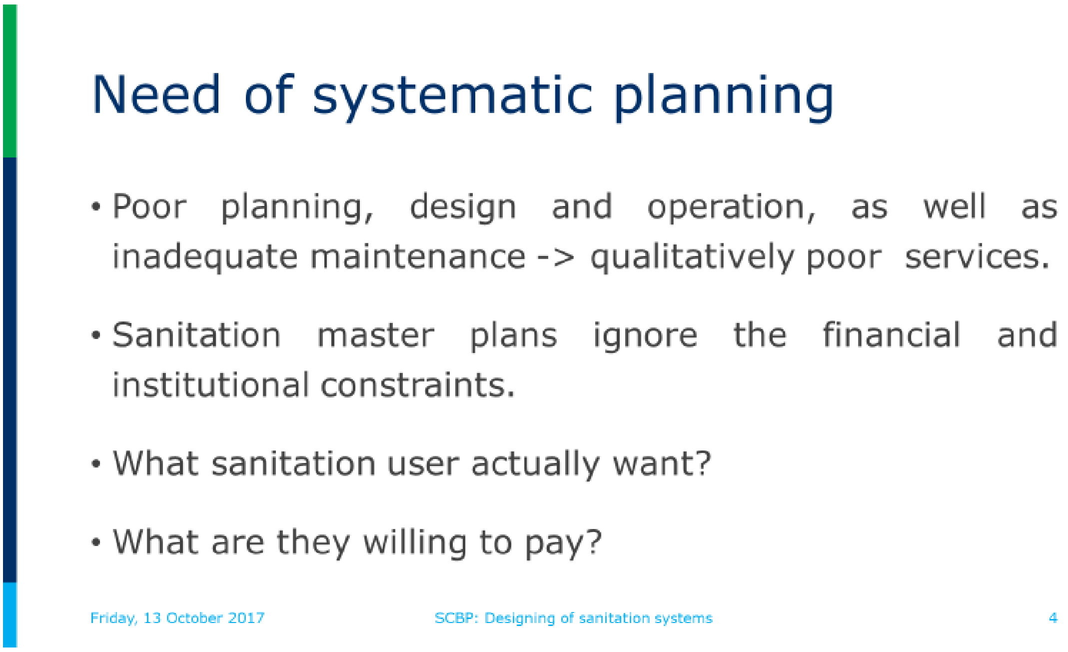
Communal trench latrine is improved version for trench defecation, where partitions are provided.

Communal pit latrines are conventional pit latrines which are shared by group of people.

Household pit latrine is the ultimate stage where emergency sanitation infrastructure should progress in order to reduce its impact on the environmental health.

4 DESIGNING OF SANITATION SYSTEMS

4.1.1 Systematic Planning



Poor planning, design and operation, as well as inadequate maintenance mean that the services in place are often also qualitatively poor. Most sanitation master plans have paid insufficient attention to financial and institutional constraints and have tended to ignore what sanitation users actually want and are willing and able to pay.

Planning model

Over riding principal	Bureaucratic organisation attempting to apply rationality of a higher order to people's behaviour
Decision makers	Administrators, engineers, public officials
Criteria for decisions	Policy and conformity to a plan
Guides for behaviour	Targets, regulations and technical standards
Sanctions	Government authority backed by coercion
Mode of operation	Top-down

(McGranahan et al., 2001)

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In the traditional planning approach, utility planners develop demand projections based on demographic and economic progress indicators. Sector professionals then translate these projections into hypothetical demand for new services, and subsequently decide on the type of service to be provided. For the growing number of western 'development' experts, government infrastructure investment in the emerging low-income countries was an attractive way of priming the engine of growth of the 'underdeveloped' countries. Development aid also fostered a top-down approach to sanitary improvement. Urban water and sanitation projects were visible, and their benefits were generally accepted. To this day, infrastructure planning and service delivery continue to be supply-driven with a high degree of centralised control, little local accountability and low consumer involvement

Market approach

Over riding principal	**Market processes relying on the market to transform individual preferences into aggregate outcomes.**
Decision makers	Individuals, households, vendors, enterprises
Criteria for decisions	Efficiency, maximisation of profit or utility
Guides for behaviour	Price signals, incorporating taxes and subsidies
Sanctions	Financial loss
Mode of operation	Individualistic

(McGranahan et al., 2001)

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In the simplest version of market-oriented sanitary improvement, competing suppliers offer a range of services and technologies, and local residents pay only for those best meeting their needs and budget. It is up to the residents to decide whether it is worth buying more water or more food, whether to spend more on improving the structure of the house or the toilet, to invest more money and effort into waste disposal or into transport, and so on. In an idealised vision of a perfect market economy, the government plays a minor or no role beyond protecting property rights. Economic affluence, technological options and residents' preferences determine sanitary conditions.

In practice, the market approach to sanitary improvement typically concentrates on increasing the role of market mechanisms, but not to the point of eliminating the role of the government. Numerous different forms of private sector involvement in water and sanitation have been identified. Much of the academic discussion on privatisation revolves around different combinations of private and public management and regulation, on the characteristics of particular components of water and sanitation provisioning systems and on the appropriate roles for private enterprise and the public sector.

Collective action model

Over riding principal	Neighbours organise themselves and demand or negotiate sanitary improvements.
Decision makers	Leaders and members of grass-root organisations
Criteria for decisions	Interests of members and visions of leader
Guides for behaviour	Agreements and accepted goals
Sanctions	Social pressure
Mode of operation	Bottom-up

(McGranahan et al., 2001)

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This approach involves a far greater participation of users and other stakeholders in planning and implementing water and sanitation projects than the previously described approaches. In the simplest version of the collective action model, residents organise, decide on the type of sanitary improvements required, as well as determine how to achieve and implement them. Compared to the planning model, it is the residents' concerns rather than paternal or expert opinions that guide the improvement effort in this model. Thus, the local collective action model is usually seen to correspond to what has been termed 'bottom-up', as opposed to 'top-down' development strategies.

When, in the absence of government action, residents get together to build a communal toilet, improve the local drainage or arrange to have waste removed, the adopted steps correspond to the collective action model. A more attenuated version of the collective action model is when residents collectively negotiate with public utilities, other government authorities or private sector actors for better service.

What is the best planning model?

- Market based approach- market should be able to provide services which consumer wants at price they are willing to pay.
- Collective action model- services are provided through efforts of voluntary organisations.
- Reduces burden on the ULB but allow limited resources to extend further.

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Those who advocate a market-based approach argue that since people are consumers of sanitation services, the market should be able to provide them with the services they want at a price they are willing to pay.

Others advocate a collective action model in which improved facilities are provided through the efforts of voluntary organisations. Both these approaches reduce the direct burden on the state and, hence, allow limited resources to extend further. However, both also have their limitations.

Framework for strategic planning

STEP 1

- Where are we now? – Grounding plans of current situations.
  - What already exists?
  - Respond to actual problems and deficiencies.

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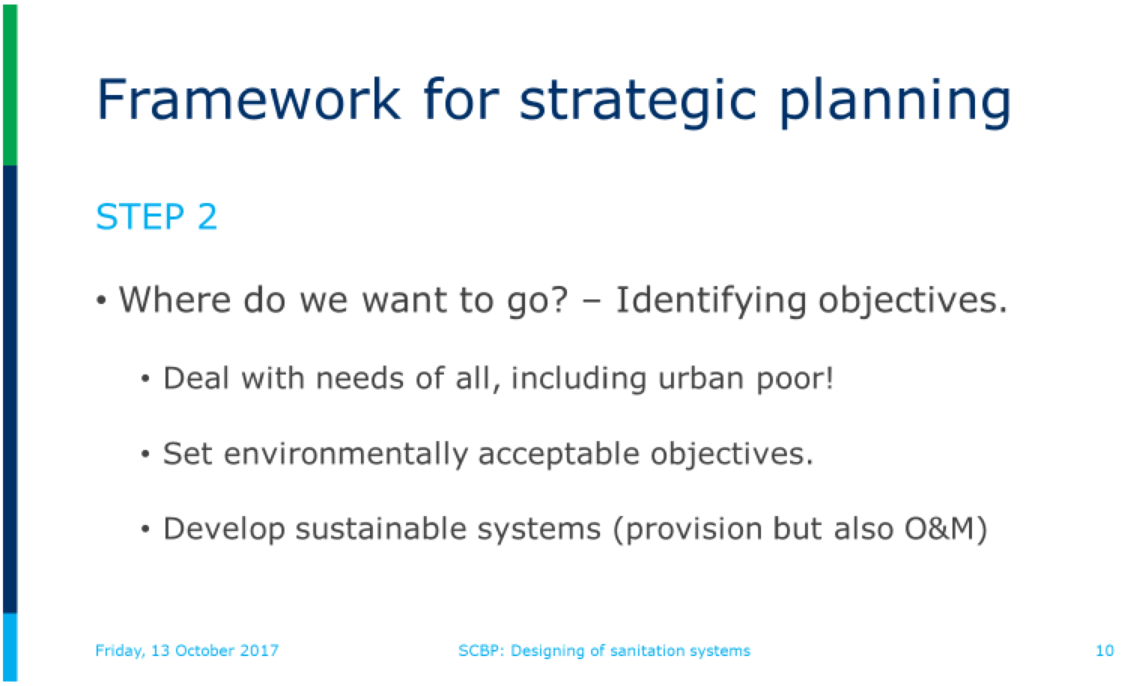
The first step necessarily includes;

1) Collection of base line data and to assess the service level benchmarking.
2) Identifying the systems and the water and nutrient flow in the local systems. If the need be a bigger system can be classified into smaller system for better and deeper analysis of the current situation.
3) While doing so identifying the actual problems faced by the population, the root cause of the problems.



After identifying the problems and their root causes, one needs to set the aims and objectives of the whole process.

1. The targets should include the needs of all the categories of demography of the city, especially the urban poor.
2. The targets set should be environmentally acceptable. Example: If the treated wastewater is disposed into surface water bodies, the nitrates and phosphates should be monitored. In terms of quantity, adequate amount of treated wastewater ought to be put back into the natural water system to sustain its ecological services.

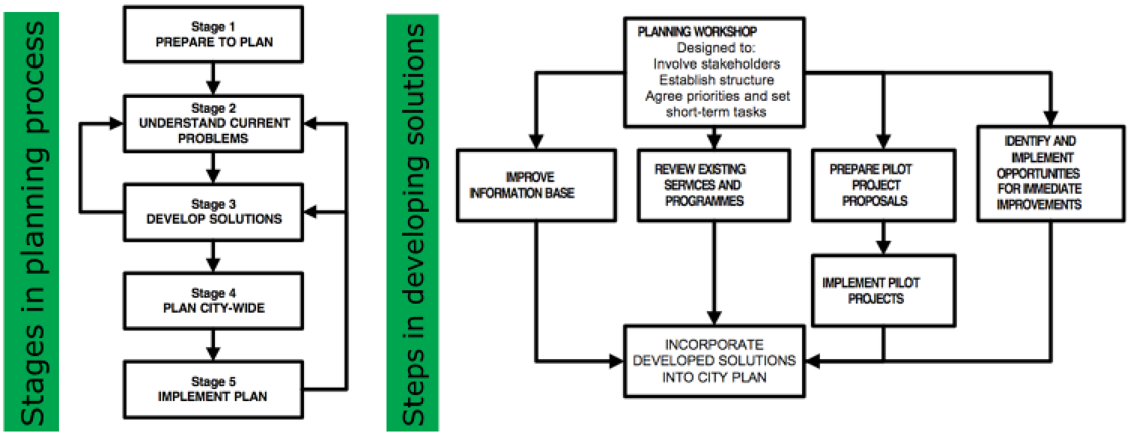
3. Sustainable systems should be identified. While doing so importance should be given to the operation and maintenance cost, since this cost has to be borne by the ULB.

Once the targets are set, methodology to implement the strategies should be identified.

The ultimate focus of the process should be to improve the sanitation services without burdening the ULB too much.

The plans should be flexible and adaptable so as to accommodate any change in the ground situation. If the need be, the plans should also be revised according to the developments happening in the system.

City sanitation plan



Points to ponder!

To what extent can the planning process be outsourced to local partner? What are relevant criteria?

Key take away points!

- There is no “Best Planning Model”. Different approaches can compliment each other.

- Sanitation programs should respond to local demand and build on existing infrastructure.

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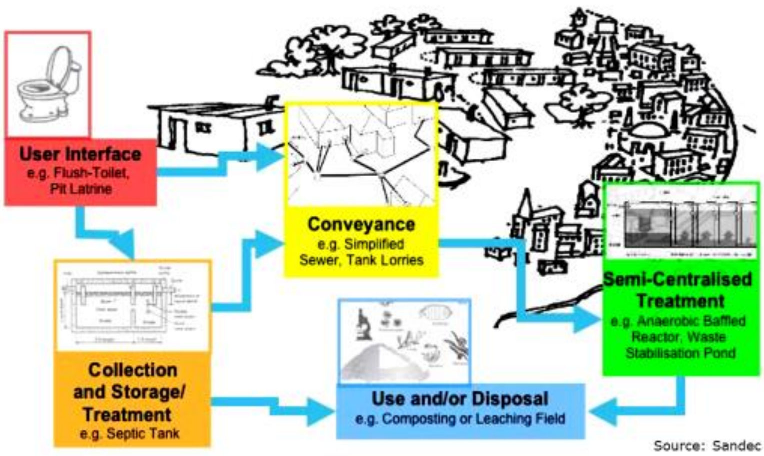
A review of existing models suggests that no single approach to sanitation provision can address all aspects of the problem, irrespective of whether it is based on planning, the market, local or collective initiatives. The question is not “which is the best model”, but rather how to combine planning, market-oriented aspects and local initiatives into strategies making best use of all three.

4.1.2 Designing of Sanitation Systems

Functional groups



Source: Sandec Training Tool

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All sanitation systems start with User Interface. From this the product either goes to Collection and Storage/Treatment group or to Conveyance. This mainly depends on whether there is adequate supply of water available for water based system.

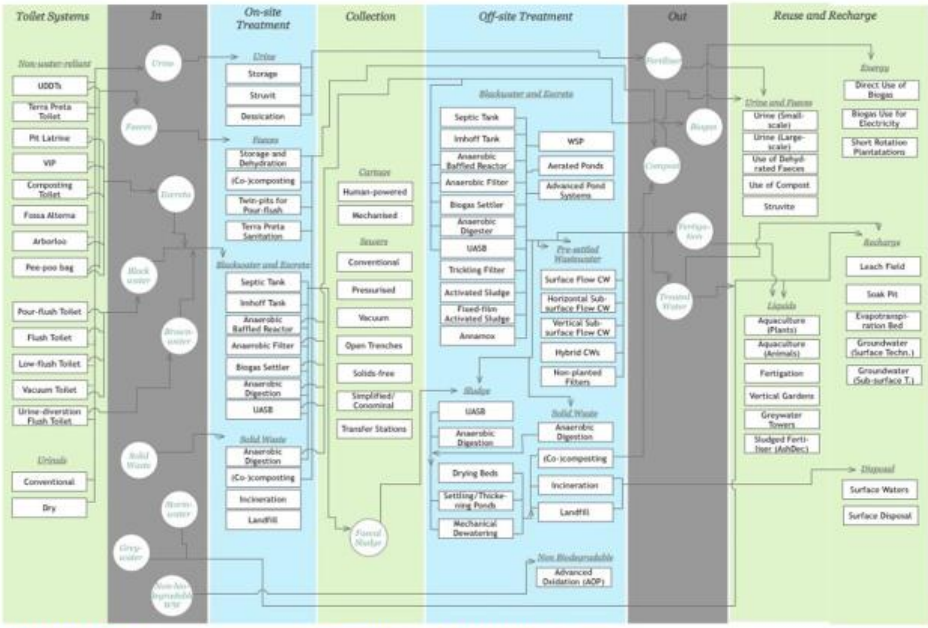
After conveyance the products flow in the Centralised Treatment function group, where the products are treated before moving on to Use/Disposal group. The product though Collection and Storage/Treatment also end up into Use/Disposal functional group.

Depending on the system, not every Functional Group is required.

An ideal system should manage all the waste products which are generated in the built environment.

A system is a set of technologies, each processing the products until they are ultimately disposed of. In other words, processing all the waste products "from cradle to grave" should be considered.

The ideal system accommodates the existing infrastructure and compliments it.



Source: Sphuler 2010

Points to ponder!

Who should choose the technology options and based on what criteria?

For identifying an appropriate system, local needs, demands and habits are to be assessed. The very important functional group is the "User Interface" because this decides the number and characteristics of the waste.

Though the system templates (i. e. groups of processes and products) are predefined, the exact system and favoured technologies still have to be selected from among the options provided.

The choice is context-specific and should be made on the basis of the local environment, culture and resources. Despite the different technology options available, a comprehensive study of the specific situation is necessary prior to making the final decision.

The appropriate system

The most site-specific system option has to be selected on a case-to-case basis.

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The appropriate option in each functional group has to be chosen site specific and might vary from case to case basis. Successful systems should be adopted and not copied as this ensures the sustainability of the solutions in long term.

4.1.3 Decentralized Systems

Shift in paradigm

- Water borne sanitation system - densely populated areas of industrialised countries.
- In developing countries - urgent need for affordable and sustainable infrastructure.
- There is a need in shift of approach.

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The conventional, centralised wastewater management concept, consisting of a water-borne wastewater collection system leading to a central treatment plant, has been successfully applied over many decades in densely populated areas of industrialised countries and has greatly contributed to improving the hygienic conditions in these areas. However, the appropriateness of this model in the context of cities in developing countries must be questioned, given their urgent need for affordable and sustainable infrastructure.

Aside from its proven benefits, the centralised wastewater management system is nothing more than a transport system for human excreta and industrial waste to a central discharge point or a treatment system. By using valuable drinking water as transport medium, this system is wasteful of water and nutrients that could otherwise be easily treated and reused.

A centralised wastewater management system reduces wastewater reuse opportunities and increases the risk to humans and the environment in the event of system failure.

In the past, conventional thinking favoured centralised systems since they are easier to plan and manage than decentralised treatment units. This belief is partly true if municipal administration systems are centralised. However, experience reveals that centralised systems have been particularly poor at reaching peri-urban areas and informal settlements.

Centralised treatment systems are usually much more complex and require professional and skilled operators. Operation and maintenance of centralised systems must be financed by the local government often unable or unwilling to guarantee regular operation.

Limitations of centralised systems

Engineering solution based on centralised systems built and maintained by subsidised public agencies are inappropriate to the extraordinary pace and character of the urbanisation process in the developing world.

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Features of decentralised systems

- Reduces risks associated with system failure.
- Allows segregation of waste streams and local reuse.
- Increases responsiveness to local demands – needs.
- Permits tailormade solutions.
- Minimises the freshwater requirements.
- Allows incremental development and investment.

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Decentralised wastewater management decreases the risk associated with system failure. The probability of simultaneous failure of many small systems is significantly lower than failure of one system serving the entire community.

Decentralised treatment processes can be tailored to the quality of the wastewater stream generated by each separate subsystem and to the effluent quality required. The treatment requirements will vary considerably depending on the final destination of the treated wastewater (e. g. agricultural reuse, discharge into water bodies, infiltration).

Decentralised management increases wastewater reuse opportunities by keeping the wastewater as close as possible to the generating community. Demand for treated liquid waste in developing countries often comes from urban centres for use in public parks and urban agriculture. Where wastewater is used for irrigation, it is pointless to collect the waste flows in one location for treatment and subsequently distribute the treated effluent where it is needed.

Decentralised management may apply a combination of cost-effective solutions and technologies, which are tailored to the prevailing conditions in the various sections of the community. For example, a sewerage system and treatment works can be provided to highly developed and densely populated commercial and residential centres of a community. Sparsely populated housing neighbourhoods can be served by a settled sewerage system or dry sanitation systems where soil and groundwater conditions allow such options.

Decentralised management allows incremental development and investment in community wastewater systems. Settled sewers can be used to upgrade already existing decentralised systems such as septic tanks if necessary. New, independent and properly sized systems can be added to serve new and well defined residential, industrial or commercial developments. In contrast, investments in centralised systems have to be made within a short time, thus burdening the local economy. Centralised systems are usually sized to handle wastewater flows planned to occur in 30–50 years. Centralised systems are initially often oversized but eventually become undersized.

Even where policy-makers accept the decentralised approach, they may lack the capacity to plan, design, implement, and operate decentralised systems, thus leading to severe constrains in ensuring its widespread implementation.

Most developing countries have no suitable institutional arrangements for managing decentralised systems and lack an appropriate policy framework to promote a decentralised approach. There is a risk that decentralisation will lead to fragmentation and failure to address overall problems adequately. Without technical assistance and other capacity building measures, problems of institutional capacity existing under a centralised operation are simply passed on to the new structures.

Without a formal institutional framework within which decentralised systems can be located, efforts to introduce decentralised management are likely to remain fragmented and unreliable. Decentralisation therefore requires greater coordination between the government, private sector and civil society. Decentralised systems must be compatible with the knowledge and skills available at local level, as even the simplest technologies often fail in practice for lack of attention to operational and maintenance requirements.

Key take away points

- In developing countries, decentralised sanitation systems and technologies are often more affordable and sustainable.

- Decentralised solutions are usually more responsive to local needs and conditions.

Decentralised and centralised systems should complement and not exclude each other.

SCBP

Thank you...

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ecosan SERVICES FOUNDATION

5 NON-TECHNICAL ASPECTS

5.1.1 Stakeholders and Enabling Environment

To adopt integrated planning approaches, it is essential to identify all key stakeholders as well as secondary stakeholders within a given project framework.

Government Support: Political support at all levels is essential. Programme promoters should plan to invest considerable efforts to familiarise elected officials, senior sector staff and advisers with the concepts of the planned sanitation programme. The municipal authority is the focal point in both the creation of an enabling environment and implementation of the programme, as it is, along with senior staff, responsible for providing infrastructural services to all stakeholders within the municipality. it is important that the actions necessary for project implementation fit the policy and strategic framework without violating specific existing legal requirements.

Legal Frameworks: Since many of the existing standards (national or municipal) are derived from those developed in industrialised countries under totally different conditions, they are often inappropriate. Unrealistic standards are sometimes applied to national and municipal aspects like health and building codes, but also to technical requirements in the field of water supply and wastewater management.

Institutional Arrangements: Institutional arrangements can, on the one hand, refer to the formation of special interest groups like CBOs; on the other hand they can also refer to agreements and relationships between different groups, for example public, non-state, community-led and donor institutions. Local organization may provide support in the form of technical assistance. This may range from information dissemination and capacity building at household, neighbourhood and community level (help to improve the understanding of service benefits and stakeholders' responsibilities) to the provision of advice and support services to local service providers. Examples: Public institutions, Non state institutions, Community led institutions, Donor institutions.

Capacity Building: Many groups and organisations will need training and orientation if they are to be involved in a participatory planning process. In some cases (such as government and municipal officials), this will have to occur at a very early stage of the process, whereas for others, capacity building will be more appropriate at a later stage to improve the understanding of their roles in implementing the approach.

Financing: Financing is a key factor, which has to comply with administrative rules and provisions governing expenditure for local service improvements. National, regional and local level investment plans and budgetary allocations should prioritise the areas of greatest need. Rather than resorting to grants or subsidies, governments and their agencies should consider the establishment of a line of credit or the provision of equipment and materials against regular payments. The provision of grants and subsidies often has the unintended effect of encouraging users and organisations (at whatever level) to choose systems and technologies they are unable to sustain, thus leading to rapid deterioration of the facilities and to deficient services. Therefore, they should only be considered where other strategies have been tried and failed.

Points to ponder

Informal urban settlements are highly complex. The main problem is the weak capacity at all levels of public institution. Is capacity building and training the solution to this problem?

Unserved areas tend to be politicised and contested urban territories. What are the key elements in building an enabling environment allowing a project or programme to be successful?

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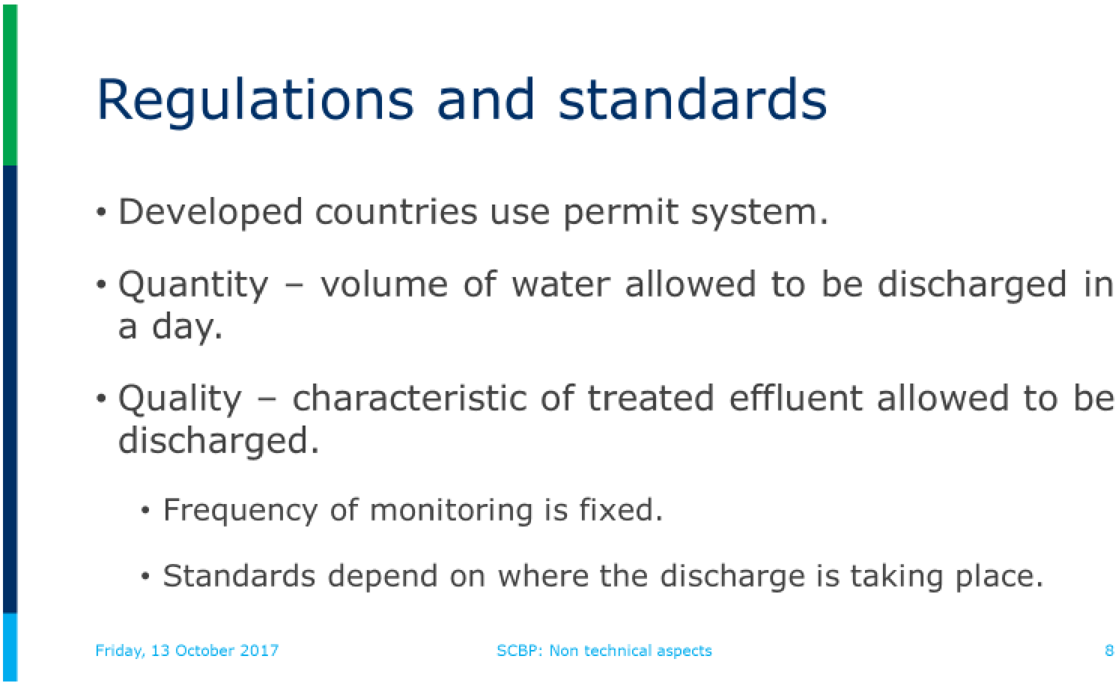
5.1.2 Institutional and Political Aspects



There are many different systems for controlling the release of wastewater in to the environment. One such system that is common in North America and Europe is a permit system: when used water or wastewater is discharged into the environment, a permit is issued which describes, quantitatively, the wastewater that can be discharged.

Parameters that may be described include the amount of water to be discharged (volume), the parameters to be monitored (e. g. BOD, total phosphate etc.) and their monitoring frequency (weekly, monthly etc.).

All these factors will be based on the type of water body into which the water is being discharged (i. e. recreational, ocean etc.).

Regulations and standards

- Developing countries – permit system does not exist or is not enforced.
- Households and community based sanitation systems are beyond the scope of regulations.
- Growing number of on-site sanitation systems, regulations and standards will be enforced strictly.

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In many developing countries, such a permit system may not exist or if it does it may not be enforced. Household and community-based sanitations systems are generally beyond the scope of most regulations. However, their growing number will also increase the likeliness of regulations and standards being introduced.

Organisational setup

Sanitation systems need functional organisational setup of sanitation stakeholders with clearly defined responsibilities.

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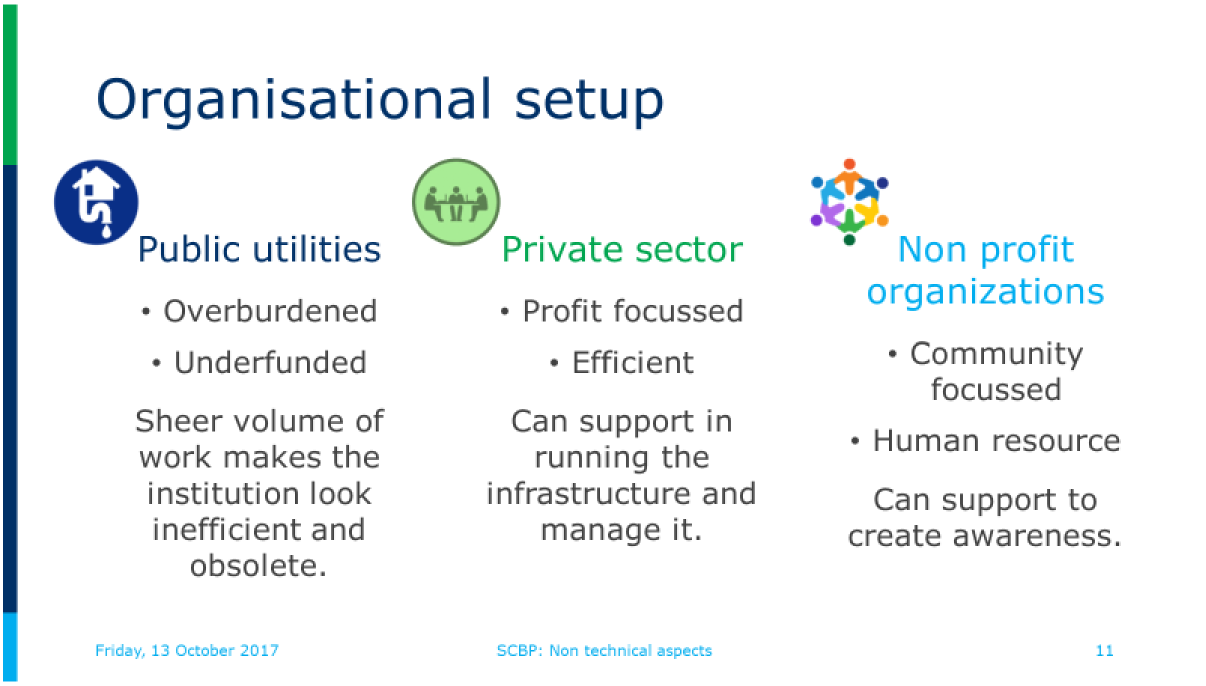
The success of any sanitation programme greatly depends on the existence of a functional organisational setup of sanitation stakeholders with clearly defined responsibilities. In general, three types of organisations manage and organise sanitation systems: private organisations, which run the businesses at a profit; public utility companies, financed by public funds (taxes) and operating at a loss or on a cost-recovery basis; and community groups or individuals who operate and maintain a sanitation system without any external funds.



Private companies have recently emerged as an alternative to state-run utilities, which are sometimes inefficient and financially unsustainable. They have, however, been criticised for catering only to customers who can pay. They do not provide equitable services nor invest in infrastructure.

On the other hand, public utilities are often overburdened and underfunded. Although they have a mandate to provide services to all inhabitants of an area, the need for cost recovery and the sheer volume of work make these institutions appear inefficient and obsolete.

To fill these service gaps, community groups, NGOs, homeowners, and citizens groups have begun to organise themselves and provide their services, often with little or no input from government institutions.

A supportive political environment is essential for the successful implementation of a sanitation programme, especially when departing from conventional methods.

An overarching vision and political will at the highest level, taking on the challenges and articulating broad objectives, may be the first step to changing the environment.

To be effective, government support should be translated into expressions of support for environmental sanitation, advocacy messages and other appropriate mechanisms for mass communication to raise public awareness.

Programme promoters should plan to increase their efforts in familiarising elected officials, senior sector staff and advisers with the concepts of the implemented sanitation programme.

Political aspects

- Governments tend to sacrifice environmental concerns for other fiscal priorities.
- Political and administrative preferences lean heavily towards large-scale, centralised wastewater and sewerage systems.

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In reality, most governments tend to sacrifice environmental concerns for other fiscal priorities. Furthermore, political and administrative preferences lean heavily towards large-scale, centralised wastewater and sewerage systems.

Bureaucracy

- Responsibilities of different authorities are not clearly defined.
- Three tier: central, regional and local authorities.
- Lack of coordination and communication mechanism.
- Sanitation programs get hindered in terms of execution.

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In many developing countries, the responsibilities of different authorities are not clearly defined and reveal a lack of coordination/communication mechanisms between them.

The responsibilities between central, regional and local authorities are also not well defined, thereby resulting in a slow and inefficient working manner.

Sanitation programmes can be hindered by such bureaucratic procedures. Applications may be delayed because documents require the approval of various offices.

Requests to different authorities can lead to contradictory answers.

5.1.3 Economic Aspects

The skills and experience of locally available personnel may be important constraints when selecting appropriate interventions. Complex technical designs may be inappropriate if construction personnel are unable to implement them.

However, community participation is not merely the provision of self-help labour (e. g. to excavate latrine pits), which is certainly important to reduce costs, however, the facilities have to be managed (supervised) to ensure their effectiveness. Inputs by a participating community are valuable not only at the planning and implementing stages, but also during monitoring and evaluation.

If facilities can be constructed with local materials, it may significantly reduce implementation time and costs. It is therefore important to ascertain what resources are available and whether they can be used without adverse effects on the local environment and economy.

For example, the kind of filter material available influences the choice of treatment option. Expertise is needed to modify standard designs or, if necessary, develop new designs, which can be constructed with locally available material.

Affordable technology

- On site or local sanitation systems seems to be less expensive to build and operate.
- Not all on plot facilities are equally affordable to all.
- Pour flush toilets linked to septic tank > Pour flush toilet linked to twin soak pit > Pit latrines
- Designing a suitable and affordable sanitation and environmentally safe system is the key to achieving the targets.

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In many instances, on-plot or local sanitation facilities will be less expensive to build and operate than centralised sewerage systems. However, experience in Africa has revealed that not all on-plot facilities are equally affordable.

Designing a suitable and affordable sanitation and environmentally safe system is the key to achieving the targets.

Appropriate service level and willingness to pay

- The level of service appropriate to the need of the communities.
- Higher satisfaction leads to more willingness to pay.

Should we design storm water drainage system for six month monsoon season or recurring 10 year storm period?

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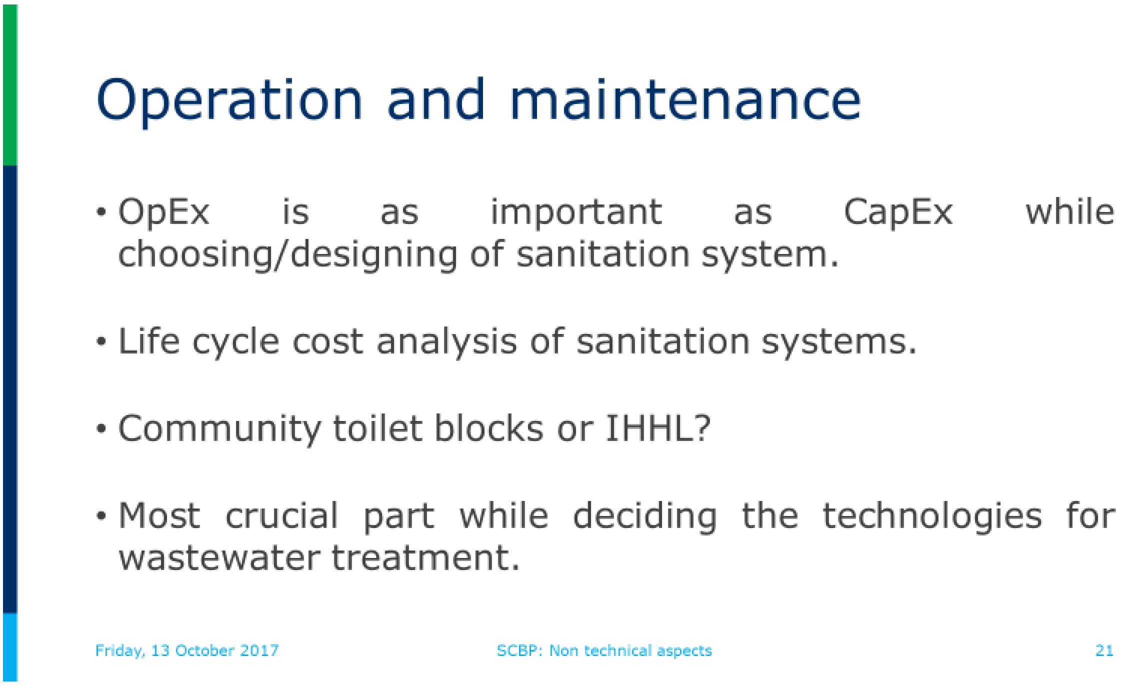
Urban services only need to satisfy the level of service appropriate to the need of communities and relate to the communities' willingness to pay for the service.



Operation and maintenance (O&M) of latrines should be given equal emphasis as their construction.

Life cycle cost analysis of various scenarios help the decision maker to make correct choice of technology.

For example, if responsibility for O&M is assumed by the implementing agency (i. e. if the end-users will not or cannot clean and maintain facilities), then only communal facilities should be provided. If community members are willing to assume the responsibility for O&M, family latrines may be a more appropriate option.

Points to ponder

What should be done if the end users are not willing to pay for the services provided?

How can sustainability of the sanitation projects be increased?

Key take away points

- Community participation is valuable not only at the planning and implementation stages but also during monitoring and evaluation.

- Using local skills and material increases project sustainability and support the local economy

5.1.4 Financial Aspects

Cost benefit analysis

- Ideally should be undertaken for all possible sanitation systems.
- Virtually impossible as improved health and user convenience cannot be quantified.
- Evaluation w.r.t. economic costs and financial costs.
- Economic costs necessary for decision makers.
- Financial costs are dependent on policy variables.

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Ideally, a cost-benefit analysis should be conducted to compare different sanitation technologies. However, it is virtually impossible to quantify all the benefits (such as improved health or user convenience). Clearly, the costs and all the details of the technology options have to be discussed with the community for it to decide what it wants and is willing to pay. With sanitation technologies, as with any other public-sector investment, whose benefits are not fully quantifiable, a method is required to determine their real costs (economic costs) in relation to the national economy.

For example, local engineers may favour conventional sewerage, however, its dependence on large volumes of flushing water could place too great a demand on local water resources and burden the country's budget allotted to exploiting these water resources.

So, competing sanitation alternatives should be evaluated with respect to their economic costs (including all costs, regardless of who incurs them or on what level), and user costs (financial costs) will subsequently have to be determined. Economic costing provides the policy-makers with an appropriate economic basis for their decisions.

Financial costs are entirely dependent on policy variables and may vary widely. However, they are for example useful to households and sewerage authorities.

Subsidies or loan?

- Is direct subsidy going to make sanitation affordable?
- Discounts on some key components of sanitation system?
- Should not reduce sense of ownership and responsibilities.

- Will beneficiaries avail loan facility?
- Setting the interest rate and loan repayment term is crucial.
- Control is needed to ensure proper utilisation of loan.

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It is a fact that for many low-income and especially very low-income communities, low-cost sanitation is not necessarily cheap. Possible solutions could include subsidies for the cost of the sanitary facility or making loans available (even perhaps at a subsidised rate of interest).

Subsidies obviously cost money! If money is available (e.g. from central government or bilateral aid agency), it is still questionable if it should be invested in direct subsidies to households rather than used to cover the overheads of a hygiene education programme. Another alternative is to provide reduced interest rates or sell some key component for half-price or less, such as the fly screen for a VIP latrine. However, subsidies must not eliminate or reduce the household's sense of ownership and responsibility.

Loans, possibly at a subsidised interest rate, can possibly be made available to households to allow them install their sanitary facility. Care should be exercised when setting the interest rate and loan repayment term. Some control is certainly necessary to ensure that the loan is actually spent on sanitation.

Key take away points

- Financial costs are only relevant for individual stakeholders (e.g. households).
- Accounting for economic costs allows user to compare alternative system or technology options.
- Subsidies and loans may help the poor pay the investment costs of sanitation infrastructure but at the expense of ownership and maintenance.

SCBP

Thank you…

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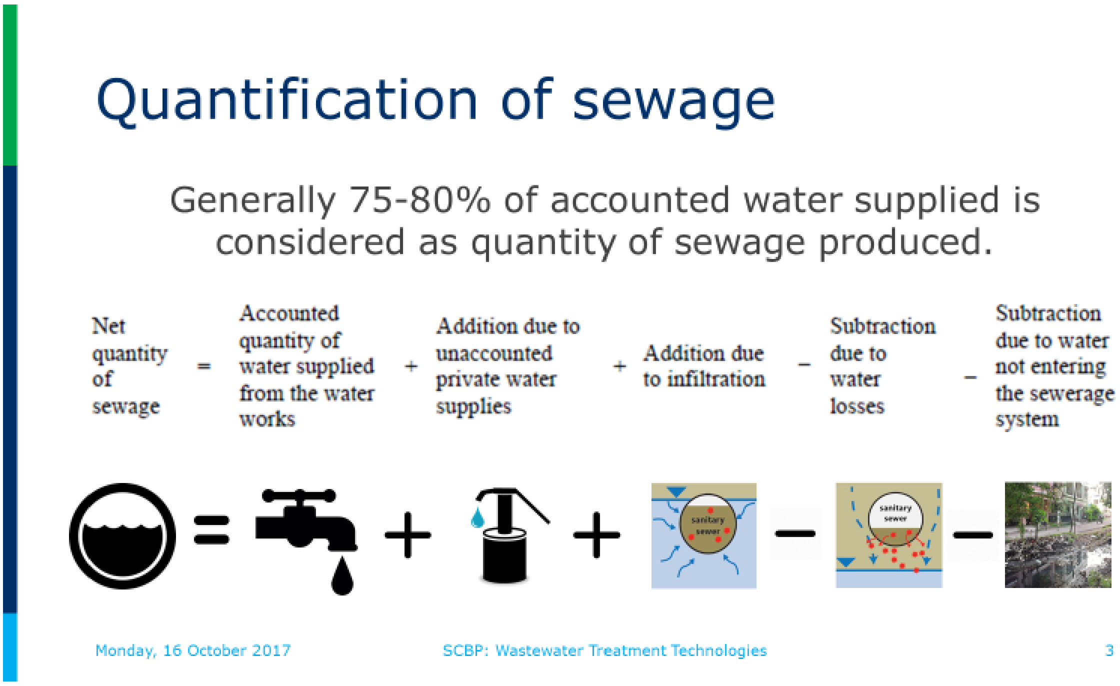
ecosan SERVICES FOUNDATION

6 WASTEWATER TREATMENT TECHNOLOGY

6.1.1 Wastewater Treatment Basics



The CPHEEO manual says that up to 80% of the water supplied to the population is converted into wastewater. However, the net quantity of sewage generated in a city might vary because of the unaccounted private water supplies, infiltration of groundwater during wet season, exfiltration of the wastewater during dry season and wastewater that is ill managed. It is important to consider all these factors for quantifying the sewage in the city of a community.

Quality of sewage

- The concentration of various parameters is important while designing the STP.
- Higher water supply leads to lower concentration of the sewage.

Item	Per capita contribution (g / c /d)	water supply (L / c / d)	Sewage Generation 80 % of (3)	Concen-tration (mg/L)
(1)	(2)	(3)	(4)	(5)
BOD	27.0	135	108	250.0
COD	45.9	135	108	425.0
TSS	40.5	135	108	375.0
VSS	28.4	135	108	262.5
Total Nitrogen	5.4	135	108	50.0
Organic Nitrogen	1.4	135	108	12.5
Ammonia Nitrogen	3.5	135	108	32.5
Nitrate Nitrogen	0.5	135	108	5.0
Total Phosphorus	0.8	135	108	7.1
Ortho Phosphorous	0.5	135	108	5.0

Illustration BOD = 27 *1000 (mg) / 135 X 0.8 (litres) = 250 mg/L

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The per capita contribution per day on an average remains constant in different cities, however what might change is the water supplied and used to transport these wastes from one point to another. Hence it is important to understand the water supply and strength (concentration) of wastewater is inversely proportional.

Treatment processes

Physical
- Sedimentation
- Floatation

Biological
- Anaerobic
- Aerobic

Chemical
- Chlorination/Ozonation
- Floccuation

Photolytic
- Ultra violet disinfection
- Photosynthesis

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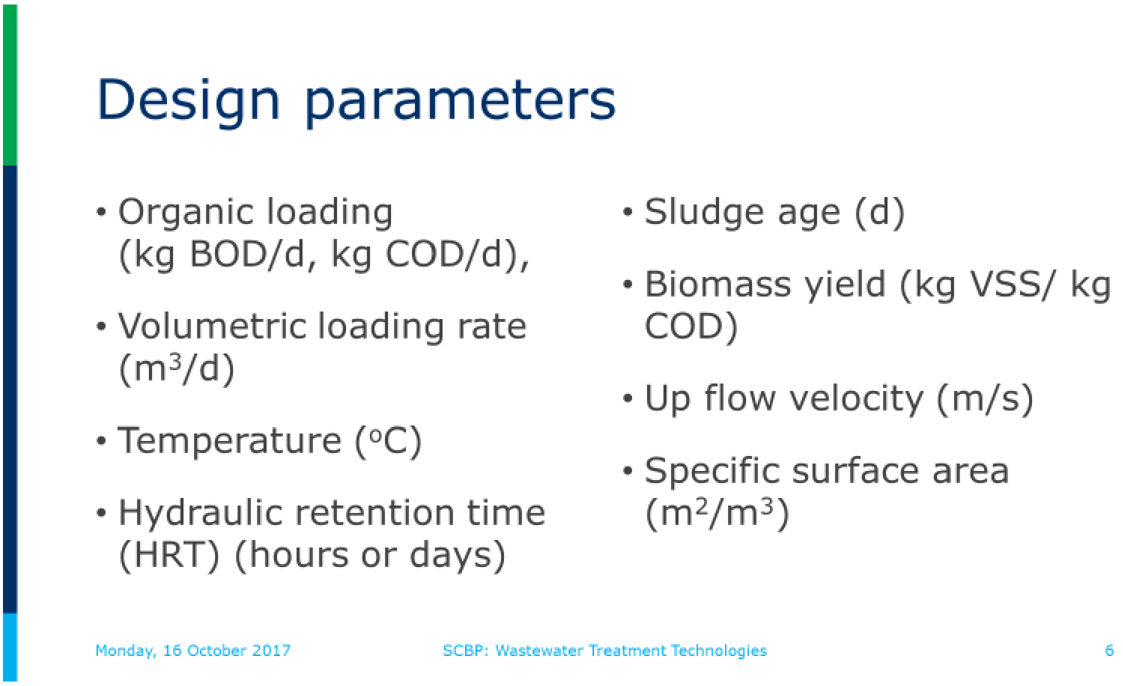
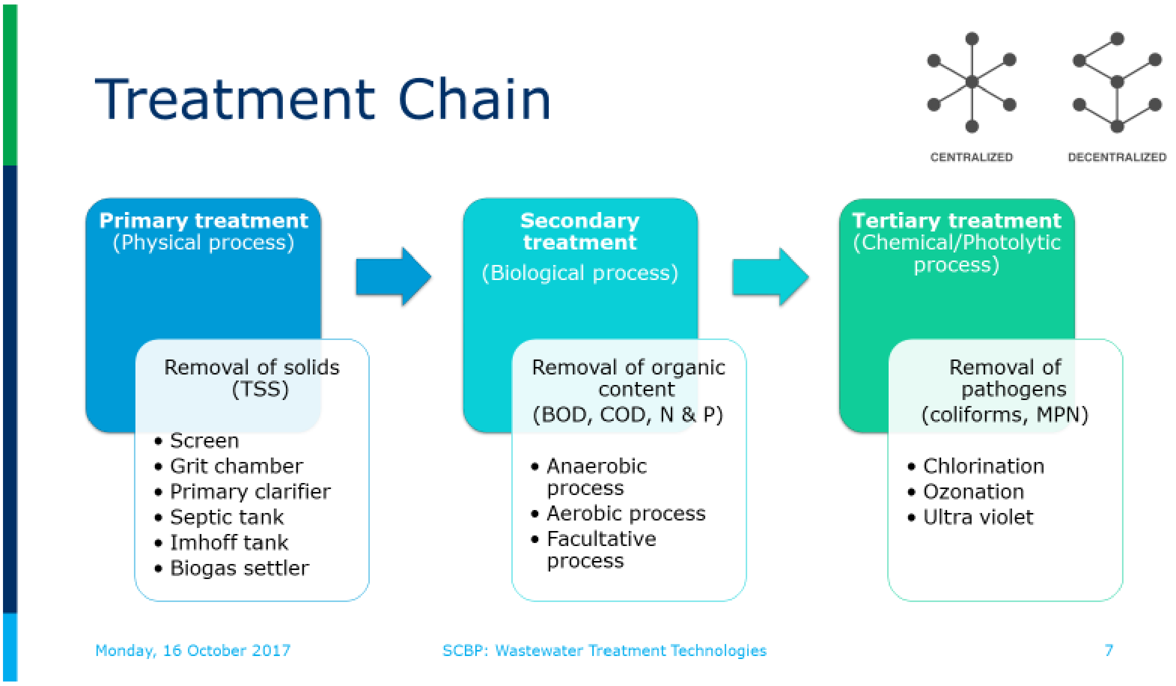
The wastewater treatment involves mainly four processes; physical, biological, chemical and photolytic. The physical processes take advantage of physical properties (ex. Density) of the constituents of wastewater for its treatment. The biological process takes help of the anaerobic and aerobic microorganisms to degrade the organic constituents. The chemical processes are carried out using chemicals and usually supports the physical or biological processes. For example, the chemical such as coagulant is used to speed up sedimentation process where as chlorination is done to disinfect the water. The photolytic process takes the support of light (sunlight, UV light etc) for processes such as disinfection.



Organic loading is the mass of organic matter that can be loaded into the system and is measured in kg of BOD or COD per day. Similarly the volumetric loading rate denotes the volume of wastewater the system can handle and is measured in cubic meter per day. The temperature is important design parameter especially in the high altitude areas where the winter temperature can drop down where biological activity ceases. The HRT signifies the time for which the water is retained in the system for the treatment. This determines the volume of tanks and process time for aeration etc. The sludge age is important in technologies like ASP, SBR, MBBR and MBR etc, where the influent is mixed with active sludge. The old sludge has low activity of microorganisms and hence needs to be taken out of the system.

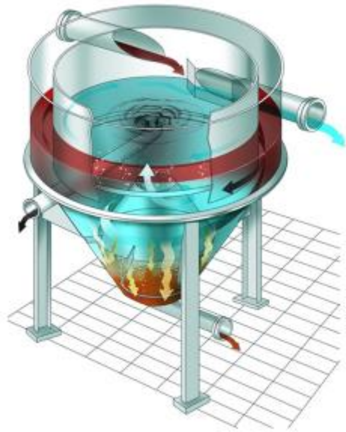


The treatment chain consist of three stages and the first stage capitalizes on the physical properties of the different constituents of wastewater. Hence the primary treatment includes processes such as physical exclusion with respect to screen or difference in density etc. The secondary treatment consists of the main treatment process and is usually biological treatment in presence or absence of oxygen. The third stage is chemical or photolytic and consists of disinfection of wastewater to kill pathogens.

6.1.2 Primary Treatment

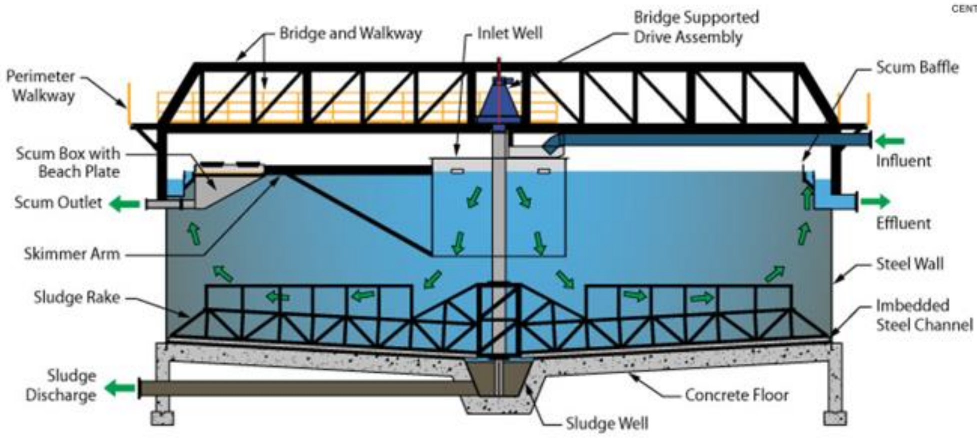
Grit chamber

CENTRALIZED



Primary clarifier

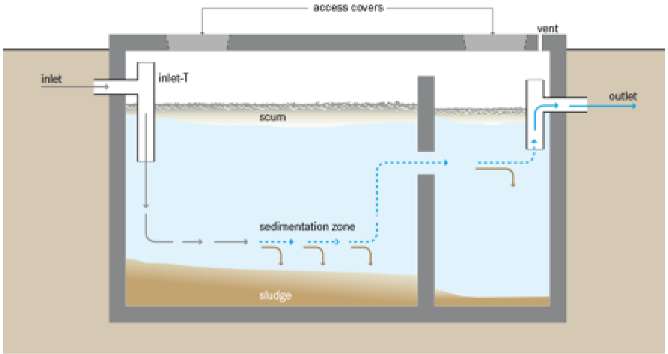
CENTRALIZED



Septic tank

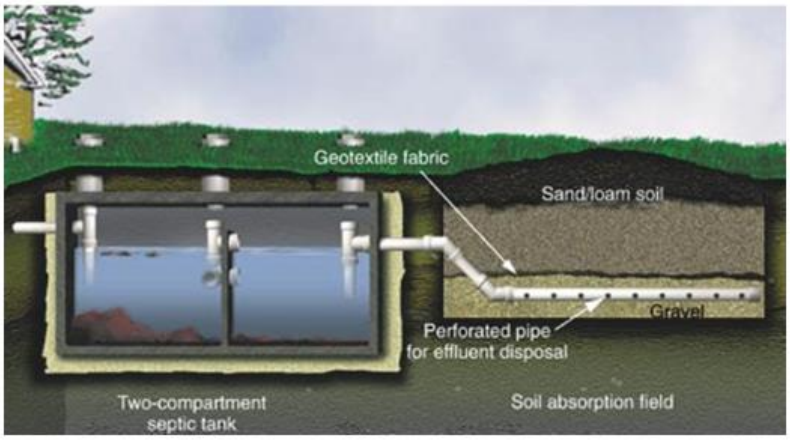
DECENTRALIZED

- Sedimentation
- Settled sludge is stabilized by anaerobic digestion
- *BOD*: 30 to 50%; *TSS*: 40 to 60 %; *E. coli*: 1 log units *HRT*: about 1 day



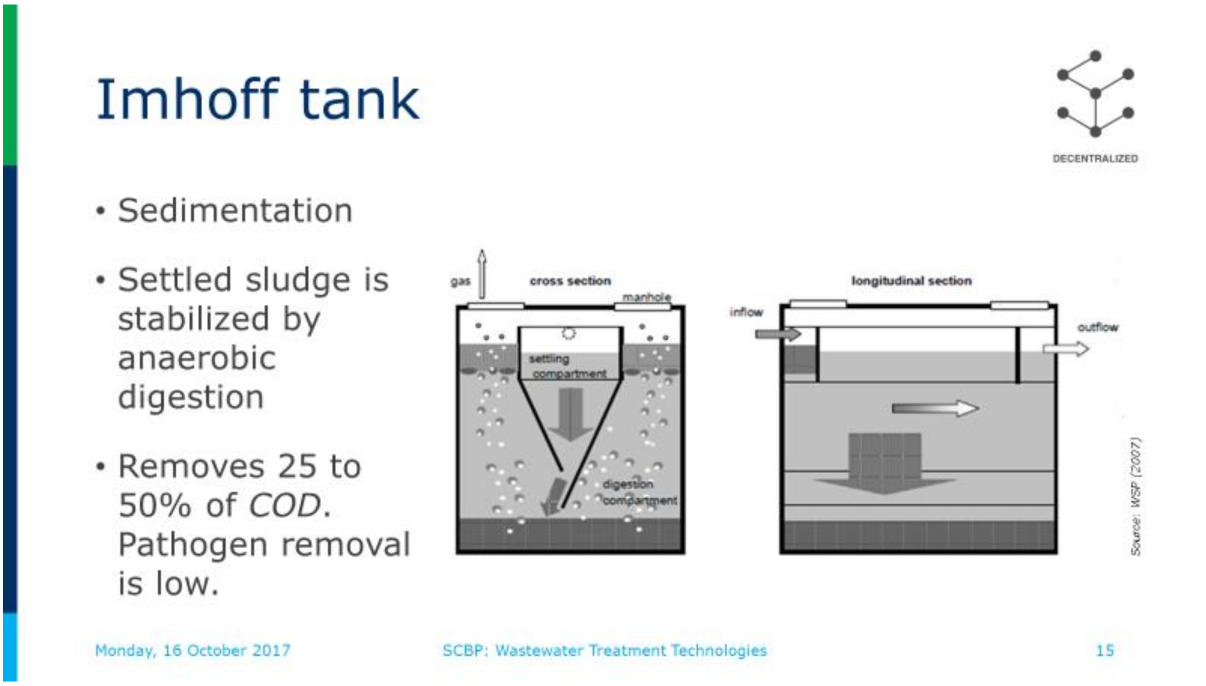
Septic tank + disposal

DECENTRALIZED

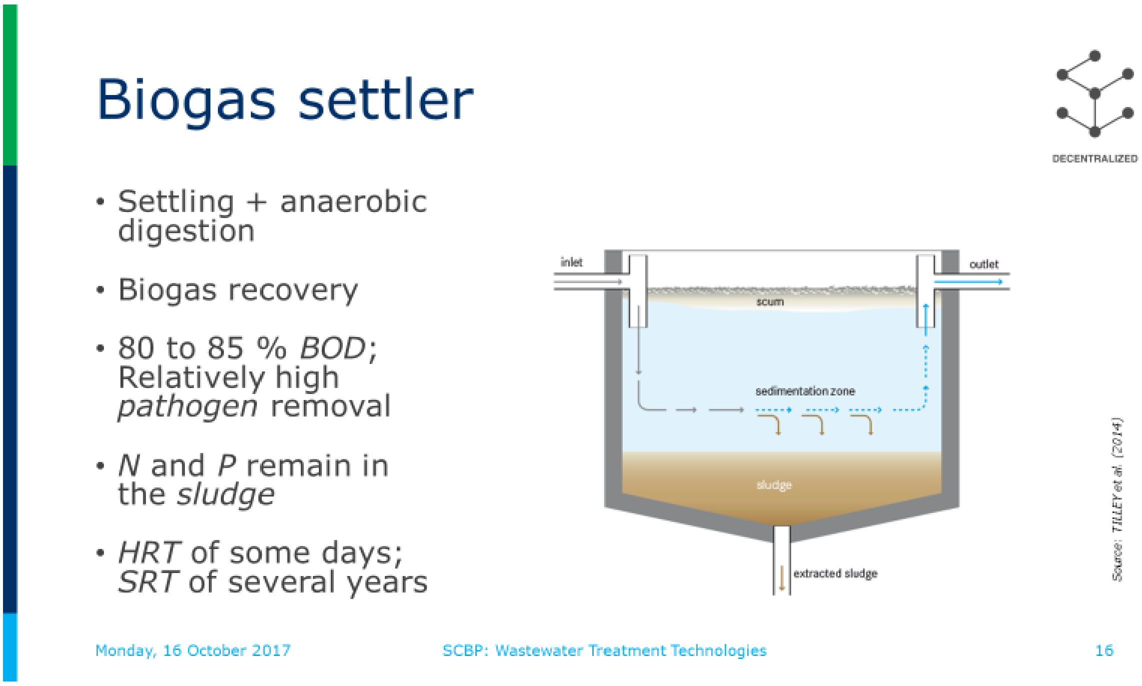


Working Principle	Basically, a sedimentation tank (physical treatment) in which settled sludge is stabilised by anaerobic digestion (biological treatment). Dissolved and suspended matter leaves the tank more or less untreated.

Capacity/Adequacy	Household and community level; Primary treatment for domestic grey- and blackwater. Depending on the following treatment, septic tanks can also be used for industrial wastewater. Not adapted for areas with high groundwater table or prone to flooding.
Performance	BOD: 30 to 50%; TSS: 40 to 60 %; E. coli: 1 log units HRT: about 1 day
Costs	Low-cost, depending on availability of materials and frequency of de-sludging.
Self-help Compatibility	Requires expert design, but can be constructed with locally available material.
O&M	Should be checked for water tightness, scum and sludge levels regularly. Sludge needs to be dug out every 1 to 5 years and discharged properly (e.g. in composting or drying bed). Needs to be vented.
Reliability	When not regularly emptied, wastewater flows through without being treated. Generally good resistance to shock loading.
Main strength	Simple to construct and to operate.
Main weakness	Effluent and sludge require further treatment. Long start-up phase.



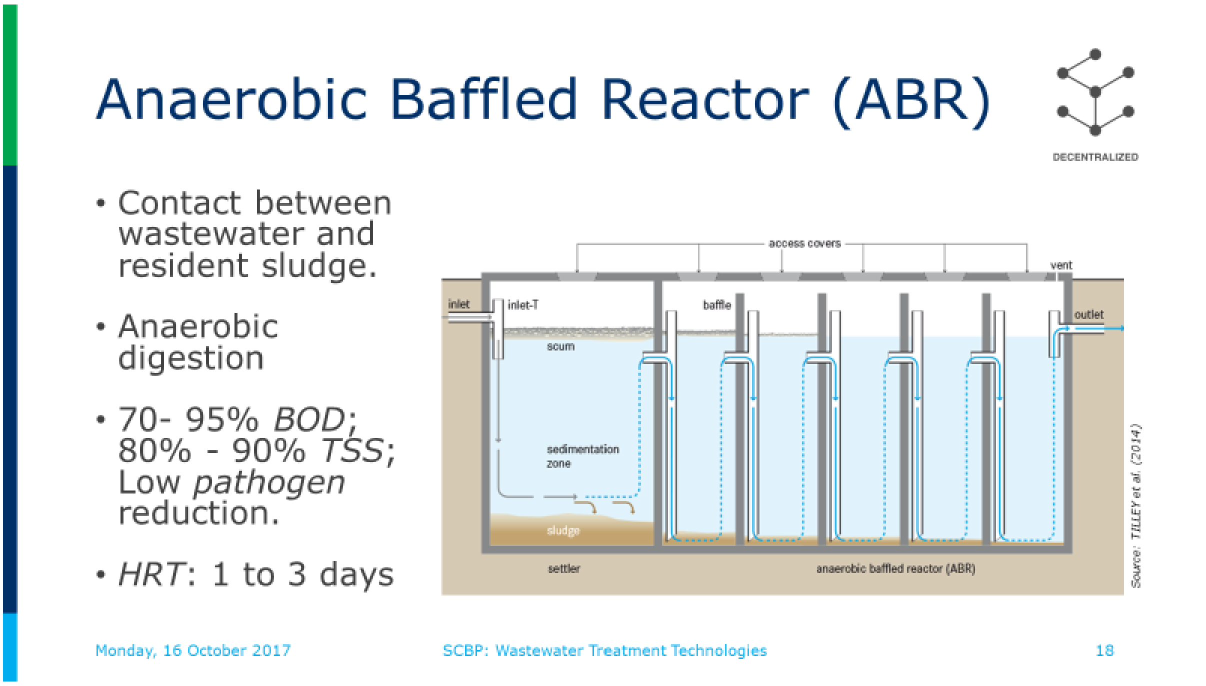
Working Principle	*Settling* of solids occurs in the upper compartment. *Sludge* falls through the slot to the bottom of the *settling* compartment into the lower tank, where it is digested.
Capacity/Adequacy	*Imhoff tanks* are used by small communities for *primary treatment* of grey- and *blackwater*.
Performance	Removes 25 to 50% of *COD*. Pathogen removal is low.
Costs	Construction costs are slightly higher than the costs of a septic tank.
Self-help Compatibility	Requires expert design, but can be constructed with locally available material.
O&M	Should be checked for water tightness, *scum* and *sludge* levels regularly. *Sludge* needs to be dug out every 1 to 5 years and discharged properly (e.g. in *composting* or drying bed). Needs to be vented.
Reliability	Reliable if amply designed and *desludging* carried out routinely. *Imhoff tanks* are resistant against shock loads.
Main strength	Simple to construct and to operate.
Main weakness	*Effluent* and *sludge* require further treatment.



Working Principle	Biogas settlers are often used as a primary settling treatment and function much like septic tanks, with the difference that biogas is recovered. Wastewater and organic wastes are introduced in an airtight reactor, solids settle to the bottom, where they are decomposed by anaerobic digestion and transformed to biogas and fertilising slurry. The supernatant flows to further treatment steps or the storage tank to be reused for irrigation.
Capacity/Adequacy	Biogas settlers are most suited for decentralised wastewater treatment systems at household, community or institutional level. They are applicable in both urban and rural areas as long as the wastewater contains sufficient organic matter and is biodegradable.
Performance	80 to 85 % BOD; Relatively high pathogen removal; N and P remain in the sludge; HRT of some days; SRT of several years
Costs	Low capital and low operating costs
Self-help Compatibility	Expert design is required and the construction needs to be supervised; operation staff needs to receive training to

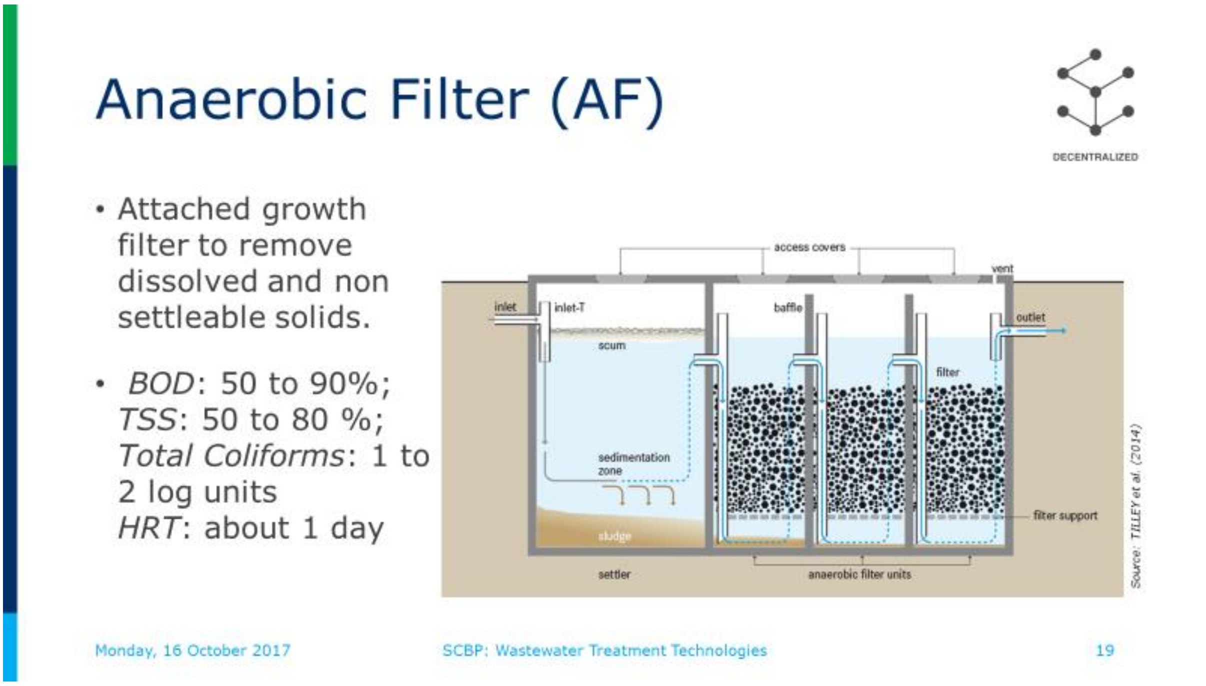
	understand the functioning. Can be constructed with locally available material.
O&M	De-sludging every 2 to 5 years; Checking for gas-tightness should be done regularly.
Reliability	Resistant to shock loading. Reliable if operated and maintained well.
Main strength	High removal of organic pollutants without any requirement for energy; Generation of biogas and fertiliser (compost).
Main weakness	Expert design is required; The organic and solid content in the influent needs to monitored.

6.1.3 Secondary Treatment



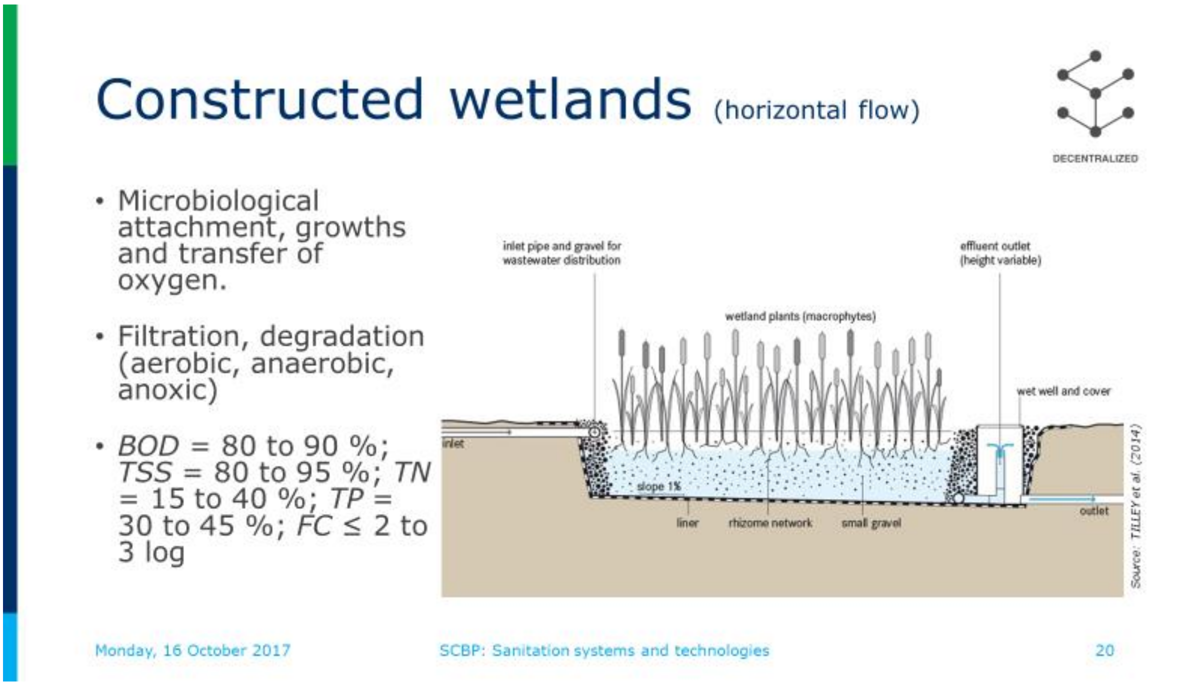
Working Principle	Vertical baffles in the tank force the pre-settled wastewater to flow under and over the baffles guaranteeing contact between wastewater and resident sludge and allowing an enhanced anaerobic digestion of suspended and dissolved

	solids; at least 1 sedimentation chamber and 2–5 up-flow chambers.
Capacity/Adequacy	Community (and household) level; For pre-settled domestic or (high-strength) industrial wastewater of narrow COD/BOD ration. Typically integrated in DEWATS systems; Not adapted for areas with high ground-water table or prone to flooding.
Performance	70- 95% BOD; 80% - 90% TSS; Low pathogen reduction. HRT: 1 to 3 days
Costs	Generally low-cost; depending on availability of materials and economy of scale.
Self-help Compatibility	Requires expert design, but can be constructed with locally available material.
O&M	Should be checked for water tightness, scum and sludge levels regularly; Sludge needs to be dug out and discharged properly (e.g. in composting or drying bed); needs to be vented.
Reliability	High resistance to shock loading and changing temperature, pH or chemical composition of the influent; requires no energy.
Main strengths	Strong resistance; built from local material; biogas can be recovered.
Main weakness	Long start-up phase.



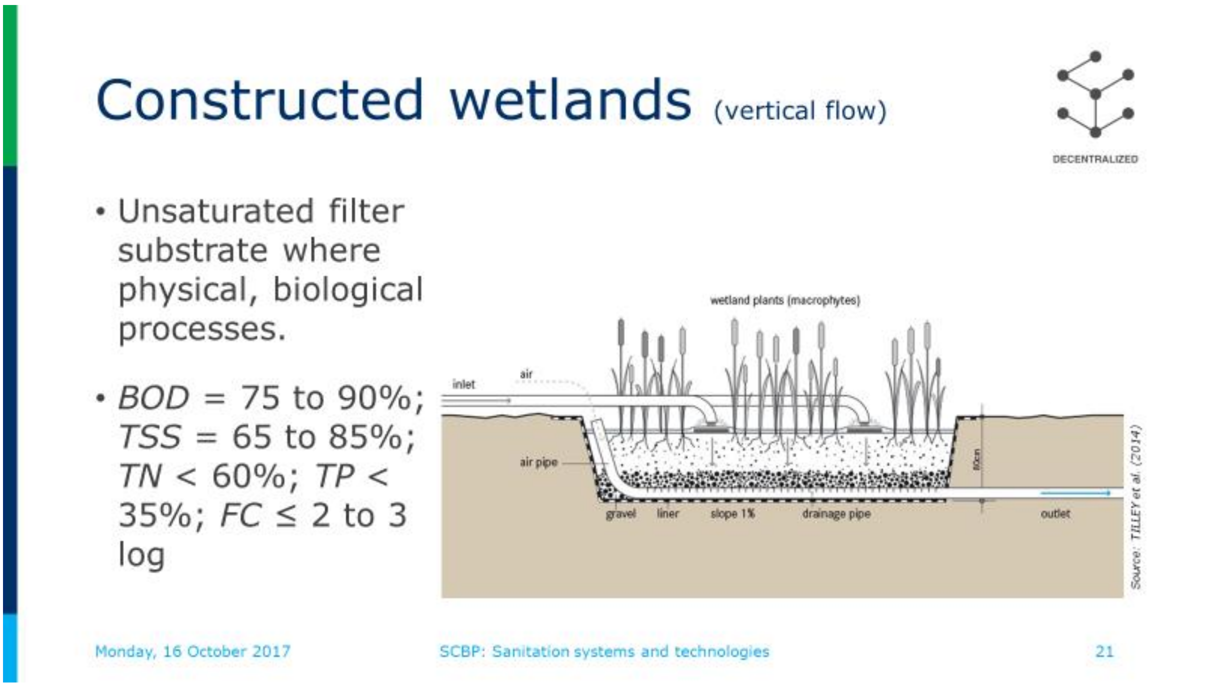
Working Principle	Dissolved and non-settleable solids are removed by anaerobic digestion through close contact with bacteria attached to the filter media
Capacity/Adequacy	Household and community level; as secondary treatment step after primary treatment in a septic tank or an anaerobic baffled reactor; effluents can be infiltrated into soil or reused for irrigation; not adapted if high ground-water table or in areas prone to flooding.
Performance	BOD: 50 to 90%; TSS: 50 to 80 %; Total Coliforms: 1 to 2 log units HRT: about 1 day
Costs	Generally low-cost; depending on availability of materials and frequency of back flushing and desludging.
Self-help Compatibility	Requires expert design, but can be constructed with locally available material.
O&M	Regularly backflush to prevent clogging (without washing out the biofilm); desludging of the primary settling chambers; needs to be vented if biogas not recovered.

Reliability	Reliable if construction is watertight and influent is primary settled; Generally good resistance to shock loading.
Main strength	Resistant to shock loading; High reduction of BOD and TSS.
Main weakness	Long start-up phase.



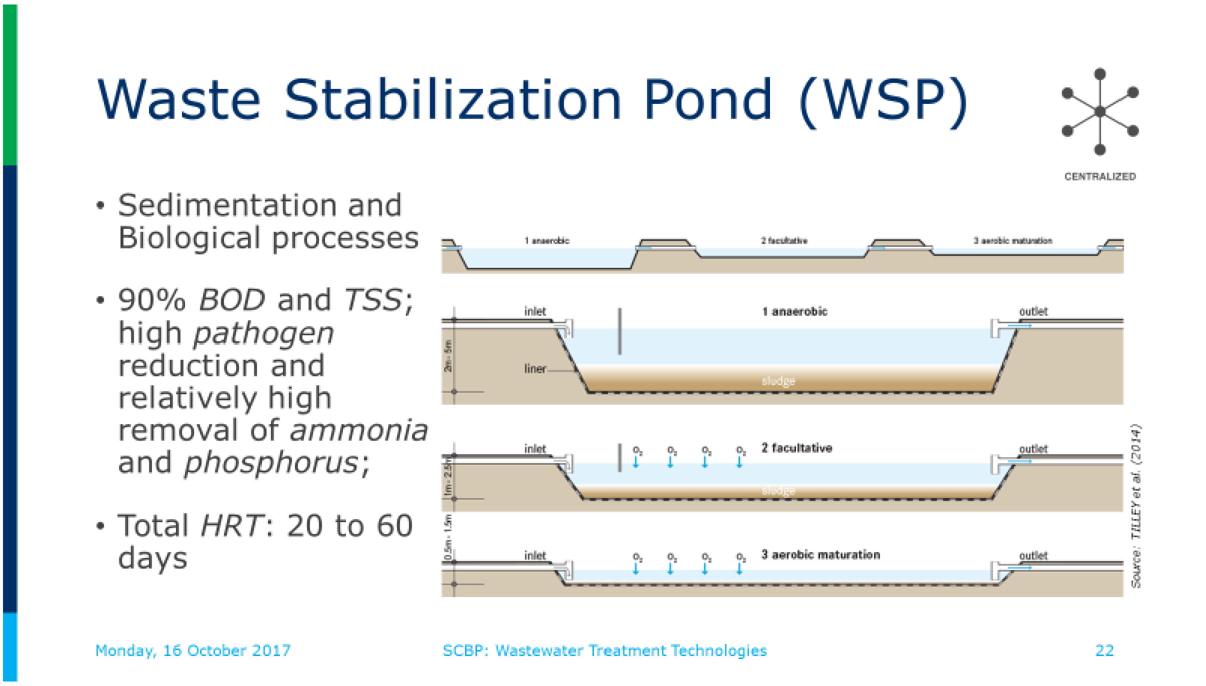
Working Principle	Pre-treated grey or blackwater flows continuously and horizontally through a planted filter bed. Plants provide appropriate environments for microbiological attachment, growths and transfer of oxygen to the root zone. Organic matter and suspended solids are removed by filtration and microbiological degradation in aerobic anoxic and anaerobic conditions (MOREL and DIENER 2006).
Capacity/Adequacy	It can be applied for single households or small communities as a secondary or tertiary treatment facility of grey- or blackwater. Effluent can be reused for irrigation or is discharged into surface water (MOREL and DIENER 2006).
Performance	BOD = 80 to 90 %; TSS = 80 to 95 %; TN = 15 to 40 %; TP = 30 to 45 %; FC ≤ 2 to 3 log; LAS > 90 %

Costs	The capital costs of constructed wetlands are dependent on the costs of sand and gravel and also on the cost of land required for the CW. The operation and maintenance costs are very low (MOREL and DIENER 2006).
Self-help Compatibility	O&M by trained labourers, most of construction material locally available, except filter substrate could be a problem. Construction needs expert design.
O&M	Emptying of pre-settled sludge, removal of unwanted vegetation, cleaning of inlet/outlet systems.
Reliability	Clogging of the filter bed is the main risk of this system, but treatment performance is satisfactory.
Main strength	Efficient removal of suspended and dissolved organic matter, nutrients and pathogens; no wastewater above ground level and therefore no odour nuisance; plants have a landscaping and ornamental purpose (MOREL and DIENER 2006).
Main weakness	Permanent space required; risk of clogging if wastewater is not well pre-treated, high quality filter material is not always available and expensive; expertise required for design, construction and monitoring (MOREL and DIENER 2006).



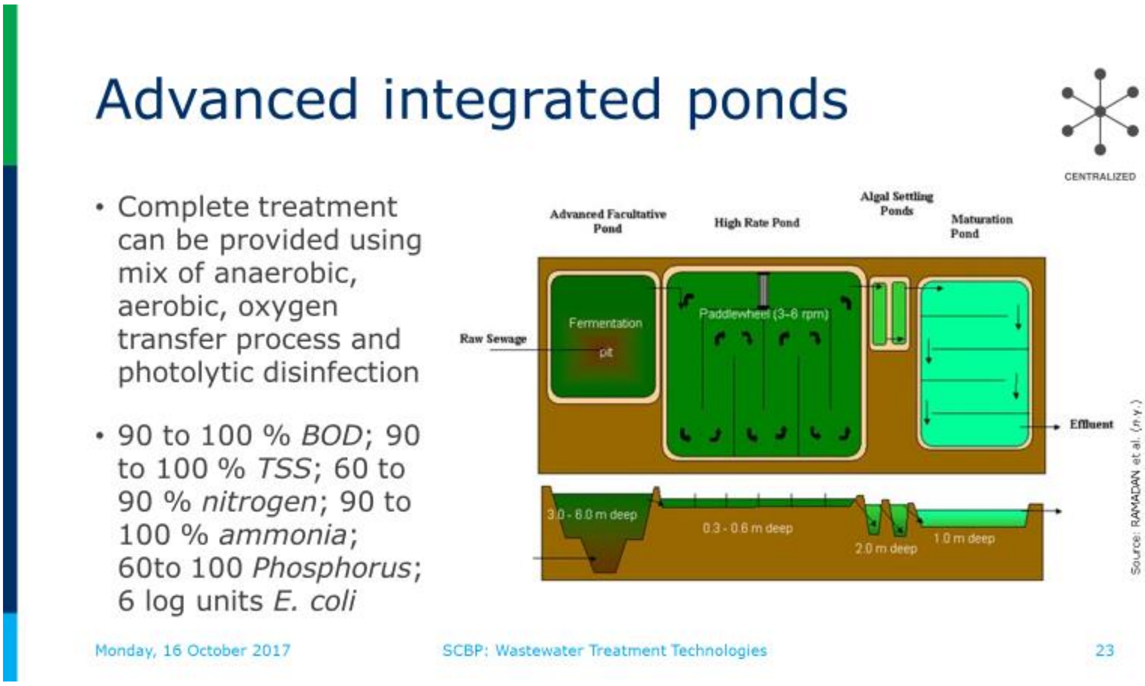
Working Principle	Pre-treated grey- or blackwater is applied intermittently to a planted filter surface, percolates through the unsaturated filter substrate where physical, biological and chemical processes purify the water. The treated wastewater is collected in a drainage network (adapted from MOREL and DIENER 2006).
Capacity/Adequacy	It can be applied for single households or small communities as a secondary or tertiary treatment facility of grey- or blackwater. Effluent can be reused for irrigation or is discharged into surface water (MOREL and DIENER 2006).
Performance	BOD = 75 to 90%; TSS = 65 to 85%; TN < 60%; TP < 35%; FC ≤ 2 to 3 log; MBAS ~ 90%; (adapted from: MOREL & DIENER 2006)
Costs	The capital costs of constructed wetlands are dependent on the costs of sand and gravel and also on the cost of land required for the CW. The operation and maintenance costs are very low (MOREL and DIENER 2006).
Self-help Compatibility	O&M by trained labourers, most of construction material locally available, except filter substrate could be a problem. Construction needs expert design. Electricity pumps may be necessary.
O&M	Emptying of pre-settled sludge, removal of unwanted vegetation, cleaning of inlet/outlet systems.
Reliability	Clogging of the filter bed is the main risk of this system, but treatment performance is satisfactory.
Main strength	Efficient removal of suspended and dissolved organic matter, nutrients and pathogens; no wastewater above ground level and therefore no odour nuisance; plants have a landscaping and ornamental purpose (MOREL and DIENER 2006).
Main weakness	Even distribution on a filter bed requires a well-functioning pressure distribution with pump or siphon. Uneven distribution causes clogging zones and plug flows with

	reduced treatment performance; high quality filter material is not always available and expensive; expertise required for design, construction and monitoring (MOREL and DIENER 2006).



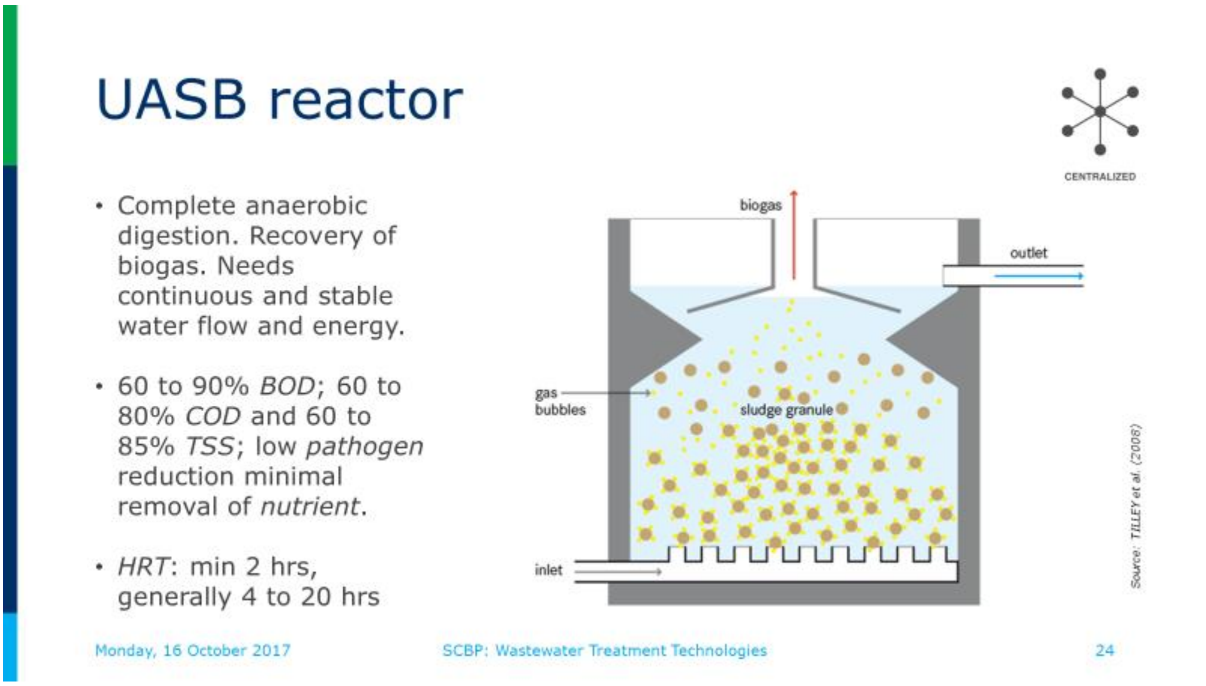
Working Principle	In a first pond (anaerobic pond), solids and settleable organics settles to the bottom forming a sludge, which is, digested anaerobic by microorganism. In a second pond (facultative pond), algae growing on the surface provide the water with oxygen leading to both anaerobic digestion and aerobic oxidation of the organic pollutants. Due to the algal activity, pH rises leading to inactivation of some pathogens and volatilisation of ammonia. The last ponds serves for the retention of stabilised solids and the inactivation of pathogenic microorganisms via heating rise of pH and solar disinfection.
Capacity/Adequacy	Almost all wastewaters (including heavily loaded industrial wastewater) can be treated, but as higher the organic load, as higher the required surface. In the case of high salt

	content, the use of the water for irrigation is not recommended.
Performance	90% BOD and TSS; high pathogen reduction and relatively high removal of ammonia and phosphorus; Total HRT: 20 to 60 days
Costs	Low capital costs where land prices are low; very low operation costs
Self-help Compatibility	Design must be carried out by expert. Construction can take place by semi- or unskilled labourers. High self-help compatibility concerning maintenance.
O&M	Very simple. Removing vegetation (to prevent BOD increase and mosquito breath) scum and floating vegetation from pond surfaces, keeping inlets and outlets clear, and repairing any embankment damage.
Reliability	Reliable if ponds are maintained well, and if temperatures are not too low.
Main strength	High efficiency while very simple operation and maintenance.
Main weakness	Large surface areas required and needs to be protected to prevent contact with human or animals



Working Principle	In a primary advanced facultative pond (AFP) containing a digester pit on its bottom, solids and organic are trapped and degraded via anaerobic digestion and aerobic degradation. In a high rate algae pond (HRP) BOD is further aerobically degraded and taken up by growing microalgae. In the next step, algae are settled in the algal settling pond (ASP) and can be harvested (and used as fish fodder or fertiliser). A final maturation pond (MP) enhances pathogen abatement.
Capacity/Adequacy	Due to the complexity of the system it is adapted for community or large scale application, but almost every wastewater can be treated.
Performance	90 to 100 % BOD; 90 to 100 % TSS; 60 to 90 % nitrogen; 90 to 100 % ammonia; 60to 100 Phosphorus; 6 log units E. coli
Costs	Compared to the high BOD, TSS and pathogen removal, AIWPS are cost-effective. However, investment costs are high and expert skills for design and construction are required.

Self-help Compatibility	Presently, no clear guidelines for the design are available and planning and construction supervision. Operation and maintenance need to be carried out by technical experts; the community may contribute during construction.
O&M	Large objects and coarse particles need to be screened; The algal settling pond needs to be desludged once to twice a year. HRPs are sensitive and require skilled maintenance.
Reliability	High reliability and good resistance to shock loading.
Main strength	High removal efficiency and almost no sludge produced.
Main weakness	Not well experienced yet and expert skills required since the system is somehow complicated.



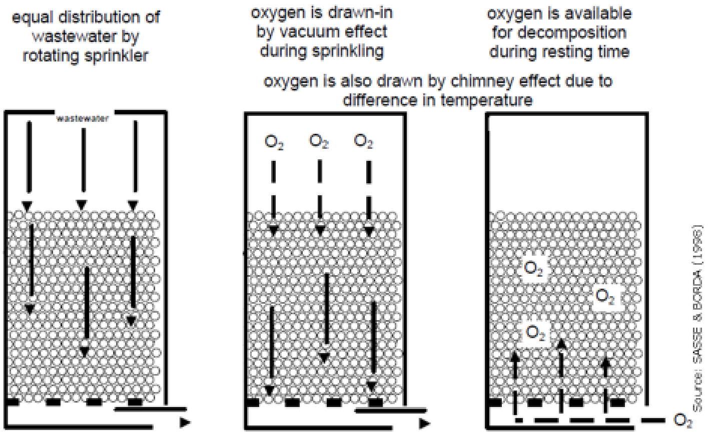
Working Principle	Industrial wastewater or blackwater flows into the bottom of an anaerobic upflow tank. Accumulated sludge forms granules. Microorganisms living in the granules degrade organic pollutants by anaerobic digestion. The sludge blanket is kept in suspension by the flow regime and formed gas bubbles. A separator at the top of the reactor allows to

	recover biogas for energy production, nutrient effluent for agriculture and to retain the sludge in the reactor. Sludge accumulation is low (emptying is only required every few years) and the sludge is stabilised and can be used as soil fertiliser.
Capacity/Adequacy	Centralised or decentralised at community level, for industrial wastewater or blackwater. The system requires a continuous and stable water flow and energy.
Performance	60 to 90 % BOD; 60 to 80 % COD and 60 to 85 % TSS; low pathogen reduction minimal removal of nutrient (N and P) HRT: minimal 2 hours, generally 4 to 20 hours
Costs	Investment is comparable to baffled reactors. For operation usually no costs arise beneath desludging costs and operation of feeding pump.
Self-help Compatibility	Can be constructed with locally available material but requires skilled staff for construction, maintenance and operation.
O&M	Desludging is not frequent but feeder pump and control of organic loads requires skilled staff for operation and maintenance.
Reliability	Not resistant to shock loading and sensitive to organic load fluctuations.
Main strength	High removal of organics and solids (BOD and TSS) with low production of sludge and the possibility to recover biogas; only little land required.
Main weakness	Requires skilled staff, electricity and is sensitive to variable flows.

Trickling filter

CENTRALIZED

- Attached growth on the media (biofilm).
- Completely aerobic process.
- *BOD*: 65 to 90 %. Low *TSS* removal. *Total Coliforms*: 1 to 2 log units *N*: 0 to 35%. *P*: 10 to 15 %.



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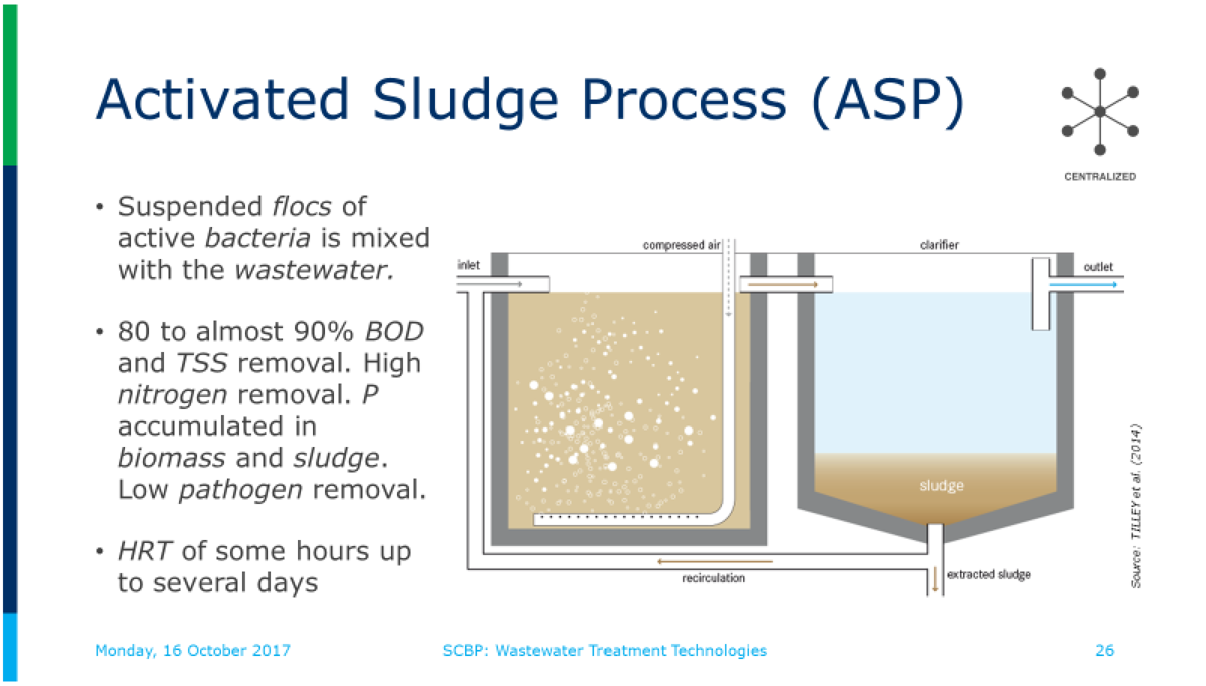
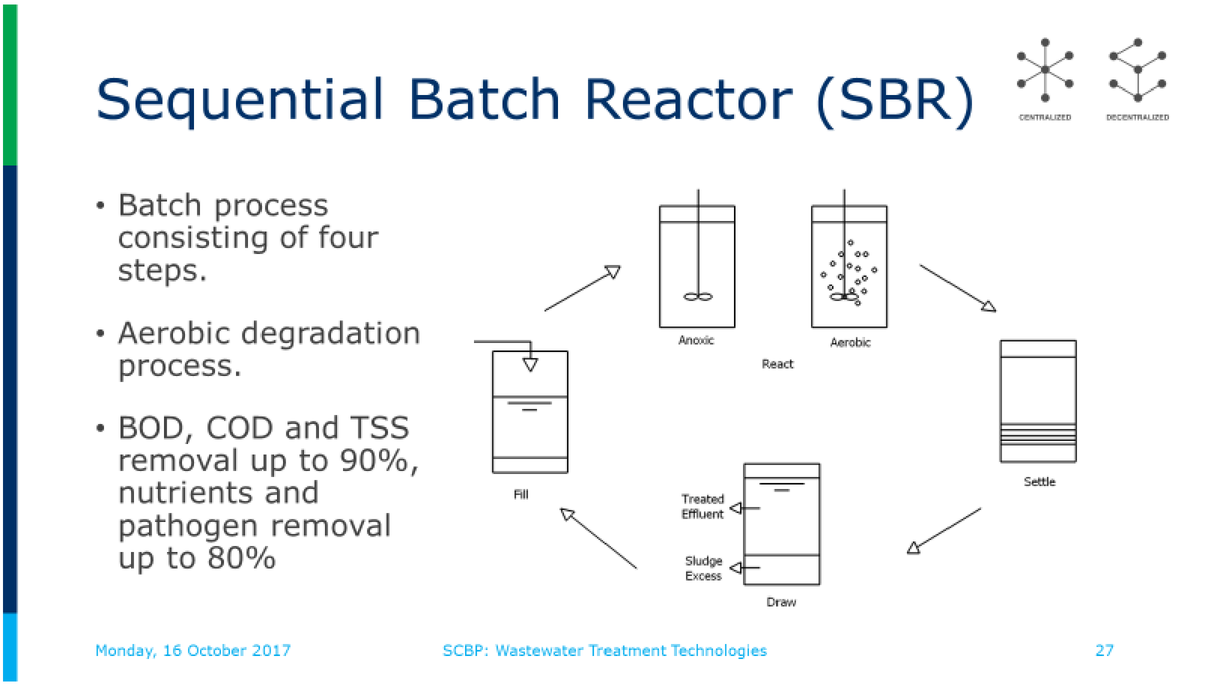
Working Principle	Wastewater trickles vertically through a porous media (e.g. a stone bed) with high specific surface. The biofilm growing on the media removes organic matter under aerobic conditions.
Capacity/Adequacy	Semi-centralised to centralised. The system is usually applied in urban areas for treatment of domestic wastewater. It can be applied for bigger and smaller communities.
Performance	BOD: 65 to 90 %. Low TSS removal. Total Coliforms: 1 to 2 log units N: 0 to 35%. P: 10 to 15 %.
Costs	Medium; investment costs depend on type of filter materials and feeder pumps used; operational costs determined by electricity consumption of feeder pumps.
Self-help Compatibility	Low. Design, planning and implementation by expert consultants; no community labour contribution possible; feeder pumps required; permanent staff required for operation.
O&M	Civil engineer needed for construction, professional service providers required

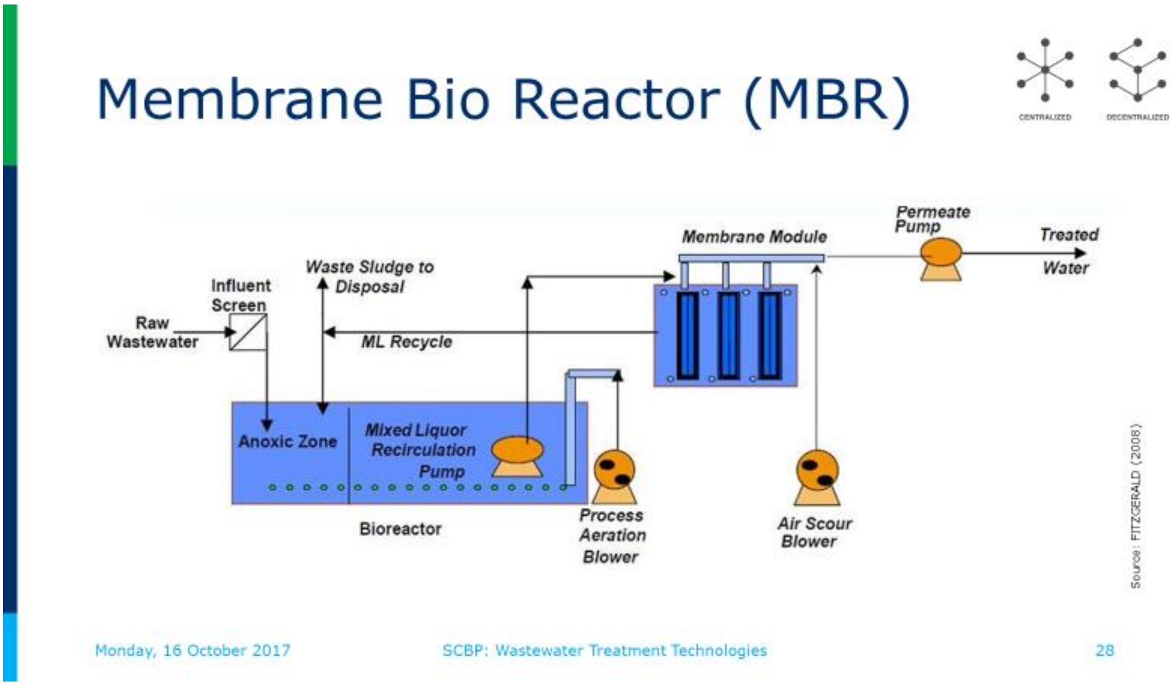
Reliability	Resistant to shock loadings but the systems does not work during power failures.
Main strength	High treatment efficiency with lower area requirement compared to wetlands or ponds; resistant to shock loading.
Main weakness	Requires expert skills, pumps and continuous electrical power, as well as ample and continuous wastewater flow required

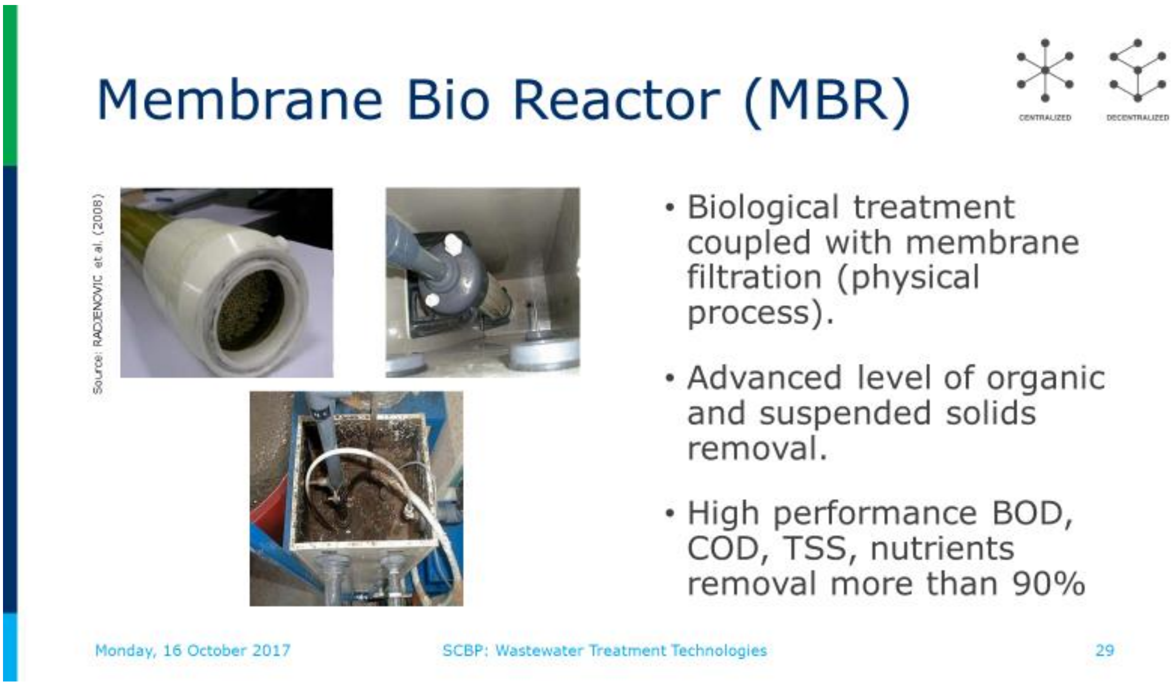


Working Principle	Activated sludge consisting of suspended flocs of active bacteria is mixed with the wastewater. The organic pollutants are used for growth by bacteria and thereby transformed to water, CO2 and new cell material. Nitrogen is removed by nitrification/denitrification and phosphorus is either removed chemically or biologically and accumulated in the excess sludge. Excess sludge requires a further treatment chain.
Capacity/Adequacy	High-tech centralized system, not adapted for small communities. Almost every wastewater can be treated as

	long as it is biodegradable. Usually applied in densely populated areas for treatment of domestic wastewater.
Performance	80 to almost 100% BOD and TSS removal. High nitrogen removal. P accumulated in biomass and sludge. Low pathogen removal. HRT of some hours up to several days
Costs	Very high construction and maintenance costs; operation very expensive due to requirement of permanent professional operation, high electricity consumption and costly mechanical parts.
Self-help Compatibility	System parts not locally available; implementation only possible by experienced consultant firms.
O&M	Activated sludge units require professional operation and maintenance providers.
Reliability	Fails in case of power failure or fall-out of technical equipment.
Main strength	High removal efficiency for large range of wastewaters.
Main weakness	Highly mechanized system requiring expert design, operation and maintenance as well as mechanical spare parts. Large energy requirements (e.g. for aeration).



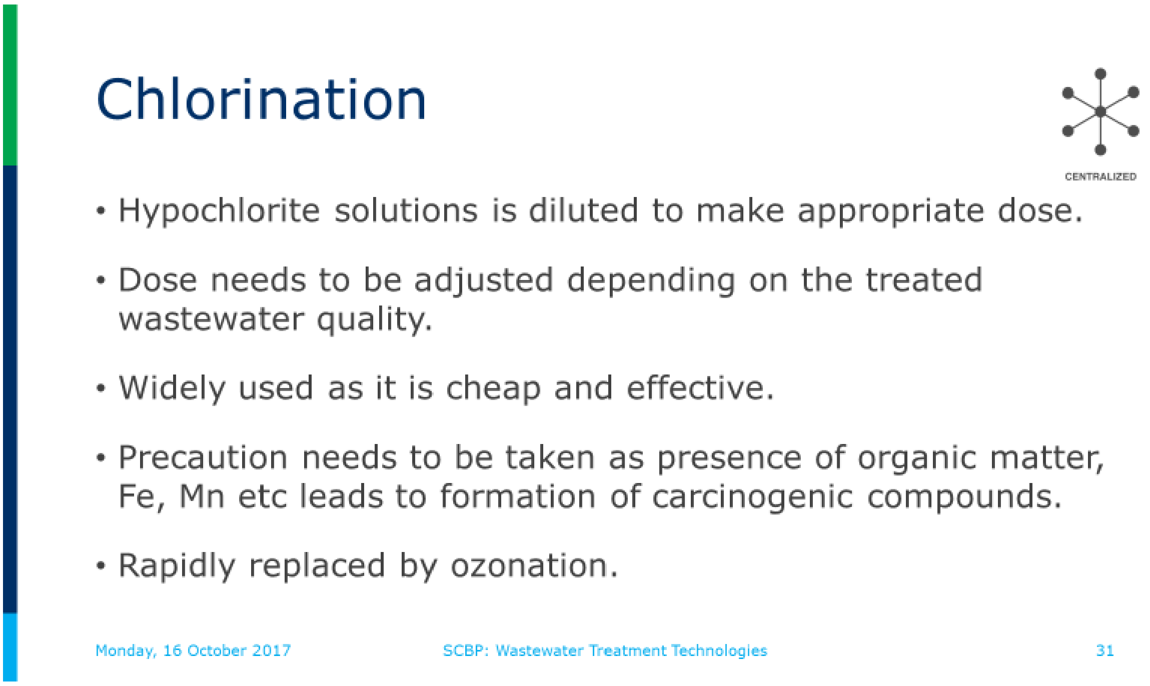


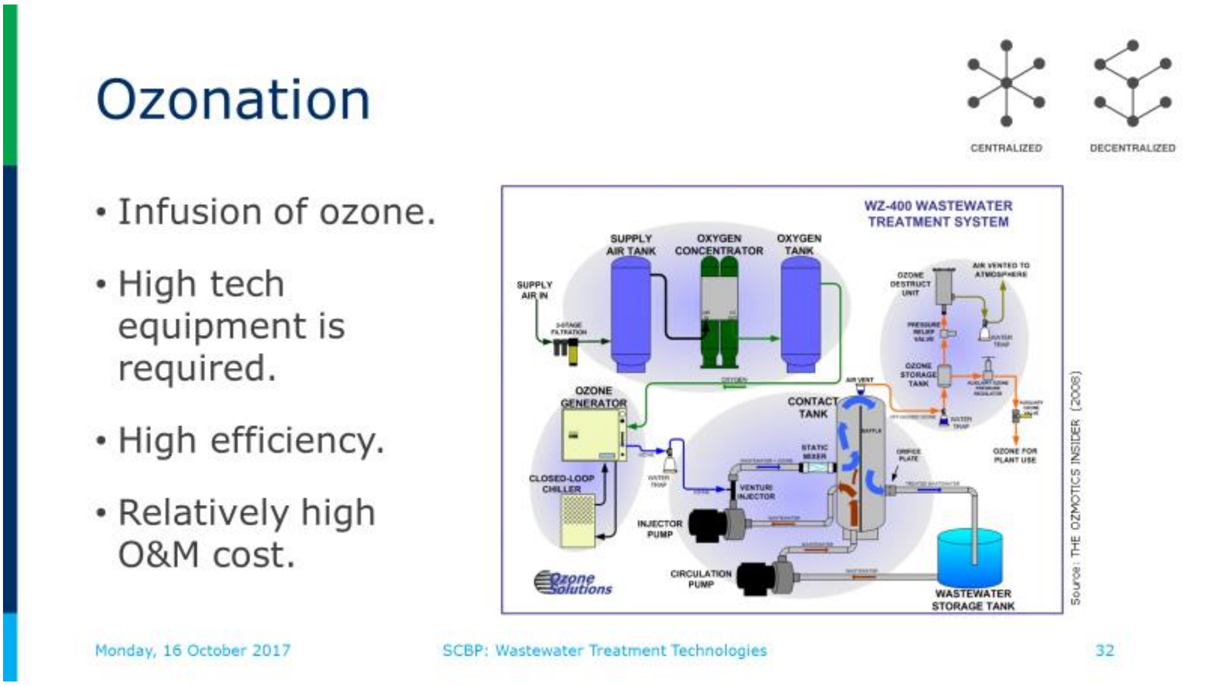


Working Principle	Membrane Bioreactors (MBRs) combine conventional biological treatment (e.g. activated sludge) processes with membrane filtration to provide an advanced level of organic and suspended solids removal.

Capacity/Adequacy	Applicable in conventional wastewater plants.
Performance	High
Costs	High capital and operational costs.
Self-help Compatibility	Low
O&M	Membranes need to be cleaned regularly.
Reliability	High if membranes are maintained correctly.
Main strength	Secondary clarifiers and tertiary filtration processes are eliminated, thereby reducing plant footprint.
Main weakness	High operation and capital costs (membranes).

6.1.4 Tertiary Treatment





Working Principle	Infusion of ozone, a gas produced by subjecting oxygen molecules to high electrical voltage, which reacts with microorganisms and pollutants
Capacity/Adequacy	High tech equipment required
Performance	High efficiency
Costs	Relatively high operation costs
Self-help Compatibility	Engineers are required for the design
O&M	Continuous input of electrical power required
Reliability	Reliable if operating conditions are scaled taking into account wastewater content
Main strength	Very efficient and fast method for disinfection and as a AOP
Main weakness	Requires complicated equipment as well as large amounts of energy and qualified operators

6.1.5 Appropriate Treatment Systems

Purpose and goal

- Reduce quantity of pollutants going in to the natural environment.
- Specific purpose and goals
  - Reuse in industry (cement industry, pipe manufacturing industry)
  - To reduce eutrophication of surface water bodies
  - Reuse in the agriculture (in drought prone areas)
  - Reuse in indirect aquifer recharge

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Treatability

- Treatability at various scale.
- Treatability of various waste streams.
- Robustness to shock loading (volume, organic load)

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The treatability of technologies change depending on the scale (capacity) of the plant. It also changes depending on the characteristic of the influent to the system. The ability to recover or give consistent performance under shock loading is known as robustness. Robustness of the treatment system needs to be referred to during selection.

Other parameters

- Capital Expenditure (CapEx)
  - When you pay too much- you may lose a little money
  - If you pay too little- you may lose everything
- Operational Expenditure (OpEx)
  - Spend a bit more money up front to reduce the ongoing costs

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Although CapEx is important, it should not be only the deciding criteria for selection of technology. Sometimes opting for an expensive technology might seem like one is losing money but it is always better than choosing a cheaper technology and later losing complete system.

The OpEx is important criteria that needs to be seen while deciding the technology. Most often the technologies which are cheaper in the installation have higher O&M cost and vice versa.

Other parameters

- Demonstrated experience
  - Ask for reference site! Visit them and ensure.
- Local service and support
  - Who fixes it when it breaks, and where are they located?
  - Local service for key equipment is a must

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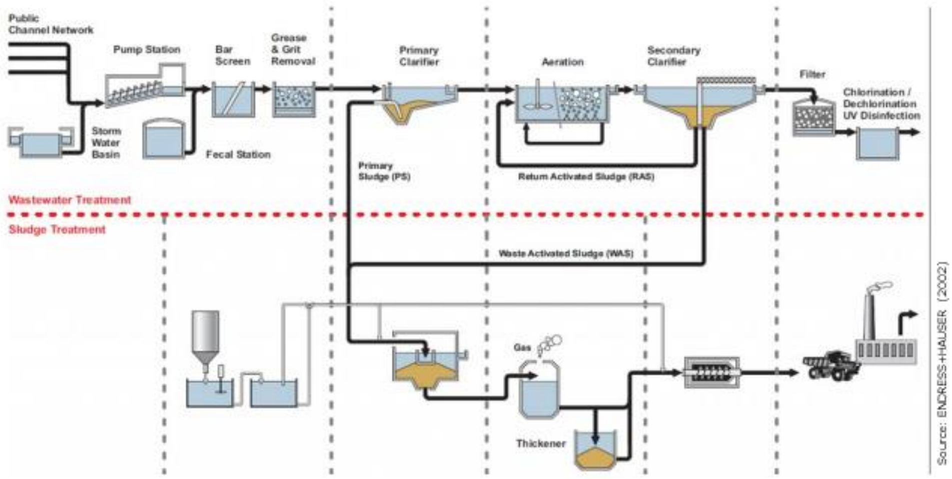
6.1.6 Treatment Chain

Case I: ASP



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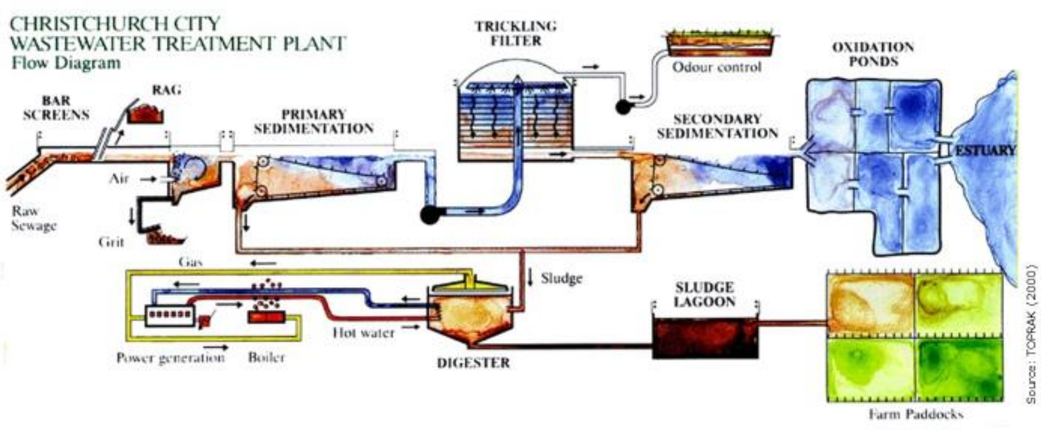
Case II: Trickling filter



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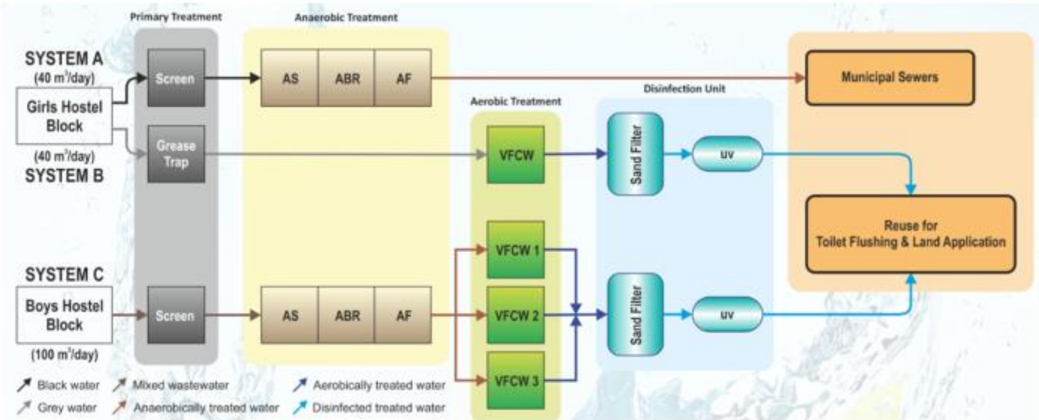
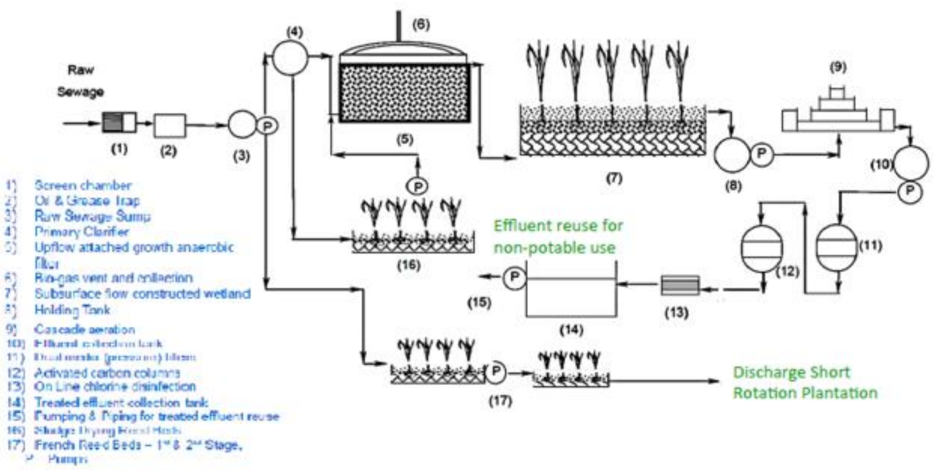
Case III: DTS



Case IV: DTS



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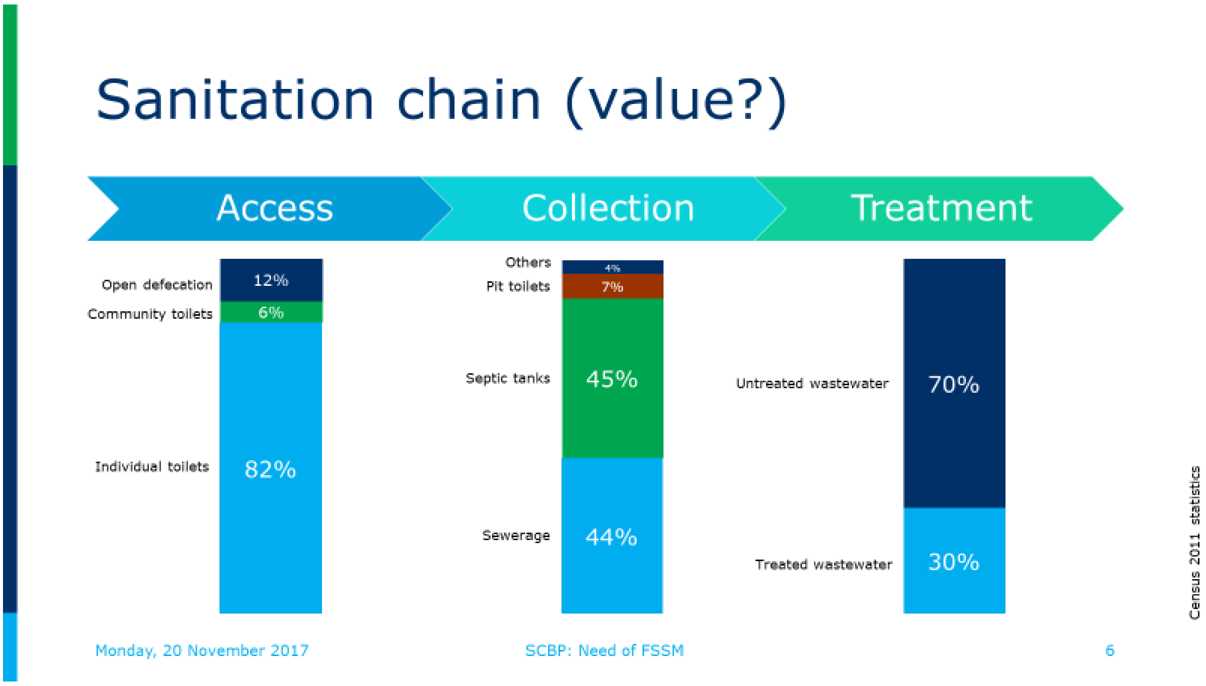
7 NEED OF FAECAL SLUDGE AND SEPTAGE MANAGEMENT

Sanitation facts – INDIA (2011 census)

- 18.6% urban HHs have NO TOILETS!
- 32.7% of urban HHs have access to PIPED SEWER!
- 38.2% HHs are connected to SEPTIC TANKS.
- 6% of HHs depend on PUBLIC TOILET!



37 million people practice open defecation in urban India. 28 million people with individual toilets use insanitary methods of disposal of waste. 43,117 MLD of untreated wastewater is discharged in water bodies or on land.

7.1.1 National Program and Policies

National program and policies

Swachh Bharat Mission (Urban), National Policy on FSSM, FSSM in AMRUT

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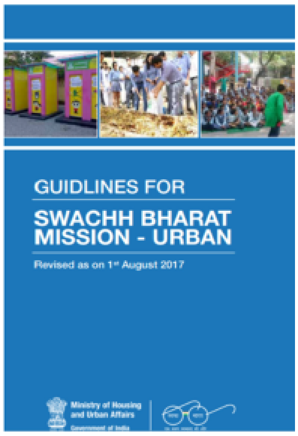
Swachh Bharat Mission - Urban

- Objectives
  - Eliminating open defecation
  - Eliminating manual scavenging
- To ensure that
  - No HH engages in OD
  - No new insanitary toilets are constructed
  - Pit latrines are converted into sanitary toilets
- Components
  - IHHT | Community Toilets | Public Toilets



Swachh Bharat Mission - Urban

Recognition to FSSM

- National policy on FSSM by MoHUA, GoI
- National declaration on Septage Management by MoHUA, GoI
- One of the major thrust areas under AMRUT
- Primer on FSSM under NFSSM Alliance
- Septage Management Advisory of GoI provides guidelines, standards and resources for preparing plans.

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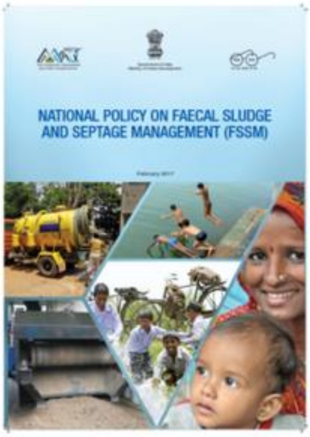
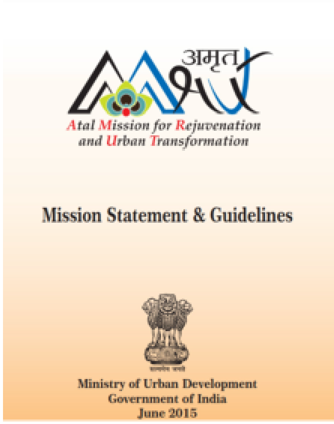
National Policy on FSSM

- Leveraging FSSM to achieve 100% access to safe sanitation.
- Achieving integrated citywide sanitation.
- Sanitary and safe disposal.
- Awareness generation and behaviour change.

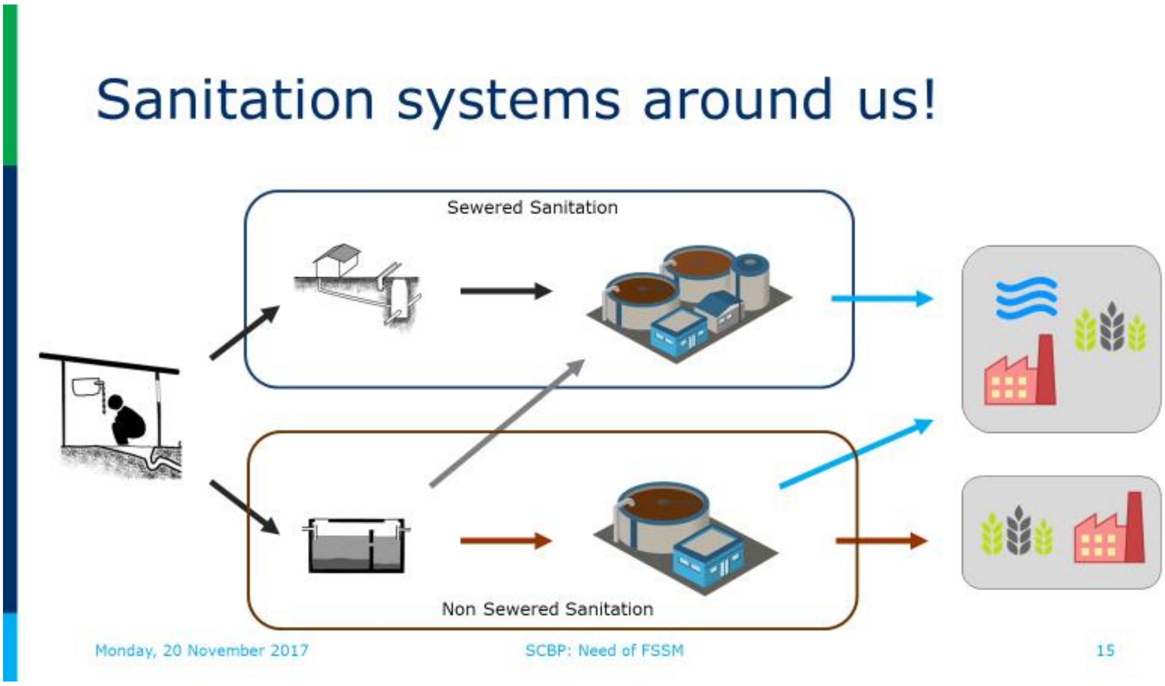


FSSM in AMRUT

- Focus on sanitation services delivery to the citizens.
- Incentives for achievement of reforms.
- States to prepare their own FSSM policy.
- Financial allocations under AMRUT for FSSM related projects.



7.1.2 Introduction to FSSM



There are mostly wo types of sanitation systems around us; sewered sanitation systems and unsewered sanitation systems. The sewered sanitation systems mixes the waste and uses water to transport the waste to the treatment plant there both he solids and liquid are separated and disposed or sent for reused. These systems are not only capital intensive but also intensive in terms of O&M.

The unsewered sanitation systems are simple and keeps the solids contained onsite in storage and treatment unit such as septic tank. This system allows incremental investment in terms of CapEx.

What is faecal sludge & septage?

- All liquid and semi-liquid contents of pits and vaults accumulating in on-site sanitations installations.
- High TSS and TDS than wastewater.
- Faecal sludge- fresh and yellowish, higher BOD, needs higher degree of treatment.
- Septage- well digested and blackish, lower BOD, needs lesser degree of treatment.

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There is a difference in the two terms faecal sludge and septage. The faecal sludge is usually found in pit latrines where the lined pit contains all the excreta. This pit is usually small and hence needs to be emptied quite frequently. The result of which is the excreta remain undigested and hence is called faecal sludge. On the other hand when the user interface is connected to onsite storage and treatment unit like septic tank or improved systems like ABR or AF, the solids are retained for more than 2 years and hence get fully digested and constitute as septage.

Faecal sludge and Septage

EAWAG Sandec

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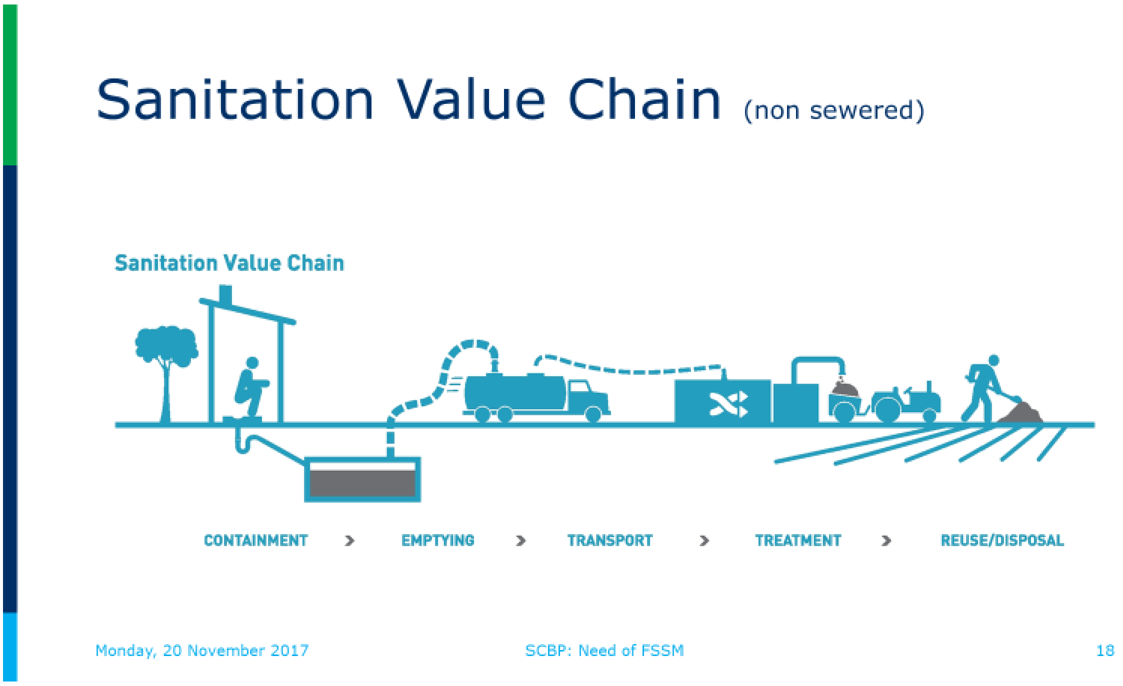
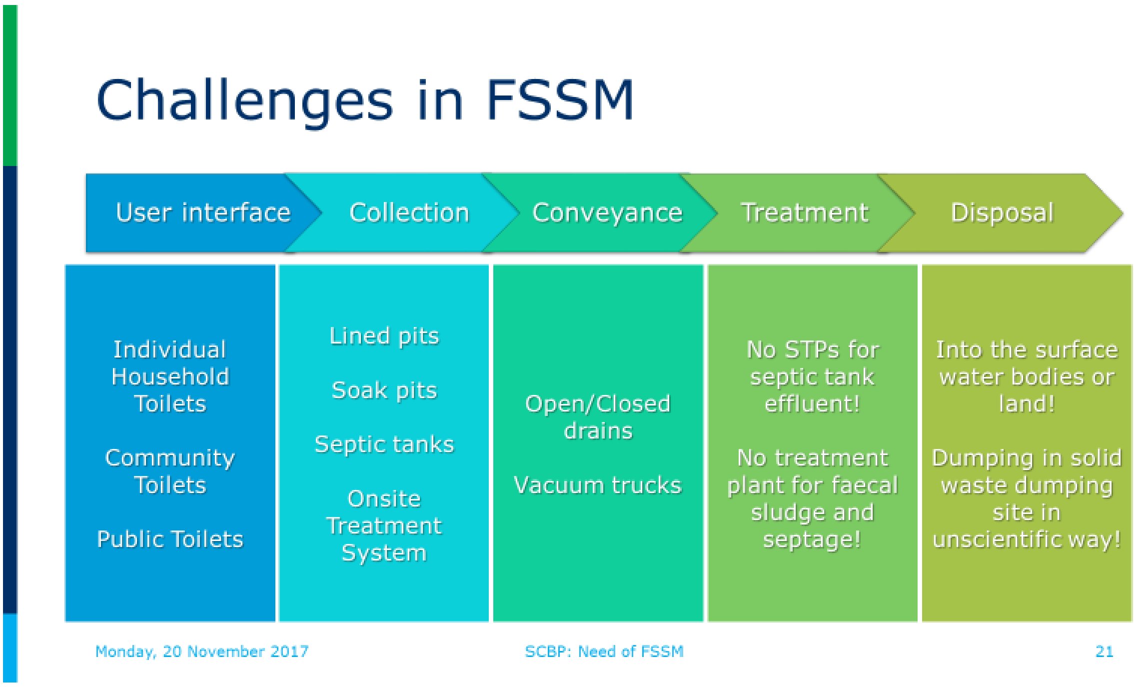


A sanitation value chain in non sewered sanitation system consists of containment (user interface and onsite storage) followed by collection and then transport. This is followed by treatment and then reuse or disposal. The combination of all the five stages is a sanitation value chain.

7.1.3 Needs and Challenges in FSSM

The need of FSSM is quite evident however, it can be summarised in these four points. The insufficient infrastructure for covering the city with sewered sanitation approach, FSSM can complement the cities until the sewerage system is implemented in the city. As per the guidelines, manual scavenging is banned in India, however, till date there are people who are employed by ULBs to clean the sewer systems and drains. This process is not far from being manual scavenging. The regulations for managing the solids are not clearly enforced and hence there is a need for formalising the FSSM landscape in the city. The resource recovery from the waste produced, is simpler in the FSSM approach. The nutrients or energy of high quality can be recovered consistently from the faecal sludge and septage.



Apart from the all listed challenges, quality of workmanship and material is often neglected while rapidly implementing toilets in the cities or villages. Speeding up the process of construction usually puts the quality of material and workmanship at stake.

Non enforcement of standard design of septic tanks, is the most grave problem in the collection phase of FSSM.

Indiscriminate disposal of septage in the environment is equivalent to 5000 people practicing open defecation at the same time at the same place. Hence by emptying the vacuum truck in the environment in an unsafe manner is like transferring the problem from the households to some place away from the habitation.

Challenges in FSSM

Disposal

Into the surface water bodies or land!

Dumping in solid waste dumping site in unscientific way!

- BOD and other parameters of FS and septage are higher than wastewater.
- Once the solids are stabilised and separated from FS/septage, liquid effluent should be treated.
- CPCB has revised new standards for discharge of treated effluents.

Challenges in FSSM

User interface	Collection	Conveyance	Treatment	Disposal
Pour flush toilets • Dilapidated condition, • Operation and maintenance, • Behaviours and habits.	Septic tanks • Old and leaking, • Not as per standards, • No emptied regularly	Open/Closed drains Under capacity, & old Vacuum trucks Inadequate to provide service	No STPs for septic tank effluent! No treatment plant for faecal sludge and septage!	Into the surface water bodies or land! Dumping in solid waste dumping site in unscientific way!

Thank you…

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8 FAECAL SLUDGE AND SEPTAGE MANAGEMENT PLANNING PROCESS

Contents

- Assessment of initial situation
- Stakeholder analysis
- Stakeholder engagement
- Planning IFSM systems

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8.1.1 Assessment of initial situation

Assessment of initial situation

- Is crucial and provides baseline information for decision making.
- Understanding the context, getting to know stakeholders.
- Elaborating faecal sludge management scenarios.
- Identifies existing service chain.
- Identifies enabling environment.

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Tools and method of data collection

- Literature review
- Semi structured interviews
- Household level surveys
- Qualitative field observations
- Mapping
- Laboratory analyses
- SWOT analysis

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Literature review of the existing documents of the city followed by semi structured interviews of the key stakeholders in the city is the beginning of the data collection. A sample household survey can be carried for a sample of 10% of households in each ward. While carrying out survey, qualitative observations need to be done in terms of the practices followed by households for managing the waste. Mapping using GIS or manual mapping of the city helps to note important points on the map of the city. This representation is easy to explain to mayor or elected representative rather than a report. Lab analysis of septage from number of septic tanks helps to confirm the design parameters of design of treatment system.

Data to be collected

- Sanitation sector (Service Level Benchmarking)
- Profile of manual and mechanical service providers
- Practices at household level
- Legal and regulatory framework
- Estimation of design parameters
- Climatic data
- Spatial data and city structure
- Enduse practices and market studies

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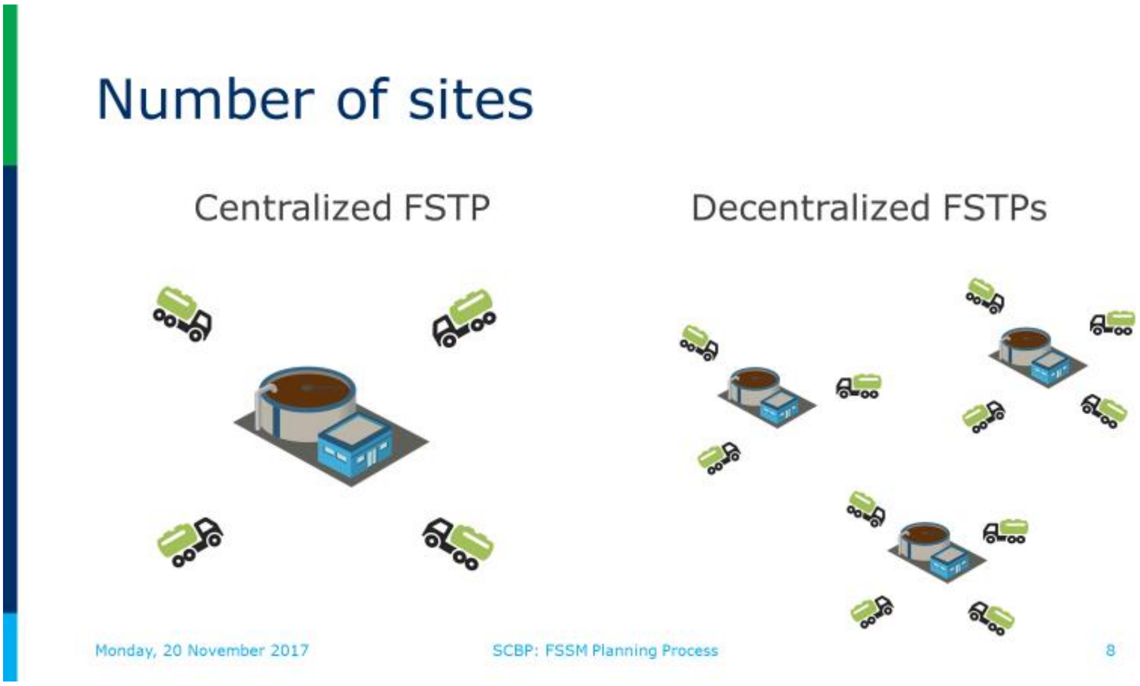
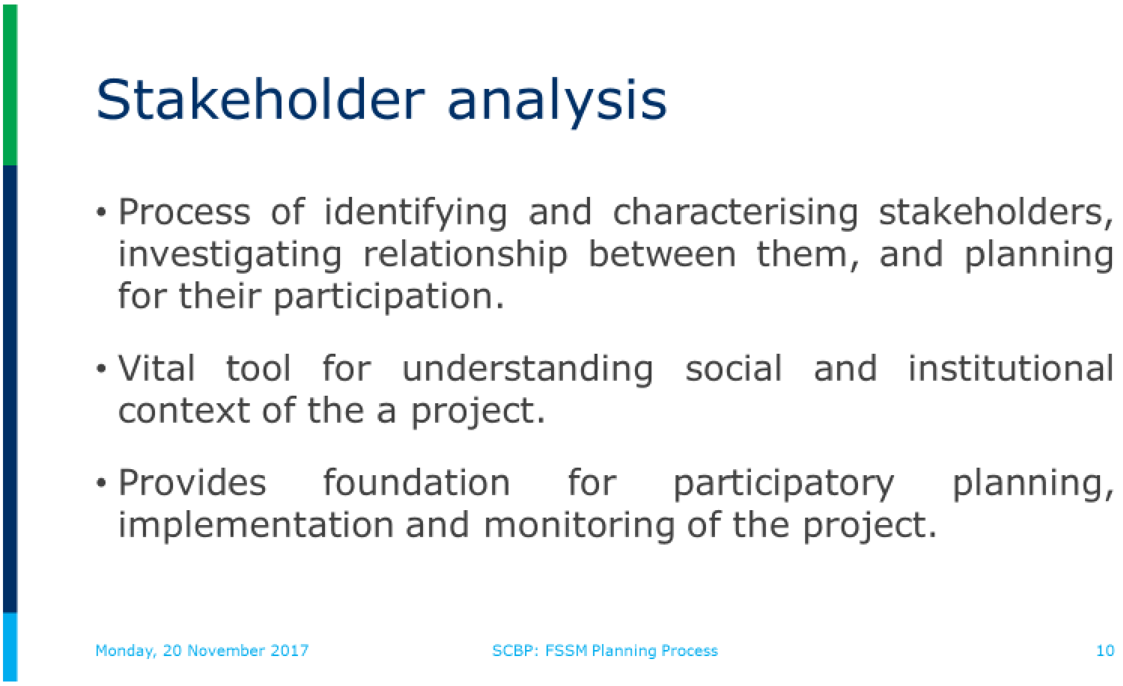


Depending upon the size of the city, the city may need one centralized FSTP or multiple FSTPs in order to bring down the cost of collection and transport and encourage the practice of desludging the septic tank once in 2-3 years.

8.1.2 Stakeholders Analysis



Identification of stakeholders

- Municipal authorities
- Regional and national authorities
- Utilities
- Traditional authorities and influential leaders
- Small scale FS business
- Organisations active in WASH
- Potential end users
- Households

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Characterisation of stakeholders

Stakeholders	Interests	Strengths	Weaknesses	Opportunities/ threats	Relationships	Impacts	Involvement needs
Stakeholder a							
Stakeholder b							
Stakeholder c							
...							

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Main interest: Consultation with stakeholders should be carried out in order to determine how each interest can be taken into account in the future FS systems.

Strength: Establish what the process leader can count on.

Weakness: Establish where information, empowerment and capacity building is needed.

Opportunities/threats: Characterise the potential positive (negative) perspective of the project.

Relationship between stakeholders: Hierarchy, friendship, competition or professional link. Good, bad can decide which working groups can be built.

Impacts: Type of impact of the project on the stakeholder determines the measure needed to maximise positive impact and mitigate negative impact.

Involvement needs: The action required, results mainly from identified interest, weakness and potential.

Influence and interest

	Low influence	**High influence**
Low interest	Stakeholders are unlikely to be closely involved in the project and require not more than information sharing aimed at general public. *INFORMATION*	Stakeholders may oppose the intervention; therefore, they should be kept informed and their views acknowledged to avoid disruption or conflict. *CONSULTATION - INFORMATION*
High interest	Stakeholders require special efforts to ensure that their needs are met and their participation is meaningful. *CONSULTATION - EMPOWERMENT*	Stakeholders should be closely involved to ensure their support for the project. *CONSULTATION – COLLABORATION – EMPOWERMENT / DELEGATION*

Adapted from Reitberger et al. 1988

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Influence vs interest chart helps to prioritize the activities and defines which stakeholder should be closely involved in the planning of city wide FSSM.

8.1.3 Stakeholder Engagement

Participation levels

		Participation levels			
		Information	Consultation	Collaboration	Empowerment / delegation
Planning	*Launch of the planning process*	All stakeholders		Municipality, utilities	
	Detailed assessment of current situation		Key stakeholders[1]	Municipality, utilities	
	Identification of service options		Key stakeholders[1]	Municipality, utilities	
	Development of an Action Plan	All stakeholders	Endusers	Municipality, utilities, FS operators, NGOs	Empower weak and non-organised groups

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Information: Objective is to enable the stakeholders to understand the situation, the different options and their implications. This is one-way flow of communication.

Consultation: Objective is to have stakeholders' feedback on the situation, options, scenarios and / or decisions.

Collaboration: Objective is to work as a partner with the stakeholder on various aspects such as creating scenarios and identification of preferred solution.

Empowerment / Delegation: Objective is to build capacities of the stakeholders so that they can make informed decision, take responsibility of final decision making, and assume their roles and responsibilities in the FSM system.

Participation levels

	Participation levels			
	Information	Consultation	Collaboration	Empowerment / delegation
Implementation	Households, traditional authorities and opinion leaders	Endusers	Municipality, utilities, FS operators, NGOs	Empower and delegate to municipality, utilities, FS operators, NGOs
Monitoring & Evaluation	Key stakeholders	Households, FS operators, endusers	Municipality, utilities, selected NGOs	

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Milestones and cross cutting tasks

Milestones

- Initial launching workshop.
- Validation workshop of selected options by all stakeholders.
- Validation workshop of the Action Plan.

Cross cutting tasks

- Raising awareness.
- Training and capacity building.

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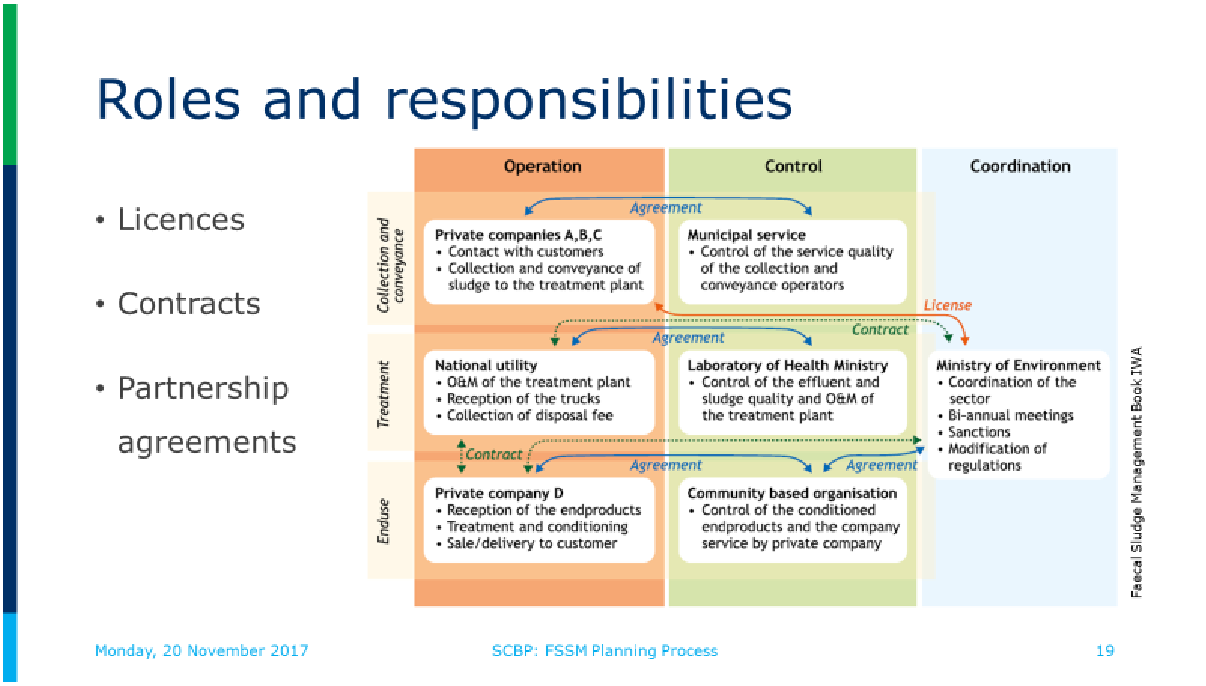
The milestones help to inform, consult and validate the plan with the different stakeholders.

During this planning process, awareness raising and training and capacity building of important stakeholders is necessary in order to have smoother implementation of the plan.



Licences: Issued by authorities for services throughout the whole supply chain. Licence document should contain list of requirements, activities allowed and validity of the licence.

Contracts: Contracts can be signed between the stakeholders involved in the FSM supply chain for specific activities or services. (1) contracts linking a service provider to its customers (2) contracts linking two operators undertaking different activities in the supply chain (3) contracts between one operator and the authorities.

Partnership agreements: Agreements can be signed between two stakeholders to provide a collaborative framework for the institutional or technical management of any component of FS supply chain. Public private partnership where stakeholders from the public and the private sector collaborate to provide services to the population.

8.1.4 Planning of IFSM System

Need for an integrated approach

- Many projects have failed due to lack of integrated approach.
- Projects are mostly physical infrastructure driven.
- Stakeholders' participation, O&M, financial schemes, institutionalization, organizational capacities, lack of cost recovery mechanism.
- Enabling environment and participatory approach is very important part of planning process for IFSM system.

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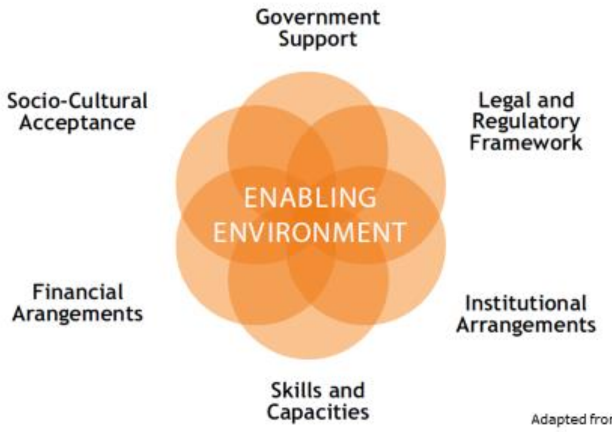
Enabling environment



Adapted from Luthi et al, 2011

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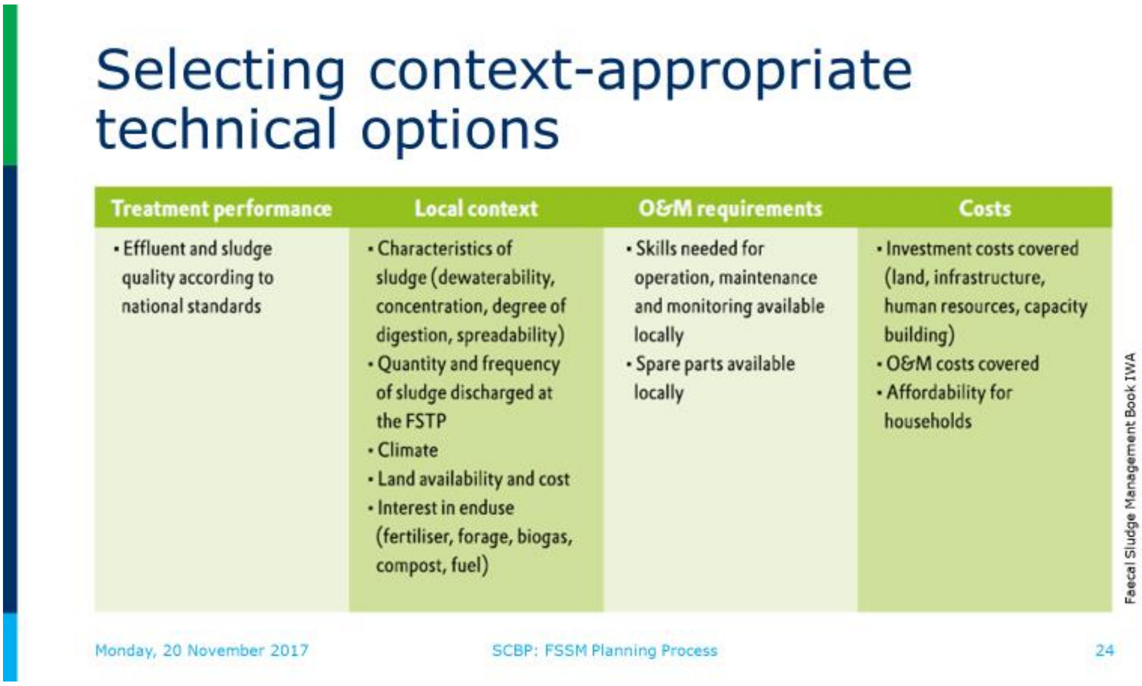
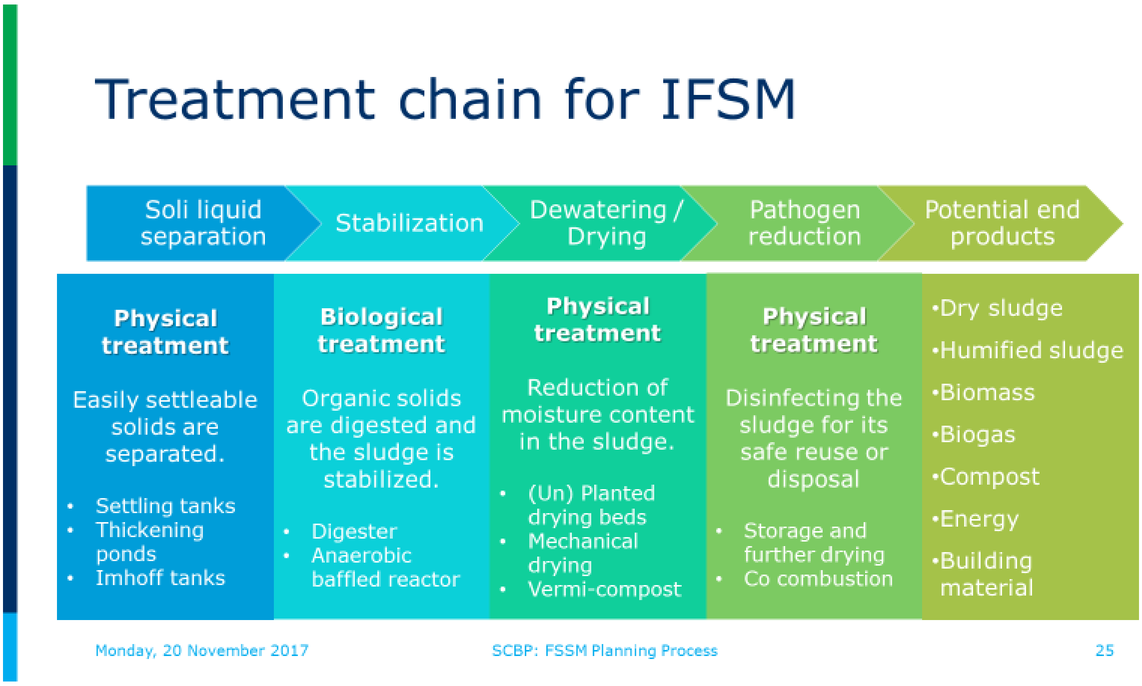
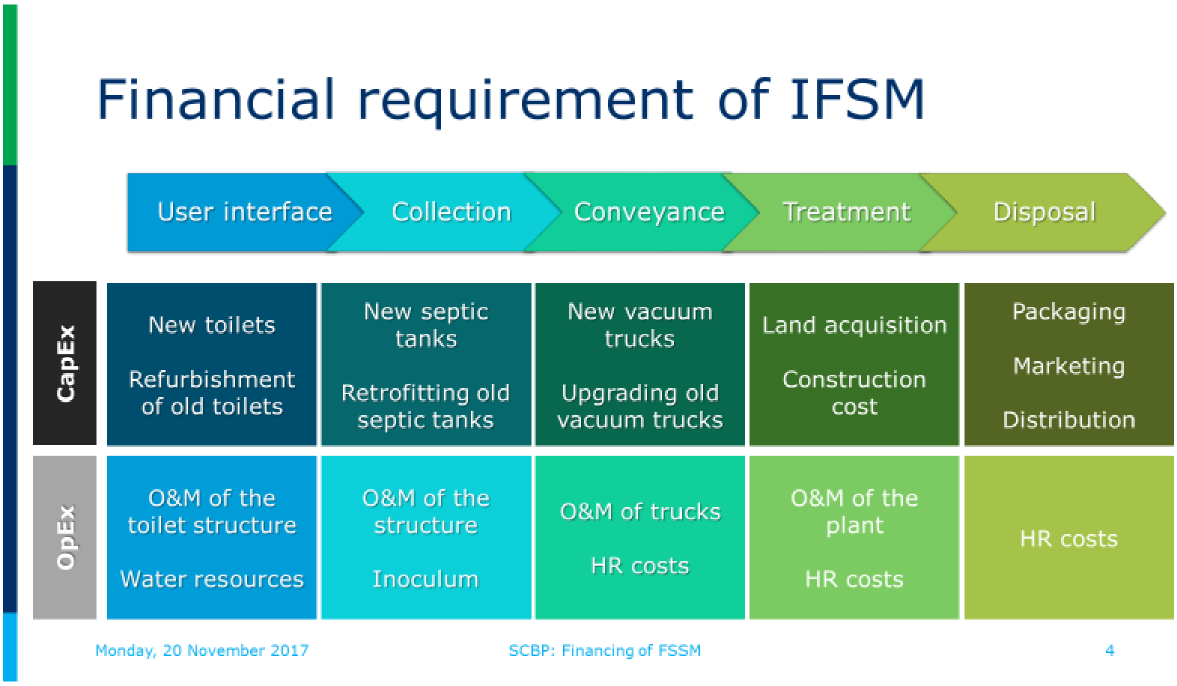




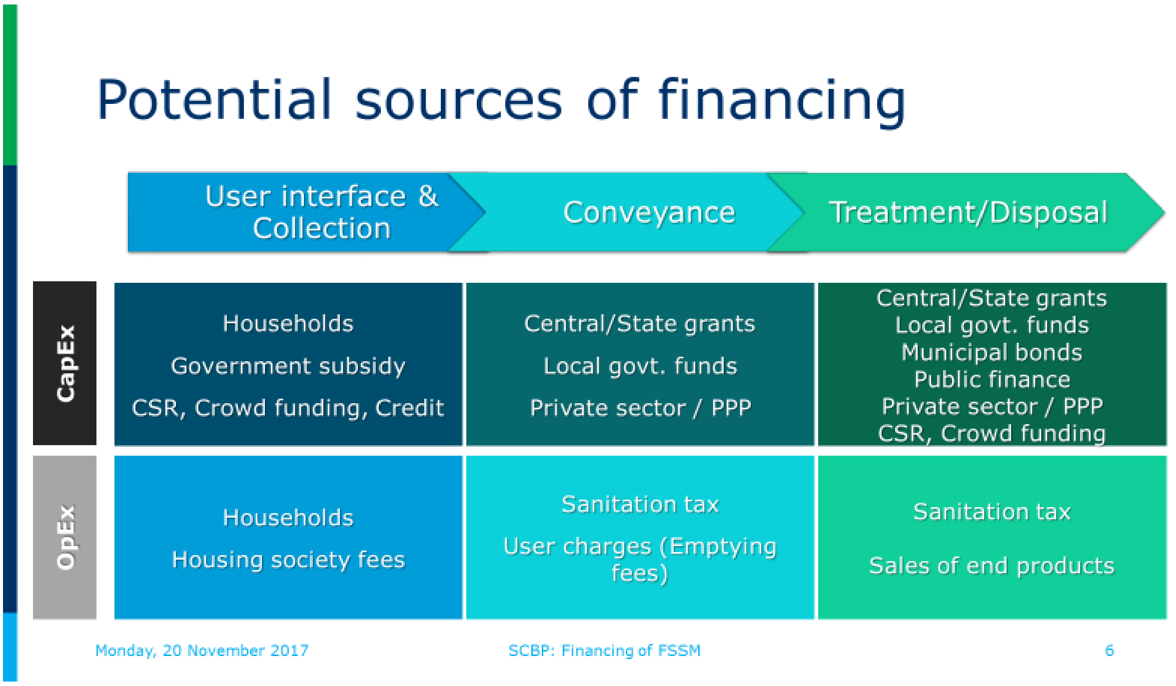
The faecal sludge and septage contain more than 95% water, hence as the first step of treatment, the easily settleable solids are removed using sedimentation process. These solids are then treated biologically to digest and stabilize. In case of well digested septage, the solids can be directly sent to dewatering or drying stage, where the bound water and moisture is removed and the solids are completely dried. The pathogen reduction happens after that and is usually carried out by further sun drying the sludge or co combustion. The end product thus obtained can be numerous use as listed above.

9 FINANCING OF FAECAL SLUDGE AND SEPTAGE MANAGEMENT

9.1.1 Assessment of Financial Requirements



9.1.2 Potential Sources of Financing



9.1.3 Stakeholders involved in Financial Transfers

Stakeholders

- End use industries
  - Relatively new but growing sector in FSSM
  - Ensures good quality of end products
  - Financial benefits and environmental necessity will become drivers of improving FSSM
- Government authorities
  - Sets rules and regulations
  - Allocates budget and out sources processes
  - Collection of taxes, received foreign aid for CapEx and OpEx

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Stakeholders

- Households
  - Owners of user interface and collection system
  - Responsible for emptying the containment system
- Non Government Organizations
  - Are functional where government and private sector not willing or operational

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Stakeholders

- Private enterprises
  - Operate for profit
  - Bound by laws of state and may accept contracts for works
- Public utilities (PU)
  - Responsible for O&M of public infrastructure
  - Extensions of government authorities, and as such, are funded by government budgets.
  - PUs usually operate at loss

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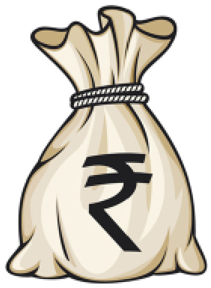
9.1.4 Financial Transfers

Financial transfers

- Budget support
- Capital investment
- Discharge fee
- Discharge incentive
- Discharge license



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Budget support

- Cash transfers between stakeholders to partly or fully cover one stakeholder's operating budget.
- Government authority would provide a public utility
- Usually long-term and non-conditional

Capital investment

- Paid once, at the beginning of the project to cover all expenses needed to build the facility

Discharge fee

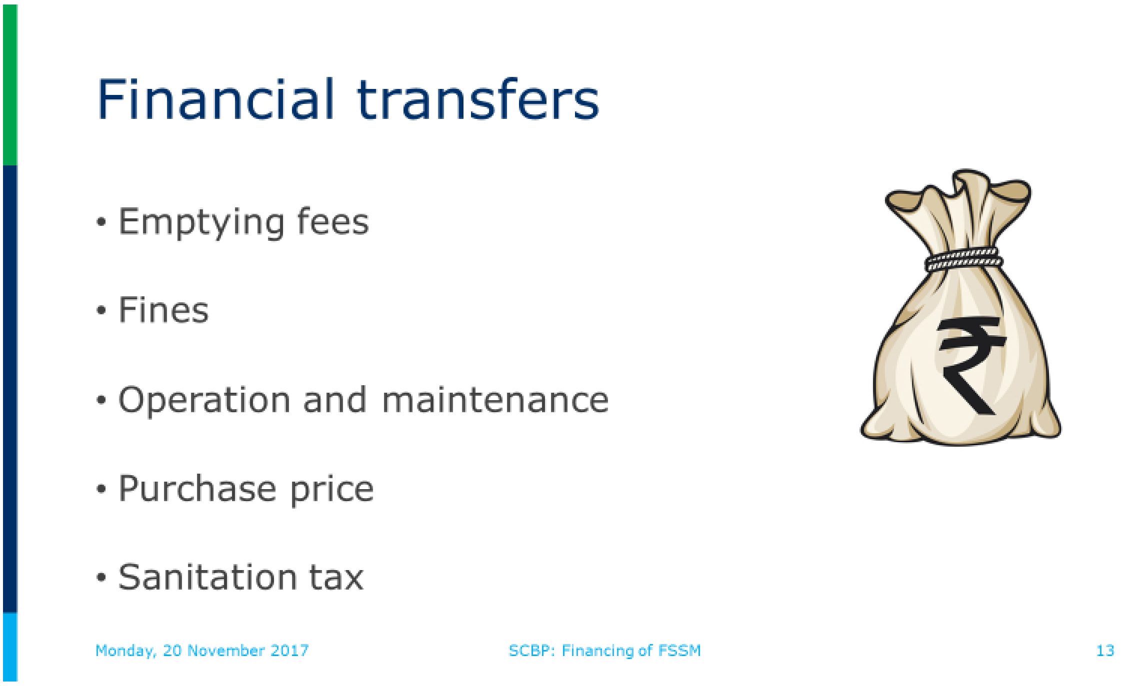
- Charged in exchange for permission to discharge FS at some type of facility.
- Responsibility transfer to a stakeholder who has the legal and technical ability to safely process and/or transfer FS to another responsible stakeholder.
- Highly influences and collection and transport and treatment stage in FSSM. (per trip, per volume)

Discharge incentive

- To reward the C&T business for discharge the sludge in a designated location
- Other means of meeting their costs (sanitation tax)
- Highly effective, more of "carrot" than the "stick" approach!

Discharge license

- Used to control the number and quality of collection and transport enterprises
- Unwanted effect of creating parallel black market.



Emptying fees

- Charged at the household level for removing FS from the onsite sanitation technology

- The emptying fee can be paid once the service is provided, but this type of payment model does not encourage the household to arrange for the emptying until it is absolutely necessary or long overdue.
- Emptying fees vary depending on country, region, currency, market, volume, road condition and a host of other criteria.

Fines

- tools used by the government, or other legal authorities to control and discourage undesirable behaviour.
- fines should be high enough, and enforced often enough, to present a genuine threat to illegal/informal practices
- However, there should be an alternative option to fines that is a functional FSTP which is easily accessible.

Operation and maintenance

- expenses that must be paid regularly and continually until the service life of the infrastructure/equipment has been reached.
- Proper O&M reduces the frequent replacement cost of the equipment and machinery

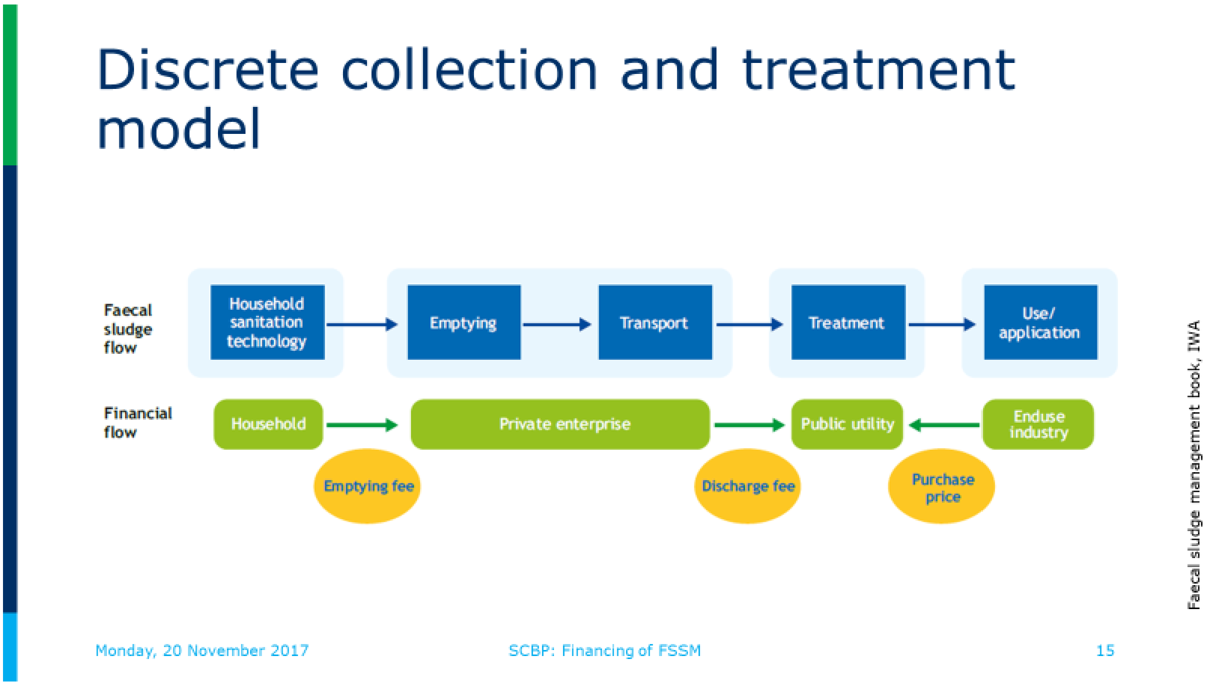
Purchase price

- the price paid by one stakeholder to another in exchange for becoming the sole owner of a good.
- The purchase price is dependent on supply, demand, and any subsidies that may be available.

Sanitation tax

- fee collected either once, or at regular intervals, and which is paid in exchange for environmental services such as a water connection, a sewer connection / removal of FS, or any combination of these services.
- provides a steady source of income allowing treatment and upgrade activities to be more easily planned.

9.1.5 Financial Flow Models

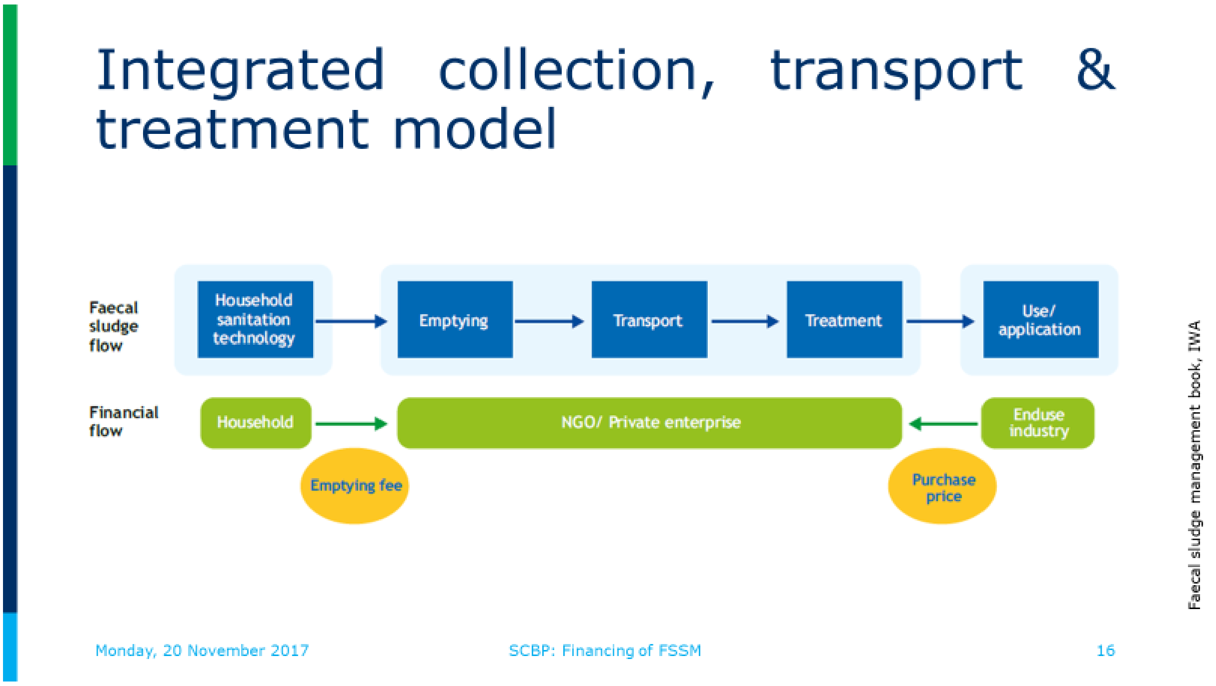


PROS

- Households are free to choose the most competitive price on offer for emptying;
- Timing of emptying is flexible and can be done when financially feasible
- The household is not committed to a fixed sanitation tax

CONS

- The utility's operating expenses must be covered by the discharge fee

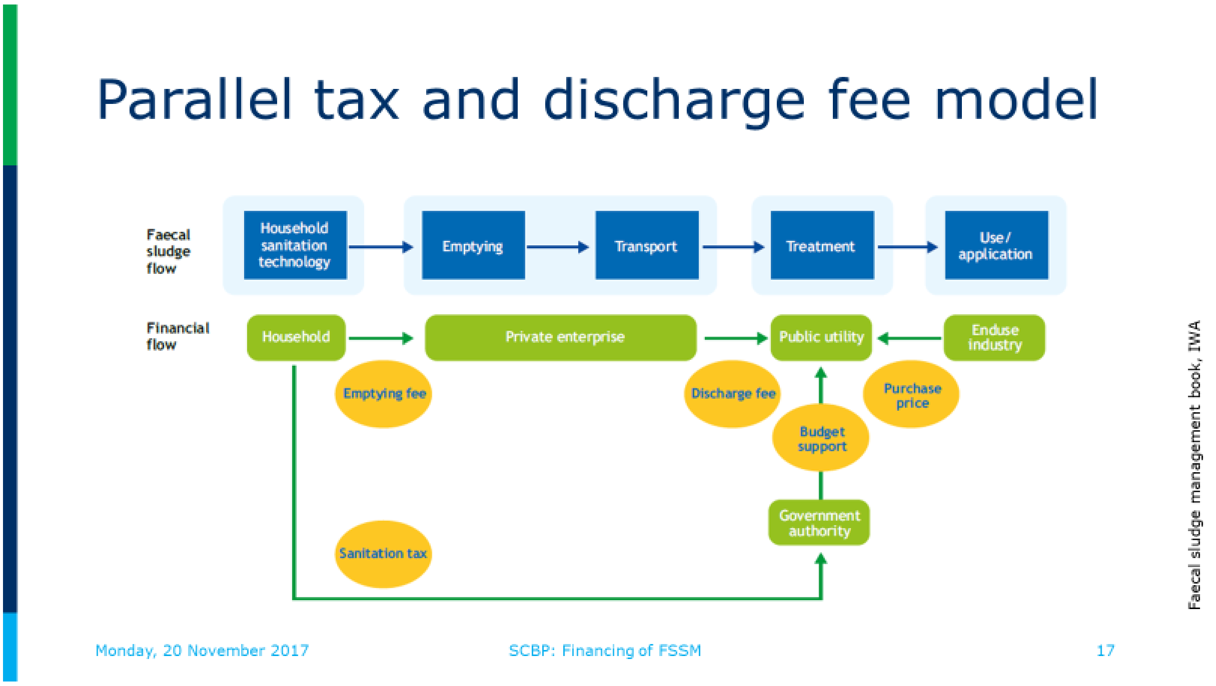


PROS

- A single operator is able to optimise the business model and improve efficiency;
- Less potential for illegal discharge as the single entity will discharge at the self-run treatment works

CONS

- High fees may be passed onto the household

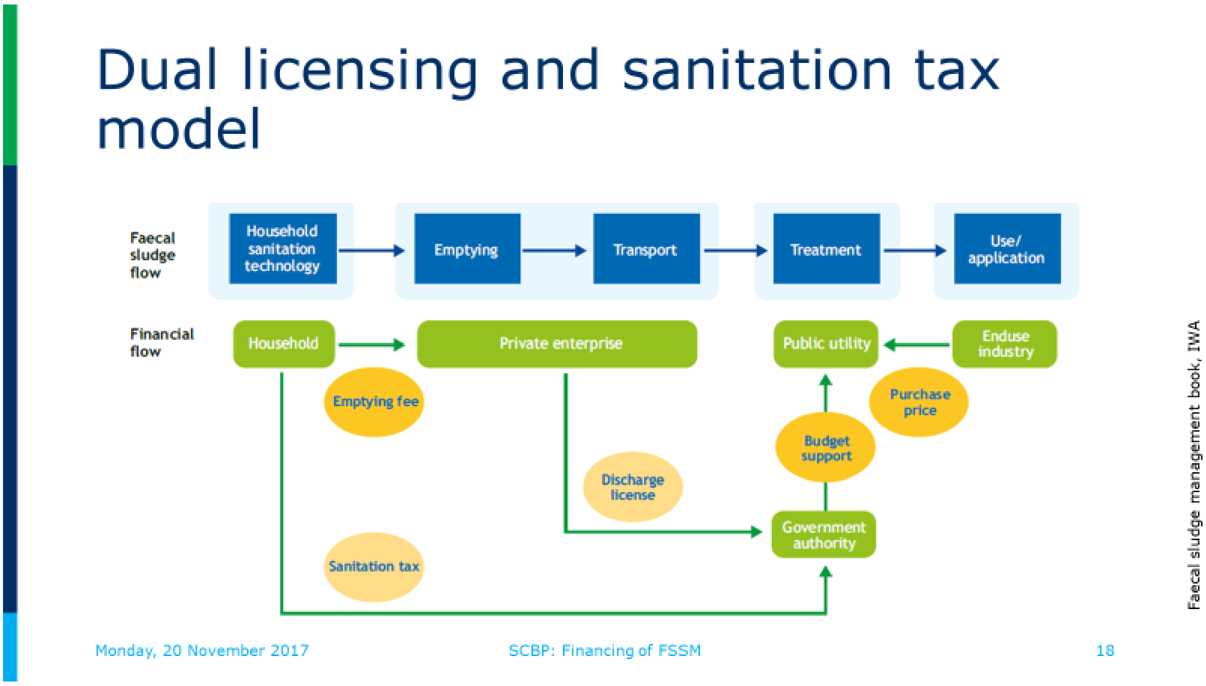


PROS

- Low-income households' that are not connected to the sewer may have lower C&T costs from cross subsidies;
- C&T operators may benefit from lower discharge fees
- Collection and coverage increases

CONS

- C&T businesses may avoid discharge fees by discharge illegally

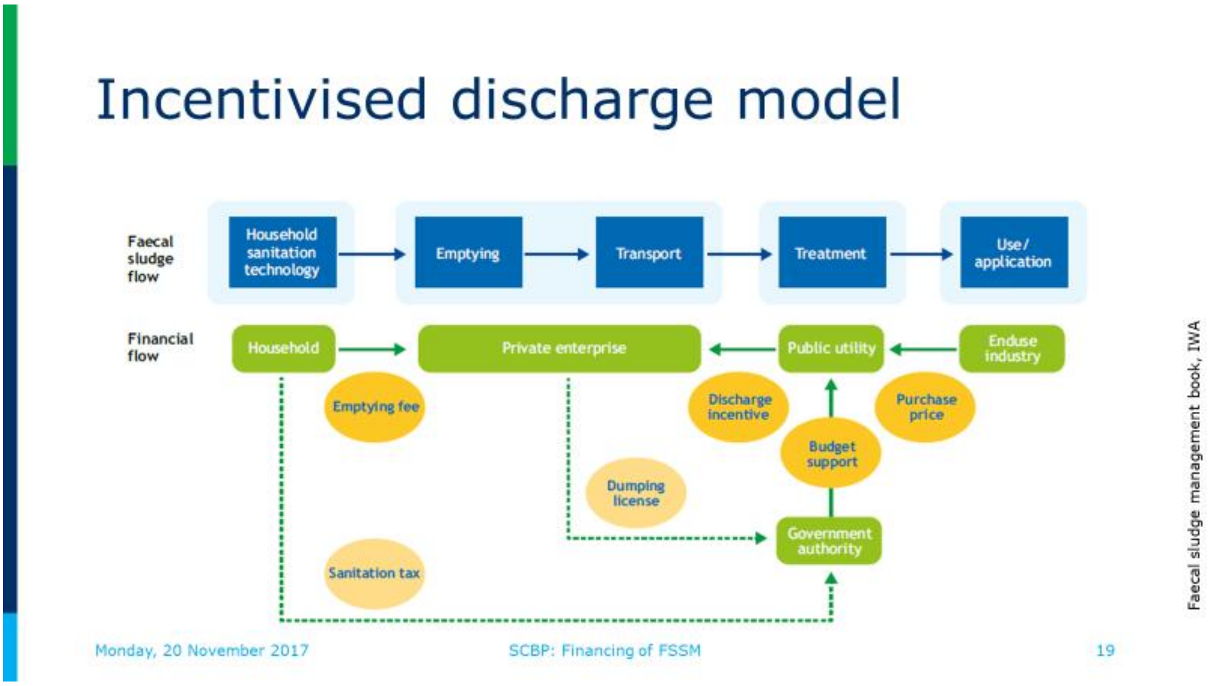


PROS

- Industry regulation and legitimisation through licensing
- Improvement in health and safety conditions;
- Unlimited discharges minimise risk of illegal dumping

CONS

- The management of too many aspects of the service chain by one entity could prove difficult for a new business or NGO



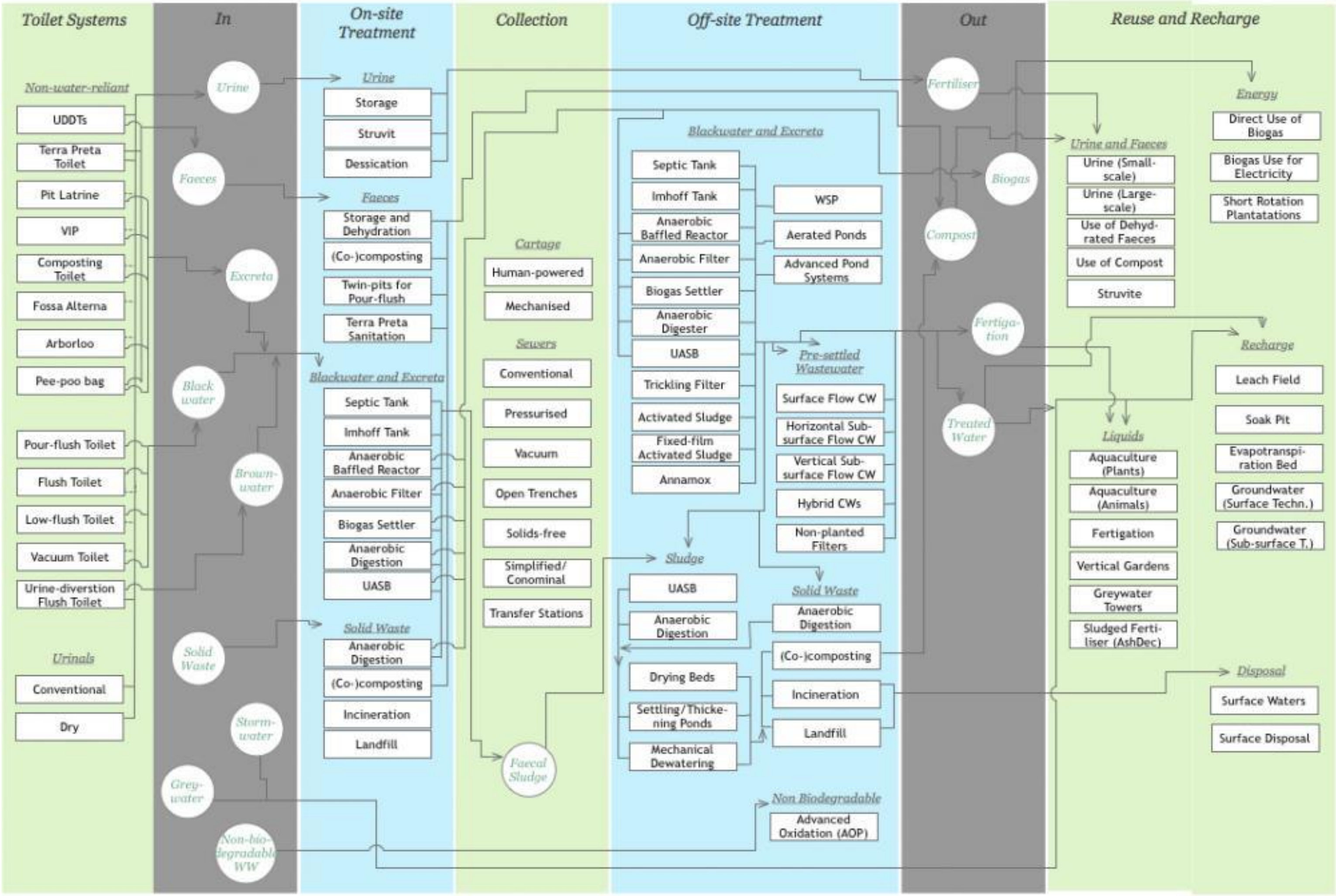
PROS

- Emptying fees for households may be reduced;
- Households that are difficult to access, or located far from the treatment plant, may become attractive to C&T operators because of incentives

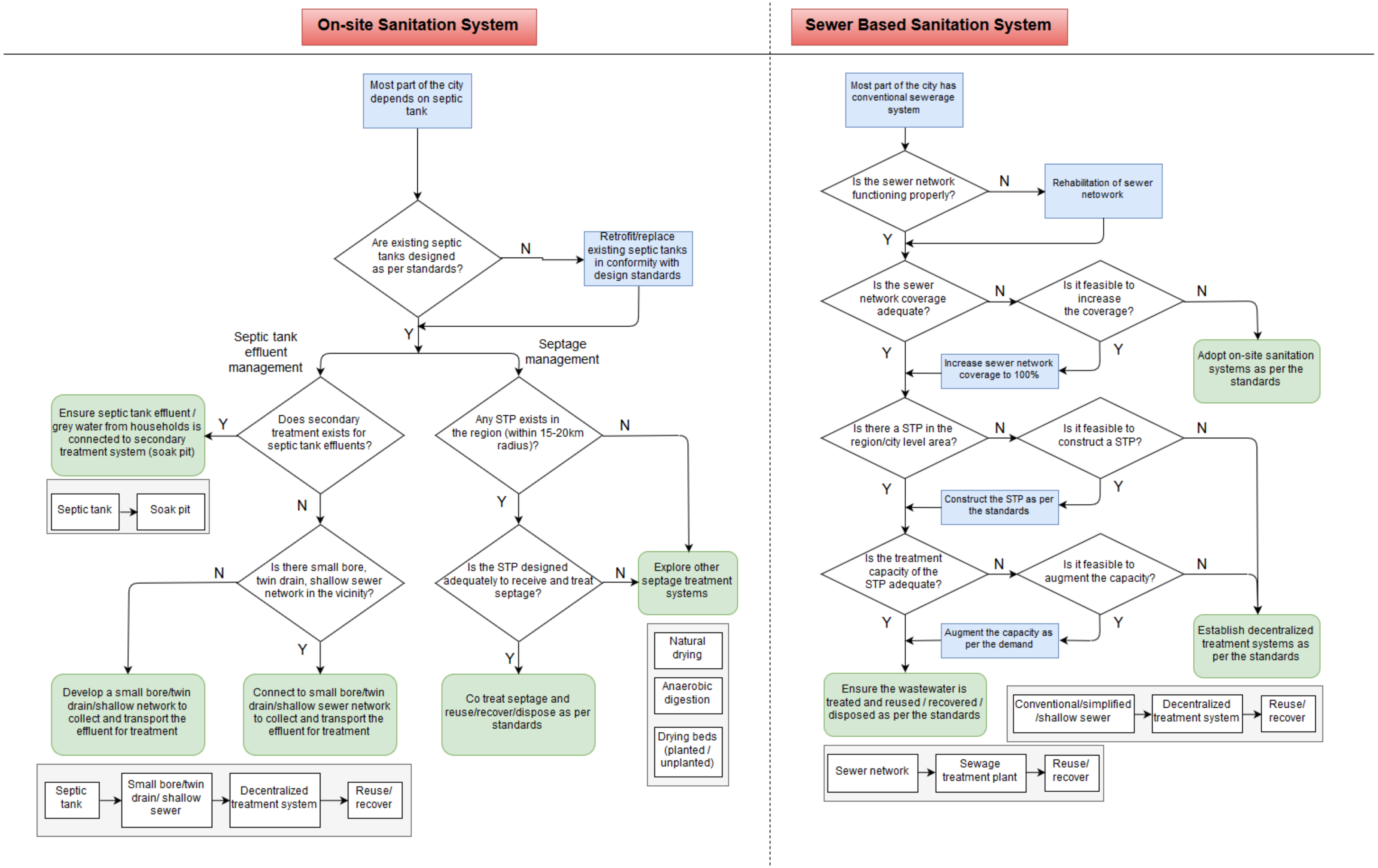
CONS

- Incentives must be corruption proof (e.g. not given for diluted sludge etc.)
- FSTP operator requires significant budget support to function budget support to function

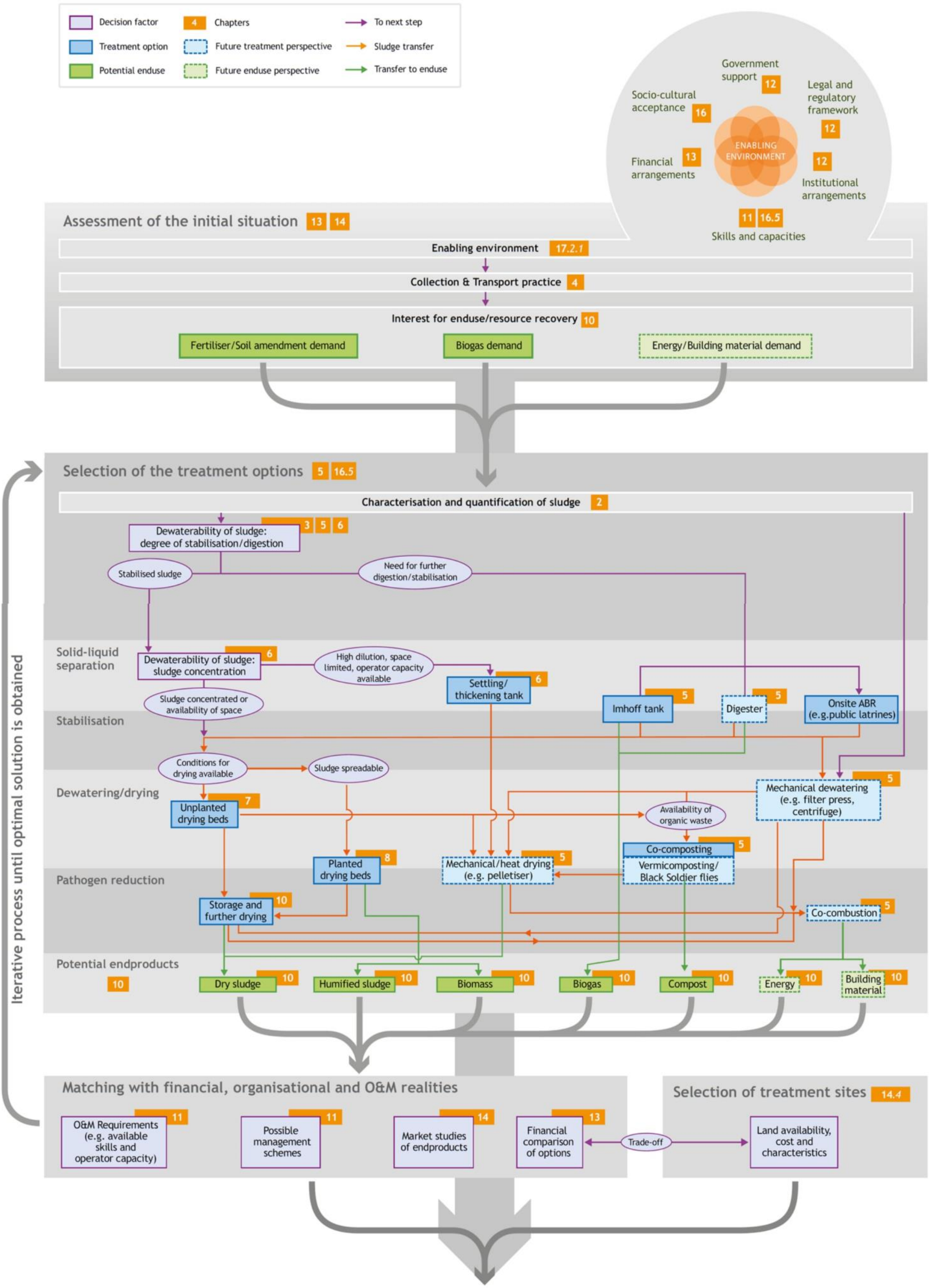
10 IDENTIFYING APPROPRIATE SYSTEMS FOR YOUR CITY



Logic diagram like these should be formulated after collection of base line data and adopted before planning of sanitation system.



Selecting a context-appropriate combination of faecal sludge treatment technologies



Final choice of combination of technologies

National Institute of Urban Affairs

National Institute of Urban Affairs

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