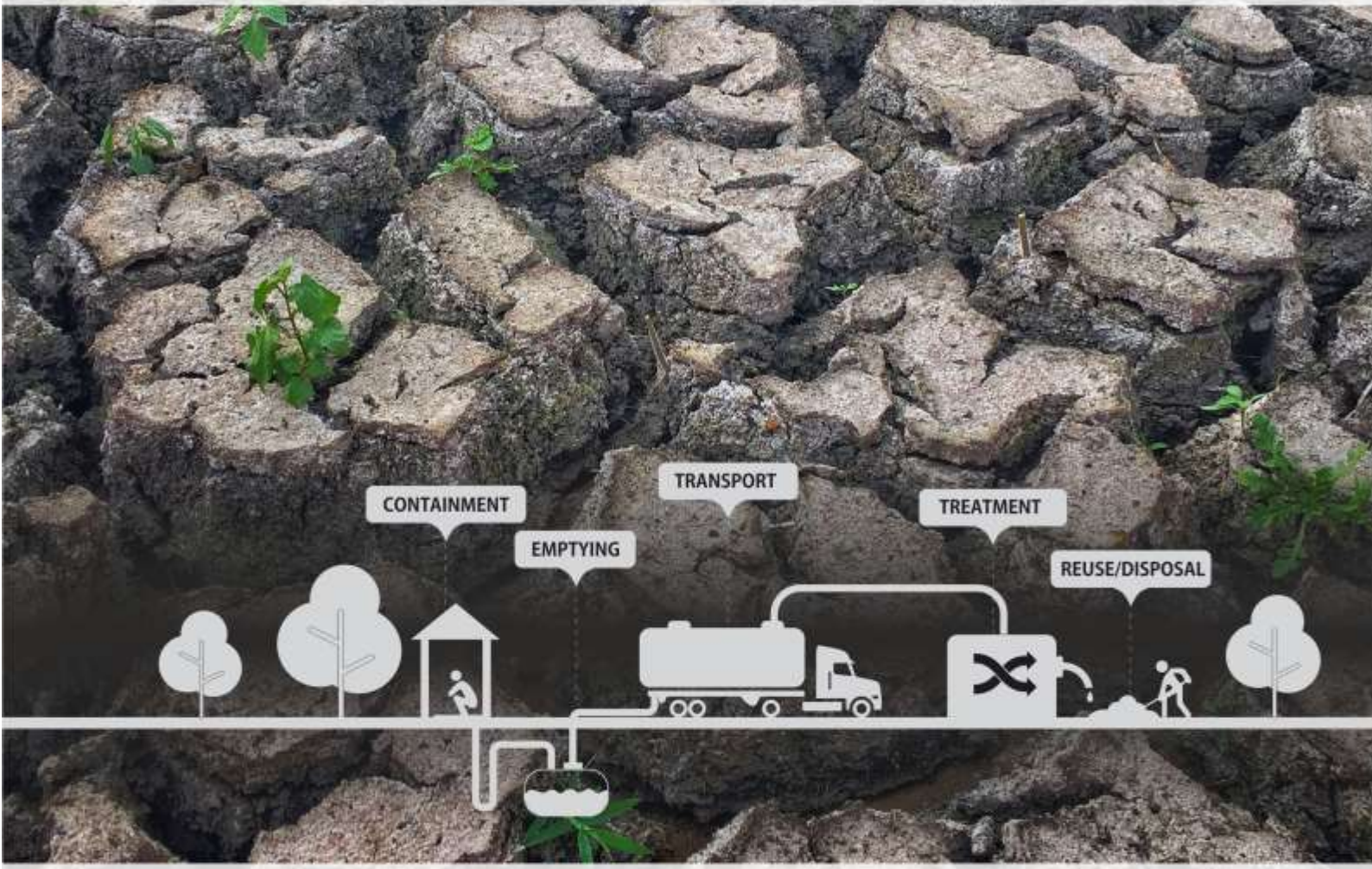
SCBP

Faculty Development Program on Integrated Wastewater and Septage Management

March 16th - 20th, 2019



National Institute of Urban Affairs

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Faculty Development Program

on

Integrated Wastewater and Septage Management

Presentation Slides

TITLE

FACULTY DEVELOPMENT PROGRAM ON INTEGRATED WASTEWATER AND SEPTAGE MANAGEMENT

RESEARCH PROJECT

SANITATION CAPACITY BUILDING PLATFORM,

ANCHORED BY

NATIONAL INSTITUTE OF URBAN AFFAIRS, DELHI

CONTENT

The module is prepared by College of Engineering, Pune and Ecosan Services Foundation (ESF), Pune

GRAPHIC DESIGN

Dhawal Patil, Ecosan Services Foundation

DISCLAIMER

CONTACT

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Website: www.niua.org, www.scbp.niua.org

Faculty Development Program
On
Integrated Wastewater and Septage Management (IWSM)

Venue: COEP, Pune

16th – 20th March, 2019

Time	Day 1: March 16, 2019	Facilitated by,
9.30 am-10.00 am	Registration	COEP
10.00 am-10.45 am	Introduction about the SCBP and FDP on IWSM, Introduction of Participants, Setting the Ground Rules	COEP, NIUA and ESF
10.45 am-11.00 am	*Coffee Break*	
11.00 am –11.45 am	Water and Sanitation in Developing Countries	Prof. Pratap Raval, COEP
11.45 am – 1.00 pm	Sustainable Sanitation and Water Management (SSWM)	Mr. Saurabh Kale, ESF
1.00 pm - 2.00 pm	Lunch	
2.00 pm- 3.00 pm	SSWM Group work:1 Define boundaries, identify sanitation components of your system/city	Mr. Saurabh Kale, ESF
3.00 pm- 3.15 pm	Coffee Break	
3.15 pm- 4.15 pm	Designing of Sanitation System	Mr. Dhawal Patil, ESF
4.15 pm- 5.00 pm	SSWM Group work:1 Understand Your System w.r.t. Water and Nutrient Cycle: Issues, Challenges and Solutions	Mr. Dhawal Patil, ESF

Time	Day 2: March 17, 2019	Facilitated by,
10.00 am - 11.00 am	Sanitation Systems and Technologies	Mr. Dhawal Patil, ESF
11.00 am - 11.15 am	Coffee Break	
11.15 am - 12.15 pm	Wastewater Treatment Technologies: Centralised and Decentralised Approach	Mr. Dhawal Patil, ESF
12.15 pm – 1.15 pm	Planning Approach: City Sanitation Action Plan to ULBs	Prof. Pratap Raval, COEP
1.15 pm - 2.00 pm	Lunch	
2.00 pm – 3.00 pm	Group Work: Review CSP of a City	Prof. Pratap Raval, COEP
3.00 pm - 3.15 pm	Coffee Break	
3.15 pm – 5.00 pm	Visit to DTS & CW Site, COEP Hostel Campus	ESF and COEP

Time	Day 3: March 18, 2019	Facilitated by,
10.00 am -10.45 am	Need of Faecal Sludge and Septage Management (FSSM), National FSSM Policy, India	Mr. Saurabh Kale, ESF
10.45 am -11.00 pm	Coffee Break	
11.00 am- 11.45 pm	Planning of Integrated Faecal Sludge and Septage Management (IFSSM)	Mr. Dhawal Patil. ESF
11.45 pm- 1.00 pm	Assessment of Initial Situation, FS Quantification and Characterisation	Mr. Saurabh Kale, ESF
1.00 pm- 2.00 pm	Lunch	
2.00 pm- 3.00 pm	Methods and Means of FS Collection and Transport	Mr. Saurabh Kale, ESF
3.00 pm- 3.15 pm	Coffee Break	
3.15 pm- 3.45 pm	Group Work: Collection and Transportation	Mr. Dhawal Patil, ESF
4.00 pm- 5.00 pm	FS Treatment Mechanism and Technologies	Mr. Dhawal Patil, ESF

Time	Day 4: March 19, 2019	Conducted by,
7.00 am -5.00 pm	• Visit to Decentralised On-Site Integrated Waste Management (DOSIWAM) System, Dehu • Visit to Sewage Treatment Plant and Vermi-Composting Plant, PCMC	COEP

Time	Day 5: March 20, 2019	Facilitated by,
10.00 am -11.00 am	Non-Technical Aspects Group Work: Stakeholders Analysis	Mr. Saurabh Kale, ESF
11.00 am -11.15 pm	Coffee Break	
11.15 am- 12.15 pm	Financing of Faecal Sludge and Septage Management (FSSM)	Mr. Dhawal Patil, ESF
12.15 pm- 1.15 pm	Backwards Course Design and Communication and Teaching Styles	Mr. Dhawal Patil, ESF
1.15 pm- 2.00 pm	Lunch	
2.00 pm- 3.00 pm	Exercise and Discussion: Application – Course Design and Way Forward	Prof. Pratap Raval, COEP
3.00 pm- 3.30 pm	Wrap-up and Feedback Session	COEP and ESF

National Institute of Urban Affairs

SANITATION CAPACITY BUILDING PROGRAM

Water and Sanitation in Developing countries

Prof. Pratap Raval,
College of Engineering, Pune

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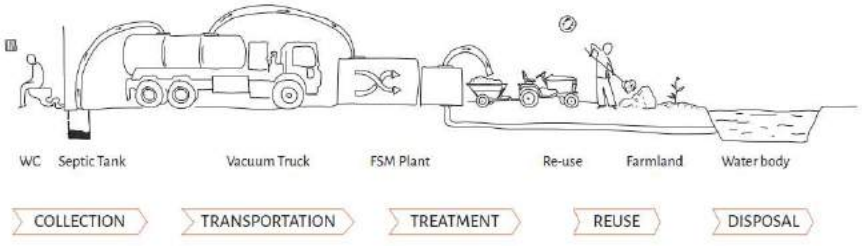
CONTENT

- Overview
- Wastewater generation scenario,
- Water supply and environmental sanitation,
- Resource and waste systems,
- Objectives of water supply and sanitation systems



OVERVIEW

At the beginning of the 21st century, the world faces a water quality crisis resulting from continuous population growth, urbanization, land use change, industrialization, food production practices, increased living standards and poor water use practices and wastewater management strategies. Wastewater management (or the lack thereof) has a direct impact on the biological diversity of aquatic ecosystems (Corcoran et al. 2010).

This is becoming increasingly a global problem as urban populations are projected to nearly double in 40 years, from current 3.4 billion to over six billion people – but already most cities lack adequate wastewater management due to aging, absent or inadequate sewage infrastructure" (World Water Council, 2012).

WASTEWATER GENERATION SCENARIO

It is estimated that about 38,254 million litres per day (mld) of wastewater is generated in urban centres comprising Class I cities and Class II towns having population of more than 50,000 (accounting for more than 70 per cent of the total urban population).

The municipal wastewater treatment capacity developed so far is about 11,787 mld, that is about 31 per cent of wastewater generation.

It is estimated that the projected wastewater from urban centres may cross 120,000 mld by 2051 and that rural India will also generate not less than 50,000 mld in view of water supply designs for community supplies in rural areas.

Source: India Infrastructure Report 2011

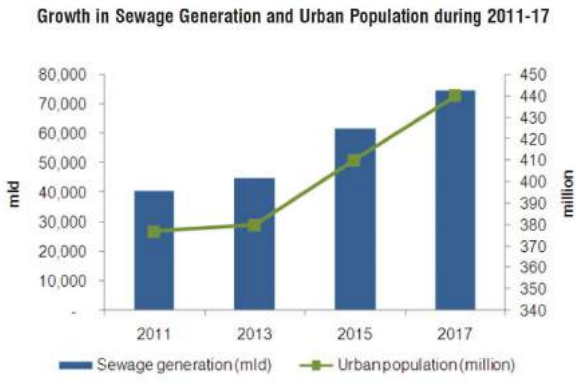
WASTEWATER GENERATION SCENARIO

Maharashtra, Delhi, Uttar Pradesh, West Bengal and Gujarat are the major contributors of wastewater (63%; CPCB, 2007a).

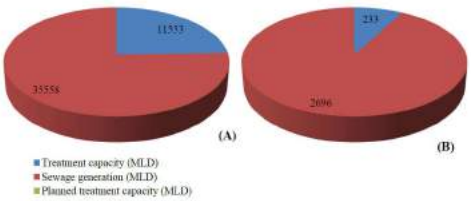
Between 2011 and 2017, the total sewage generated by Class I and Class II cities increased from 40,715 million litres per day (mld) in 2011 to 75,020 mld in 2017. (increase of 10.72 %) (India Infrastructure Research 2017)
The country's sewage treatment capacity increased from 11,787 mld in 2009 to 26,066.31 mld in 2018 (as of July 2018). About 83% is currently operational.

A major part of Urban India is yet to be provided with sewer system and the people are mainly dependent on conventional individual septic tanks. Census 2011 (provisional) results show 30 million urban households (38 percent of urban households) have septic tanks. USAID (2010) estimates, that by 2017, about 148 million urban people would have septic tanks.

WASTEWATER GENERATION SCENARIO



The National Rating of 423 Class I Indian Cities (covering 72% of Indian urban population) on Sanitation (MOUD, Govt. of India, May, 2010) found that 65% per cent (274) of these cities had unsatisfactory arrangements for safe collection of human excreta (whether on-site or sewerage). (NUSP 2008)



Sewage generation and treatment capacity in 498 Class I cities and 410 class II towns in India. (CPCB, 2009)

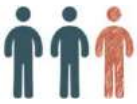
GOVT. OF INDIA'S EFFORTS

India's National Urban Sanitation Policy (NUSP, 2008) defines sanitation as "safe management of human excreta, including its safe confinement treatment, disposal and associated hygiene-related practices."

The NUSP envisages preparation of State Sanitation Strategies by States, and City Sanitation Plans (CSPs) by cities. The overall goal of the NUSP is "to transform Urban India into community-driven, totally sanitized, healthy and liveable cities and towns."

The specific goals include awareness generation and behaviour change; open defecation free cities; and integrated city-wide sanitation.

WATER AND SANITATION IN OUR WORLD TODAY



1 in 3 people don't have access to toilets or latrines

With no other choice, **1 billion** people defecate outside.

WATER QUALITY

2 million tones of human waste enter water sources every day.

1.8 billion people use faecally contaminated water, polluted water and poor sanitation practices spread diseases such as diarrhoea, cholera and malaria.

WASTEWATER IMPACT IN DEVELOPED WORLD

- A family of four can use 220,000 litres of water a year. This requires 120 kWh of energy to provide it and 100 kWh to treat it as sewerage. The energy used release 200 kg of CO_2 into the atmosphere each year
- Despite the efforts devoted to water treatment at sewage plants in the Netherlands, upwards of 50,000 tonnes of pollutants enter surface aquatic ecosystems annually from municipal water system, including almost 500 tonnes of heavy metal. The system also produces 3.2 million tonnes of unusable solid sewage sludge.
- The World Water Vision statement say that trend of freshwater withdrawal and consumption will continue to increase over next twenty-five years. Related to 1995 figures, water withdrawal and consumption in municipalities will respectively by 43% and 100% greater in 2025.

UN STATISTICS ON THE WATER CRISIS

- "WATER SCARCITY AFFECTS MORE THAN 40 PERCENT O F THE GLOBAL POPULATION AND IS PROJECTED TO RISE."
- "MORE THAN 80 PERCENT OF WASTEWATER RESULTING FROM HUMAN ACTIVITIES IS DISCHARGED INTO RIVERS OR SEA WITHOUT ANY TREATMENT, LEADING TO POLLUTION."
- "MORE THAN 2 MILLION PEOPLE DIE EVERY YEAR FROM DIARRHOEAL DISEASES. POOR HYGIENE AND UNSAFE WATER ARE RESPONSIBLE FOR NEARLY 90 PERCENT OF THESE DEATHS AND MOSTLY AFFECT CHILDREN."; "MORE THAN 800 CHILDREN DIE EVERY DAY FROM DIARRHOEAL DISEASES LINKED TO POOR HYGIENE"

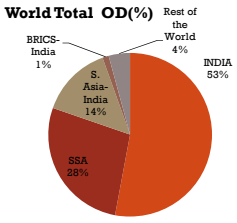
HTTP://WWW.UN.ORG/SUSTAINABLEDEVELOPMENT/WP-CONTENT/UPLOADS/2016/06/WHY-IT-MATTERS_SANITATION_1P.PDF

UN STATISTICS ON THE WATER CRISIS

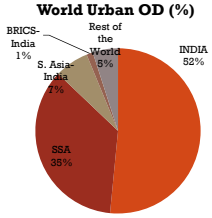
- "EXTENDING BASIC WATER AND SANITATION SERVICES TO THE UNSERVED WOULD COST US$28.4 BILLION PER YEAR FROM 2015 TO 2030, OR 0.10 PER CENT OF THE GLOBAL PRODUCT OF THE 140 COUNTRIES INCLUDED IN ITS STUDY"
- THE ECONOMIC IMPACT OF NOT INVESTING IN WATER AND SANITATION COSTS AN ENORMOUS 4.3 PERCENT OF SUB-SAHARAN AFRICAN GDP. THE WORLD BANK ESTIMATES THAT 6.4 PER CENT OF INDIA'S GDP IS LOST DUE TO ADVERSE ECONOMIC IMPACTS AND COSTS OF INADEQUATE SANITATION

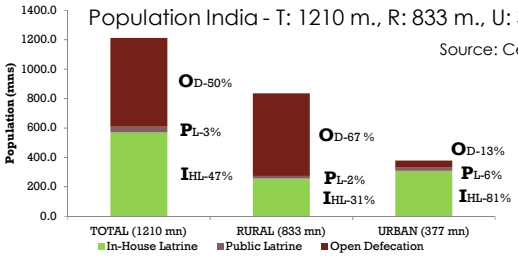
HTTP://WWW.UN.ORG/SUSTAINABLEDEVELOPMENT/WP-CONTENT/UPLOADS/2016/06/WHY-IT-MATTERS_SANITATION_1P.PDF

SCALE OF CHALLENGES : INDIA AND THE WORLD



SCBP: Sustainable Sanitation & Water Management

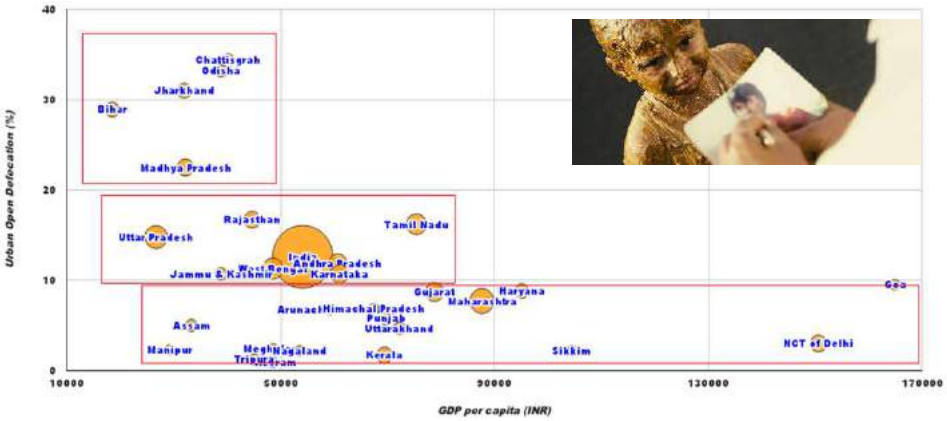




MDG Goal/ Target/ Indicator	India's Baseline - 1990	India's Target for 2015	India's achievement in 2012
Safe drinking water (T)	70	85	93
Improved Sanitation (T)	18	59	36
Improved Sanitation (U)	50	75	60
Improved Sanitation (R)	7	71	25

Source: MOPSI 2013

STATE DIFFERENCES: URBAN SANITATION



Source: Census of India (2011), Planning Commission (2012)

Urban Open defecation in India, as against per capita State GDP shows three clear clusters
1. Smaller, higher income states, have lower OD; 2. Large sized states have OD similar to India's average : 3. Medium sized lower urbanized states have higher OD

Source: S. Dasgupta, Center for Policy Research, New Delhi

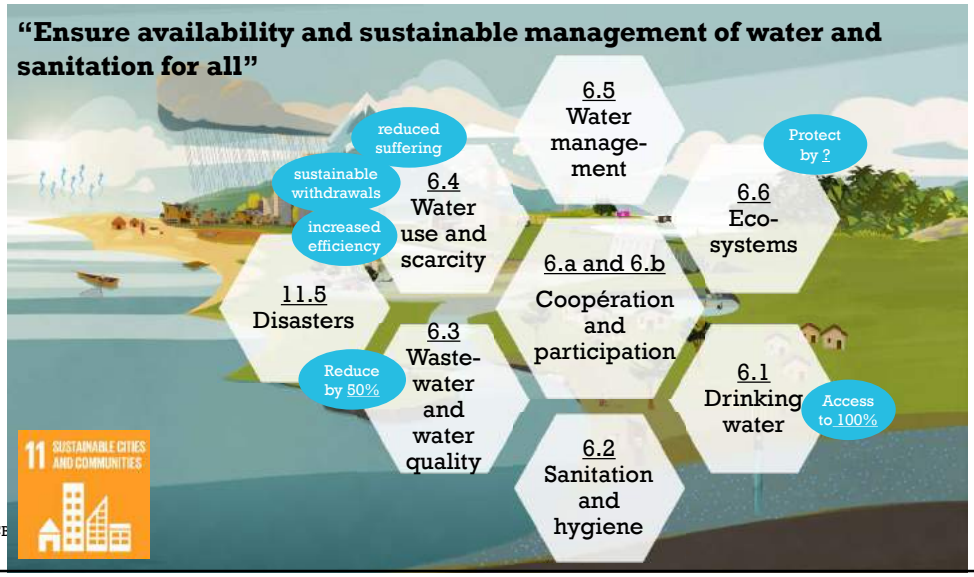
Millennium Development Goals MDGs

- UN-led
- 8 goals and 21 targets, focusing on poverty reduction
- Relevant to low income countries
- 2 water and sanitation targets under MDG 7
- 3 core indicators on water and sanitation
- Monitoring through household surveys

Sustainable Development Goals SDGs

- Country-led
- 17 goals and 169 targets, focusing on the three pillars of sustainable development
- Relevant to all countries
- 8 water and sanitation targets under SDG 6
- 11 core indicators on water and sanitation
- Monitoring by national authorities, feeding into regional and global reporting

SDG 6

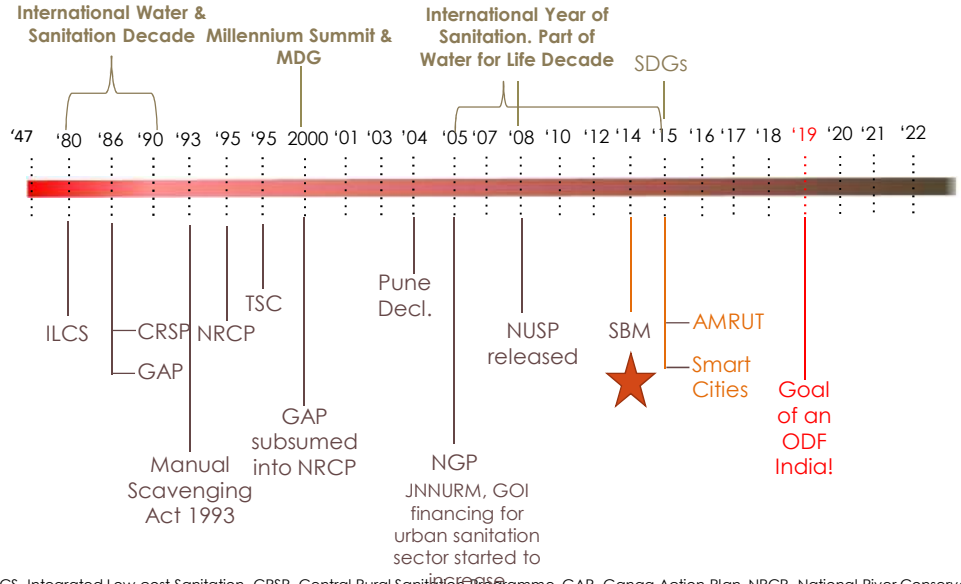


GOAL 6: ENSURE ACCESS TO WATER AND SANITATION FOR ALL

HTTP://WWW.UN.ORG/SUSTAINABLEDEVELOPMENT/WATER-AND-SANITATION/

- BY 2030, ACHIEVE UNIVERSAL AND EQUITABLE ACCESS TO SAFE AND AFFORDABLE DRINKING WATER FOR ALL
- BY 2030, ACHIEVE ACCESS TO ADEQUATE AND EQUITABLE SANITATION AND HYGIENE FOR ALL AND END OPEN DEFECATION, PAYING SPECIAL ATTENTION TO THE NEEDS OF WOMEN AND GIRLS AND THOSE IN VULNERABLE SITUATIONS
- BY 2030, IMPROVE WATER QUALITY BY REDUCING POLLUTION, ELIMINATING DUMPING AND MINIMIZING RELEASE OF HAZARDOUS CHEMICALS AND MATERIALS, HALVING THE PROPORTION OF UNTREATED WASTEWATER AND SUBSTANTIALLY INCREASING RECYCLING AND SAFE REUSE GLOBALLY
- BY 2030, SUBSTANTIALLY INCREASE WATER-USE EFFICIENCY ACROSS ALL SECTORS AND ENSURE SUSTAINABLE WITHDRAWALS AND SUPPLY OF FRESHWATER TO ADDRESS WATER SCARCITY AND SUBSTANTIALLY REDUCE THE NUMBER OF PEOPLE SUFFERING FROM WATER SCARCITY

NATIONAL: INCREASED ATTENTION TO SANITATION POLICY



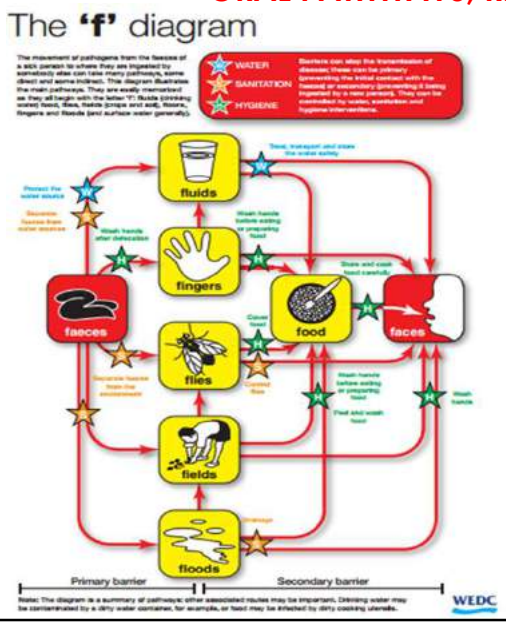
ILCS- Integrated Low-cost Sanitation, CRSP- Central Rural Sanitation Programme, GAP- Ganga Action Plan, NRCP- National River Conservation Programme, TSC- Total Sanitation Campaign, NGP- Nirmal Gram Puraskar, JNNURM- Jawaharlal Nehru National Urban Renewal Mission, NUSP- National Urban Sanitation Policy , SBM – Swachh Bharat Mission, NUDM – National Urban Development Mission

ENVIRONENTAL HEALTH

Global Burdon of Diseases

- **Faecal-oral (focus of this presentation)**
  - **Diarrhoeal disease**
    - **2 million deaths/year from diarrhoea, mostly under 5**
      - **Jumbo jet crash every hour and a half…**
    - **One billion cases/year**
    - **4.3% of Burden of Disease DALYs**
    - **88% (?) attributable to inadequate WSH**
  - **1/3 of developing world pop'n carry intestinal worms**
  - **200 million infected by schistosomiasis (bilharzia)**
- **6-9 million blind from trachoma (1/4 reduced by adequate water supply)**

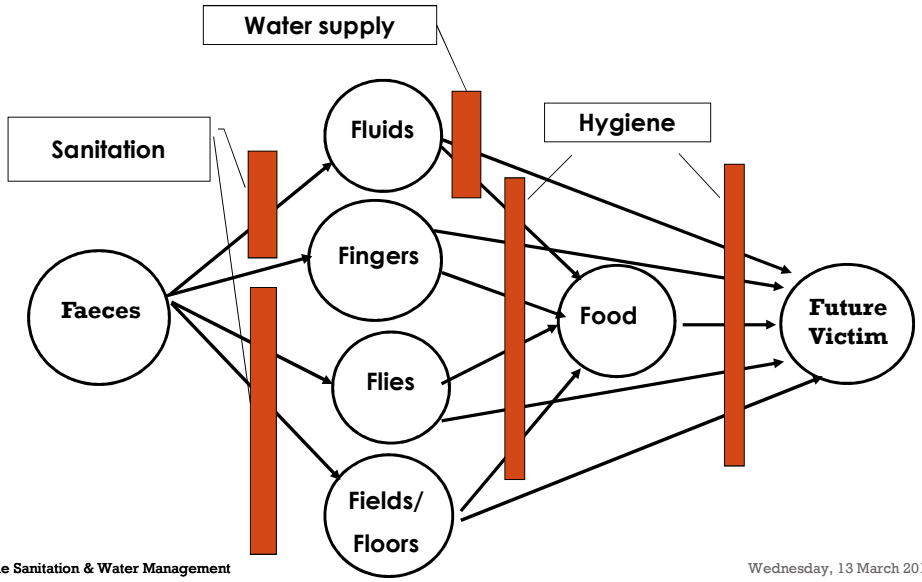
TRANSMISSION ROUTE OF PATHOGENS FAECAL – ORAL PATHWAYS, RISKS, IMPACT



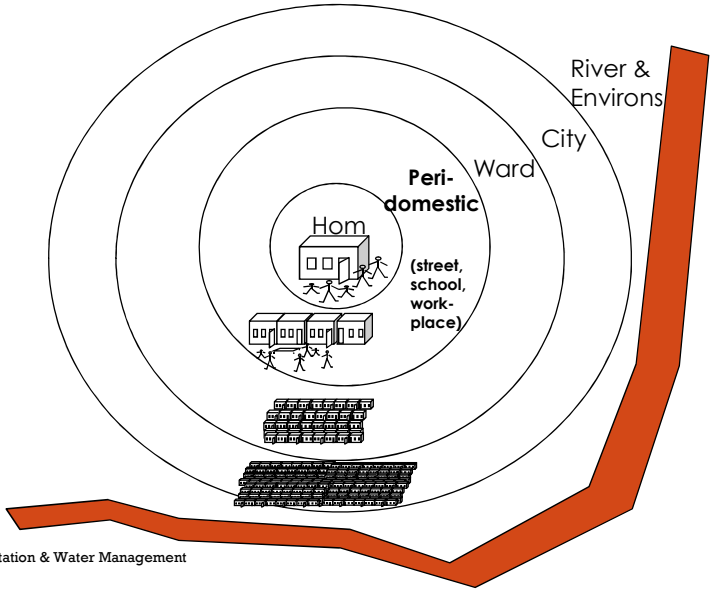
- Water borne diseases
  - Diarrhoea: estimated 600 mill. adult cases, 300 mill. U-5
    : about 400,000 U-5 deaths
- Vector borne
  - Malaria: 900,000 (2013) reported cases to 24 mill. annual cases (estimated 2012)
  - Dengue : ~ 50,000 cases & 250 deaths (2012)
- Stunting

  - undernutrition in India is largely explained by open defecation, population density, and lack of sanitation and hygiene

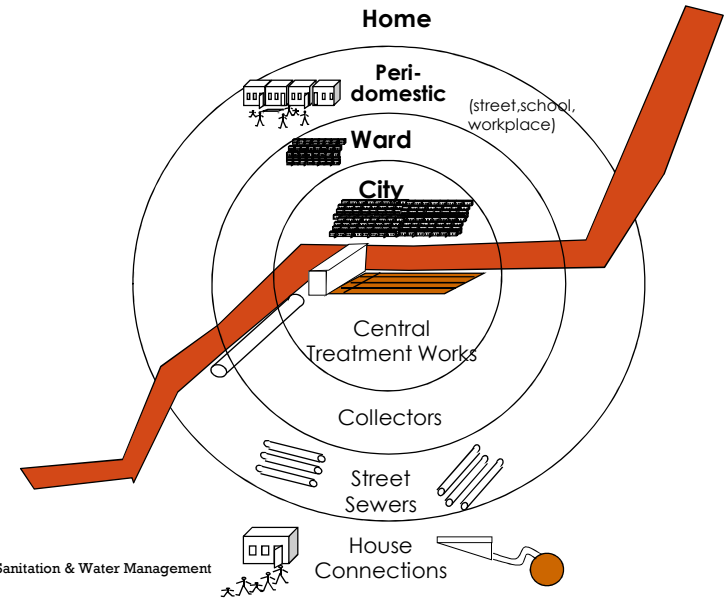
THE F-DIAGRAM



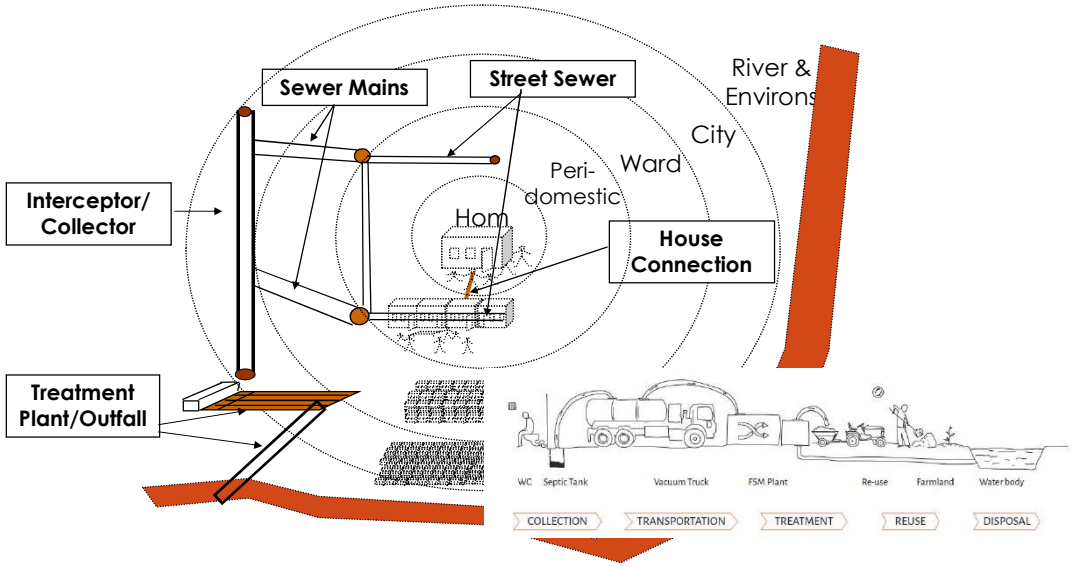
HOW PEOPLE SEE THEIR CITY



AN ENVIRONMENTAL VIEW



A PUBLIC HEALTH VIEW



FSM WAY FORWARD

- Specific urban contexts
- The way forward for urban sanitation
- Academic institute-Interface between research, implementation & dissemination

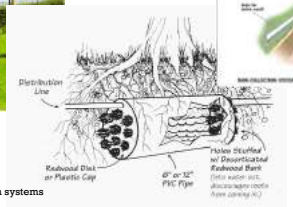
Non-tenured low-income settlem. (inner-city slums)	Tenured or non-tenured peri-urban interface	Planned urban development areas (low income)	Non-residential buildings
			

REFERENCES

Corcoran E, Nellemann C, Baker E, Bos R, Osborn D, Savelli H (eds) (2010) *Sick Water? The central role of wastewater management in sustainable development. A Rapid Response Assessment. UNEP/UNHABITAT*

World Water Council (2012) *6th World Water Forum, Marseille, 12-17 March, 2012. http://www.solutionsforwater.org/ objectifs/1-2-8-operator-efficiency-and-effectiveness-in-urban-wastewater-collection-and-treatment*

Thank you



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Leachfield irrigation systems

National Institute of Urban Affairs

SANITATION CAPACITY BUILDING PROGRAM

Sustainable Sanitation and Water Management

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CONTENTS

- Waste products
- Parameters for characterising wastewater
- Understand your system
- Ecological sanitation
- Resource management
- Planning of sanitation system
- Closing the loop

3 WASTE PRODUCTS

Black water, Grey water, Excreta, Faecal sludge, Domestic wastewater and Stormwater

BLACK WATER

Mixture of

- Urine,
- Faeces,
- Flushing water and
- anal cleansing water or
- dry cleansing material (toilet paper)

GREY WATER

Is generated through,

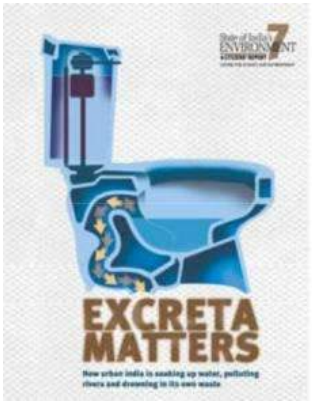
- Bathing,
- Handwashing,
- Washing utensils and
- Laundry

EXCRETA

Mixture of

- **Urine,**
- **Faeces and**
- **Small amount of anal cleansing water**

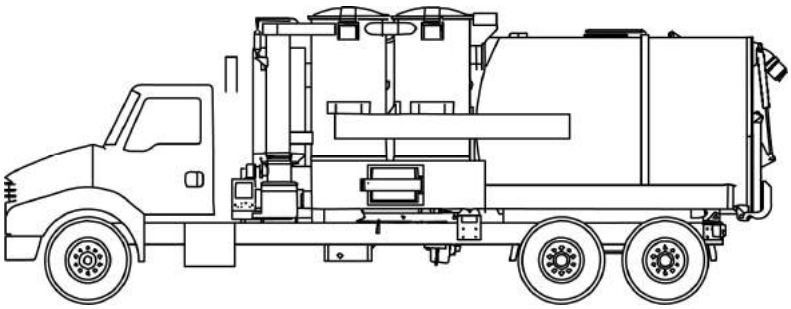
No flushing water!



Source: India Water Portal

FAECAL SLUDGE

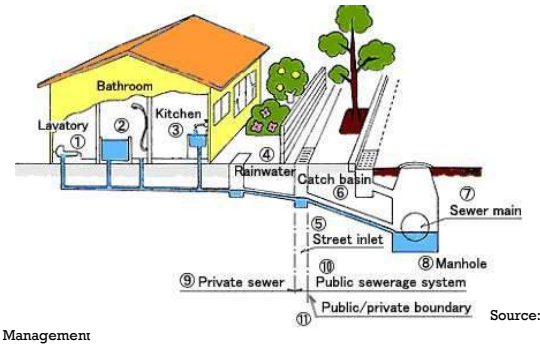
Undigested or partially digested slurry or solid resulting from storage of blackwater or excreta.



Source: Martin Engineering

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

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

10

PARAMETERS TO CHARACTERIZE WASTEWATER

Solids, Organic constituents, Nutrients, Pathogens and other parameters

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.

ORGANIC CONSTITUENTS

- BOD: Biochemical Oxygen Demand

  COD: Chemical Oxygen Demand
- Biodegradable organics: proteins, carbohydrates and fats.
- BOD signifies approximate amount of oxygen required to stabilise the organic matter.

Used to size treatment plants, measure efficiency of the processes, evaluate compliance with the discharge standards.

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**

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.

OTHER PARAMETERS

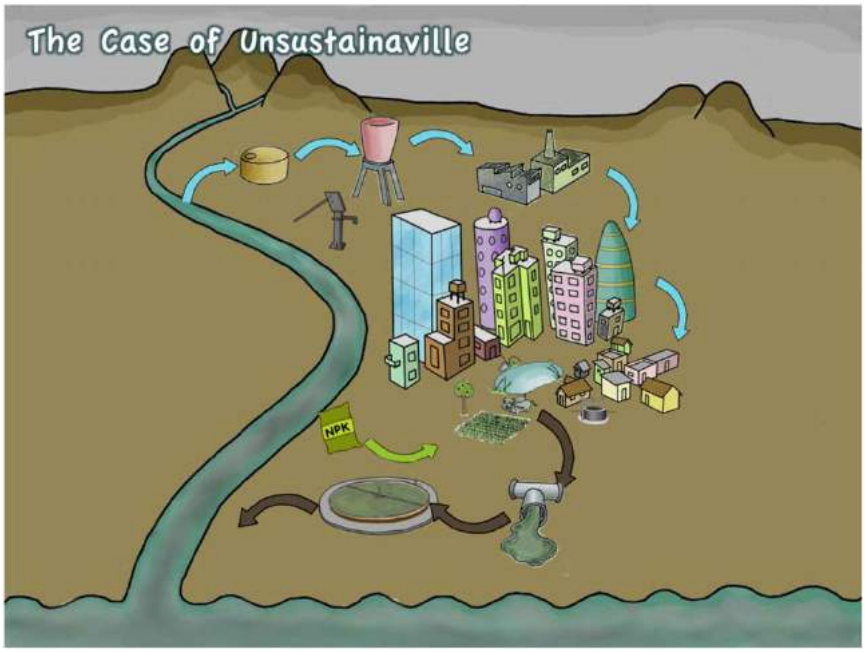
- Heavy metals
- Acidity/Basicity (pH)
- Alkalinity (Ca & Mg Bicarbonates)
- Electrical Conductivity (EC)
- Temperature

16

UNDERSTAND YOUR SYSTEM

UNDERSTAND YOUR SYSTEM

- **Define system boundaries**
  - Physical, Political, Social and Economical boundaries
- **Identify local water cycle**
- **Identify local nutrient cycle**
- **Identify problems, root cause, linkages**



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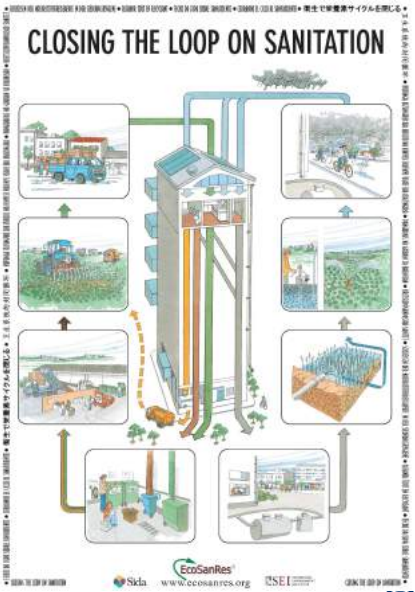
ECOLOGICAL SANITATION

Hygienically safe, economical and closed loop system

ECOLOGICAL SANITATION

- Resource recovery and reuse.
- Minimizing the consumption of non renewable resource.

Hygienically safe, economical and closed loop system!



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**

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.

SANITATION AND THE NEXUS

SANITATION AND THE NEXUS

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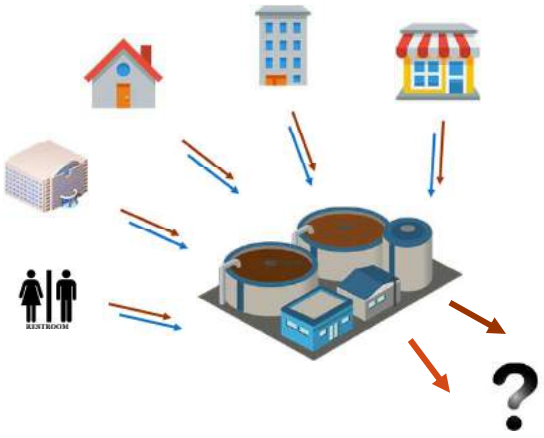
RESOURCE MANAGEMENT

Centralized and decentralized approaches

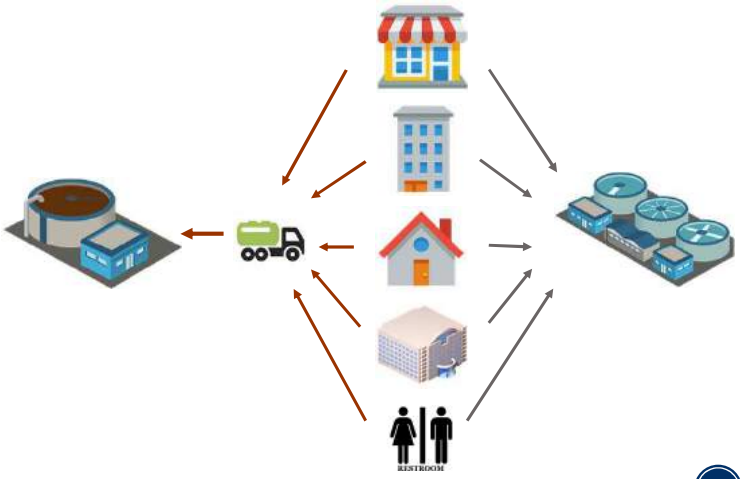
IWM: CENTRALIZED APPROACH

- Various stakeholders / customers.
- Collection and conveyance infrastructure.
- Water driven infrastructure.
- Hi tech treatment systems.



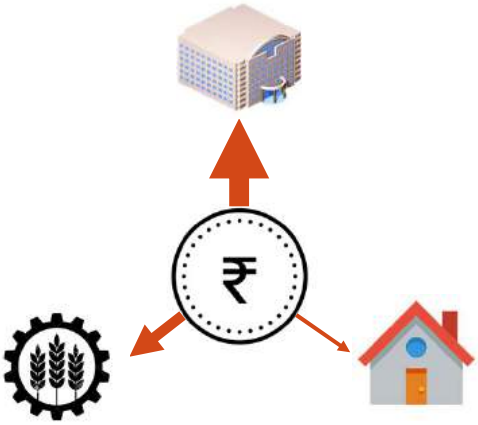
IWM: DECENTRALIZED APPROACH

- Separate collection and conveyance infrastructure.
- Streams are separately treated.
- Relatively simple technologies can be implemented.

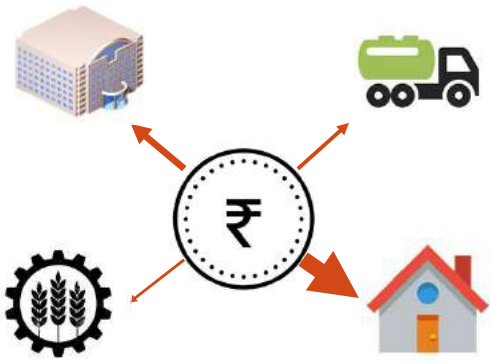


ECONOMICS OF IWM

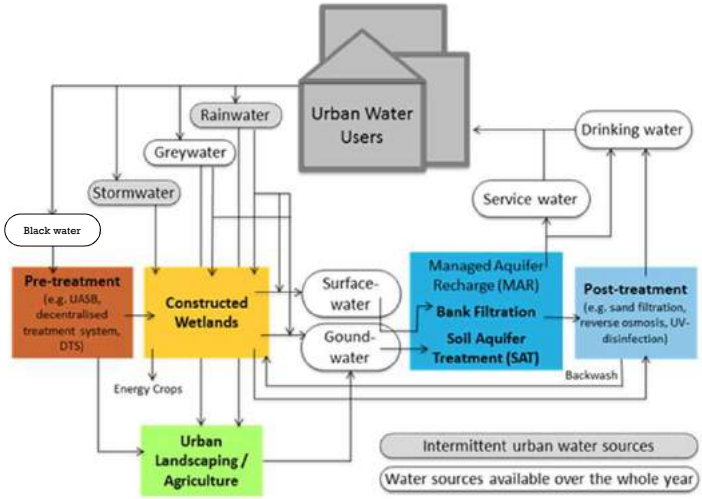
Centralized approach



Decentralized approach



MULTI BARRIER APPROACH



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PLANNING OF SANITATION SYSTEMS

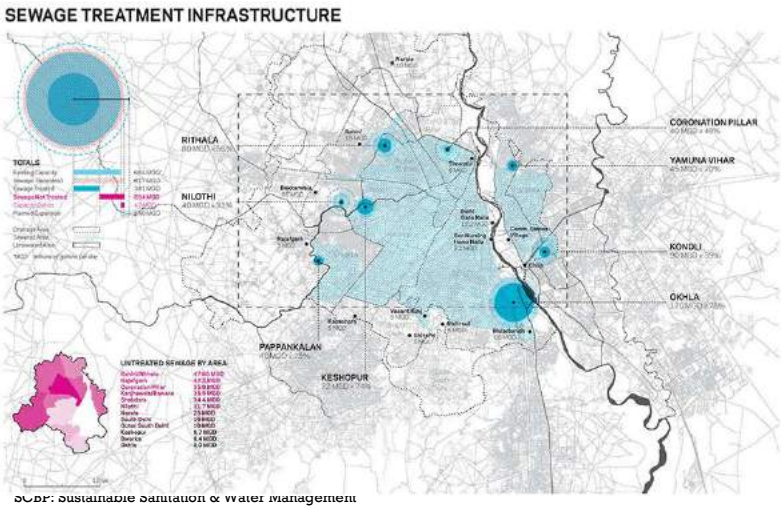
Introduction

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

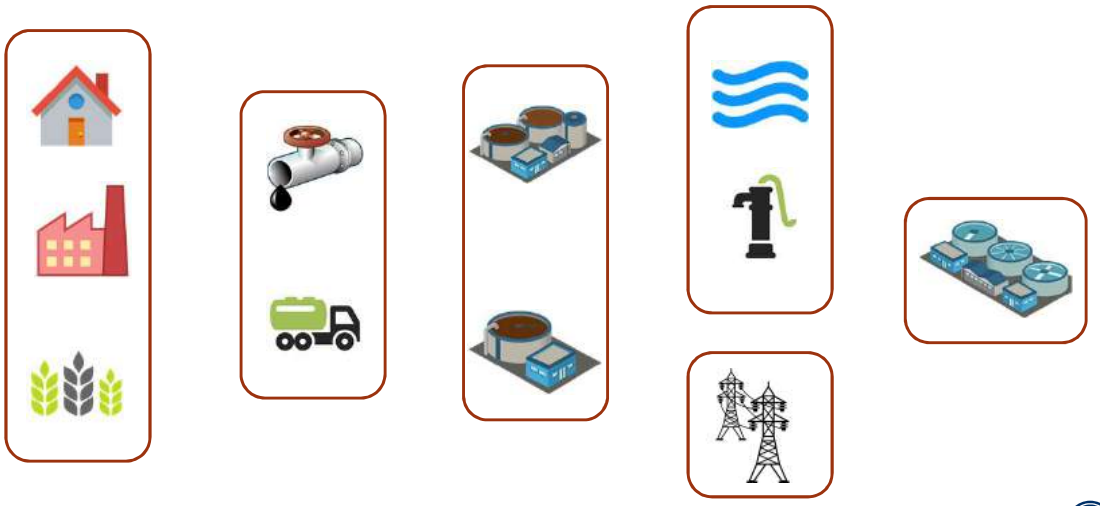
Design of sewers, gradient of network, pumping requirements, technology options, construction techniques and associated costs

SPATIAL INTEGRATION

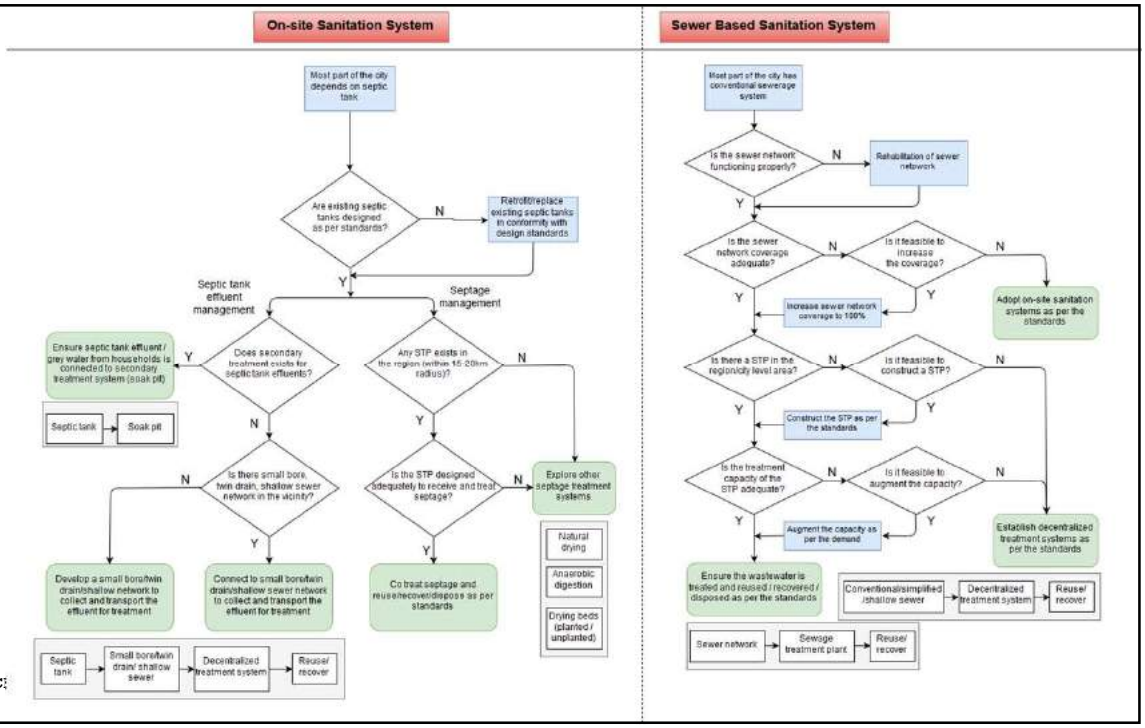


- Use of GIS for mapping the existing infrastructure level.
- Identification of deficiencies in sanitation value chain.

PROCESS INTEGRATION



LOGIC DIAGRAM



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.**

CASE STUDIES

- **Tadipatri, Andhra Pradesh** (2.5 MLD)
  - Centralized approach
  - Facilitated industrial reuse of treated wastewater from STP.
  - Industry to pay for reuse infrastructure.
- **Mancherial, Telangana** (0.5 MLD STP)
  - Decentralized approach
  - No buyers for treated wastewater.
- **Tirupati, Andhra Pradesh** (50 MLD)
  - Centralized approach
  - Conveyance of treated wastewater most expensive!

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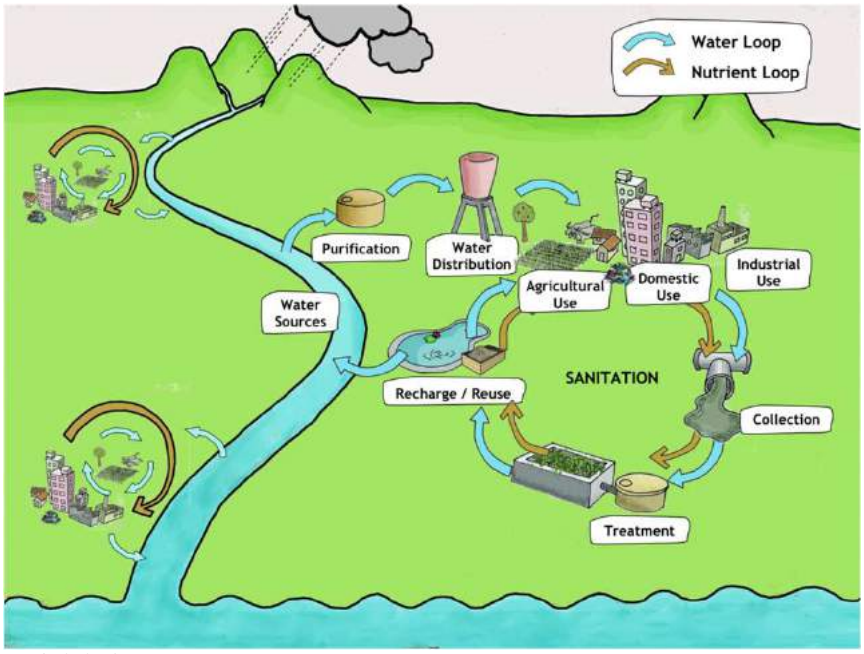
CLOSING THE LOOP!

Urban water cycle loop

Urban nutrient cycle loop



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.

Thank you…

National Institute of Urban Affairs

SANITATION CAPACITY BUILDING PROGRAM

Designing of sanitation systems

Mr. Dhawal Patil,
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General Manager - Operations

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CONTENTS

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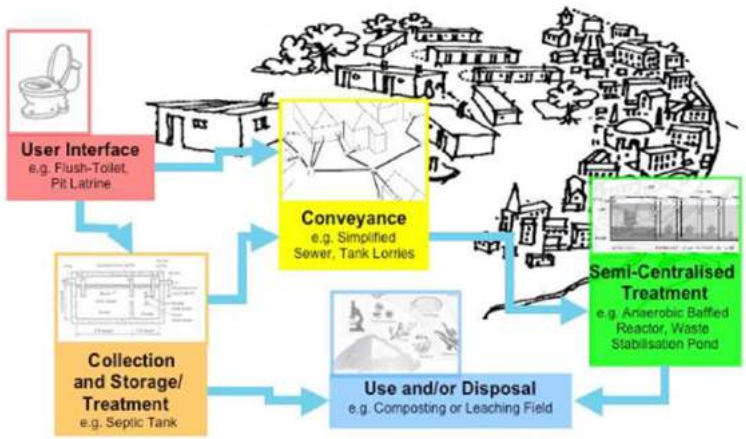
DESIGNING OF SANITATION SYSTEM

Functional groups, The Ideal System, The Appropriate System

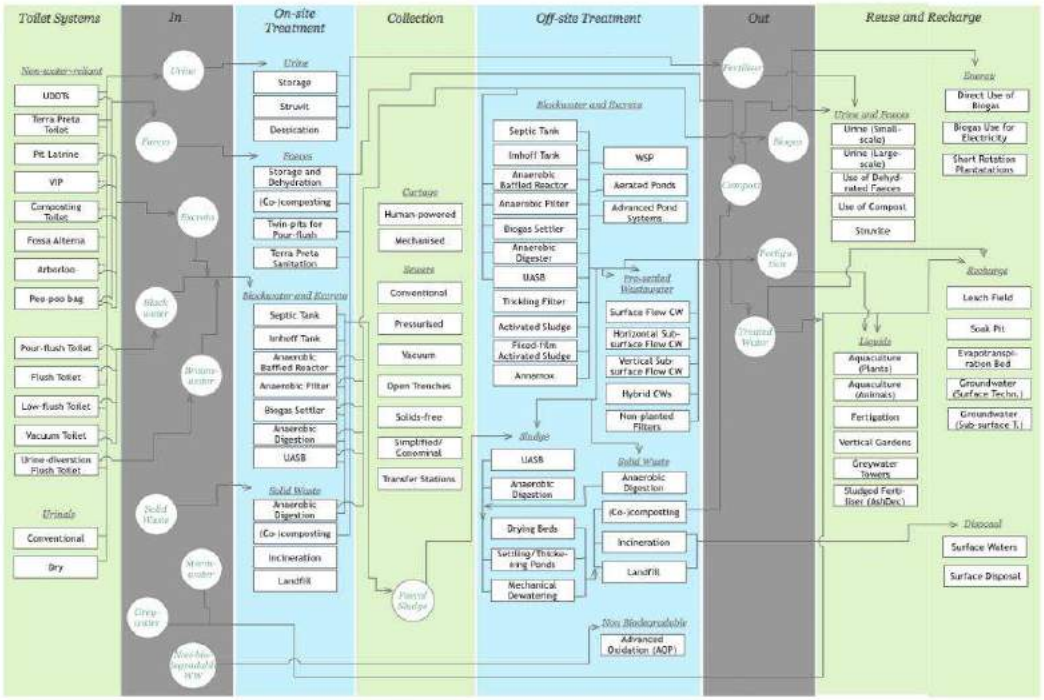
FUNCTIONAL GROUPS



Source: Sandec Training Tool

THE IDEAL SYSTEM

- Manages all the waste products generated.
- "from cradle to grave" approach.
- Should be designed using existing infrastructure.



Source: Sphuler 2010

POINTS TO PONDER!

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

THE APPROPRIATE SYSTEM

- **User interface: Local needs, demand and habits need to be assessed.**
- **Although template is present, careful selection of technologies need to be done.**
- **Local environment, technical, social, economic aspects and resources.**

THE APPROPRIATE SYSTEM

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

10

DECENTRALIZED SYSTEMS

Shift in paradigm, Limitations of centralised systems, Features and Constraints of Decentralised 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.

LIMITATIONS OF CENTRALISED SYSTEMS

- Increases risk in event of system failure.
- Poor reachability in peri urban areas and informal settlements.
- Complex and require professional and skilled operators.
- O&M to be financed by the local government.
- Reduces wastewater reuse opportunities.

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.

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.

CONSTRAINTS OF DECENTRALISED SYSTEMS

- Capacity to plan, design, implement and operate.
- Appropriate policy framework.
- Coordination between government, private sector and civil society.
- Compatibility with knowledge, skills locally available.
- Number of small investments = BIG investment!

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.

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SYSTEMATIC PLANNING

Need of systematic planning, The Best Planning Model, Framework for strategic planning

NEED OF SYSTEMATIC PLANNING

- Poor planning, design and operation, as well as inadequate maintenance -> qualitatively poor services.
- Sanitation master plans ignore the financial and institutional constraints.
- What sanitation user actually want?
- What are they willing 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)

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)

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)

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.

FRAMEWORK FOR STRATEGIC PLANNING

STEP 1

Where are we now? – Grounding plans of current situations.

- What already exists?
- Respond to actual problems and deficiencies.

FRAMEWORK FOR STRATEGIC PLANNING

STEP 2

Where do we want to go? – Identifying objectives.

- Deal with needs of all, including urban poor!
- Set environmentally acceptable objectives.
- Develop sustainable systems (provision but also O&M)

FRAMEWORK FOR STRATEGIC PLANNING

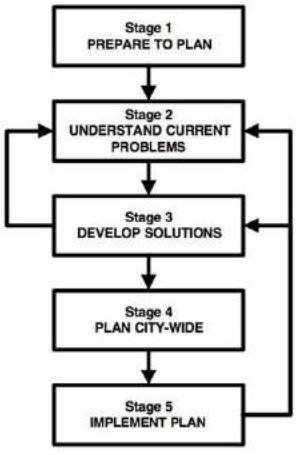
STEP 3

How do we get from here to there? – Moving towards objectives.

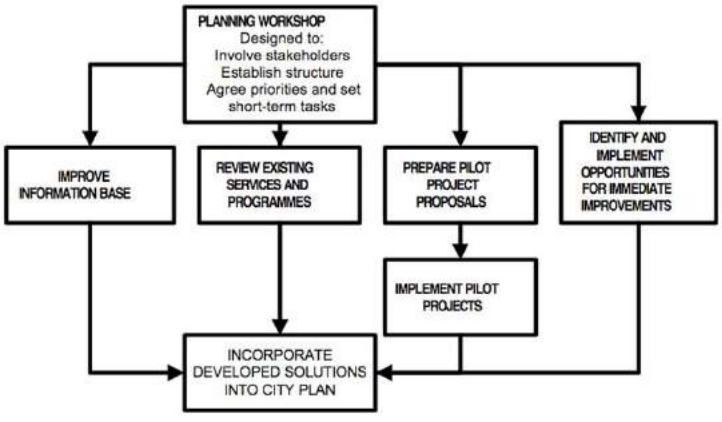
- Identify fundamental principles to improve sanitation services.
- Strategic plan need to be flexible and adaptable.

CITY SANITATION PLAN

Stages in planning process



Steps in developing solutions



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.**

Thank you...

National Institute of Urban Affairs

SANITATION CAPACITY BUILDING PROGRAM

Sanitation systems and technologies

Mr. Dhawal Patil,
M.Sc. Hydro Science and Engineering
General Manager - Operations

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CONTENTS

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

3

SANITATION & ITS OBJECTIVES

Definition and 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

OBJECTIVES

- Protect and promote health
- Protect the environment
- Be simple
- Be affordable
- Be culturally acceptable
- Works for everyone

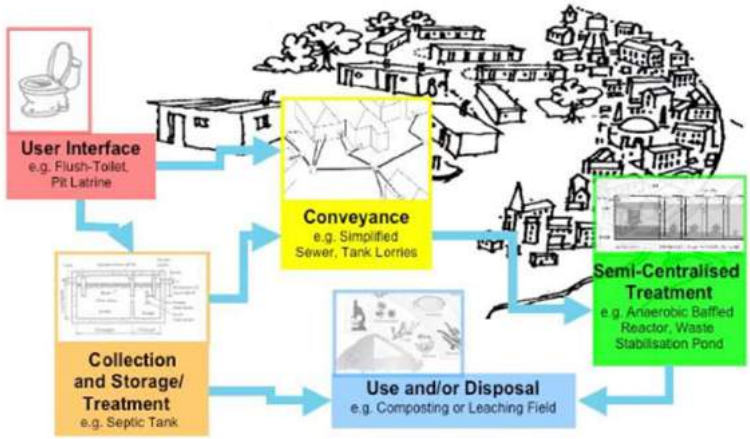
6

FUNCTIONAL GROUPS

FUNCTIONAL GROUPS

- Technologies which perform the same, or similar function are grouped into "Functional Groups"
- A sanitation system is a combination of technologies through which the products flow.
- Only selected combinations of technologies will lead to functional systems.
- Domestic products mainly run through five different Functional Groups.

FUNCTIONAL GROUPS



Source: Sandec Training Tool

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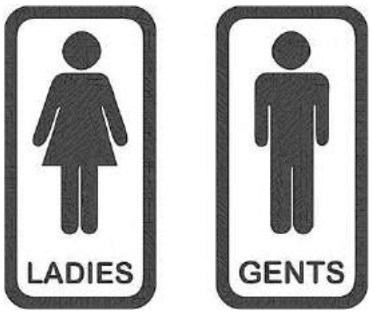
USER INTERFACE



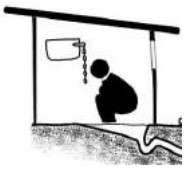
Functional group

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.

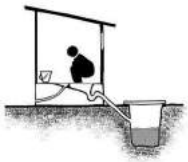
USER INTERFACE

Pour flush toilet



Cistern flush toilet

Urine diversion dehydration toilet



Urine diversion flush toilet

Low flush toilet

Vacuum toilet

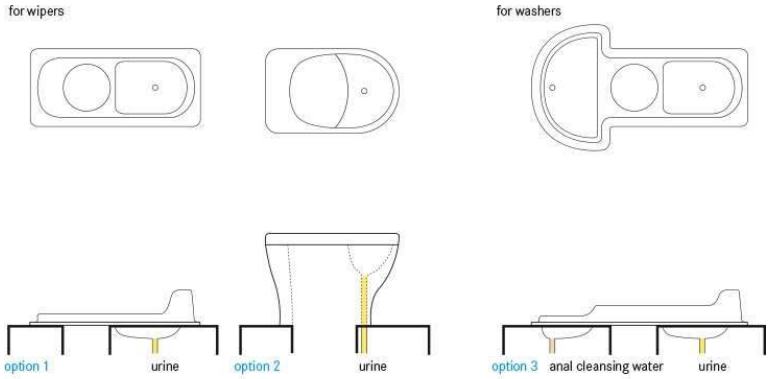
Urinals

Source: SSWM Tool Box

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)

URINE DIVERSION DEHYDRATION TOILET

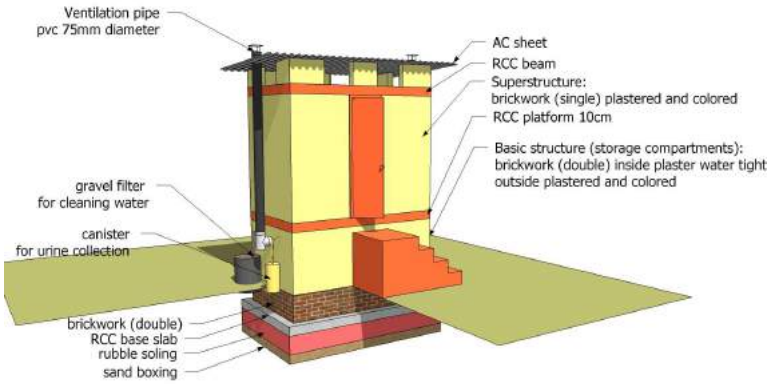


Source: Tilley et al. 2014

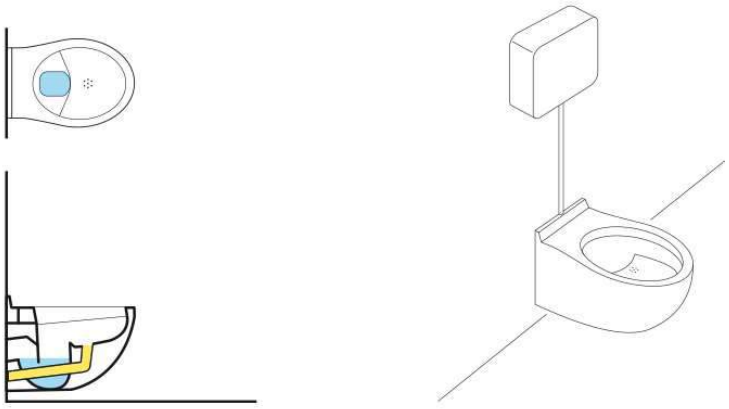
URINE DIVERSION DEHYDRATION TOILET

Source: Waffler (2010); UNESCO-IHE (n.y.)

URINE DIVERSION DEHYDRATION TOILET



URINE DIVERSION FLUSH TOILET



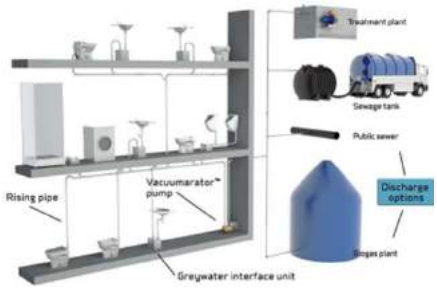
Source: Tilley et al. 2014

URINE DIVERSION FLUSH TOILET



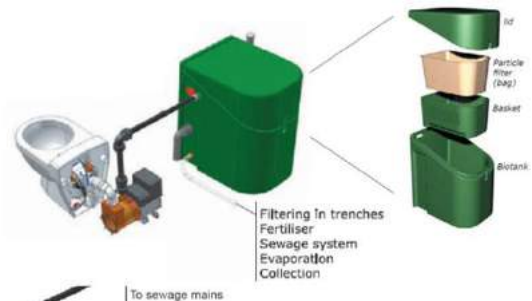

Source: dubbletten.nu; gustavsberg.com; stman.se; rroevac.de

VACUUM TOILET



Constant vacuum system

Vacuum toilet with biotank



Vacuum on demand system

Source: Jets Group (2005 & 2009)

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COLLECTION & STORAGE/TREATMENT

Functional group

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.

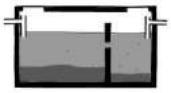
COLLECTION & STORAGE/TREATMENT

Twin pit for flush toilet

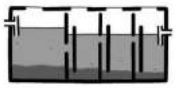
Urine diversion dehydration toilet

Jerry cans for urine storage

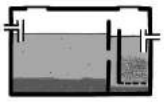
Biogas reactor



Septic tank



Anaerobic baffled reactor



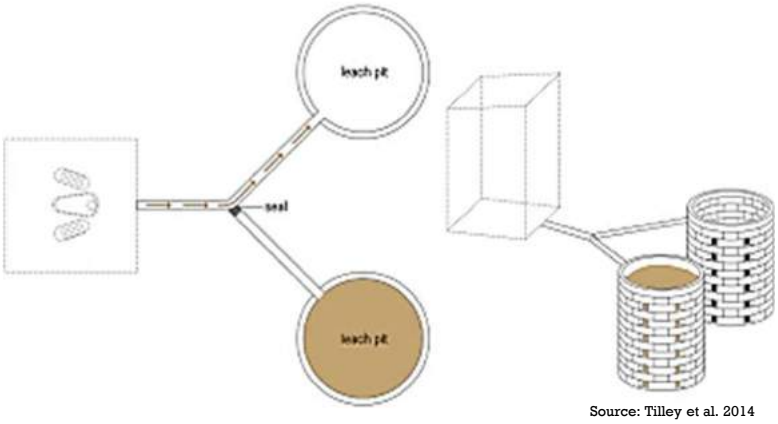
Anaerobic up-flow reactor

Source: SSWM Tool Box

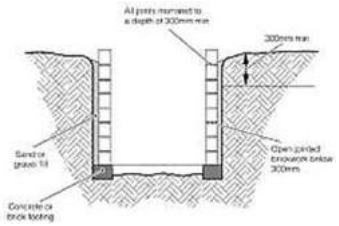
TECHNICAL AND PHYSICAL CRITERIA

- **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)

TWIN PIT FOR POUR FLUSH TOILET

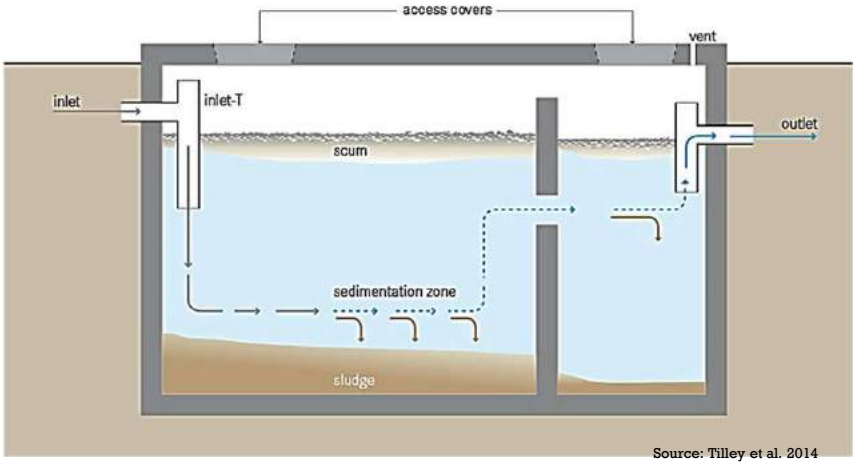


Source: Tilley et al. 2014



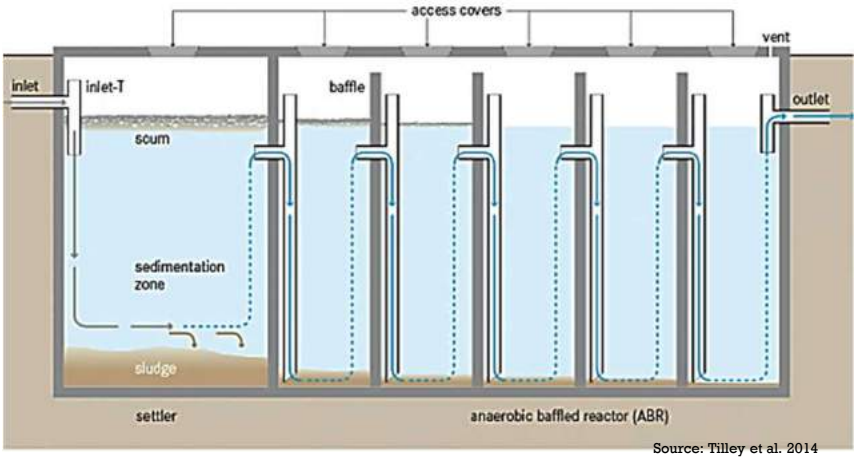
Source: D. Friedman

SEPTIC TANK



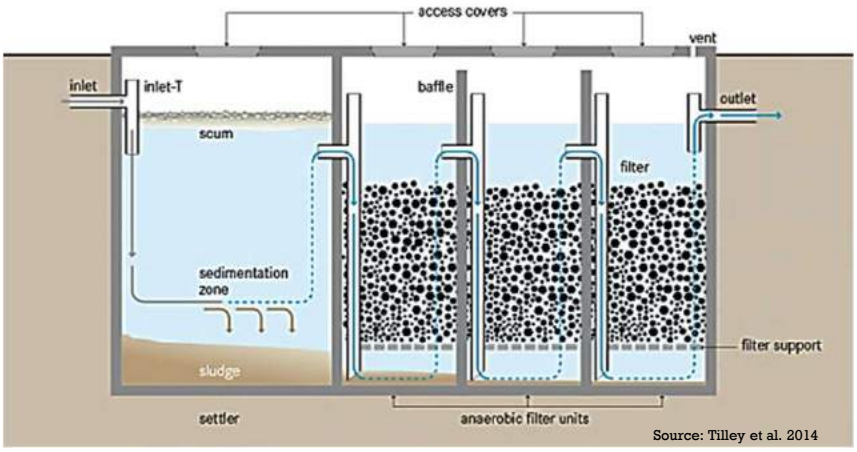
Source: Tilley et al. 2014

ANAEROBIC BAFFLED REACTOR



Source: Tilley et al. 2014

ANAEROBIC UP-FLOW FILTER



Source: Tilley et al. 2014

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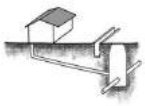
CONVEYANCE

Functional group

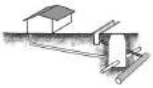
CONVEYANCE

- 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.

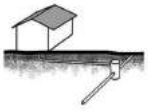
CONVEYANCE



Conventional sewers

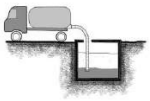


Separate sewers

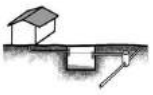


Simplified sewers

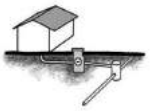
Human powered Emptying & transport



Motorised Emptying & transport

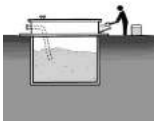


Small bore sewers



Vacuum sewers

Pumping stations



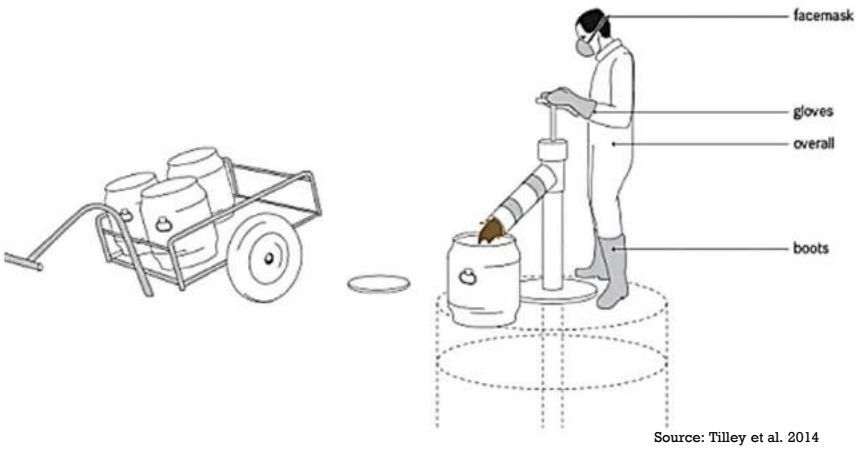
Transfer stations

Source: SSWM Tool Box

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

HUMAN POWERED EMPTYING

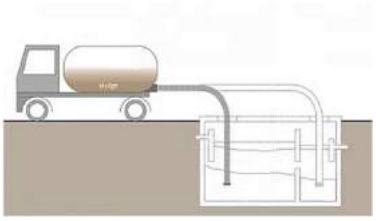


Source: Tilley et al. 2014

GULPER

Source: IaW (2007)

MOTORISED EMPTYING



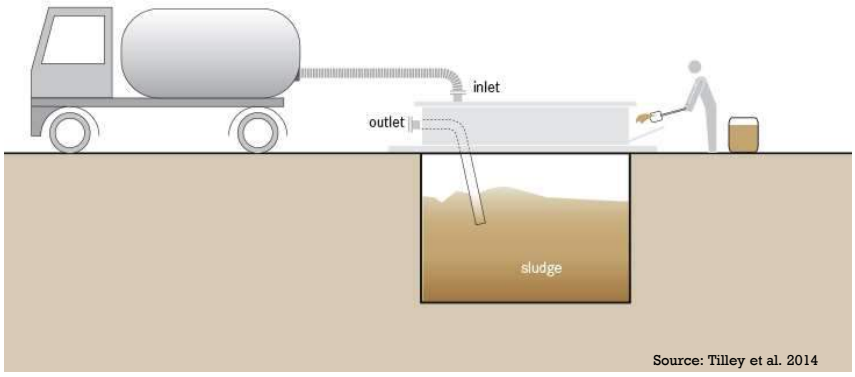
Source: Tilley et al. 2014

Source: KAMAVIDA

Source: KAMAVIDA

Source: Strauss et al. 2002

TRANSFER STATION



Source: Tilley et al. 2014

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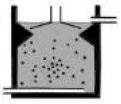
SEMI-CENTRALISED TREATMENT

Functional group

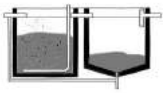
SEMI-CENTRALISED TREATMENT

- 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



UASB

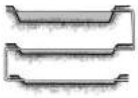


ASP

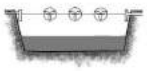
Trickling filter

SBR

MBR



WSP



Aerated ponds

Advanced integrated ponds

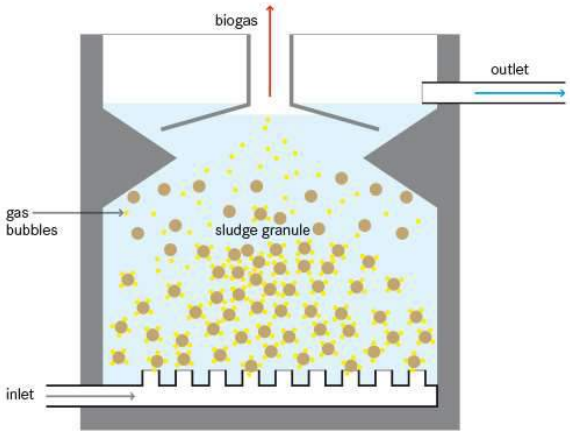
Constructed wetlands

Source: SSWM Tool Box

TECHNICAL AND PHYSICAL CRITERIA

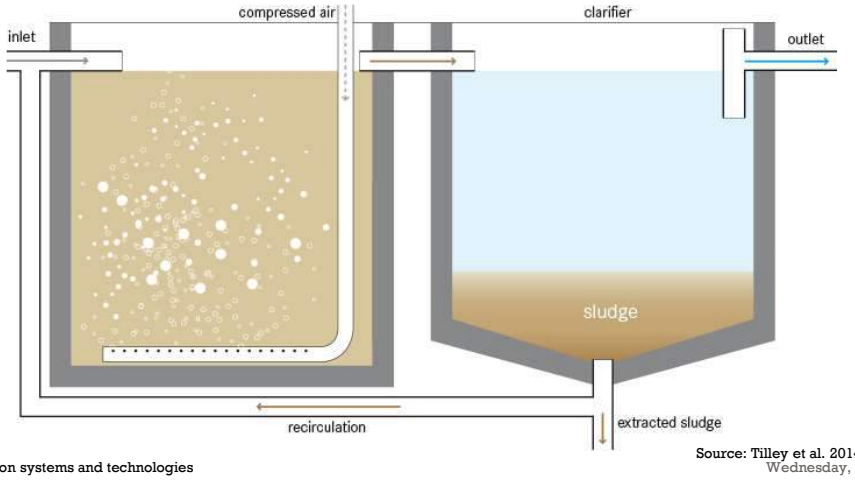
- Availability of space and other resources (Choice of technology)
- Climate (Temperature affects rate of reactions)
- Ground condition (Flood prone area)
- Groundwater level and contamination (Cross contamination from tanks underground)

UASB REACTOR



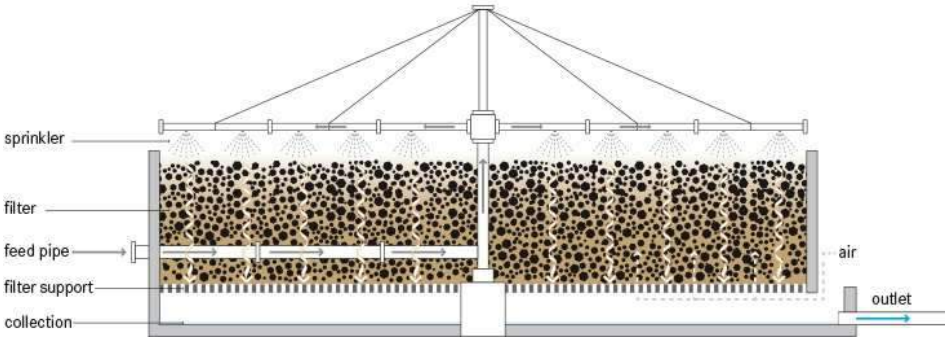
Source: Tilley et al. 2008

ASP TREATMENT



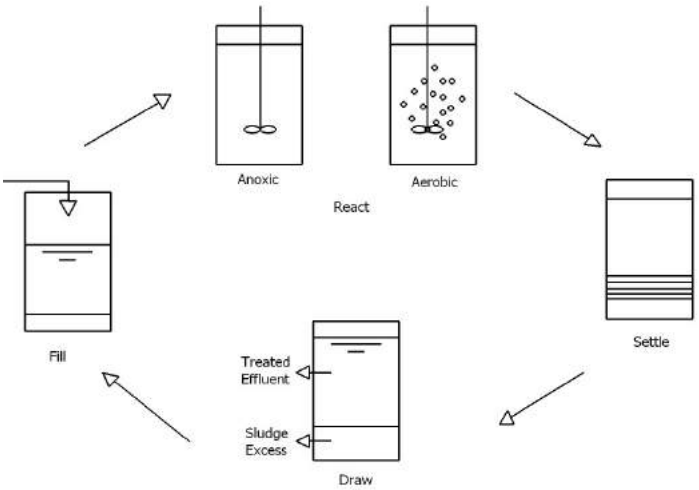
Source: Tilley et al. 2014

TRICKLING FILTER

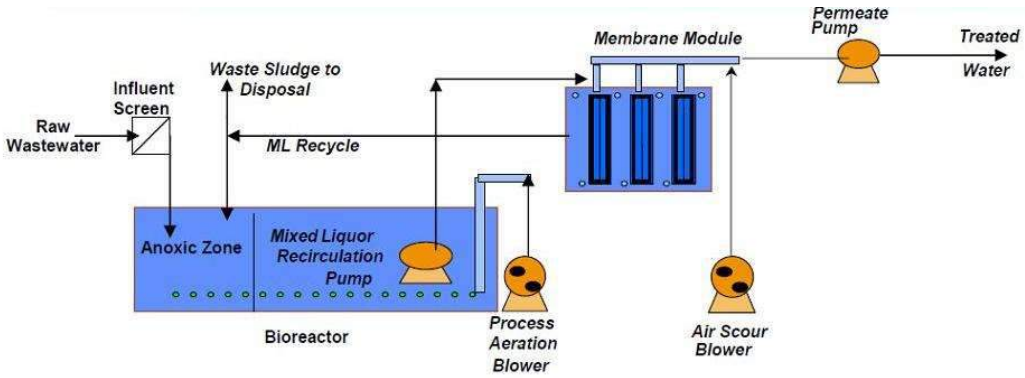


Source: Tilley et al. 2014

SBR

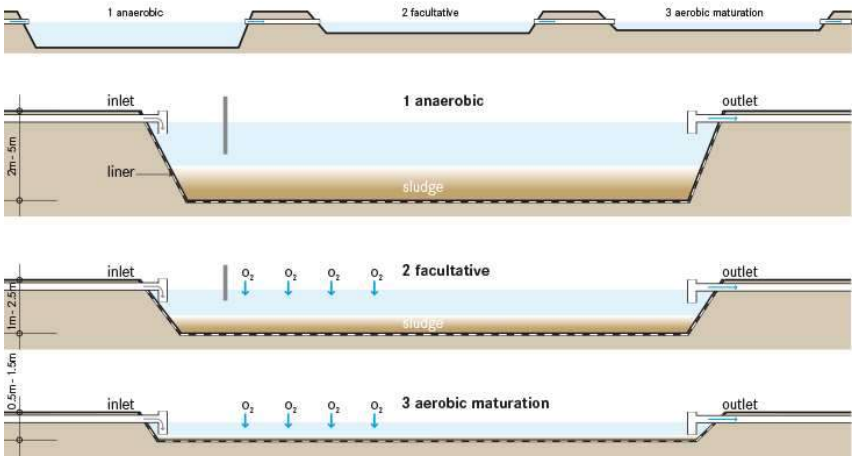


MBR



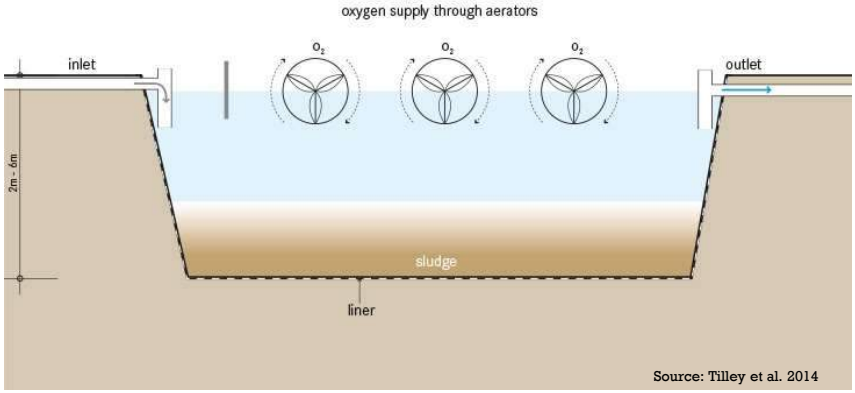
Source: Fitzgerald 2008

WSP TREATMENT



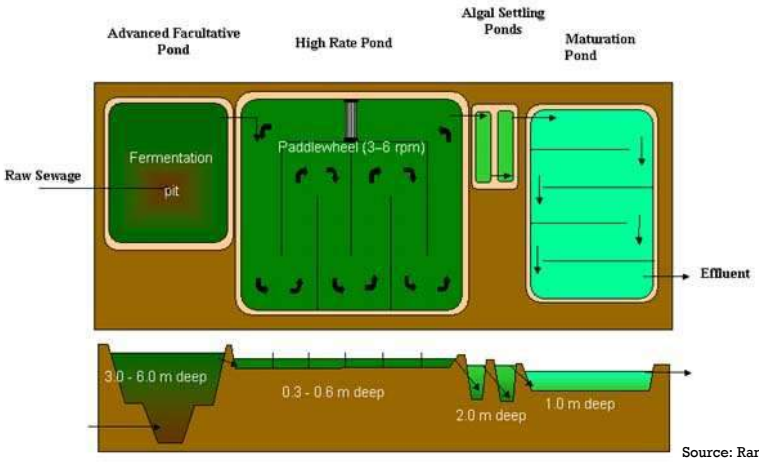
Source: Tilley et al. 2014

AERATED POND TREATMENT



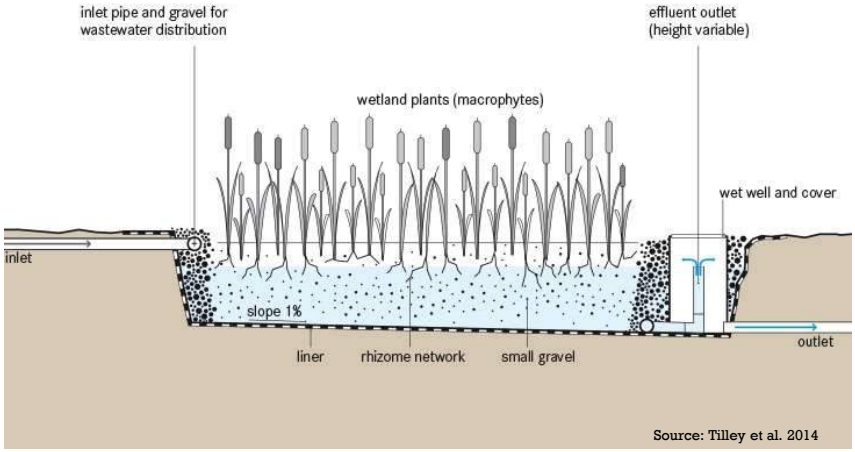
Source: Tilley et al. 2014

ADVANCED INTEGRATED PONDS



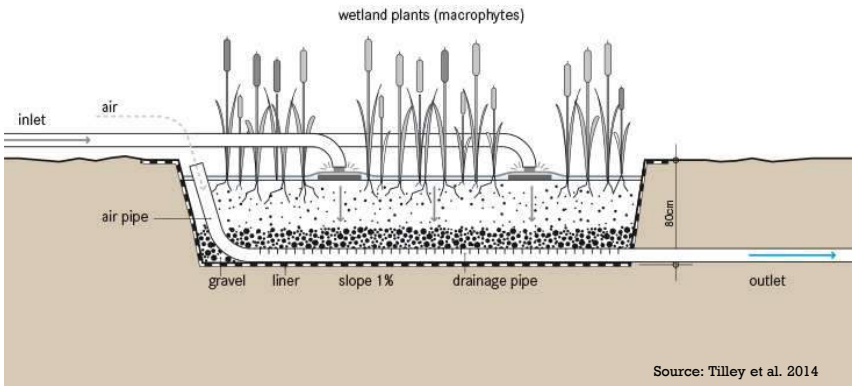
Source: Ramadan et al. (n.y.)

CONSTRUCTED WETLANDS (HORIZONTAL FLOW)



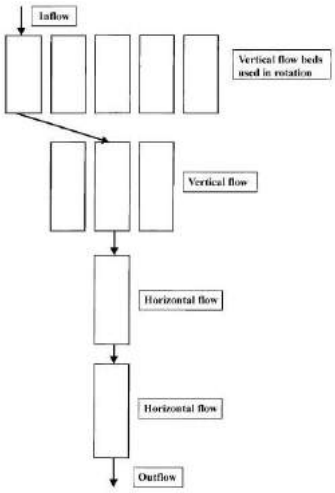
Source: Tilley et al. 2014

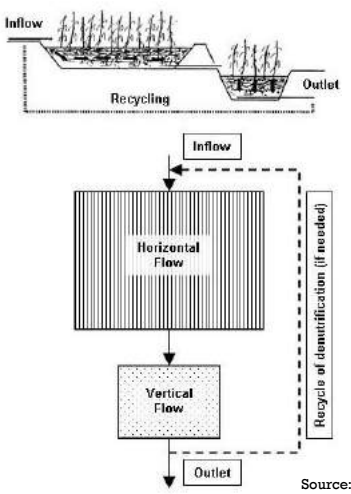
CONSTRUCTED WETLANDS (VERTICAL FLOW)



Source: Tilley et al. 2014

HYBRID CONSTRUCTED WETLANDS





Source: Vymazal 2005

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USE AND/OR DISPOSAL

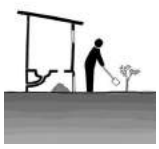
Functional group

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

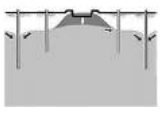
USE AND/OR DISPOSAL

- Agriculture
- Aquaculture
- Recharge or disposal
- Energy products from sludge

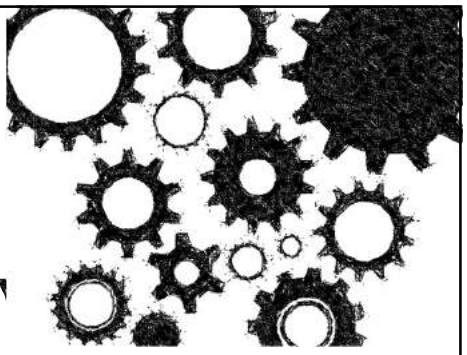








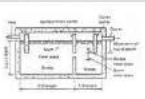
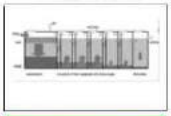

Source: SSWM Tool Box



53 SANITATION S'

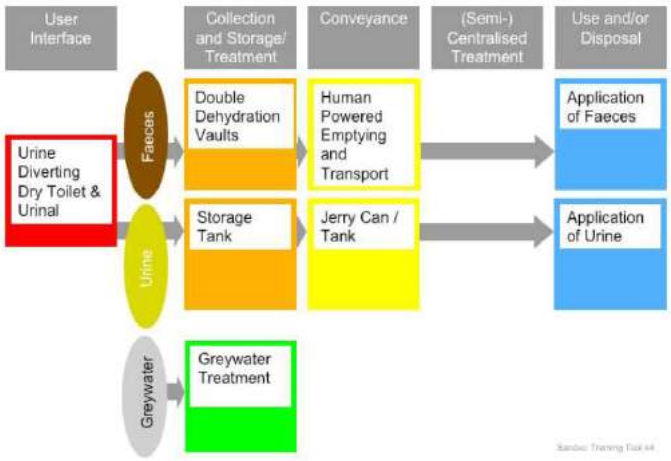
Only selected combinations of technologies will lead to functional systems!

SANITATION VALUE CHAIN

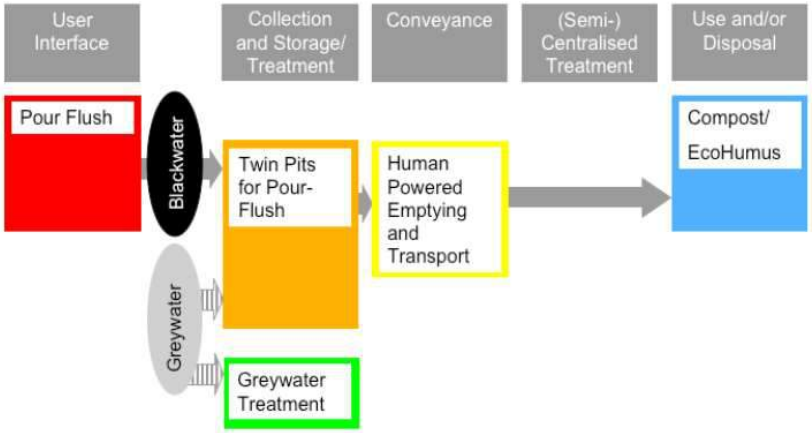
User Interface	Collection and Storage/ Treatment	Conveyance	(Semi-) Centralised Treatment	Use and/or Disposal
				
• Dry Toilet • Urine Diverting Dry Toilet • Urinal • Pour-Flush Toilet • Flush Toilet • Urine Diverting Flush Toilet	• Single Pit • Single VIP • Dehydration Vaults • Septic Tank • Composting Chamber • Anaerobic Baffled Reactor • Anaerobic Filter etc.	• Human-Powered Emptying and Transport • Motorized Emptying and Transport • Simplified Sewers • Small-Bore Sewer • Conventional Gravity Sewer • Jerry Can/Tank etc.	• Anaerobic Baffled Reactor • Anaerobic Filter • Trickling Filter • Waste Stabilisation Ponds • Activated Sludge • Constructed Wetland • Co-composting etc.	• Application of Urine • Application of Dehydr. Faeces • Compost • Irrigation • Aquaculture • Soak Pit • Leach Field • Land Application • Surface Disposal etc.

Source: Sandec Training Tool

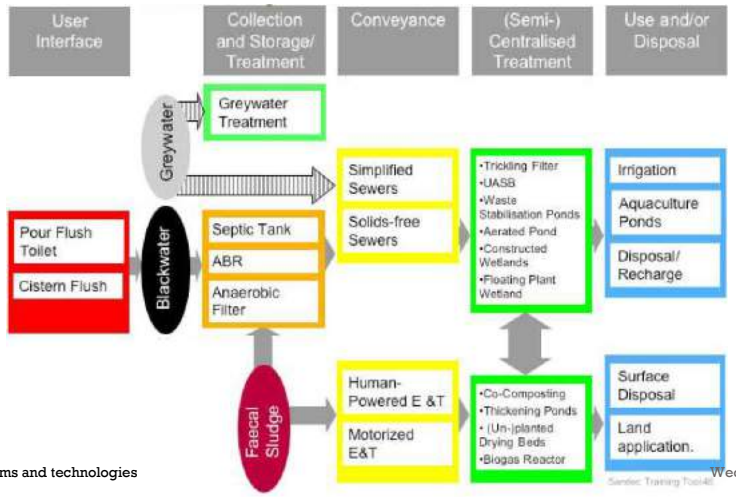
CASE 1
WATERLESS SYSTEM WITH URINE DIVERSION



CASE 2
WATER BASED, ALTERNATING DOUBLE PIT



CASE 3
WATER BASED, SMALL BORE SYSTEM



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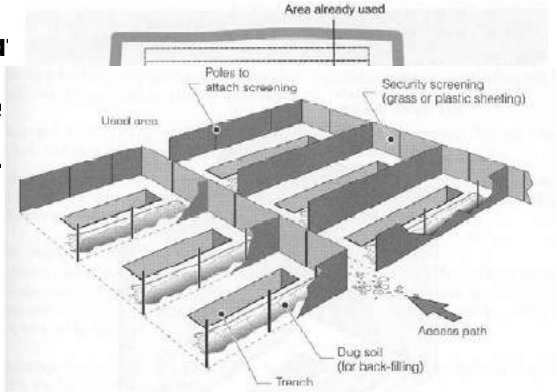
EMERGENCY SANITATION INFRASTRUCTURE

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.**

EMERGENCY SANITATION

- **Open defecation fields**
- **Trench defeca**
- **Communal tre**
- **Communal pit**
- **Household pit**



Source: Harvey et al. 2002, pp. 64

Thank you...

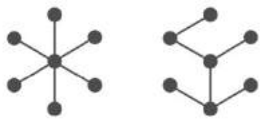
National Institute of Urban Affairs

SANITATION CAPACITY BUILDING PROGRAM

Wastewater Treatment Technology

Mr. Dhawal Patil,
M.Sc. Hydro Science and Engineering
General Manager - Operations

ecosan SERVICES FOUNDATION



2

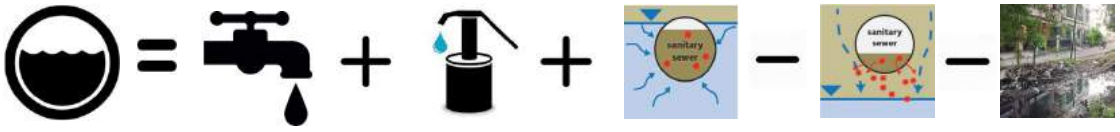
WASTEWATER TREATMENT BASICS

Quantification of sewage, quality of sewage, treatment processes, design parameters, stage of wastewater treatment

QUANTIFICATION OF SEWAGE

Generally 75-80% of accounted water supplied is considered as quantity of sewage produced.

Net quantity of sewage = Accounted quantity of water supplied from the water works + Addition due to unaccounted private water supplies + Addition due to infiltration − Subtraction due to water losses − Subtraction due to water not entering the sewerage system



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

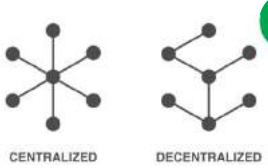
TREATMENT PROCESSES

Physical	• Sedimentation • Floatation
Biological	• Anaerobic • Aerobic
Chemical	• Chlorination/Ozonation • Flocculation
Photolytic	• Ultra violet disinfection • Photosynthesis

DESIGN PARAMETERS

- Organic loading (kg BOD/d, kg COD/d),
- Volumetric loading rate (m^3/d)
- Temperature (^oC)
- Hydraulic retention time (HRT) (hours or days)
- Sludge age (d)
- Biomass yield (kg VSS/ kg COD)
- Up flow velocity (m/s)
- Specific surface area (m^2/m^3)

TREATMENT CHAIN



Primary treatment (Physical process)

Removal of solids (TSS)

- Screen
- Grit chamber
- Primary clarifier
- Septic tank
- Imhoff tank
- Biogas settler

Secondary treatment (Biological process)

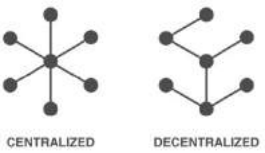
Removal of organic content (BOD, COD, N & P)

- Anaerobic process
- Aerobic process
- Facultative process

Tertiary treatment (Chemical/ Photolytic process)

Removal of pathogens (coliforms, MPN)

- Chlorination
- Ozonation
- Ultra violet



8

PRIMARY TREATMENT

Physical process assisted by biological treatment in some cases

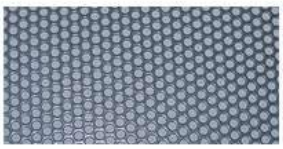
Reduction in TSS and thereby in BOD and COD

SCREENS

CENTRALIZED DECENTRALIZED

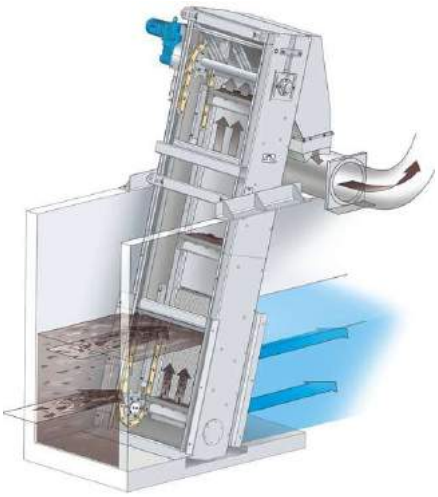
Coarse Screen

Fine Screen



Perforated Plate Screen

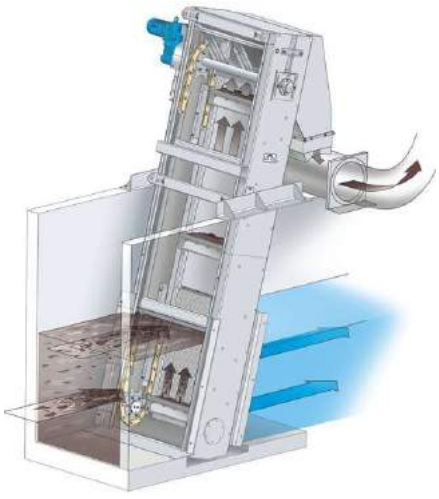
Mesh Screen



Source: www.huber.de

SCREENS

CENTRALIZED DECENTRALIZED



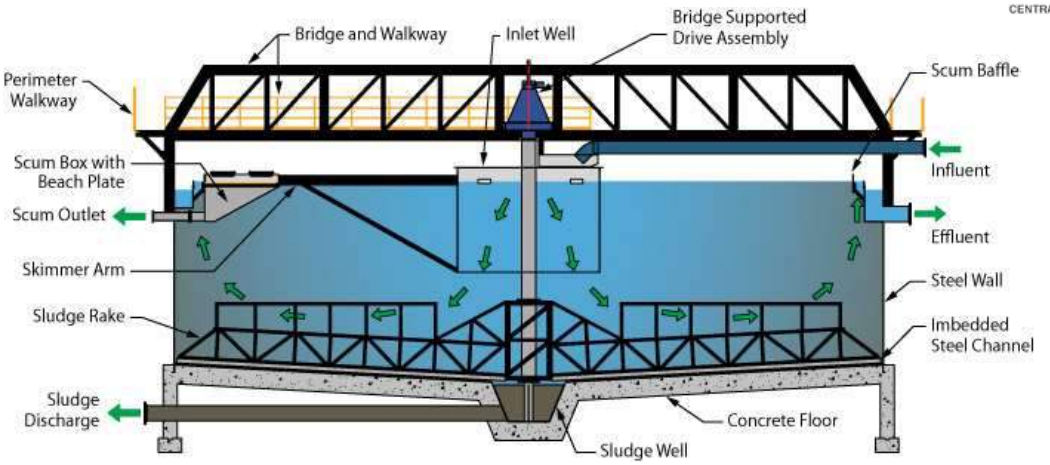
Source: www.huber.de

GRIT CHAMBER

CENTRALIZED

PRIMARY CLARIFIER

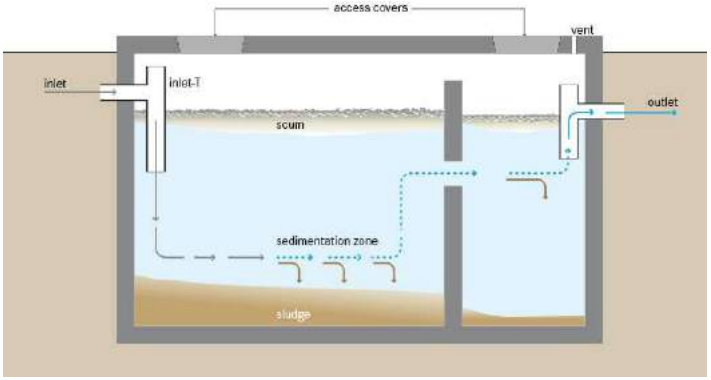
CENTRALIZED



SEPTIC TANK

DECENTRALIZED

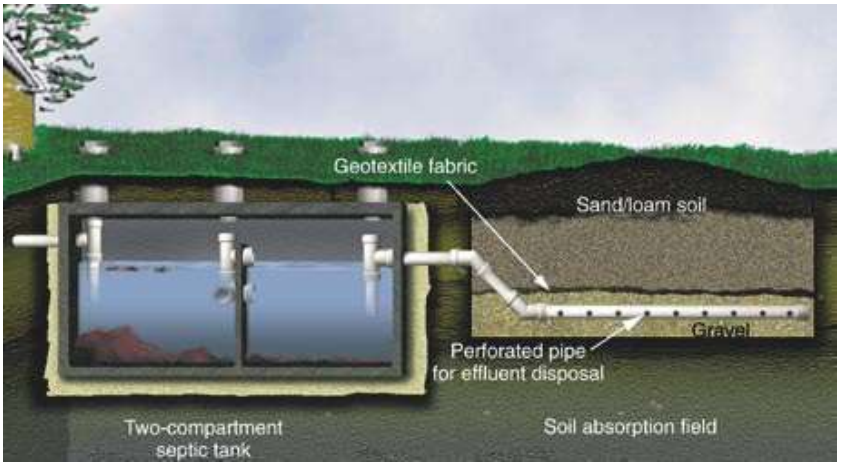
- Sedimentation
- Settled sludge is stabilized by anaerobic digestion
- *BOD*: 30 to 50%; *TSS*: 40 to 60 %; *E. coli*: 1 log units
  HRT: about 1 day



Source: TILLEY et al. (2014)

SEPTIC TANK + DISPOSAL

DECENTRALIZED

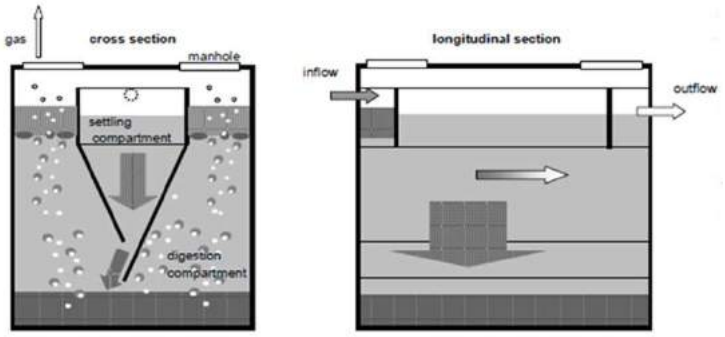


Source: U.S. EPA

IMHOFF TANK

DECENTRALIZED

- Sedimentation
- Settled sludge is stabilized by anaerobic digestion
- Removes 25 to 50% of *COD*. Pathogen removal is low.

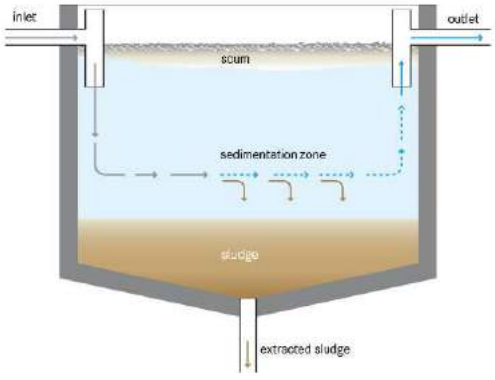


Source: WSP (2007)

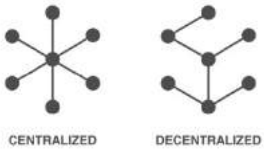
BIOGAS SETTLER

DECENTRALIZED

- Settling + anaerobic digestion
- Biogas recovery
- 80 to 85 % *BOD*; Relatively high *pathogen* removal
- *N* and *P* remain in the *sludge*
- *HRT* of some days; *SRT* of several years



Source: TILLEY et al. (2014)



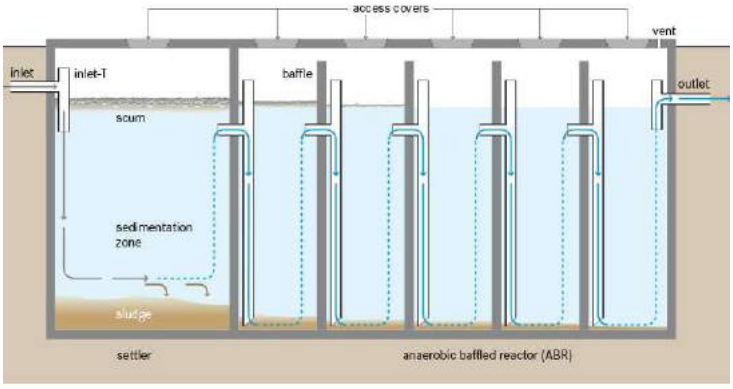
17 SECONDARY TREATMENT

Biological process for reduction of organic content

Reduction in BOD, COD, TSS, N and P

ANAEROBIC BAFFLED REACTOR (ABR)

- **Contact between wastewater and resident sludge.**
- **Anaerobic digestion**
- **70- 95% *BOD*; 80% - 90% *TSS*; Low *pathogen* reduction.**
- ***HRT*: 1 to 3 days**

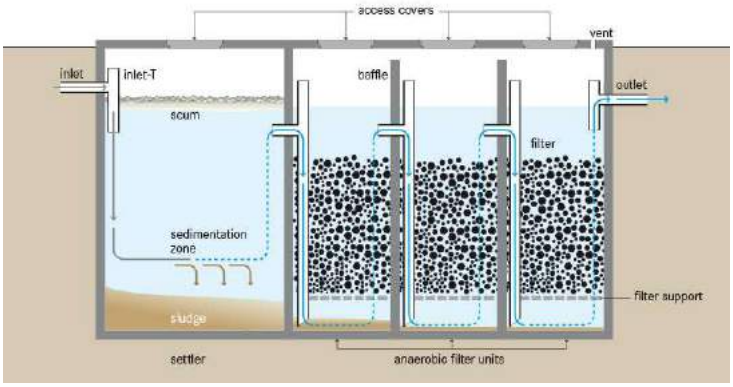


Source: TILLEY et al. (2014)

ANAEROBIC FILTER (AF)

DECENTRALIZED

- Attached growth filter to remove dissolved and non settleable solids.
- *BOD*: 50 to 90%; *TSS*: 50 to 80 %; *Total Coliforms*: 1 to 2 log units
  HRT: about 1 day

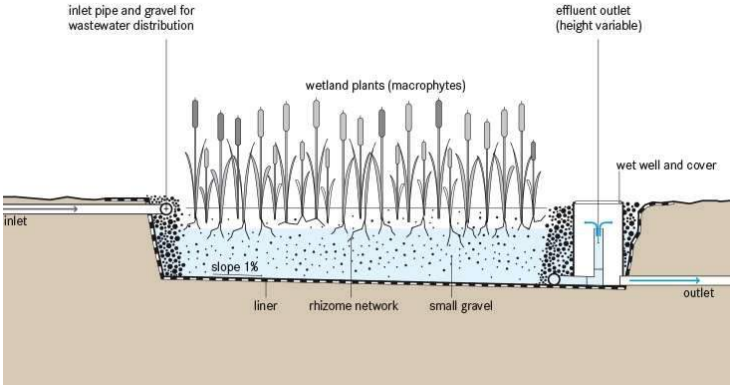


Source: TILLEY et al. (2014)

CONSTRUCTED WETLANDS (HORIZONTAL FLOW)

DECENTRALIZED

- Microbiological attachment, growths and transfer of oxygen.
- Filtration, degradation (aerobic, anaerobic, anoxic)
- *BOD* = 80 to 90 %; *TSS* = 80 to 95 %; *TN* = 15 to 40 %; *TP* = 30 to 45 %; *FC* ≤ 2 to 3 log

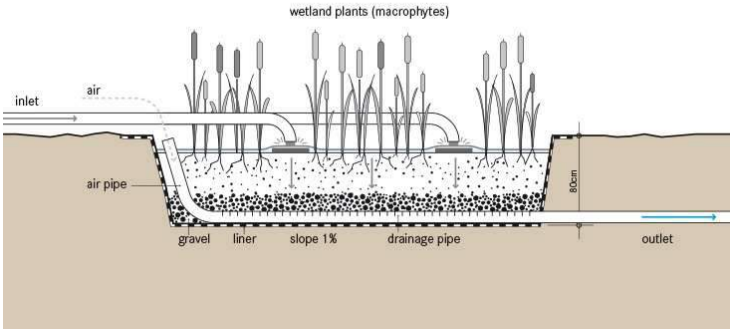


Source: TILLEY et al. (2014)

CONSTRUCTED WETLANDS (VERTICAL FLOW)

DECENTRALIZED

- Unsaturated filter substrate where physical, biological processes.
- *BOD* = 75 to 90%; *TSS* = 65 to 85%; *TN* < 60%; *TP* < 35%; *FC* ≤ 2 to 3 log

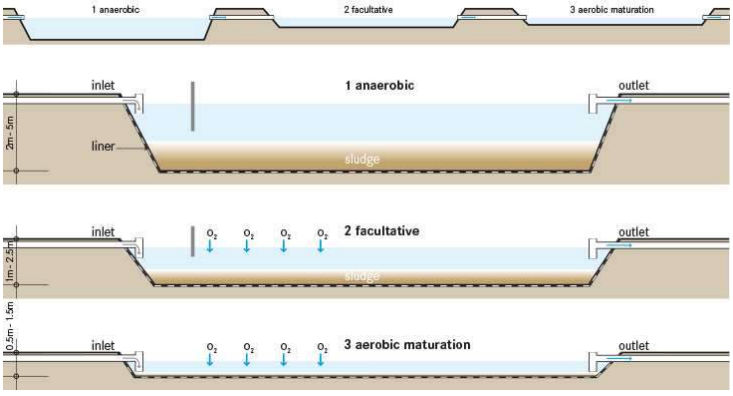


Source: TILLEY et al. (2014)

WASTE STABILIZATION POND (WSP)

CENTRALIZED

- Sedimentation and Biological processes
- 90% *BOD* and *TSS*; high *pathogen* reduction and relatively high removal of *ammonia* and *phosphorus*;
- Total *HRT*: 20 to 60 days

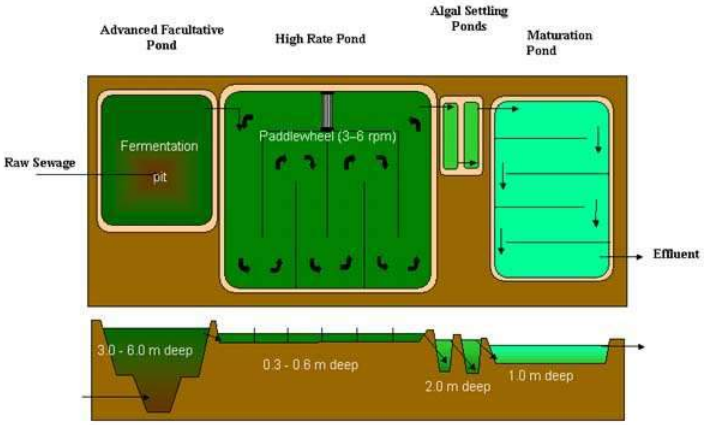


Source: TILLEY et al. (2014)

ADVANCED INTEGRATED PONDS

CENTRALIZED

- Complete treatment can b provided using mix of anaerobic, aerobic, oxygen transfer process and photolytic disinfection
- 90 to 100 % *BOD*; 90 to 100 % *TSS*; 60 to 90 % *nitrogen*; 90 to 100 % *ammonia*; 60to 100 *Phosphorus*; 6 log units *E. coli*

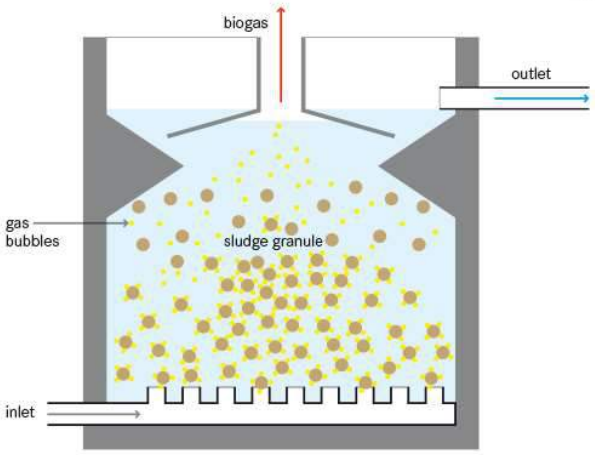


Source: RAMADAN et al. (n.y.)

UASB REACTOR

CENTRALIZED

- Complete anaerobic digestion. Recovery of biogas. Needs continuous and stable water flow and energy.
- 60 to 90% *BOD*; 60 to 80% *COD* and 60 to 85% *TSS*; low *pathogen* reduction minimal removal of *nutrient*.
- *HRT*: min 2 hrs, generally 4 to 20 hrs

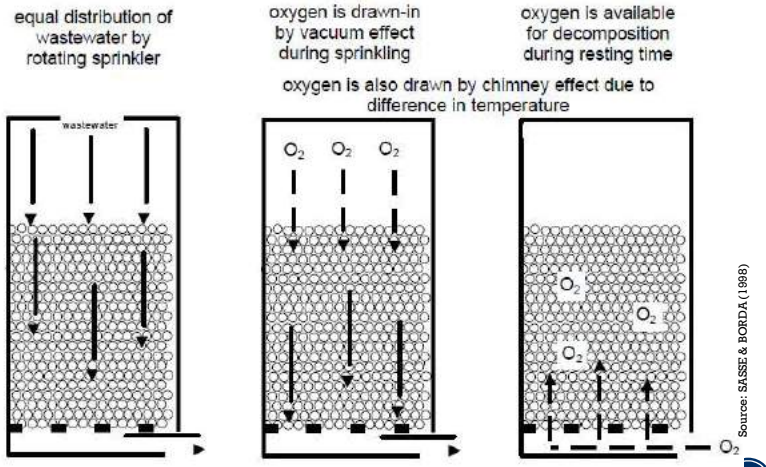


Source: TILLEY et al. (2008)

TRICKLING FILTER

CENTRALIZED

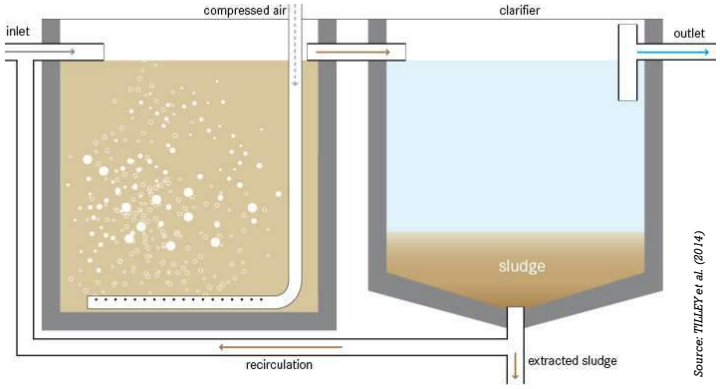
- Attached growth on the media (biofilm).
- Completely aerobic process.
- *BOD*: 65 to 90 %. Low *TSS* removal. *Total Coliforms*: 1 to 2 log units
  N: 0 to 35%. *P*: 10 to 15 %.



ACTIVATED SLUDGE PROCESS (ASP)

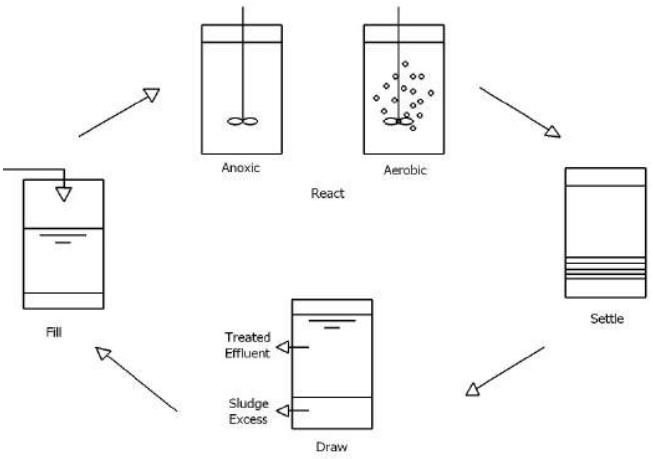
CENTRALIZED

- Suspended *flocs* of active *bacteria* is mixed with the *wastewater*.
- 80 to almost 90% *BOD* and *TSS* removal. High *nitrogen* removal. *P* accumulated in *biomass* and *sludge*. Low *pathogen* removal.
- *HRT* of some hours up to several days

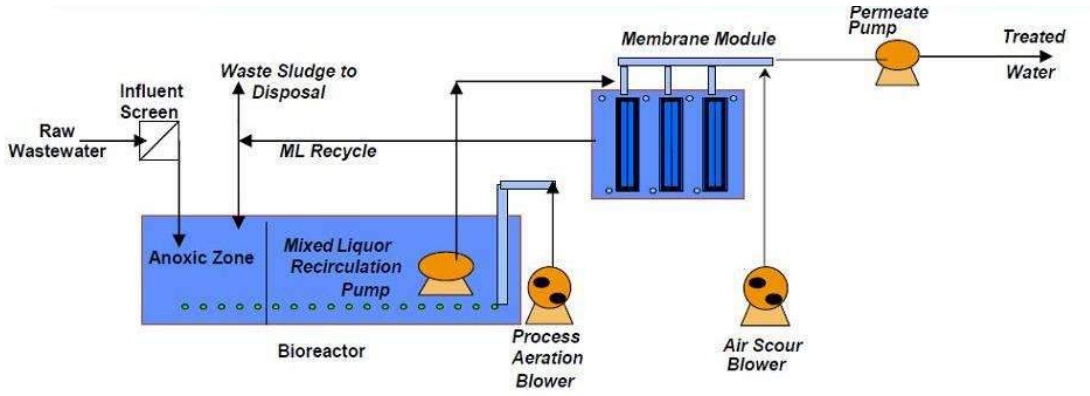


SEQUENTIAL BATCH REACTOR (SBR)

- Batch process consisting of four steps.
- Aerobic degradation process.
- BOD, COD and TSS removal up to 90%, nutrients and pathogen removal up to 80%



MEMBRANE BIO REACTOR (MBR)



Source: FITZGERALD (2008)

MEMBRANE BIO REACTOR (MBR)

Source: RADJENOVIC et al. (2008)

- Biological treatment coupled with membrane filtration (physical process).
- Advanced level of organic and suspended solids removal.
- High performance BOD, COD, TSS, nutrients removal more than 90%

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TERTIARY TREATMENT

Chemical / Photolytic process for disinfection

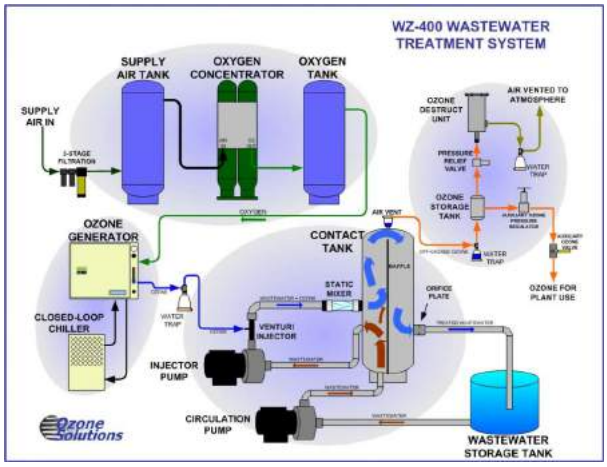
Reduction in E. Coli, MPN

CHLORINATION

- Hypochlorite solutions is diluted to make appropriate dose.
- Dose needs to be adjusted depending on the treated wastewater quality.
- Widely used as it is cheap and effective.
- Precaution needs to be taken as presence of organic matter, Fe, Mn etc leads to formation of carcinogenic compounds.
- Rapidly replaced by ozonation.

OZONATION

- Infusion of ozone.
- High tech equipment is required.
- High efficiency.
- Relatively high O&M cost.



Source: THE OZMOTICS INSIDER (2008)

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APPROPRIATE TREATMENT SYSTEM

Choosing the most appropriate combination of technologies for three stages is the key to have sustainable wastewater treatment plant.

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

TREATABILITY

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

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

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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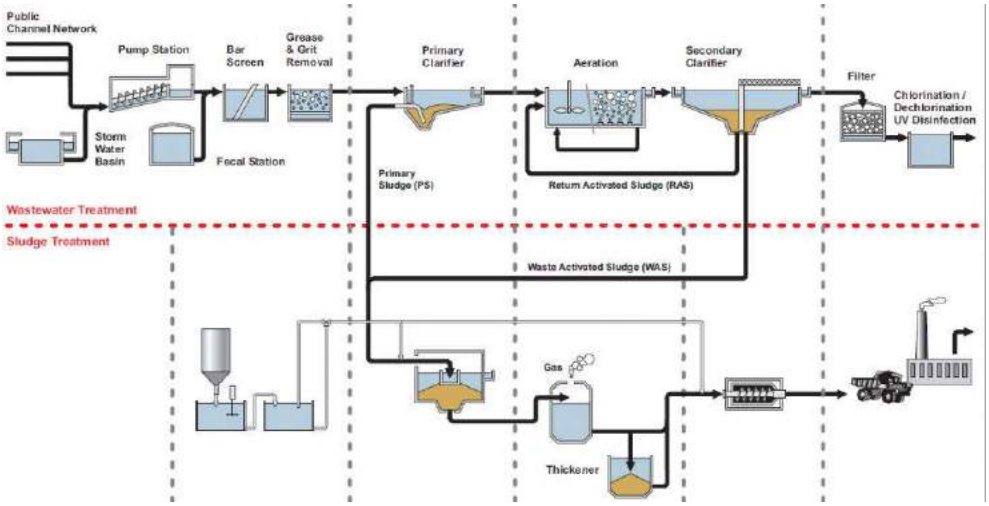
TREATMENT CHAIN

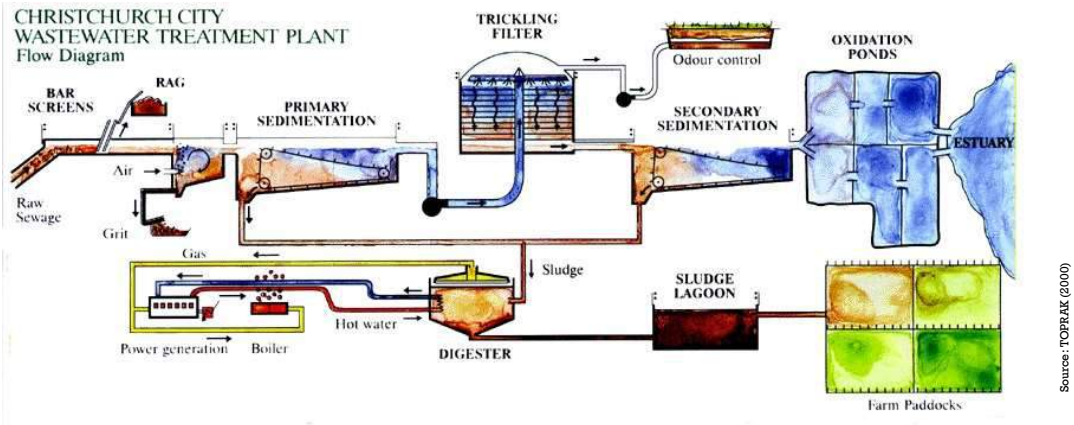
A sewage treatment plant is combination of appropriate technologies for primary, secondary and tertiary treatment.

CASE I: ASP



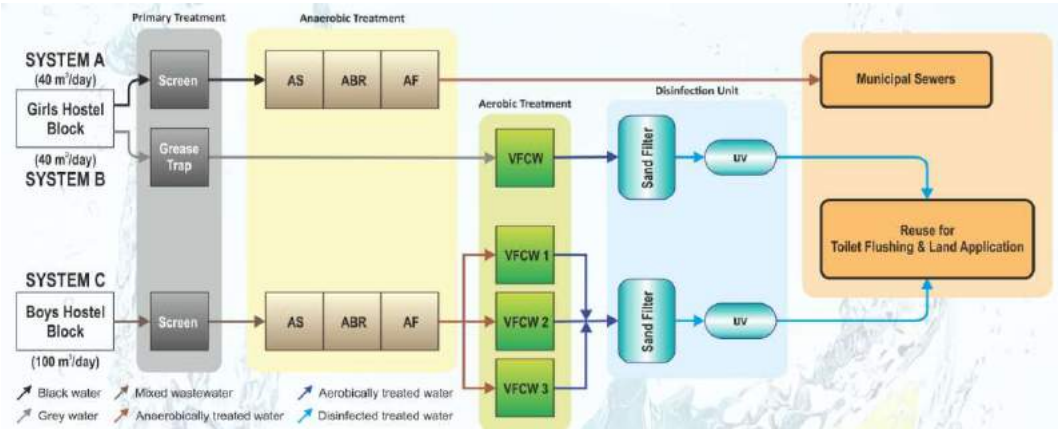
Source: ENDRESS+HAUSER (2002)

CASE II: TRICKLING FILTER



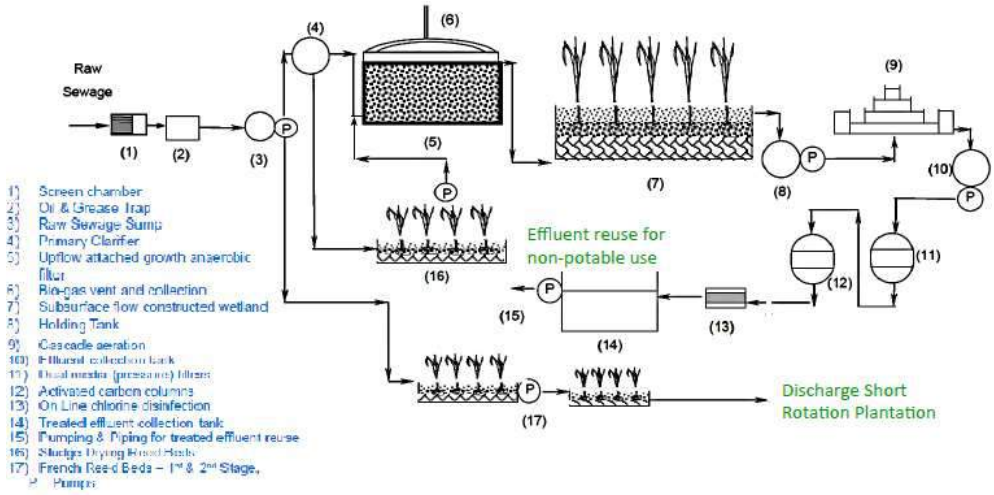
Source: TOPRAK (2000)

CASE III: DTS



Source: TOPRAK (2000)

CASE IV: DTS



Thank you...

National Institute of Urban Affairs

SANITATION CAPACITY BUILDING PROGRAM

Need of Faecal Sludge and Septage Management (FSSM)

Mr. Saurabh Kale
Trainer and Sr. Project Manager, ESF
saurabh.kale@ecosanservices.org

ecosan SERVICES FOUNDATION

CONTENTS

- Sanitation facts – INDIA
- National programs and policies
- What is Faecal Sludge and Septage?
- Sanitation Value Chain
- Need and Challenges in FSSM

http://quicksand.co.in/work/project-sammaan

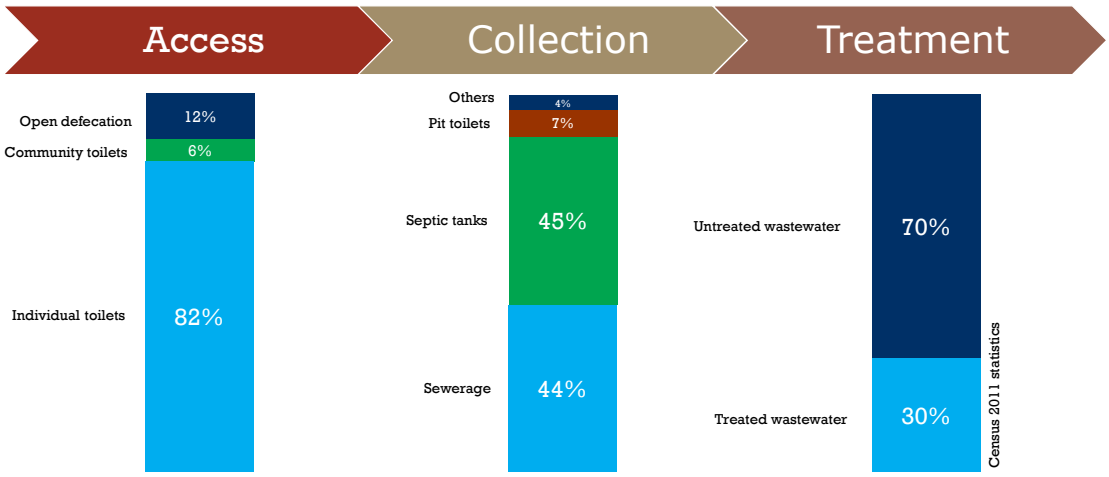
SANITATION FACTS – INDIA

(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!**

SANITATION CHAIN (VALUE?)



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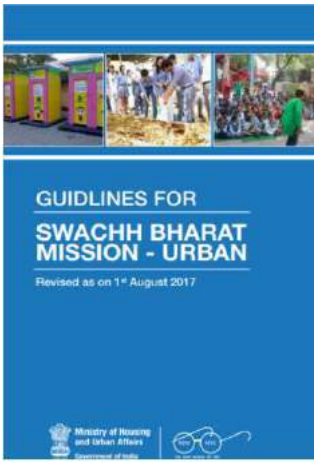
NATIONAL PROGRAM AND POLICIES

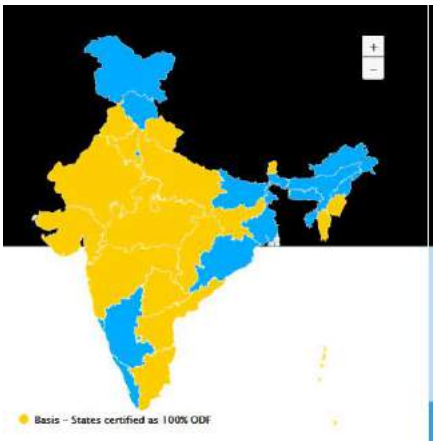
Swachh Bharat Mission (Urban), National Policy on FSSM, FSSM in AMRUT

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



54,64,727	4,64,250	3,518
Constructions Achieved	Constructions Achieved	No. of Cities
Individual Toilets	Community & Public Toilets	Open Defecation free
100% Door to Door Waste Collection	Waste to Energy	Waste to Compost
Wards Achieved	Current Production (Mega Watt)	Current Production (Metric Ton)
67,085	88.4	15,06,501

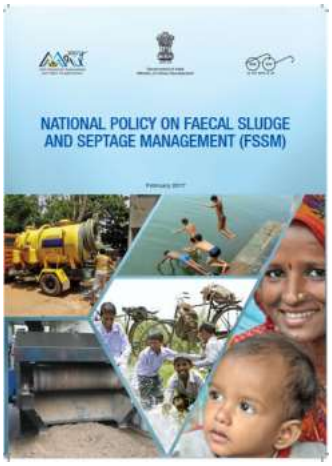
As on March, 2019

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.

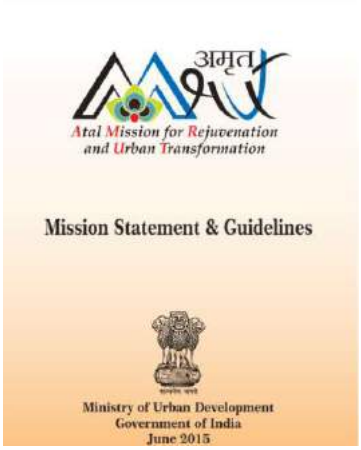
NATIONAL POLICY ON FSSM

- 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.



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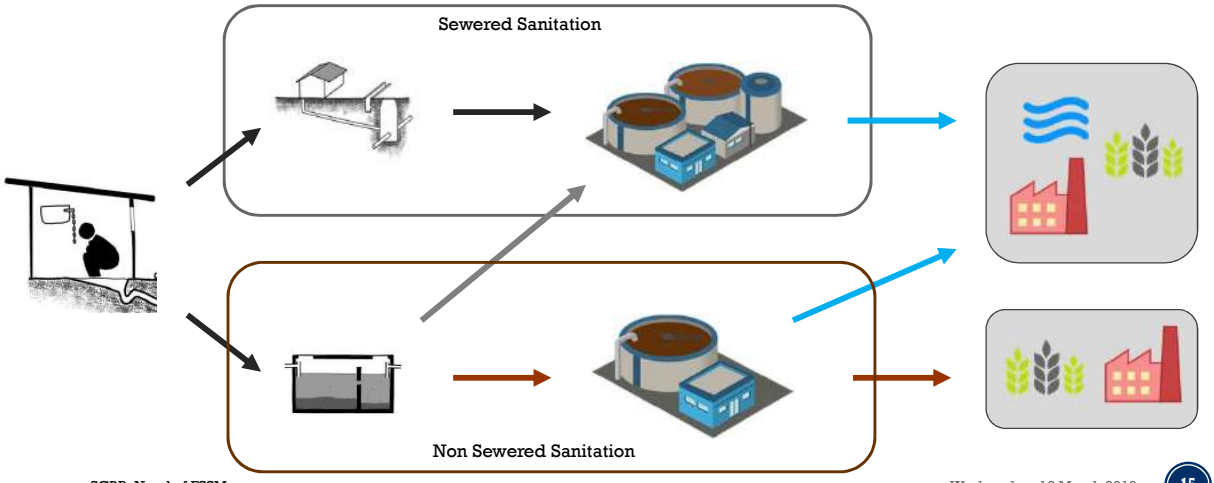
INTRODUCTION TO FSSM

Sanitation systems, Faecal sludge - septage and its characteristics, Faecal sludge and septage management, Sanitation value chain

SANITATION SYSTEMS AROUND US!



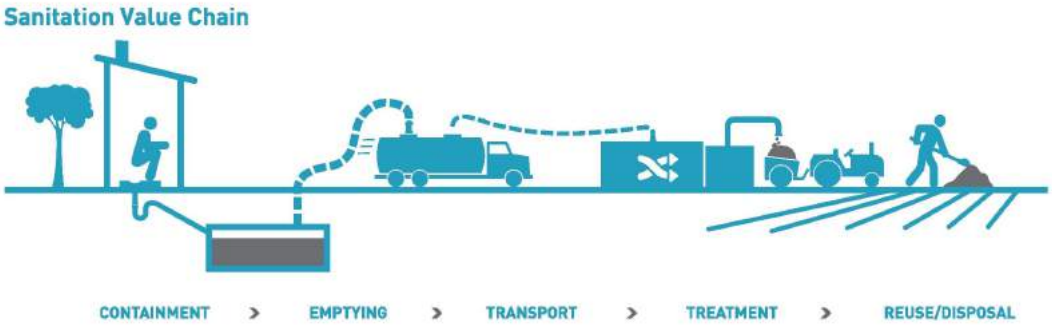
WHAT IS FAECAL SLUDGE & SEPTAGE?

- 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.

FAECAL SLUDGE AND SEPTAGE

EAWAG Sandec

SANITATION VALUE CHAIN (NON SEWERED)



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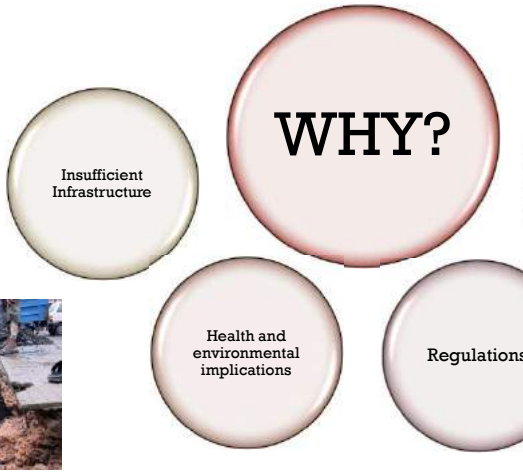
NEEDS AND CHALLENGES IN FSSM

Why is it important to understand FSSM? What are the needs of FSSM in India? What are the issues and challenges which India is facing?

NEED OF FSSM



CHALLENGES IN FSSM

User interface	Collection	Conveyance	Treatment	Disposal
Individual Household Toilets Community Toilets Public Toilets	Lined pits Soak pits Septic tanks Onsite Treatment System	Open/Closed drains Vacuum trucks	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!

CHALLENGES IN FSSM

User interface

Individual Household Toilets

Community Toilets

Public Toilets

- Space
- Affordability
- Water supply
- Electricity
- Poor O&M
- Quality of material and workmansh

CHALLENGES IN FSSM

Collection

Lined pits

Soak pits

Septic tanks

Onsite Treatment System

- Space
- Affordability
- Location
- No standard design
- Poor O&M

CHALLENGES IN FSSM

Conveyance

Open/Closed drains

Vacuum trucks

- No monitoring of informal sector
- Unsafe handling
- Irregular desludging
- Inadequate equipme and machineries

CHALLENGES IN FSSM

Treatment

No STPs for septic tank effluent!

No treatment plant for faecal sludge and septage!

Indiscriminate disposal in

- Surface water bodies
- Land
- Drains
- Dump site

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...

National Institute of Urban Affairs

SANITATION CAPACITY BUILDING PROGRAM

Planning of Integrated Faecal Sludge and Septage Management System (IFSSM)

Mr. Dhawal Patil,
M.Sc. Hydro Science and Engineering
General Manager - Operations

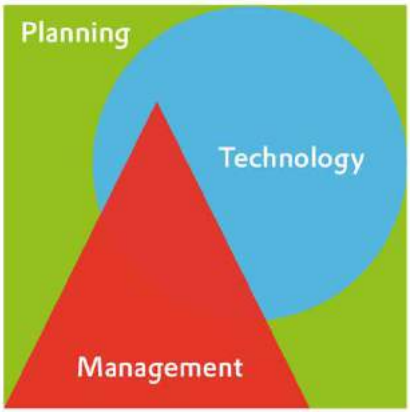
ecosan SERVICES FOUNDATION

CONTENTS

- **Need for an integrated approach**
  - Enabling environment
  - Participatory approach
- **Planning approach and logical framework**
  - FSM planning from A to Z
  - Detailed project development stage
- **Selecting context appropriate technical options**
  - Services
  - Selection of treatment options
  - Sanitation system scheme

INTEGRATED APPROACH?

- Incorporating technology, management and planning
- Helps to ensure vested participation and management, without which technologies implemented in low-income countries will fail over the long term



NEED FOR INTEGRATED APPROACH

Common reasons for failure of water and sanitation projects

- Lack of stakeholder consultation
- Lack of planning of O&M and financial schemes
- Lack of institutionalisation
- Lack of cost recovery mechanism

ENABLING ENVIRONMENT

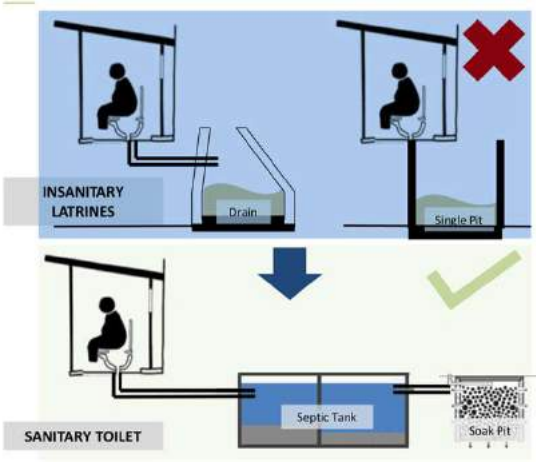
PARTICIPATORY APPROACH

- Top down approach is prone to failure.
- Blue print systems are more expensive!
- Stakeholder involvement – most appropriate and cost effective system.
- FSM needs to be government driven, but inclusion of other stakeholders needs to be done for filling in the gaps.
- PPP partnerships need to be investigated.

STEPS FOR CITYWIDE FSM PLANNING

STEP 1: PROPER DESIGN OF TOILETS

A All insanitary latrines to be converted to sanitary toilets with twin pits/ septic tanks.



Source: Guidebook for ULBs to implement septage management plan, SMM, UDD, GoM

STEP 1: PROPER DESIGN OF TOILETS

B The design and construction of septic tanks should be as per Swacha Bharat Mission, 2014.

C Notices to be issued to all property owners whose septic tanks do not meet the standard design guideline

STEP 2: DESLUDGING OF SEPTIC TANKS

A Desludging / emptying of septic tanks should be undertaken by mechanical devices like suction emptier trucks / vacuum tankers, as per the Government of India act on the Employment of Manual Scavengers and Construction of Dry Latrines (Prohibition) Act, 1993

B ULBs can also license existing septic tank operators in their city to operate their services

STEP 2: DESLUDGING OF SEPTIC TANKS

C It is essential for the employees engaged in the activity of septic tank emptying to use protective gear like gloves, boots, face mask etc.

D ULBs should adopt pre-determined scheduled septic tank desludging services. The city can be divided into zones and then a quarterly desludging service plan for a given year can be developed.

STEP 2: DESLUDGING OF SEPTIC TANKS

E ULBs should either provide the emptying services themselves or enter into appropriate management contracts with private agencies.

The contracts can be structured in the following two ways:-

- The ULBs own the emptying truck and contract out the cleaning and emptying services to licensed contractors. The contractors can work according to the scheduled septic tank cleaning plan
- The contractors can invest in procuring emptying trucks as well as operate them.

STEP 3: TREATMENT AND REUSE/DISPOSAL OF SEPTAGE

A As per the CPCB Norms Septage collected from the septic tanks or pits should not be disposed without any treatment.

B If STP is not available in the city or nearby that can receive the septage, then ULB should plan for new septage treatment facility.

STEP 3: TREATMENT AND REUSE/DISPOSAL OF SEPTAGE

C Input quality of the collected septage should be tested by the operators at the treatment facility for checking presence of any metal or traces of industrial waste.

D Septage can be reused , if it meets the parameters mentioned in Guidelines for Septage Management, then ULB should plan for new septage treatment facility.

STEP 3: TREATMENT AND REUSE/DISPOSAL OF SEPTAGE

E

ULBs should consider the involvement of private sector parties for activities related to operation and maintenance of treatment facility. To assign a contractor;

- Defining the operational role of the Contractors
- Ascertaining Investment and Ownership of Asset
- Determining the Source of Revenue
- Finalizing the Payment Structure
- Deciding on Contract Length and Value
- Mitigating and Allocating Risks

MEASURES FOR PLANNING SEPTAGE TREATMENT FACILITY

Distance of treatment site

Land availability

Reliability of Electricity

MEASURES FOR PLANNING SEPTAGE TREATMENT FACILITY

Neighborhood

Geological parameters

STEP 4: MONITORING FSM SYSTEMS

A Recordkeeping and manifest forms should be an integral part of a comprehensive septage management program.

B The completed document or documents with signatures of the household/property, suction truck operator and treatment plant operator should be submitted to the local government for their records and this should be linked to payment of operators.

STEP 4: MONITORING FSM SYSTEMS

C GIS should be used to be plan the route of suction emptier trucks and tracking these for regular record keeping.

D An MIS system to monitor the services at property / household level needs to be developed using SaniTab or as suggested in Guidelines for Septage Management of the state

STEP 4: MONITORING FSM SYSTEMS

C Consumer grievance redressal system for faecal sludge management should also be set up as a part of urban local body record keeping systems and helpline numbers to be shared with residents as a part of monitoring and record keeping systems for faecal sludge management.

SCBP: Integrated Faecal Sludge Management System

Wednesday, 13 March 2019

STEP 5: AWARENESS GENERATION AND CAPACITY BUILDING

A Awareness generation activities should be carried out at the beginning of introducing a scheduled service in all wards and then repeated periodically over the three year cycle.

B Municipal Commissioners/ Chief Officers, Engineers, Sanitary Inspectors, Health Officers, and Sanitary Workers should be well trained in safe septage management and its best practices.

PLANNING APPROACH AND FRAMEWORK

Standard project phase	Outcome
Exploratory study	Inception report *Overview of the situation, facilitators are identified.*
Pre feasibility studies	Pre-feasibility report • *Enabling environment is described.* • *Orientation of the process towards realistic option.* • *First contact with stakeholders.*
Feasibility study	Feasibility study report • *Process leaders knows what needs to be treated.* • *Appropriate site is selected.* • *Scenarios are elaborated.* • *System scenarios are evaluated and optimised.* • *Stakeholders are consulted and agreement is secured.*

PLANNING APPROACH AND FRAMEWORK

Standard project phase	Outcome
Detailed project development	Detailed project document • *The action plan is written.* • *The whole system is described in detail* • *The action plan is validated by all stakeholders.* • *Roles and responsibilities of stakeholders are redefined according to the action plan.*
Implementation	• *FSM is transferred to corresponding stakeholders.* • *Capacity building.* • *State of art FSTP is constructed.* • *FSTP is officially transferred to the city authorities / private company.*
M&E	• *The system is monitored to ensure sustainability.*

Thank you...

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SANITATION CAPACITY BUILDING PROGRAM

Assessment of Initial Situation

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ecosan SERVICES FOUNDATION

CONTENTS

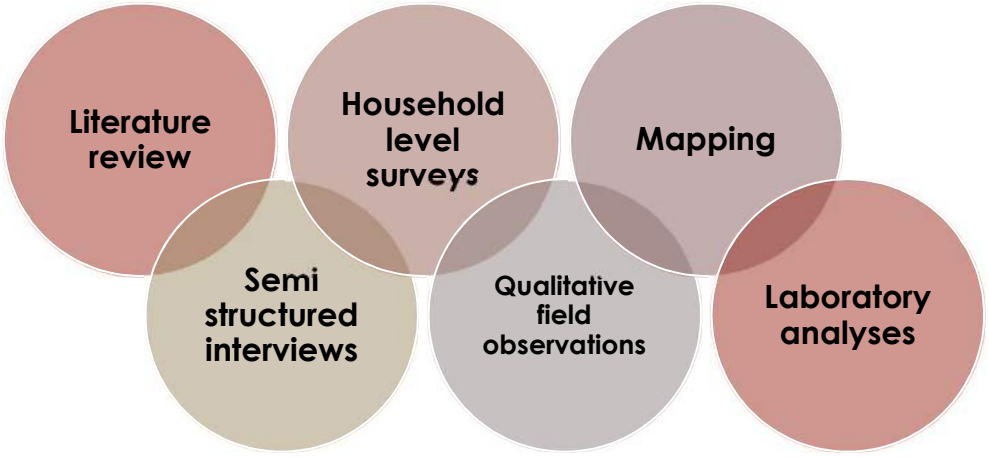
- Tools and methods for data collection
- Data to be collected, characterization, evaluation and selection of treatment sites

TOOLS AND METHODS FOR DATA COLLECTION

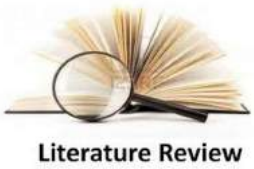
ASSESSMENT OF INITIAL SITUATION

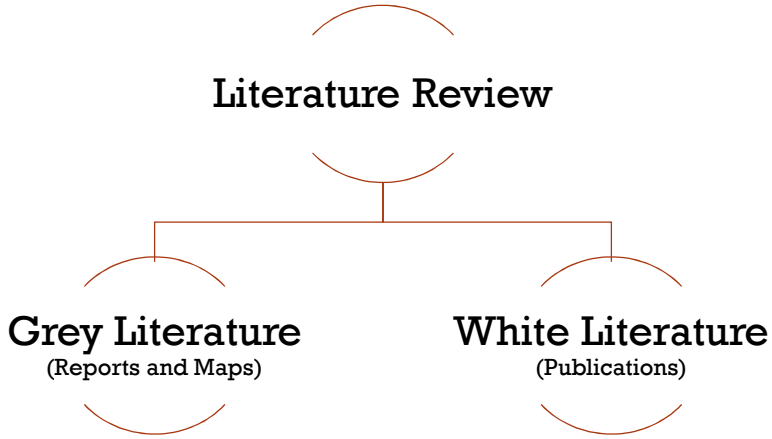
- Is crucial and provides baseline information for decision making.
- Understanding the context, getting to know stakeholders.
- Elaborating faecal sludge management scenarios.
- Identifies existing service chain.
- Identifies enabling environment.

TOOLS AND METHOD OF DATA COLLECTION



LITERATURE REVIEW





SEMI-STRUCTURED INTERVIEWS

- Qualitative method of inquiry that combines a pre-determined set of open questions
- used to understand how interventions work and how they could be improved

Pros	Cons
Provides valuable information from stakeholders experiences	Can be time consuming to collect and analyse the data
Use of pre-determined questions provides uniformity	Requires some level of training or practice in order to prevent interviewer suggesting answers

HOUSEHOLD LEVEL SURVEYS

- What is the purpose of data to be collected and its expected use?
- Is the information available elsewhere?
- Stick to only the necessary questions, so as not to overburden the persons being surveyed
- Try to view the questions through the respondent's eyes wording is important
- The response or information obtained is only as good as the question is

SANITAB TOOL

- To create database for Onsite sanitation system
- Mobile application developed by CEPT University, India
- Stakeholders - ULB's, Consultants
- Quick and ease in data collection and minimizes the human errors
- Real-time Monitoring

http://www.fsmtoolbox.com/view-all-tools/?

HOUSEHOLD LEVEL SURVEYS

Characterization of the interviewee:
status, family, cultural background, household size

Water supply:
water sources, water quality, service quality, water consumption, costs

Hygiene and sanitation:
sanitation facilities, faecal sludge and septage management, greywater management, solid waste management, stormwater management

Institutional/organizational aspects:
who is responsible for each service, positive/negative aspects

Environmental awareness:
perception of cleanliness and health impacts, willingness to improve

Communications channels:
main information sources, information on consumption habits

MAPPING

QUALITATIVE FIELD OBSERVATIONS

- Field Visits
- Transect Walk
- Consultations with FSM Stakeholders, Focus group discussions
- Site Investigations

LABORATORY ANALYSIS

- Sampling Campaigns
- Parameters to be measured

SWOT ANALYSIS

Strengths	Opportunities
• Awareness of the problems at the municipal level • Existence of a national framework for decentralisation • Strong private sector	• Willingness of the municipality to take action • Presence of a strong sanitation NGO which can act as a facilitator • Interest for sludge enduse by local farmers
• Lack of regulations specific to FS • Lack of organisation among the private service providers • Lack of human, material and financial resources belonging to the municipality • Difficulty in enforcing regulations	• Elections coming soon, with the risk of changes of leaders/administrators • Lack of skilled technicians • Lack of state-owned land
Weaknesses	Threats

DATA TO BE COLLECTED AND SELECTION OF TREATMENT SITES

Data to be collected, characterization, evaluation and selection of treatment sites

DATA TO BE COLLECTED

- Sanitation sector (Service Level Benchmarking)
- Legal and regulatory framework
- Climatic data
- Spatial data and city structure
- Enduse practices and market studies

DATA TO BE COLLECTED

Scheduled Desludging

- Household Level Survey
- Consultations with mechanical service providers (public or private)

On-demand desludging

- Consultations with Households or Community
- Profile of mechanical service providers

SANITATION SECTOR (EXISTING SERVICES DATA)

Latrines and On-site treatment	Water Availability
	Sanitation facilities
	On-site treatment
Waste Collection and Conveyance	Existing sewerage infrastructure
	Faecal sludge and septage collection services
Offsite wastewater treatment	Wastewater Treatment
	Discharge or enduse

PRACTICES AT HOUSEHOLD LEVEL

- Types of Toilets
- Emptying mode and means
- Emptying frequency
- Seasonal variability
- Number of operators per emptying mode
- Proportion of manual or mechanical emptying
- Tariffs, capacity to pay, willingness to pay for improved services, Proposed tariffs

MANUAL AND MECHANICAL SERVICE PROVIDERS

Socio Professional Profile

Tariffs and Tariffs breakdown

Frequency of the activity: main / regular / occasional

Problems encountered e.g. accessibility, social pressure and health

Staff and equipments used

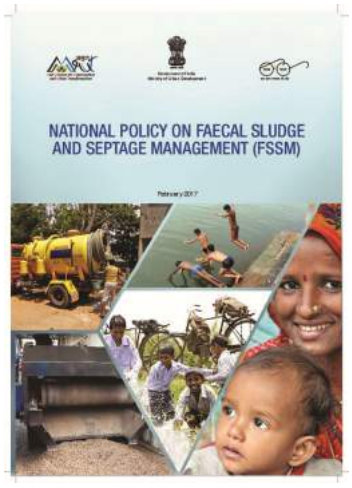
Methods

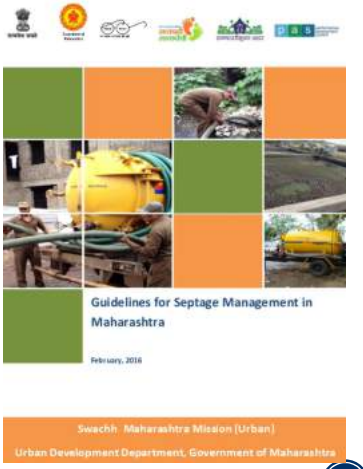
LEGAL AND REGULATORY FRAMEWORK

Laws and Regulations

Legal structures in charge of applications

Enforcement





CLIMATE DATA

Temperature over time

Quantity of precipitation, maximum/minimum and distribution over time, frequency of rain episodes, seasons (dry or rainy)

Evaporation rates, Runoff

SPATIAL DATA AND CITY STRUCTURES

- What sanitation infrastructure and services are in place and how effective are they?
- What are the sanitation problems most acute?
- Where is there a need for new infrastructure or services and where is there a need for upgrading?
- Which areas should be prioritised for improvement?
- Where the potential sites for FSTPs?
- Which areas are inaccessible for mechanical emptying
- Where are the potential interferences between these inaccessible areas and the city-level services?

IDENTIFICATION OF SITES

Criteria	Conditions
Average transport distance for mechanical service provider	Acceptability and affordability for service providers, as defined during interviews
Accessibility	Ease of access
Surface area	> 0.3 ha
Land ownership and price	Guarantee to be able to buy, at a reasonable price
Neighbourhood, potential for urbanisation	Risk of future access
Topography	No risk of flooding
Soil type	Free soil (unconsolidated)
Groundwater table	> 2m
Opportunities for disposal	Must have end use possibilities or disposal

NUMBER OF SITES

Centralized FSTP

Decentralized FSTPs

Thank you...

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SANITATION CAPACITY BUILDING PROGRAM

Quantification and Characterization of Faecal Sludge

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CONTENTS

Faecal sludge quantification

- Why quantification is necessary?
- Sludge production method
- Sludge collection method
  - Seasonal variation
  - Peaking factor

FS Characterization

- Parameters
- Comparison of different sludges
- Characterisation ratios
- Operational factors

QUANTIFICATION OF FAECAL SLUDGE

Quantification, Sludge production method, Sludge collection method

WHY QUANTIFICATION IS NECESSARY?

- **Type of desludging envisaged?**
  - Demand desludging
  - Scheduled desludging
- **Scale of collection and transport network**
- **Identifying discharge sites (co treatment)**
- **Proper sizing of infrastructure**
  - Faecal sludge and septage treatment plant
  - End-use and disposal mechanism

METHODS OF QUANTIFICATION

Sludge production method

- Estimates total sludge production
- Starts with primary data collection – household survey
- Carried out in case of scheduled desludging

Sludge collection method

- Estimates sludge loading rate at the treatment plant
- Start with collection and transport companies (legal & illegal)
- Carried out in case of demand desludging

Many assumptions need to be made in both the methods due to lack of available information!

SLUDGE PRODUCTION METHOD

- **Number of users**
- **Location**
- **Types and number of various onsite systems**
- **FS accumulation rates ~ 230 L/capita * year**
  - Varies from 190 L/capita * year to 380 L/capita*year
- **Population of socio-economic levels**

CHALLENGES FACED!

- Faeces production vary significantly on dietary habits.
- Not just the quantity but quality of the faecal sludge also vary.
- Volume of urine excreted also change depending on liquid consumption, physical activity and climate.
- Scarcity of data: onsite sanitation systems built informally.
- Not all what is collected reaches the treatment plant.

SLUDGE COLLECTION METHOD

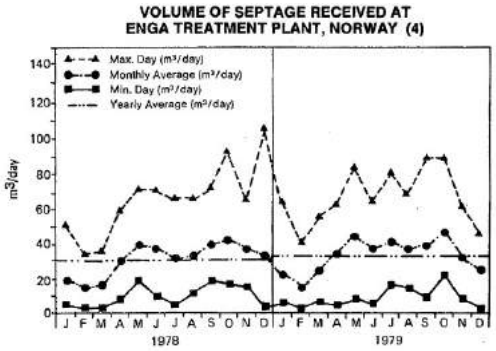
Factors affecting the collection

- Acceptance and promotion of FSM
- Demand for emptying and collection services
- Availability of legal discharge or treatment sites

Volume estimates

- Interviews, site visits, and a review of internal records of FS C&T companies
- Number of collections/day, Volume of FS /collection,
- Average emptying frequency at the HH level,
- Estimated proportion of the population that employ the services of C&T companies

SEASONAL VARIATIONS

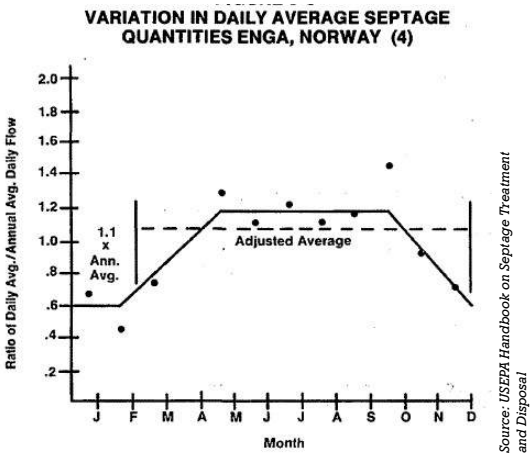


Source: USEPA Handbook on Septage Treatment and Disposal

- Desludging demand increases during high ground water tables, extended rainfall or snowmelt.
- Some desludging takes place all round the year (hotels, schools, restaurants, community sanitation blocks, public sanitation blocks)

PEAKING FACTORS

- Peaking factor is the ratio of the maximum to the average quantity received over a period of time.
- Peaking factor can range from 1.5 to 4.0 in some cases.
- Data needs to be collected and analysed to know the peaking factor.



Source: USEPA Handbook on Septage Treatment and Disposal

CHALLENGES FACED!

- Number of discharge location or demand for the septage.
- In case of discharge at STP, affordability of discharge fee.
- A large informal sector is working in the business of "septic tank cleaning".
- Not all what is collected reaches the treatment plant.
- Identification of new legal discharge point might increase the frequency of the desludging.

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CHARACTERIZATION OF FAECAL SLUDGE

Parameters, Comparison of Septage and Sewage

Characteristics of faecal sludge from different sources and WWTP sludge, Characterisation ratio

Operational factors that impact the variability of Faecal Sludge

PARAMETERS

- Solid Concentration (TS, TVS, TSS, VSS)
- Chemical Oxygen Demand (COD)
- Biochemical Oxygen Demand (BOD)
- Nutrients (TKN, NH_3-N, Total P)
- Pathogens
- Metals

COMPARISON OF SEPTAGE AND SEWAGE

Parameter	Septage	Sewage	Ratio of septage to sewage
TS	40,000	720	55:1
TVS	25,000	365	68:1
TSS	15,000	220	68:1
VSS	10,000	165	61:1
BOD_5	7,000	220	32:1
COD	15,000	500	30:1
TKN	700	40	17:1
NH_3-N	150	25	6:1
Total P	250	8	31:1
Grease	8,000	100	80:1

Source: USEPA Handbook on Septage Treatment and Disposal

CHARACTERISTICS OF FAECAL SLUDGE FROM DIFFERENT SOURCES AND WWTP SLUDGE

Parameter	FS source		WWTP sludge	Reference
	Public toilet	Septic tank		
pH	1.5-12.6			USEPA (1994)
	6.55-9.34			Kengne *et al.* (2011)
Total Solids, TS (mg/L)	52,500	12,000-35,000	–	Koné and Strauss (2004)
	30,000	22,000	–	NWSC (2008)
		34,106		USEPA (1994)
	≥3.5%	<3%	<1%	Heinss *et al.* (1998)
Total Volatile Solids, TVS (as % of TS)	68	50-73	-	Koné and Strauss (2004)
	65	45	-	NWSC (2008)
COD (mg/L)	49,000	1,200-7,800	-	Koné and Strauss (2004)
	30,000	10,000	7-608	NWSC (2008)
	20,000-50,000	<10,000	500-2,500	Heinss *et al.* (1998)
BOD (mg/L)	7,600	840-2,600	-	Koné and Strauss (2004)
	-	-	20-229	NWSC (2008)

Source: FSM Book, 2

CHARACTERISTICS OF FAECAL SLUDGE FROM DIFFERENT SOURCES AND WWTP SLUDGE

Total Nitrogen, TN (mg/L)	-	190-300	-	Koné and Strauss (2004)
			32-250	NWSC (2008)
Total Kjeldahl Nitrogen, TKN (mg/L)	3,400	1,000	-	Katukiza *et al.* (2012)
NH_4-N (mg/L)	3,300	150-1,200	-	Koné and Strauss (2004)
	2,000	400	2-168	NWSC (2008)
	2,000-5,000	<1,000	30-70	Heinss *et al.* (1998)
Nitrates, NO_3^- (mg N/L)	-	0.2-21	-	Koottatep *et al.* (2005)
Total Phosphorus, TP (mg P/L)	450	150	9-63	NWSC (2008)
Faecal coliforms (cfu/100 mL)	$1x10^5$	$1x10^5$	$6.3x10^4$-$6.6x10^5$	NWSC (2008)
Helminth eggs (Numbers/L)	2,500	4,000-5,700	-	Heinss *et al.* (1994)
	20,000-60,000	4,000	300-2,000	Heinss *et al.* (1998)
		600-6,000		Ingallinella *et al.* (2002)
		16,000		Yen-Phi *et al.* (2010)

Source: FSM Book, 2

CHARACTERISATION RATIOS

Ratio (gm/gm)	Public toilets	Septic tanks	Medium strength wastewater
VSS:TSS	0.65-0.68	0.50-0.73	0.60-0.80
COD:BOD_5	5.0	1.43-3.0	2.0-2.5
COD:TKN	0.10	1.2-7.8	8-12
BOD_5:TKN	2.2	0.84-2.6	4-6
COD:TP	109	8.0-52	35-45
BOD_5:TP	17	5.6-17.3	15-20

Source: FSM Book, 2014

OPERATIONAL FACTORS

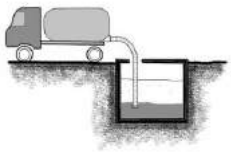
- **Toilet usage**
  - Washers & wipers
  - Inclusion – exclusion of grey water
  - Use of additives for reducing filling rates of onsite sanitation system.
- **Storage duration**
  - Type of technology
  - Toilet usage

OPERATIONAL FACTORS

- **Infiltration & exfiltration**
  - Quality of construction
  - Exfiltration – thicker sludge and infiltration – diluted sludge
- **Climate**
  - Temperature and moisture dependent
  - High temperature – high biological degradation rate

OPERATIONAL FACTORS

- **Collection method**
  - Human powered emptying – Thicker sludge, Motorised emptying – Dilute sludge
  - Sometimes the collection and transport vehicles are equipped with normal pumps with not strong vacuum



Thank you...

National Institute of Urban Affairs

SCBP

SANITATION CAPACITY BUILDING PROGRAM

Methods and Means for Collection and Transport of Faecal Sludge

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CONTENTS

- Roles and Responsibilities of Stakeholders in Faecal Sludge Collection & Transport
- Types of collection and transportation techniques
- Transfer Stations

3

ROLES AND RESPONSIBILITIES OF STAKEHOLDERS IN FAECAL SLUDGE COLLECTION & TRANSPORT

Interfacing with clients, Locating the system to be emptied, Determining accessibility, Tools of the trade

ROLES AND RESPONSIBILITIES

Stakeholders in Faecal Sludge Collection and Transport Process

Collection & Transport

Service Providers

Customers

ROLES AND RESPONSIBILITIES

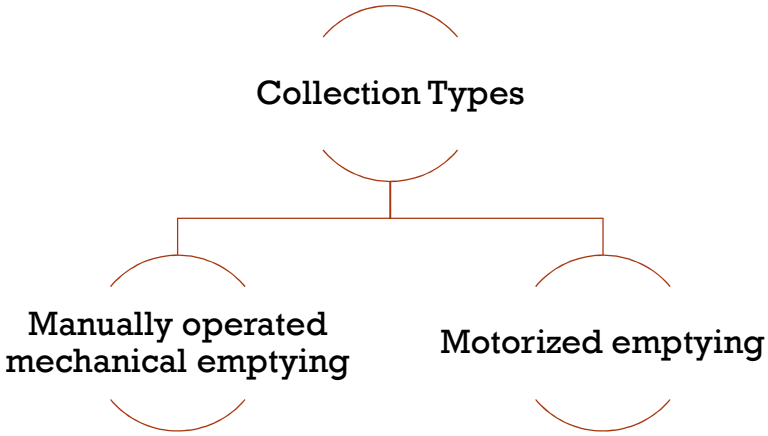
- Interaction with customers for charges and procedure of the service
- Locate onsite sanitation systems and determine the accessibility
- Open the system to facilitate the process and Collect the Faecal Sludge
- Evaluate the condition, Close the System, Clean-up and Final inspection

6

TYPES OF COLLECTION & TRANSPORTATION TECHNIQUES

Interfacing with clients, Locating the system to be emptied, Determining accessibility, Tools of the trade

TYPES OF COLLECTION



MANUALLY OPERATED MECHANICAL EMPTYING

- Manually operated pumps
- Low costs
- Availability of tools
- Little or no requirement of electric energy
- High health risk if not done properly

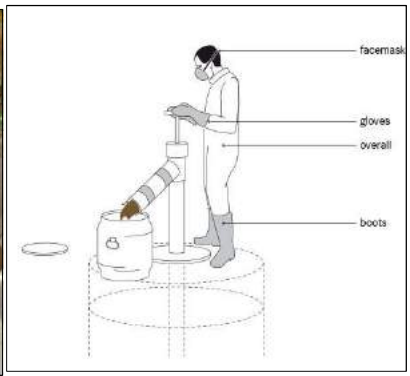
MANUALLY OPERATED MECHANICAL EQUIPMENTS

MAPET

Sludge Gulper

Performance	Purchase/ Operating Cost	Challenges
• Suitable for pumping low viscosity sludges • Average flow rates of 30 L/min • Maximum pumping head is dependent on design	• Capital Cost: INR 3000 – INR 90,000 (depending on design) • Operating Cost: Unknown	• Difficulty in accessing toilets with a small superstructure • Clogging at high nonbiodegradable material content • PVC riser pipe prone to cracking • Splashing of sludge between the spout of the pump and the receiving container

Sludge Gulper



Manual diaphragm pump

Performance	Purchase/ Operating Cost	Challenges
• Suitable for pumping low viscosity sludges • Average flow rates of 100 L/min • Maximum pumping head of 3.5m – 4.5m	• Capital Cost: INR 20,000 – INR 60,000 (depending on manufacturer and model) • Operating Cost: Unknown	• Clogging at high nonbiodegradable content • Difficult to seal fittings at the pump inlet resulting in entrainment of air • Pumps and spare parts currently not locally available

Manual diaphragm pump

MAPET

Performance	Purchase/ Operating Cost	Challenges
• Maximum flow rates of between 10 and 40 L/min depending on the viscosity of the sludge and the pumping head • Maximum pumping head of 3 m	• Capital Cost: INR 2,00,000 (1992) (depending on manufacturer and model) • Operating Cost: INR12,000/annum (Maintenance cost)	• Requires strong institutional support for MAPET service providers • A reliance on the importation of a key spare part • MAPET service providers unable to recover maintenance and transport costs from emptying Fees

MAPET

MOTORIZED EMPTYING

- Pit Screw Auger
- Vacuum Trucks
- Vacutug

Pit Screw Auger

Performance	Purchase/ Operating Cost	Challenges
• Can handle liquid sludge and a small amount of non-biodegradable waste • flow rates of over 50 L/min. pumping head of at least 3m (difficulty emptying from variable depths)	• Capital Cost: INR 45,000 – INR 50,000 • Operating Cost: Unknown	• The fixed length of the auger and riser pipe • Unsuitable for use with dry sludge and large quantities of non-biodegradable waste • Difficult to clean after use • Difficult to manoeuvre due to weight and size

Pit Screw Auger

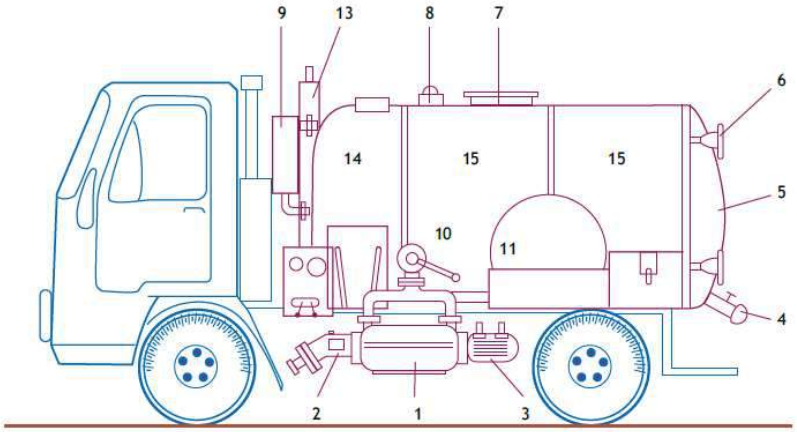
Vacuum Trucks

- Vehicle equipped with motorized pump and a storage tank often called as Vacuum Truck.
- Fast and efficient.
- Capacity 3 – 12 m^3
- Cost of 3 m^3 vacuum truck: 8 – 12 lakhs.

SELECTION OF VACUUM TRUCKS

- Typical volume of the tanks or vaults that will be serviced
- Road widths and weight constraints
- Distance to the treatment plant
- Availability
- Budget and
- Skill level of the operators.

COMPONENTS OF VACUUM TRUCKS



1 Liquid ring vacuum pomp
2 Hydraulic motor
3 Service liquid pomp
4 Suction and discharge valves
5 Swing-out rear door
6 Handwheel
7 Hatch
8 Pressure safety valve
9 Water separator for discharge air
10 Load/discharge control valve
11 Spare wheel
12 Tool locker
13 Hydraulic tank tipping cylinder
14 Service liquid (water tank)
15 Slurry tank

Source: IWA FSM Book

COMPONENTS OF VACUUM TRUCKS

Source: http://www.vacutrux.com

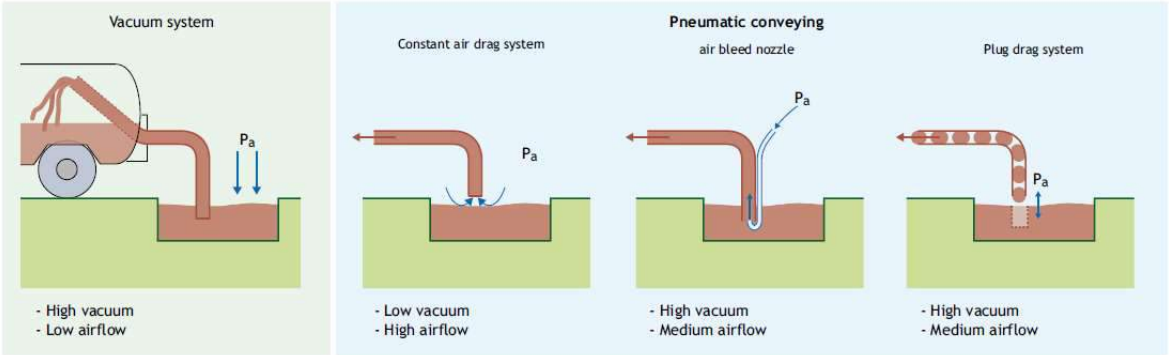
(A) Tank
(B) Skid w/ slope to rear
(C) Ladder step assembly
(D) Ramp
(E) Primary check valve
(F) Dome hatch
(G) Lifting lugs
(H) Sight glass
(I) Rear door
(J) Load port (with riser and deflector)
(K) Rear aluminium modules
(L) Mud flaps
(M) Wire reinforced vacuum pressure hose
(N) Oil Catch Muffler
(O) Secondary moisture trap, pressure relief valve.
(P) Vacuum pump

VACUUM PUMPS

Vacuum pumps

Low volume sliding vane pump	Liquid ring pump		
High vacuum, low air flow; suitable for low viscosity sludge	Air drag	Air bleed	Plug drag

VACUUM TYPES



ADVANTAGES AND DISADVANTAGES

Advantages	Disadvantages
• Fast, hygienic and effective sludge removal • Efficient transport possible with large vacuum trucks • Potential for local job creation and income generation • Provides an essential service to un-sewered areas	• Cannot pump thick, dried sludge • Garbage in pits may block hose • Very high capital costs; variable operating costs depending on use and maintenance • Hiring a vacuum truck may be unaffordable for poor households • Not all parts and materials may be locally available • Improper discharge of the collected sludge could generate public health and environmental problems

O&M OF VACUUM TRUCKS

- Spare parts – difficult to procure and expensive
- Mechanics – difficult to locate skilled person for pumps
- Older trucks – higher O&M expenses (2/3 of total expenditure)
- Lack of preventive maintenance – major breakdown!

O&M: DAILY CHECKS - BEFORE WORK

- Oil levels – vacuum pump, oil cooling tank, hydraulic tank, tanker engine
- Fuel levels – tanker and pump (if not connected to truck)
- Water levels – tanker engine, windscreen bottle, wash tank, water tank for vacuum pump
- Cooling radiator – hydraulic oil and pump oil
- Rear door – closed and secured
- All necessary equipment

O&M: WEEKLY CHECKS

- Truck - tyre pressures, lights, indicators, horns
- Vacuum pump - valves that prevent the tank from being overfilled
- Storage tank - contacts between gaskets and seats, and performance steel balls;
- Truck accessories - leaks in the hydraulic system (tighten couplings), and power take-off shafts (depending on type)

Vacutug

- Tank mounted on a cart which can be manually or pulled by smaller vehicles.
- Equipped with a vacuum pump with smaller capacity.
- Access to smaller lanes.
- Suitable for densely populated area and slums.

ACCESSIBILITY!

TYPES OF VACUTUG

Type	Capacity (Litres)	Relative Width	Travel Distance	Mounting & Propulsion	Cost (INR)
I & II	500	Very Narrow	Short-Haul	Mounted on self propelled chassis	6,50,250
III	1900	Average	Long-Haul	Mounted on trailer chassis and propelled by tractor or pick-up	13,00,500
IV	700	Narrow	Medium-Haul	Mounted on chassis of motorised tricycle	9,75,375
V	1000	Narrow	Medium Haul	Mounted on chassis of motorised tricycle	9,75,375

TYPES OF VACUTUG

33 TRANSFER STATION

Introduction, Types of Transfer Station

TRANSFER STATION

- Small scale equipment good for collection, however not suitable for transporting for long distances.
- Two stage process,
  - Primary stage: collection using small scale equipments and transferring it to transfer station
  - Secondary stage: emptying the transfer station using large vehicles

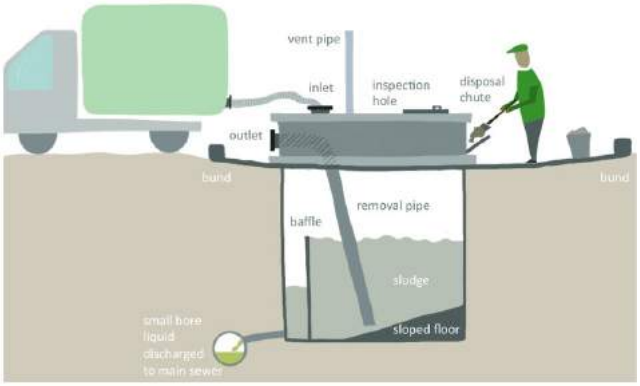
TYPES OF TRANSFER STATION

Transfer stations

- **Fixed transfer station**
  - Permanent storage types
  - Modular transfer stations
  - Multi functional permanent tank
  - Network connected station
- **Mobile transfer station**

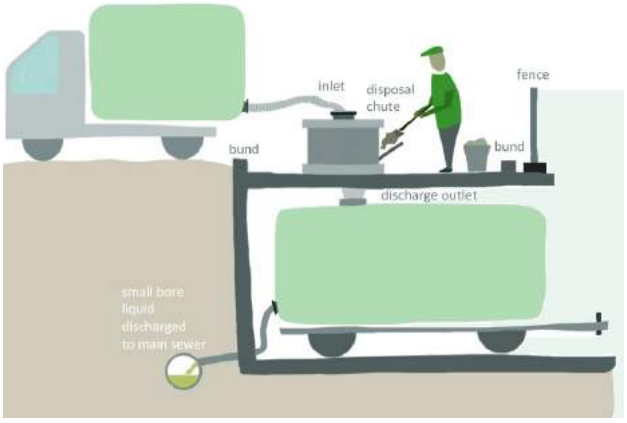
FIXED TRANSFER STATION -

PERMANENT STORAGE TYPE STATION



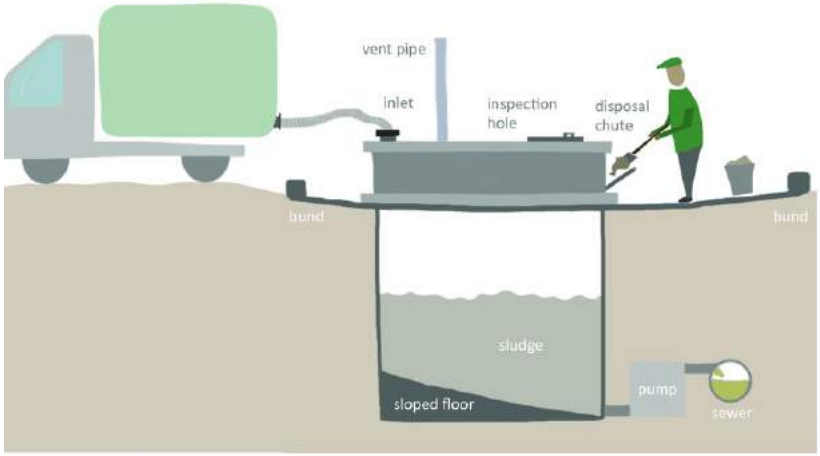
FIXED TRANSFER STATION -

MODULAR TRANSFER STATIONS (MOBILIZED)



FIXED TRANSFER STATION -

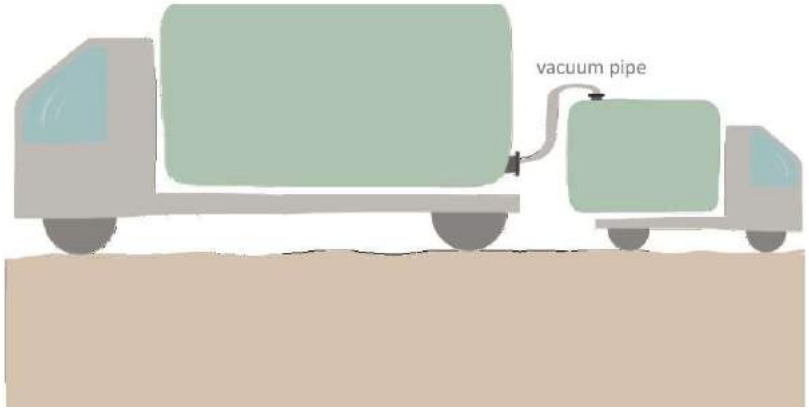
NETWORK CONNECTED STATION



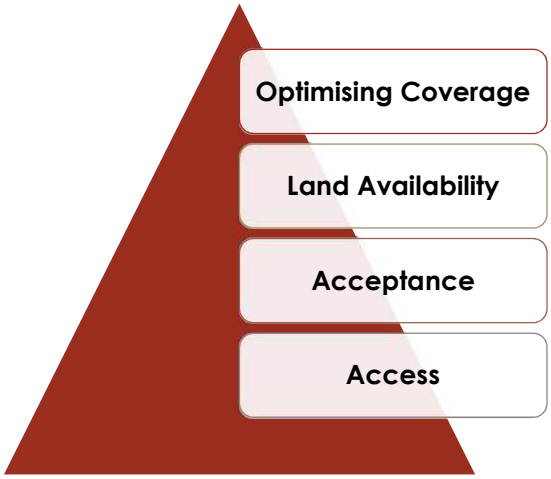
FIXED TRANSFER STATION -

MULTI FUNCTIONAL PERMANENT TANK

MOBILE TRANSFER STATION



SITING OF TRANSFER STATIONS - ASPECTS



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OCCUPATIONAL HEALTH AND SAFETY

Physical Hazards, Chemical Hazards, Biological Hazards, Mitigating Risks

PHYSICAL HAZARDS

- Low bearing capacity of the soil surrounding an unlined pit can lead to the collapse of its sidewalls during emptying
- Slips, trips and falls
- Exposure to sharp objects contained in the sludge
- Carrying heavy loads
- Traffic (during conveyance)

CHEMICAL HAZARDS

- **Direct and indirect oral, nasal and dermal exposure to chemicals**
  - hydrocarbons that are introduced as odour suppressants
- **Working in confined spaces in the presence of harmful gases or in an oxygen depleted environment**
  - methane
  - Ammonia
  - sulphur dioxide

BIOLOGICAL HAZARDS

- **Direct and indirect oral, nasal and dermal exposure to multiple types of pathogens in FS**
  - Bacteria
  - Viruses
  - Protozoa
  - helminthes

PREVENTIVE MEASURES

- Personal Protective Equipment (PPE) - to avoid direct and indirect exposure (e.g. gloves, coveralls, rubber boots with a metal sole, safety glasses and safety masks)
- Develop and provide training on use of tools customised for local conditions and local containment systems in order to avoid direct contact
- Provide a training programme on standard operating procedures (SOPs) - proper use of PPE, tools and equipment

Thank you...

National Institute of Urban Affairs

SANITATION CAPACITY BUILDING PROGRAM

Faecal Sludge Treatment I

Mr. Dhawal Patil,
M.Sc. Hydro Science and Engineering
General Manager - Operations

ecosan SERVICES FOUNDATION

CONTENTS

FS treatment Mechanisms

- Physical mechanisms
- Biological mechanisms
- Chemical mechanisms

Design of FS treatment plant

- Selection of context appropriate combination of faecal sludge treatment technologies

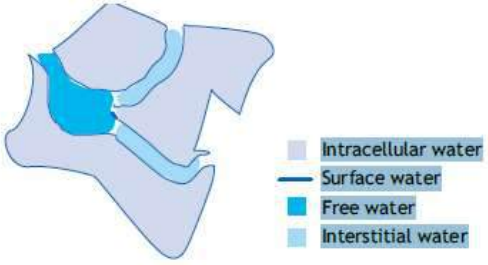
3

FS TREATMENT MECHANISMS

Physical mechanisms, Biological mechanisms and Chemical mechanisms

1. PHYSICAL MECHANISMS

- Dewatering- the most important treatment objective.
- Water is heavy and expensive to transport!
- Water in FS is available in "bulk" or "bound" forms.



Source: Faecal Sludge Management, IWA

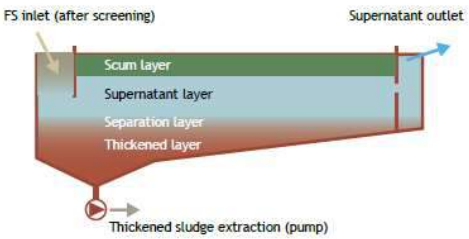
1.1 SCREENING

- Physical exclusion of solid waste (not solids!) from the FS.
- The flow of the FS should be between 0.3 m/s and 1.0 m/s.

Source: Faecal Sludge Management, IWA

1.2 GRAVITY SEPARATION

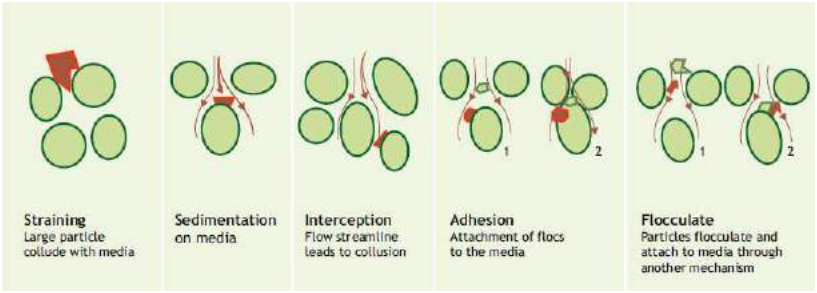
- **Most commonly employed method.**
- **Based on size of the particles, suspended solids concentration and flocculation.**
- **Settling mechanisms**
  - Discrete particle
  - Flocculent
  - Hindered
  - Compression



Source: Faecal Sludge Management, IWA

1.3 FILTRATION

- Filtration media- Membrane, granular
- Types- slow, rapid, pressurized
- For FS- planted and unplanted drying beds!



Source: Faecal Sludge Management, IWA

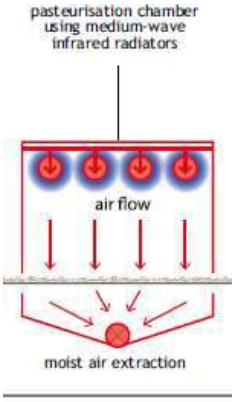
1.4 EVAPORATION & EVAPOTRANSPIRATION

- Evaporation- Release of water into the air as vapour.
- Evapotranspiration- Evaporation + release of water vapour into air by plants.
- Dependent on climate, heat and moisture content, wind speed.

Source: Faecal Sludge Management, IWA

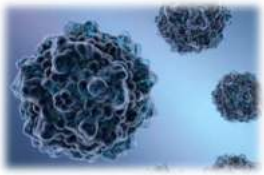
1.5 HEAT DRYING

- Used to evaporate and dewater sludge beyond what can be achieved by passive methods.
- Achieves reduction in volume as well as weight.
- Involves either conduction, convection, radiation or combination of these processes.



Source: Faecal Sludge Management, IWA

2. BIOLOGICAL MECHANISMS



- Transformation of organic matter and nutrients.
- Harness the metabolism and growth rate of microorganisms- in controlled situations to optimise desired outcomes.
- Stabilisation- degradation of putrefiable, readily degradable material, leaving behind more stable, less degradable organics.

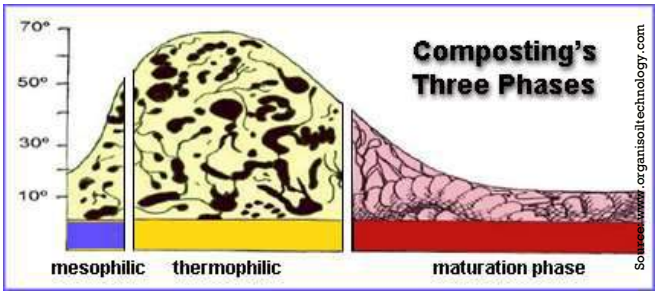
2.1 AEROBIC TREATMENT

- Aerobic environment refers to the presence of oxygen.
- Aerobic organisms reply on oxygen for their respiration.
- Aerobic treatment processes in wastewater treatment are activated sludge, sequencing batch reactors, trickling filters etc.
- Solubility of oxygen in FS is low, hence aeration can be energy intensive.

2.2 COMPOSTING

Composting process is controlled using;

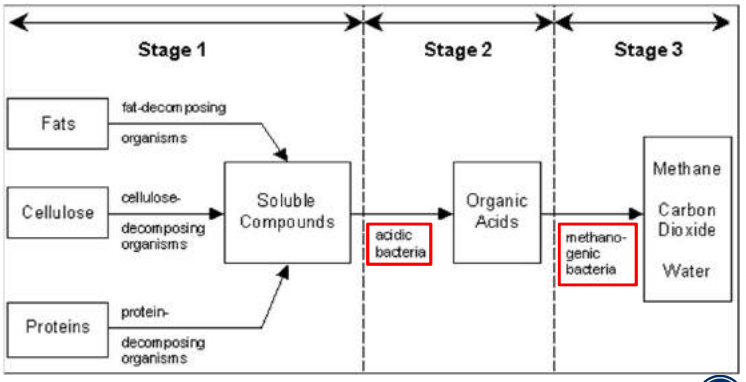
- C:N = 20-30
- Moisture content: 40-60%
- Oxygen content: free pore space of 20% by volume.



2.3 ANAEROBIC TREATMENT

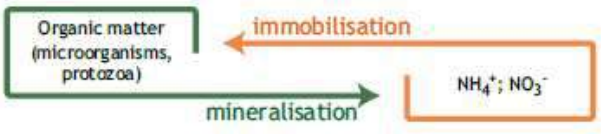
- Used for stabilising of FS, produces biogas!
- Complex chemistry consisting of three stages

1. Hydrolysis
2. Acidogenesis
3. Acetogenesis
4. Methanogenesis



Source: www.floatingcovers.wordpress.com

NITROGEN CYCLING



- Nitrification: Ammonia – Nitrite – Nitrate (aerobic environment)
- Denitrification: Biological removal of nitrogen (anoxic environment)
- Phosphorus cycling: orthophosphoric acid, phosphates, organically bound phosphorus.

2.4 PATHOGEN REDUCTION

- Temperature: pathogens are inactive above 60°C
- Sorption: 50% helminth eggs separate during settling, up to 90% are retained in the sludge in drying beds.
- Desiccation: dehydration reduces the activity of pathogens.
- UV: Solar/ UV radiation (300-400 nm) inactivates the pathogens.
- pH: Microorganisms survive and grow within range of 2-3 pH units

3. CHEMICAL MECHANISM

- To improve the performance of other physical mechanisms,
- To inactivate pathogens in FS,
- To stabilise the FS.

Addition of chemical increases the cost of treatment, hence "cost-benefit analysis" needs to be done!

3.1 ALKALINE STABILISATION

- **Used for stabilisation of FS.**
- **Addition of lime;**
  - Raises the pH to 12, ceases microbial activity.
  - Results in odour and pathogen reduction.
- **Addition of quick lime;**
  - Raises the temperature up to 60 ^{0}C.
  - Inactivates Helminth eggs too!
  - pH lowers down, hence excess Lime addition is needed.

3.2 COAGULATION AND FLOCCULATION

- Removal of colloidal particles through gravity settling.
- Polymers can be natural or synthetic based chemicals.

Ferric Chloride

Alum

Lime

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DESIGN OF FS TREATMENT PLANT

Selecting a context appropriate combination of faecal sludge treatment technologies

TREATMENT CHAIN FOR IFSM

Soli liquid separation	Stabilization	Dewatering / Drying	Pathogen reduction	Potential end products
Physical treatment Easily settleable solids are separated. • Settling tanks • Thickening ponds • Imhoff tanks	**Biological treatment** Organic solids are digested and the sludge is stabilized. • Digester • Anaerobic baffled reactor	**Physical treatment** Reduction of moisture content in the sludge. • (Un) Planted drying beds • Mechanical drying • Vermi-compost	**Physical treatment** Disinfecting the sludge for its safe reuse or disposal • Storage and further drying • Co combustion	•Dry sludge •Humified sludge •Biomass •Biogas •Compost •Energy •Building material

SELECTING CONTEXT-APPROPRIATE TECHNICAL OPTIONS

Treatment performance	Local context	O&M requirements	Costs
• Effluent and sludge quality according to national standards	• Characteristics of sludge (dewaterability, concentration, degree of digestion, spreadability) • Quantity and frequency of sludge discharged at the FSTP • Climate • Land availability and cost • Interest in enduse (fertiliser, forage, biogas, compost, fuel)	• Skills needed for operation, maintenance and monitoring available locally • Spare parts available locally	• Investment costs covered (land, infrastructure, human resources, capacity building) • O&M costs covered • Affordability for households

Faecal Sludge Management Book IWA

Thank you...

National Institute of Urban Affairs

SANITATION CAPACITY BUILDING PROGRAM

Faecal Sludge Treatment II

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ecosan SERVICES FOUNDATION

CONTENTS

- Co treatment in STP
- Deep row entrenchment
- Anaerobic Digestion
- Unplanted drying beds
- Planted drying beds
- Geotubes
- Mechanical dewatering
  - Centrifuge
  - Screw press
  - Belt press
  - Frame filter press
- Co composting
- Sludge incineration
- Thermal drying and pelletising

CO TREATMENT IN STP

- **Limiting factor: Organic & hydraulic loading**
- **Application**
  - At the Manhole Chamber before the inlet of STP
  - At the inlet of Screens of the STP
  - At the Sludge Management Process of the STP

Source: ESF/Dhawal Patil

Source: ESF/Dhawal Patil

Source: Faecal Sludge Management, IWA

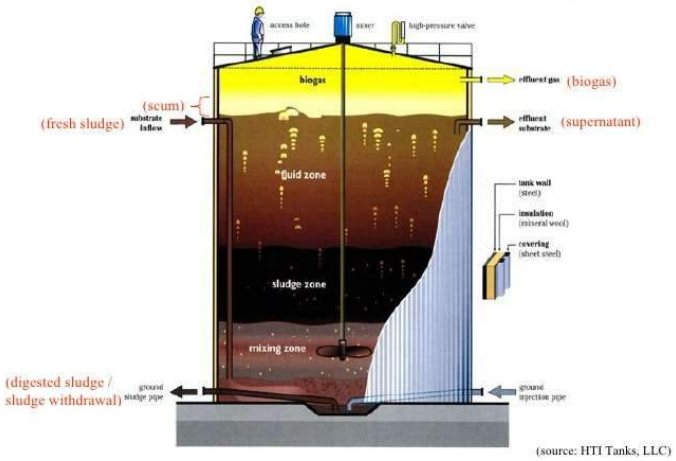
DEEP ROW ENTRENCHMENT

- Deep trenches, filled with sludge and covered with soil.
- Advantages: Simple, low cost, limited O&M, no visible or olfactory nuisance.
- Limiting factor: Land and groundwater table, legislation.

Source: Faecal Sludge Management, IWA

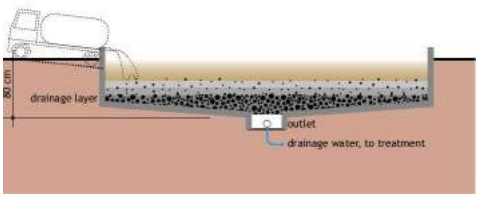
ANAEROBIC DIGESTION

- Organic matter- Biogas (methane and CO_2) and digestate.
- Advantages: Production of biogas, reduction of sludge volume and odours.
- Limiting factor: High level of skilled operation and monitoring.

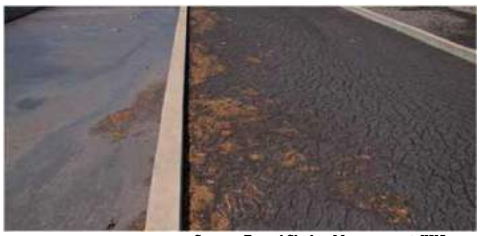


(source: HTI Tanks, LLC)

UNPLANTED DRYING BEDS



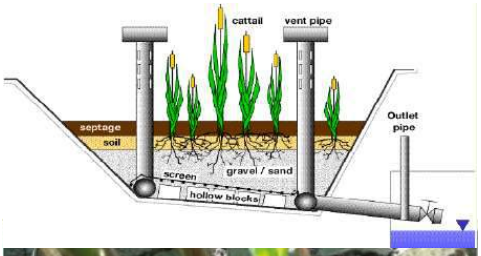
Source: Tilley et al. 2014


Source: Faecal Sludge Management, IWA

- Shallow filters with sand and gravels with under drain to collect filtrate.
- Application: Climatic factor and types of sludge
- Advantages: Low cost and ease of operation.
- Limitation: Large footprint and odour potential

PLANTED DRYING BEDS

- Unplanted drying bed with emergent macrophyte.
- Application: Climatic factor
- Advantages: Low cost and ease of operation.
- Limitation: Large footprint and odour potential



Source: AIT, Thailand

Source: Faecal Sludge Management, IWA

GEOTUBES

- Non woven geotextile is used to create long tubes.
- Application: fully digested sludge, increasing efficiency of SDB.
- Advantages: Low cost and ease of operation.
- Limitation: One time use

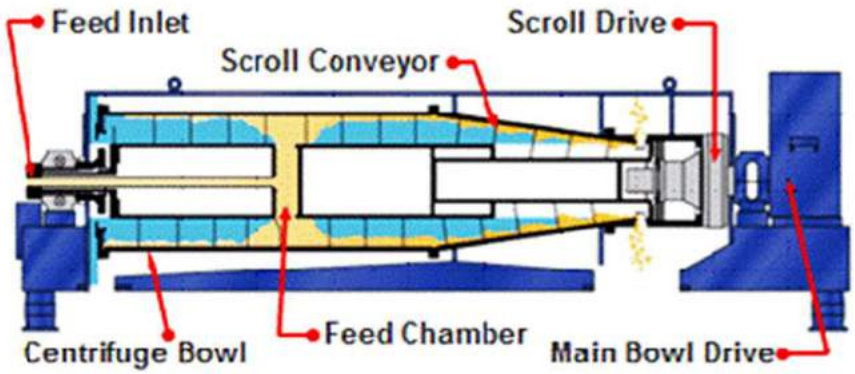
Source: ESF/Dhawal Patil

Source: cementingproductsinc.com

MECHANICAL SLUDGE TREATMENT

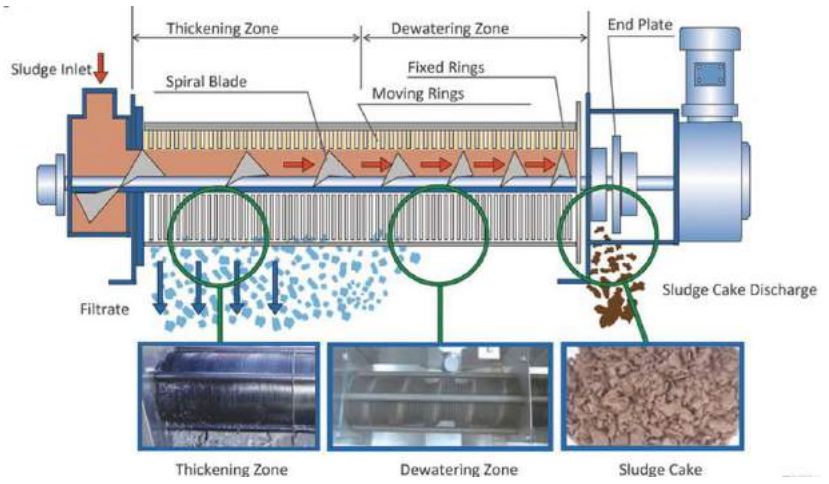
- Belt filter, Centrifuge, Frame filter press and the Screw press.
- Mostly used for sludge generated in STP, transferable to FS and septage.
- Malaysia: centrifugation to dewater FS after screening and addition of flocculants.
- Advantages: Compactness, speed of the process.
- Limiting factors: investment costs, O&M costs, dependency on electricity.

CENTRIFUGE



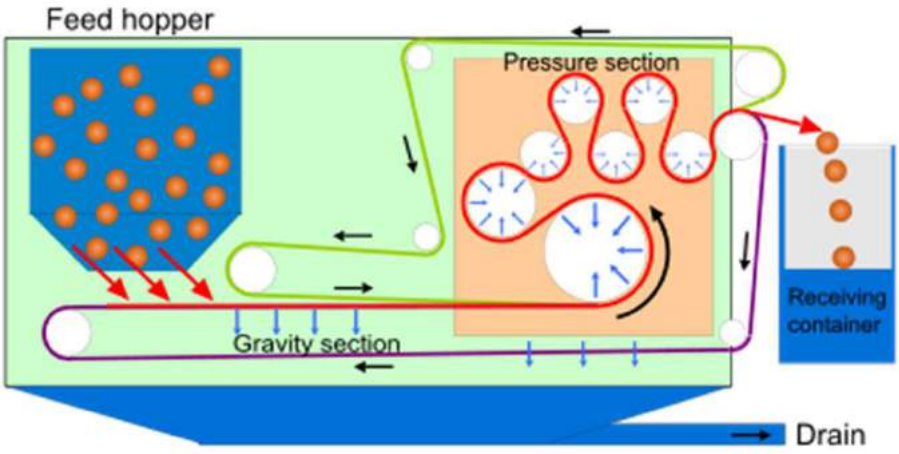
Source: www.hiler-us.com

SCREW PRESS



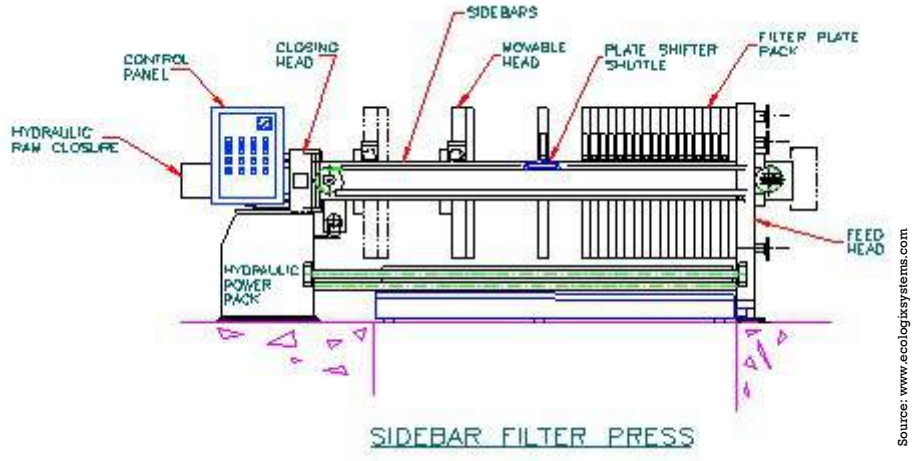
Source: www.ecologixsystems.com

BELT FILTER



Source: wikiwayan, Wikimedia.com

FRAME FILTER PRESS

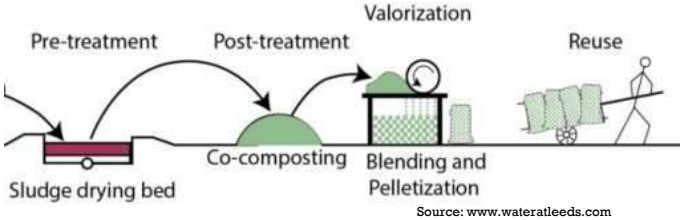


Source: www.ecologixsystems.com

CO COMPOSTING

- C:N Ratio = 20-30:1, Oxygen concentration: 40-60%, Particle diameter < 5 cm
- Advantages: Thermophilic condition- Pathogen inactivation
- Limiting factors: Technical and managerial skills

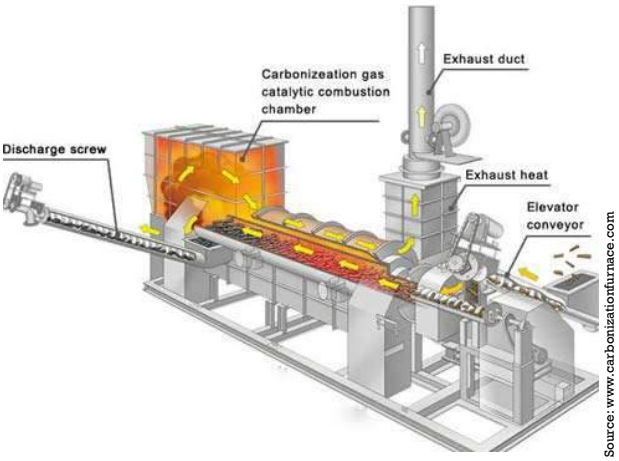
Source: www.iwmi.cgiar.com



Source: www.wateratleeds.com

SLUDGE INCINERATION

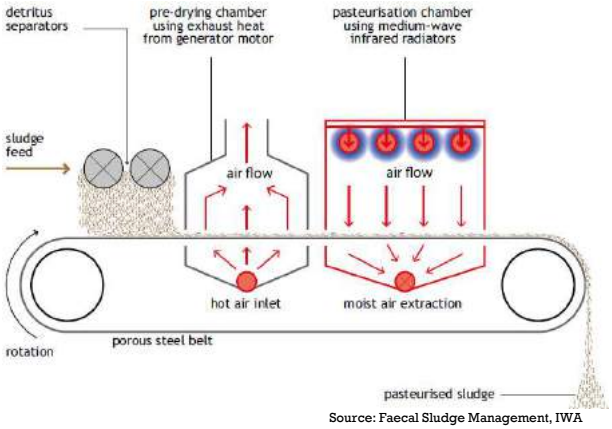
- Burning of sludge at temperature 850-900°C.
- Advantages: Volume and pathogen reduction.
- Limiting factors: emission of pollutants, high skilled operator and maintenance staff, high capital and O& cost.



Source: www.carbonizationfurnace.com

THERMAL DRYING AND PELLETISING

- Direct (hot air or gas) or indirect thermal driers (hot water or oil).
- Advantages: Reduction in volume and pathogen content.
- Limiting factors: high energy requirements, risk of fire and explosion, high maintenance.



Source: Faecal Sludge Management, IWA

Thank you...

National Institute of Urban Affairs

SANITATION CAPACITY BUILDING PROGRAM

Stakeholder Analysis & Engagement

Mr. Saurabh Kale
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ecosan SERVICES FOUNDATION

CONTENTS

- Characterize the key stakeholders, and their main interests and constraints.
- How to determine the degree to which stakeholders should be engaged with the participation levels.
- How to engage them with an introduction to different involvement tools

STAKEHOLDER

The stakeholders in a group, organization, or individual that can influence or be influenced by the faecal sludge management scheme.

WHY STAKEHOLDER ANALYSIS?

- Identify and characterize stakeholders
- Understand social and institutional context
- Plan for their participation
- Meet people and build trust

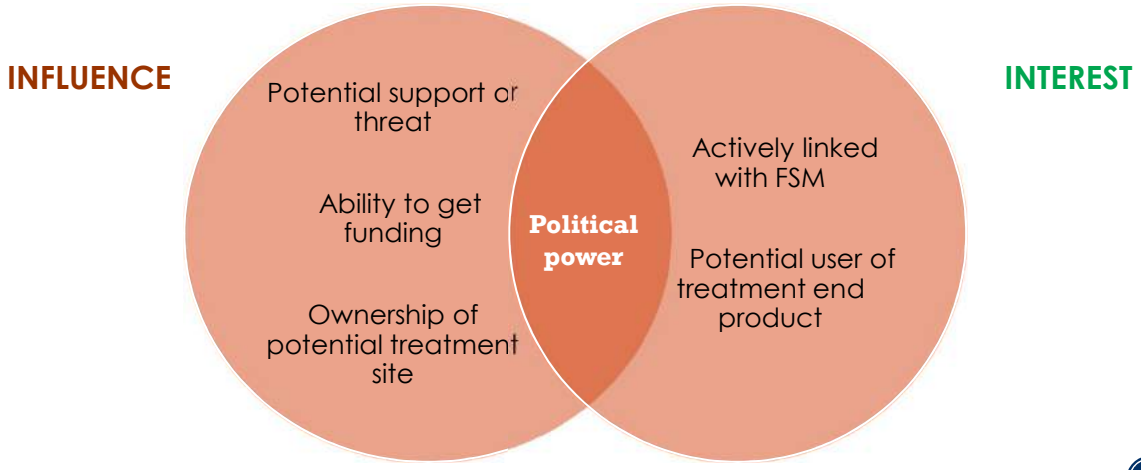
IDENTIFICATION STAKEHOLDERS

- Mechanical & Manual Emptiers
- Households (customers)
- Farmers/Industries (Potential End users)
- Institutions(Utility)
- Municipal Authorities
- Regional & National Authorities
- Traditional Authorities and Influential leaders
- NGO's, CBO's and Academic institutions
- Donor Organizations

TYPICAL ISSUES

- Lack of influence and recognition
- Constraints in collection and transport business
- Lack of resource and capacities
- Tensions between stakeholders, Power games
- Lack of awareness

STAKEHOLDER CHARACTERISATION



STAKEHOLDER CHARACTERISATION

INFLUENCE

INTEREST

	Low	High
Low		Ministry
High	Company	Municipal Authorities

ENGAGING STAKEHOLDERS

- Information
- Consultation
- Collaboration
- Empowerment and Delegation

Increasing Engagement

ENGAGING STAKEHOLDERS

INFLUENCE

INTEREST

	Low	High
Low	Information	Information Consultation
High	Consultation Empowerment	Consultation Collaboration Delegation

INVOLVEMENT TOOLS

- Personal Meetings
- Household surveys
- Focus groups
- Workshops
- Site Visits
- Participatory mapping
- Media campaigns
- Advocacy/lobbying
- Mediation

Thank you...

National Institute of Urban Affairs

SANITATION CAPACITY BUILDING PROGRAM

Financing of FSSM

Mr. Dhawal Patil,
M.Sc. Hydro Science and Engineering
General Manager - Operations

ecosan SERVICES FOUNDATION

CONTENTS

Financial aspects

- Capital expenditure
- Operational expenditure
- Income and revenue
- Annualized cost

Financial flow models

- Discrete model
- Integrated model
- Sanitation tax model
- License model
- Incentivised model

3 FINANCIAL ASPECTS

Capital expenditure, Operational expenditure, Income and revenue and Annualised cost

CAPITAL EXPENDITURE

- Cost of land & site preparation
- Civil structures (life span of 30 years)
- Plumbing and electrical component (life span of 15 years)
- Electromechanical components (life span of 10 years)
- Planning and supervision cost
- Cost for site investigation and sampling
- Transport and overheads

OPERATIONAL EXPENDITURE

- **Direct costs**
  - Expenditure to be borne in treating the faecal sludge and septage received at the treatment plant.
  - Cost of material for operation
  - Cost of power for operation
  - Cost of chemicals (if required any)
- **Indirect costs**
  - Expenditure to be borne even if faecal sludge and septage is not received at the treatment plant.
  - Human resource cost

INCOME AND REVENUE

- **Discharge fee**
  - Fee collected from the collection and transport company to discharge faecal sludge and septage at the treatment plant.
- **Budget support**
  - Financial support provided by the government authority (ULB) to the company operating and maintaining the treatment plant.
- **Purchase price**
  - Revenue generated from the sell of end products such as soil conditioner, solid / liquid fuel, building material etc.

ANNUALIZED COST

$$Annual\ CapEx = CapEx \times \frac{(1+r)^N \times r}{(1+r)^N - 1}$$

$$Annualized\ Cost = Annual\ CapEx + OpEx - R$$

Where;

CapEx: Capital expenditure

r: Rate of interest (bank rate – inflation rate)

N: life span of the component

Where;

OpEx: Operational expenditure

R: Revenue

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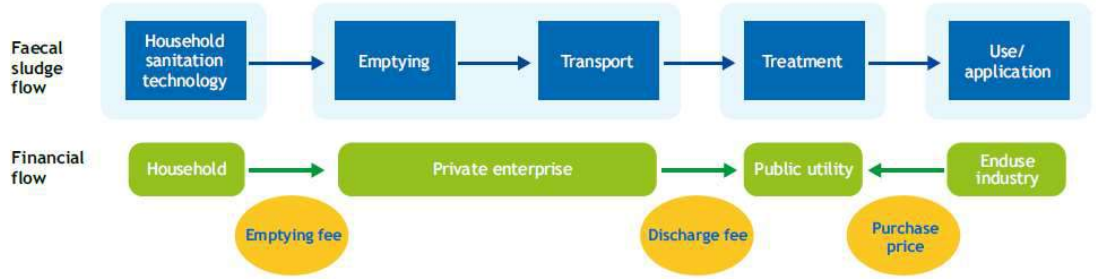
FINANCIAL FLOW MODELS

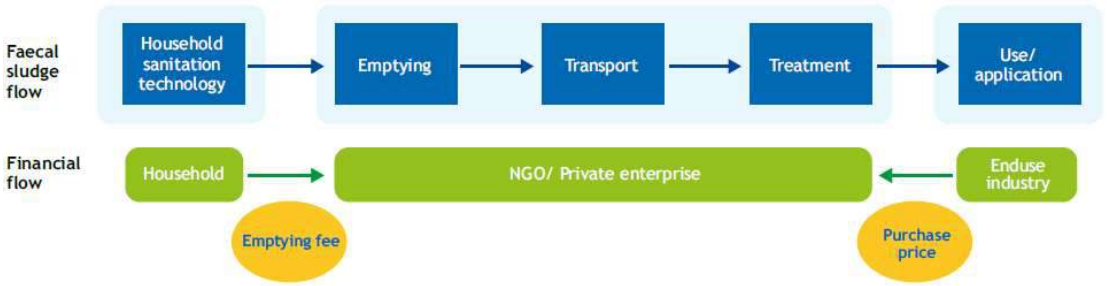
1. Discrete model
2. Integrated model
3. Sanitation tax model
4. License model
5. Incentivised model

DISCRETE COLLECTION AND TREATMENT MODEL



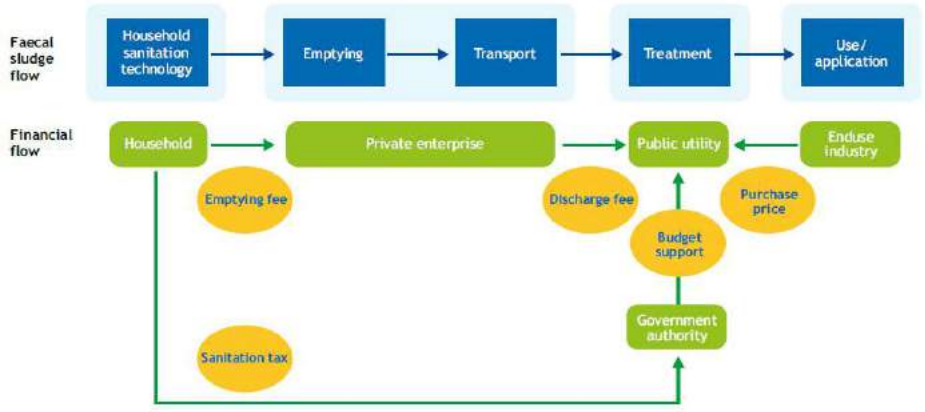
Faecal sludge management book, IWA

INTEGRATED COLLECTION, TRANSPORT & TREATMENT MODEL



Faecal sludge management book, IWA

PARALLEL TAX AND DISCHARGE FEE MODEL



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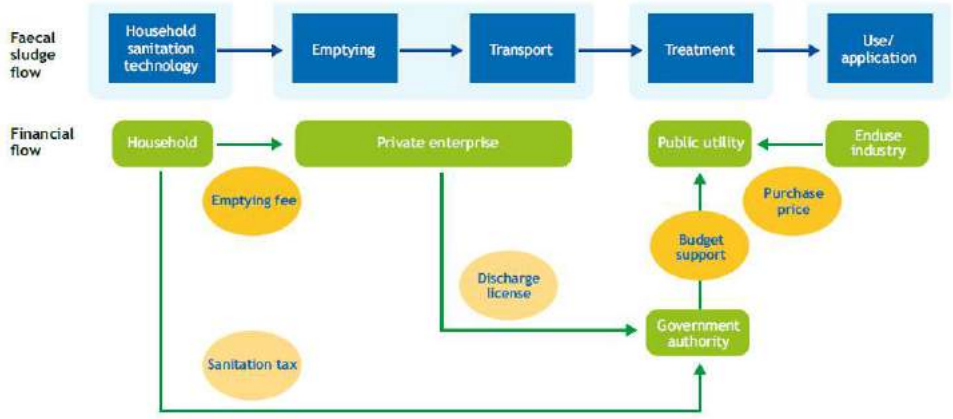
DUAL LICENSING AND SANITATION TAX MODEL



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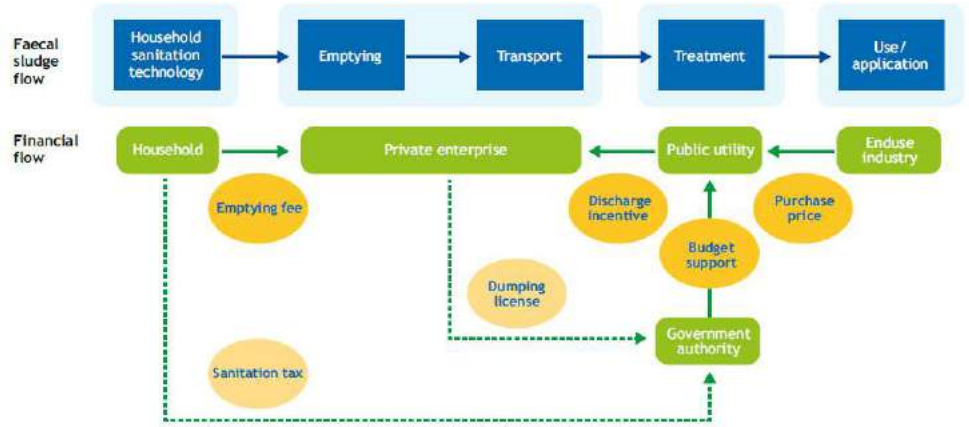
INCENTIVISED DISCHARGE MODEL



Faecal sludge management book, IWA

Thank you...

National Institute of Urban Affairs

SANITATION CAPACITY BUILDING PROGRAM

Backward Course Design

Mr. Dhawal Patil,
M.Sc. Hydro Science and Engineering
General Manager - Operations

ecosan SERVICES FOUNDATION

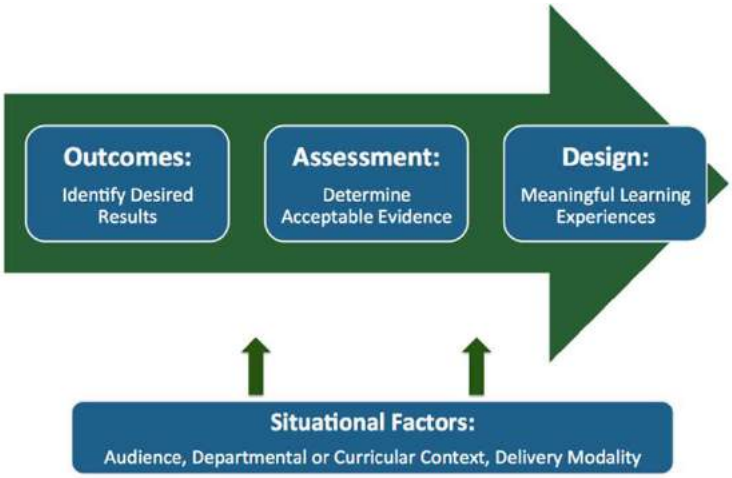
CONTENTS

- What is backward course design?
- Steps required to design a course
- Create meaningful assessment types
- Formulate Learning Goals based on Bloom's Taxonomy
- Choose adequate teaching formats
- Formulate a Learning Goal for yourself

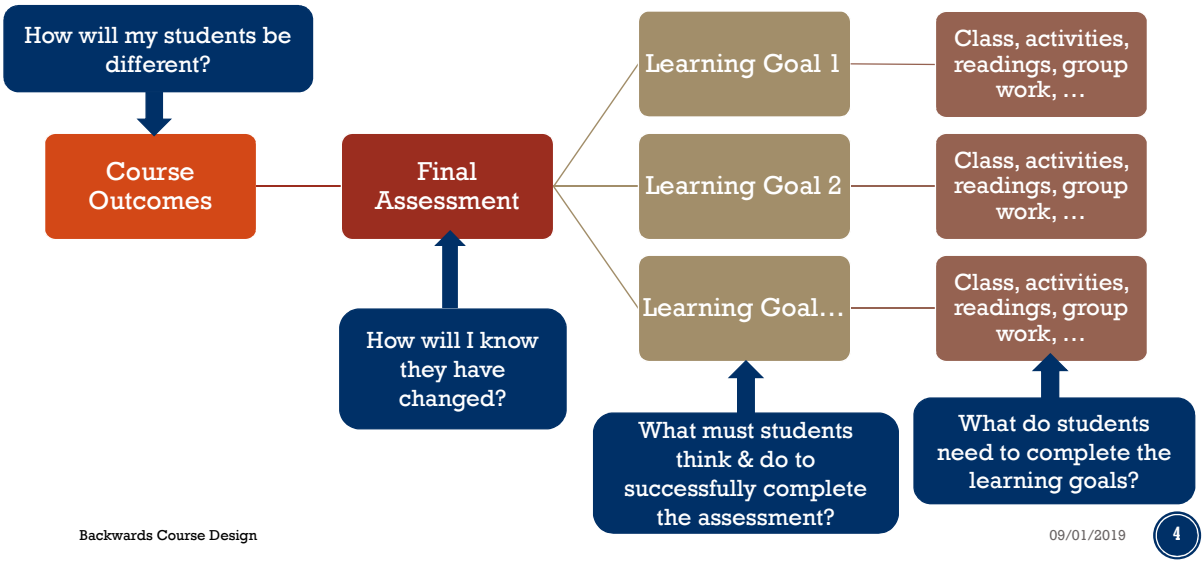
WHAT IS BACKWARD DESIGN?

- Invented by Wiggins and McTighe
- Instructional Design method

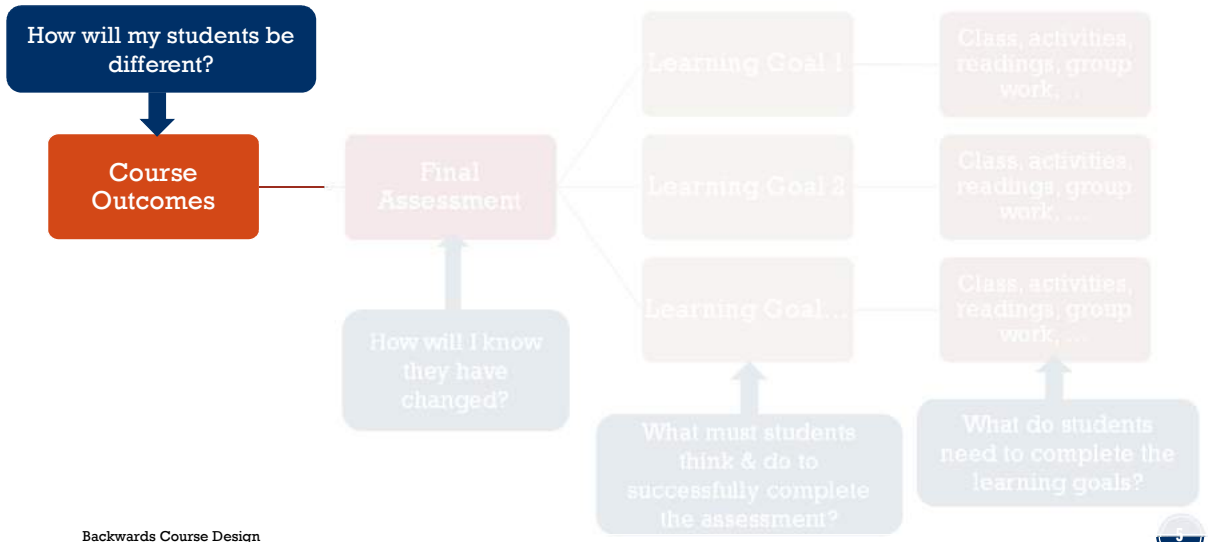
"Start with the end"



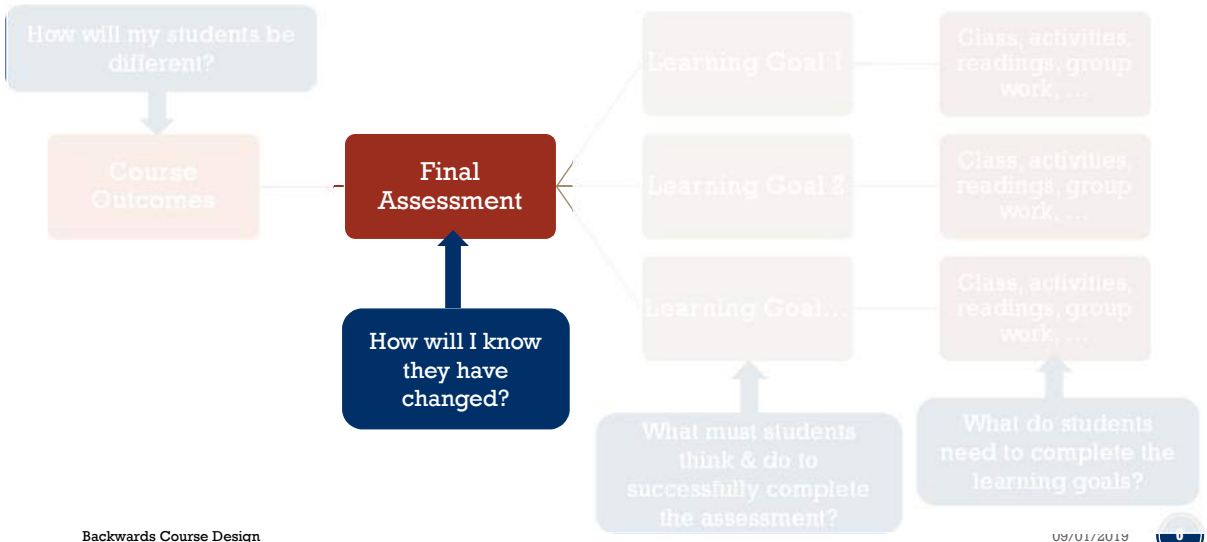
BACKWARDS DESIGN IN COURSE DEVELOPMENT



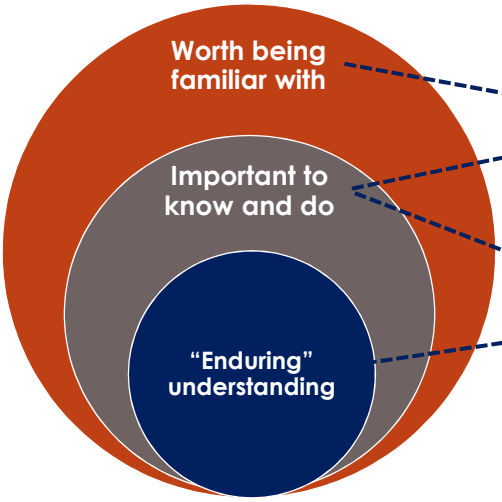
STEP 1: FORMULATE DESIRED COURSE OUTCOMES



STEP 2: DETERMINE FINAL ASSESSMENT



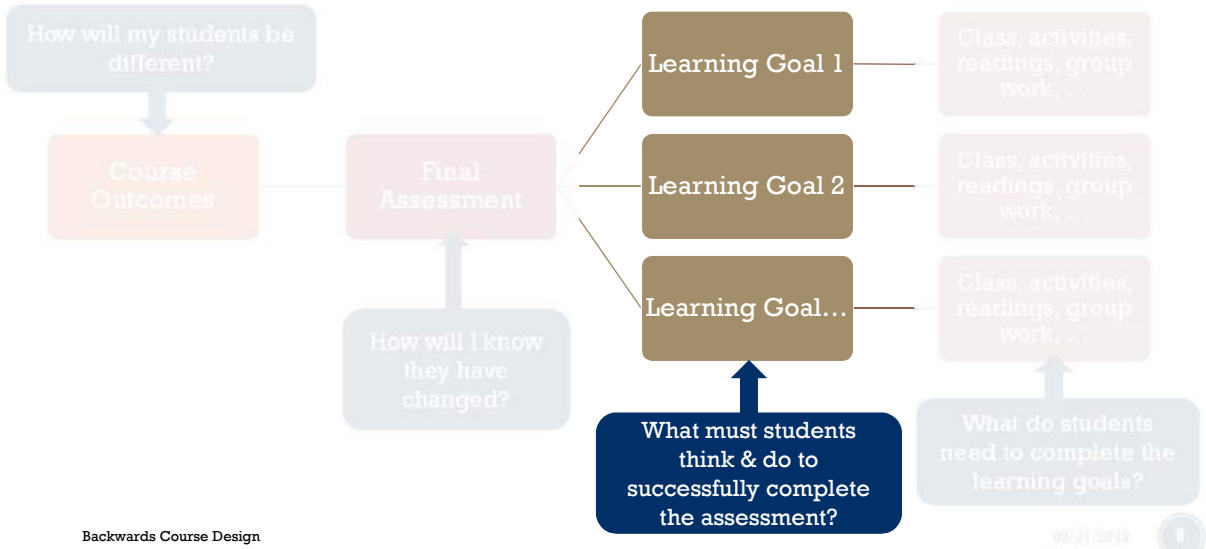
ASSESSMENT TYPES



Assessment Types
Traditional Quizzes and Tests
→ selected-/constructed-response
Performance Tasks and Projects
→ open-ended → authentic → complex

Adapted from Wiggins & McTighe

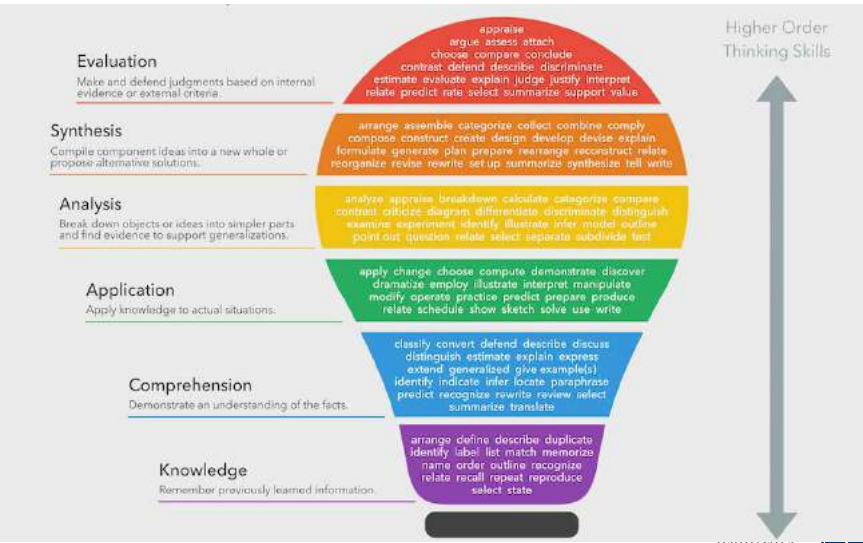
STEP 3: FORMULATE LEARNING GOALS



STEP 3: FORMULATE LEARNING GOALS

Bloom's Taxonomy (revised 2001):

1. **Remember**
2. **Understand**
3. **Apply**
4. **Analyse**
5. **Evaluate**
6. **Create**



STEP 3: FORMULATE LEARNING GOALS

LEARNING OBJECTIVES

FS treatment Mechanisms

- Physical mechanisms
- Biological mechanisms
- Chemical mechanisms

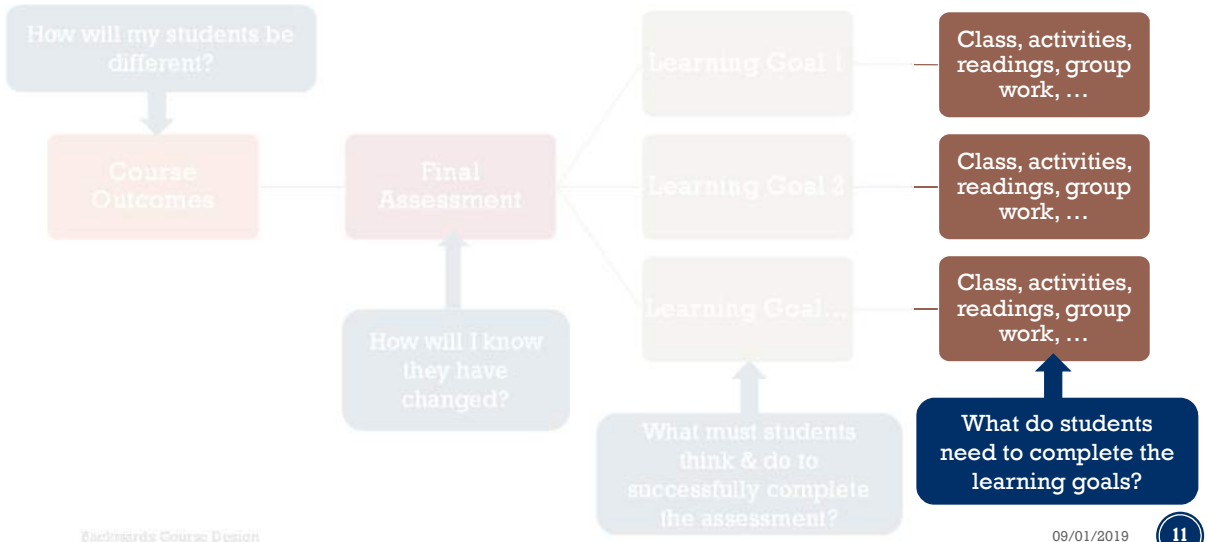
Design of FS treatment plant

- Selection of context appropriate combination of faecal sludge treatment technologies

SCBP:Faecal Sludge Treatment I

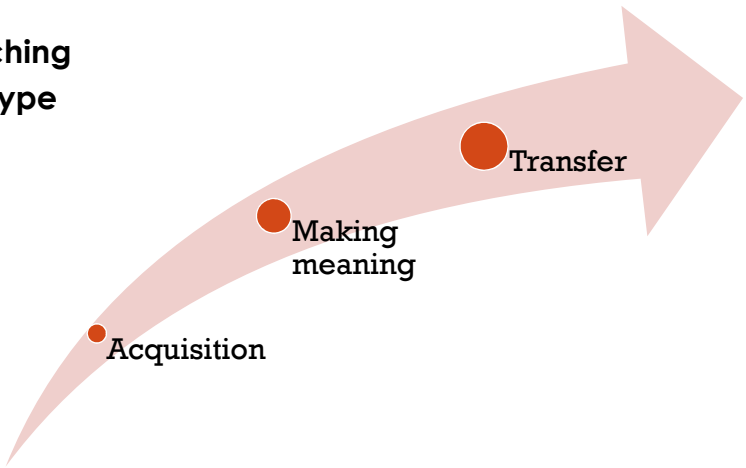
Tuesday, 12 March 2019

STEP 4: DEVELOP TEACHING FORMATS



STEP 4: DEVELOP TEACHING FORMATS

- What kind of teaching formats for what type of learning goal?
- 3 main levels of learning:



WHAT CAN WE DO TO INFLUENCE WHERE AND HOW STUDENTS LEARN?

Clicker questions

Lecture on topic

One-minute paper

Problem solving session

Reading

Testing

ACTIVITY: WRITE YOUR OWN LEARNING GOAL

1. 2 minutes: Write down one thing you want to learn during this workshop. Formulate it as a Learning Goal using the Bloom's Taxonomy Schematic. Begin the sentence with a verb that corresponds to the level of learning you are aiming for.
2. Underneath your Learning Goal, note down the "level" of learning according to Bloom's Taxonomy ("remember" – "create").

Thank you...

National Institute of Urban Affairs

SANITATION CAPACITY BUILDING PROGRAM

Communication and Teaching Styles

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General Manager - Operations

ecosan SERVICES FOUNDATION

CONTENTS

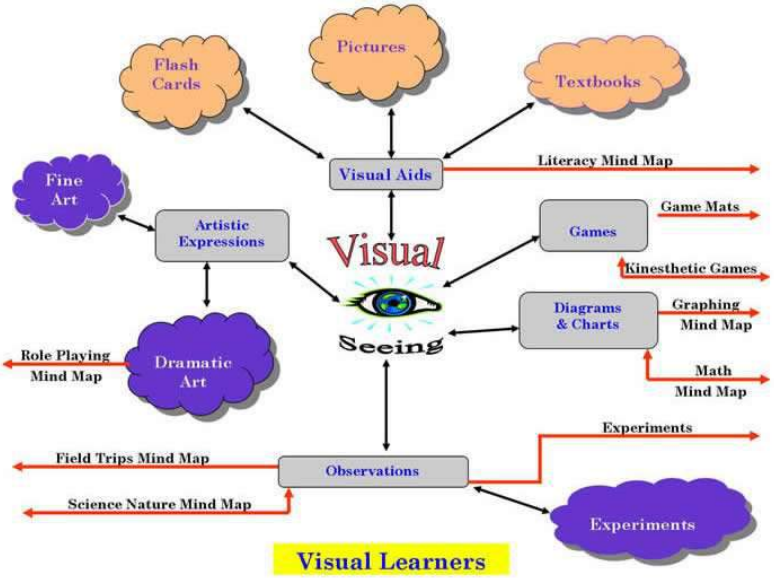
- How do we learn?
- Some learning styles
- Engaging with the audience
- Do's and Dont's
- Discussion, Q&A

PATHWAYS TO ADULT LEARNING

- **V**isual - see it
- **A**ural - hear it, say it
- **R**ead/write it
- **K**inaesthetic - do it

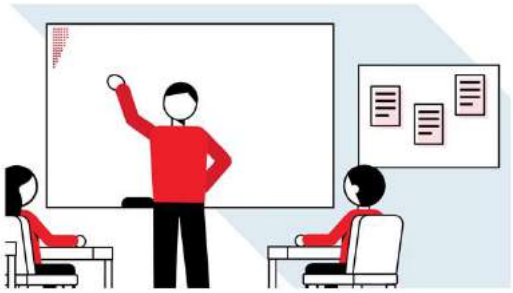
"VARK"

VISUAL LEARNERS PREFER...



AURAL LEARNERS LIKE...

- Discussing topics with others
- Listening to others discussing topics
- Explaining new ideas to others
- Interesting examples, stories, jokes...
- Describing the PPTs, pictures and other visuals



READERS PREFER...

- Lists, headings
- Glossaries, definitions
- Handouts
- Textbooks, references
- Notes of discussions
- Teachers who use words well and have lots of information
- Rewriting ideas and principles into other words
- Organize any diagrams, graphs ... into statements

KINAESTHETIC LEARNERS LIKE..

- Using their senses – e.g. sight, touch, singing, hearing ...
- Field trips and tours
- Examples of principles, real-life examples
- Experiential activities, like simulations, games, role plays
- Trial and error
- Collections of samples, photographs...
- Solutions to problems, methods to follow

WHAT ABOUT YOU?

How do you successfully learn?

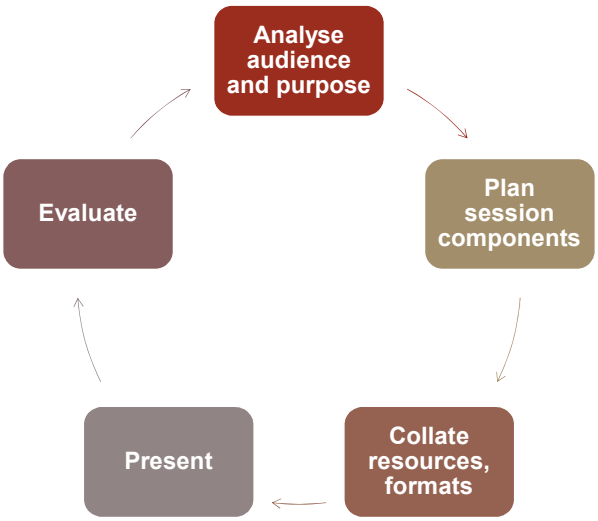
VARK TEACHING

Understanding your own learning preferences

Understanding how others learn

Workshop design & presentation

TEACHING PROCESS



TEACHING STEPS

Linking
- Link to participant's prior knowledge
- Find out what they know
- Remind them of earlier sessions

Inputting
- Teach new material
- Use different techniques

Processing
- Increase understanding of information
- Do activity, discussion or case study to help comprehension

Applying
- Show how the information is used in practice (Processing and Application may be compressed in some situations)

INFORMATION OVERKILL

RULES & AGREEMENTS

Meeting agreements
Be willing to:
✓ Listen
✓ State views and ask questions
✓ Share relevant information
✓ Be present

Rules of the session
Phones: off or on flight mode


Lunch & Tea breaks


Take aways


BODY LANGUAGE: POSTURE

- Default position: facing audience, both legs shoulder-wide apart
- Arms above waistline
- Energy: in arms and hands, not pacing
- "1 hand for confidence, 2 hands for arrogance"

ENGAGING WITH THE AUDIENCE: FACE & VOICE

- Fine-tune facial expression & gesture
- Friendly, smile (but don't overdo it)
- Eye contact – 3 to 4 sec. per person
- Use voice & tonality – oratory skills. speak loud enough
- Don't speak to your slides & visuals
- Don't read your slides word for word

PROACTIVE TEACHING (I) ICE BREAKERS

Single word
What's the one word you'd use to describe yourself? Everyone picks one and then they're referred to by that name throughout the meeting. It's more than a silly way to start the meeting; it helps everyone get to know one another a bit better!

One-word only
This works well in every meeting, training, and team building sessions. In a team building session on the topic of conflict resolution, participants were asked to start out the session by saying what they think of when they think of conflict. In a second example, in a session on sanitation, the participants are asked to describe local FSM practices in one word.

In pairs
You have 5 minutes discussion with someone sitting next to you to find 10 things in common.

PROACTIVE TEACHING (II) ICE BREAKERS

Sweets
Everyone loves sweets. Why not get a bag of chocolates and pass them out. Whatever color the person gets means that they have to answer a specific question about themselves. You can have some fun figuring out what the questions are…

Team drawing
You divide a piece of paper in three, and then three people must draw the head, torso and legs, respectively, without seeing what the person before them drew. Inevitably, the final drawing is a hoot. So, break the group up into threes and have them get drawing as you set up the meeting.

Check in
Participants shortly present themselves, where they are from and add a sentence about how they feel or what they expect.

PROACTIVE TEACHING (III) ENERGIZERS

Human knot **Time:** 15 minutes **Participants:** 8 - 20 people **Rules:** Have everyone stand in a circle facing each other, shoulder to shoulder. Instruct everyone to put their right hand out and grab a random hand of someone across from them. Then, tell them to put their left hand out and grab another random hand from a different person across the circle. Within a set time limit, the group needs to untangle the knot of arms without releasing their hands. If the group is too large, make multiple smaller circles and have the separate groups compete.	**Dragons & princesses** **Time:** 15 minutes **Participants:** 8 - 20 people **Rules:** Choose 1 dragon, the rest are princesses. The dragon must jump around the room and touch the princesses with both hands – she too becomes a dragon. Everytime a dragon catches someone, he must give a loud howl. At the end of the energizer, all participants have transformed into dragons.
Chocolate quizz Participants all stand up. The MC asks a content question from any of the last sessions. Whoever answers first gets a chocolate and can sit down.	**Spelling B** Participants stand up and use hands, arms, elbows or their head to visually spell out different words.

ENSURE MIX OF FORMATS

PowerPoints


Group Work


Multimedia


Case studies


Breaks & Lunches

4 GOLDEN RULES

AVOID DEATH by POWERPOINT	LEAVE TIME FOR DISCUSSION
KEEP THE ENERGY LEVELS HIGH	MIX FORMATS: PP, GROUP WORK, MULTI-MEDIA, ENERGIZERS

DISCUSSION

ON-LINE MATERIALS

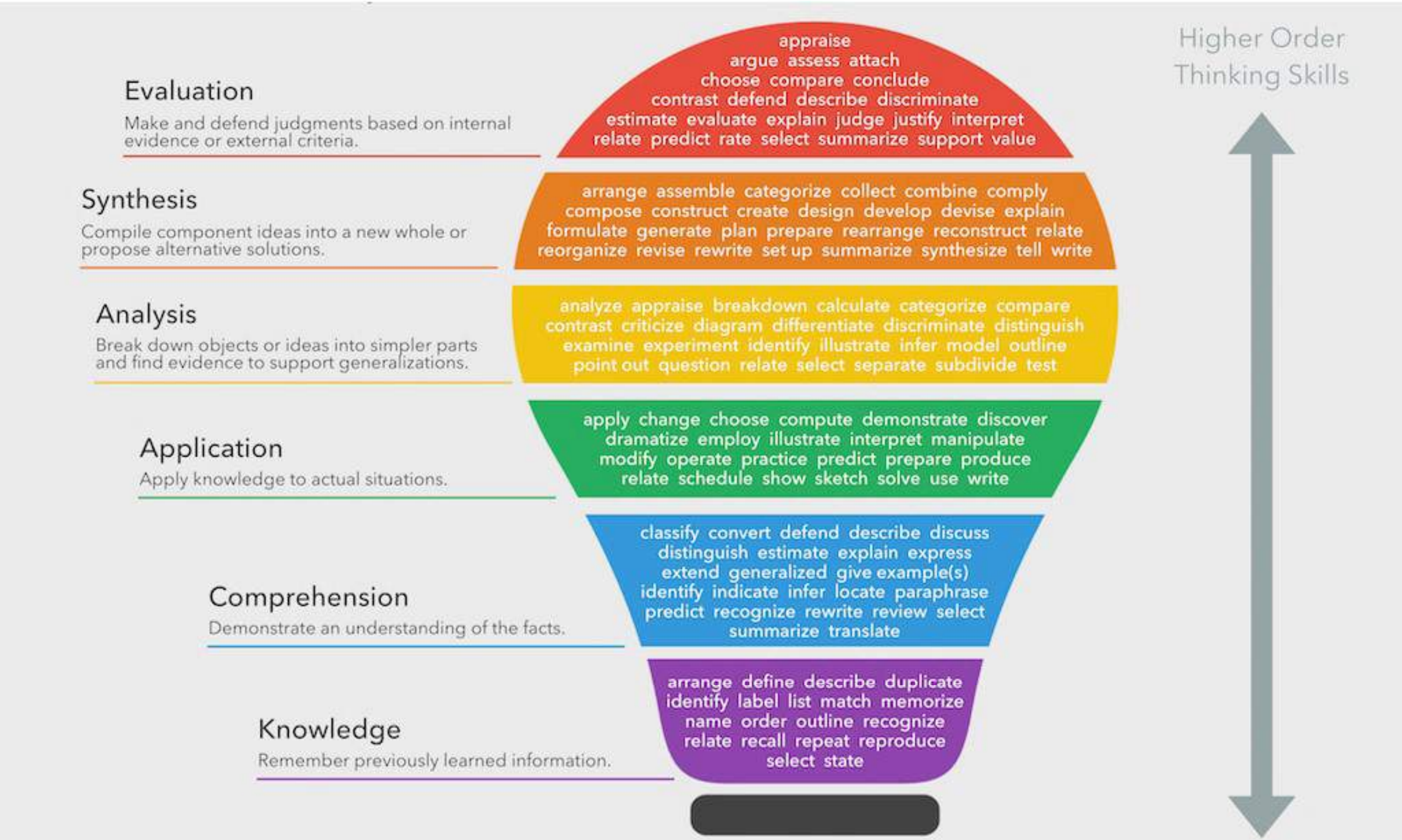
On-line tutorials: https://www.youtube.com/watch?v=pZy1ttzuqrc

Art of teaching: https://www.youtube.com/watch?v=8AsURUV0118

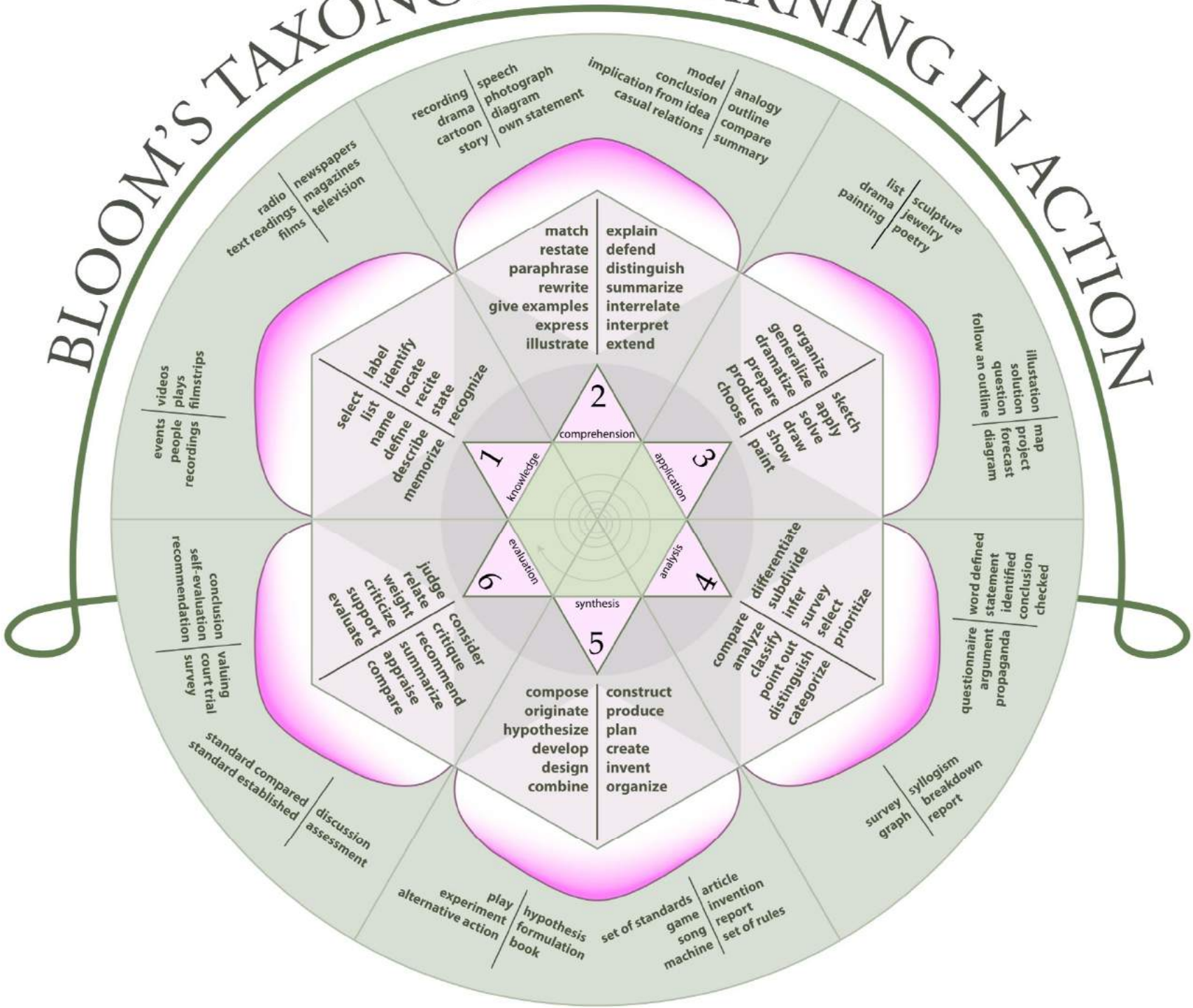
What makes a good teacher great? (TEDx):
https://youtu.be/vrU6YJle6Q4

Good powerpoints: https://www.youtube.com/watch?v=7b1SZcfZLUg

Thank you...


Higher Order Thinking Skills
Evaluation
Make and defend judgments based on internal evidence or external criteria.
appraise argue assess attach choose compare conclude contrast defend describe discriminate estimate evaluate explain judge justify interpret relate predict rate select summarize support value
Synthesis
Compile component ideas into a new whole or propose alternative solutions.
arrange assemble categorize collect combine comply compose construct create design develop devise explain formulate generate plan prepare rearrange reconstruct relate reorganize revise rewrite set up summarize synthesize tell write
Analysis
Break down objects or ideas into simpler parts and find evidence to support generalizations.
analyze appraise breakdown calculate categorize compare contrast criticize diagram differentiate discriminate distinguish examine experiment identify illustrate infer model outline point out question relate select separate subdivide test
Application
Apply knowledge to actual situations.
apply change choose compute demonstrate discover dramatize employ illustrate interpret manipulate modify operate practice predict prepare produce relate schedule show sketch solve use write
Comprehension
Demonstrate an understanding of the facts.
classify convert defend describe discuss distinguish estimate explain express extend generalized give example(s) identify indicate infer locate paraphrase predict recognize rewrite review select summarize translate
Knowledge
Remember previously learned information.
arrange define describe duplicate identify label list match memorize name order outline recognize relate recall repeat reproduce select state

BLOOM'S TAXONOMY - LEARNING IN ACTION



Handout - Face to Face (F2F) Teaching Best Practices

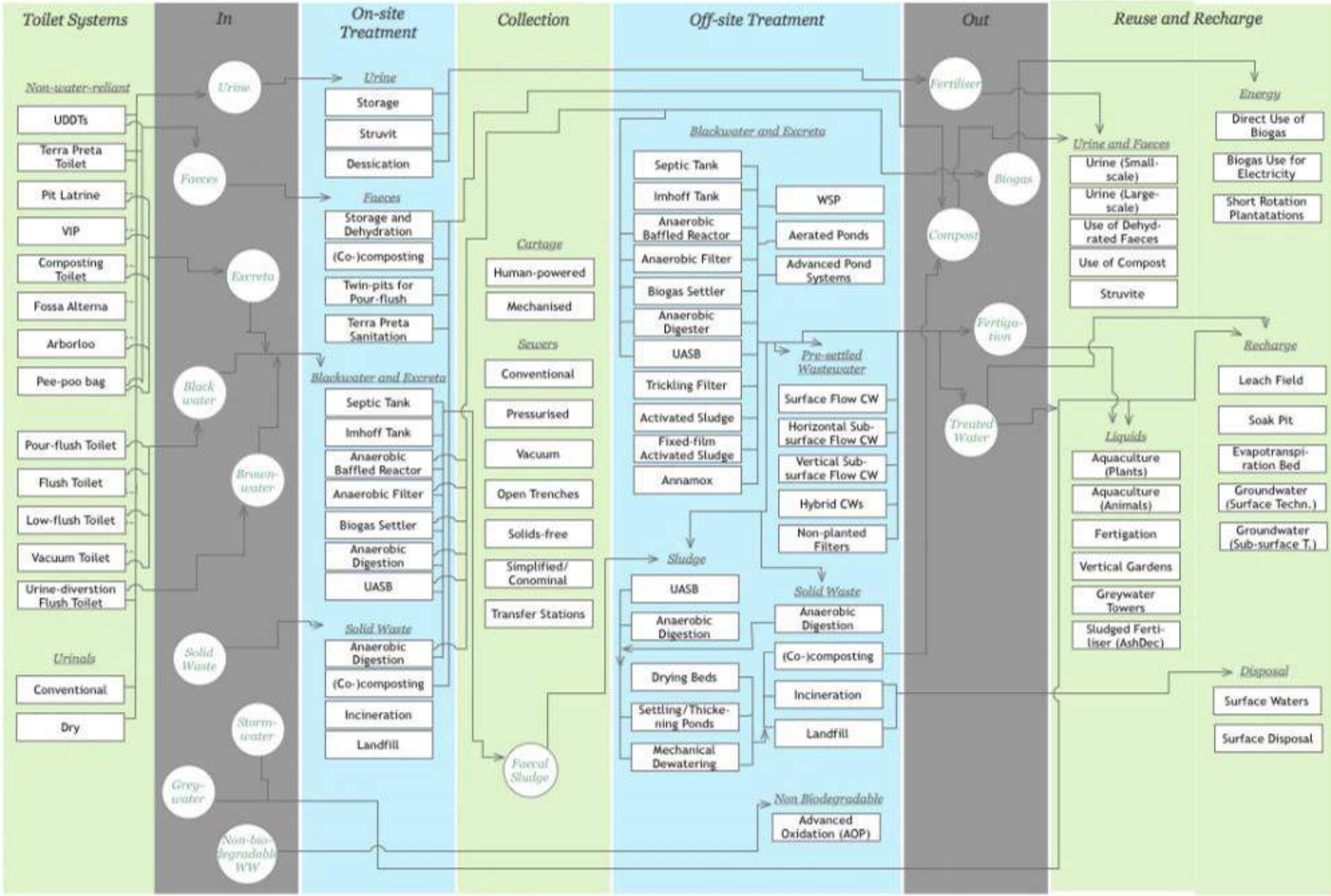
List of Useful Online Resources for Presentations

- www.menti.com - votes live
- www.twitterfall.com - Twitter Live Feed
- www.canva.com - Excellent resource as such for all types of disseminations
- www.prezi.com - Alternative to PowerPoint
- www.kialo.com - Debate Structuring
- www.slidescarnival.com/ - For various PPT templates FREE
- www.graphicriver.net - Market place for all templates, fonts etc
- www.pexels.com/ - Stock Images
- www.unsplash.com/ - For free photographs. Less on WASH related
- www.pixabay.com - More pictures
- www.diagrammer.duarte.com - Free data visualisation charts
- www.kahoot.com/ - Interactive Quizzes
- www.surveymonkey.com - Surveys just like google forms
- www.xmind.com - Mind mapping tool
- www.mindmup.com - intuitive mind maps and storyboarding
- www.pptsplit.com - to make animations into separate slides for pdf use
- www.color.adobe.com/create/color-wheel - To choose colour combinations
- www.draw.io - To make your own smart art

Handout - Face to Face Teaching Best Practices

List of Golden Rules for PowerPoints

- 5-6 lines of text max.
- Text should be read in 10 secs or less.
- Always try to add an icon or picture or any visual tools
- Use bullets.
- Have clear headings (5 words max)
- Commit to 1 idea per slide.
- Facts and Procedures can be made as handouts
- For large screens ensure image resolution
- Sizing down ppts for emails, publishing, websites.
- Use Smart Art!
- Easy to understand Statistics
- Right Colors for text. Yellow is a No.
- Right Fonts – not Comic sans or Size
- Have a library of photos
- Bookmarks – use them!
- No glowing animations!
- Use comments to give the information not on slide
- Use presenter's view
- Consistent fonts and colors and style.
- Content important. So is style.
- Remember to cite even in ppt.
- Credit even Photos.
- Be familiar with slides. You lead the slides. Not opposite.
- Use the online resources mentioned above.


Toilet Systems
In
On-site Treatment
Collection
Off-site Treatment
Out
Reuse and Recharge
Non-water-reliant
UDDTs
Terra Preta Toilet
Pit Latrine
VIP
Composting Toilet
Fossa Alterna
Arborloo
Pee-poo bag
Pour-flush Toilet
Flush Toilet
Low-flush Toilet
Vacuum Toilet
Urine-diversion Flush Toilet
Urinals
Conventional
Dry
Urine
Faeces
Excreta
Black water
Brown-water
Solid Waste
Storm-water
Grey-water
Non-bio-degradable WW
Urine
Storage
Struvit
Dessication
Faeces
Storage and Dehydration
(Co-)composting
Twin-pits for Pour-flush
Terra Preta Sanitation
Blackwater and Excreta
Septic Tank
Imhoff Tank
Anaerobic Baffled Reactor
Anaerobic Filter
Biogas Settler
Anaerobic Digestion
UASB
Solid Waste
Anaerobic Digestion
(Co-)composting
Incineration
Landfill
Cartage
Human-powered
Mechanised
Sewers
Conventional
Pressurised
Vacuum
Open Trenches
Solids-free
Simplified/ Conominal
Transfer Stations
Faecal Sludge
Blackwater and Excreta
Septic Tank
Imhoff Tank
Anaerobic Baffled Reactor
Anaerobic Filter
Biogas Settler
Anaerobic Digester
UASB
Trickling Filter
Activated Sludge
Fixed-film Activated Sludge
Annamox
WSP
Aerated Ponds
Advanced Pond Systems
Pre-settled Wastewater
Surface Flow CW
Horizontal Sub-surface Flow CW
Vertical Sub-surface Flow CW
Hybrid CWs
Non-planted Filters
Sludge
UASB
Anaerobic Digestion
Drying Beds
Settling/Thicke-ning Ponds
Mechanical Dewatering
Solid Waste
Anaerobic Digestion
(Co-)composting
Incineration
Landfill
Non Biodegradable
Advanced Oxidation (AOP)
Fertiliser
Biogas
Compost
Fertiga-tion
Treated Water
Energy
Direct Use of Biogas
Biogas Use for Electricity
Short Rotation Plantatations
Urine and Faeces
Urine (Small-scale)
Urine (Large-scale)
Use of Dehyd-rated Faeces
Use of Compost
Struvite
Recharge
Leach Field
Soak Pit
Evapotranspi-ration Bed
Groundwater (Surface Techn.)
Groundwater (Sub-surface T.)
Liquids
Aquaculture (Plants)
Aquaculture (Animals)
Fertigation
Vertical Gardens
Greywater Towers
Sludged Ferti-liser (AshDec)
Disposal
Surface Waters
Surface Disposal

Selecting a context-appropriate combination of faecal sludge treatment technologies

Decision factor | Treatment option | Potential enduse
4 Chapters
Future treatment perspective | Future enduse perspective
To next step | Sludge transfer | Transfer to enduse

Government support 12
Socio-cultural acceptance 16
Legal and regulatory framework 12
ENABLING ENVIRONMENT
Financial arrangements 13
Institutional arrangements 12
Skills and capacities 11 16.5

Assessment of the initial situation 13 14

Enabling environment 17.2.1

Collection & Transport practice 4

Interest for enduse/resource recovery 10

Fertiliser/Soil amendment demand | Biogas demand | Energy/Building material demand

Iterative process until optimal solution is obtained

Selection of the treatment options 5 16.5

Characterisation and quantification of sludge 2

Dewaterability of sludge: degree of stabilisation/digestion 3 5 6

Stabilised sludge | Need for further digestion/stabilisation

Solid-liquid separation

Dewaterability of sludge: sludge concentration 6

High dilution, space limited, operator capacity available

Settling/ thickening tank 6

Sludge concentrated or availability of space

Stabilisation

Imhoff tank 5 | Digester 5 | Onsite ABR (e.g.public latrines)

Conditions for drying available

Sludge spreadable

Dewatering/drying

Unplanted drying beds 7

Mechanical dewatering (e.g. filter press, centrifuge) 5

Availability of organic waste

Co-composting 5

Vermicomposting/ Black Soldier flies

Planted drying beds 8

Mechanical/heat drying (e.g. pelletiser) 5

Pathogen reduction

Storage and further drying 10

Co-combustion 5

Potential endproducts 10

Dry sludge 10 | Humified sludge 10 | Biomass 10 | Biogas 10 | Compost 10 | Energy 10 | Building material 10

Matching with financial, organisational and O&M realities

O&M Requirements (e.g. available skills and operator capacity) 11

Possible management schemes 11

Market studies of endproducts 14

Financial comparison of options 13

Trade-off

Selection of treatment sites 14.4

Land availability, cost and characteristics

Final choice of combination of technologies