DESIGN MODULE

FOR

CO-TREATMENT OF FAECAL SLUDGE AND SEPTAGE WITH SEWAGE IN SEWAGE TREATMENT PLANT

PART C: WORKBOOK

National Institute of Urban Affairs

NFSSM Alliance

ECOSAN SERVICES FOUNDATION

TITLE
Co-Treatment of Faecal Sludge and Septage with Sewage in Sewage Treatment Plant (Part C: Workbook)

PUBLISHER
National Institute of Urban Affairs, New Delhi

RESEARCH PROJECT
Sanitation Capacity building Platform (SCBP)

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Year of Publishing: 2021

CONTENT
The module has been developed with the collaborative effort of NFSSMA partner organisations under Training Module Review Committee (TMRC) anchored by NIUA.

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DESIGN MODULE FOR CO-TREATMENT OF FAECAL SLUDGE AND SEPTAGE WITH SEWAGE IN SEWAGE TREATMENT PLANT

PART C: WORKBOOK

Collaborative Effort Under Training Module Review Committee (TMRC)

National Institute of Urban Affairs

NFSSM Alliance

ecosan SERVICES FOUNDATION

About National Faecal sludge and Septage Management Alliance (NFSSMA)

The 'NFSSM Alliance' was formed with a vision to "Create an enabling environment which amplifies scaling of safe, sustainable and inclusive FSSM through knowledge, partnerships and innovative solutions by 2024."

Convened by Bill and Melinda Gates Foundation in 2016, the Alliance is a voluntary body that aims to:

- Build consensus and drive the discourse on FSSM at a policy level, and
- Promote peer learning among members to achieve synergies for scaled implementation and reduce duplication of efforts.

The Alliance currently comprises 28 organizations across the country working towards solutions for Indian states and cities. The Alliance works in close collaboration with the Ministry of Housing and Urban Affairs (MoHUA) and several state and city governments through its members to support the progress and derive actions towards mainstreaming of FSSM at state and national level. The NFSSM Alliance works on all aspects of city sanitation plans to regulatory and institutional frameworks across the sanitation value chain. The NFSSM Alliance working in collaboration with the Ministry of Housing and Urban Affairs has been instrumental in the drafting of India's First Policy on FSSM launched in 2017. This resulted in 19 out of 36 states and UTs adopting guidelines and policies for FSSM in India.

The strength of the Alliance lies in its diverse membership, which includes research institutes, academic institutions, think-tanks, quasi-government bodies, implementing organizations, data experts, consultants, and intermediaries. This enabled a multi-disciplinary view of urban sanitation, with members building on each other's expertise. The alliance has had enormous success in championing FSSM as a viable solution to the Government of India by broadly focussing on:

1. Influencing and informing policy.
2. Demonstrating success through innovation and pilots.
3. Building capacities of key stakeholders across the value chain.

The collaborative continues to work towards promoting the FSSM agenda through policy recommendations and sharing best practices which are inclusive, comprehensive, and have buy-in from several stakeholders in the sector.

NFSSM Alliance

ASCI	CSTEP	EY	NIUA	USAID
Athena Infonomics	CDD	GIZ	PSI	WASHi
BBC Media Action	CPR	IIHS	RTI International	Water Aid
BMGF	CFAR	ISC	Tide Technocrafts	World Bank Group
Borda	CSE	IWMI	UMC	
CEPT University	Dasra	KPMG	UNICEF	

About Training Module Review Committee (TMRC)

To ensure quality control in content and delivery of trainings and capacity building efforts, a **Training Module Review Committee (TMRC)** was formed with the collaborative effort of all Alliance partners. TMRC which is **anchored by National Institute of Urban Affairs (NIUA)**, has the following broad objectives:

- Identification of priority stakeholders and accordingly training modules for Capacity Building
- Development of a Normative Framework – For Capacity Building at State Level.
- Standardization of priority training modules – appropriate standardization of content with flexibility for customization based on State context.
- Quality Control of Trainings – criteria for ensuring minimum quality of training content and delivery.
- Strategy for measuring impact of trainings and capacity building efforts.

About the Training Module

Title	Co-Treatment of Faecal Sludge and Septage with Sewage in Sewage Treatment Plant (Part C: Workbook)
Purpose	This module gives the participants hands-on knowledge about designing a co-treatment system including assessment of existing STP capacities and available treatment technology options. With the announcement of SBM-U 2.0 and AMRUT 2.0, continuation of NMCG and the recommendations of the 15th Finance Commission, this module provides participants a detailed understanding for adopting co-treatment, which is a key component under septage management in these national missions.
Target Audience	Officials with engineering background and professional experience in wastewater and septage management such as technical faculties from nodal training institutes, technical officials/ engineers from state govt, parastatal bodies and ULBs; consultants from TSU/PMUs and sector partners.
Learning Objectives	The module aims to convey the following learnings: 1. Understand the working principles of Sewage Treatment Plant 2. Understand how to conduct feasibility assessment of existing sewage treatment plants (STPs) to evaluate co-treatment potential and quantify the amount of FSS that can be co-treated 3. Know the approaches for adding faecal sludge in a STP for co-treatment along with the design of additional components such as septage receiving station 4. Gain insight into the operation and maintenance as well as mitigation measures for different treatment units in a STP
Structure of the module	The training module is based on case methodology where in the sessions will be combined with exercises based on real-life cases. This helps to trainees to apply the knowledge grasped during the session and reinforce it further. The module is divided into three parts: Part A: This contains the slides used during the session in the presentation format. Part B: This is a comprehensive compilation of the all the session briefs and further reading material which helps to strengthen the learning. **Part C: This contains the exercise developed for training based on the real-life cases**
Duration	In this face-to-face training format, this training is conceptualized for two days without site visits and can be adopted for including the site visits depending upon the city where it is being conducted.

Contents

LIST OF TABLES

List of Units

SI units

Quantity	Name of Unit	Symbol
Length	meter	m
Mass	kilogram	kg
Time	second	s
Volume	cubic meter or kilo litre	m^3 or KL

CONVERSION TABLES

Length

	millimeter (mm)	centimeter (cm)	meter (m)	kilometer (km)
1 millimeter (mm)	1	0.1	0.001	0.000001
1 centimeter (cm)	10	1	0.01	0.00001
1 meter (m)	1000	100	1	0.001
1 kilometer (km)	1000000	100000	1000	1

Mass

	milligram (mg)	gram (g)	kilogram (kg)
1 milligram (mg)	1	0.001	0.000001
1 gram (g)	1000	1	0.001
1 kilogram (kg)	1000000	1000	1

Time

	second (s)	min (m)	hour (h)	day (d)
1 second (s)	1	1/60	1/3600	1/86400
1 min (m)	1000	1	1/60	1/1440
1 hour (h)	3600	60	1	1/24
1 day (d)	86400	1440	24	1

Volume

	litre (L)	cubic meter (cum, m^3) or kilolitre (KL)	million litre (ML)
1 litre (L)	1	0.001	0.000001
1 cubic meter (m^3) or kilolitre (KL)	1000	1	0.001
1 million litre (ML)	10,00,000	1000	1

SECTION

01

FOUNDATION

1. Foundation

In order to understand the design of treatment units, it is important to be well versed with the terminologies, their definitions and their significance.

1.1 Design capacity

The design capacity of the treatment plant is defined as the volume of liquid that a plant can treat in a day. For example, “The design capacity of the STP is 18 MLD” means, that the STP can treat 18 ML of sewage in a day. Please note this does not necessarily mean that the STP is operational for 24 hours during the day.

1.2 Flow rate

Flow rate (also known as hydraulic loading rate) is defined as the volume of liquid flowing per unit time. For example, “The design flow rate for the 18 MLD STP with 20 h of operation is 900 m^3/h” means the STP is designed to treat 900 m^3 of sewage in 1 h.

However, the flow rate of the STP is not constant and changes with time during the day. This is known as the diurnal variation of flow. Typically, an STP faces two peaks of flow in a day, once during morning between 0800 – 1200 hours and the other during evening between 1900 – 2300 hours. This is defined as the peak flow rate. Please note that the peak flow rate is always higher than the average flow rate. The peaking factor (multiplication factor) is determined by the population connected to the sewerage network. Higher the population, lower is the peaking factor.

1.3 Mass concentration

Mass concentration (also commonly known as concentration) is defined as the mass of constituent in a unit volume of the liquid. For example, “BOD of the sewage is 300 mg/L” means there is 300 mg of BOD in 1 L of the sewage. Similar to the changing flow rate of influent to the STP, the concentration of the influent sewage also keeps on changing.

1.4 Mass load

Mass load (also commonly known as load) is defined as the mass of the constituent. For example, “The BOD load of 1 ML treated sewage as per the treated wastewater discharge standard for STP is 20 kg.” This means that 1 ML of treated sewage with a concentration of 20 mg/L discharged into a surface water body will add 20 kg of BOD to the surface water body.

1.5 Loading rate

Loading rate is similar to the flow rate. It is defined as the mass (or volume) of the constituent applied per unit time to a treatment unit. Thus, the loading rate can be classified as organic (or solids) loading rate and hydraulic loading rate. For example, “The gravity thickener in the STP is designed for the solids loading rate of 5,000 kg TSS/d” means the thickener can handle a load of 5000 kg TSS on a daily basis.

1.6 Problem statement

A moderately sized town has access to a good water source using which the ULB is providing a water supply of 135 LPCD to its population. The ULB conducted a detailed survey and stakeholder consultation for assessing the situation and understanding the feasibility of wastewater management and FSSM. The current generation of wastewater was estimated to be 1 MLD whereas the collection of the faecal sludge and septage was approximately 10 KLD.

Table 1: Characteristics of sewage and septage

Parameter	Unit	Sewage	Septage
BOD	mg/L	250.00	7000.00
COD		425.00	40,000.00
TSS	%	0.04%	1.50%

Given the condition that the ULB does not have any financial and land constraints, please explain whether setting up a sewage treatment plant (STP) is recommended or not?

SOLUTION

$$Pollution\ load\ \left[\frac{kg}{d}\right] = Pollution\ concentration\ \left[\frac{mg}{L}\right] \times Volume\ generation$$

Hint: TSS of 1.5% = 15 g/L

SECTION

02

SEWAGE TREATMENT PLANT

2. Sewage treatment plant (STP)

A semi-urban city is experiencing urbanization due to the development of an IT hub in it's peri-urban region. As a result, the ULB is unable to keep pace with the implementation of sewerage network in the fringe areas of the town.

The city had built and commissioned an 18 MLD STP 7 years ago. The following data was used to calculate the design capacity of the STP.

2.1 Design criteria

The ULB is supplying water at the rate of 135 LPCD to the consumer and has managed to connect 96,000 population to the STP. Due to byelaws and their stringent enforcement, the remaining households are connected to septic tanks. The majority of the population in the adjacent ULBs are also dependent on septic tanks.

Table 2: Design criteria for the STP

Sr. No.	Description	Quantity	Unit
1	Design period	15	Years
2	Projected population	1,66,000	no.
3	Water consumption	135	LPCD
4	Wastewater generation	80	% of water consumption

2.2 Design parameters

The consultants who were engaged by the ULB for preparing the DPR had based the assumption on the Central Public Health and Environmental Engineering Organization (CPHEEO) Manual on Sewerage and Sewage Treatment (2013).

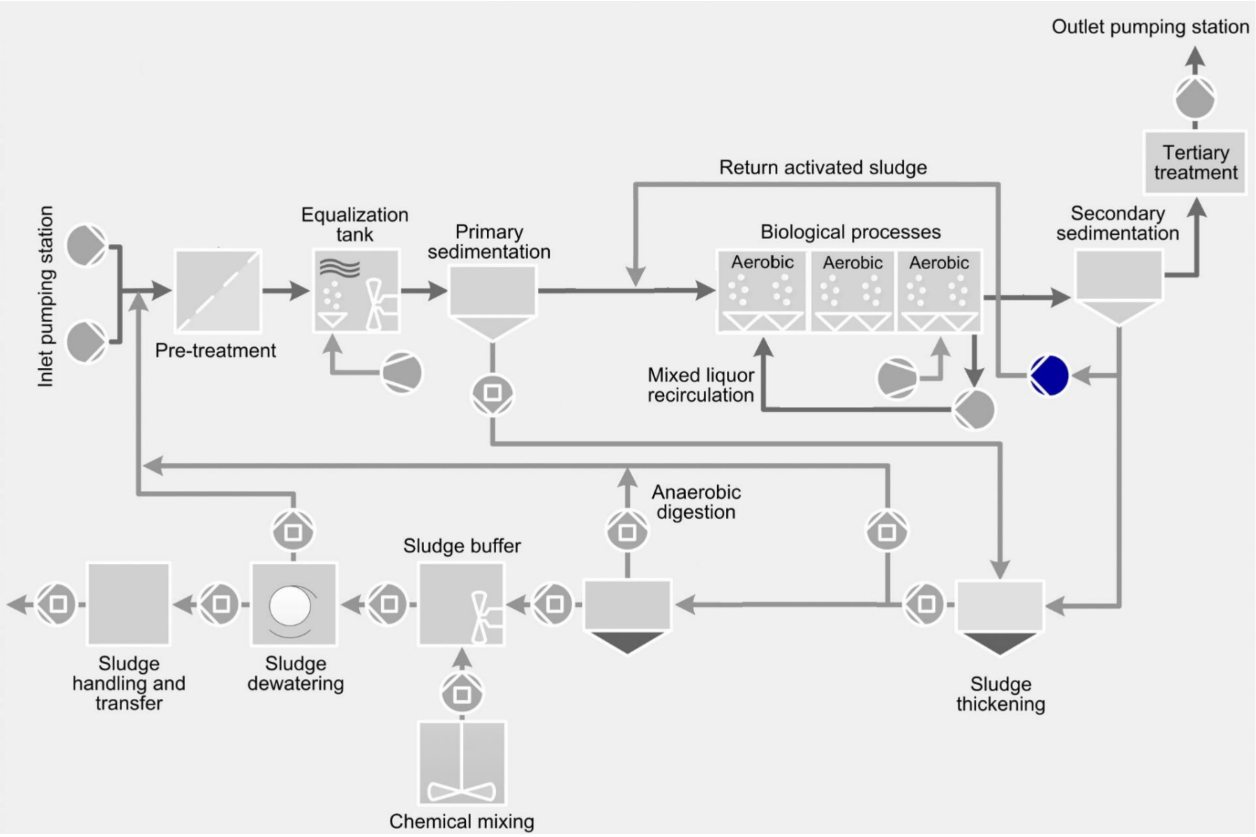
Table 3: Standard design parameters for the STP

Parameter	Unit	Design concentration	Discharge Standards
BOD	mg/L	250.00	20.00
COD	mg/L	425.00	100.00
TSS	mg/L	375.00	50.00

2.3 Treatment chain

The STP has two treatment chains – one for handling the sewage (liquid) and the other for handling the sewage sludge (solids). The figure below shows the two treatment chains in the STP. The top chain is the liquid treatment chain and the bottom one is the solids treatment chain.

Process flow diagram depicting the two treatment chains at the STP



2.4 Details of the treatment units

The following table gives details of treatment unit in the liquid treatment chain and solid treatment chain:

Table 4: Dimensions of the treatment units at STP

Primary clarifier	Dimension	Unit
Number	3.00	no.
Diameter	15.00	m
Depth	3.00	m
Activated Sludge Process (ASP) reactor	**Dimension**	**Unit**
Number	3.00	no.
Length	15.00	m
Breadth	15.00	m
Depth	5.20	m
Secondary clarifier	**Dimension**	**Unit**
Number	3.00	no.
Diameter	19.50	m
Depth	3.50	m
Gravity thickener	**Dimension**	**Unit**
Number	2.00	no.
Diameter	11.40	m
Depth	3.00	m
Anaerobic digester	**Dimension**	**Unit**
Number	2.00	no.
Diameter	18.00	m
Depth	5.20	m

2.5 Efficiency of treatment units

Table 5: Efficiency (%) of the treatment units at the STP

Primary clarifier	
TSS removal efficiency	60%
BOD removal efficiency	30%
Secondary clarifier	
TSS removal efficiency (with respect to TSS_{in} to the clarifier)	99%
Gravity thickener	
TSS removal efficiency	60%
Anaerobic digester	
TSS removal efficiency	35%

2.6 Sludge characteristics

Table 6: Characteristic of sludge generated at the STP

Parameter	Primary sludge	Secondary sludge	Thickened sludge	Digested sludge
Solid content [%]	4.00%	0.60%	8.00%	6%
Density [kg/m³]	1010	1001	1010	1020

2.7 Sludge production

Table 7: Sludge production rate at the STP

Parameter	Primary sludge	Secondary sludge
Volume [m³/h]	1.20	4.60
Solid loading rate [kg/h]	48.00	27.00

SECTION

03

PRE-FEASIBILITY ASSESSMENT

3. Pre-feasibility Assessment

3.1 Problem statement

In order to curb the indiscriminate disposal of faecal sludge and septage into surface water bodies, the ULB wishes to utilize the current STP for co-treatment of faecal sludge and septage with sewage. You are appointed as a consultant by the Water Supply and Sewerage Board (WSSB) to carry out a rapid assessment of the STP for checking the feasibility of co-treatment of faecal sludge and septage with sewage at the STP. A meeting is convened by the WSSB where you have to present the following data:

- Current utilization of the volumetric capacity of the STP.
- Current utilization of the loading capacity with respect to BOD, COD and TSS.
- Volume of septage feasible for co-treatment.

Composite sampling was carried out in order to assess the characteristics of the influent sewage. Similarly, in case of faecal sludge and septage, multiple samples were taken and sent for analysis to the lab. The tables below provide the results from the lab analysis.

Table 8: Influent sewage characteristics at the STP

Parameters	Influent concentration	
BOD	182.00	mg/L
COD	305.00	mg/L
TSS	157.00	mg/L

Table 9: Faecal sludge and septage characteristics collected in the city

Parameters	Concentration	
BOD	7000.00	mg/L
COD	20000.00	mg/L
TSS	15000.00	mg/L

3.2 Solution

3.2.1 Volumetric utilization

Using information given in section 2.1, calculate the volumetric utilization.

$$\begin{aligned} &\textit{Volumetric utilization } [MLD] \\ &\qquad = \textit{Connected Population } [no.] \times \textit{Water consumption } [LPCD] \\ &\qquad \times \textit{Wastewater generation } [\%] \end{aligned}$$

Volumetric utilization = ________________ MLD

Volumetric utilization [%] = $\frac{\textit{Current utilization } [MLD]}{\textit{Design capacity } [MLD]} \times 100$

Volumetric utilization = __________ %

3.2.2 Load utilization

Using information given in section 2.1, calculate the design load.

$$Design\ load\ \left[\frac{kg}{d}\right] = Design\ capacity\ [MLD] \times Design\ concentration\ \left[\frac{mg}{L}\right]$$

Table 10: Design load of the STP

Parameters	Design capacity [MLD]	Design concentration [mg/L]	Design load [kg/d]
BOD			
COD			
TSS			

$$Load\ utilization\ \left[\frac{kg}{d}\right] = Volumetric\ utilization\ [MLD] \times Influent\ concentration\ \left[\frac{mg}{L}\right]$$

Table 11: Load utilization of the STP

Parameters	Utilization [MLD]	Influent concentration [mg/L]	Load utilization [kg/d]
BOD			
COD			
TSS			

$$Load\ utilization\ [\%] = \frac{Load\ utilization\ [kg/d]}{Design\ Load\ [kg/d]} \times 100$$

Table 12: Load utilization (%) of the STP

Parameters	Design load [kg/d]	Load utilization [kg/d]	Load utilization [%]
BOD			
COD			
TSS			

3.2.3 Co-treatment feasibility

$$Unutilized\ load\ \left[\frac{kg}{d}\right] = Design\ load\ \left[\frac{kg}{d}\right] - Load\ utilization\ \left[\frac{kg}{d}\right]$$

Table 13: Unutilized load of the STP

Parameters	Design load [kg/d]	Load utilization [kg/d]	Unutilized load [kg/d]
BOD			
COD			
TSS			

Using information given in the section 3.1, calculate the faecal sludge and septage (FSS) handling capacity.

$$Septage\ handling\ capacity\ [KLD] = \frac{Unutilized\ load\ \left[\frac{kg}{d}\right]}{Septage\ Concentration\ \left[\frac{mg}{L}\right]}$$

Table 14: Faecal sludge and septage handling capacity of the STP

Parameters	Unutilized load [kg/d]	Concentration [mg/L]	Handling capacity [KLD]
BOD			
COD			
TSS			

Constraining parameter is ____________.

INFERENCE:

Write your inference here from the findings and observations from the above section of the exercise.

SECTION

04

DETAILED ASSESSMENT

4. Detailed Assessment

4.1 Problem statement

The WSSB decided to go ahead with carrying out the detailed assessment of the STP in order to understand the implications of the co-treatment on the operation and maintenance cost of the STP. This would enable them to draft better terms for the maintenance contract with a private operator.

As a consultant, your job is to carry out a detailed assessment and provide recommendations for co-treatment of faecal sludge and septage with sewage at the STP.

4.2 Solution

The addition of equalization tank or a receiving sump at the inlet of the STP is mostly to ensure a continuous flow of sewage into the STP. The optimization in area requirements and improvement in treatment efficiency of STP are some of the additional benefits of providing an equalization tank. This depends on the hours of operation of STP. In this case, the STP was designed for 20 hours of operation in a day. This means that the 18 MLD sewage will be treated in 20 hours in a day (and not 24 hours!).

In order to maximize the potential of co-treatment, let's assume that the STP will be operated for 20 hours during the co-treatment of faecal sludge and septage with sewage.

4.2.1 Flow rate

Calculate the design and actual flow rate.

$$Flow\ rate\ \left[\frac{cum}{h}\right] = \frac{Design\ Capacity\ or\ Utilized\ Capacity\ [MLD]}{Operation\ hours\ [h]}$$

Table 15: Design and actual flow rate at the STP

Parameter	Quantity	Unit
Design flow rate		m^3/h
Actual flow rate		m^3/h

4.2.2 Loading rate

Calculate the organic loading rate and solids loading rate based on the information provided in sections 2.2 and 3.1.

$$Loading\ rate\ \left[\frac{kg}{h}\right] = Flow\ rate\ \left[\frac{cum}{h}\right] \times Concentration\ \left[\frac{mg}{L}\right]$$

Table 16: Organic and solids loading rate at the STP

Parameter	Flow rate [m³/h]		Concentration [mg/L]	
	Design	Actual	Design	Actual
BOD			250.00	182.00
COD			425.00	305.00
TSS			375.00	157.00
Parameter	**Loading rate [kg/h]**		**Unutilized Loading [kg/h]**	
	Design	**Actual**		
BOD				
COD				
TSS				

4.2.3 Faecal sludge and septage (FSS) load

Calculate load of FSS assuming, one truck load of FSS is added to the sewage every hour.

Parameter	Concentration [mg/L]	Truck capacity [KL]	Truck decanted [no./h]	Truck load [kg/h]
BOD	7,000.00	3.00	1.0	
COD	20,000.00			
TSS	15,000.00			

4.2.4 Addition of faecal sludge and septage (FSS)

There are two options for co-treating FSS with sewage at an STP: (1) addition of FSS in the sewage (liquid) stream, and (2) addition of FSS in the sewage sludge (solid) stream.

In case of option one, there is a further option of direct addition in the receiving sump and addition after solid-liquid separation. This mainly depends on the utilization of design capacity and the availability of land area within the plant premises. In this section, we will explore the option of addition after solid-liquid separation and addition of septage in the solid stream.

At this stage, a safety factor needs to be considered in order to accommodate any change in the quality of the influent sewage or septage. In this case, **a safety factor of 20% is assumed**.

If direct addition of FSS is to be done in the receiving sump, then the feasible load that can be added per hour is 2 truckloads with COD as the constraining parameter.

4.2.5 Solid-liquid separation

Let us assume a settling thickening tank is provided having an efficiency of 60%. For every truck emptied in the settling thickening tank, part of the solids are settled in the tank as thickened sludge and the rest of the solids are retained in the liquid phase.

Parameter	Quantity	Unit
Volume of septage	3.00	m³/h
TSS	15,000.00	mg/L
Solid content	1.50	%
Solid loading	________	kg/h
Efficiency	60.00	%
Dry solid content	8.00	%
Thickened sludge density	1020	kg/m³

Calculate the suspended solids (SS) load in supernatant and thickened sludge stream.

$$SS\ load\ in\ sludge\ stream\ \left[\frac{kg}{h}\right] = Solids\ loading\ \left[\frac{kg}{h}\right] \times Efficiency\ [\%]$$

SS load in supernatant stream = __________ kg/h

$$SS\ load\ in\ supernatant\ stream\ \left[\frac{kg}{h}\right] = Solids\ loading\ \left[\frac{kg}{h}\right] \times (1 - Efficiency\ [\%])$$

SS load in supernatant stream = __________ kg/h

Calculate the volume of thickened sludge.

$$Volume\ of\ sludge\ \left[\frac{cum}{h}\right] = \frac{SS\ load\ in\ sludge\ \left[\frac{kg}{h}\right]}{Dry\ solid\ content\ [\%] \times Sludge\ density\ \left[\frac{kg}{cum}\right]}$$

Volume of thickened sludge =__________ m³/h

$$Volume\ of\ supernatant\ \left[\frac{cum}{h}\right] = Volume\ of\ septage\ \left[\frac{cum}{h}\right] - Volume\ of\ thickened\ sludge\ \left[\frac{cum}{h}\right]$$

Volume of supernatant = __________ m³/h

Calculate the solid content in the supernatant.

$$Solid\ content\ [\%] = \frac{SS\ load\ in\ supernatant\ \left[\frac{kg}{h}\right]}{Volume\ of\ supernatant\ \left[\frac{cum}{h}\right] \times Density\ of\ water\ \left[\frac{kg}{cum}\right]}$$

Solid content = _______ %

Solid content = __________ mg/L

In case of FSS, the organic pollutants are correlated to the total suspended solids. Hence, removal of TSS in the FSS also reduces the COD and BOD in the supernatant.

Consider the approximate values for the BOD and COD of the supernatant based on the TSS content of the supernatant and corresponding ratio (BOD: TSS and COD: TSS) of the FSS.

Table 17: Characteristics of supernatant from settling thickening tank

Parameter	Concentration [mg/L]	
	FSS	Supernatant
BOD	7,000.00	
COD	20,000.00	
TSS	15,000.00	

4.2.6 Supernatant load

Using the information from 4.2.5, calculate the load of supernatant.

Table 18: Organic and solids load of supernatant from settling thickening tank

Parameter	Concentration [mg/L]	Supernatant volume [m³/h]	Supernatant load [kg/h]
BOD			
COD			
TSS			

4.2.7 Feasible truck load

$$Feasible\ truck\ load\ \left[\frac{no.}{h}\right] = \frac{Unutilized\ loading\ \left[\frac{kg}{h}\right]}{Supernatant\ load\ \left[\frac{kg}{h}\right]}$$

Table 19: Feasible truck load for co-treatment of FSS with sewage at the STP

Parameter	Unutilized loading [kg/h]	Supernatant load [kg/h]	Feasible truck load [no./h]
BOD			
COD			
TSS			

Thus, for safer treatment the constraining parameter is identified and corresponding truck loads are taken for further calculation. Thus, in this case, the feasible truck loads are ________ no./h.

It can also be inferred that because of solid-liquid separation, the STP can handle almost _______ times the load when compared to direct addition of faecal sludge and septage in the receiving sump.

4.3 Addition after solid-liquid separation

In this section, a detailed assessment of all the treatment units will be done upon addition of supernatant and thickened sludge from settling thickening tank into the sewage (liquid) stream and gravity thickener, respectively.

4.3.1 Primary clarifier

Using the information from sections 4.2.6 and 4.2.7, calculate the total solids loading rate and hydraulic loading rate to the primary clarifier after addition of supernatant to the liquid stream.

$$Solids\ loading\ rate\ \left[\frac{kg}{h}\right]$$
$$= Solids\ loading\ rate\ of\ sewage\ \left[\frac{kg}{h}\right]$$
$$+ \left\{Feasible\ truck\ loads\ \left[\frac{no.}{h}\right] \times Supernatant\ load\ \left[\frac{kg}{h}\right]\right\}$$

Solids loading rate = ____________ kg/h

$$Hydraulic\ loading\ rate\ \left[\frac{cum}{h}\right]$$
$$= Hydraulic\ loading\ rate\ of\ sewage\ \left[\frac{cum}{h}\right]$$
$$+ \left\{Feasible\ truck\ loads\ \left[\frac{no.}{h}\right] \times Supernatant\ volume\ [cum]\right\}$$

Hydraulic loading rate = ____________ m³/h

This hydraulic loading rate is assumed to be constant for the subsequent liquid treatment units.

FEASIBILITY CHECK!

The hydraulic loading rate should be lower than the design flow rate. This usually holds true provided there is no mistake in the calculations done before.

Calculate the TSS concentration.

$$TSS\ concentration\ \left[\frac{mg}{L}\right] = \frac{Solids\ loading\ rate\ \left[\frac{kg}{h}\right]}{Hydraulic\ loading\ rate\ \left[\frac{cum}{h}\right]}$$

TSS concentration = ______________ mg/L

FEASIBILITY CHECK!

The TSS concentration should be lower than 1000 mg/L. Primary clarifier is designed for flocculant settling of solids assuming that the solids loading rate will be below 1000 mg/L.

Using the information given in section 2.5, calculate primary sludge generation in kg/h and m³/h.

$$Primary\ sludge\ generation\ \left[\frac{kg}{h}\right] = Solids\ loading\ rate\ \left[\frac{kg}{h}\right] \times TSS\ removal\ efficiency\ [\%]$$

Primary sludge generation = _____________ kg/h

Using the information given in section 2.6, calculate the primary sludge generation rate.

$$Primary\ sludge\ generation\ \left[\frac{cum}{h}\right] = \frac{Primary\ sludge\ generation\ \left[\frac{kg}{h}\right]}{Solid\ content\ [\%] \times Sludge\ density\ \left[\frac{kg}{cum}\right]}$$

Primary sludge generation = ____________ m³/h

Using the information from sections 4.2.6 and 4.2.7, using the calculations done for solids loading rate on primary clarifier kindly calculate the BOD loading rate.

BOD loading rate = _____________ kg/h

BOD_{in} = ___________ mg/L

Using the information from section 2.5, calculate the BOD_{out} from the primary clarifier.

$BOD_{out} = BOD_{in} \times (1 - BOD\ removal\ efficiency)$

BOD_{out} = ______________ mg/L

4.3.2. ASP Reactor

Using information from section 2.4, calculate the design BOD (S_0) for ASP reactor.

Volume of the reactor (V) = ___________ m³

Design hydraulic load (Q) = ___________ MLD

Standard design criteria for an ASP Reactor: F/M ratio = 0.45 /d and MLSS (X) = 3500 mg/L

$$So\ \left[\frac{g\ BOD}{L}\right] = \frac{\frac{F}{M}\left[\frac{1}{d}\right] \times V\ [cum] \times X\ \left[\frac{mg}{L}\right]}{Q\ \left[\frac{cum}{d}\right]}$$

Design BOD (S_0) = ________________ mg/L

FEASIBILITY CHECK!

The BOD_{out} of a primary clarifier (i.e. BOD_{in} of the ASP reactor) should be less than the design BOD of the ASP reactor. During the operation of plant, the operator will have to adjust the return flow of the activated sludge from the secondary clarifier to maintain the MLSS and F/M ratio of the reactor.

Calculate the hydraulic retention time.

$$Design\ HRT\ [h] = \frac{V\ [cum]}{Q\ [MLD]}$$

Design HRT = ___________ h

$$Actual\ HRT\ [h] = \frac{V\ [cum]}{Hydraulic\ loading\ rate\ \left[\frac{cum}{h}\right]}$$

Actual HRT = ____________ h

FEASIBILITY CHECK!

The actual HRT should be more than the design HRT for an ASP reactor. This ensures that the aeration capacity of the reactor is sufficient to handle the incoming BOD load and to maintain the BOD removal efficiency of the ASP reactor.

4.3.3 Secondary Clarifier

Using the information given in sections 2.4 and 4.3.2, calculate the solids loading rate (solids loading per day per unit area of the clarifier).

TSS_{in} concentration [mg/L] = MLSS in ASP reactor = _____________ mgTSS/L

Area of the clarifier = _____________ m²

$$Solids\ loading\ rate\ \left[\frac{kg\ TSS}{d \times sqm}\right] = \frac{TSSin\ \left[\frac{mg}{L}\right] \times Hydraulic\ loading\ rate\ \left[\frac{cum}{h}\right] \times Operation\ hours\ [h]}{Area\ of\ clarifier\ [sqm]}$$

Solids loading rate per unit area of clarifier = ______________ kgTSS/d/m²

FEASIBILITY CHECK!

The solids loading rate per day per unit area of a secondary clarifier should be lower than 120 kgTSS/d/m². This ensures that the TSS removal efficiency of the clarifier is not affected and sludge wash-out does not take place.

Using information given in sections 4.1, 4.3.1 and 4.3.3, calculate the surface loading rate (hydraulic loading per day per unit area of the clarifier).

$$Surface\ loading\ rate\ \left[\frac{cum}{d \times sqm}\right] = \frac{Hydraulic\ loading\ rate\ \left[\frac{cum}{h}\right] \times Operation\ hours\ [h]}{Area\ of\ secondary\ clarifier\ [sqm]}$$

Surface loading rate per unit area of the clarifier = _______________ m³/d/m²

FEASIBILITY CHECK!

The surface loading rate per day per unit area of a secondary clarifier should be lower than 30 $m^3/d/m^2$. This ensures that the TSS removal efficiency of the clarifier is not affected and sludge wash out does not take place.

Using information provided in section 2.5, calculate TSS_{out} of the secondary clarifier.

$$TSSin \left[\frac{kg}{h}\right] = TSSin \left[\frac{mg}{L}\right] \times Hydraulic\ loading\ rate \left[\frac{cum}{h}\right]$$

$$TSSout \left[\frac{kg}{h}\right] = TSSin \left[\frac{kg}{h}\right] \times TSS\ removal\ efficiency\ [\%]$$

TSS_{out} = ____________ kg/h

$$TSSout \left[\frac{mg}{L}\right] = \frac{TSSout \left[\frac{kg}{h}\right]}{Hydraulic\ loading\ rate \left[\frac{cum}{h}\right]}$$

TSS_{out} = _______________ mg/L

FEASIBILITY CHECK!

The TSS_{out} for a secondary clarifier should be less than the discharge standards as mandated by the state pollution control board or the design outlet parameter of the STP.

Calculate the sludge wastage in the secondary stage of STP.

Secondary stage of the STP refers to a combination of the ASP reactor and the secondary clarifier. The sludge waste is equal to 0.50 kg/kgBOD removed in the secondary stage.

BOD_{in} to the ASP reactor = BOD_{out} of primary clarifier = ____________ mg/L

BOD_{out} of the secondary clarifier = 20 mg/L

$$BOD\ removed \left[\frac{kg\ BOD}{h}\right] = \{BODin - BODout\} \left[\frac{mg}{L}\right] \times Hydraulic\ loading\ rate \left[\frac{cum}{h}\right]$$

$$Sludge\ wastage \left[\frac{kg}{h}\right] = BOD\ removed \left[\frac{kg}{h}\right] \times 0.50 \left[\frac{kg}{kg\ BOD}\right]$$

Sludge wastage = ______________ kg/h

$$Sludge\ wastage \left[\frac{cum}{h}\right] = \frac{Sludge\ wastage \left[\frac{kg}{h}\right]}{Dry\ solid\ content\ [\%] \times Sludge\ density \left[\frac{kg}{cum}\right]}$$

Sludge wastage = _______________ m^3/h

4.3.4 Gravity Thickener

Using information from section 2.4, calculate the following:

Area of the gravity thickener = ____________ m^2

Volume of the gravity thickener = ____________ m^3

Solids loading rate [kg/h] applied to the gravity thickener is equal to the sum of primary sludge production [kg/h], sludge wastage from secondary stage [kg/h] and thickened sludge from the settling thickening tank [kg/h]. Multiply the above number with operation hours [h] to get solids loading rate in [kg/d].

Solids loading rate = ______________ kg/d

Similarly, calculate hydraulic loading rate [m^3/d].

Hydraulic loading rate = _______________ m^3/d

Calculate the solids loading rate (solids loading per day per unit area of the gravity thickener).

$$Solids\ loading\ rate \left[\frac{kg\ TSS}{d \times sqm}\right] = \frac{Solids\ loading\ rate \left[\frac{kg\ TSS}{d \times sqm}\right]}{Area\ of\ gravity\ thickener\ [sqm]}$$

Solids loading rate per unit area of gravity thickener = ________________ kgTSS/d/m^2

FEASIBILITY CHECK!

The solids loading rate per day per unit area of a gravity thickener should lie between 25 kgTSS/d/m^2 and 80 kgTSS/d/m^2. If the solids loading rate is less than 25 kgTSS/d/m^2, then the return flow of the effluent from anaerobic digester needs to be adjusted. This ensures that the TSS removal efficiency of the gravity thickener is not affected and sludge wash-out does not take place.

Move to the next step as the adjustment is done later.

Calculate the surface loading rate (hydraulic loading per day per unit area of the gravity thickener).

$$Surface\ loading\ rate \left[\frac{cum}{d \times sqm}\right] = \frac{Hydraulic\ loading\ rate \left[\frac{cum}{d}\right]}{Area\ of\ gravity\ thickener\ [sqm]}$$

Surface loading rate per unit area of the gravity thickener = _____________ $m^3/d/m^2$

FEASIBILITY CHECK!

The surface loading rate per day per unit area of a gravity thickener should lie between 20 $m^3/d/m^2$ and 30 $m^3/d/m^2$. If the surface loading rate is less than 20 $m^3/d/m^2$, then the return flow of the effluent from anaerobic digester needs to be adjusted. This ensures that the TSS removal efficiency of the gravity thickener is not affected and sludge wash-out does not take place.

Move to the next step as the adjustment is done later.

Calculate the hydraulic retention time (HRT) of gravity thickener.

$$HRT\ [d] = \frac{Volume\ of\ the\ gravity\ thickener\ [cum]}{Hydraulic\ loading\ rate\ \left[\frac{cum}{d}\right]}$$

HRT = ____________ d

FEASIBILITY CHECK!

The HRT of a gravity thickener should be less than 1 day i.e. 24 hours. This ensures that the conditions in the gravity thickener do not turn septic and issues related foul odor do not arise in the STP.

ADJUSTMENT

Adjusting the return flow of the effluent from the anaerobic digester automatically adjusts the solids loading rate, the surface loading rate and the HRT of the gravity thickener.

The operator needs to calculate the return flow based on the dimensions of gravity thickener and the design criteria (solids loading rate and surface loading rate).

$$Solids\ loading\ \left[\frac{kg}{d}\right] = Area\ of\ the\ gravity\ thickener\ [sqm] \times Design\ solids\ loading\ rate\ [\frac{kg\ TSS}{d\ \times sqm}]$$

$$Hydraulic\ loading\ \left[\frac{cum}{d}\right] = Area\ of\ the\ gravity\ thickener\ [sqm] \times Design\ surface\ loading\ rate\ [\frac{cum}{d\ \times sqm}]$$

Thus, after adjusting the return flow of the effluent:

Solids loading to the gravity thickener = ______________ kg/d

Hydraulic loading rate to the gravity thickener = _____________ m³/d

Using the information from section 2.5, calculate the production of thickened sludge from the gravity thickener.

$$Mass\ of\ thickened\ sludge\ \left[\frac{kg}{d}\right] = Solids\ loading\ to\ gravity\ thickener\ \left[\frac{kg}{d}\right] \times TSS\ removal\ efficiency\ [\%]$$

Mass of thickened sludge = ______________ kg/d

Using the information from section 2.6, calculate the volume of the thickened sludge.

$$Volume\ of\ thickened\ sludge\ \left[\frac{cum}{d}\right] = \frac{Mass\ of\ thickened\ sludge\ \left[\frac{kg}{d}\right]}{Solid\ content\ [\%] \times Sludge\ density\ \left[\frac{kg}{cum}\right]}$$

Volume of thickened sludge = _____________ m³/d

4.3.5 Anaerobic Digester

Using the information from section 2.4, calculate the following:

Area of the anaerobic digester = ______________ m²

Volume of the anaerobic digester = ____________ m³

Solids loading = mass of the thickened sludge = ____________ kg/h

Hydraulic loading = volume of the thickened sludge = ____________ m³/d

Calculate the detention time of anaerobic digester.

$$Detention\ time\ [d] = \frac{Volume\ of\ the\ anaerobic\ digester\ [cum]}{Hydraulic\ loading\ \left[\frac{cum}{d}\right]}$$

Detention time = _________ d

FEASIBILITY CHECK!

The recommended value for detention time of an anaerobic digester is 30 days at a minimum temperature of 25 °C. This provides enough time for the sludge to get digested and produce maximum methane gas.

Calculate the solids volumetric load.

$$Solids\ volumetric\ loading\ \left[\frac{kg\ TSS}{d\ \times cum}\right] = \frac{Solids\ loading\ \left[\frac{kg}{d}\right]}{Volume\ of\ the\ anaerobic\ digester\ [cum]}$$

Solids volumetric loading = ______________ kgTSS/d/m³

FEASIBILITY CHECK!

The solids volumetric loading for an anaerobic digester should be between 1 kgTSS/d/m³ and 2 kgTSS/d/m³. This ensures that the performance efficiency of the digester is not hampered.

The anaerobic digester produces two effluent streams: (1) liquid stream from the top of the digester, and (2) digested sludge stream from the bottom of the digester. The liquid stream is returned to the gravity thickener or the inlet of the STP and the digested sludge stream is sent to the dewatering unit/s.

Using the information from section 2.5, calculate the production of digested sludge from the anaerobic digester.

$$Mass\ of\ digested\ sludge\ \left[\frac{kg\ TSS}{d}\right]$$
$$= Solids\ loading\ to\ anaerobic\ digester\ \left[\frac{kg}{d}\right] \times TSS\ removal\ efficiency\ [\%]$$

Mass of digested sludge = ______________ kgTSS/d

Using the information from section 2.6, calculate the volume of the digested sludge.

$$Volume\ of\ digested\ sludge\ \left[\frac{cum}{d}\right] = \frac{Mass\ of\ digested\ sludge\ \left[\frac{kg}{d}\right]}{Solid\ content\ [\%] \times Sludge\ density\ \left[\frac{kg}{cum}\right]}$$

Volume of digested sludge = ____________ m^3/d

4.3.6 Sludge Dewatering

At this stage, the dewatering of the digested sludge is done using a mechanical equipment such as centrifuge, screw press or belt press. The aim of this stage is to increase the solid content of the sludge upto 25%.

To increase the efficiency of the mechanical dewatering equipment, adjustments are done to the operating parameters such as:

- Centrifuge: RPM and feeding rate.
- Screw press: Feeding rate and the tension in the spring of the compaction plate.
- Belt press: Feeding rate and tension in the belt.

Apart from this, the operator needs to adjust the dosage of the polymer to condition the sludge so that the mechanical dewatering equipment gives highest efficiency.

Calculate the dosage of polymer.

Dose 10 g polymer/kgTSS of sludge

$$Dosage\ [kg/d] = Mass\ of\ digested\ sludge\ \left[\frac{kg\ TSS}{d}\right] \times 10\ \left[\frac{g}{kg\ TSS}\right]$$

Dosage = __________ kg/d

INFERENCE:

Write your inference here from the findings and observations from the above section of the exercise.

4.4 Addition in sewage sludge stream

By adding the septage directly in the sewage sludge (solid) stream, the primary and secondary sludge production will not change significantly. Using information from section 2.7, please fill the following data:

Primary sludge generation = ____________ m^3/h & ______________ kg/h

Secondary sludge generation = ____________ m^3/h & ______________ kg/h

4.4.1 Gravity Thickener

Using information from section 4.3.4, please fill the following:

Area of the gravity thickener = ____________ m^2

Volume of the gravity thickener = ____________ m^3

Following assumptions are based on the design criteria:

Design solids loading rate = 52.50 kg/d/m^2...................... (average of 25-80 kg/d/m^2)

Design surface loading rate = 25 m3/d/m^2........................ (average of 20-30 $m^3/d/m^2$)

Calculate the design solids and hydraulic loading.

$$Design\ solids\ loading\ \left[\frac{kg}{d}\right] = Area\ [sqm] \times Design\ solids\ loading\ rate\ \left[\frac{kg}{d \times sqm}\right]$$

$$Design\ hydraulic\ loading\ \left[\frac{cum}{d}\right] = Area\ [sqm] \times Design\ surface\ loading\ rate\ \left[\frac{cum}{d \times sqm}\right]$$

Design solids loading = ____________ kg/d

Design hydraulic loading = ___________ m^3/d

Calculate current solids and hydraulic loading before addition of the septage.

Current solids and hydraulic loading are only due to primary and secondary sludge generated in the STP. Use the given sludge generation rate above and multiply it with operations hours to get the current solids loading rate [kg/d] and hydraulic loading rate [m^3/d].

Current solids loading rate = ______________ kg/d

Current hydraulic loading rate = _______________ m³/d

The solids load of one 3 KL truck load of FSS with TSS content of 15,000 mg/L is 45 kg/truck load.

Assuming 20% as a factor of safety, calculate the unutilized solids loading rate.

$$Unutilized\ solids\ loading\ rate\ \left[\frac{kg}{d}\right] = Solids\ loading\ rate\ \left[\frac{kg}{d}\right] \times (1 - safety\ factor)$$

Unutilized solids loading rate = ______________ kg/d

Calculate the feasible truck load.

$$Feasible\ truck\ load\ \left[\frac{no.}{d}\right] = \frac{Unutilized\ loading\ \left[\frac{kg}{d}\right]}{Septage\ load\ \left[\frac{kg}{truck\ load}\right]}$$

Feasible truck load = ___________ no./d

Calculate the actual solids and hydraulic loading after addition of FSS in sewage sludge stream.

$$Actual\ solids\ loading\ \left[\frac{kg}{d}\right] = Current\ solids\ loading\ \left[\frac{kg}{d}\right] + \left\{Feasible\ truck\ load\ \left[\frac{no.}{d}\right] \times Septage\ load\ \left[\frac{kg}{truckload}\right]\right\}$$

Actual solids loading = _____________ kg/d

$$Actual\ hydraulic\ loading\ \left[\frac{cum}{d}\right] = Current\ hydraulic\ loading\ \left[\frac{cum}{d}\right] + \left\{Feasible\ truck\ load\ \left[\frac{no.}{d}\right] \times Septage\ volume\ \left[\frac{cum}{truckload}\right]\right\}$$

Actual hydraulic loading = _____________ m³/d

Calculate the solids loading rate per unit area of the gravity thickener.

$$Solids\ loading\ rate\ \left[\frac{kg\ TSS}{d\ \times sqm}\right] = \frac{Actual\ solids\ loading\ rate\ \left[\frac{kg\ TSS}{d\ \times sqm}\right]}{Area\ of\ gravity\ thickener\ [sqm]}$$

Solids loading rate per unit area of gravity thickener = _____________ kgTSS/d/m²

FEASIBILITY CHECK!

The solids loading rate per day per unit area of a gravity thickener should lie between 25 kgTSS/d/m² and 80 kgTSS/d/m². If the solids loading rate is less than 25 kgTSS/d/m², then the return flow of the effluent from anaerobic digester needs to be adjusted. This ensures that the TSS removal efficiency of the gravity thickener is not affected and sludge wash out does not take place.

Calculate the surface loading rate (hydraulic loading per day per unit area of the gravity thickener).

$$Surface\ loading\ rate\ \left[\frac{cum}{d\ \times sqm}\right] = \frac{Hydraulic\ loading\ rate\ \left[\frac{cum}{d}\right]}{Area\ of\ gravity\ thickener\ [sqm]}$$

Surface loading rate per unit area of the gravity thickener = _____________ m³/d/m²

FEASIBILITY CHECK!

The surface loading rate per day per unit area of a gravity thickener should lie between 20 m³/d/m² and 30 m³/d/m². If the solids loading rate is less than 20 m³/d/m², then the return flow of the effluent from anaerobic digester needs to be adjusted. This ensures that the TSS removal efficiency of the gravity thickener is not affected and sludge wash out does not take place.

Move to the next step as the adjustment is done later.

Calculate the hydraulic retention time (HRT) of the gravity thickener.

$$HRT\ [d] = \frac{Volume\ of\ the\ gravity\ thickener\ [cum]}{Hydraulic\ loading\ rate\ \left[\frac{cum}{d}\right]}$$

HRT = __________ d

FEASIBILITY CHECK!

The HRT of a gravity thickener should be less than 1 day i.e. 24 hours. This ensures that the conditions in the gravity thickener does not turn septic and issues of foul odour do not arise in the STP.

ADJUSTMENT

Adjusting the return flow of the effluent from the anaerobic digester automatically adjusts the surface loading rate of the gravity thickener.

The operator needs to calculate the return flow based on dimensions of the gravity thickener and the design criteria (solids loading rate and surface loading rate).

$$Hydraulic\ loading\ \left[\frac{cum}{d}\right] = Area\ of\ the\ gravity\ thickener\ [sqm] \times Design\ surface\ loading\ rate\ \left[\frac{cum}{d\ \times sqm}\right]$$

Thus, after adjusting the return flow of the effluent:

Hydraulic loading rate to the gravity thickener = ______________ m^3/d

Calculate the production of thickened sludge from gravity thickener.

$$Mass\ of\ thickened\ sludge\ \left[\frac{kg}{d}\right]$$
$$= Solids\ loading\ to\ gravity\ thickener\ \left[\frac{kg}{d}\right] \times TSS\ removal\ efficiency\ [\%]$$

Mass of thickened sludge = ______________ kg/d

$$Volume\ of\ thickened\ sludge\ \left[\frac{cum}{d}\right] = \frac{Mass\ of\ thickened\ sludge\ \left[\frac{kg}{d}\right]}{Solid\ content\ [\%] \times Sludge\ density\ \left[\frac{kg}{cum}\right]}$$

Volume of thickened sludge = _____________ m^3/d

4.4.2 Anaerobic Digester

Using the information from section 2.4, fill the following:

Area of the anaerobic digester = ______________ m^2

Volume of the anaerobic digester = _____________ m^3

Solids loading = mass of the thickened sludge = _____________ kg/h

Hydraulic loading = volume of the thickened sludge = ____________ m^3/d

Calculate the detention time of anaerobic digester.

$$Detention\ time\ [d] = \frac{Volume\ of\ the\ anaerobic\ digester\ [cum]}{Hydraulic\ loading\ \left[\frac{cum}{d}\right]}$$

Detention time = ____________ d

FEASIBILITY CHECK!

The recommended value for detention time of an anaerobic digester is 30 days at a minimum temperature of 25 ^{0}C. This provides enough time for the sludge to get digested and produce maximum methane gas.

Calculate the solids volumetric load.

$$Solids\ volumetric\ loading\ \left[\frac{kg\ TSS}{d\ \times cum}\right] = \frac{Solids\ loading\ \left[\frac{kg}{d}\right]}{Volume\ of\ the\ anaerobic\ digester\ [cum]}$$

Solids volumetric loading = _____________ $kgTSS/d/m^3$

FEASIBILITY CHECK!

The solids volumetric loading for an anaerobic digester should lie between 1 $kgTSS/d/m^3$ and 2 $kgTSS/d/m^3$. This ensures that the performance efficiency of the digester is not hampered.

The anaerobic digester produces two effluent streams: (1) liquid stream from the top of the digester, and (2) digested sludge stream from the bottom of the digester. The liquid stream is returned to the gravity thickener or the inlet of the STP and the digested sludge stream is sent to the dewatering unit/s.

Using the information from section 2.5, calculate the production of digested sludge from the anaerobic digester.

$$Mass\ of\ digested\ sludge\ \left[\frac{kg\ TSS}{d}\right]$$
$$= Solids\ loading\ to\ anaerobic\ digester\ \left[\frac{kg}{d}\right] \times TSS\ removal\ efficiency\ [\%]$$

Mass of digested sludge = ____________ kgTSS/d

Using the information from section 2.6, calculate the volume of digested sludge.

$$Volume\ of\ digested\ sludge\ \left[\frac{cum}{d}\right] = \frac{Mass\ of\ digested\ sludge\ \left[\frac{kg}{d}\right]}{Solid\ content\ [\%] \times Sludge\ density\ \left[\frac{kg}{cum}\right]}$$

Volume of digested sludge = ____________ m^3/d

4.4.3 Sludge Dewatering

At this stage, the dewatering of the digested sludge is done using a mechanical equipment such as centrifuge, screw press or belt press. The aim of this stage is to increase the solid content of the sludge to up to 25%.

To increase the efficiency of the mechanical dewatering equipment, adjustments are done to the operating parameters such as:

- Centrifuge: RPM and feeding rate.
- Screw press: Feeding rate and the tension in the spring of the compaction plate.
- Belt press: Feeding rate and tension in the belt.

Apart from this, the operator needs to adjust the dosage of the polymer to condition the sludge so that the mechanical dewater equipment gives highest performance efficiency.

Calculate the dosage of polymer.

Dose 10 g polymer/kgTSS of sludge

$$Dosage\ [kg/d] = Mass\ of\ digested\ sludge\ \left[\frac{kg\ TSS}{d}\right] \times 10\ [\frac{g}{kg\ TSS}]$$

Dosage = ________________ kg/d

INFERENCE:

Write your inference here from the findings and observations from the above section of the exercise.

4.5 Summary

The exercise covered in this workbook gives us an insight into the following aspects of co-treatment of faecal sludge and septage (FSS) with sewage in a sewage treatment plant (STP):

- Solid-liquid separation allows higher volume of faecal sludge and septage to be handled at the STP as compared to the direct addition of FSS in the sewage stream.

- The settling thickening tank also provides homogenization of FSS with supernatant thereby reduceing the risk of process upset in the STP due to co-treatment.

- Addition of FSS to the sewage stream affects the liquid treatment chain as well as the sewage sludge treatment chain. Thus, the monitoring of the STP operation becomes very critical. In this case, the operator needs to be technically sound.

- Addition of FSS to the sewage sludge (solid) treatment chain in an STP have either insignificant or no impact on the liquid treatment chain of the STP.

- In case of addition to sewage sludge (solid) stream, proper care needs to be taken regarding ammonia concentration and pH of the FSS. These parameters are very important for the functioning of an anaerobic digester and monitoring becomes critical in this case.

- Co-treatment of FSS with sewage in an STP provides a good opportunity to handle waste generated from onsite sanitation systems with minimal investment in terms of capital and operational expenditure.

Notes:

Notes:

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- Developing training modules, learning and advocacy material including key messages and content, assessment reports and collating knowledge products on FSSM. Through its website (scbp.niua.org), SCBP is striving to create a resource centre on learning and advocacy materials, relevant government reports, policy documents and case studies;
- Dissemination of FSSM research, advocacy and outreach to State governments and ULBs.

Its strength is its ability to bring together partners to contribute towards developing state sanitation policy, training of trainers and training content development, technical and social assessments, training programme delivery, research and documentation.

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CO-TREATMENT OF FAECAL SLUDGE AND SEPTAGE WITH SEWAGE IN SEWAGE TREATMENT PLANT

PART C: WORKBOOK