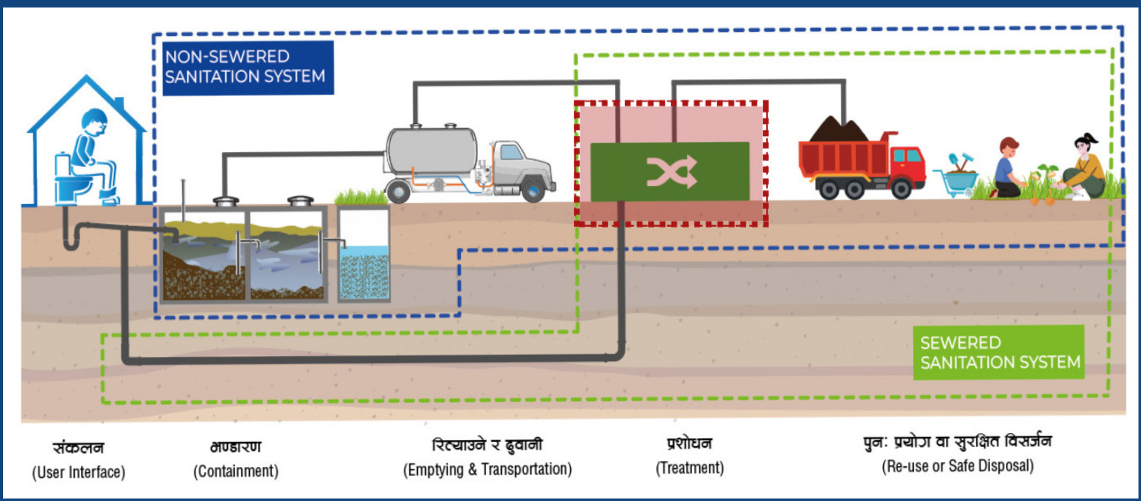
Government of Nepal
Ministry of Water Supply
National Water Supply and Sanitation Research, Innovation and Capacity Development Center

Design of Faecal Sludge Treatment Plant

Power Point Presentation Slide Note for Participants



2025

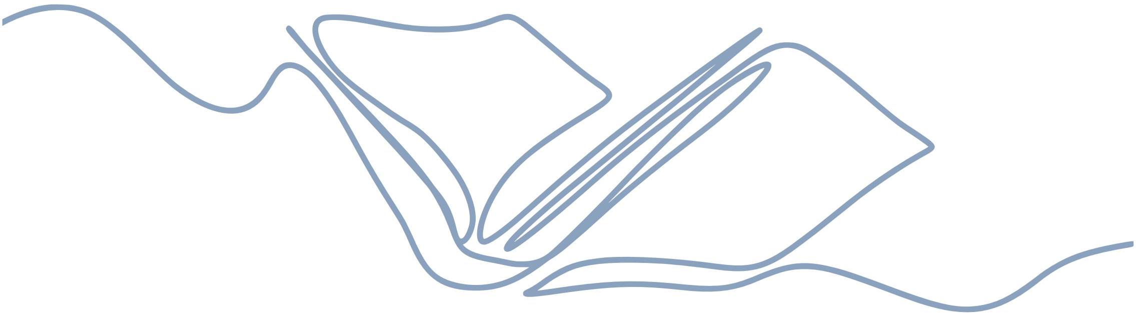


Table of Contents

1. INTRODUCTION

This document, power point presentation with slide notes, is a supporting document for the trainers/presenter to conduct the “Design of Faecal Sludge Treatment Plant” training. This is a compilation of all the slides to be presented in the training along with the notes for the trainer as of what to describe while presenting the particular slide.

2. OBJECTIVE

The main objective of the document is to guide the content that a presenter would be discussing on each slide. To this, it also provides a preview of all the slides contained in the training along with the slide notes.

3. HOW TO USE?

The document consists of slides from all sessions. Slide notes for each slide is presented just below the slide itself. The trainers or presenters can go through the notes and describe the slides as per the information provided in the slide notes.

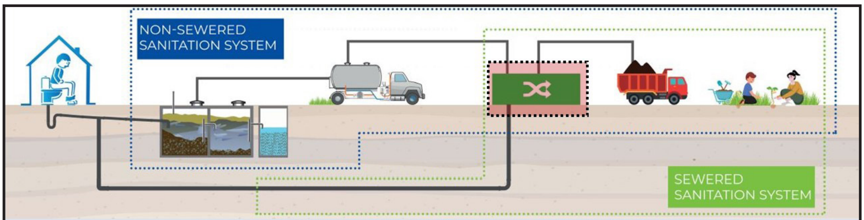
For the effective use of the documents, a trainer or presenter is recommended to use simultaneously with the “Trainer Manual” with instructions.

Session

1

Training Opening

Slide No.-1



Design of Faecal Sludge Treatment Plant

Training Opening

Resource Person

Government of Nepal
Ministry of Water Supply
National Water Supply and Sanitation Research, Innovation and Capacity Development Center

Slide No. 2

Training Introduction

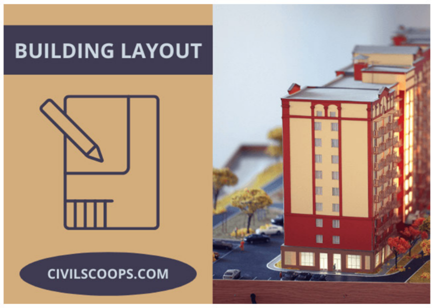
Objectives

- Explain and design different components of faecal sludge treatment plant
- Select the appropriate technology as per ecological zone

Slide No. 3

Building Layout

- Bathroom Location
- Emergency Exits
- First Aid



Slide No. 4

Introduction

- Pair up with neighboring participant
- Write down the details about themselves (name, address, profession, experience and fun fact)

Slide No. 5

Introduction

- Exchange meta-cards with each other
- Introduce the partner to the group sharing the key highlights

Slide No. 6

Learning Expectations

- Two learning expectations from each participant

Slide No. 7

Pre-test

5-10 minutes

Slide No. 8

Orientation Format and Agenda

- Experiential, hands-on and learn by doing
- Individual and group activities
- Case studies and learning from others' experience
- Open discussion, questions and answers
- Develop a sense of community and network within the group

Slide No. 9

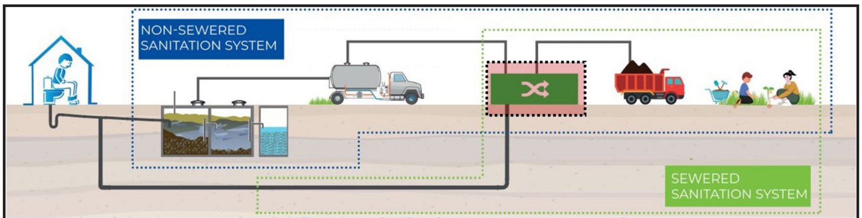

Thank you!
धन्यवाद !
Government of Nepal
Ministry of Water Supply
National Water Supply and Sanitation Research, Innovation and
Capacity Development Center
Nagarkot, Bhaktapur
Phone No:+977-1-6680171, :+977-1-6680172
Email: wash.nwssricdc@gmail.com
Technical Support
Environment and Public Health Organization (ENPHO)
110/25 Adarsa Marg-1, Thapagaon, New Baneshwor
Tel: 977-1-5244641; 5244051; 5244992; 5244609
Email: enpho@enpho.org

Session

2

Urban Sanitation in Global and Local Context

Slide No. 1



Design of Faecal Sludge Treatment Plant

Urban Sanitation in Global and Local Context

Resource Person

Government of Nepal
Ministry of Water Supply
National Water Supply and Sanitation Research, Innovation and Capacity Development Center

Slide No. 2

Just waste or something else

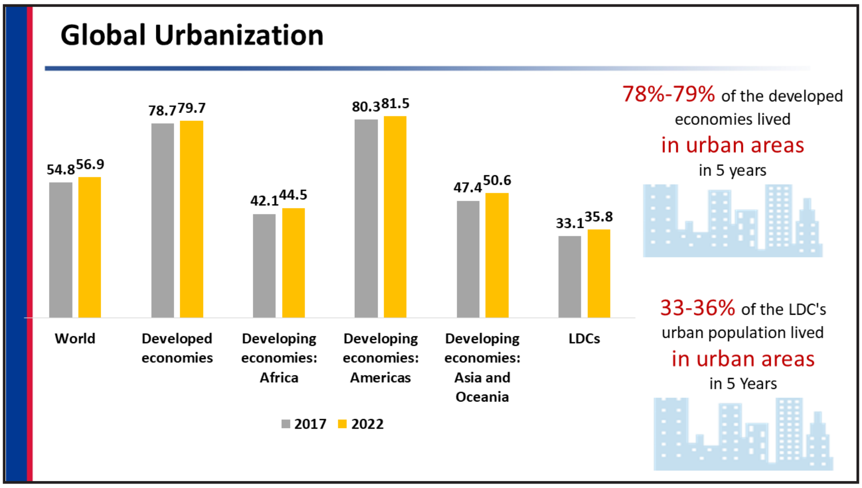
Change the perspective

2

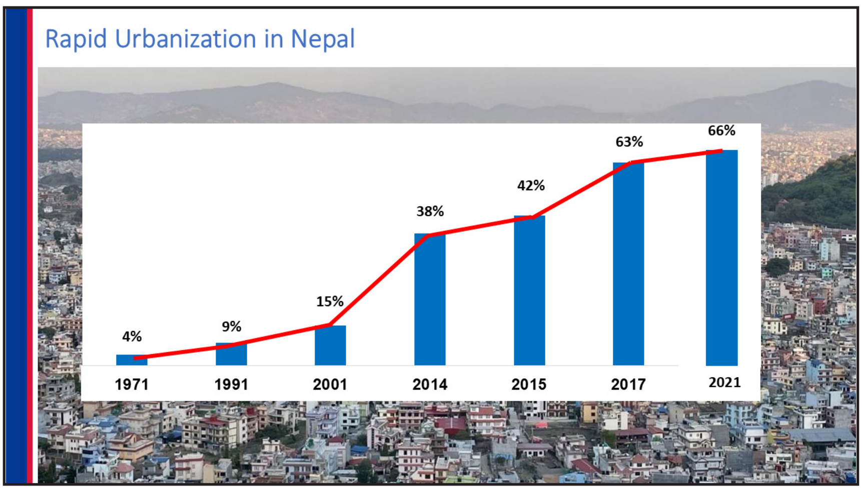
Slide No.3

Slide No. 4

Slide No.5

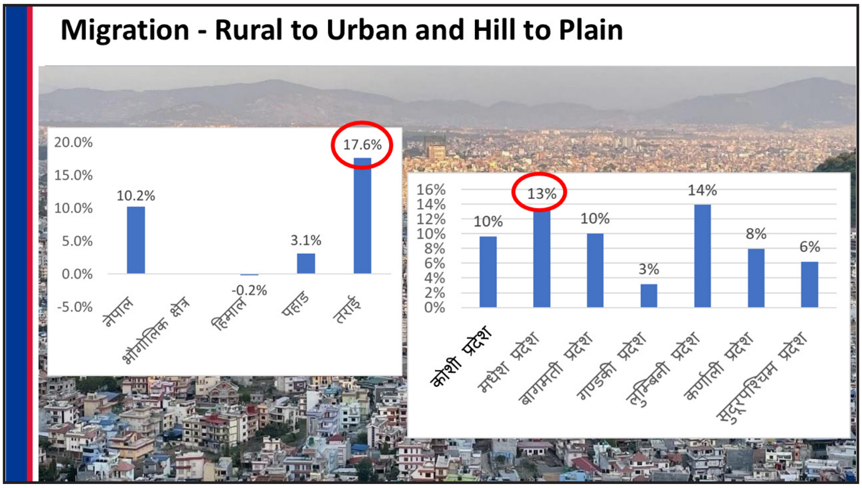


Slide No.6



As urbanization takes place over the course of time.
Nepal is one of the fastest urbanizing countries in South Asia. If we see the urbanization trend in Nepal, it is climbing each year. In 2001, only 15% of the population lived in urban areas while the number increased significantly in 2014 and 66% in 2022.

Slide No.7

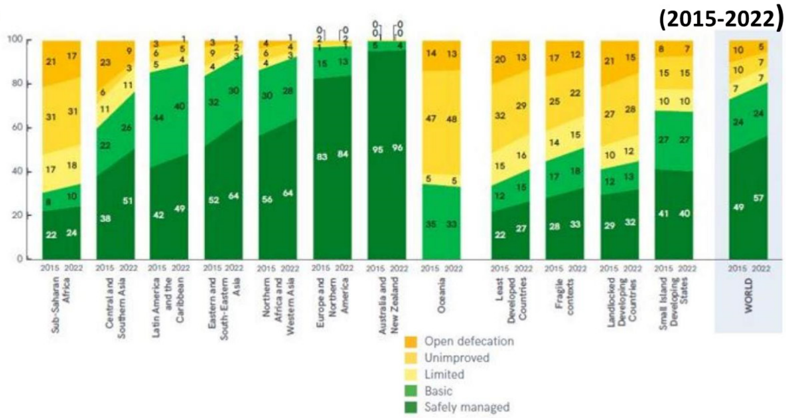


Slide No.8

Slide No. 9

Regional and global coverage of sanitation services

(2015-2022)

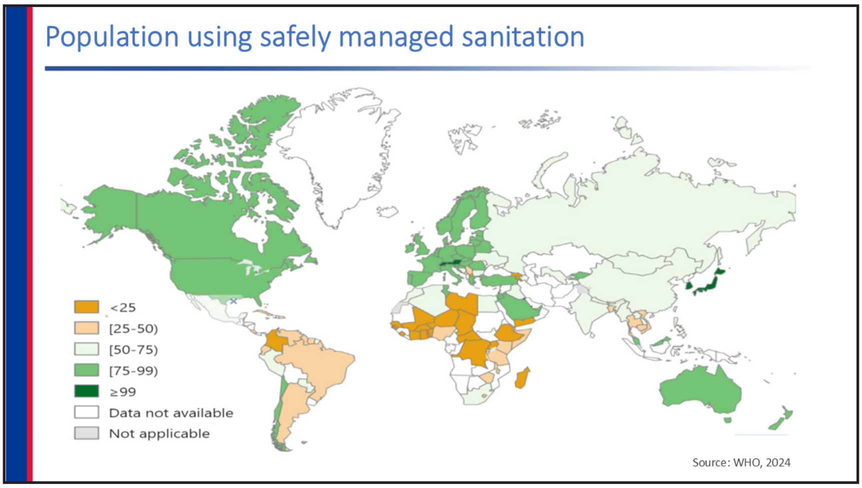


Slide No. 10

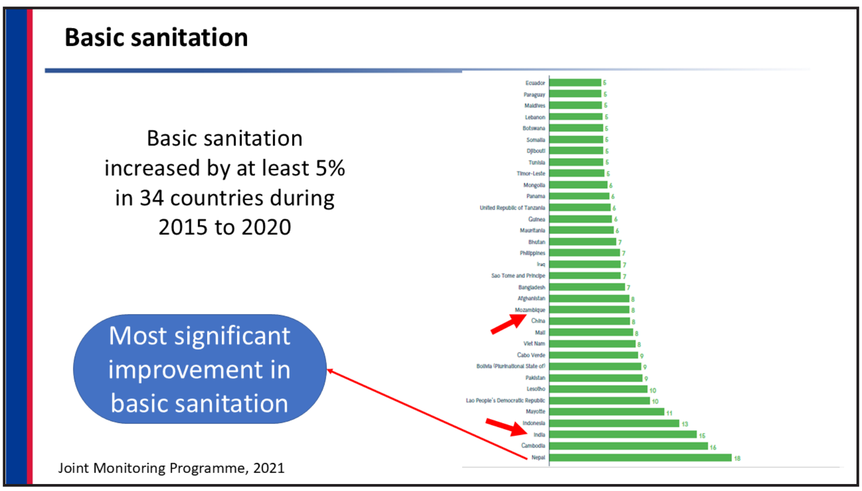
The JMP ladder for Sanitation

- Safely managed : Use of improved facilities that are not shared with other households and where excreta are safely disposed of in situ or removed and treated offsite
- Basic : Use of improved facilities which are not shared with other households
- Limited : Use of improved facilities shared between two or more households
- Unimproved : Use of pit latrines without a slab or platform, hanging latrines or bucket latrines
- Open defecation : Disposal of human faeces in fields, forests, bushes, open bodies of water, beaches and other open spaces or with solid waste

Slide No.11

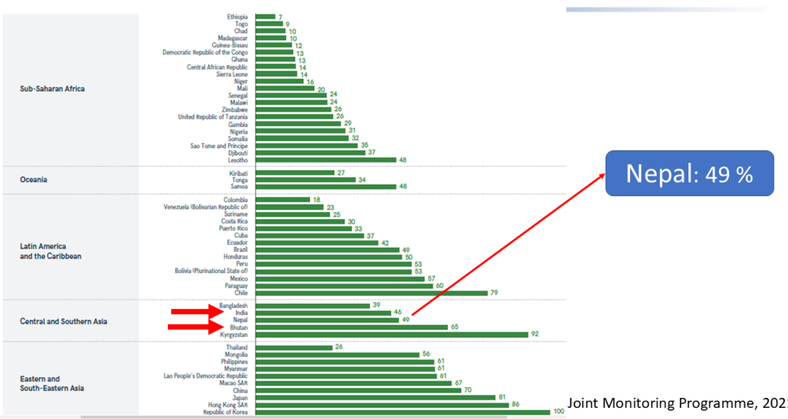


Slide No. 12



Slide No. 13

Safely managed sanitation in 2020



Joint Monitoring Programme, 2021

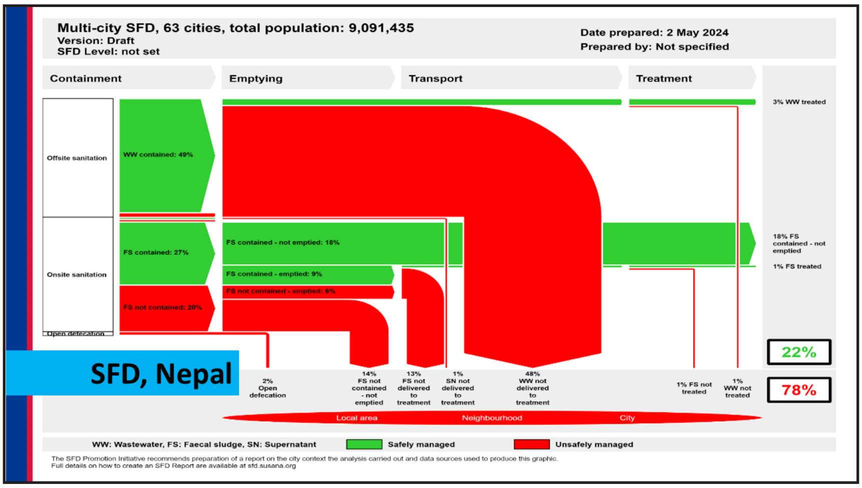
Slide No. 14

Terminologies

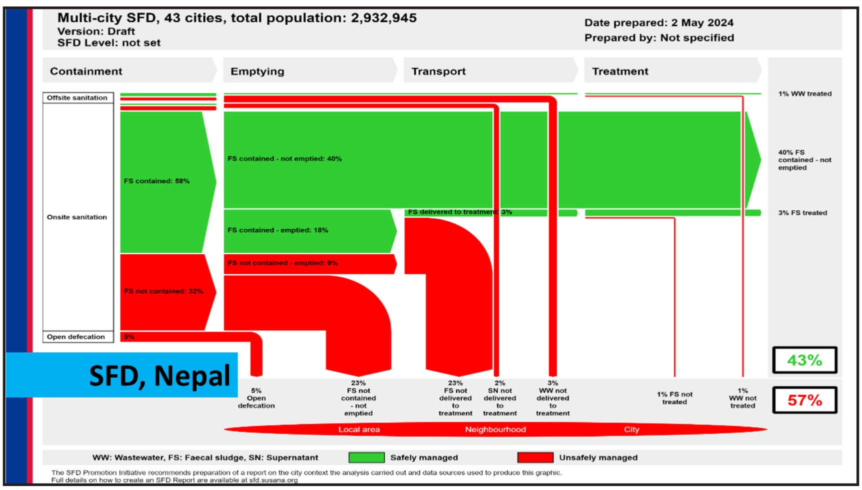
- Improved sanitation facilities: It includes flush/pour flush to piped sewer systems, septic tanks or pit latrines; pit latrines with slabs (including ventilated pit latrines), and composting toilets.

- Safely Managed Sanitation: Population using an improved sanitation facility that is not shared with other households and where excreta are safely disposed of in situ or treated off.

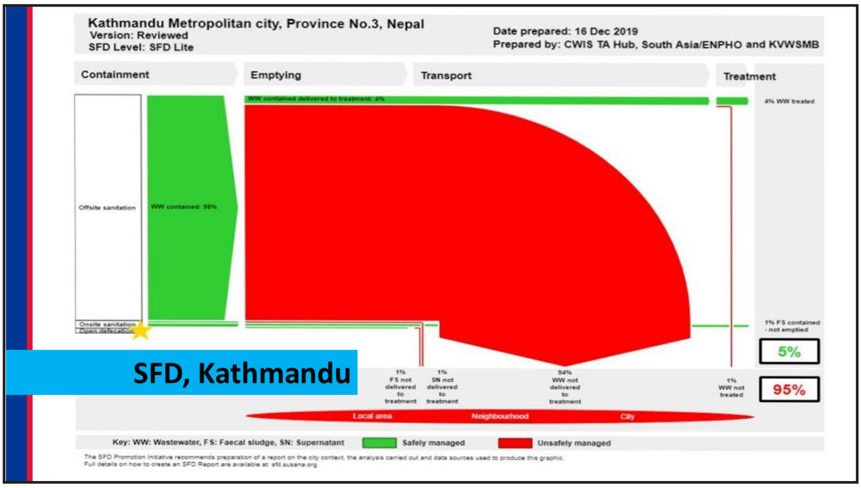
Slide No. 15



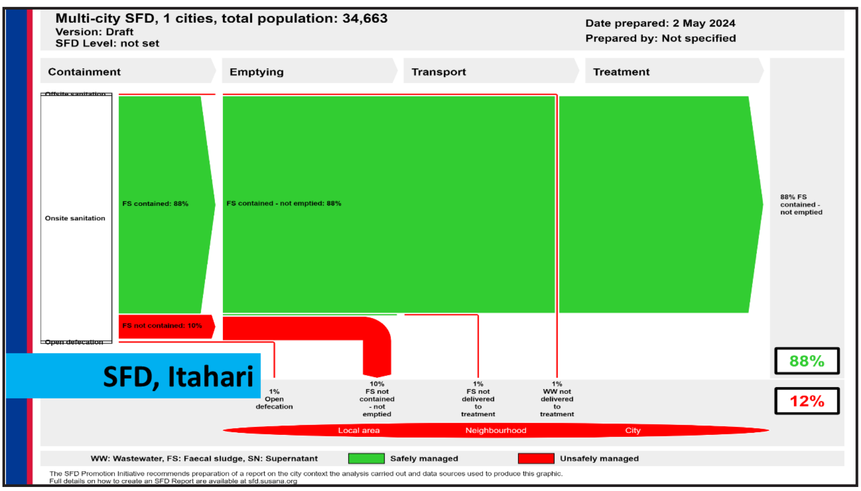
Slide No. 16



Slide No. 17



Slide No. 18



Slide No. 19

Sanitation in Nepal

MDG 2015 and The country declared as **ODF** in **2019**

The GoN prioritized **Sanitation** since **1981**

Drainage system during the **Malla dynasty** (1200-1768)

the first ever **Toilet** in Nepal during **1696 - 1722 AD**

https://kathmandupost.com/16/2019/11/12/there-is-a-significant-dearth-of-public-toilets-in-nepal#:~:text=The%20history%20of%20toilets%20in,it%20was%20an%20incomplete%20triumph.

Slide No.20

Aim of 2030 SDG

- to **ensure** that all people enjoy **health, justice and prosperity**.
- It is critical that **no one is left behind**.
- **a call to action** to **end poverty** and **inequality**, protect the **planet**, and

SDG 6.2, achieve access to **adequate** and **equitable** sanitation and **hygiene for all**

SDG **indicator 6.2.1**, **Safely managed sanitation services**

Slide No. 21

SDG Indicators and targets of Nepal

SDG 6: Ensure availability and sustainable management of water and sanitation for all

Targets and Indicators	2015	2019	2022	2025	2030
Target 6.2 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					
6.2.1 Households using improved sanitation facilities which are not shared (%)	60[d]	69.3	78.7	85.7	95
6.2.2 Proportion of population using latrine (%)	67.6[e]	75.7	83.8	90.0	98
6.2.3 Local authority areas that have declared Open Defecation Free (%)	41[f]	56.5	71.9	83.5	99
6.2.4 Sanitation coverage (%)	70[g]	77.7	77.5	83.3	99
6.2.5 Urban households with toilets connected to sewer systems/ proper FSM (%)	30[a]	46	62	74	90
Target 6.3 By 2030, improve water quality by reducing pollution, eliminating dumping and minimizing release of hazardous chemicals and materials, halving the proportion of untreated waste water and increasing recycling and safe reuse.					
6.3.1 Proportion of untreated domestic waste water (%)	99[c]	89.9	83.1	76.3	65
6.3.2 Proportion of untreated industrial waste water (%)	99[c]	75.3	57.5	39.7	10
6.3.3 Proportion of bodies of water with good ambient water quality	-	-	-	-	-

Slide No. 22

Sanitation in Government's policy and program

Slide No. 23

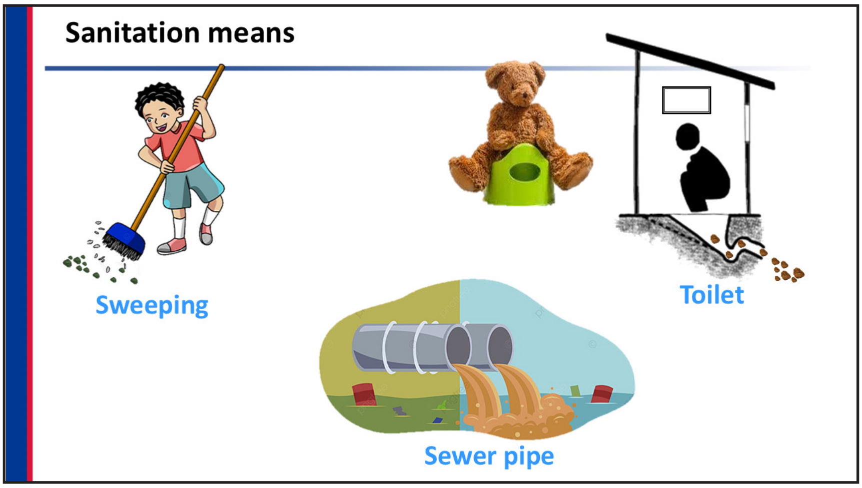
Slide No. 24

The problem of proper sanitation remains globally the same. However, the reason causing poor sanitation different in different countries or cities. The following are the majors: These problems are complex and diverse. How can these problems solve/ manage?

- **Inequity and Non-inclusive investment**
- **Lack of Capacity**
- **Discrete Planning**
- **Poor Legal instruments and their implementation**
- **Inappropriate Technology**
- **Toilet/sewer-focused sanitation planning**
- **Lack priority: Misconception that sanitation is only having toilets. Investment in sanitation is unproductive and sanitation improvement is no development**

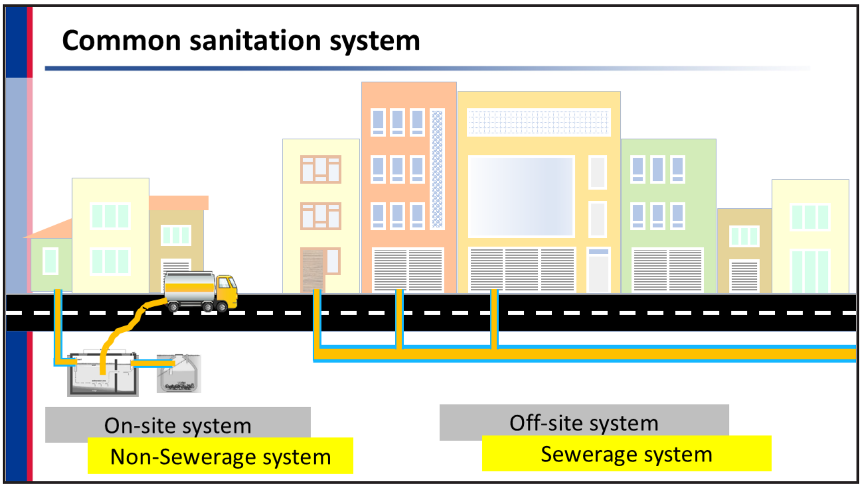
Let's discuss these issues.

Slide No. 25



Slide No. 26

Slide No.27



The reason behind the pollution is incomplete sanitation practices.

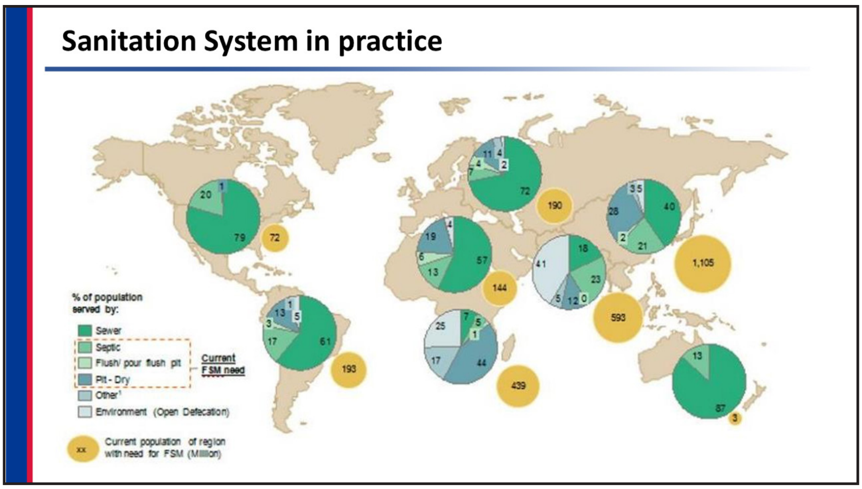
Slide No.28

The ultimate point of waste disposal of the current sanitation practice is river and open land.

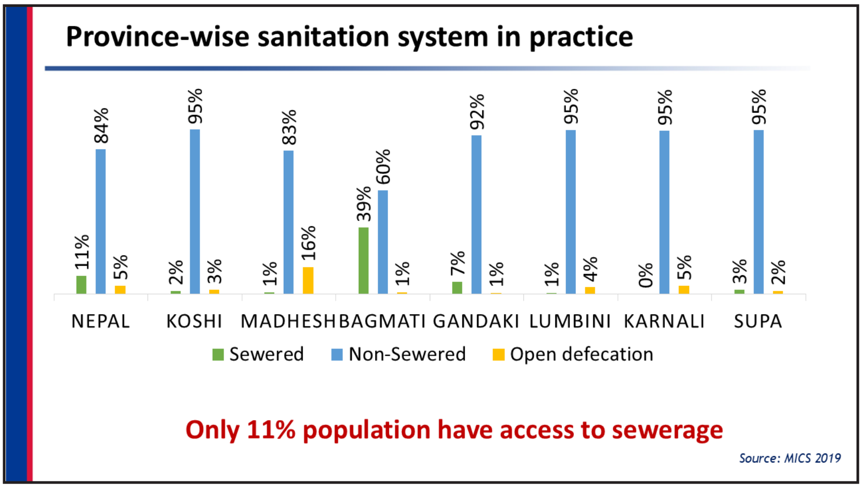
Slide No.29

The ultimate point of waste disposal of the current sanitation practice is river and open land.

Slide No. 30



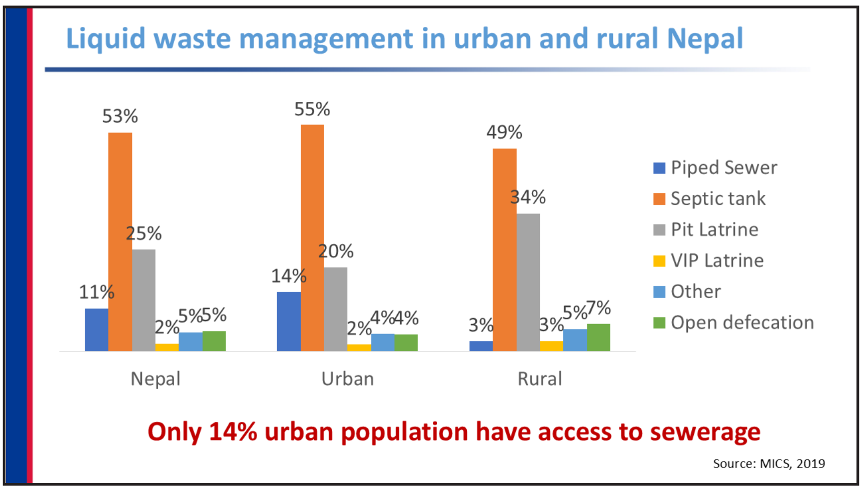
Slide No. 31



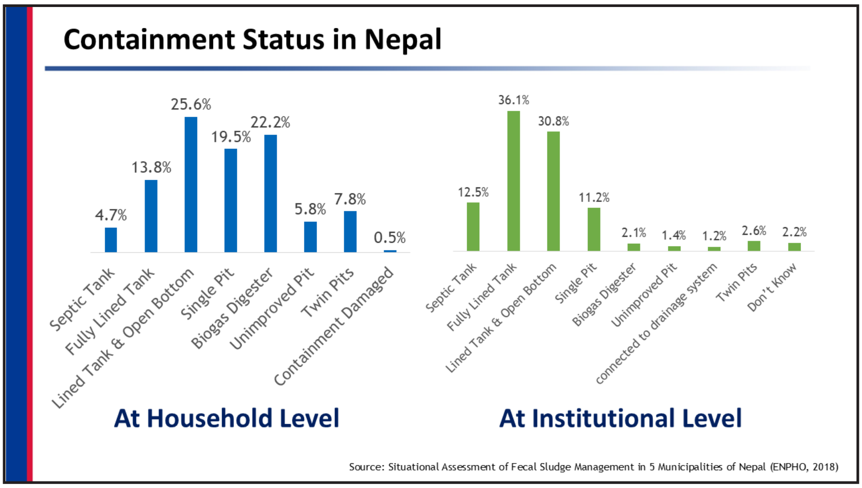
As we see the coverage of the existing sewer connection, the graph represents that a very large portion of the population is using non-sewered sanitation services.

Except for the Bagmati province of Nepal, all provinces have less than 10Ü coverage of sewer connection.

Slide No. 32



Slide No. 33

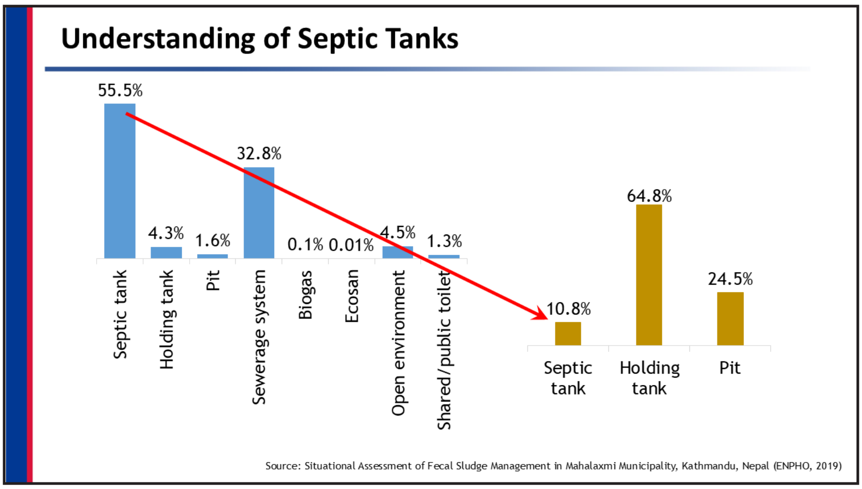


Having properly functioning septic tanks for the safe disposal of on-site and off-site sanitation into the environment is a challenge.

A survey conducted by ENPHO in 2018 revealed that, outside of Kathmandu Valley, there is only 5 percent containment, which can be termed as a proper septic tank use, at the household level, and only 13 percent at the institutional level.

Generally, containment with lined tanks is considered a septic tank at both the household and institutional levels. This clearly shows the lack of understanding about septic tanks outside KTM.

Slide No. 34

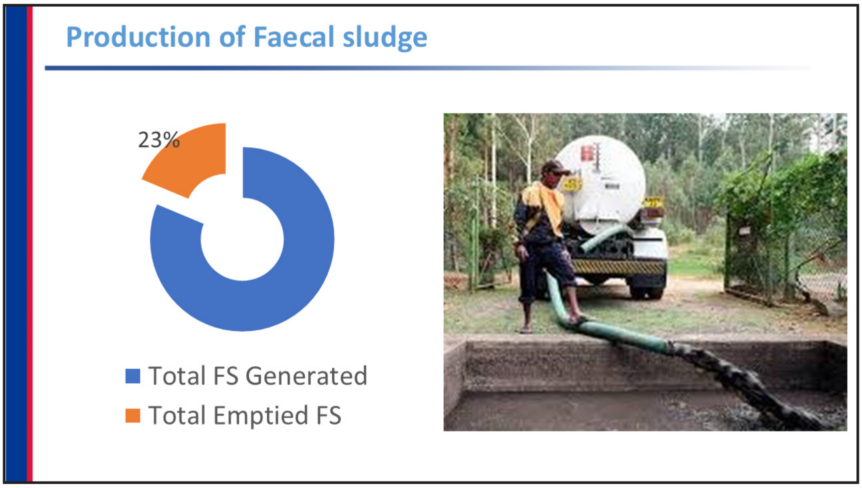


Understanding of septic tanks among the people residing in Kathmandu is a challenge.

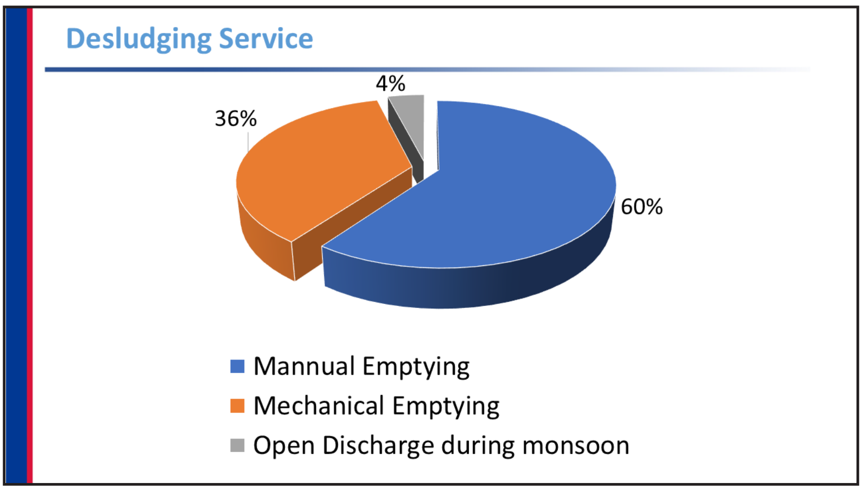
In Kathmandu, the capital and most developed part of the country, a survey revealed that any containment with rectangular shape is considered as a septic tank, but that is not the case.

As the graph indicates, more than 55% of the people in the municipality said the wastewater coming out of their houses goes into their septic tank. However, it was found that only 10.8% out of the 55.5% of households have septic tanks and the rest have only holding tanks and pits.

Slide No.- 35



Slide No. 36



Slide No. 37

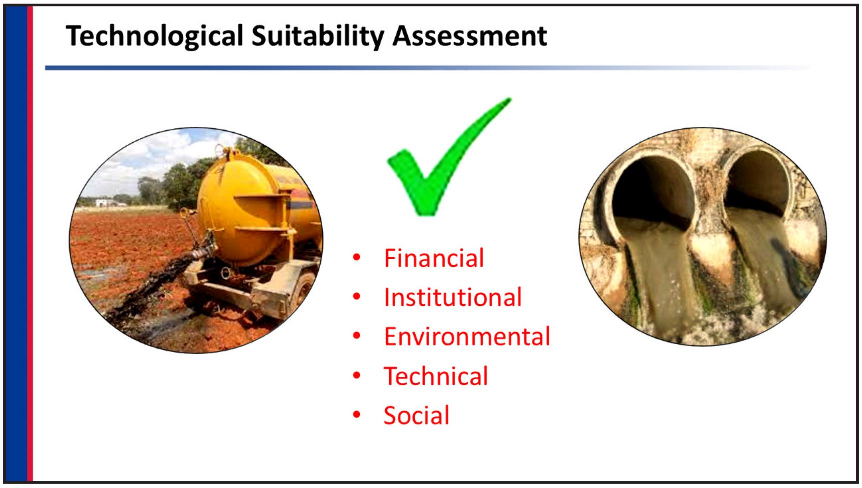
Ask participants what might be the impact on these types of sanitation workers?

Are not they the citizen of the town/ municipality?

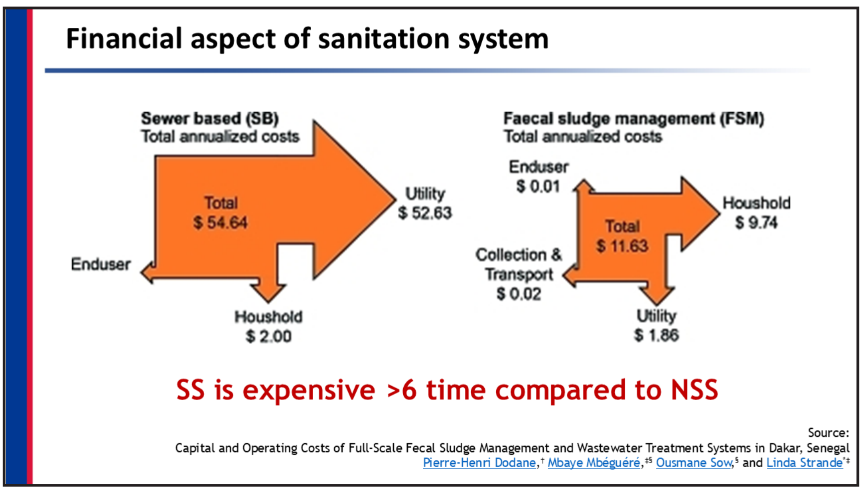
Are we not responsible for their health and safety?

Slide No.38

Slide No. 39



Slide No.-40



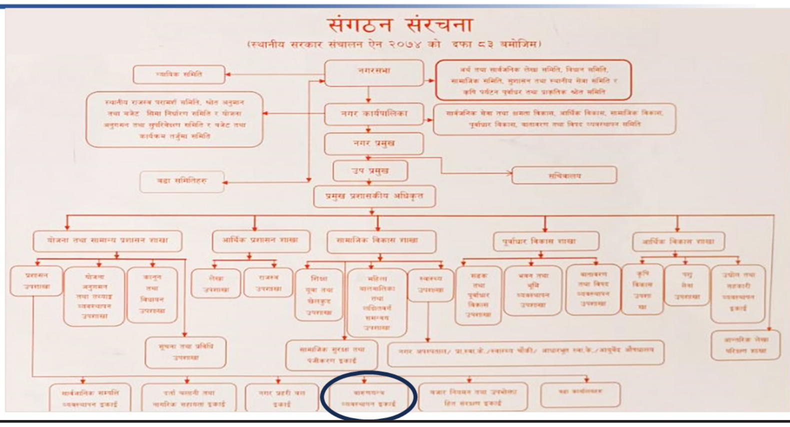
Slide No.41

Technical Aspect of Sanitation system

- Gradient - Need Pumping system in plain terrain due to low gradient
- Scatter community : Issue in collection of wastewater from all the communities
- Coverage : Difficult to provide service to 100% in sewer
- Engagement : engagement of people, private and public sector
- Social Acceptance

Slide No. 42

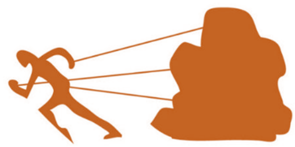
Institutional and Legal status of sanitation



Slide No. 43

Challenges of Urban Sanitation

- Heterogeneous urban setting
- Lack of legal and regulatory instrument
- Difficulties in land acquisition
- Priority of sanitation particularly FSM
- The mind set
- Opportunities of designing



Slide No. 44

Summary

- Sanitation system in practice : Majorly onsite
- In densely populated area : Sewerage system
- Technological Suitability assessment is crucial
- No FSTP or Proper disposal station
- Particularly in countries of Low income : FSM

Slide No. 45

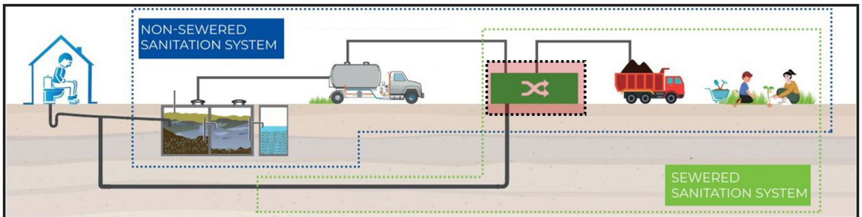
Trainer: Have participants open up the Power Point Handouts booklet (the green booklet) to the appropriate location and encourage them to take notes during the session.

Session

3

Feacal Sludge Characteristics

Slide No.1



Design of Faecal Sludge Treatment Plant

Faecal Sludge Characteristics

Resource Person

Government of Nepal
Ministry of Water Supply
National Water Supply and Sanitation Research, Innovation and Capacity Development Center

Slide No.2

What is Faecal Sludge?

- Undigested or partially digested slurry or solids, resulting from storage or treatment of black water or excreta (Eawag/Sandec, 2008);

- Sludges of variable consistency accumulating in septic tanks, aqua privies, family pit or bucket latrines and unsewered public toilets. These contents comprise varying concentrations of settleable or settled faecal solids as well as of other, non-faecal matter (Heinss et al., 1998)

Slide No. 3

FS contents

Water:

- On average 91-96% of urine is water and 75% of faeces are water (Rose et. al. 2015);
- Liquid content in FS is about 97%.

Organic materials:

- 25% of faeces are solid, of which 84-93% is organic material;
- 4-9% urine is dissolved and suspended solids, of which 65-85% is organic material;
- More discussion in later sections

3

Slide No. 4

FS Characterization: Parameters

Physical
- Temperature
- Color
- Odor
- Solids

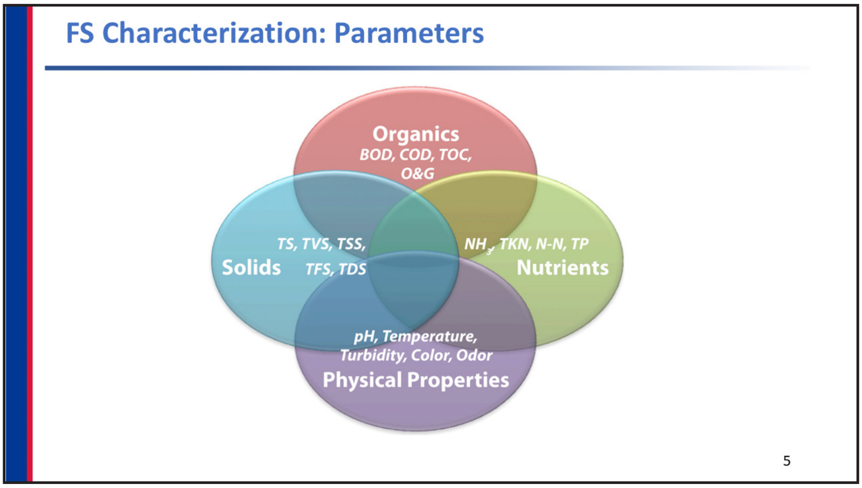
Chemical
- pH
- COD
- BOD
- Nutrients
  - Nitrogen
  - Phosphorus

Biological
- Pathogens
  - Virus
  - Bacteria
  - Protozoa
  - Helminths

4

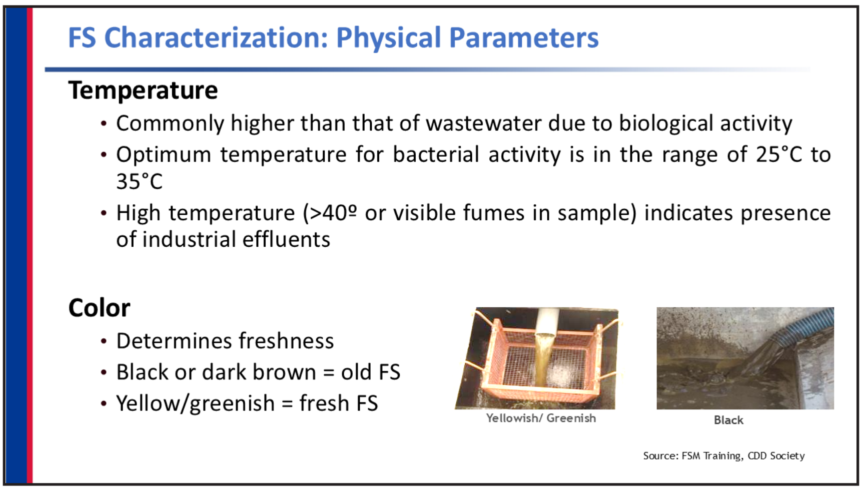
Basic parameters of fecal sludge that need to be understood by the designers of the treatment systems. These parameters will influence the selection of technology, which will be covered in the next session.

Slide No. 5



Basic parameters of fecal sludge that need to be understood by the designers of the treatment systems. These parameters will influence the selection of technology, which will be covered in the next session

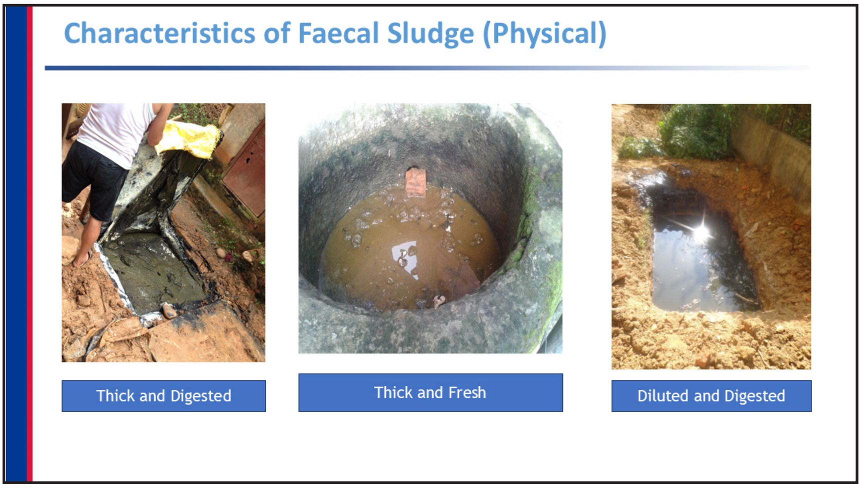
Slide No. 6



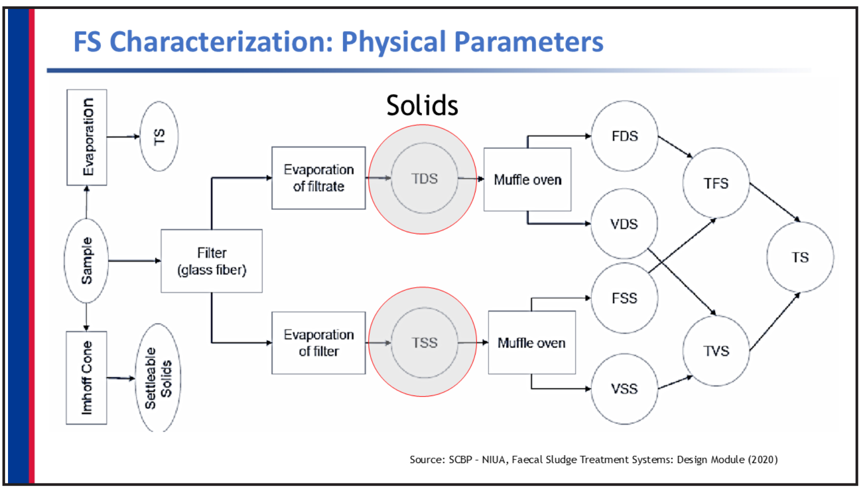
Explain the importance of the temperature of the FS using the pointers in the slide. This is more pronounced in the nature-based systems which are dependent on microbial activity for digestion/treatment. Hence a range is usually considered during designing by the Engineers.

Colour of FS is a good indicator of the age and also the presence of toxic industrial effluents. If the colour of FS does not match the above scale/ gradient, like white or any other colour it is because of the presence of toxic chemicals. Hence the FS load should not be taken into the FSTP as it will upset the biological process adopted.

Slide No. 7



Slide No. 8



The solids in the wastewater, fecal sludge and septage can be classified as shown in the diagram above. It indicates the different stages and processes used to measure the solid content and the type of solids retained at the end of each stage.

The solids are either dissolved or suspended. The suspended solids are further classified in easily settleable solids. The suspended and dissolved can be further classified into volatile and fixed solids. Fixed solids are those which are retained in the sample after exposing it to higher temperatures. The content of volatile solids determines the degree of stabilization of the solids. However, the literature says that the TSS in septage is quite high and most of which are easily settleable. Hence a simple solid liquid separation helps to reduce the VSS and COD of the liquid portion of the septage.

Settleable Solids

Those solids which, when the flow is quieted will settle. The settleable solids are heavier than water.

Suspended Solids

Those solids which can be removed by filtering using a glass fiber filter. Suspended solids consist of settleable, floatable and colloidal solids. Total suspended solids concentration is normally in the range of 100 – 350 mg/l.

Dissolved Solids

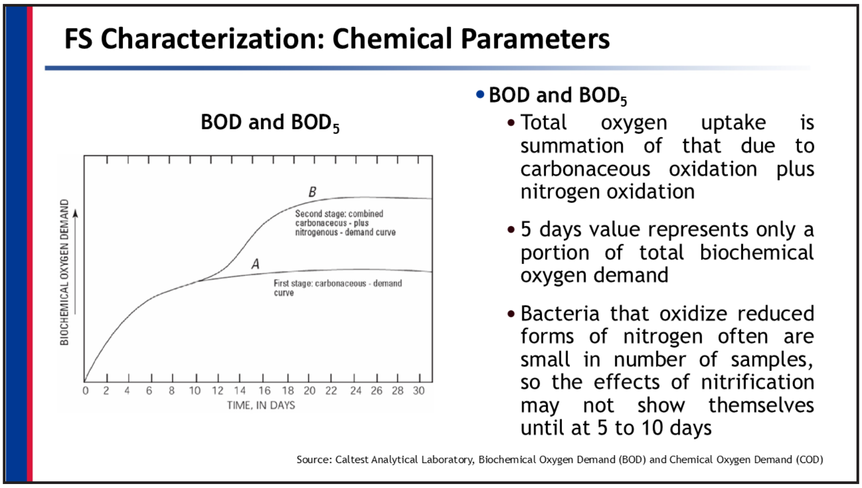
Those solids which will pass through a glass fiber filter. The dissolved solids concentration of wastewater is normally in the range of 250 – 850 mg/l.

Total Solids

The material that remains after the water is removed from a wastewater sample. Total solids are made of organic and inorganic dissolved and suspended solids.
Volatile Solids
High volatile solids mean the FS relatively fresh and not undergone digestion process
Low volatile solids means the FS must have undergone complete digestion or partial digestion. This parameter helps the designer to choose between the Stabilization process or direct dewatering like screw press or PDB.

Source: http://niua.org/scbp/sites/default/files/DESIGN_MODULE_Part%20A_0.pdf

Slide No. 9

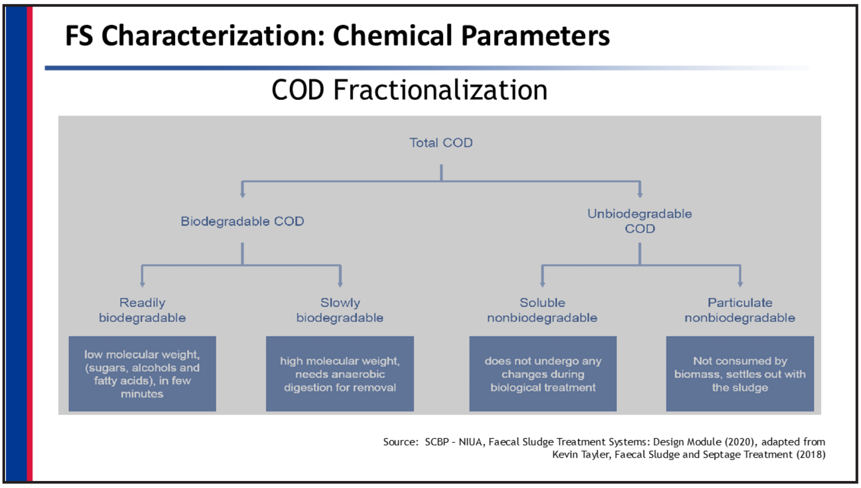


Biochemical oxygen demand (BOD) is the amount of dissolved oxygen needed by biological organisms to break down organic material present in a given sample at a certain temperature over a specific time period. The BOD5 value is most commonly expressed in milligrams of oxygen consumed per litre of sample during 5 days of incubation at 20 °C and is often used as a surrogate of the degree of organic pollution of water.

Image in the slide illustrates a Hypothetical BOD curves (A) Carbonaceous curve for oxidation of organic matter and (B) Carbonaceous plus nitrogenous curve for oxidation of ammonia and nitrite (modified after Sawyer and McCarty, 1978).

Source: https://caltestlabs.com/analytical-services/priority-pollutants/bodandcod/

Slide No.10



The slide shows classification of COD in liquid waste such as fecal sludge or septage. COD (chemical oxygen demand) represents the oxygen equivalent of the organic matter that can be oxidized chemically with dichromate, a powerful chemical oxidant. The laboratory analysis of COD is more convenient than that for BOD, taking between a few minutes to hours depending on the method. COD concentrations will be higher than BOD for a number of reasons including:

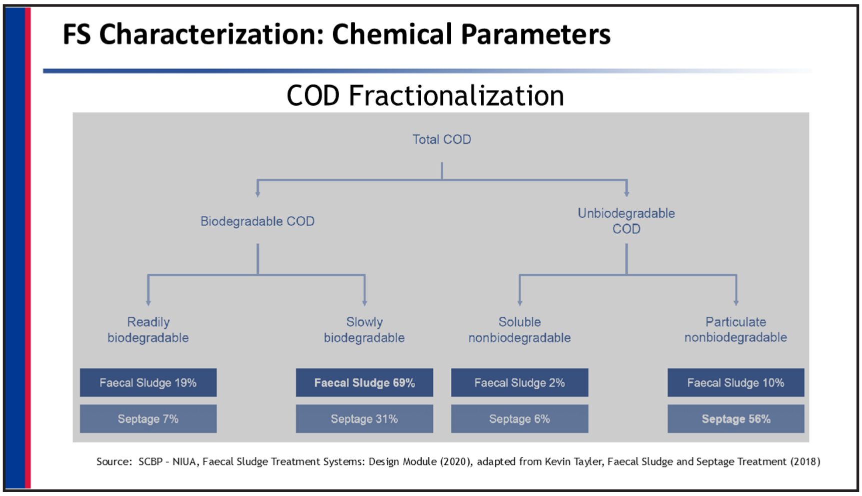
- Complex organic molecules like lignin which are resistant to biodegradation, being oxidized by COD;
- Some inorganic substances also being oxidized by COD;
- Inhibition of bacteria in the BOD test.

COD is determined in the laboratory with an open or closed reflux method, and commercial kits are also readily available (APHA/AWWA/WEF, 2005). The ratio of BOD to COD can also be used as an indicator of the relative biodegradability of the organic matter in different waste streams.
The total COD can be classified into biodegradable and non-biodegradable COD. The Biodegradable COD can be further classified into readily biodegradable and slowly biodegradable.

The slowly biodegradable COD content of fecal sludge is much higher than septage. Hence in order to stabilize the fecal sludge, anaerobic digestion with more retention time is required. The non-biodegradable COD can be further classified into soluble and particulate non-biodegradable COD.

It is important to note that septage has significantly higher amount of particulate non-biodegradable COD. This means septage does not need much stabilization and COD reduction in septage can be achieved by simply removing the suspended solids from the liquid fraction

Slide No. 11



This slide explains the fraction of COD for fresh fecal sludge and septage.

Trainer should explain that COD represents the oxygen equivalent of the organic matter that can be oxidized chemically with dichromate, a powerful chemical oxidant. The laboratory analysis of COD is more convenient than that for BOD, taking between a few minutes to hours depending on the method.

COD concentrations will be higher than BOD for a number of reasons including:

- Complex organic molecules like lignin which are resistant to biodegradation, being oxidized by COD;
- Some inorganic substances also being oxidized by COD;
- Inhibition of bacteria in the BOD test.

The fractions given in the figure relate to particular cases and actual fractions will vary, depending on local circumstances. Typical biodegradable and non-biodegradable fractions for fresh and digested faecal sludge; the figures for readily biodegradable COD are the sum of figures given for acidogenic bacteria, fermentable organic matter, and volatile fatty acids.

Slide No. 12

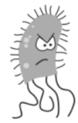
FS Characterization: Chemical Parameters

Nutrients

- Nitrogen (N), Phosphorous (P), Potassium (K)

Nutrients	Urine (%)	Feces (%)
Nitrogen	88	12
Phosphorous	67	33
Potassium	73	27

Source: Jonsson & Vinneras, Adapting the Nutrient Content of Urine and Faeces in Different Countries using FAO and Swedish Data (2004)



- Total nitrogen concentrations typically quite high (e.g. 10-100 times of domestic WW)
- Total phosphorus concentration quite high (e.g. 2-50 times of domestic WW)

Source: Linda Strande et al., Faecal Sludge Management: Systems Approach for Implementation and Operation (2014)

Fecal sludge is rich source of nutrients such as nitrogen, phosphorous and potassium. Use this slide to highlight the concentration and relate to the importance in FS analysis and treatment. Excess of any of these parameters can have health and safety affects and hence become important in analysis of characteristics of FS both before and after treatment

Depending on factors such as pH, length of storage, the presence of oxygen, and the type of FS, nitrogen will be present in a combination of the following forms; ammonium(NH4-N)/ammonia (NH3-N), nitrate (NO3-N)/nitrite (NO2-N), and organic forms of nitrogen (e.g. amino acids and amines).

Phosphorus in FS will be present as phosphate, the acid or base form of orthophosphoric acid (H3PO4 / PO4-P), or as organically bound phosphate (e.g. nucleic acids, phospholipids and phosphorylated proteins).

Fate of phosphorus in the various treatment processes will be based on factors such as sorption, precipitation, complexation, sedimentation, mineralization, pH, plant uptake in planted drying beds, and redox potential

Slide No.13

FS Characterization: Biological Parameters

Concentration of Bacteria and Helminths in Fecal Sludge

Group	Pathogen	Count
Bacteria	*Escherichia coli, Salmonella typhi, Shigella spp. Vibrio cholera*	1x10^5 CFU/ml
Helminths	*Ascaris lumbricoides, Trichuris trichura,* Hookworm	20,000- 60,000 Nos/Lit

Source: Linda Strande et al., Faecal Sludge Management: Systems Approach for Implementation and Operation (2014)

Use this slide to highlight the key groups of pathogens used to analyze FS. These are chosen for a reason of ease of measurement and indication of health hazards associated with them. The Helminthes have found to be the most difficult ones to neutralize and hence are commonly used as an indicator for assessing the safety of discharge of FS after treatment.

- Indicator organisms like Escherichia Coli (E. Coli) are often used instead of any other type of bacteria present in FS for ease of identification/measurement. E. Coli are high in number in excreta (3,000,000 CFU/100ml) and they appear exclusively in human and animal faeces.
- Coliform bacteria, fecal coliform and Enterococci are some more examples for indicator organisms.
- Helminths ('parasitic worms') are eukaryotic parasites, which are prevalent in about one third of the world's population. Helminths include nematodes (round worms), cestodes (flat worms) and trematodes (flukes).
- Ascaris lumbricoides eggs to remain viable stems from a highly impermeable eggshell, which is considered to be one of the most resistant biological structures. The shell allows the passage of essential respiratory gases while protecting the eggs from a wide array of chemicals and extreme pH conditions (Nordin et al., 2009). The monitoring of the removal of Ascaris eggs therefore provides an indication that less resistant pathogens have also been inactivated.

Slide No.-14

Comparison between FS and Sewage

Item	Type "A" (High-Strength)	Type "B" (Low-Strength)	Sewage (For comparison's sake)
Example	Public toilet or bucket latrine sludge	Septage	Tropical sewage
Characterization	**Highly concentrated, mostly fresh FS; stored for days or weeks only**	**FS of low concentration; usually stored for several years; more stabilized than Type "A"**	
COD mg/l	20,000-50,000	<15,000	500-2,500
COD/BOD	2:1 - 5:1	5:1 - 10:1	2:1
NH4-N mg/l	2,000 - 5,000	<1,000	30-70
TS mg/l	≥ 3.5%	< 3%	< 1%
SS mg/l	≥ 30,000	≈ 7,000	200-700
Helm. eggs, no./l	20,000 - 60,000	≈ 4,000	300-2,000

Faecal Sludge ≠ Sewage

(Heinss et al., 1998)

The characteristics of faecal sludge is shown in the table. The faecal sludge can be categorized as high-strength, medium strength and low strength. The table shows the comparison of characteristics high strength, low strength and sewage. Most of the parameters are in high concentration in high strength faecal sludge and lowest in sewage. This shows the difference betweent the faecal sludge and sewage

Slide No.15

Characteristics of FS across different region

Parameters	Accra (Ghana)	Accra (Ghana)	Ouagadougou (Burkina Faso.)	Bangkok (Thailand)	Alcorta (Argentina)
Type of FS	*Public toilet sludge*	*septage*	*Septage*	*septage mean (range)*	*septage mean (range)*
TS (mg/L)	52,500	12,000	19,000	15,350 (2,200 – 67,200)	(6,000 – 35,000 SS)
TVS (% of TS)	68	59	47	73	50 (VSS)
COD (mg/L)	49,000	7,800	13,500	15,700 (1,200 – 76,000)	4,200
BOD_5 (mg/L)	7,600	840	2,240	2,300 (600 – 5,500)	(750 – 2,600)
TN (mg/L)	---	---	2,100	1,100 (300 – 5,000)	190
NH_4-N (mg/L)	3,300	330	-	415 (120 – 1,200)	150

Characteristics of FS is highly variable!!!

(EAWAG, 2004)

Slide No. 16

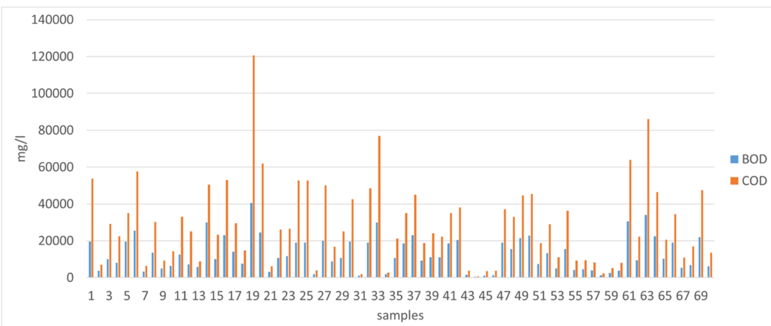
Characteristics of FS (70) sampled from containment

Parameters	Maximum	Average	Minimum
Total Solids	166400	47476	1981
Volatile Solid	89696	27971	850
Total Phosphorus	5375	621	20
Total Kjeldahl Nitrogen (TKN)	15232	5564	221
Biochemical Oxygen Demand (BOD)	40500	12829	430
Chemical Oxygen Demand (COD)	120640	28969	730

Studied between 2015 and 2020 by ENPHO

Slide No. 17

Highly variable across FS samples collected from containments



Slide No. 18

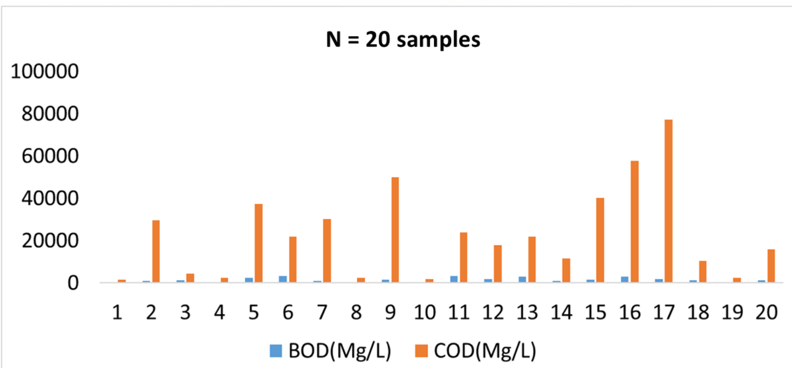
Characteristics of FS (20)samples from desludging Vehicles

Parameters	Mean (mg/l)
TSS	11,947
VS	10,551
BOD	1478
COD	23,031
TKN	937
Potassium	137
TP	156

Studied during 2022 ENPHO, PID

Slide No. 19

Variation of BOD and COD from desludging Vehicles



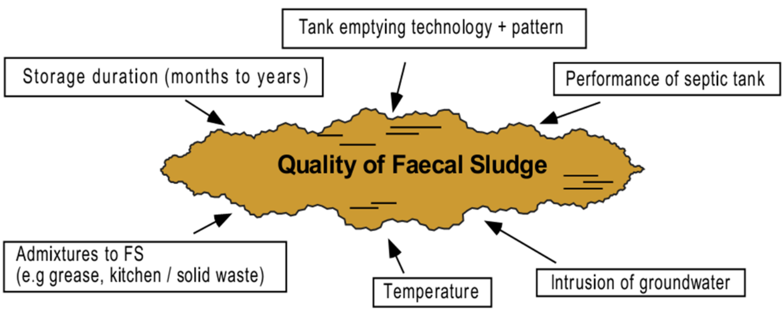
Slide No. 20

Factors Determining Characteristics

Faeces / Excreta	Wastewater	Faecal Sludge
Individual's Health	Types of source • Household • Institutional • Industrial	Characteristics of toilet/ Toilet use
Food habit	Types of Sewerage • Combine • Separate • Simplified	Storage technology
	Types of WW connected • Black water • Grey water • Storm water	Storage duration
		Storage temperature

Slide No. 21

Influencing Factors



Source: Heinss et al., 1998

Slide No. 22

Influencing factors

Storage duration:

- Depends on the type & volume of technology, quality of construction, toilet usage, inflow and infiltration;
- Digestion of organic matter that occurs during storage affects the FS characteristics;
- FS from public toilets – not stabilized and have high BOD and COD concentrations (low storage duration)
- FS from septic tank more stabilized and have low BOD and COD concentrations (high storage duration)

Slide No. 23

Influencing factors

Toilet usage:

- TS concentration depends on factors such as dry vs. flush toilet, volume of water flushed, inclusion or exclusion of grey water;
- Fat, oil and grease concentration increases with inclusion of kitchen wastewater – reduces microbial degradation;
- Filling rate increases as more waste streams enter the toilet and the number of people using the toilet;
- Chemical additives can be harmful for digestion process

Slide No. 24

Influencing factors

Inflow and infiltration:

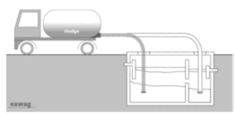
- Filling rate of systems will be slower if there is more leaching – resulting in thicker FS;
- FS leaching leads to groundwater pollution;
- Groundwater intrusion may increase the filling rate of systems – resulting in thinner FS;

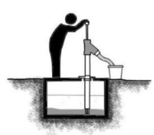
Slide No.25

Influencing factors

Collection method:

- FS at bottom is too thick to pump mechanically;
  - ➢ Usually manually emptied with shovels or water is added to decrease viscosity to enable pumping;
- FS removed by pumping is generally more dilute and less viscous than FS emptied manually;
- FS emptied from septic tanks is more dilute if more supernatant that sludge is collected, which is very common due to absence of strong vacuums & pumps.



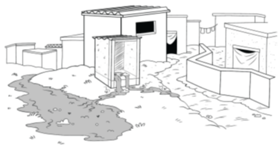


Slide No.26

Influencing factors

Climate:

- Temperature and moisture has influence on FS characteristics;
- FS mixed with rainwater is less viscous;
- Rates of biological degradation increase with warmer temperature;
- Hotter the temperature, the faster pathogens are killed.



26

Slide No. 27

Effects of various factors on FS Characteristics

Toilet Type/Use

- Dry Vs Flush Toilet
- Cleansing method (washers vs wipers)
- Inclusion or exclusion of greywater

→ ***Total Solid (TS)***

$$\text{Infiltration or Inflow} \propto \frac{\mathbf{1}}{\boldsymbol{concentration}}$$

$$\text{Storage duration} \propto \frac{1}{Organic\ matter\ (BOD), Ammonium - Nitrogen}$$

Slide No.28

Quality Parameters to be assessed for FS

Quality parameter	Required treatment process	Effect on unmanaged disposal without treatment
Organic Matter (BOD and COD) (proteins, carbohydrates, fats, organic matter)	Stabilization	Depletion of natural oxygen resources & Development of septic conditions in receiving body
Total Suspended Solid (TSS) (sand, silt, clay, mineral precipitates and decaying organic matter)	Sludge/scum segregation	Sludge deposits and anaerobic conditions when untreated discharged in the aquatic environment
Nutrients (NPK)	Stabilization	Growth of undesirable aquatic life. Lead to the pollution of groundwater when discharged to land
Pathogens	Disinfection	Human health hazard

Slide No.-29

Significance of FS for determining biological stabilization

- pH > Existence of biological life (pH: 6-9)
- VS:TS > Higher value indicates high organic matter compared to inorganic matter
- BOD:COD > A value greater than 0.5 indicates biologically treatable

Slide No. 30

Summary

- Characteristic of FS is highly variable
- Many factors determine the characteristics
- FS emptied and transported by desludging vehicles showed lower BOD as compared to FS accumulated in the containment
- **Faecal Sludge ≠ Sewage**

Slide No.31

Thank you!
धन्यवाद !

Government of Nepal
Ministry of Water Supply
National Water Supply and Sanitation Research, Innovation and Capacity Development Center
Nagarkot, Bhaktapur
Phone No:+977-1-6680171, :+977-1-6680172
Email: wash.nwssricdc@gmail.com

Technical Support

Environment and Public Health Organization (ENPHO)
110/25 Adarsa Marg-1, Thapagaon, New Baneshwor
Tel: 977-1-5244641; 5244051; 5244992; 5244609
Email: enpho@enpho.org

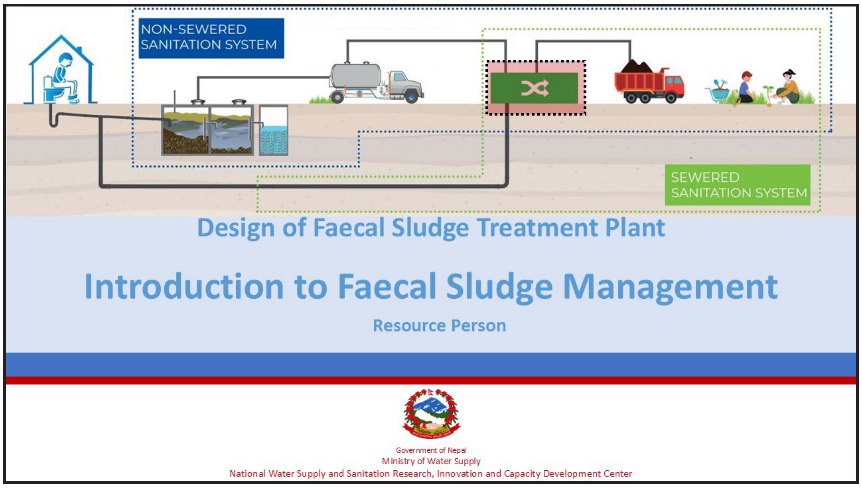
Trainer: Have participants open up the Power Point Handouts booklet (the green booklet) to the appropriate location and encourage them to take notes during the session.

Session

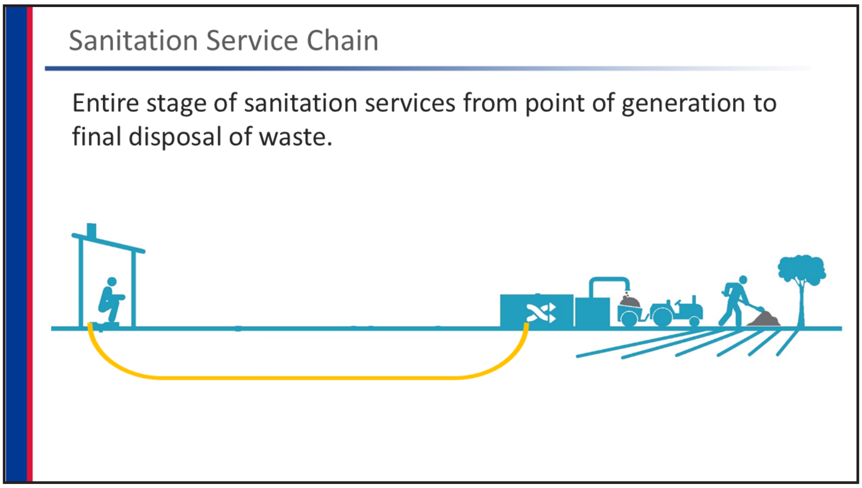
4

Introduction to Faecal Sludge Management

Slide No.1



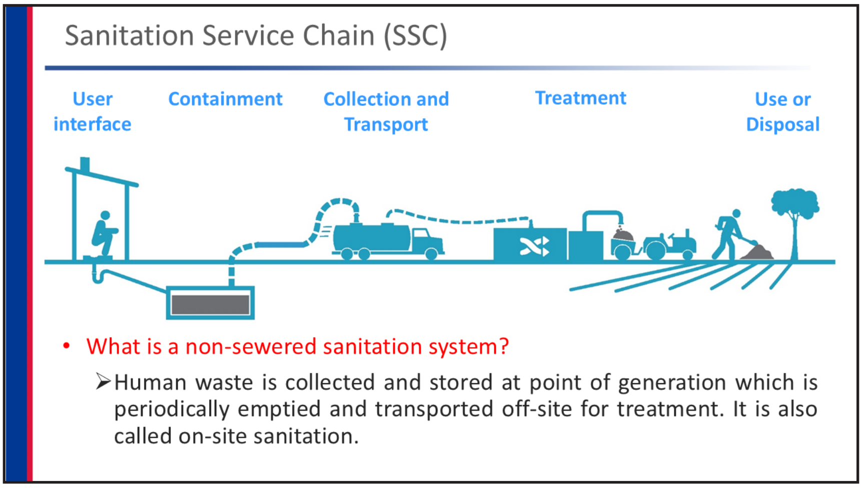
Slide No. 2



Explain that the sanitation service chain is a general term for both on-site and off-site sanitation.

Ask “What is a sewered sanitation system?” and then show definition.
Ask “What is a non-sewered sanitation system?” and then show definition.

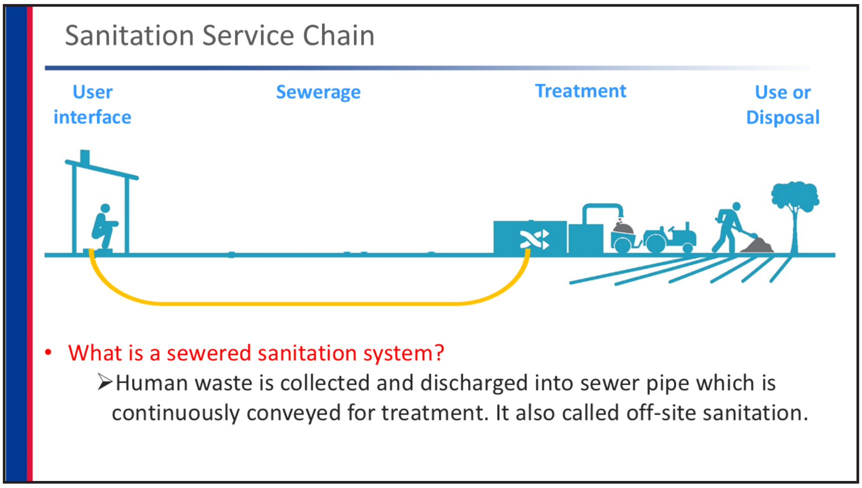
Slide No. 3



- **User interface:** Toilet, slab, superstructure, latrine accessories (e.g., anal cleansing materials, a place to dispose of menstrual hygiene products, handwashing station). May also be called: User experience, toilet, or latrine.
- **Containment:** On-site sanitation technologies need to include some type of pit, tank or chamber to safely collect and store excreta until it is removed. Treatment may or may not occur in the containment. May also be called: excreta storage.
- **Collection and transport:** Manual or mechanical methods to remove faecal sludge and transport it (e.g., vacuum trucks)
- **Treatment:** This refers to treatment after the fecal sludge is collected. It does not include the treatment that happens in the containment.
- **Use or disposal:** May also be called end-use or resource recovery. Disposal is the return of fecal sludge to the environment, ideally in a way that poses less risk to the environment and public health. Disposal is sometimes described as the containment of fecal sludge on-site. This is not disposal – it is containment.

Explain that that sanitation service chain is also called other names, like sanitation system or sanitation chain.

Slide No. 4



- **User interface:** Toilet, slab, superstructure, latrine accessories (e.g., anal cleansing materials, a place to dispose of menstrual hygiene products, handwashing station). May also be called: User experience, toilet, or latrine.
- **Containment:** On-site sanitation technologies need to include some type of pit, tank or chamber to safely collect and store excreta until it is removed. Treatment may or may not occur in the containment. May also be called: excreta storage.
- **Collection and transport:** Manual or mechanical methods to remove faecal sludge and transport it (e.g., vacuum trucks)
- **Treatment:** This refers to treatment after the fecal sludge is collected. It does not include the treatment that happens in the containment.
- **Use or disposal:** May also be called end-use or resource recovery. Disposal is the return of fecal sludge to the environment, ideally in a way that poses less risk to the environment and public health. Disposal is sometimes described as the containment of fecal sludge on-site. This is not disposal – it is containment.

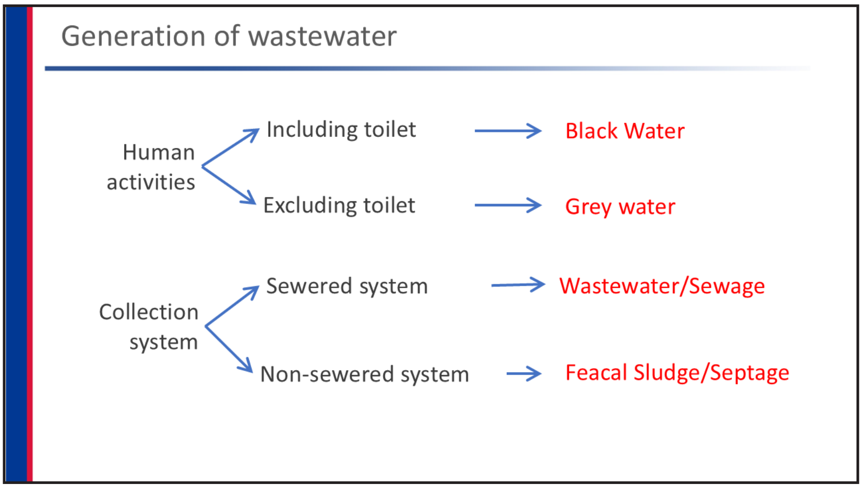
Explain that that sanitation service chain is also called other names, like sanitation system or sanitation chain.

Slide No. 5

Components of SSC

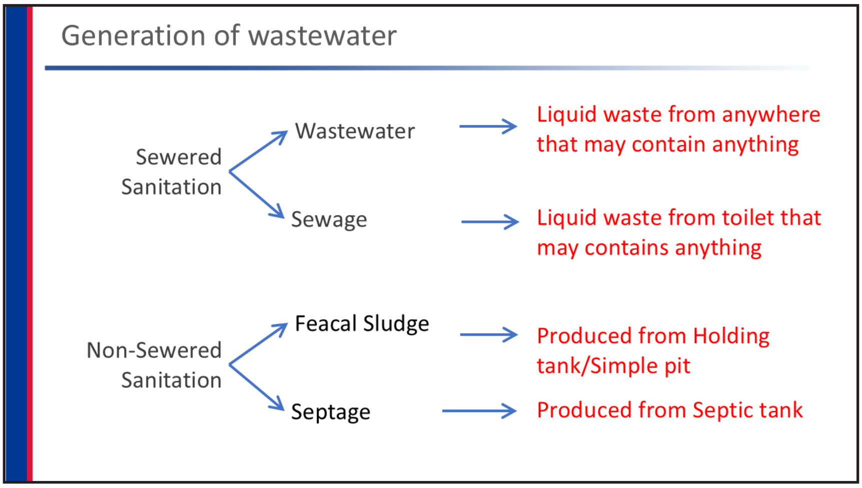
- User Interface : the ways of accessing to the sanitation system. It helps to collect human waste into containment
- Containment: the technology used to collect human waste from toilets and stored for a period. E.g. a septic tank, pit etc.
- Emptying and Transportation: taking out human waste of containment and transporting to the treatment.
- Treatment : A process of reducing pollution/contamination from human waste to safer level
- Safe Disposal/Use : disposal or use of treated water or sludge

Slide No.6



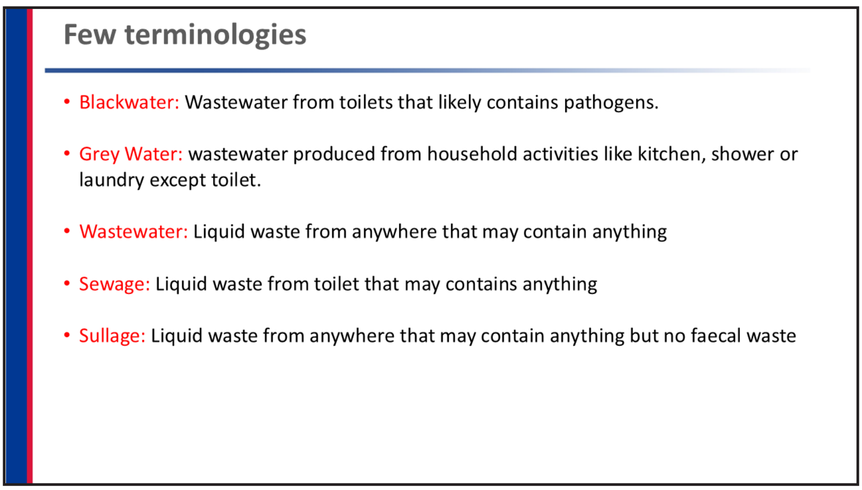
Explain that this terminology is not universal, but to avoid confusion in this workshop this is the way we will use these terms.

Slide No. 7



Explain that this terminology is not universal, but to avoid confusion in this workshop this is the way we will use these terms.

Slide No. 8



Slide No. 9

Few terminologies

- Sewer: Underground drainage/conduit that convey human waste sewage.
- Sewerage: human waste conveyance system without using vehicle.
- Faecal sludge: sludge produced from any type containment
- Septage: Fecal sludge produced from septic tank

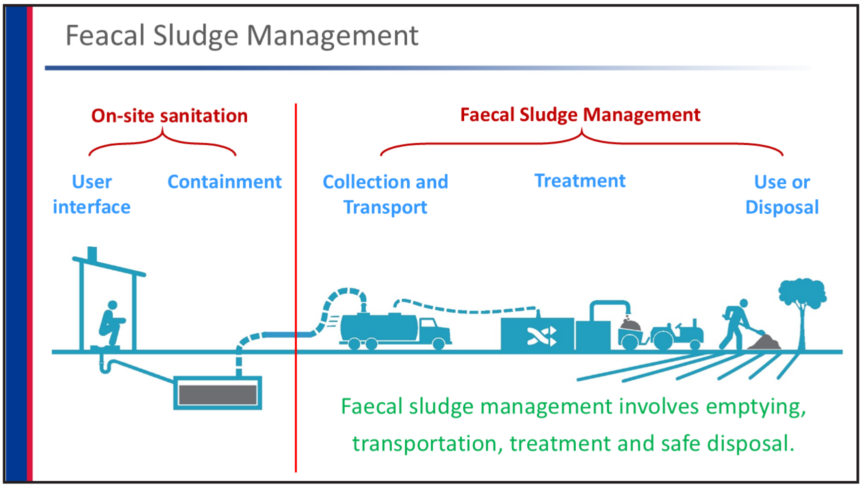
Slide No.-10

Few terminologies - by product

- Biogas: Mixture of gases produced by the fermentation of organic materials present in waste and wastewater. Gases lie CH4, CO, H are combustible.
- Treated wastewater: Effluent safe to discharge into open environment
- Compost: a stable, inoffensive product that can be safely handled and used as a soil conditioner.
- Biochar: Kind of ash produced through pyrolysis which is the process of burning in the absence of air or oxygen.

Reference: Metcalf & Eddy, Inc. 2003MMecalfandEddy2003ecalfandEddy2003

Slide No. 11



- **User interface:** Toilet, slab, superstructure, latrine accessories (e.g., anal cleansing materials, a place to dispose of menstrual hygiene products, handwashing station). May also be called: User experience, toilet, or latrine.
- **Containment:** On-site sanitation technologies need to include some type of pit, tank or chamber to safely collect and store excreta until it is removed. Treatment may or may not occur in the containment. May also be called: excreta storage.
- **Collection and transport:** Manual or mechanical methods to remove faecal sludge and transport it (e.g., vacuum trucks)
- **Treatment:** This refers to treatment after the fecal sludge is collected. It does not include the treatment that happens in the containment.
- **Use or disposal:** May also be called end-use or resource recovery. Disposal is the return of fecal sludge to the environment, ideally in a way that poses less risk to the environment and public health. Disposal is sometimes described as the containment of fecal sludge on-site. This is not disposal – it is containment.

Explain that that sanitation service chain is also called other names, like sanitation system or sanitation chain.

Slide No. 12

Why FSM: Financial Aspect

Source:
Capital and Operating Costs of Full-Scale Fecal Sludge Management and Wastewater Treatment Systems in Dakar, Senegal
Pierre-Henri Dodane,[†] Mbaye Mbéguéré,[‡§] Ousmane Sow,[§] and Linda Strande[*‡]

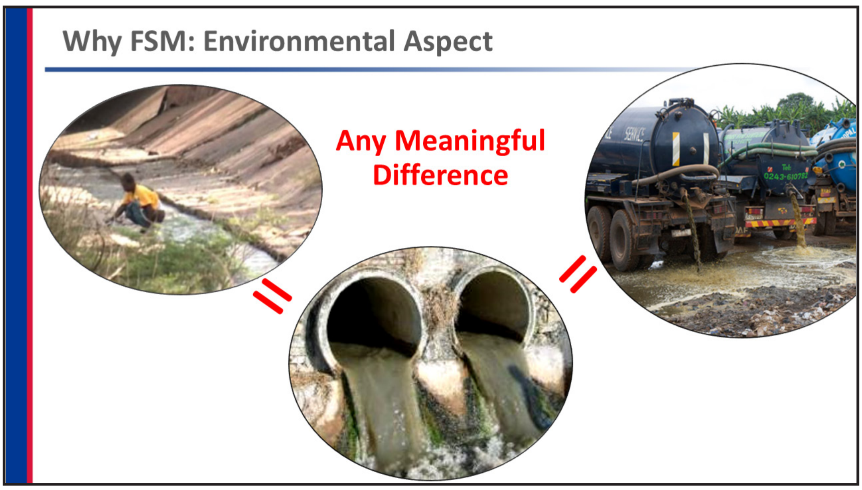
Slide No.13

Why FSM: Technical Aspect

- Gradient - Need Pumping system in plain terrain
- Scatter community : Not possible to collect wastewater from all the communities
- Coverage : Not possible to provide service to 100% people
- Engagement : engagement of people, private and public sector

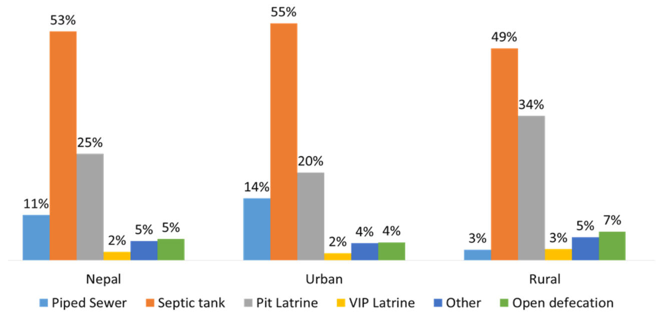
Slide No.14

Slide No. 15



Slide No.16

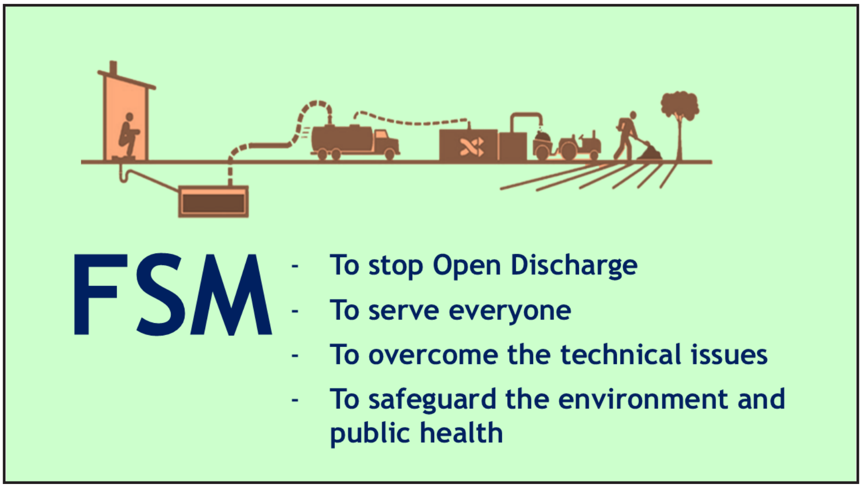
Why FSM: Social Aspect



Slide No.17

Why FSM: Social Aspect

Slide No.18



Slide No. 19

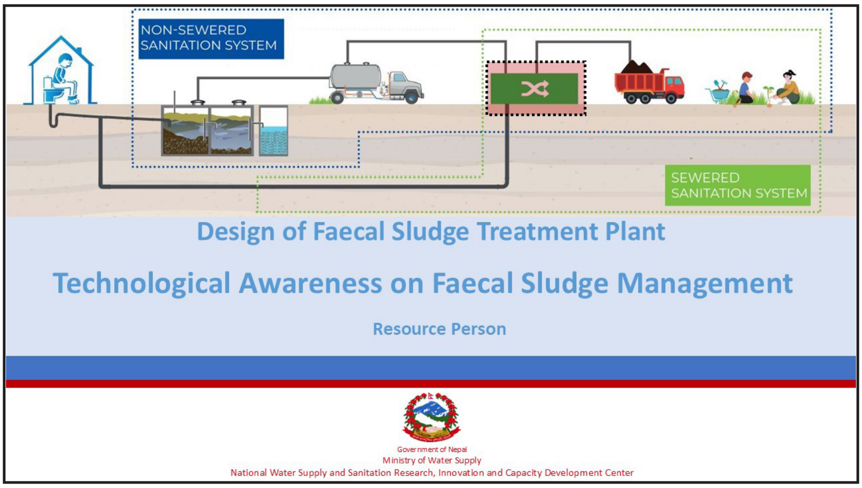
Trainer: Have participants open up the Power Point Handouts booklet (the green booklet) to the appropriate location and encourage them to take notes during the session.

Session

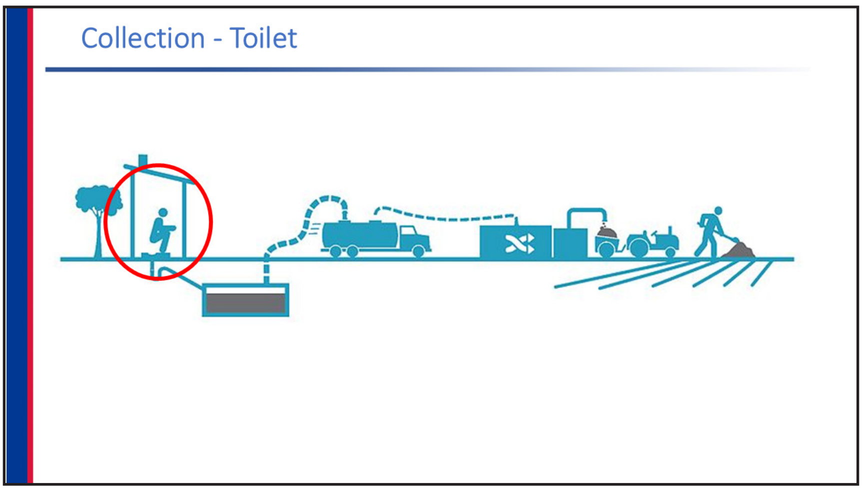
5

Technological Awareness on Faecal Sludge Management

Slide No. 1



Slide No. 2



Slide No.3

Is your Latrine “Hygienic” ?

A “hygienic latrine” is defined as a sanitation facility, which effectively breaks the cycle of disease transmission.

Criteria for a “hygienic latrine”:

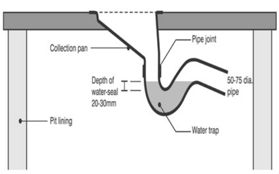
- Clean with no feacal traces
- Seal the passage between toilet and the containment >>
- Venting out of foul gases >> proper ventilation

A hygienic latrine would include all of the following:

1. Clean with no feacal traces
2. Sealing of the passage between the squat hole and the pit to effectively block pathways for flies and other insect vectors, thereby breaking the cycle of disease transmission, and
3. Venting out of foul gases generated in the pit through a properly positioned vent pipe to keep latrine odor free and encourage its continual use.

Slide No. 4

Sealing the passage….



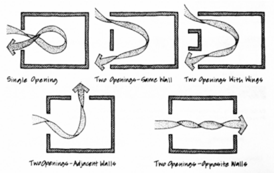
©Internet

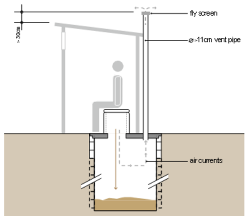
Water Seal

SaTo Pan: “Seal” with Counterweight Mechanism

Slide No. 5

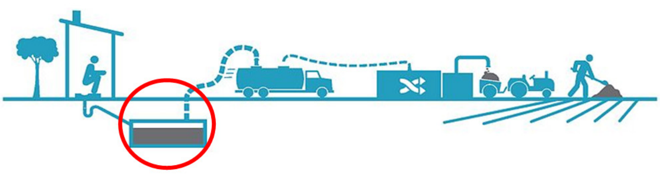
Venting out the odour





Slide No. 6

Confinement of Waste (In Containments)



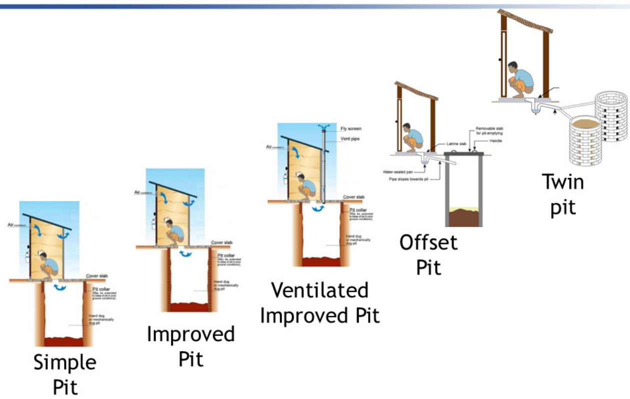
Slide No. 7

Types of Containment

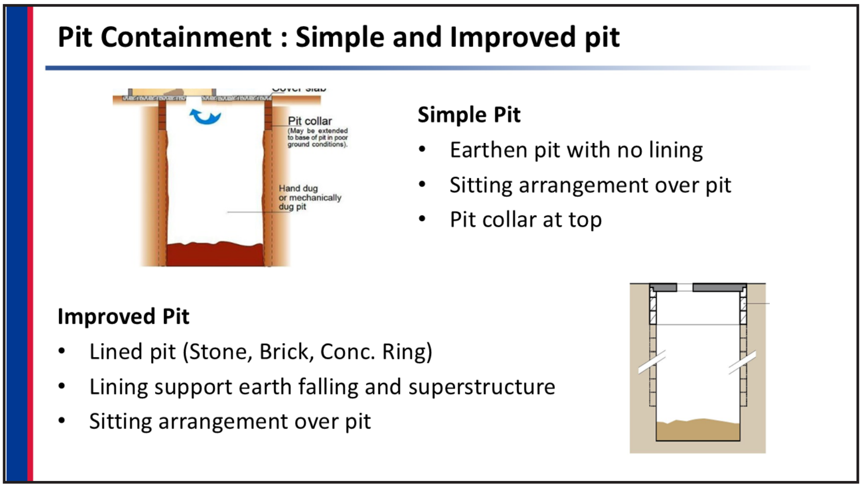
- Pit containment
  - Simple pit/Dry pit
  - Improved/Simple lined pit
  - Ventilated Improved pit
  - Single offset pit
  - Twin pits/Double offset pit
  - Holding tank
- Septic Tank
- Biogas Digester
- Ecosan Vault

Slide No. 8

Types of Pits

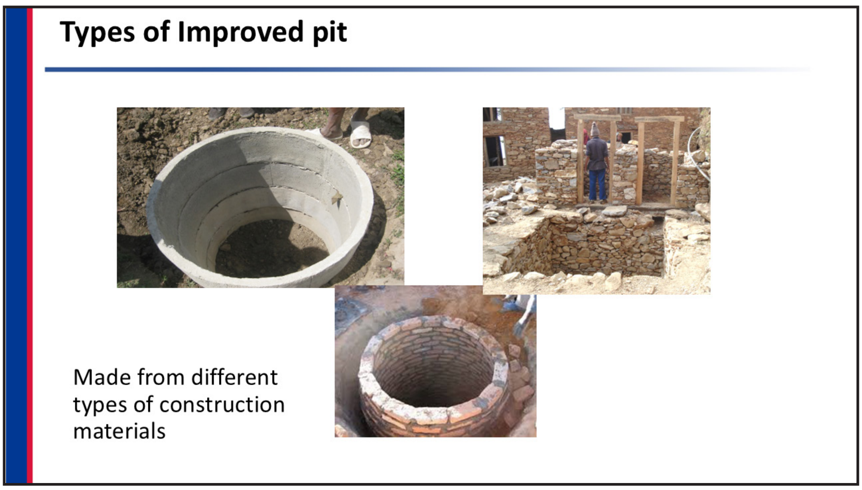


Slide No. 9



- The volume of pit should be designed to contain at least 1000 lt.
- The pit should be at least 4’ to 6’ deep and 3’ to 4’ round or square (if the pit diameter is more then there is increased risk of collapse).
- The bottom of pit should be at least 6’ above groundwater table (rule of thumb).
- The pit should be constructed at least 90’ away from the water source.
- In case of reusing of the pit, the pit should be lined with brick or stone masonry.
- The pit lining extends at least 3’ below ground level (deeper if the soil is unstable).
- The bottom of the pit should be unlined to allow infiltration of liquid out of pit.

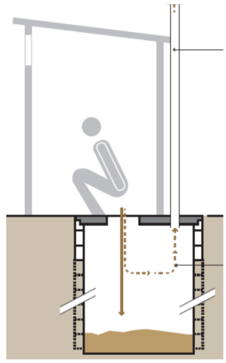
Slide No. 10



Slide No. 11

Pit Containment : VIP

- Lined pit
- With vent pipe to scape gas out
- Vent pit – Black and above eye level
- Sitting arrangement over pit

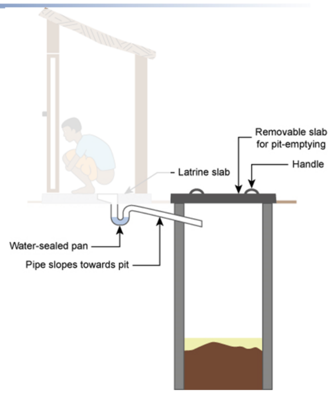


- The vent pipe should have an internal diameter of at least 4" and reach more than 1' above the highest point of the toilet superstructure.
- The mesh size of the fly screen must be large enough to prevent clogging with dust and allow air to circulate freely. Aluminum screens, with a hole-size of 1.2mm to 1.5 mm, have proven to be the most effective.

Slide No. 12

Pit Containment : Offset Pit

- Lined pit
- (With) vent pipe to scape gas out
- Sitting arrangement aside the pit
- Easy to desludge
- Most popularly used in Nepal



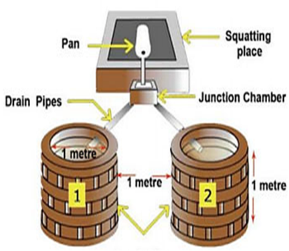
- The vent pipe should have an internal diameter of at least 4" and reach more than 1' above the highest point of the toilet superstructure.
- The mesh size of the fly screen must be large enough to prevent clogging with dust and allow air to circulate freely. Aluminum screens, with a hole-size of 1.2mm to 1.5 mm, have proven to be the most effective.

Slide No. 13

Ventilated Improved Pit (VIP)

Slide No. 14

Pit Containment : Twin pits



- Two pits are used alternatively
- Manhole is provided to divert flow
- Generally, know as Sulav Toilet
- Sludge is taken out after dried (2 years)
- 1 m space between two pit

In this system also, the pits are used ulternatively. It is used for flush toilets where diversion system is installed to use the pits alternatively.

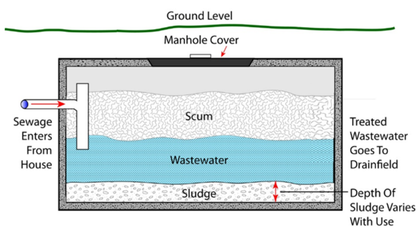
Slide No. 15

Twin pits

Slide No.16

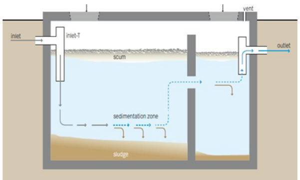
Holding Tank

- Generally rectangular in shape and bigger in size
- Leaky wall
- Only hold wastewater
- No outlet
- Need frequent desludging



Slide No. 17

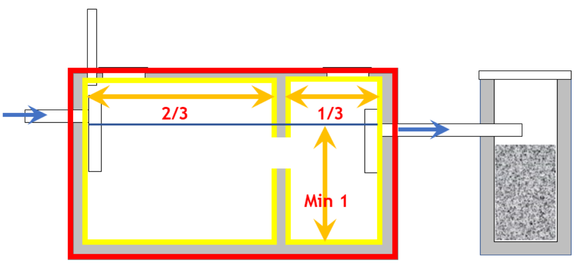
All Rectangular tank is not Septic tank



- Double chambered
- Water seal
- Have outlet connected to Soak pit
- Treat wastewater up to 40%

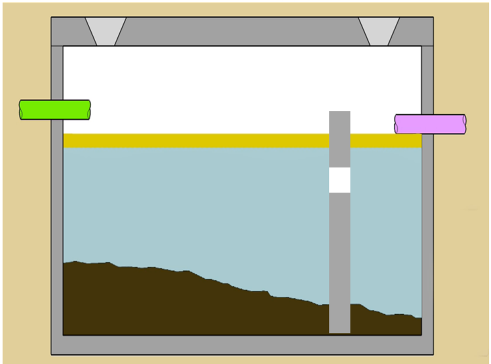
Slide No. 18

Septic Tank



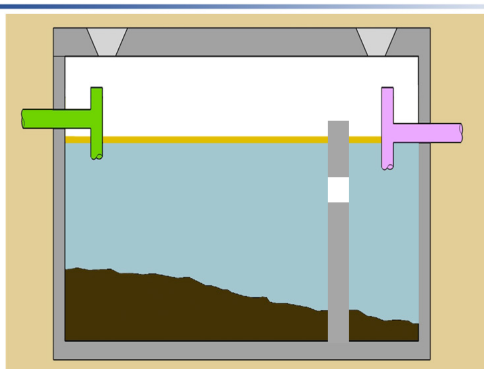
Slide No. 19

Importance of proper inlet and outlet in Septic Tank



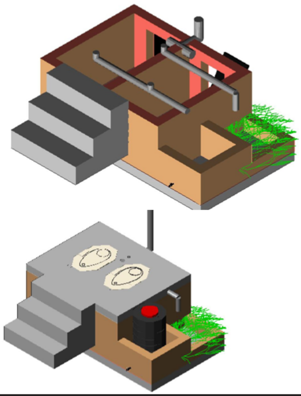
Slide No. 20

Importance of proper inlet and outlet in Septic Tank



Slide No. 21

Dry Ecosan Vault



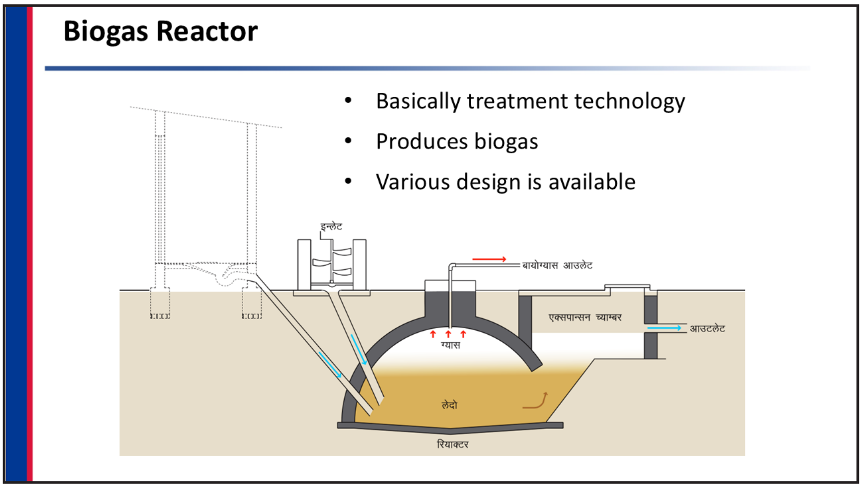
- Also called UDDT
- Collects only feaces and additives
- Constructed above ground
- Two vault is used alternatively for 6 months
- Emptied after 1 year

In this type of toilet, urine and excreta are collected separately. Excreta is collected in dehydration vaults where ashes is applied after each defecation. Urine are collected in plastic container. The anal cleansing water is connected to soak pit/wetland. The dehydration vaults are used alternatively.

Slide No.22

Dry Ecosan

Slide No. 23



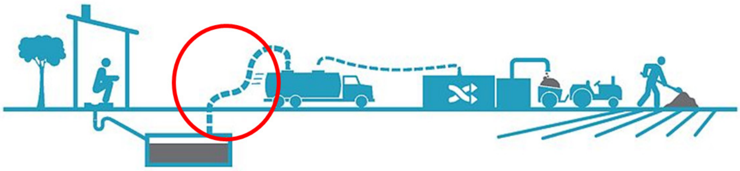
The popular biogas in Nepal is Gober gas. In this type of biogas plant, the animal exceta(especially from cows, buffalo) are used for biogas plant in which the excreta from household toilet is also connected. Organic waste are also mixed. The biogas obtained is used for cooking. The digested sludge obtained is called bio-slurry which is used in farming.

Slide No. 24

The popular biogas in Nepal is Gober gas. In this type of biogas plant, the animal exceta(especially from cows, buffalo) are used for biogas plant in which the excreta from household toilet is also connected. Organic waste are also mixed. The biogas obtained is used for cooking. The digested sludge obtained is called bio-slurry which is used in farming.

Slide No. 25

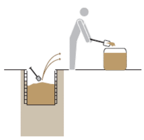
Desludging Service



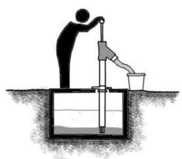
Slide No.26

Methods of Desludging

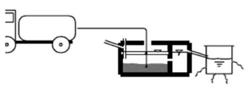
- Manual Desludging



- Semi Mechanized Desludging



- Fully Mechanized Desludging



Slide No. 27

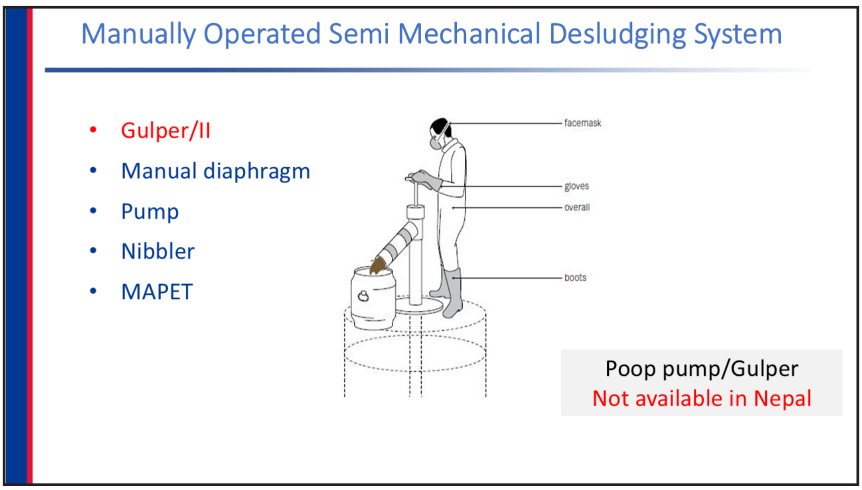
-The first picture is desludging of septic tank or pit whereas the second picture is desludging of containment of a dry ecosan toilet.

Dry ecosan toilet:

- Is a urine diverting dry toilet (UDDT) that operates without water. It uses a differently designed pan or comode which separates feces and urine.
- Thus, separated feces is composted and used as a soil conditioner andurine is used as liquid fertilizer.
- It was introduced in 2002 by ENPHO in Nepal.

Manual desludging, in general is not safe, and is also prohibited by the government. However manual desludging of dry ecosan toilet and sulav toilet is safe.

Slide No.-28



Poop pump/Gulper is a manual operated pump which is used to pump out sludge from containment. This is basically useful and financially viable both for an entrepreneur and house owner to empty small sized containment. This equipment is not available in Nepal till date.

Slide No. 29

GULPERS

Motorized Gulper Manual Gulper

Gulpers are used for collecting sludge in Faridpur Municipality

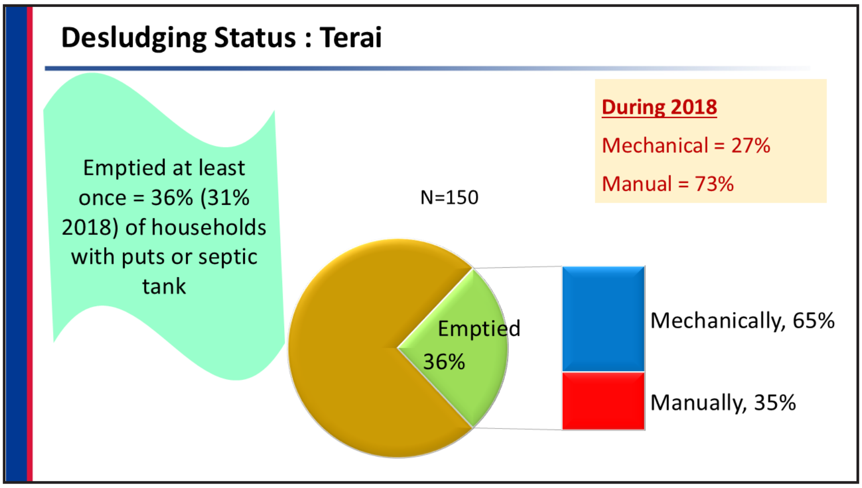
Slide No. 30

Mechanical Emptying Using a Vacuum Tanker

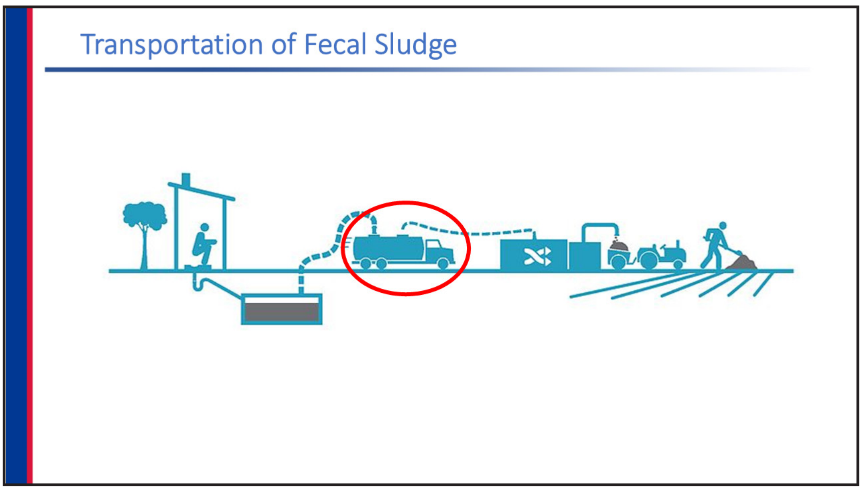
Vacutug mini-tanker manufactured in Bangladesh. Source: EAWAG/SANDEC (2008)

- A small-scaled motorised alternative to trucks.
- Designed for areas where big trucks can not enter.
- 0.5 m3 steel vacuum tank, vacuum pump, gasoline engine.
- The vehicle has a speed of 5 km/h (level ground)
- Emptied by gravity or pressure

Slide No.31



Slide No. 32



Slide No. 33

Slide No. 34

Desludging service is growing in the city. There are several companies who provide desludging service in the cities.

Interesting fact is, sewer line is laid down to collect fecal matter but discharging of fecal sludge into the drain is illegal. Since there is not sufficient treatment facilities in the cities, these companies discharge sludge into river via sewer, or open land. Some of the private companies dispose FS openly into their own land.

Most of the companies discharge it in a designated place with small intervention making discharge station and it goes into sewer network whereas few companies/service providers are dumping it into their private land away from the city area.

Average cost for desludging is 3-5 thousand, depending up on cities, haulage distance and containment volume

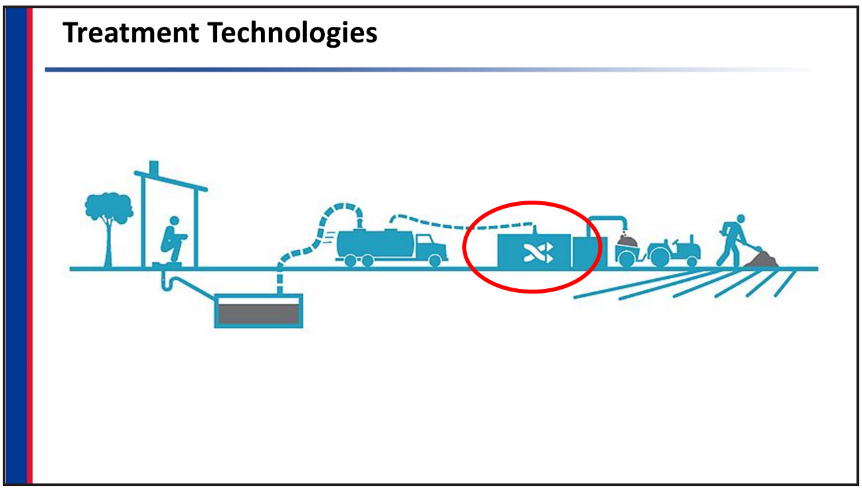
Slide No. 35

Any Question ?

Break

Trainer: Have participants open up the Power Point Handouts booklet (the green booklet) to the appropriate location and encourage them to take notes during the session.

Slide No. 36



Slide No.37

Based on treatment Location

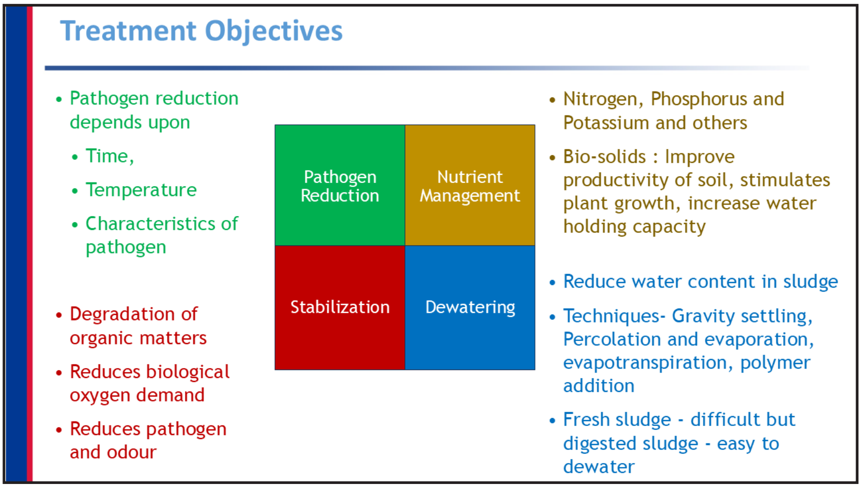
- On-site Treatment (Decentralized)
- Off-site Treatment (Centralized)

Slide No. 38

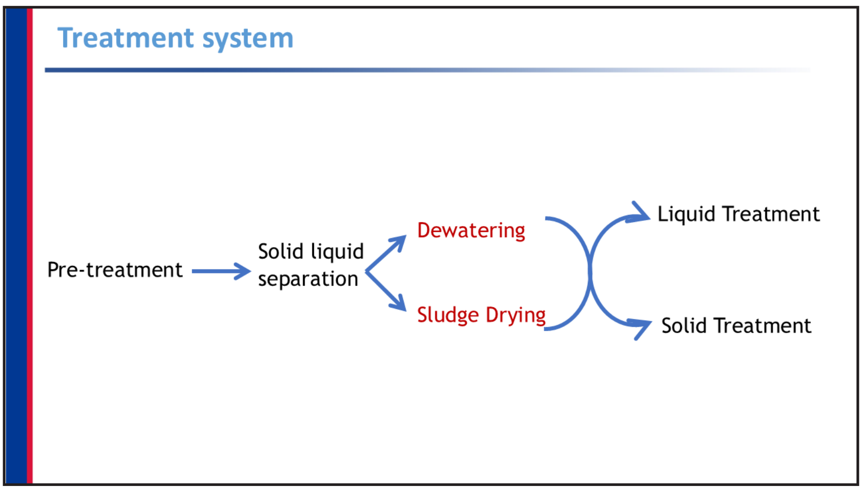
Based on treatment mechanism

- Nature based/Biological Treatment
- Mechanical Treatment
- Hybrid treatment
- Innovative Technologies

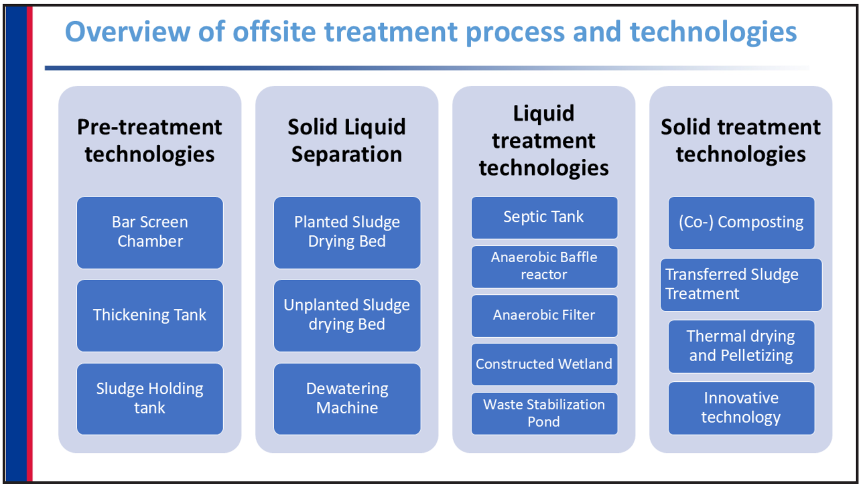
Slide No. 39



Slide No.40

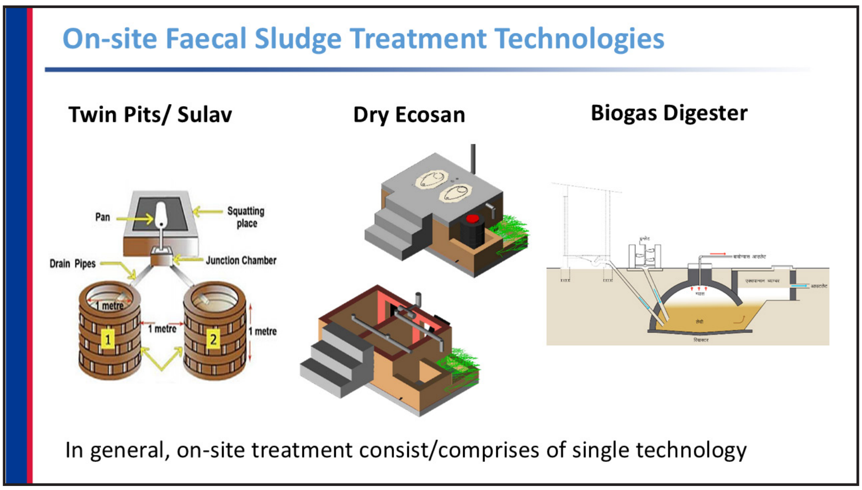


Slide No. 41



These are some of the example of treaetment technologies under various stages of treatment process. There could be more to this example

Slide No. 42



Twin-pit for pour-flush toilets are improved **pit latrines**, which allow on-site treatment and transformation of fecal sludge into a hygienized soil amendment.

This technology consists of two alternating pits connected to a pour flush toilet. Fecal sludge is collected in the pits and allowed to slowly infiltrate into the surrounding soil. Over time, the solids are sufficiently dewatered and can be manually removed with a shovel and reused on-site, much like compost, to improve soil fertility and fertilize crops

Slide No. 43

Slide No.-44

Passing through a barrier, Screening - solids are screened by various barriers depending on the size of the solids.

Coarse material, such as rocks, sticks, leaves, plastics and other debris, should be removed because they could damage pumps or settlers. Screening devices such as bar racks and screens are recommended for this kind of pre-treatment

Slide No. 45

Bar Screen

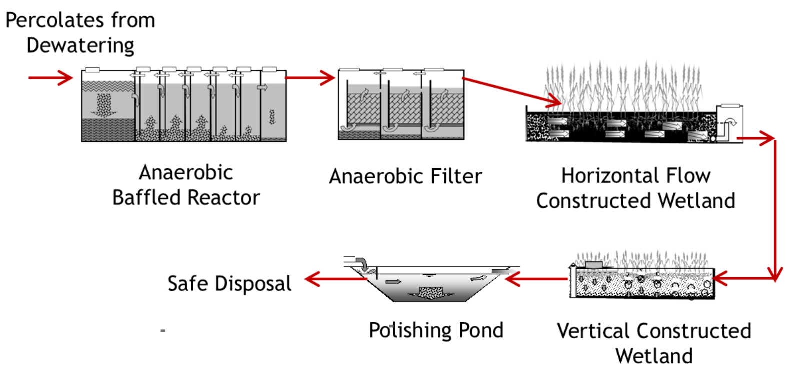
- It is imperative to remove municipal waste and large soild objects from the faecal sludge.
- Prevents clogging and pump failures thus enhancing the value of treatment endproducts.
- Installed in a vertical or inclined position against the incoming flow make a physical barrier that retains coarse solids.

Passing through a barrier, Screening - solids are screened by various barriers depending on the size of the solids.

Coarse material, such as rocks, sticks, leaves, plastics and other debris, should be removed because they could damage pumps or settlers. Screening devices such as bar racks and screens are recommended for this kind of pre-treatment.

Slide No. 46

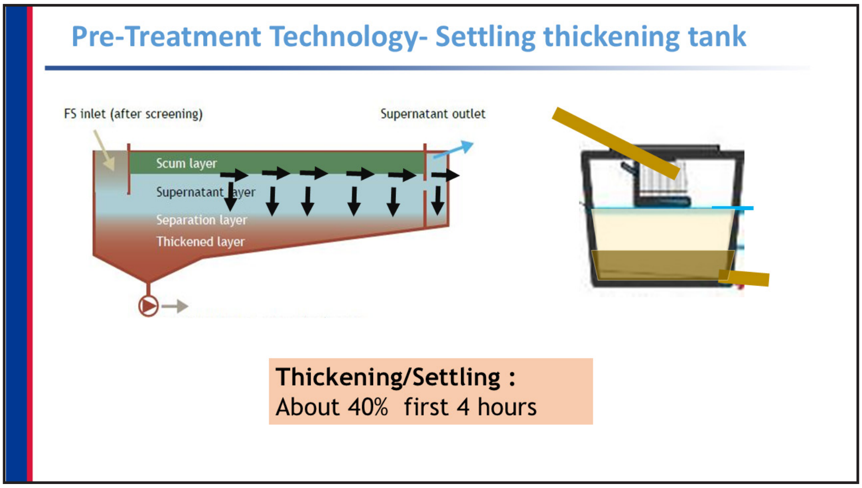
Liquid treatment system



Passing through a barrier, Screening - solids are screened by various barriers depending on the size of the solids.

Coarse material, such as rocks, sticks, leaves, plastics and other debris, should be removed because they could damage pumps or settlers. Screening devices such as bar racks and screens are recommended for this kind of pre-treatment.

Slide No. 47



Settling thickening tank : for solid and liquid separation.

Primarily used also in wastewater treatment plant.

It is designed with settling velocity more than the flow velocity due to which the solid particle retains below and only supernatant passes out outlet.

The FS should undergo screening before input to settling tank to avoid the solidwaste in the tank.

There are mainly 3 layers in the tank: scum layer, supernatant layer and thickened sludge layer

scum layer: oil and grease that floats in liquid

supernatant layer: layer with liquid portion

thickened sludge layer: layer of sludge at bottom which has thickened over time due to addition of sludge on top of eachother

The mean settling efficiency of operating tanks and ponds is about 50-60% of SS in the settled volume. This efficiency can reach up to 80% where the tanks have been adequately designed and operated (Heinss et al., 1999).

Slide No. 48

Settling thickening tank

- Separate solid and liquid fractions of faecal sludge
- Rectangular tanks in which FS is discharged into an inlet at the top of one side and the supernatant exists through an outlet situated at the opposite side.
- Settled solids are retained at the bottom of the tank, and scum floats on the surface
- Can be used in any climate, but are especially beneficial when treating FS with a relatively low solids concentration, and/or in temperate or rainy climates

Settling thickening tank : for solid and liquid separation

Primarily used also in wastewater treatment plant

It is designed with settling velocity more than the flow velocity due to which the solid particle retains below and only supernatant passes out outlet.

The FS should undergo screening before input to settling tank to avoid the solidwaste in the tank.

There are mainly 3 layers in the tank: scum layer, supernatant layer and thickened sludge layer

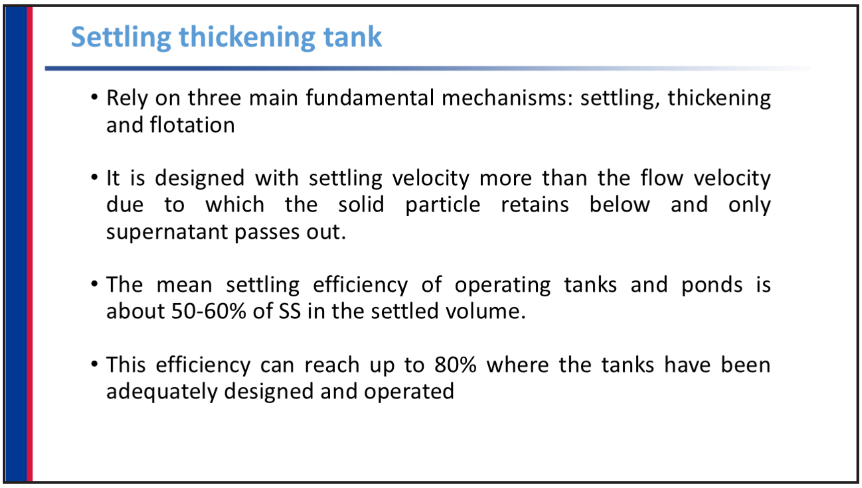
scum layer: oil and grease that floats in liquid

supernatant layer: layer with liquid portion

thickened sludge layer: layer of sludge at bottom which has thickened over time due to addition of sludge on top of each other

The mean settling efficiency of operating tanks and ponds is about 50-60% of SS in the settled volume. This efficiency can reach up to 80% where the tanks have been adequately designed and operated (Heinss et al., 1999).

Slide No. 49



Settling thickening tank : for solid and liquid separation

Primarily used also in wastewater treatment plant

It is designed with settling velocity more than the flow velocity due to which the solid particle retains below and only supernatant passes out outlet.

The FS should undergo screening before input to settling tank to avoid the solidwaste in the tank.

There are mainly 3 layers in the tank: scum layer, supernatant layer and thickened sludge layer

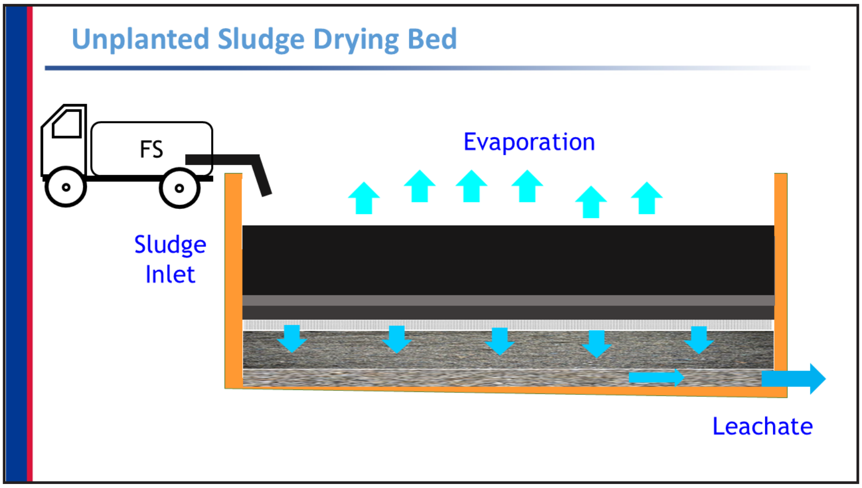
scum layer: oil and grease that floats in liquid

supernatant layer: layer with liquid portion

thickened sludge layer: layer of sludge at bottom which has thickened over time due to addition of sludge on top of eachother

The mean settling efficiency of operating tanks and ponds is about 50-60% of SS in the settled volume. This efficiency can reach up to 80% where the tanks have been adequately designed and operated (Heinss et al., 1999).

Slide No.-50



When the sludge is applied at the top, the dewatering process occurs by filtration from filter bed where solid retains and leachate is drain out from drainage pipe at the bottom. Besides filtration, evaporation also plays important role in dewatering Dried sludge is obtained from this treatment technology

Slide No.-51

Unplanted Sludge Drying Bed

- A simple, permeable bed that, when loaded with sludge, collects percolated leachate and allows the sludge to dry by evaporation
- Approximately 50% to 80% of the sludge volume drains off as liquid or evaporates.
- The drainage pipes are covered by 3-5 graded layers of gravel and sand.
- The bottom layer should be coarse gravel and the top fine which is 250 to 300 mm thick
- To improve drying and percolation, sludge application can alternate between two or more beds.

Unplanted drying bed is one of the established technology for sludge dewatering. The bed consists of filter media of 40 cm depth with 20 cm depth of 15-30 mm size gravel layer at bottom, 10 cm depth of 7-15mm size gravel at middle and 10cm of 0.2-0.6mm size sand layer at top. Generally the it is designed for sludge layer of 30cm.

Slide No. 52

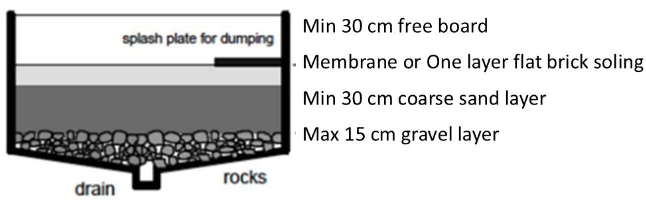
Unplanted Sludge Drying Bed

- Dried sludge can be removed after 10 to 15 days, but this depends on the climate conditions
- An effective way to decrease the volume of sludge, which is especially important when it has to be transported elsewhere for further treatment, end-use or disposal.
- Appropriate for small to medium communities with populations up to 100,000 people
- Best suited for rural and peri-urban areas

Unplanted drying bed is one of the established technology for sludge dewatering. The bed consists of filter media of 40 cm depth with 20 cm depth of 15-30 mm size gravel layer at bottom, 10 cm depth of 7-15mm size gravel at middle and 10cm of 0.2-0.6mm size sand layer at top. Generally the it is designed for sludge layer of 30cm.

Slide No. 53

Unplanted Sludge Drying Bed



Parameters	Removal Rates
Suspended solids	≥ 95%
COD	70-90%
NH_4	40-60%

©BORDA/CDD

Unplanted drying bed is one of the established technology for sludge dewatering. The bed consists of filter media of 40 cm depth with 20 cm depth of 15-30 mm size gravel layer at bottom, 10 cm depth of 7-15mm size gravel at middle and 10cm of 0.2-0.6mm size sand layer at top. Generally the it is designed for sludge layer of 30cm.

Slide No. 54

Unplanted Sludge Drying Bed

Pros

- Good dewatering efficiency, especially in dry and hot Climates
- Can be built and repaired with locally available materials
- Relatively low capital costs; low operating costs
- Simple operation, No electrical energy is required

Cons

- Requires a large land area
- Labour intensive removal
- Limited stabilization and pathogen reduction
- Requires expert design and construction
- Leachate requires further treatment

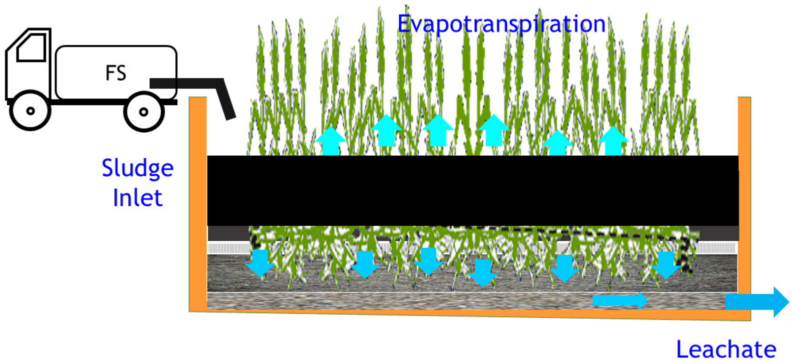
Slide No. 55

Unplanted Sludge Drying Bed

Example of the unplanted sludge drying bed

Slide No. 56

Planted Sludge Drying Bed



Slide No. 57

Planted Sludge Drying Bed

- Similar to an Unplanted Drying Bed, but has the added benefit of transpiration and enhanced sludge treatment due to the plants
- Ventilation pipes connected to the drainage system contribute to aerobic conditions in the filter.
- A general design for layering the bed include: (1) 250 mm of coarse gravel, (2) 250 mm of fine gravel and (3) 100 to 150 mm of sand
- Free space of 1 m should be left above the top of the sand layer to account for about 3 to 5 years of accumulation.

Slide No. 58

Planted Sludge Drying Bed

- Reeds, cattails antelope grass and papyrus are suitable plants, depending on the climate.
- Sludge should be applied in layers between 75 to 100 mm thick and reapplied every 3 to 7 days
- Sludge application rates varies from100 to 250 kg/m2/year in warm tropical climates and in colder climates, rates up to 80 kg/m2/year
- Effective at decreasing the sludge volume (down to 50%) through decomposition and drying

Slide No. 59

Planted Sludge Drying Bed

Pros

- Can handle high loading
- Better sludge treatment than in Unplanted Drying Beds
- Relatively low capital costs; low operating costs

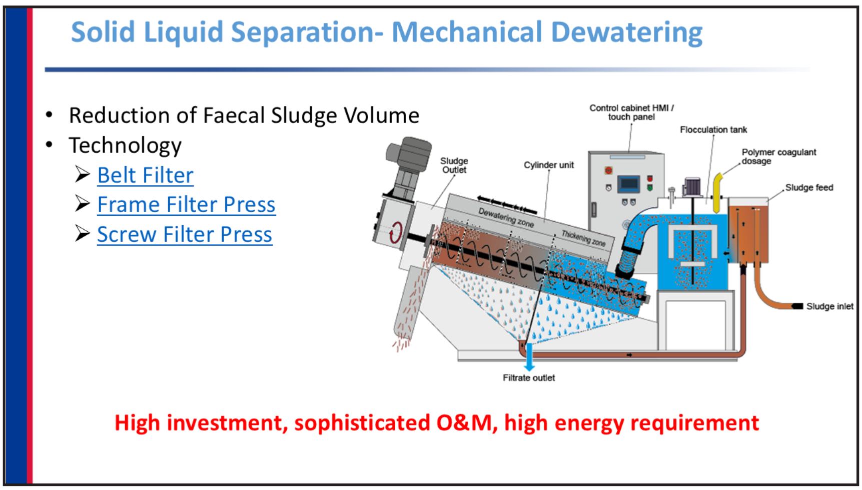
Cons

- Requires a large land area
- Labour intensive removal
- Requires expert design and construction
- Leachate requires further treatment

Slide No. 60

- Depth and characteristics of filter media same as unplanted drying bed
- Plantation of reeds, cana, cattails, bulrushes, etc on filter media
- Sludge dewatered by filtration, evaporation and evapo-transpiration
- Liquid fraction flows vertically downwards through media and is collected at bottom and treated separately
- Sludge retention time is 2-3 years depending on sludge loading rate TS

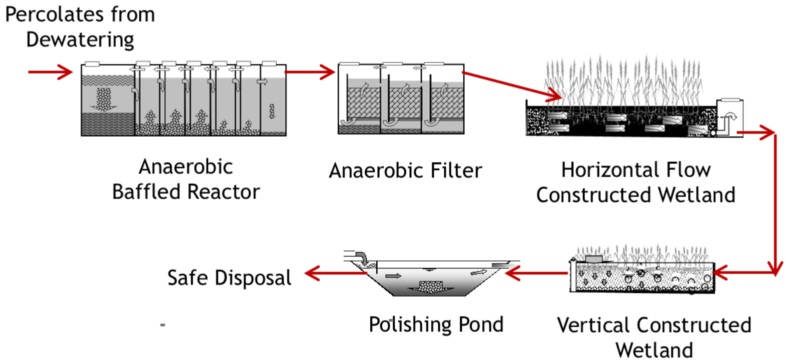
Slide No. 61



- Mechanical dewatering conducted by machine process such as centrifugation or pressing.
- belt filter: sludge compressed between two belts.
- centrifuge: cylinder rotating around its horizontal axis, due to the centrifugal force
- frame filter press: porous vertical frames fixed in two walls that are positioned in front one of the other to create a chamber.
- screw press: rotational screw placed in a perforated cylinder
- Mobile Dewatering-

Slide No. 62

Liquid treatment system



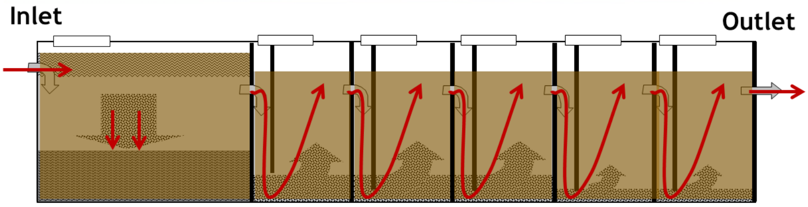
Slide No. 63

Anaerobic Baffle Reactor

- Anaerobic treatment (in the absence of oxygen)
- Wastewater passes a series of up-flow chambers
- Bacteria mass (activated sludge) at bottom of each chamber
- Further treatment (degradation) of suspended and dissolved solids by anaerobic bacteria
- Efficiency 75%- 85%
- Desludging is needed only if excess sludge is generated

Slide No. 64

Anaerobic Baffle Reactor



- This is Secondary treatment unit consisting series of up-flow chamber

Slide No. 65

Anaerobic Baffle Reactor

- It functions under anaerobic digestion
- Liquid comes in contact with the activated sludge (bacteria mass) and dissolved/suspended matters undergoes into degradation by anaerobic bacteria
- The increased contact time with the active biomass (sludge) results in improved treatment
- Critical design parameters include
  - a hydraulic retention time (HRT) between 48 to 72 hours
  - upflow velocity of the wastewater below 0.6 m/h
  - the number of upflow chambers (3 to 6)

- Anaerobic treatment (in the absence of oxygen)
- Wastewater passes a series of up-flow chambers
- Bacteria mass (activated sludge) at bottom of each chamber
- Further treatment (degradation) of suspended and dissolved solids by anaerobic bacteria
- Efficiency 75%- 85%
- Desludging is needed only if excess sludge is generated

Slide No. 66

- Anaerobic treatment (in the absence of oxygen)
- Wastewater passes a series of up-flow chambers
- Bacteria mass (activated sludge) at bottom of each chamber
- Further treatment (degradation) of suspended and dissolved solids by anaerobic bacteria
- Efficiency 75%- 85%
- Desludging is needed only if excess sludge is generated

Slide No. 67

- Anaerobic treatment (in the absence of oxygen)
- Wastewater passes a series of up-flow chambers
- Bacteria mass (activated sludge) at bottom of each chamber
- Further treatment (degradation) of suspended and dissolved solids by anaerobic bacteria
- Efficiency 75%- 85%
- Desludging is needed only if excess sludge is generated

Slide No. 68

Anaerobic Baffle Reactor

Pros

- Resistant to organic and hydraulic shock loads
- No electrical energy is required
- Low operating costs
- Long service life
- High reduction of BOD

Cons

- Requires expert design and construction
- Low reduction of pathogens and nutrients
- Effluent and sludge require further treatment and/or appropriate discharge

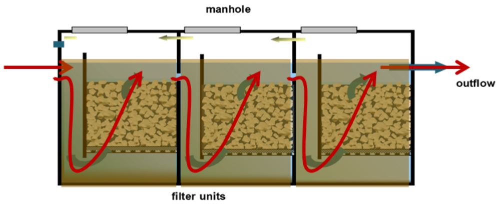
Slide No. 69

Anaerobic Filter

- Anaerobic treatment (in the absence of oxygen)
- Wastewater passes in a series of up-flow chambers with carrier material (filter material)
- The filter is made out of gravel, slag or plastic elements
- To avoid plugging pre-treatment (sedimentation) is necessary.
- Efficiency 75%- 90%
- Desludging is needed only if excess sludge is generated

Slide No. 70

Anaerobic Filter



- Secondary treatment unit consisting series of up-flow chamber embedded with filter media
- To avoid clogging of filter bed, pre-treatment unit is necessary before it

- Anaerobic treatment (in the absence of oxygen)
- Wastewater passes in a series of up-flow chambers with carrier material (filter material)
- The filter is made out of gravel, slag or plastic elements
- To avoid plugging pre-treatment (sedimentation) is necessary.
- Efficiency 75%- 90%
- Desludging is needed only if excess sludge is generated

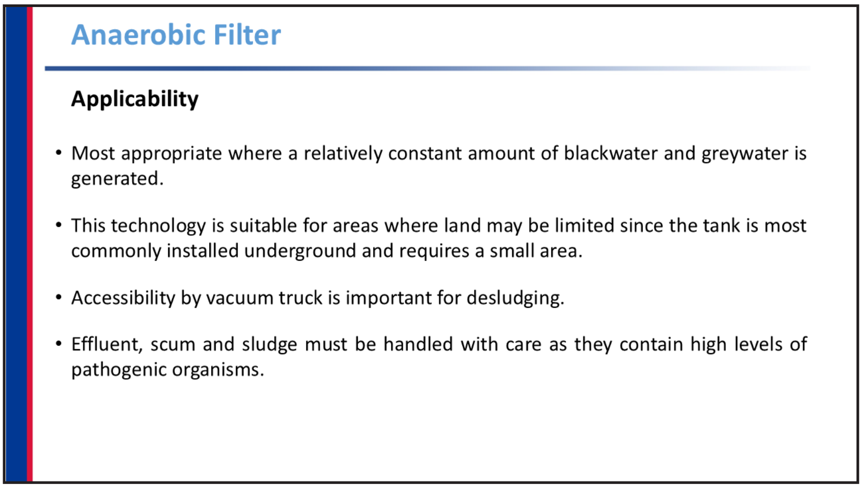
Slide No. 71

Anaerobic Filter

- As wastewater flows through the filter, particles are trapped and organic trapped degraded by the active biomass that is attached to the surface of the filter material.
- Usually operated in upflow mode
- The water level should cover the filter media by at least 0.3 m
- An HRT of 12 to 36 hours is recommended.
- Typical filter material sizes range from 12 to 55 mm in diameter.
- Filter materials commonly used include gravel, crushed rocks or bricks, cinder, pumice, or specially formed plastic pieces, depending on local availability.

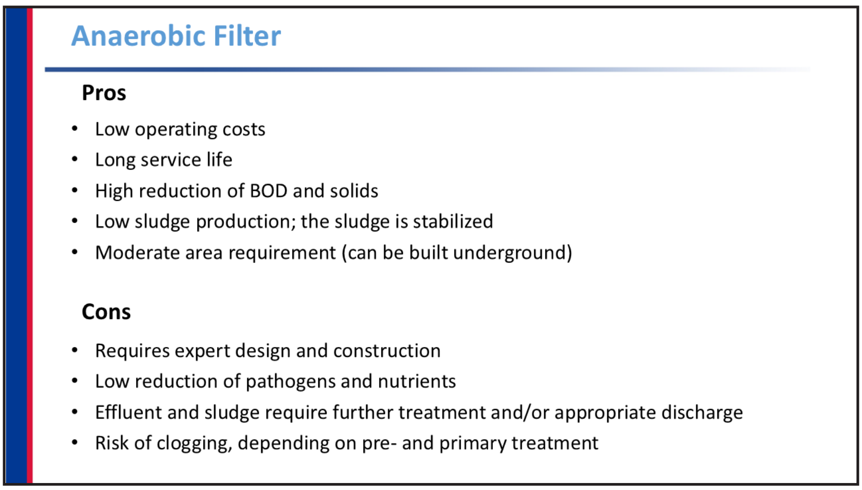
- Anaerobic treatment (in the absence of oxygen)
- Wastewater passes in a series of up-flow chambers with carrier material (filter material)
- The filter is made out of gravel, slag or plastic elements
- To avoid plugging pre-treatment (sedimentation) is necessary.
- Efficiency 75%- 90%
- Desludging is needed only if excess sludge is generated

Slide No. 72



- Anaerobic treatment (in the absence of oxygen)
- Wastewater passes in a series of up-flow chambers with carrier material (filter material)
- The filter is made out of gravel, slag or plastic elementsTo avoid plugging pre-treatment (sedimentation) is necessary.
- Efficiency 75%- 90%
- Desludging is needed only if excess sludge is generated

Slide No. 73



Slide No. 74

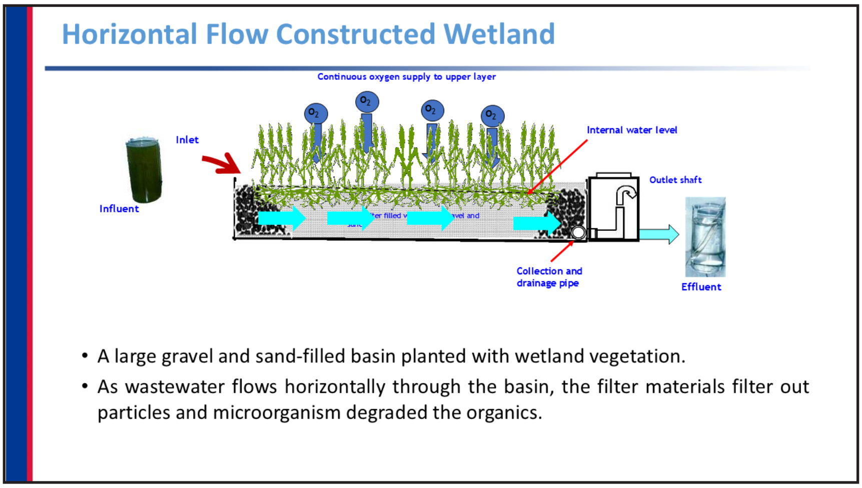
Constructed wetlands are treatment systems that use natural processes involving wetland vegetation, soils, and their associated microbial assemblages to improve water quality.

Wetland plants also foster the necessary conditions for microorganisms to live there. Through a series of complex processes, these microrganisms also transform and remove pollutants from the water. Nutrients, such as nitrogen and phosphorous, are deposited into wetlands from stormwater runoff, from areas where fertilizers or manure have been applied and from leaking septic fields. These excess nutrients are often absorbed by wetland soils and taken up by plants and microorganisms.

Picture source: (Sketch- https://www.frtr.gov/matrix/Constructed-Wetlands/)

https://upload.wikimedia.org/wikipedia/commons/1/1b/S_Koirala_Hospital_Constructed_Wetland_%284975034182%29.jpg

Slide No. 75



Constructed wetlands are treatment systems that use natural processes involving wetland vegetation, soils, and their associated microbial assemblages to improve water quality.

Wetland plants also foster the necessary conditions for microorganisms to live there. Through a series of complex processes, these microrganisms also transform and remove pollutants from the water. Nutrients, such as nitrogen and phosphorous, are deposited into wetlands from stormwater runoff, from areas where fertilizers or manure have been applied and from leaking septic fields. These excess nutrients are often absorbed by wetland soils and taken up by plants and microorganisms.

Picture source: (Sketch- https://www.frtr.gov/matrix/Constructed-Wetlands/)

https://upload.wikimedia.org/wikipedia/commons/1/1b/S_Koirala_Hospital_Constructed_Wetland_%284975034182%29.jpg

Slide No. 76

Horizontal Flow Constructed Wetland

- The design depends on treatment target and the amount and quality of the influent.
- The removal efficiency of the wetland is a function of the surface area (length multiplied by width), while the cross-sectional area (width multiplied by depth) determines the maximum possible flow.
- Small, round, evenly sized gravel (3 to 32 mm in diameter) is most used to fill the bed to a depth of 0.5 to 1 m.
- The water level in the wetland is maintained at 5 to 15 cm below the surface to ensure subsurface flow.

Constructed wetlands are treatment systems that use natural processes involving wetland vegetation, soils, and their associated microbial assemblages to improve water quality.

Wetland plants also foster the necessary conditions for microorganisms to live there. Through a series of complex processes, these microrganisms also transform and remove pollutants from the water. Nutrients, such as nitrogen and phosphorous, are deposited into wetlands from stormwater runoff, from areas where fertilizers or manure have been applied and from leaking septic fields. These excess nutrients are often absorbed by wetland soils and taken up by plants and microorganisms.

Picture source: (Sketch- https://www.frtr.gov/matrix/Constructed-Wetlands/)

https://upload.wikimedia.org/wikipedia/commons/1/1b/S_Koirala_Hospital_Constructed_Wetland_%284975034182%29.jpg

Slide No. 77

Horizontal Flow Constructed Wetland

Applicability

- Not appropriate for untreated domestic wastewater (i.e. blackwater).
- A good option where land is cheap and available.
- Depending on the volume of the water and the corresponding area requirement of the wetland, it can be appropriate for small sections of urban areas, as well as for peri-urban and rural communities.
- As the water flows below the surface, any contact of pathogenic organisms with humans and wildlife is minimized.
- The filter material at the inlet zone will require replacement every 10 or more years.

Constructed wetlands are treatment systems that use natural processes involving wetland vegetation, soils, and their associated microbial assemblages to improve water quality.

Wetland plants also foster the necessary conditions for microorganisms to live there. Through a series of complex processes, these microrganisms also transform and remove pollutants from the water. Nutrients, such as nitrogen and phosphorous, are deposited into wetlands from stormwater runoff, from areas where fertilizers or manure have been applied and from leaking septic fields. These excess nutrients are often absorbed by wetland soils and taken up by plants and microorganisms.

Picture source: (Sketch- https://www.frtr.gov/matrix/Constructed-Wetlands/)

https://upload.wikimedia.org/wikipedia/commons/1/1b/S_Koirala_Hospital_Constructed_Wetland_%284975034182%29.jpg

Slide No. 78

Horizontal Flow Constructed Wetland

Pros

- High reduction of BOD, suspended solids and pathogens
- Does not have the mosquito problems of the Free-Water Surface Constructed Wetland
- No electrical energy is required
- Low operating costs.

Cons

- Requires a large land area
- Little nutrient removal
- Risk of clogging, depending on pre- and primary treatment
- Long start-up time to work at full capacity
- Requires expert design and construction

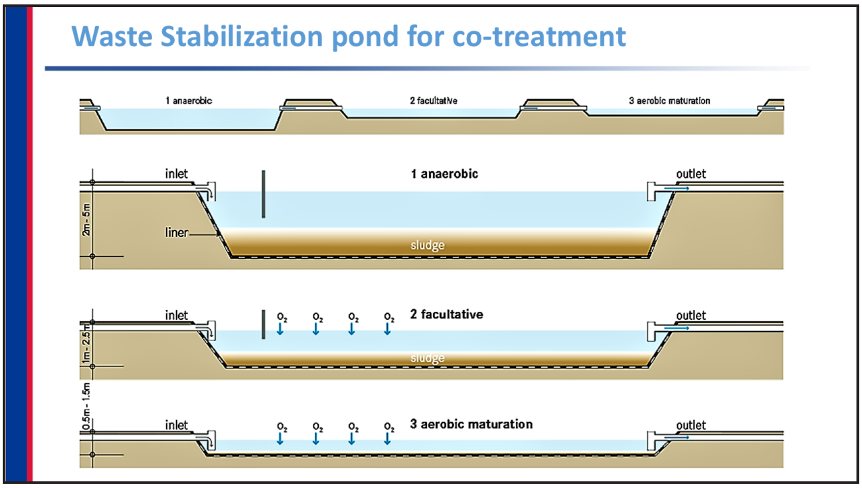
Constructed wetlands are treatment systems that use natural processes involving wetland vegetation, soils, and their associated microbial assemblages to improve water quality.

Wetland plants also foster the necessary conditions for microorganisms to live there. Through a series of complex processes, these microrganisms also transform and remove pollutants from the water. Nutrients, such as nitrogen and phosphorous, are deposited into wetlands from stormwater runoff, from areas where fertilizers or manure have been applied and from leaking septic fields. These excess nutrients are often absorbed by wetland soils and taken up by plants and microorganisms.

Picture source: (Sketch- https://www.frtr.gov/matrix/Constructed-Wetlands/)

https://upload.wikimedia.org/wikipedia/commons/1/1b/S_Koirala_Hospital_Constructed_Wetland_%284975034182%29.jpg

Slide No. 79



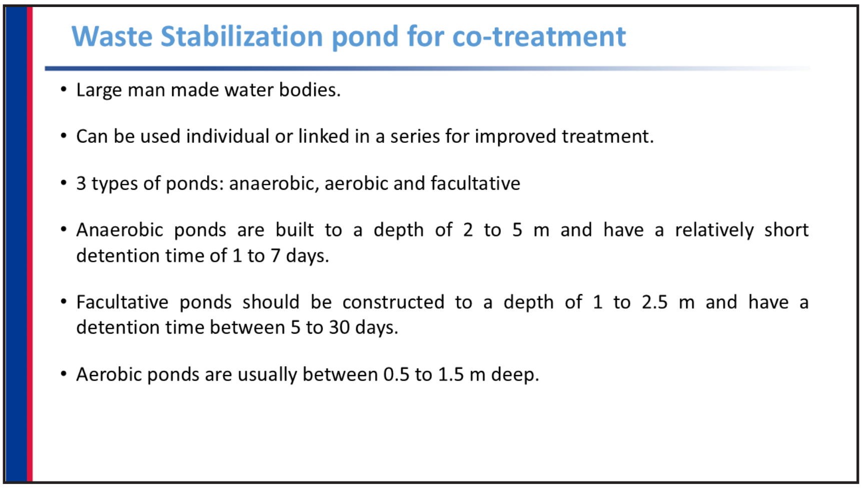
Waste stabilization ponds (WSPs or stabilization ponds or waste stabilization lagoons) are ponds designed and built for wastewater treatment to reduce the organic content and remove pathogens from wastewater. They are man-made depressions confined by earthen structures. Wastewater or "influent" enters on one side of the waste stabilization pond and exits on the other side as "effluent", after spending several days in the pond, during which treatment processes take place. (Wikipedia)

Waste stabilization ponds consists of 3 types of ponds: anaerobic, facultative and aerobic maturation pond

Anaerobic pond is deeper (2-5)m for anaerobic condition to occur at bottom of pond. Facultative ponds are (1-2)m where both anaerobic and aerobic condition occurs. The aerobic pond are shallower (0.5-1)m to allow aerobic condition in pond.

Picture source: https://sswm.info/taxonomy/term/3932/waste-stabilization-ponds-%28wsp%29

Slide No. 80



Waste stabilization ponds (WSPs or stabilization ponds or waste stabilization lagoons) are ponds designed and built for wastewater treatment to reduce the organic content and remove pathogens from wastewater. They are man-made depressions confined by earthen structures. Wastewater or "influent" enters on one side of the waste stabilization pond and exits on the other side as "effluent", after spending several days in the pond, during which treatment processes take place. (Wikipedia)

Waste stabilization ponds consists of 3 types of ponds: anaerobic, facultative and aerobic maturation pond

Anaerobic pond is deeper (2-5)m for anaerobic condition to occur at bottom of pond. Facultative ponds are (1-2)m where both anaerobic and aerobic condition occurs. The aerobic pond are shallower (0.5-1)m to allow aerobic condition in pond.

Picture source: https://sswm.info/taxonomy/term/3932/waste-stabilization-ponds-%28wsp%29

Slide No.-81

Waste Stabilization pond for co-treatment

Applicability

- The most common and efficient methods of wastewater treatment around the world.
- They are especially appropriate for rural and peri-urban communities that have large, unused land, at a distance from homes and public spaces.
- They are not appropriate for very dense or urban areas.
- The anaerobic pond must be desludged approximately once every 2 to 5 years, when the accumulated solids reach one third of the pond volume. For facultative ponds, sludge removal is even rarer and maturation ponds hardly ever need desludging.

Waste stabilization ponds (WSPs or stabilization ponds or waste stabilization lagoons) are ponds designed and built for wastewater treatment to reduce the organic content and remove pathogens from wastewater. They are man-made depressions confined by earthen structures. Wastewater or "influent" enters on one side of the waste stabilization pond and exits on the other side as "effluent", after spending several days in the pond, during which treatment processes take place. (Wikipedia)

Waste stabilization ponds consists of 3 types of ponds: anaerobic, facultative and aerobic maturation pond

Anaerobic pond is deeper (2-5)m for anaerobic condition to occur at bottom of pond. Facultative ponds are (1-2)m where both anaerobic and aerobic condition occurs. The aerobic pond are shallower (0.5-1)m to allow aerobic condition in pond.

Picture source: https://sswm.info/taxonomy/term/3932/waste-stabilization-ponds-%28wsp%29

Slide No.-82

Waste Stabilization pond for co-treatment

Pros

- Resistant to organic and hydraulic shock loads
- High reduction of solids, BOD and pathogens
- High nutrient removal if combined with aquaculture
- Low operating costs
- No electrical energy is required
- No real problems with insects or odours if designed and maintained correctly

Cons

- Requires a large land area
- High capital costs depending on the price of land
- Requires expert design and construction
- Sludge requires proper removal and treatment

Waste stabilization ponds (WSPs or stabilization ponds or waste stabilization lagoons) are ponds designed and built for wastewater treatment to reduce the organic content and remove pathogens from wastewater. They are man-made depressions confined by earthen structures. Wastewater or "influent" enters on one side of the waste stabilization pond and exits on the other side as "effluent", after spending several days in the pond, during which treatment processes take place. (Wikipedia)

Waste stabilization ponds consists of 3 types of ponds: anaerobic, facultative and aerobic maturation pond

Anaerobic pond is deeper (2-5)m for anaerobic condition to occur at bottom of pond. Facultative ponds are (1-2)m where both anaerobic and aerobic condition occurs. The aerobic pond are shallower (0.5-1)m to allow aerobic condition in pond.

Picture source: https://sswm.info/taxonomy/term/3932/waste-stabilization-ponds-%28wsp%29

Slide No. 83

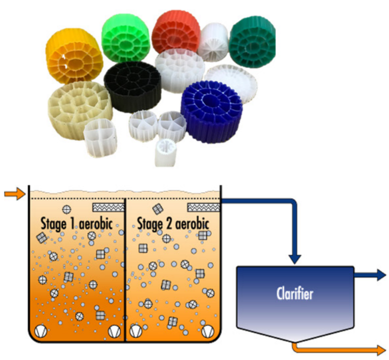
Fully Mechanical Liquid Treatment Option

- Land requires minimal
- Complex and Expensive

Ex. Guheswori WWTP

Slide No. 84

Fully Mechanical Liquid Treatment Option

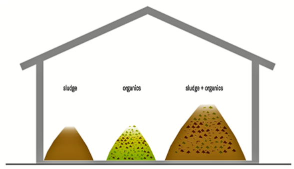


Ex. Guheswori WWTP

Slide No. 85

Composting, co-composting

- Carbon to nitrogen ratio (C:N): 20-30:1
- Oxygen concentration: 5-10%
- Moisture content: 40-60% by weight
- Particle diameter < 5 cm for static pile
- Composting period: 6-8 weeks
- Peak heap temperature: 60°C - 70°C



Sketch Source: TILLEY et al. (2014)

Slide No. 86

Types of Composting

https://extension.umn.edu/sites/extension.umn.edu/files/styles/caption_medium/public/Full-horse-compost-pile.jpg?itok=W88mxyv0

Slide No. 87

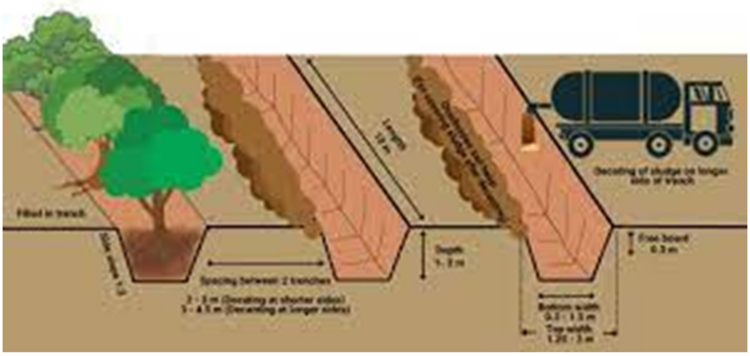
Faecal Sludge Incineration

- Burn at 850-900°C.
- Dewatering is required before combustion
- potential emission of pollutants; the need for highly skilled operating
- Maintenance staff, high capital and O&M costs;
- Electrical can be generated

- Widely used technologies for Faecal sludge treatment plant
- Deep row entrenchment: traditional and simpler technology
- Unplanted drying bed: Dewatering of sludge in filter bed
- Planted drying bed: Dewatering of sludge in filter bed with the help of plants
- Co-composting: mixing of sludge with municipal waste and composting it together
- Settling thickening tanks: helps in solid liquid separation

Slide No. 88

Trenching for FSM



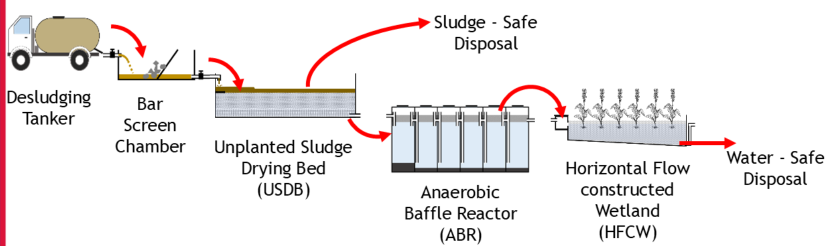
Slide No. 89

Challenges in selecting and design of FSTP

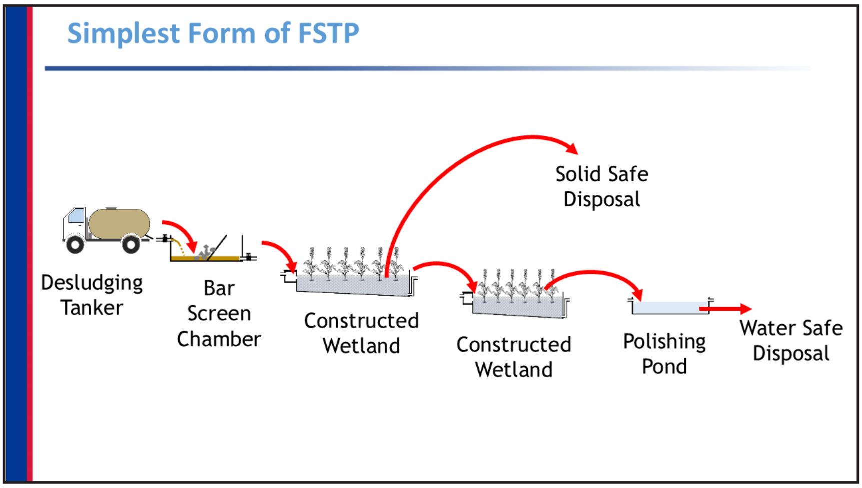
- Variations in sludge characteristics and volume produced
- Availability of limited land space
- Compliance with local environmental standards for effluent and biosolid disposal
- Management of odor and leachate
- Selection of cost effective and appropriate sanitation technologies
- Absence of skilled operators in FSTP
- Constraints or limited budget affecting the scope and quality of the treatment plant
- Secondary preference of local bodies in design and construction of FSTP
- Built and forget

Slide No.-90

Simplest Form of FSTP



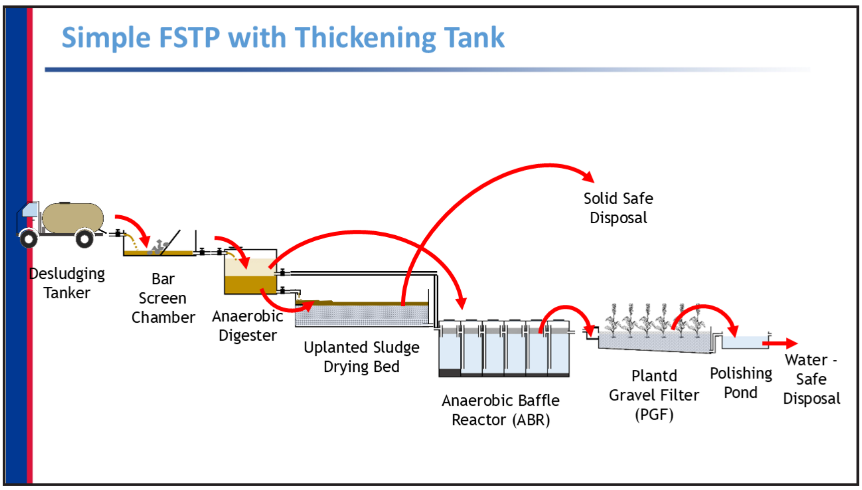
Slide No. 91



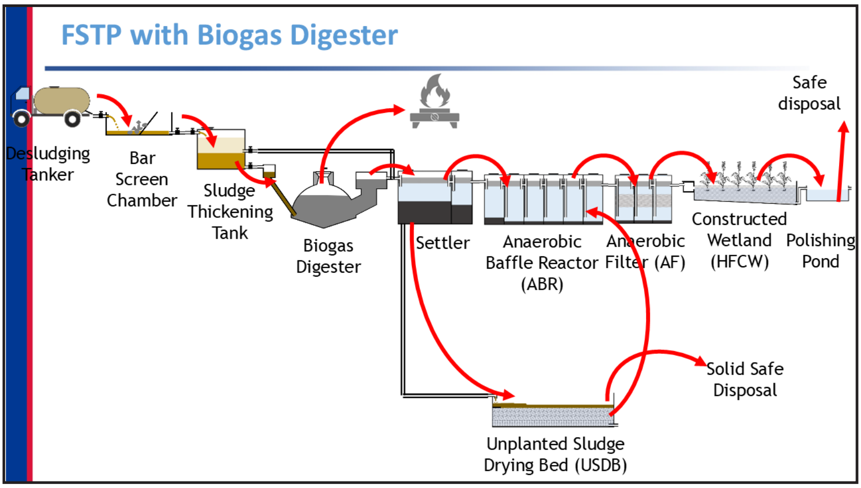
The combination of each of these technologies of the different process of the FS treatment makes a treatment system or treatment plant.

Ex. the above shown example is a very simple form of FSTP.

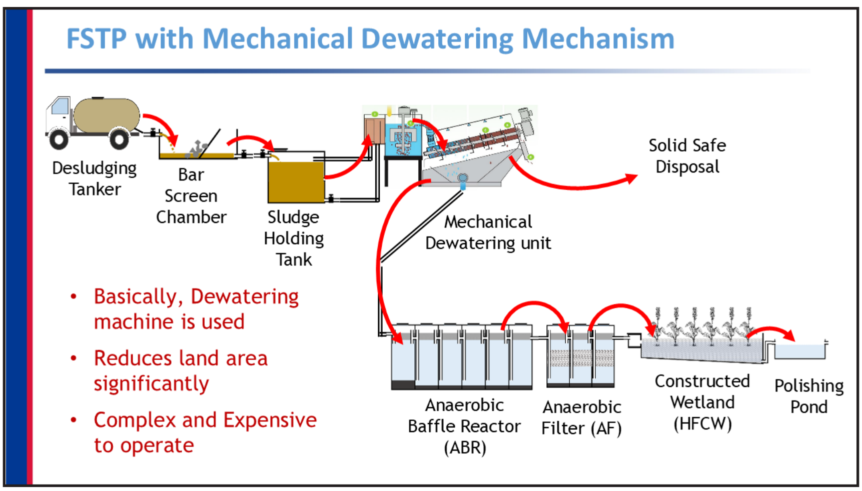
Slide No.-92



Slide No.-93



Slide No. 94



Slide No. 95

Newly Invented Technologies

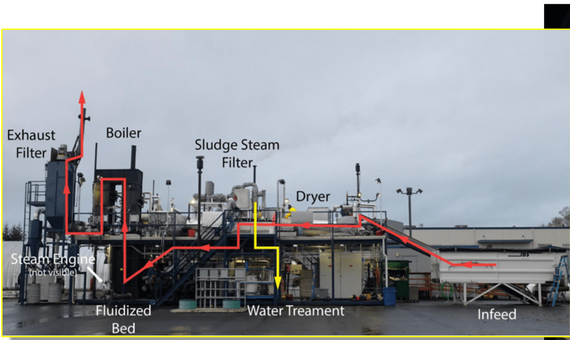
"Reinvent the Toilet Challenge" initiated by the BMGF in 2011, continues today and supports the development and commercialization of products that:

- Remove harmful pathogens from human waste and recover valuable resources such as energy, clean water, and nutrients
- Operate "off the grid" without connections to water and sewers and require minimal electricity
- Cost less than US$.05 cents per user per day
- Promote sustainable and profitable sanitation services and businesses in poor urban settings
- Can appeal to everyone, in developed as well as developing nations

In addition, there have been other initiatives aimed at developing "transformative technologies" – that can quickly contribute to improving safely managed sanitation.

Slide No. 96

Omni-Processor (Thermal Process)



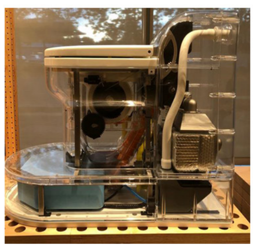
Slide No. 97

Janicki Omni-Processor

Slide No. 98

Nano-Membrane Toilet (Mechanical Processes)

IWA Project Innovation Awards - Gold winner!!



http://www.nanomembranetoilet.org/

Nano-membrane toilet: Cranfield University

Slide No. 99

Slide No. 100

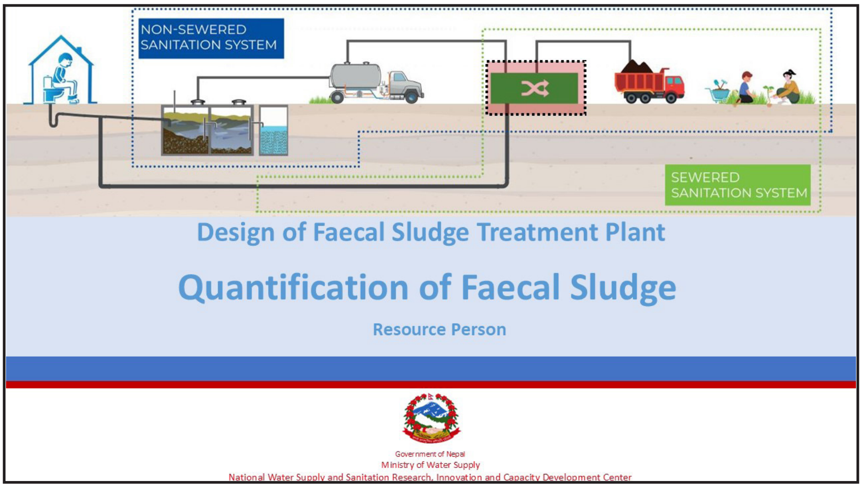
Trainer: Have participants open up the Power Point Handouts booklet (the green booklet) to the appropriate location and encourage them to take notes during the session.

Session

6

Quantification of Feacal Sludge

Slide No.-1



Slide No. 2

Factors Affecting Quantity of FS

- **Location**

Location	Wet weight of faeces (g/person/year)
High income countries	100-200
Low income countries, rural	350
Low income countries, urban	250

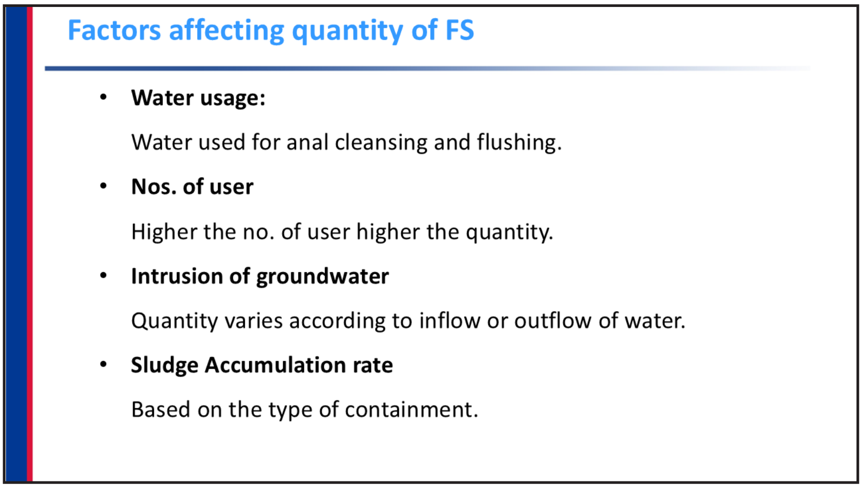
Faecal Production rate

- **Processed food: lesser faeces than natural foods**

FSM book (Lentner et al.(1981): Feachem et al. (1983); Jonsson et al. (2005); Vinneras et al. (2006)

One of the factor affecting Faecal Sludge is location. The literature shows that the wet weight of faeces in about 100-200 in high income countries and higher in rural part of low income countries (350). The reason behind this is the fooding habit. Higher the comsumption of processed food, lesser is quantity of faeces.

Slide No. 3



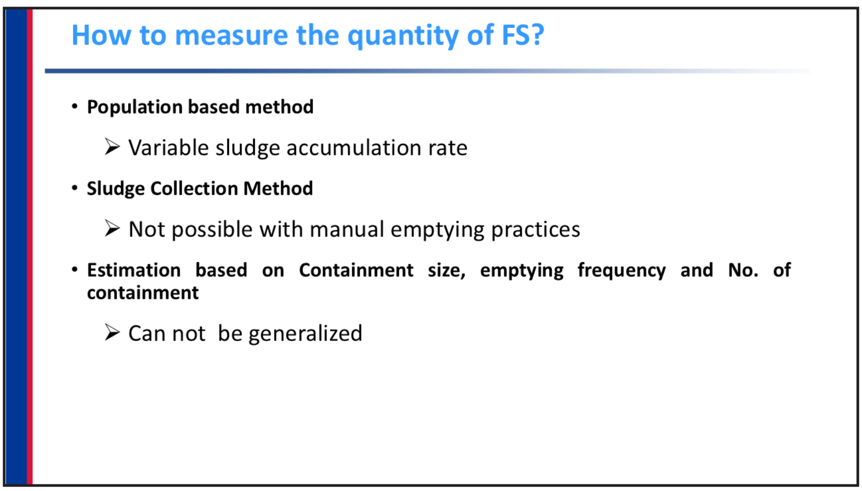
Another factor is water usage. The amount of water used by the users and their behavior of using or not using water for anal cleansing also determines the quantity of faecal sludge.

The next one is number of users using the system. Higher the number of user higher is the volume of faecal sludge they generate.

Infiltration is passing of water from storage to the surrounding soil or vice versa. Mostly in dry seasons, the water infiltrates in the soil and the volume is lesser and during rainy season when the soil is fully saturated, the water infiltrates inside the storage unit increasing the quantity of faecal sludge.

In general, the lined pits fill up in designed desludging period while unlined pits does not fill up sooner

Slide No. 4



Slide No.-5

Population based method

- **Estimates total sludge accumulated in the containments**

Data required

- Population/No. of users
- Average Household Size
- Type of containment
- Sludge accumulation rate

Slide No. 6

Exercise : FS quantification (Population based method)

Data Available:

- Municipality Name: Rudranagar
- Total household: 50,000
- Population: 250,000
- Average Household Size: 5

Nos. of Household with septic tank = 30,000
Nos. of Household with pit = 20,000

- **Sludge accumulation rate for septic tank = 0.03 m3/person/year**
- **Sludge accumulation rate for pit = 0.04 m3/person/year**

Slide No. 7

Exercise : FS quantification (Population based)

- Population using septic tank = HH with Septic Tank * Avg. HH Size = ?
- Population using pit = HH with Pit * Avg. HH Size = ?
- Total sludge accumulated in septic tank = population using septic tank * sludge accumulation rate of septic tank

  = ?
- Total sludge accumulated in pit = population using pit * sludge accumulation rate of pit

  = ?
- Total sludge volume = sludge accumulated in septic tank + sludge accumulated in pit

  = ?

Show this presentation until all participants complete their task and give you an answer

Slide No. 8

Exercise : FS quantification (Population based)

- Population using septic tank= 30,000 * 5 = 1,50,000
- Population using pit=20,000 * 5 = 1,00,000
- Total sludge accumulated in septic tank = population using septic tank * sludge accumulation rate of septic tank

  = 1,50,000 * 0.03 = 4500 m3 per year
- Total sludge accumulated in pit = population using pit * sludge accumulation rate of pit

  = 1,00,000 * 0.04 = 4000 m3 per year
- Total sludge volume = sludge accumulated in septic tank + sludge accumulated in pit

  = 4500+4000 = 8,500 m3/year ~ 24 m3/day

Slide No. 9

Sludge collection method

- **Estimates total sludge collected by service provider in terms of number of trucks**

Data Required:

- No. of vehicles
- Capacity of vehicle (m3)
- No. of trips

Slide No. 10

Exercise : FS quantification (Sludge Collection based)

- Municipality name: Sundari Nagar
- Nos. of desludging vehicles = 5
- Vol. of vehicle tank = 4 m3
- Nos. of trips per day = 3 trips/day/vehicle

- Vol. of FS generation per day = Nos. of vehicles * Vol. of vehicle tank * Nos. of trips per day = ?
- **Vol. of FS generation per day = 5 * 4 * 3 = 60 m3/d**

Show the case study first and ask the participants to calculate the volume of FS generation. Later show the answer

Slide No. 11

Estimation based on Containment type, size and emptying frequency

Step 1: Determine households with different types of containment

Step 2: Find the average size/volume of each containment

Step 3: Find the average emptying frequency of each containment

$$\boldsymbol{FS\ generated = no.of\ containment \times average\ volume\ \times empting\ frequency\ factor}$$

Slide No.-12

Estimation based on Containment type, size and emptying frequency

$$\boldsymbol{FS\ generated = no.of\ containment \times average\ volume\ \times empting\ frequency\ factor}$$

Containment	Total number of containments	Average Size	Average Emptying frequency factor (years)	Volume (m^3 per year)
Septic tank	48	18.3	0.125	110
Fully lined tank	3,320	8.0	0.32	8,499
Lined tank with impermeable walls and open bottom	4,505	10.0	0.126	5,676
Twin Pits	1,565	4.9	1.06	8,129
Single Pit	7,397	5.0	0.55	20,342
Total				42,756

Slide No.-13

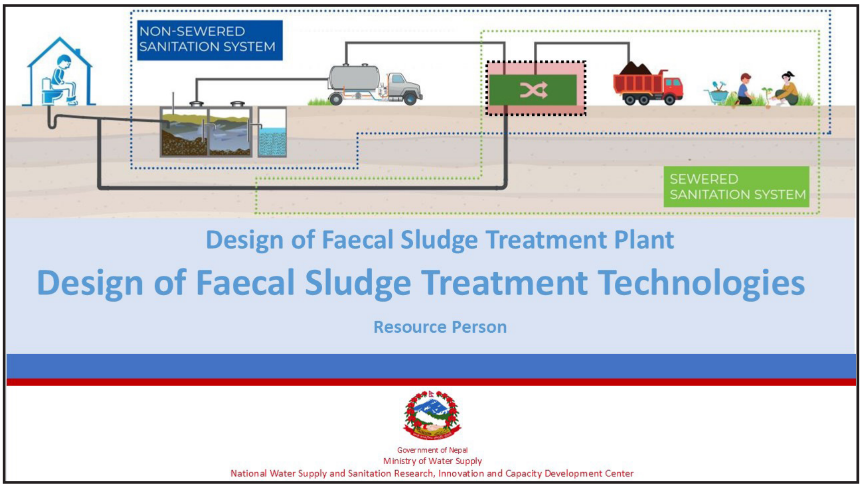
Trainer: Have participants open up the Power Point Handouts booklet (the green booklet) to the appropriate location and encourage them to take notes during the session.

Session

7

Design of Feacal Sludge Treatment Technologies

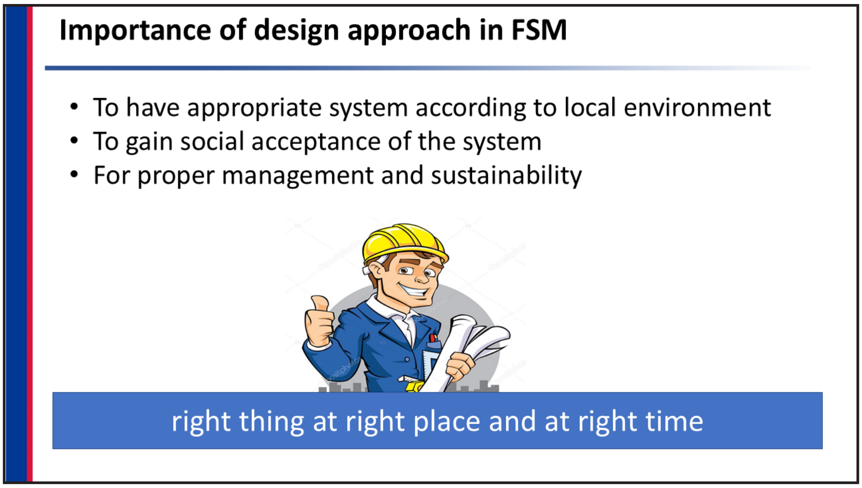
Slide No. 1



Slide No. 2

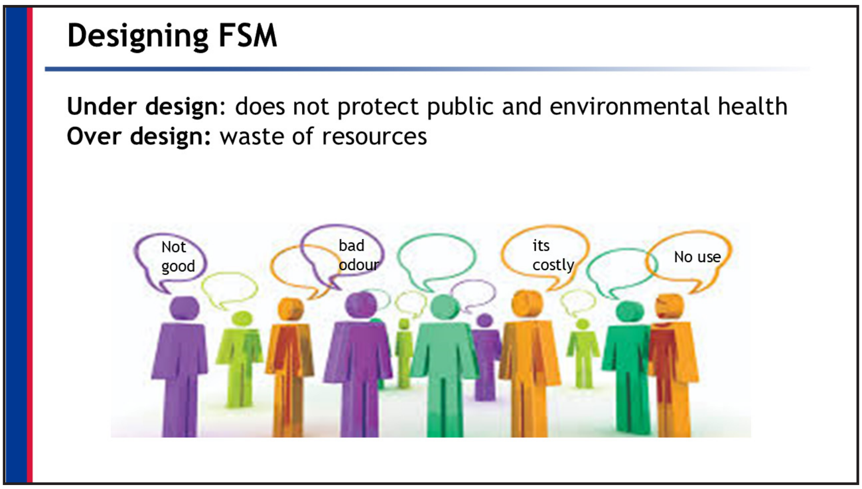
Ask the participants what things do they consider before buying their house. Get there answers. The probable answers are location, its area, cost, etc. Ask them what happens if the house is larger for their family or if the cost is higher than they can pay.

Slide No. 3



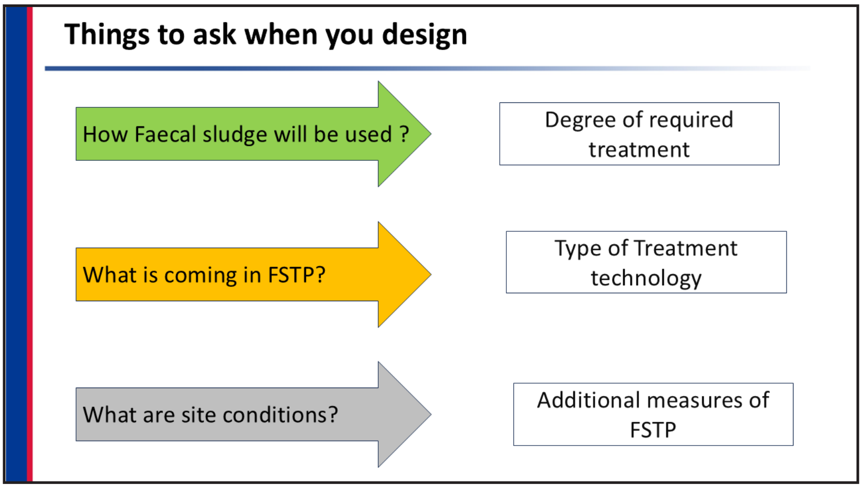
Note to speakers:
Rational design approach is necessary for FSM. This approach helps to find out suitable technological solutions according to local environment. Similarly the social consider ations should be taken for acceptance by the locality. The rational design can only ensure their proper management and sustainability
examples:

Slide No. 4

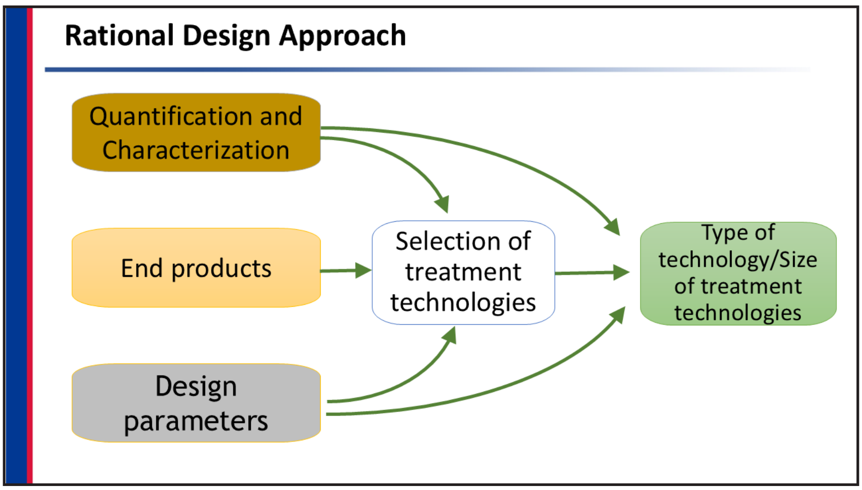


The FSM system can be under designed or over design in lack of proper study. If it is underdesign, it cannot function as per the demand and fails to protect public and environmental health
In case of over design, the cost and resources used for the establishment of system goes to waste as they are not in use

Slide No. 5



Slide No. 6



In FSM, the rational design approach includes the diagram shown in slide. Prior to selection of treatment technologies, reuse options should be considered, quantification and characterization of Faecal sludge should be conducted and various other design factors should considered. Then the size of the treatment technologies can be designed based on the quantification, characterization, selected technologies and design factors.

Slide No. 7

Other Design Factors

Socio cultural

- Workers safety
- Pathogen free sludge
- No detectable odour
- No visual impact

Health and Environment

- Ground water/ Surface Water Protection
- No or Less use of fossil fuel
- Reduction of GHG emission
- Less Secondary Waste

Economics and Technology

- Affordable Technology
- Use of Local Resources
- Meet minimum Land Requirement
- less O&M cost
- Technology with commercial application
- Availability of local manpower

Institutional

- Acceptability of all stakeholders
- Meet legal requirements
- Regulation for health and environment Protection
- Regulation to support FSM

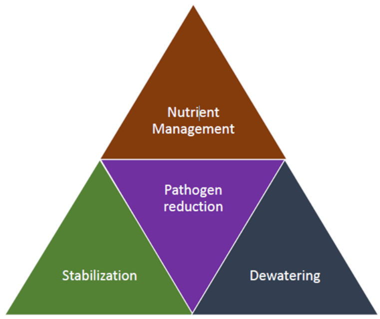
Slide No. 8

Prerequisite for design

- Avoid complexity – Easy to build, operate and maintain
- Optimum use of local resources
- No/Less use of machine/external energy
- Minimise Capex, Opex and Capmainex
- Prevent ground water pollution
- Buffering the fluctuation of incoming volume and quality
- Meet effluent quality standards
- Be user friendly
- Reuse options – Biogas, **Nutrients** and **Water**

Slide No. 9

Treatment Objectives



Slide No. 10

Dewatering

- Reducing water content in sludge
- Techniques – Gravity Settling, Filter drying beds, and Evaporation, Evapotranspiration, Polymer addition
- Fresh sludge – Difficult to dewater
- Digested Sludge – Easy to dewater
- Reduce cost in sludge transportation

Slide No.11

Stabilization

- Degradation of organic matters in sludge
- Reduces Biological oxygen Demand
- Reduces Pathogens
- Eliminates odours
- Stabilization Technique
  - Chemical : Lime addition (PH> 11)
  - Biological : Anaerobic Digestion, Vermistabilisation

Slide No. 12

Pathogen Reduction

- Exposure to untreated FS is always pathogenic
- Potential Pathogens in FS

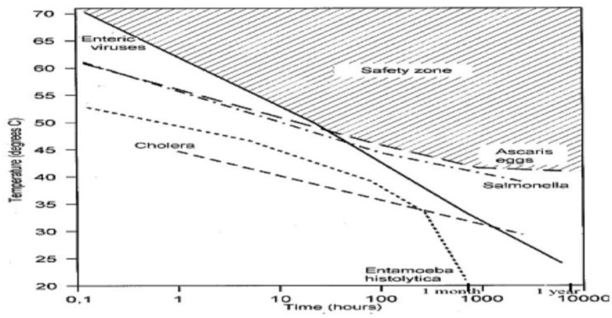
Group	Pathogen	Diseases
Bacteria	Escherichia Coli	Enteritis
	Vibrio cholera	Watery diarrhoea
Virus	Hepatitis A,E	Fever, Jaundice
	Rotavirus	Enteritis
Parasitic Protozoa	Giardia	Diarrhoea, Abdominal pain
Helminths	Hook worm	Itch,rash, cough, protein deficiency
	Ascaris	Fever, enteritis, pulmonary eosinophilia

Source: FSM book by IWA

Slide No. 13

Pathogen Reduction

- Reduction Depends upon Time- Temperature Characteristics of Pathogen

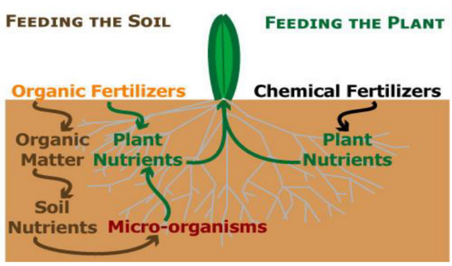


Source: http://www.waterpathogens.org

Slide No. 14

Nutrient Management

- Bio-solids, Nitrogen, Phosphorus, and Potassium
- Uses: Soil Nutrients, Plant Nutrients



Untreated Faecal Sludge
- Eutrophication
- Oxygen Depletion of water body
- Loss of Resources

Slide No. 15

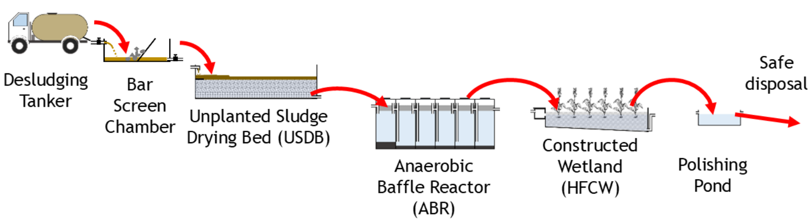
Steps of DPR preparation or Design of Treatment Plant

1. Selection of treatment module and its combination
2. Sizing of each module and its drawing, estimate

Slide No. 16

Design a nature based FSTP based on following information

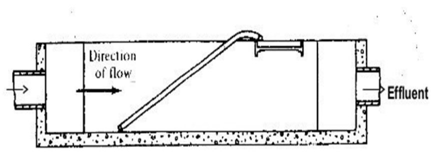
- Volume of FS = 9 m2 per day OR 3 trip per day @ tanker size 3 m3
- BOD, COD and TSS of FS = 2500 mg/l, 5000 mg/l and 15000 kg/m3



Nepal Standard

- BOD = 50 mg/l COD= 250 mg/l TSS = 50 mg/l

Slide No. 17

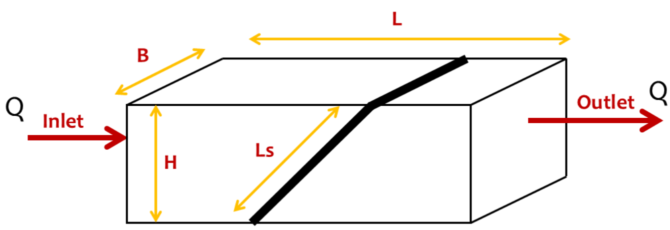


Design of Bar Screen Chamber

17

Slide No.18

Design of Bar Screen



Breadth of chamber B = ?
Height of chamber H = ?
Length of Bar Screen L = ?

Slide No. 19

Design of Bar Screen

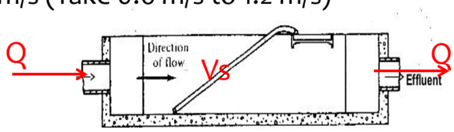
Determine Peak Flow

Let, Max time reqd. to desludge = 60 min

Peak Flow, Qp = Q/tp = 3/(10*60) = 0.005 m3/s

Net Submerged area of screen Ac = Qp/Vs = 0.005/0.6 = 0.0084 m2

Where,
Velocity at Screen, Vs = 0.6 m/s (Take 0.6 m/s to 1.2 m/s)
Qp = Peak flow



Slide No. 20

Design of Bar Screen

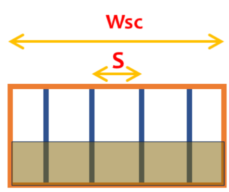
Total clear spacing,
Ws = (nos of bars +1) x Clear spacing
= (20+1) x 30 = 630 mm

Total Width of screen,
Wsc = WS+ nos. of bar x dia
= 630 + 20 x 10 = 850 mm

Gross submerged area of screen
Ag = Ac/(Ws/Wsc)
= 0.0084 / (630 / 830) = 0.011 m2

Assume

- Nos. of Bar = 20 (15-30)
- Clear Spacing of Screen,
  S = 30 mm (20 -30 mm)
- Dia of Bar = 10 mm (10-20 mm)



Slide No. 21

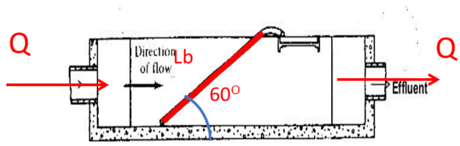
Design of Bar Screen

Submerged vertical cross section area,
Aver = Ag x Sinθ = 0.011 x Sin60 = 0.0095 m2

Assume θ = 30 - 60°

Flow Velocity in chamber Vc = Qp/Aver
= 0.005/0.0095 = 0.52 m/s

Liquid depth = Aver / Wsc = 0.0059/0.83 = 0.012 = 120 mm



Slide No. 22

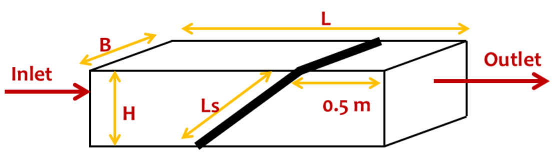
Design of Bar Screen

Total Depth of chamber
D = liquid depth +free board
= 0.012+0.3 = 0.312 = 0.5 m

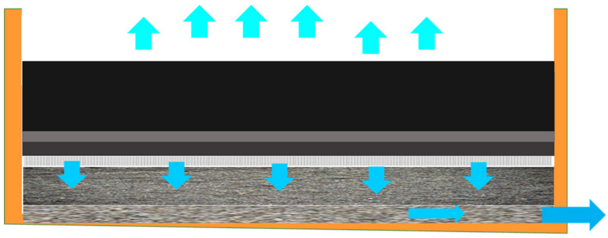
Width of screen chamber
W = Wsc = 830 mm = 0.83 m = 1 m

Assume
- Free board = 0.3-0.5 m
- Length of screen chamber L= 2 m (take 1-2 m)

Length of bar screen, Ls = D/Sin60 = 0.5/Sin60 = 0.577 = 0.6 m



Slide No.-23



Unplanted Sludge Drying Bed

23

Slide No. 24

Design of Unplanted Sludge Drying Bed (USDB)

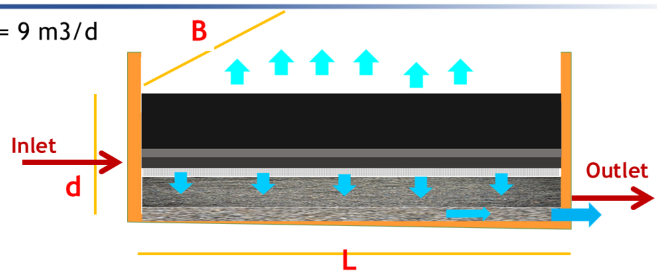
- Nature based Solid Liquid separation/Dewatering Unit.
- A Bed filled with coarse sand and gravel.
- Major function > to separate the water from sludge
- Organic Loading: <300 kg TS per year
- BOD removal efficiency for septic tank 86-91%
- Desludging period : Generally 1-5 yrs

24

Slide No. 25

Design of USDB

$Q = 9\ m3/d$



BODin = 2500 mg/l
CODin = 5000 mg/l
TSSin = 15000 mg/l

Number of Wetland = ?
Length L= ?
Breadth B= ?
Height d = ?

BODout = ?
CODout = ?
TSSout = ?

Slide No. 26

Design of USDB

Peak Vol. (Qp) = (Q/nd)*365

= (9*(30/26) =10.5 = 11 m3/d

Surface area of a bed required Ab = Qp/ds

=11/0.3 = 36.7 = 37 m2

Length of bed L = A/B =37/2 = 18.5 = 19 m

Assume,
Nos. of working day = 312 day in a year

Depth of sludge application = 30 cm (20-30 cm)

Width of Bed B = 2 m

Number of bed reqd N =tLoading+tdrying+tremoving = 1+9+1 =11

Total area reqd A =N x Lx B =11 x 19x 2 = 532 m2

Slide No.27

Design of USDB

Nos. of loading cycle per year = (Nos. cycle / nos. of week reqd)*52

= (7/13) x 52 = 28

Check for solid loading rate= ds x organic loading x Ncycle in a year

=(0.3 x 15000 x 25)/1000 = 112.5 kg TS/m2 per year

Check

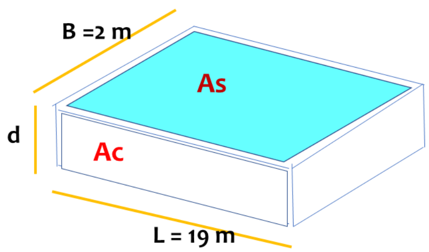
Solid loading rate = 100-300 kg TS/m2 per year

Slide No.28

Design of USDB

Depth of bed D = depth of filter media + ds + free board

= 0.5 + .3+ .3 =1.1 m



Effective Size of sand = 0.3–0.75 mm with uniformity coefficient <0.35

Slide No. 29

Design of USDB

BODout = BODin - BODin x BOD removal rate

= 2500 - 2500*.7 =750 mg/l

CODout = CODin - CODin x COD removal rate

= 5000 - 5000*.8 =1000 mg/l

TSSout = TSSin - TSSin x TSS removal rate

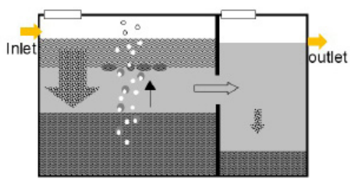
= 15000 -15000*0.9 =1500 mg/l

Leachate out of SDB = Qp x percolation rate

= 11 x 0.8 = 8.8 m3

BOD removal rate : 86-91%
COD removal rate : 70-90%
TSS removal rate : 70-90%
percolation rate : 50-80% and 70% within first 2 days

Slide No. 30



Design of Septic Tank

30

Slide No.-31

Design of Septic Tank

- Septic tank is a primary treatment unit.
- Septic tank consist of 2-3 (Septic Tank) compartments
- Major function > to retain settleable particles and partial reduction of BOD and COD
- Hydraulic Retention Time: 12-24 hrs
- BOD removal efficiency for septic tank 25%-40%
- Desludging period : Generally 1-5 yrs

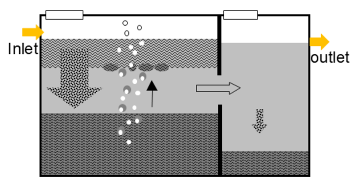
31

Slide No. 32

Design of Septic Tank

Design a Septic Tank under following situation

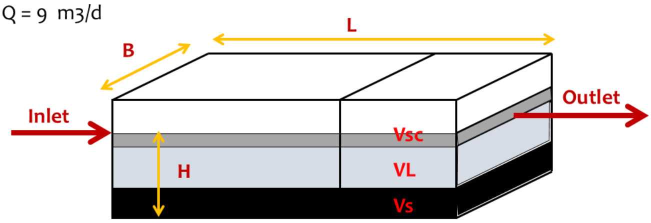
Wastewater Flow = Q = 8.8 = 9 m3/d
BODin = 750 mg/l
CODin = 1000 mg/l
TSSin = 1500 mg/l



Slide No. 33

Design of Septic tank

Q = 9 m3/d



BODin = 750 mg/l
CODin = 100 mg/l
TSSin = 1500 mg/l

Number of chamber = ?
Length L = ?
Breadth B = ?
Height H = ?

BODout = ?
CODout = ?
TSSout = ?

Slide No. 34

Design of Septic Tank

Determine Peak Flow

Peak flow Qp= Q/tp = 9/8= 1.13 m3/h
Where,
Q= daily flow
tp = peak hour

Determine Volume of Settler

Volume of Settler, V = VL+Vs+Vsc

Determine Liquid Volume

Volume of Liquid, VL = Qp*tHRT = 1.13*24 = 27.12 m3
Where,
tHRT = Hydraulic retention = 24 (12-24 h)

Slide No.35

Design of Septic Tank

Determine Sludge Volume

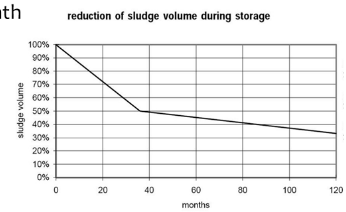
Volume of Sludge Vs = Vs/BOD * (BODin-BODout)*Q * (t*30)*fsR/1000

Where,

Sludge production per BOD removal, Vs/BOD = 0.005 l/g

Desludging period in month = t = 12 month

Factor reduction of sludge volume, fSR = 0.83



BOD removal rate, BOD rem.rate = ƒ(BODtoCOD)* CODrem.rate

Where, f(BODtoCOD)= factor in relation to BOD removal rate

Slide No. 36

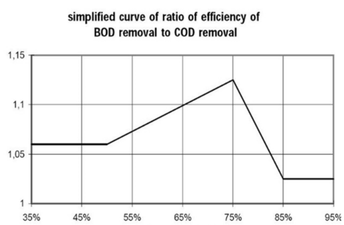
Design of Septic Tank

COD removal rate = (SStoCOD ratio/0.6) * ƒHRT = = 0.42/0.6 * 0.55 = 35%

Where,

SStoCOD ratio = 0.42 (0.35 - 0.55 for domestic WW 0.42)

fHRT = factor HRT



From graph, ƒ(BODtoCOD) = 1.06

BOD removal rate= ƒ(BODtoCOD)* CODrem.rate

= 1.05 * 30% = 26%

Slide No. 37

Design of Septic Tank

BODout = BODin * (1-BODrem.rate)   = 750 *(1-32%) = 410 mg/l

Then

Volume of Sludge   = Vs/BOD * (BODin-BODout)*Q * (t*30)*fsR/1000

= 0.005*(750 - 510)*9*(12*30)*0.83/1000 = 14.34 m3

Determine Scum Volume

Volume of Scum Vsc = (VL/H)*Hsc

= 2.7 m3

Where

H = Depth of liquid >> Take H=2 m

Hsc = thickness of Scum (take 0.2 m)

Volume of Settler, V = VL+Vs+Vsc

= 44.16 m3

Slide No. 38

Sizing of Septic Tank

Assume H = 2m

Surface area of Septic Tank A = V/H = 22 m2

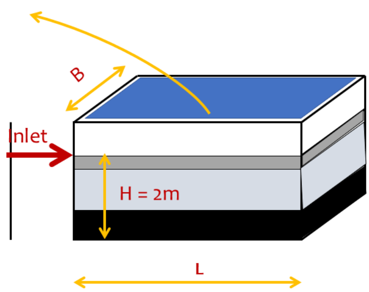
Length to Breadth ratio = L:B = 2-5 >> Take 3

Determine Length

Surface Area, A = L*B = B*3B = $3B^2$

Therefore, Breadth B = Sqrt(A/3) = 2.7 m

Length L = 3B = 8 m

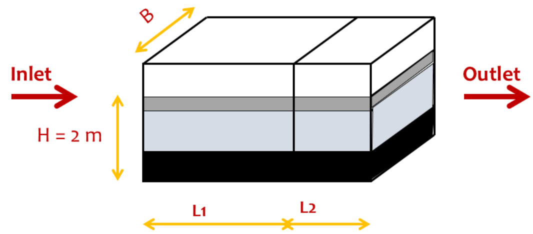


Slide No. 39

Sizing of Septic Tank

If the number of Chamber = 2
Length of first chamber = 2/3 L and Second Chamber = 1/3 L

i.e. Length of first chamber of ST = L1 = 5.33 m`
Length of second chamber of ST = L2 = 2.67 m



Slide No. 40

Determination of treatment efficiency

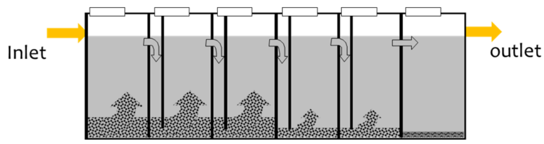
BOD of effluent, BODout = BODin * (1-BODrem.rate) = 750 *(1-32%) = 510 mg/l

COD of effluent, CODout = CODin * (1-CODrem.rate) = 1000 * (1-30%) = 700 mg/l

TSS of effluent, TSSout = TSSin * (1-TSSrem.rate) = 1500 * (1-40%) = 900 mg/l

TSS removal rate is
- 40-60% (Sasse, 1998),
- 58%-75% (Bounds, 1997)
- 65% (Fayza Aly Nasr & Basem Mikhaeil, 2014)

Slide No. 41

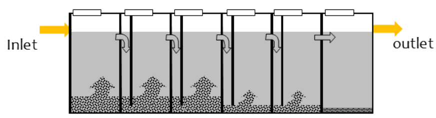


Design of Anaerobic Baffle Reactor

41

Slide No. 42

DEWATS modules : Anaerobic Baffled Reactor (ABR)



- Secondary treatment unit consisting series of up-flow chamber (3-8 or more)
- Functions under anaerobic digestion
- Downward flow arrangement facilitates wastewater to bring into contact with the activated sludge (bacteria mass) accumulated in bottom which increase treatment efficiency
- Dissolved and suspended matters undergoes into degradation by anaerobic bacteria
- Hydraulic Retention Time = 12-24 hrs
- BOD removal efficiency 75%-95%
- Q, Qp, pollution load, HRT and Vup are basic design parameters

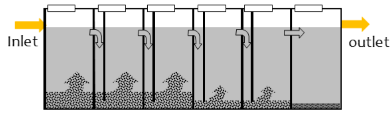
42

Slide No.43

Design of ABR

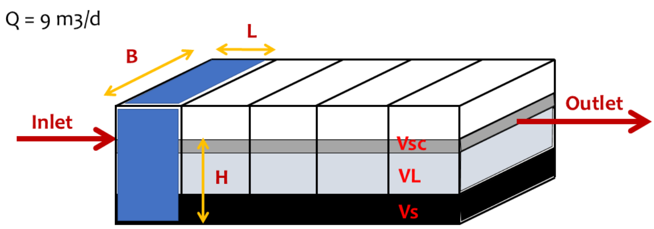
Situation provided

Daily Flow = Q = 9 m3/d
Peak Hour = tp = 8 h
Average Temperature = T= 20 °C
Influent BOD, BODin = 510 mg/l
Influent COD, CODin = 700 mg/l
Influent TSS, TSSin =900 mg/l



Slide No. 44

Design of ABR



BODin = 510 mg/l
CODin = 700 mg/l
TSSin = 900 mg/l

Number of chamber = ?
Length L = ?
Breadth B = ?
Height H = ?

BODout = ?
CODout = ?
TSSout = ?

Slide No. 45

Design of ABR

Determine of Peak Flow

Peak Flow = Qp = Q/tPEAK = 9/8 =1.125 m3/h

Where,

tp = time of peak flow = 8 hr

Q = 9 m3/d

Determine surface area

Surface Area = As = Qp/Vup = 1.125/1 = 1.125 m2

Where,

Qp = Peak Flow

Vup = Upflow velocity inside ABR >>> take 1 m/h (0.9 to 1.2 m/h)

Slide No. 46

Sizing of ABR

Determine Size of ABR

Let, Water depth, H = 2 m

Then, Length of ABR, L = 0.4 * H = 0.8 m

Then, Breadth of ABR, B = As/L = 1.125 /0.8 = 1.4 m

Determine volume of ABR

Liquid volume of ABR, VL = n*L*B*H = =8 x 0.8x 1.4 x 2 = 17.9 m3

Where, n= number of chambers in ABR

Sludge Volume of ABR, Vs = 5% of VL = 0.89 m3

Therefore, Volume of ABR, V = VL+Vs = 18.8 m3

Slide No.-47

Design Check

Check for HRT

HRT of ABR = tHRT = V/Qp = =18.8/1.125 = 16.7 h **Check for 14-24 h**

Check for Organic Loading

Organic Loading = (Qp*24* BODin)/(V*1000) =

= 1.125 x 24 x 510)/(18.8x 1000)
= 0.7 kg/m3

Check for < 6 kg/m3

Slide No.-48

Determine treatment efficiency

Determine BODout

BOD out = BODin * (1-BODrem.rate) Where, BOD rem.rate = fs * fT * fo * fHRT * fc

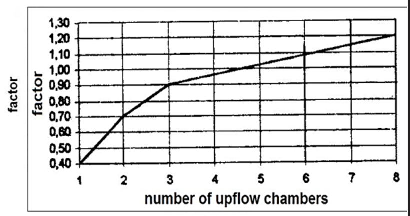
Factor strength fs = 0.93

Factor temperature fT (for temp 20 °C)=0.8

Factor Organic Load fo = 1

Factor HRT, fHRT = 0.9

Factor nos. of Chamber, fc = 1.2



BOD removal rate by factor = fs * fT * fo * fHRT * fc = 86%

BOD out = BODin * (1-BODrem.rate) = 510 * (1-0.86) = 71 mg/l

Slide No. 49

Determine treatment efficiency

Determine CODout and TSSout

Factor Efficiency of CODrem to BODrem = fBODtoCOD = 1.025

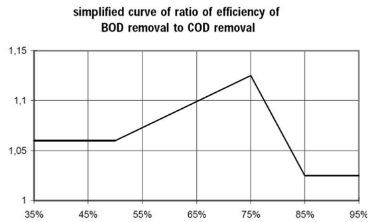
COD removal rate = BODrem.rate * fBODtoCOD = 0.88

CODout = CODin * (1-CODrem.rate) = 700 * (1-0.88) = 84 mg/l

TSSout = TSSin * (1-70%)

= 900 *(1-0.7) = 270 mg/l

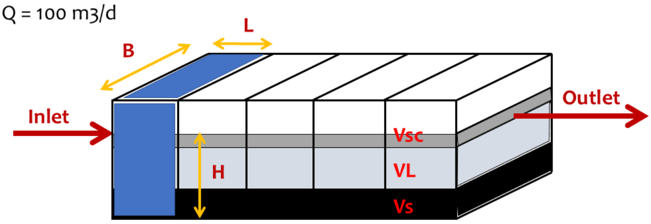
- 68.9 ± 6.5 % for 8 HRT
- 70.5 ± 6.0 % for 12 HRT
- 73.4 ± 5.8 % for 18 HRT
- 82.0 ± 5.2 % for 24 HRT



Slide No. 50

Design of ABR

Q = 100 m3/d

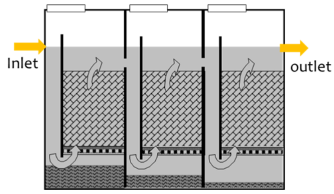


BODin = 510 mg/l
CODin = 700 mg/l
TSSin = 900 mg/l

Number of chamber = 8
Length = 0.8 m
Breadth = 1.4 m
Height = 2 m

BODout = 71 mg/l
CODout = 84 mg/l
TSSout = 270 mg/l

Slide No. 51



Design of Anaerobic Filter

51

Slide No. 52

Design of Anaerobic Filter (AF)

- Secondary treatment unit consisting series of up-flow chamber embedded with filter media
- Filter media is made up of gravel, slag, plastic materials
- It also functions under anaerobic digestion
- Hydraulic Retention Time = 15 - 20 or 24 - 48 hrs
- To avoid clogging of filter bed pre-treatment unit is necessary
- BOD removal efficiency 75%-90%

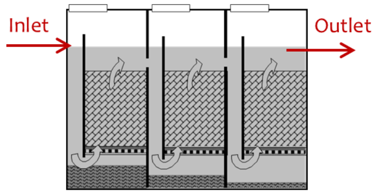
52

Slide No.53

Exercise for Design of AF

Situation provided

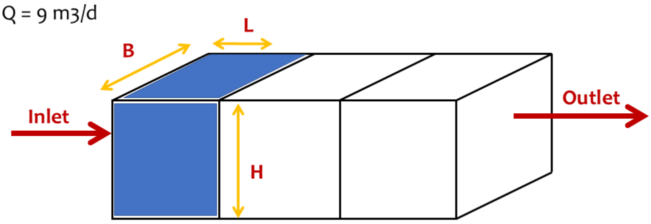
Daily Flow = Q = 9 m3/d
Peak Hour = tp = 12 h
Average Temperature = T= 15 ^{o}C
BODin = 71 mg/l
CODin = 84 mg/l
TSSin = 270 mg/l
Filter media porosity = 30 – 45%



Slide No. 54

Design of AF

Q = 9 m3/d



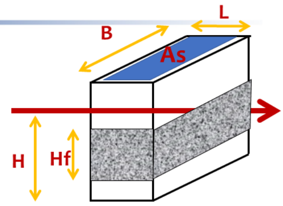
BODout = 71 mg/l
CODout = 84 mg/l
TSSout = 270 mg/l

Number of chamber = ?
Length L = ?
Breadth B = ?
Height H = ?

BODin = ?
CODin = ?
TSSin = ?

Slide No. 55

Sizing of AF



Determine the size of AF

Let, Depth of liquid H = 2 m

Length of chamber L= 1.2 m

where L=< Liquid depth H

Depth of filter media, Hf = H - 0.6 - 0.4 =

= 2 – 0.6 – 0.4 = 1 m

Hf = 60-100 cm

We assume width of filter media equal to width ABR = H = 1.5 m

Slide No. 56

Design Check

Check for HRT (15-20 or 24-48 h)

HRT inside the chamber, HRT = (H-Hf*(1-n%))*L*B*N)/(Q/24)

= (2-1*(1-40%)*1.2*1.5*2)/(9/24) = 13.5 h

Take n% = 30-45%

Check for upflow velocity (0.9 < Vup < 2 m/h)

Upflow velocity, Vup = Qp/(L*B*Void%) =2.08/(2*4*0.45) = 0.6 m/h

Peak Flow = Qp = Q/tPEAK = 25/12 = 2.08 m3/h

Where, tp = time of peak flow = 12 hr

Q = 25 m3/d

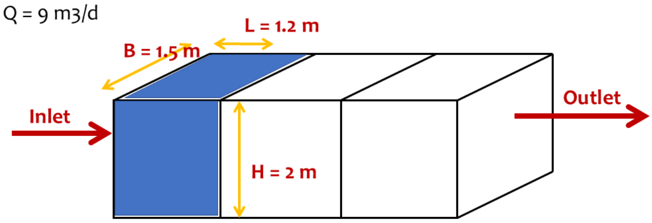
Slide No. 57

Design Check

Check for Organic Loading (< 4.5 kgCOD/m3d)

Organic Loading =(CODin*Q/(H*B*L*n*N))/1000 = 0.42 kgCOD/m3d

Q = 9 m3/d



Slide No. 58

Determine treatment efficiency

Determine CODout

COD out = CODin * (1-CODrem.rate)   Where, CODrem.rate = fs * fT * fHRT * fsur * fO

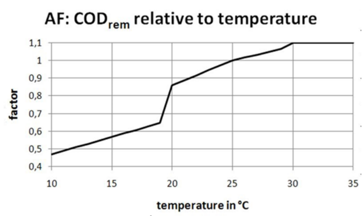
Factor strength fs = 0.9

Factor temperature fT (for 15 ^{O}C)= 0.6

Factor HRT, fHRT = 0.95

Factor surface area, fsur(for 100) = 0.96

Take 80-120 m2 per m3



COD removal rate by factor = fs * fT * fHRT * fsur * fO = 35%

COD out = CODin * (1-CODrem.rate) = 130 mg/l

Slide No. 59

Determine treatment efficiency

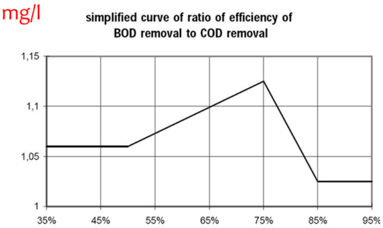
Determine BODout and TSSout

Factor Efficiency of CODrem to BODrem = fBODtoCOD = 1.06

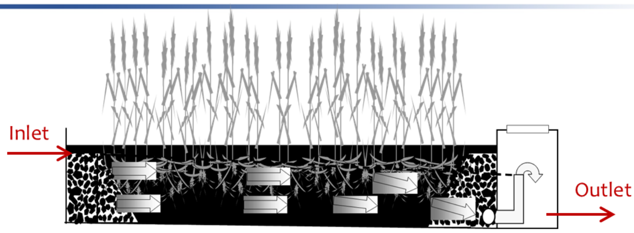
BOD removal rate = CODrem.rate * fBODtoCOD = 0.37

BODout = BODin * (1-BODrem.rate) = 57 mg/l

TSSout = TSSin * (1-80%) = 30 mg/l



Slide No. 60



Design of Horizontal Flow Constructed Wetland

60

Slide No. 61

Design of Horizontal Flow Constructed Wetland (HFCW

Situation provided

Daily Flow = Q = 100 m3/d

BODout = 10 mg/l

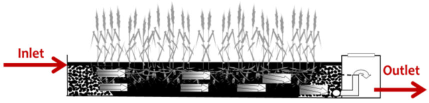
Porosity of filter media, n = 35%

Average Temperature = T= 15 °C

Influent BOD, BODin = 55 mg/l

Influent COD, CODin = 220 mg/l

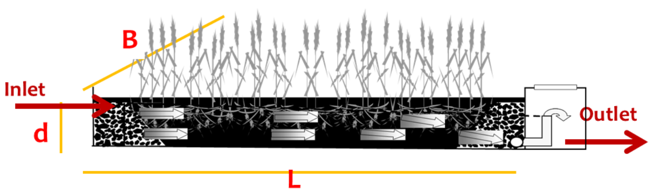
Influent TSS, TSSin = 275 mg/l



Slide No. 62

Design of HFCW

Q = 100 m3/d



BODin = 55 mg/l
CODin = 220 mg/l
TSSin = 275 mg/l

Number of Wetland = ?
Length L= ?
Breadth B= ?
Height d = ?

BODout = ?
CODout = ?
TSSout = ?

Slide No. 63

Sizing of HFCW

Determine of Surface Area

Surface Area (As) = (Q*(LN(BODin)-LN(BODout))/KBOD) =1300 m2

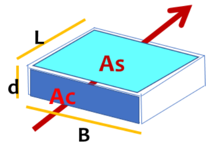
Where KBOD = 0.13 for temp 15 degree Celsius

Cross section area of bed, Ac = Q/(K*S)= 100/(420*1%) = 23.8 m2

Where,

K= Hydraulic Conductivity = 420 m3/m2-d

S = Bed slope = 1%



Determine of Dimension of CW

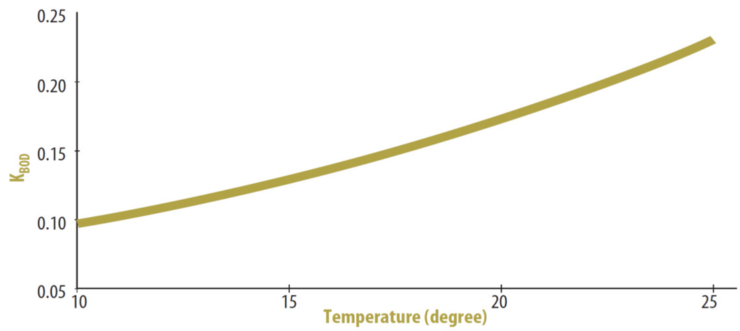
Bed width, B = Ac/d= =23.8/0.4 = 59.5 = 60 m

Bed Length, L = A/B = 1300/60 = 30 m

Divide wetland if the L > 15 m

Slide No. 64

Graph for KBOD



K_{BOD} for HF plotted against Temperature for substrate depth 40 cm and porosity 40%

Slide No. 65

Reference table for Hydraulic Conductivity

Table 3-4. Media Characteristics for Subsurface Flow Systems

Media Type	Max. 10% Grain Size, mm	Porosity (n)	Hydraulic Conductivity (k_s), m^3/m^2-d	K_{20}
Medium Sand	1	0.42	420	**1.84**
Coarse Sand	2	0.39	480	1.35
Gravelly Sand	8	0.35	500	0.86

Slide No. 66

Determine Treatment Efficiency

Determine HRT of Wetland = As*d*n/(Q*24) = 2.1 day

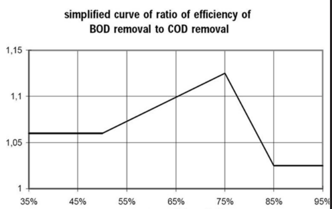
BOD rem.rate = 1 - (BODout/BODin)*100 = 82%

Factor fBODtoCOD = 1.025

COD rem.rate = fBODtoCOD*BODrem.rate = 80%

CODout = CODin* (1-CODrem.rate) = 44 mg/l

TSSout = TSSin* (1-70%) = 83 mg/l



(TSS removal rate 80-95%)

Slide No. 67

Trainer: Have participants open up the Power Point Handouts booklet (the green booklet) to the appropriate location and encourage them to take notes during the session.

Technical Support By:

Environment & Public Health Organization
110/25 Adarsa Marg, New Baneshwor, G.P.O Box: 4102, Kathmandu, Nepal
Tel: 977-1-5244641; 5244051; 5244992; 5244609, Fax: 977-1-5244376
E-mail: enpho@enpho.org, Website: www.enpho.org

Government of Nepal

Ministry of Water Supply

National Water Supply and Sanitation Research, Innovation and Capacity Development Center

Nagarkot, Bhaktapur
Phone No: +977-1-6680171, +977-1-6680172
E-mail: wash.nwssricdc@gmail.com
https://www.nwssricdc.gov.np