Quality in Faecal Sludge Management

BENCHMARKS, STANDARDS AND SPECIFICATIONS

QUALITY IN FAECAL SLUDGE MANAGEMENT

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ACRONYMS AND ABBREVIATIONS

AD	Anaerobic Digestion
ASTM	American Society for Testing and Materials
BIS	Bureau of Indian Standards
BOD	Biochemical Oxygen Demand
BS	British Standards
CBR	Californian Bearing Ratio
CFU	Colony-Forming Unit
COD	Chemical Oxygen Demand
CPHEEO	Central Public Health and Environmental Engineering Organisation
CPVC	Chlorinated PVC
CPWD	Central Public Works Department
E&T	Emptying and Transport
EN	European Standards
EP	Environment Protection
FSM	Faecal Sludge Management
FSTP	Faecal Sludge Treatment Plants
GoI	Government of India
GPS	Global Positioning System
GSR	General Statutory Rules
HDPE	High Density Polyethylene
IEC	International Electrotechnical Commission
IRC	Indian Roads Congress
IS	Indian Standards
ISO	International Organization for Standardization
LTF	Liquid Treatment Facility
MoRTH	Ministry of Road Transport and Highways
MPN	Most Probable Number
NIOSH	National Institute for Occupational Safety and Health
O&M	Operations & Maintenance
OSHA	Occupational Safety and Health Administration
OSS	Onsite Sanitation System
PDB	Planted Drying Beds
PLC	Programmable Logic Controller
PPE	Personal Protective Equipment
PVC	Polyvinyl Chloride
PWD	Public Works Department
SBM	Swachh Bharat Mission
SOP	Standard Operating Procedure
SR	Schedules of Rates
SRT	Sludge Retention Time
STP	Sewage Treatment Plant
TS	Total Solids
UPVC	Unplasticized PVC
VAR	Vector Attraction Reduction
VS	Volatile Solids
VSP	Volute Screw Press
(US) EPA	United States Environmental Protection Agency
WHO	World Health Organization

PREFACE

Faecal Sludge Management (FSM) has seen tremendous uptake since 2016. At the time of writing this document, there are around 200 Faecal Sludge Treatment Plants (FSTPs) under construction in just six states. Similar efforts are ongoing on the emptying and transport aspects so that entire value chain from user interface to treatment and reuse is managed for improved public health and environmental outcomes. Other states are expected to adopt FSM at scale given that it is relatively inexpensive, fast to implement and is being addressed as a priority by the Government of India (GoI). Such rapid scaling up means that the technical, institutional, procurement and stakeholder communication aspects of FSM are all evolving quickly. As a result, a major challenge is to ensure quality in FSM implementation. To aid in developing a common understanding of quality, this document compiles a set of quality definitions, with suggested benchmarks, standards and specifications, called 'Quality in FSM'.

In Chapter A, components of quality in FSM are identified, defined and benchmarks for each are assigned. Defining quality in FSM will help cities, towns and districts measure if their FSM implementation is of acceptable quality. Chapter B defines treatment standards for the faecal sludge fractions and process by-products. A combination of process and output-based standards have been proposed, based on the capacities and constraints of the sector in India. Chapter C specifies technical processes that may be adopted in treatment plants. It is essential to flag here that a technology approval process that encourages unproven technical processes to be validated – away from the mainstream public procurement process – is an urgent need in the sector. Chapter D specifies ancillary infrastructure that completes a good quality FSTP and Chapter E details the specifications for the materials and construction processes to be used in implementing the same. Chapter F lists technical specifications for equipment and personal protective gear used in emptying and transport (E&T) operations.

A companion document titled *"Background note to Quality in FSM"* is published along with this document. This provides details regarding the rationale, approach and discussions on the various options considered. Readers of this document are referred to the companion document.

This document is based on path-breaking work from FSM practitioners. Acknowledgements are due to the member organizations of the National Faecal Sludge and Septage Management Alliance and, more specifically, to Consortium for DEWATS Dissemination Society, Bengaluru, C-WAS of CEPT University, Ahmedabad, Centre for Science and Environment, New Delhi, Ernst & Young, Bhubaneshwar, Indian Institute for Human Settlements, Bengaluru, and National Institute of Urban Affairs, New Delhi. Heartfelt gratitude is expressed to all the reviewers for their constructive comments that helped improve this document. Finally, the Bill and Melinda Gates Foundation is thanked for supporting this effort.

This document shall remain a work in progress for the foreseeable future. As FSM scales up, it is expected that higher benchmarks will be set, newer specifications will be added and progressive standards will evolve from the collective efforts of all practitioners.

Chapter A

FSM QUALITY DEFINITIONS AND BENCHMARKS

The four primary objectives of FSM – mitigating public health risk, preventing pollution of the environment, ensuring safety of sanitation workers and sustaining the initiative – translate to quality definitions and benchmarks as shown in **Table 1**. ISO (2016), WHO (2000) and CEPT University (June 2015) have been referred to while developing the following definitions and benchmarks. A more detailed description of each definition is provided in *Appendix 1*.

Table 1. FSM Quality Definitions and Benchmarks

FSM Quality Definition		Benchmark
1.	Population with access to toilets	100%
2.	Onsite Sanitation System (OSS) conforming to standards	100%
3.	Physical coverage of desludging service	100% of OSS
4.	Affordability of desludging service	100% of OSS-based toilet users
5.	Customer satisfaction ratings for E&T service	75% or above rating on single question survey
6.	Response time for service requests and grievances	48 hours
7.	Safe transport of faecal sludge	At most one incident of spillage in 10,000 trips of faecal sludge transport
8.	Worker safety during desludging	Zero death or disability due to avoidable causes At most one incident in 10,000 desludgings leading to loss of work hours for an operator
9.	Percentage of disposal at designated site	100% of collected faecal sludge
10.	Maximum non-value added time (time taken other than for decanting) taken by truck at designated disposal site	25 minutes

(continued)

Table 1. FSM Quality Definitions and Benchmarks (continued)

FSM Quality Definition	Benchmark
11. Treating faecal sludge to requisite standards	Biosolids, effluent, emissions standards, and proper disposal of wastes
12. Worker safety in FSTP	Zero death or disability due to avoidable causes At most one incident in 3 years of FSTP operations leading to loss of work hours for an operator
13. Reuse of biosolids generated by FSTP	100% of biosolids evacuated for reuse within one year
14. Reuse or safe discharge of treated wastewater from FSTP	100% of treated wastewater within 3 days
15. Payments for FSM services (government-contracted truck operators, FSTP Operations & Maintenance (O&M) made promptly by the local government	100% of payments made within 3 months of invoicing
16. FSM is inclusive	100% specifications for inclusivity met

Chapter B

STANDARDS FOR TREATMENT OF FAECAL SLUDGE

FSTP should adhere to standards and reporting protocols described in this Chapter.

1. STANDARDS FOR BIOSOLIDS

The standards for biosolids are classified under four components - pathogen reduction, vector attraction reduction (VAR), contaminant standards, and general criteria. It is expected that FSTPs adhere to requirements specified under all these components.

1.1 Pathogen Reduction Standards

The pathogen load in biosolids should be reduced in order to minimize risk to public health. The FSTP shall implement any of the processes listed under (a) to (c) below, or achieve the standards prescribed in (d) using any other process.

(a) Air drying on percolation beds to achieve a moisture content not more than 60% followed by storage in a dry space for at least one year.
(or)
(b) Co-composting of faecal sludge solids with organic solid waste to achieve temperatures above 45^0 C for at-least 7 consecutive days after every turning or any other time temperature combinations as prescribed in the pathogen kill curve (*Appendix 2*).
(or)
(c) Achieve temperatures homogeneously within the solids as per the pathogen kill curve using any thermal process (*Appendix 3*).
(or)
(d) Demonstrate consistent achievement of 1,000 most probable number (MPN) per gram total dry solids of E Coli or 1,000 colony-forming unit (CFU) per gram total dry solids of faecal coliform (*Appendix 4*).

1.2 Vector Attraction Reduction Standards

The pathogen in faecal sludge solids pose a risk of transmission through vectors such as insects, rodents and birds. It is therefore necessary that in addition to pathogen reduction, faecal sludge solids must be subjected to VAR. The following processes are aimed at VAR:

(a) Composting to achieve temperatures above 40^0 C for atleast 14 days with average temperatures exceeding 45^0 C in that time.
(or)
(b) Any other process which can achieve a volatile solids (VS)/total solids (TS) ratio of 40% as an output of sludge digestion.
(and)
(c) Any process which reduces the final moisture content in biosolids to less than 25%.

1.3 Contaminant Standards

The biosolids should not have toxic contamination in order to reduce risk to receiving soils.

(a) The ceiling limits for heavy metal contamination in Biosolids are stated in **Table 2**. Periodic tests should be carried out, as described in *Appendix 5*, to determine the level of contamination and therefore regulate the reuse application. If any of the heavy metals found in biosolids are above these ceiling limits then the reuse of biosolids should be stopped.

Table 2. Ceiling Limits for Heavy Metal Contamination in Biosolids

Heavy Metal	Ceiling Limit for Biosolids (mg/kg dry weight basis)
Arsenic	75
Cadmium	85
Chromium	3000
Copper	4300
Lead	840
Mercury	57
Nickel	420
Selenium	100
Zinc	7500

1.4 General Criteria

(a) No foul odour should emanate from the biosolids.
(b) In case partially treated biosolids are transported outside the FSTP for further treatment, then at least VAR standards have to be met.

2. STANDARDS FOR TREATED EFFLUENT

2.1 Proposed Standards for Treated Effluent Discharge from FSTPs

(a) The standards in **Table 3** are applicable for discharge of treated effluent to surface water bodies, land disposal and for ground water recharge.

Table 3. Effluent Discharge Standards

Parameters	Unit	Standards
pH		6.5 - 9
BOD_3	mg/L	< 30
TSS	mg/L	< 100
Faecal coliform	MPN/100 mL	< 1000

3. STANDARDS FOR EMISSIONS

3.1 Stack Emissions Standards

(a) FSTPs implementing thermal processes are expected to meet standards as listed in **Table 4** for incineration of solid waste, as prescribed in the manual for Municipal Solid Waste Management (CPHEEO, 2016).

Table 4. Emission Standards for Thermal Treatment

Parameter	Emission Standard	Measurement Period
Particulates	50 mg/Nm^3	Standard refers to half hourly average value
HCl	50 mg/Nm^3	Standard refers to half hourly average value
SO_2	200 mg/Nm^3	Standard refers to half hourly average value
CO	100 mg/Nm^3	Standard refers to half hourly average value
	50 mg/Nm^3	Standard refers to daily average value
Total Organic Carbon	20 mg/Nm^3	Standard refers to half hourly average value
HF	4 mg/Nm^3	Standard refers to half hourly average value
NO_X (NO and NO_2 expressed as NO_2)	400 mg/Nm^3	Standard refers to half hourly average value
Cd + Th + their compounds	0.05 mg/Nm^3	Standard refers to sampling time anywhere between 30 minutes and 8 hours

(continued)

Table 4. Emission Standards for Thermal Treatment (continued)

Parameter	Emission Standard	Measurement Period
Hg and its compounds	0.05 mg/Nm^3	Standard refers to sampling time anywhere between 30 minutes and 8 hours
Sb + As + Pb + Cr + Co + Cu + Mn + Ni + V + their compounds	0.5 mg/Nm^3	Standard refers to sampling time anywhere between 30 minutes and 8 hours
Total dioxins and furans	0.1 ng TEQ/Nm^2	Standard refers to 6-8 hours sampling. Please refer guidelines for 17 concerned congeners for toxic equivalence values to arrive at total toxic equivalence

4. Reporting protocol

In addition to following the above standards, FSTPs must employ the reporting and record-keeping procedures described below:

(a) All process parameters are to be logged (*Appendix 6*) by the FSTP operator.
(b) Biosolids must be sampled and analysed as per prescribed protocols (*Appendix 4* and *Appendix 5*)
(c) Effluent must be sampled and tested every month. Sampling and testing protocols may be adopted from the Guide Manual: Water and Wastewater Analysis (CPCB n.d).
(d) A register to be maintained containing information on the quantity and application of biosolids sold/ reused (*Appendix 7*)
(e) All reports mentioned above, including emission readings, should be filed and available at the FSTP for a minimum period of 2 years.

Chapter C

TREATMENT PROCESS SPECIFICATIONS

1. SPECIFIED TREATMENT PROCESSES

Treatment for faecal sludge can be broadly classified into four stages:

a) Screening – removal of solid waste, trash and grit from the incoming faecal sludge
b) Solid-liquid separation – dewatering the faecal sludge into solid and liquid streams
c) Solid treatment – to meet pathogen and VAR standards
d) Effluent (liquid) treatment – treatment of effluent to meet discharge standards

An FSTP must have technologies catering to functions in each of these stages.

This list of processes or combinations of modules is based on current implementations. Different combinations of these modules are possible and are welcomed. Newer technical approaches may be added to these specifications once demonstrated to be effective and feasible.

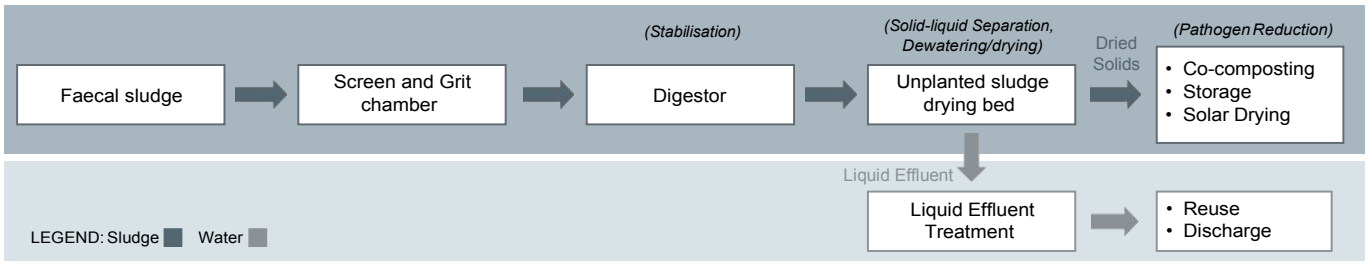
1.1 Technical Approach 1: Anaerobic Digestion and Unplanted Drying Bed based FSTP

In this process, as depicted in **Figure 1**, the faecal sludge is first passed through a screen and grit chamber to physically separate solid waste, inorganic solids like plastic, cloth, sand and silt. The screened faecal sludge/septage is stabilised (reduction of volatile solids) through an anaerobic process. This process also aids in solid-liquid separation. The digestion process must be designed as per the VAR standards for biosolids.

The partially dewatered sludge is further dried in the drying beds. The dried sludge removed from the drying beds must not contain more than 60% moisture. This sludge is then further treated for pathogen reduction by following any of a) co-composting, b) storage for periods in excess of 12 months or c) solar drying or any other process prescribed for pathogen reduction.

The supernatant from the digestor and the percolate from the drying beds are collected and further treated to reduce organic content and pathogens to achieve liquid discharge standards.

Figure 1. FSTP Process Modules in Anaerobic Digestion and Unplanted Drying Bed based FSTP



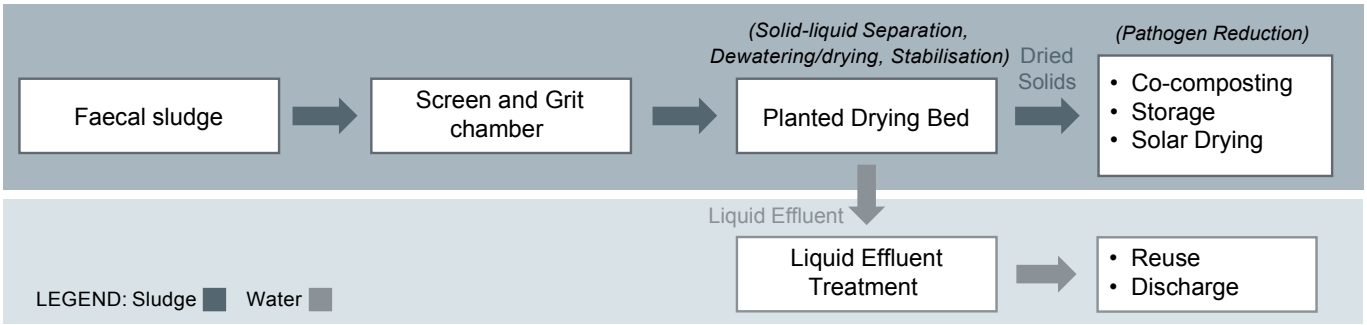
Screening	Screen and grit chamber
Solid-liquid separation	Unplanted drying bed
Solid treatment - VAR	Digestor
Solid treatment - Pathogen reduction	Co-composting, storage, solar drying

1.2 Technical Approach 2: Planted Drying Bed based FSTP

In this process, as depicted in **Figure 2**, first the faecal sludge is passed through a screen and grit chamber to physically separate solid waste, inorganic solids like plastic, cloth, sand, and silt. The screened faecal sludge/septage is disposed in planted drying beds. Unlike regular drying beds, in planted drying beds, the sludge is applied in layers and allowed to dry over very long periods of time. During these long accumulation periods, the sludge undergoes stabilisation and mineralisation. Thus, planted drying beds aid in both solid-liquid separation and VAR.

The dried solids from planted drying beds are further treated for pathogen reduction by following any of a) co-composting, b) storage for periods in excess of 12 months or c) solar drying or any other process as prescribed for pathogen reduction. The percolate from drying beds is treated in appropriate liquid treatment system to reduce organic content and pathogens to achieve liquid discharge standards.

Figure 2. FSTP Process Modules in Planted Drying Bed based FSTP



Screening	Screen and grit chamber
Solid-liquid separation	Planted drying bed
Solid treatment - VAR	Planted drying bed
Solid treatment - Pathogen reduction	Co-composting, storage, solar drying

1.3 Technical Approach 3: Mechanical Solid-Liquid Separation based FSTP

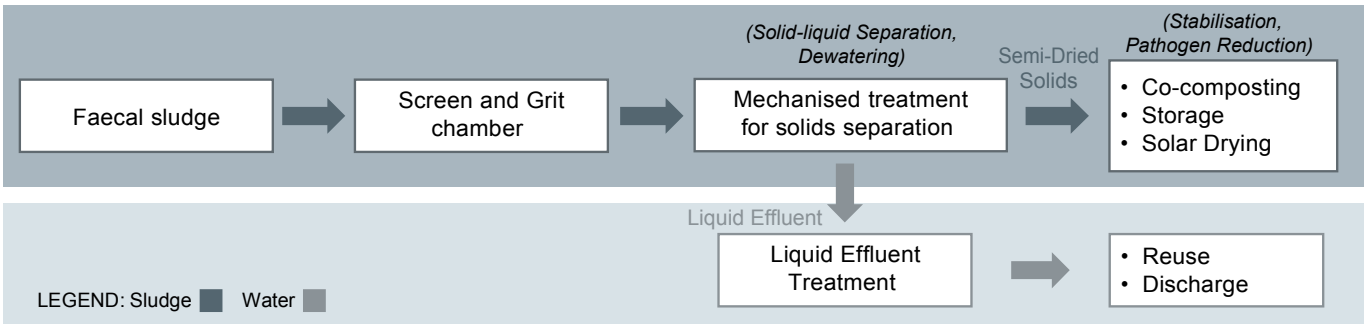
In this process, as depicted in **Figure 3**, first the faecal sludge is passed through a screen and grit chamber to physically separate solid waste, inorganic solids like plastic, cloth, sand and silt. The screened faecal sludge is stabilised through anaerobic processes as prescribed for VAR under standards for biosolids. The stabilised sludge, which also has improved dewatering capabilities, is dewatered using mechanical device such as volute screw press. The solids from the screw press are further treated for pathogen reduction through any processes prescribed in the biosolids standards guidelines. The supernatant from the digestor and the filtrate from the screw press is collected and treated in liquid treatment modules to achieve effluent discharge standards.

1.4 Technical Approach 4: Thermal Solids Treatment based FSTP

In this process, as depicted in **Figure 4**, first the faecal sludge is passed through a screen and grit chamber to physically separate solid waste, inorganic solids like plastic, cloth, sand and silt. The screened faecal sludge is dewatered using mechanical devices such as volute press. The dewatered solids are further dried in a sludge heater. The heater considerably reduces the moisture in the solids, preparing them for incineration. The dry sludge is then incinerated in combustion chambers. The drying and combustion process ensures reduction of pathogens and vector attraction potential.

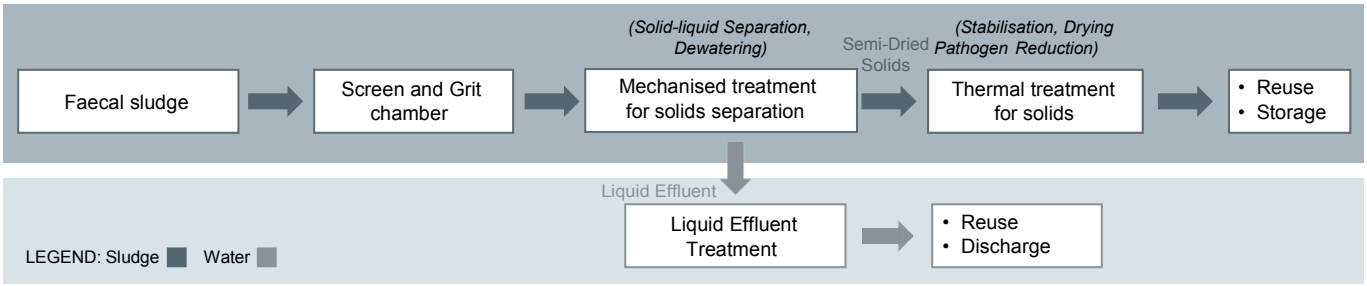
Depending on the quantity of air supplied, the combustion can be complete or partial (pyrolysis), based on which the end product varies as ash or bio-char. The liquid from various streams is collected and further treated to achieve effluent standards. Stack for exhausts from thermal treatment of biosolids must be designed considering local wind velocity and direction.

Figure 3. FSTP Process Modules in Mechanical Solid - Liquid Separation based FSTP



Screening	Screen and grit chamber
Solid-liquid separation	Volute screw press
Solid treatment - VAR	Anaerobic digestion
Solid treatment - Pathogen reduction	Co-composting, storage, solar drying

Figure 4. FSTP Process Modules in Thermal Solids Treatment based FSTP



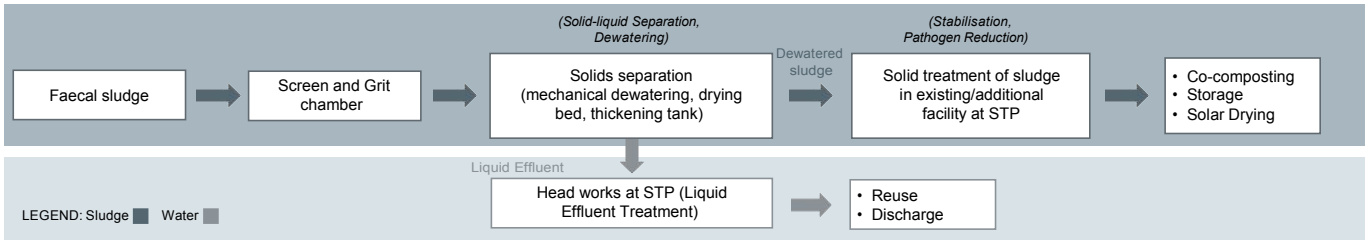
Screening	Screen and grit chamber
Solid-liquid separation	Volute screw press
Solid treatment - VAR	Dryer
Solid treatment - Pathogen reduction	Incinerator/Pyrolysis reactor

1.5 Technical Approach 5: Co-treatment of Faecal Sludge in Sewage Treatment Plants

In cities, towns or districts with access to a Sewage Treatment Plant (STP) with spare capacity, the feasibility of co-treatment of sewage and faecal sludge should be assessed. Given the high solid and organic content of faecal sludge, its direct loading into the STP is not recommended. Faecal sludge must, therefore, undergo preliminary treatment such as solid-liquid separation to render the components of faecal sludge suitable for further treatment in an STP. Solid-liquid separation can be added to the infrastructure at the STP facility (or pumping stations) or can be achieved using existing units meant for sewage sludge.

This process, as depicted in **Figure 5**, separates faecal sludge into liquid effluent (supernatant, percolate or filtrate) and solids. The effluent can be treated in the STP. The solids have to undergo further processes (in existing or newly created infrastructure) for pathogen and VAR reduction before being reused or disposed.

Figure 5. Co-treatment of Faecal Sludge in STPs



Chapter D

ADDITIONAL COMPONENTS OF FSTP SPECIFICATIONS

Infrastructure other than for treatment processes, required for effective and safe operation of the FSTP, are encapsulated in **Table 5** and **Table 6**. These lists are not prescriptive and every implementation is expected to customize the features to be included based on size and funds availability, after a careful evaluation of risk and benefits.

Table 5. Essential Components in FSTP

Feature	Specifications
Receiving station	1. The receiving station is the location in the FSTP where trucks dispose the faecal sludge for treatment 2. The inlet of the receiving station should be placed adequately below the faecal sludge discharge outlet of the truck to enable flow through gravity 3. The inlet of the receiving chamber must be provided with a cam-lock arrangement to securely fit the desludging pipe from the discharging truck 4. Each receiving station should be designed to accept flow rates of 60 m^3 per hour from the discharging truck 5. The number of receiving stations provided should be such that trucks spend less than 25 minutes at the FSTP other than during decanting 6. Receiving station must be provided with an arrangement to contain and evacuate spillage of faecal sludge during discharge from truck into the receiving inlet 7. Receiving station should be equipped to allow for testing of raw faecal sludge to ascertain if it is from a domestic source and reject it otherwise. *Appendix 8* describes the screening process 8. Handwashing arrangement should be available at a distance not more than 10 m from the receiving station
Trash and other rejects removal	1. Any other waste products generated from the treatment process should be handled and disposed as per existing regulations 2. The local government should provide a mechanism for collecting trash and rejects from the treatment plant at their cost. Such services should be operated in accordance with Solid Waste Management Rules, 2016

(continued)

Table 5. Essential Components in FSTP (continued)

Feature	Specifications
Truck washing unit	1. Provision to be made for the supply of treated wastewater (from the FSTP) or non-potable water for the purpose of washing 2. High pressure jet spray equipment to be provided for washing of trucks 3. The unit must be designed to contain, collect and treat the wastewater generated from the washing activity
Toilets and bathing rooms for FSTP and desludging operators	1. Toilets and bathing rooms shall be provided for workers – separately for men and women, located away from visitor areas 2. It shall be a permanent structure and designed according to Indian Standard (IS):2064 3. The toilets and bathing rooms must be well ventilated and illuminated 4. The wastewater generated should be treated/disposed safely within the FSTP
Compound wall (or fence)	1. The compound wall must enclose the entire FSTP premise, including areas earmarked for future expansion 2. The compound wall structure shall be made from any of the following materials: a) Reinforced cement concrete, b) Pre-cast cement, c) Masonry or stone and d) wire mesh fence 3. The design should take into account the local soil, wind and storm water flow conditions 4. The height of the compound wall shall not be less than 2 m
Entry and exit gates	1. A metal gate, at least 3.5 m wide, shall be provided at the entrance to the FSTP 2. The gate should be made of steel, conforming to IS:2062:2011 3. The minimum height of the gate shall be 2 m 4. The design of the gates should be according to British Standard(BS):1722-10
Storm water drainage	1. The FSTP premise must have a well-designed drainage system based on the natural topography of the site 2. 50-year rainfall data should be considered for designing storm water system 3. The storm water system should be designed for appropriate rainwater harvesting 4. A safe discharge point should be identified to drain excess storm and treated water from the plant. Discharge point should be protected from back flows during flooding

(continued)

Table 5. Essential Components in FSTP (continued)

Feature	Specifications
Internal roads	1. Internal roads should be designed for a minimum carriageway width of 3.5 m for single lane and 7 m for two lanes 2. The design of the road shall be determined on the basis of the local Californian Bearing Ratio (CBR) value and the maximum tonnage of the desludging vehicle 3. The road has to be designed according to Indian Roads Congress (IRC) and Ministry of Road Transport and Highways (MoRTH) specifications 4. Roads should have a provision of at least 500 mm wide shoulders on either side and with arrangement for storm water evacuation 5. The minimum turning radius for roads inside the FSTP should be 10 m 6. Roads should be all weather proof and made of cement concrete, bitumen or paver blocks only 7. Ramps in road should not exceed 1:15 slopes
Streetlighting	1. Streetlights have to be provided in the FSTP premises as prescribed under “Group B2” in IS:1944:1970 (Parts 1 & 2)
Landscaping to enhance aesthetics and minimize odours	1. A green belt of at least 1 m to be provided adjoining the compound wall inside the FSTP 2. Landscaping and selection of vegetation should be done as per 'A Handbook on Landscape', CPWD 2013 3. Landscape area should be sufficient to consume all the treated water generated on-site for irrigation during dry season
Alternate power source	1. The alternate power source should be designed based on peak load consumption and the expected number of hours of power blackouts to ensure uninterrupted operation of the FSTP 2. The alternate power supply must be able to meet the basic requirement of operations (such as agitation, aeration, pumping, etc.) and for lighting and heating needs of the operator/premise 3. Additional energy meters must be used for recording the power consumed from such alternate sources 4. A switching mechanism must be located at the electrical room to toggle between power sources 5. In case of diesel or fuel-based generators, the placement must ensure that workers and visitors are not affected by fumes or noise 6. A separate arrangement must be made for storage of fuel in a cool and well-ventilated place

(continued)

Table 5. Essential Components in FSTP (continued)

Feature	Specifications
Alternate power source	7. A fire-extinguisher must be placed in the generator room 8. Diesel/fuel generators must adhere to prescribed standards General Statutory Rules (GSR) 520(E) dt. 1/7/2003, Environment Protection (EP) rules 2003; or GSR 489(E) dt. 9/7/2002, EP Act 1986 9. In case of solar panels, the placement should be facing the south-west and avoid shadows. The batteries for storing the energy must be placed in the electrical room with sufficient ventilation and with fire extinguisher
Potable water supply	1. A reliable source of potable water, municipal piped water or on-site borewell, should be provided, with adequate quantity of drinking water, complying to IS:10500:2012 2. The per-capita water consumption should be calculated for staff of FSTP at 135 liters per capita per day (lpcd) 3. Overhead tanks and/or underground sumps for storing two days' consumption equivalent of potable water should be provided 4. Underground tanks should be designed as per IS:3370 – Parts 1,2,3 and 4 5. Overheard water tanks should comply with IS:12701
Signage within the FSTP	1. A large, clearly visible, sign board, describing the FSTP and providing a schematic diagram of its process, should be installed at the FSTP 2. Signages should be installed at various locations within the FSTP for a) traffic regulation, b) hazardous zones, c) restricted zones, d) assembly point and e) emergency exit
Safety and hazard prevention	1. All tank & roof tops, ladders, stairways and places, where there is a hazard of person or object falling, should be protected with guardrails and other safety equipment as per Occupational Safety and Health Administration (OSHA):1910.29 2. Fire prevention and control measures should be provided as per recommendations for industrial establishment (G1, IS:1641) under Chapter 7 – Fire Protection and Fire Safety requirements, Ministry of Housing and Urban Affairs, GoI. Local building codes/byelaws should also be considered for compliance
Operator room	1. The operator room shall be a well-ventilated, permanent structure, located so as to provide a view of the entire FSTP 2. The structure should be compliant with IS:875 parts 1,2,3 and 5. Structures being constructed in seismic zones 4 and above should also conform to IS:1893 3. The operator room shall include a living room, a kitchen and have bathing and toilet facilities 4. Kitchen and sanitary installation in the operator room is to be made as per IS:2064 5. The room should be fitted with rainwater harvesting system

Human-centred design thinking leads to inclusive work spaces. Technical and engineering specifications should follow from inclusive designs. While a detailed analysis of inclusive work space designs for FSTPs is beyond the scope of this document, a few questions regarding design thinking are listed here for designers to incorporate:

1. Is the FSTP designed in such a way that a worker of any gender can be employed to operate the plant? E.g., consider specific tasks, effort in each task, material movement, ergonomics of each task etc.
2. Are the amenities at the plant designed for use by men, women, transgender, and the differently abled?
3. Are the amenities at the treatment plant sufficient and sensitive to gender specific needs, e.g., menstrual product access & disposal, privacy, and safety

As treatment plants are designed across the country, decision makers, planners, engineers, and plant operators are urged to adopt inclusiveness as a core principle to create treatment plants equally suited for workers of any gender.

Table 6. Desirable Components in FSTP

Feature	Specifications
Electrical room	1. The room must be designed as per fire and electrical hazard safety requirements. The room must have an emergency exit 2. Aisle space of at least 1 metre for up to 600 volts or 4 m for up-to 75 kV must be provided between electrical panels
Laboratory	1. Labs must be designed to meet the requirements of National Accreditation Board for Testing and Calibration Laboratories accreditation for wastewater/biosolids testing
Security cabin	1. The location of the cabin should be close to the entry gate of the FSTP 2. The cabin should be an all-weather proof structure with a minimum area of 20 sq. feet
Administrative building	1. The administration room shall be a well-ventilated permanent structure, located near the parking area or internal road 2. The structure should be compliant with IS:875 parts 1,2,3 and 5. Structures being constructed in seismic zones 4 and above should also conform to IS:1893 3. The administrative building should have toilet for visitors 4. The room should be fitted with rainwater harvesting system 5. This building may be provided with additional facilities and audio-visual equipment for making presentations to visitors

Chapter E

CONSTRUCTION PROCESS AND MATERIALS SPECIFICATIONS

This chapter supplements the treatment process specifications and the technical specifications for an FSTP defined in Chapters D and E. Materials and methods of construction for all works shall be as per relevant IS specifications. Parts of these specifications are incorporated in the standard specification of State Public Works Department (PWD) and will be followed during the execution of the work. The work shall be executed as per the guidelines and provisions of Bureau of Indian Standards (BIS). All materials shall conform to IS code of practice - National Building Code and Central Public Health and Environmental Engineering Organisation (CPHEEO) manual - to maintain quality of work.

1. Materials and finishing

The term materials shall mean all materials, goods and articles of every kind whether raw, processed or manufactured and equipment and plant of every kind to be supplied by the contractor for incorporation in the works.

All materials shall be new and of the kinds and qualities described in the contract and shall be at least equal to approved samples.

All standards, specifications, codes of practices referred to herein shall be the latest editions, including all applicable official amendments and revisions. In case the material is not listed under BIS, international standard shall be followed.

If the material is new and innovative in nature, contractor has to furnish appropriate justification and records for its use. It shall only be accepted after approval by the engineer.

Where the relevant standard provides for the furnishing of a certificate to the engineer, stating that the materials supplied comply in all respects with the standard, the contractor shall obtain the certificates and forward it to the engineer, upon request.

For detailed specification of material, standard specification shall be followed. If any material is not included either in particular specification or standard specification but is required for successful completion of work, it shall comply with the relevant IS codes (with amendments up to date).

(a) Civil Works Specifications

References have been made in this section for standard civil works. In case of standards not listed herein, relevant IS should be used for material, construction process and testing of material/methods during construction. If specific materials are not listed in the IS provisions in the relevant state, Schedules of Rates (SR) or Central Public Works Department (CPWD) specifications may be used.

Unless otherwise approved, civil works shall comply with relevant quality standard test procedures and codes of practice, collectively referred to as reference standards including those listed in **Table 7**, in accordance with the requirements detailed elsewhere in this specification.

Table 7. Civil Works Specifications

Description of Work	Reference
1. Site clearance	CPWD Specifications, Civil works – 2019, Vol 1. Subhead 2.0: Section 2.4
2. Sub-surface soil exploration for foundations – Safe-bearing capacity test	IS:1892 and IS:2720
3. Excavation in all different soil types	CPWD Specifications, Civil works – 2019, Vol 1. Subhead 2.0
4. Mortars	CPWD Specifications, Civil works – 2019, Vol 1. Subhead 3.0
5. Concrete works	CPWD Specifications, Civil works – 2019, Vol 1. Subhead 4.0
6. Reinforcement cement concrete works	CPWD Specifications, Civil works – 2019, Vol 1. Subhead 5.0
7. Form works	CPWD Specifications, Civil works – 2019, Vol 1. Subhead 5.0: Section 5.2
8. Masonry work	CPWD Specifications, Civil works – 2019, Vol 1. Subhead 6.0
9. Stonework, random rubble masonry	CPWD Specifications, Civil works – 2019, Vol 1. Subhead 7.0
10. Precast concrete clock work	CPWD Specifications, Civil works – 2019, Vol 2. Section 26.43
11. Wooden and PVC doors, windows and other works	CPWD Specifications, Civil works – 2019, Vol 1. Subhead 9.0
12. Steel works	CPWD Specifications, Civil works – 2019, Vol 1. Subhead 10.0
13. Flooring	CPWD Specifications, Civil works – 2019, Vol 1. Subhead 11.0
14. Roofing	CPWD Specifications, Civil works – 2019, Vol 1. Subhead 12.0
15. Plastering, painting and finishing works	CPWD Specifications, Civil works – 2019, Vol 2. Subhead 13.0
16. Water-proofing compounds	IS:2645

(continued)

Table 7. Civil Works Specifications (continued)

Description of Work	Reference
17. Water-proofing treatment	CPWD Specifications, Civil works – 2019, Vol 2. Subhead 22.0
18. Road works	CPWD Specifications, Civil works – 2019, Vol 2. Subhead 16.0
19. Sanitary installations	CPWD Specifications, Civil works – 2019, Vol 2. Subhead 17.0
20. Access hole and covers for maintenance	CPWD Specifications, Civil works – 2019, Vol 2. Subhead 19.0: Sections 19.3 and 19.4
21. Open drains – Storm water	CPWD Specifications, Civil works – 2019, Vol 2. Subhead 19.0: Section 19.6
22. Septic tanks	IS:2470
23. Dispersion trenches	CPWD Specifications, Civil works – 2019, Vol 2. Subhead 19.0: Section 19.12
24. Rainwater harvesting and tube wells	CPWD Specifications, Civil works – 2019, Vol 2. Subhead 23.0
25. Filter material for drying beds, wetlands	IS:10037 – Part 1
26. Screens for screen chamber	IS:6280
27. Underground water wastewater storage tanks	IS:3370
28. Overhead tanks	IS:12701
29. Landscaping	CPWD Specifications, Civil works – 2009, Vol 2. Subhead 23.0
30. Polycarbonate sheets for solar drying and roofing	ISO:11963:2019
31. Slow sand filters	IS:11401
32. Grit removal system	IS:6279
33. Waste stabilisation ponds	IS:5611
34. Road gullies	IS:7740

(continued)

Table 7. Civil Works Specifications (continued)

Description of Work		Reference
35.	Filter media – sand and gravel	IS:8419 Part 1
36.	Activated sludge process and modifications	IS:8413 Part 2
37.	Trickling filters	IS:8413 Part 1
38.	Rapid sand gravity filter	IS:8419 Part 2
39.	Settling tank	IS:10261
40.	Paver blocks for roads	IS:15658

(b) Mechanical and Plumbing Works Specifications

The electromechanical works are to be as per the approved designs and drawings. The relevant IS codes/manufacturers specification are to be checked by the contractor during procurement. The make/ model of any equipment/parts to be approved by the project engineer. It shall be designed, installed, and commissioned to the satisfaction of the project engineer and shall conform to the relevant IS codes.

Unless otherwise approved, mechanical and plumbing works shall comply with relevant quality standards test procedures and codes of practice, collectively referred to as reference standards including those listed in **Table 8**, in accordance with the requirements detailed elsewhere in this specification.

Table 8. Mechanical and Plumbing Works Specifications

Description of Work		Reference
1.	Polyvinyl Chloride (PVC), Unplasticised PVC (UPVC) and Chlorinated PVC (CPVC) pipes and fittings	IS:4985, American Society for Testing and Materials (ASTM):D2467, ASTM:D2665, IS:14735, IS:15328, IS:9271
2.	Water plumbing	CPWD Specifications, Civil works – 2019, Vol 2. Subhead 18.0
3.	Plumbing – wastewater	CPWD Specifications, Civil works – 2019, Vol 2. Subhead 19.0
4.	Solid handling pumps	IS:5600
5.	Process pumps	IS:5659
6.	Submersible pumps	IS:8034
7.	Foot valves, Non-Return Valve for borewells	IS:10805

(continued)

Table 8. Mechanical and Plumbing Works Specifications (continued)

Description of Work		Reference
8.	Steel to be used for wetted parts in FSTP	IS:6911
9.	Ovens and furnaces – Thermal treatment units	National Fire Protection Association 86
10.	Flat belt conveyors	IS:8597
11.	Agitators	IS:9522
12.	Chlorination equipment	IS:10553
13.	Coagulant dozing mechanism	IS:9222 Part 1
14.	High Density Poly Ethylene (HDPE) pipes	IS:14333

(c) Electrical Works Specifications

The selection of power distribution system equipment and layout of the electrical equipment, including diesel generator set, shall consider ease of installation, maintenance and modular addition of equipment for future expansion. All the components of the electrical system shall withstand the environmental conditions of the local region.

The equipment standards applicable for the design and installation of the electrical, control, monitoring systems are the relevant Indian standards. Cognizance shall also be taken of international standards where IS is not available. The equipment shall be designed, assembled and tested to the satisfaction of the project engineer.

Unless otherwise approved, all electrical works shall comply with relevant quality standards test procedures and codes of practice, collectively referred to as reference standards including those listed in **Table 9**, in accordance with the requirements detailed elsewhere in this specification.

Table 9. Electrical Specifications

Description of Work		Reference
1.	3-phase AC motors	IS:12615, IS:325, IS:4691
2.	Single-phase AC induction motors	IS:996
3.	AC electricity meters	IS:722
4.	Switchgear equipment and installation	IS:3072, IS:4237, IS:375, IS:10118
5.	AC circuit-breaker	IS:2516

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Table 9. Electrical Specifications (continued)

Description of Work	Reference
6. Power transformers	IS:2026
7. Insulating oil for transformers	IS:335
8. Batteries	IS:1652
9. General electric circuit requirements	IS:302, IS:732
10. Cables	IS:694, IS:1554
11. Earthing	IS:3043
12. Residual Current Circuit Breaker	IS:12640
13. Air blowers and centrifugal fans	IS:4894, IS:3963,
14. Invertors	IS:13314
15. Control panels - outdoors	IP 65 rating
16. Safety procedures and practices for electrical works	IS:5216
17. Industrial lighting	IS:6665
18. Air break switches disconnectors	IS:4064, Part 1
19. Conduits for wiring	IS:9537
20. Sockets and plugs	IS:1293
21. Tungsten filament lamps	IS:418
22. Fluorescent lamps	IS:2418
23. Waterproof electrical light fittings for outdoor units	IS:3553

(d) Instrumentation and Automation Specifications

This part covers the general requirements for the design, delivery, installation, inspection and testing and commissioning of the Instrumentation, Control, Automation/Supervisory Control and Data Acquisition/ Human-Machine Interface system.

Unless otherwise approved, instrumentation and automation shall comply with relevant quality standards test procedures and codes of practice, collectively referred to as reference standards including those listed in **Table 10**, in accordance with the requirements detailed elsewhere in this specification.

Table 10. Instrumentation and Automation Specifications

Description of Work	Reference
Programmable Logic Controller	International Electrotechnical Commission :61131

2. Samples and tests of materials

The contractor shall submit samples of such materials as may be required by the engineer and shall carry out the specified tests directed by the engineer at the site, at the supplier's premises or at a laboratory approved by the engineer. Specific tests required during construction are listed in **Table 11**.

Samples shall be submitted and tests carried out sufficiently early to enable further samples to be submitted and tested if required by the engineer. Approval by the engineer as to the placing of orders for materials or as to samples or tests shall not prejudice any of the employer's powers under the contract. All standards which the contractor intends to use but which are not part of the above standards or other listed reference standards, shall be submitted to the engineer for consent before starting the designs.

Table 11. Standard Test Procedures for Construction Materials

Description of Work	Requirements	IS Code	Frequency of the Test
Cement			
Initial setting time	Not less than 30 minutes.	IS:4031 – Parts II, III, IV, V, VI	Every 50 tonnes or part thereof. Every brand of cement brought to the site all be tested
Final setting time	Not more than 600 minutes.		
Fineness by dry sieving % (90 Micron)	Not more than 10%		
Compressive strength N/mm^2 at 3 days, 7 days and 28 days	As per table 4.5, CPWD specifications – grades of concrete		
Sand			
Bulking of sand	Actual (note: deduct moisture content)	IS:383:2006, IS:2386 (Part.1) -1963, IS:2386 (Part.3) -1963 and IS:2386 (Part.4) -1963	Every 20 m^3 or part thereof or change in source or more frequently as decided by engineer-in charge.
Silt and clay content	Not more than 5%		
Specific gravity	2.6 to 2.9		
Sieve analysis	As per table 9 of IS:383		

(continued)

Table 11. Standard Test Procedures for Construction Materials (continued)

Description of Work	Requirements	IS Code	Frequency of the Test
Coarse Aggregates			
Bulk density-12.5 mm	1520 to 1680 kg/m^3	IS:383:2006, IS:2386 (Part.1) -1963, IS:2386 (Part.3) -1963 and IS:2386 (Part.4) -1963	Every 20 m^3 or part thereof or change in source or more frequently as decided by engineer-in charge.
Bulk density-20 mm	1520 to 1680 kg/m^3		
Specific gravity-12.5 mm	2.6 to 2.9		
Specific gravity-20 mm	2.6 to 2.8		
Sieve analysis-12.5 mm	As per table 7 of IS:383		
Sieve analysis-20 mm	As per table 7 of IS:383		
Impact value	Not more than 30%		
Abrasion test	Not more than 30%		
Flakiness and elongation index	Not more than 25%		
Cement Concrete			
Slump test	As per clause 7 of IS:456	IS:456:2016, IS:516 and IS:1199	Every concrete activity
Compressive strength (7 days and 28 days in N/mm^2)	Should achieve 65% at 7 days and 99% at 28 days of grade of concrete		
Cement Concrete Block Test			
Compressive strength	Not less than 3.5 Nmm^2	IS:2185 (Part 1):2015	Every load
Water absorption test			
Dimension test			
Reinforcement Steel			
	Tensile strength and weight per metre should achieve the grade and density of steel	IS:432:1982 and IS:1786:2008	Manufacturers test certificate
UPVC and PVC pipes			
			Manufacturers test certificate
Paver Blocks			
Water absorption test	Not more than 6%	IS:15658-2006	Every source
Compressive strength test	As per table of 3 IS code		
Abrasion resistance test	As per table of 4 IS code		
Breaking load/ flexural strength	As per table of 4 IS code		

(continued)

Table 11. Standard Test Procedures for Construction Materials (continued)

Description of Work	Requirements	IS Code	Frequency of the Test
Subgrade			
Gradation or sand content	As per table 400-1	MoRTH specification	1 test
Standard proctor test	Actual	IS:272 (Part 7), IS:272 (Part 8), IS:10379 (1972)	1 test
Moisture content	Actual		
Density test after rolling	Not less than 95%		1 test/500 m^3
Wet Mix Macadam			
Aggregate impact value	Not less than 25%	IS:2386 (Part.4) -1963	1 test/200 m^3 of aggregate
Flakiness and elongation index	Not less than 25%	IS:2386 (Part.1) -1963	1 test/200 m^3 of aggregate
Atterberg limit for binding material			
a) Liquid limit of material passing 425 micron	25 Maximum	IS:2720 (Part 5)	1 test/25 m^3 of binding material
b) Plastic index of material passing 425 micron	6 Maximum	IS:2720 (Part 5)	1 test/25 m^3 of binding material
Density of compacted layer	Not less than 95%	IS:2720 (Part 8)	1 test/500 m^3
Water Quality Test for Construction			
	As per table 1 of IS:456	IS:3025	One time, before commencement of the work or change in water source
Water Tightness Test for Structure			
		IS:3370 (Part1):2009	Every structure
Soil Test for Foundation			
Density test	Not less than 95%	IS:2720 (Part 8)	

Chapter F

EMPTYING AND TRANSPORT TECHNICAL SPECIFICATIONS

This chapter provides specifications for the various equipment used in E&T of faecal sludge.

1. Personal Protective Equipment

The personal protective equipment (PPE) as depicted in **Table 12** of appropriate fit and measure are to be worn by all personnel engaged in E&T of faecal sludge.

Table 12. PPE Specifications and Standards

Protection and Description	Specification	Standards	Pictorial Representation (for illustration only)
Hand protection - Chemical resistant gloves	Nitrile/Neoprene gloves with flock lining and enhanced grip for heavy-duty work, minimum thickness: 0.60 mm	EN-ISO:374:2016 EN:388:2016	
Foot protection- Steel toe, full gumboot	PVC gumboots with steel toe for protection from impact, water, oil, acid and alkali	IS:15298:2011, personal protective equipment Part II and III IS:5557:2004 EN-ISO:20345:2011	
Lung protection- Half-mask respirators	Appropriate fitting half mask with correct filters for purifying the air to be inhaled.	IS:14746:1999 Respiratory protective devices - half masks and quarter masks Half-mask respirators – NIOSH-approved for protection against organic vapours, acid gases and ammonia EN 140:1998	
Eye protection - Chemical/Impact goggles	Polycarbonate material with elastic straps for good fit	IS:5983:1980 Specification for eye protectors ISO 4849:1981 BS EN 166:2002	

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Table 12. PPE Specifications and Standards (continued)

Protection and Description	Specification	Standards	Pictorial Representation (for illustration only)
Body protection - High visibility protective wear	Wicking polyester high visibility full sleeves shirt, Breathable polyurethane coated polyester high visibility pants coveralls.	EN-ISO:13688:2013 EN-ISO:20471:2013	
Head protection - Baseball style bump cap	Front rim bump cap with poly carbonate outer shell	IS:2925:1984 Industrial safety helmet BS-EN:397:2012	
Ear Protection Bullet-shaped ear plugs	Bullet shaped ear plugs with bands	EN:352	

Note: Workers shall be provided with appropriate size and fit of PPE, by gender, for ergonomic comfort during use.

2. Emptying Vehicle Specifications

Specifications for desludging vehicles are provided in this section. The specifications given in **Table 13** and **Table 14** apply to vacuum suction and postive displacement based desludging vehicles respectively.

Table 13. Vacuum Suction Based Desludging Vehicle Specifications

Parameter	Standards
General Requirement	• The vehicle and its operation must conform to the Central Motor Vehicle Rules • Truck and the desludging equipment should comply with IS:13496:1992 • Trucks must comply with AIS:093 (Automotive Research Association of India) standards • Grade ability – The minimum grade ability shall be 19% (slope) at full load • Supplier must provide 2 sets of operating manual and relevant test certificates of the truck and installed equipment • Supplier must provide at least 24 months or 10,000 km warranty on the complete desludging truck/tractor/trailer and installed equipment • The vehicle must be fitted with a Global Positioning System (GPS) device capable of providing real time data about its location and speed.

(continued)

Table 13. Vacuum Suction Based Desludging Vehicle Specifications (continued)

Parameter	Standards
Vacuum pump	• Vacuum pump to be of heavy-duty and rotary vane type • Air or water cooled • Vacuum suction depth of at least 8 m (as per IS:13496:1992) and a flow rate allowing the sludge tank to be filled in a maximum time of 30 minutes • Vacuum suction should be attached to the sludge tank through relevant moisture traps and scrubbers • A list of spares and authorized service centers for the vacuum pump shall be made available • Manufacturer details, operating rpm and power intake must be labelled on the pump casing
Sludge tank	• Electrically welded mild steel (Grade A) conforming to IS:2062 with anti-corrosive coating • Surface preparation and finish of tank's exterior - shall be spray-painted with two coats of superior quality anti-corrosive primer and two coats of enamel metal paint • Surface preparation and finish of tank's interior - shall be with two coats of epoxy paint to resist corrosion • Cylindrical type, equipped with splash walls/baffle plates and reinforced around circumference • Filling level indication system – 2 numbers • Indicator mark on the tank for maximum and minimum level of sludge shall be furnished • Tailgate tightly locked, shall be opened over the whole section laterally for maintenance and cleaning purposes • Height from ground to connection of suction hose shall not be less than 0.5 m • Outlet from tank shall be provided with a quick connect coupling interface • Vacuum limiting valve and drain-off valve to be provided
Suction hoses	• Lightweight, heavy duty, reinforced, PVC along with quick connect coupling arrangement • Internal diameter of 80 mm or more • Total length of pipe 30 m. Length of each pipe segment shall be at least 3 m • Suction hoses to withstand 90% vacuum

(continued)

Table 13. Vacuum Suction Based Desludging Vehicle Specifications (continued)

Parameter	Standards
Instrumentation	• All gauges shall record in metric unit to include temperature gauge, pressure gauge and level control • All manufacturers' standard instruments shall be incorporated that are critical for operation
Color	• Bright yellow • White

Table 14. Positive Displacement Based Desludging Vehicle Specifications

Parameter	Standards
General Requirement	• The vehicle and its operation must comply with the Central Motor Vehicle Rules • Truck and the desludging equipment should comply with IS:13496 • Trucks must comply to AIS:093 (Automotive Research Association of India) standards • Grade ability – The minimum grade ability shall be 19% (slope) at full load. • Supplier must provide 2 sets of operating manual and relevant test certificates of the truck and installed equipment • Supplier must provide at least 24 months or 10,000 km warranty on the complete desludging truck/tractor/trailer and installed equipment. • The vehicle must be fitted with a GPS devise capable of providing real time data about its location and speed.
Positive displacement pump	• Pump should conform to IS:5600 for solid handing and IS:8034 for submersible types • Air or water-cooled and self-priming type • Suction depth of at least 8 m (as per IS:13496:1992) and a flow rate allowing the sludge tank to be filled in a maximum time of 30 minutes • Pump wetted parts to be made of anti-corrosive material • Manufacturer details, operating rpm and power intake must be labelled on the pump casing

(continued)

Table 14. Positive Displacement Based Desludging Vehicle Specifications (continued)

Parameter	Standards
Sludge tank	• Electrically welded mild steel (Grade A) conforming to IS:2062 with anti-corrosive coating • Surface preparation and finish of tank's exterior - shall be spray-painted with two coats of superior quality anti- corrosive primer and two coats of enamel metal paint • Surface preparation and finish of tank's interior - shall be with two coats of epoxy paint to resist corrosion or Triple-layered plastic tanks conforming to IS:12701 and ISI branded • Filling level indication system – 2 numbers • Indicator mark on the tank for maximum and minimum level of sludge shall be furnished • Access for cleaning and inspection shall be provided above the tank • Height from ground to connection of suction hose shall not be less than 0.5 m • Outlet from tank shall be provided with a quick connect coupling interface • Tank shall be securely anchored to the chassis
Suction hoses	• Lightweight, heavy duty, reinforced, PVC along with quick connect coupling arrangement • Internal diameter shall be 80 mm or more • Total length of pipe 30 m. Length of each pipe segment shall be at least 5 m • Suction hoses to withstand at least 6 kg/cm^2 pressure • End of suction hoses to be provided with a foot valve
Instrumentation	• All gauges shall record in metric unit to include temperature gauge, pressure gauge and level control • All manufacturers' standard instruments shall be incorporated that are critical for operation
Color	• Bright yellow • White

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Appendix 1

FSM QUALITY DEFINITIONS AND BENCHMARKS - ASSESSMENT APPROACH

Table A1. FSM Quality Definitions and Benchmarks

FSM Quality Definition	Benchmark	Description	Assessment Approach
1. Population with access to toilets	100%	• Individual Household Latrines or Community Toilets	• Swacch Bharat Mission (SBM) records and Open Defecation Free declaration • Household census undertaken every two years
2. OSS conforming to standards and guidelines	100%	• Households with toilets discharging directly given notice to build an OSS • Properties with damaged and leaking OSS given notice to rectify the OSS • Existing OSS with no damage to be accepted as it is • New OSS to conform to standards and guidelines	• HH census undertaken every two years (insanitary toilets, damaged OSS) • New OSS conformance data from building approval records

(continued)

Table A1. FSM Quality Definitions and Benchmarks (continued)

FSM Quality Definition	Benchmark	Description	Assessment Approach
3. Physical coverage of desludging service	100% of OSS	• If E&T service is provided on demand - 100% of the requests from the service area are expected to be served • If E&T service is provided as per schedule - 100% coverage is to be provided in the service area within a specified period • Where physical access to OSS is lacking and is the reason for not providing service - the Authority or operator of desludging equipment, as contractually appropriate, will be responsible for procuring suitable equipment and completing the desludging within 1 month of receiving the request	• Based on monthly report submitted by operator • Complaints of service request not being fulfilled or service not being provided
4. Affordability of desludging service	100% of OSS based toilet users	Possible ways of ensuring universal affordability: • Area-based tariff systems enabling affordability for the poor • Sanitation tax with cross subsidies enabling scheduled desludging • Nominal service charges by government vehicle where market is dominated by private E&T operators	Analysis of E&T business model adopted

(continued)

Table A1. FSM Quality Definitions and Benchmarks (continued)

FSM Quality Definition	Benchmark	Description	Assessment Approach
5. Customer satisfaction ratings for E&T service	75% or above rating on single question survey	• If average monthly satisfaction rating is between [60% to 75%] in a consecutive three-month period, it is recommended that the service provider be counselled and provided further training • If average monthly satisfaction rating is below [60%] in a consecutive three-month period or if it falls below [50%] in a month, the service provider will be penalised	• Response to survey question embedded in 'FSM customer service form' • Complaints from field inspections by Authority staff
6. Response time for service requests and grievances	48 hours	If more than 20% of the service requests and grievances in a month are not addressed within 48 hours, the service provider will be penalised	• Data collated from 'FSM customer service form' • Customer grievances regarding delay in service
7. Safe transport of faecal sludge	At most,one incident of spillage in 10,000 trips of faecal sludge transport	Every incident of spillage will be penalised	Based on complaints logged
8. Worker safety during desludging	Zero death or disability due to avoidable causes	• All safety incidents must be reported to Authority • Operators should be periodically trained on safety aspects of desludging	• Based on complaints logged • Training records and physical inspections by Authority staff during desludging

(continued)

Table A1. FSM Quality Definitions and Benchmarks (continued)

FSM Quality Definition	Benchmark	Description	Assessment Approach
8. Worker safety during desludging	At most one incident in 10,000 desludgings leading to (a) loss of work hours for an operator OR (b) an operator coming into manual contact with faecal matter.	• If PPE is not used or Standard Operating Procedure (SOP) is not adhered to, the Authority will counsel the service provider. In case of repeated violation, the Authority will insist on training to the staff at the cost of the service provider • Every incident of physical harm will be investigated and the service provider will be penalised if negligence or non conformance to SOP is found • All workers engaged in emptying & transport should be provided quarterly health check-ups by the owners or operators of these activities, as contractually appropriate	• Investigation by competent senior staff of Authority • Records of health check-ups
9. Percentage disposal at designated site	100% of collected faecal sludge	• Any violation by the E&T service provider will be penalised unless the designated disposal site does not accept the load and the service provider disposes with prior approval of the Authority • The designated disposal site operator will be penalised for rejecting a truck load unless a) the capacity of the site is exceeded for the day, b) the sludge is from a non-domestic source	• Data collated from 'FSM customer service form' • Complaints regarding indiscriminate disposal

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Table A1. FSM Quality Definitions and Benchmarks (continued)

FSM Quality Definition	Benchmark	Description	Assessment Approach
10. Maximum non-value added time (wait time for decanting taken by truck at designated disposal site	25 minutes	• If such delays occur more than 25% of trips then the Authority or operator of the designated disposal site, as contractually appropriate, should make changes at their own cost to rectify the situation • If the situation is not addressed for more than three months, then the Authority or operator of the designated disposal site, as contractually appropriate, will be penalised	Complaints from E&T operators regarding long wait at designated disposal site
11. Treating faecal sludge to requisite standards	Biosolids, effluent, emission standards and proper disposal of wastes	• Disposing of untreated or partially treated faecal sludge is prohibited and the operator of the designated disposal site will be penalised • All tests prescribed for end products of treatment must conform to standards • If biosolids tests as per *Appendix 4* show non-conformance for three consecutive months, a thorough third-party technical investigation should be conducted into the FSTP process to determine the root cause. The Authority or operator of the treatment plant, as contractually appropriate, should bear the cost of investigation and making any changes recommended	• As per lab test reports • As per process logs • All other data logs

(continued)

Table A1. FSM Quality Definitions and Benchmarks (continued)

FSM Quality Definition	Benchmark	Description	Assessment Approach
11. Treating faecal sludge to requisite standards	Biosolids, effluent, emission standards and proper disposal of wastes	• Non-compliance to logging of process parameters as per *Appendix 6* will lead to penalties • If treated wastewater samples tested show non-conformance for three consecutive months, a thorough third-party technical investigation should be conducted into the FSTP process to determine the root cause. The Authority or operator of the treatment plant, as contractually appropriate, should bear the cost of investigation and making any changes recommended • If emissions samples tested show non-compliance for seven consecutive days, a thorough third-party technical investigation should be conducted into the FSTP process to determine the root cause. The Authority or operator of the treatment plant, as contractually appropriate, should bear the cost of investigation and making any changes recommended • Dispose any other products of the treatment process, such as residual ash, garbage separated from faecal sludge and other wastes, as per existing rules (e.g., MSW 2016 rules). The local government is responsible for collection and safe disposal of trash separated from faecal sludge	• As per lab test reports • As per process logs • All other data logs

(continued)

Table A1. FSM Quality Definitions and Benchmarks (continued)

FSM Quality Definition	Benchmark	Description	Assessment Approach
12. Worker safety in FSTP	Zero death or disability due to avoidable causes.	• All safety incidents must be reported to Authority • Operators should be periodically trained on safety aspects of plant operations • If PPE is not used or SOP is not adhered to the Authority will counsel the service provider. In case of repeated violation, the Authority will insist on training to the staff at the cost of the service provider • Every incident of physical harm will be investigated and the service provider will be penalised if negligence or non conformance to SOP is found • All workers engaged in emptying & transport should be provided quarterly health check-ups by the owners or operators of these activities, as contractually appropriate	• Self-reporting by FSTP operator • Complaints from workers of FSTP • Physical inspections by Authority staff at treatment plant • Investigation by competent senior staff of Authority • Records of health check-ups
13. Reuse of biosolids generated by FSTP	100% of biosolidsevacuated for reuse within one year	• Treated solids should be evacuated from treatment plant within one year of completion of treatment • When sludge is stored to meet VAR requirements, the storage period is considered a part of the treatment process	• Data collated from monthly reports from treatment plant

(continued)

Table A1. FSM Quality Definitions and Benchmarks (continued)

FSM Quality Definition	Benchmark	Description	Assessment Approach
14. Reuse or safe discharge of treated wastewater from FSTP	100% of treated wastewater within 3 days	Treated wastewater should be safely reused for landscaping, recharged artificially or discharged	• Self-reporting by FSTP operator • Specific complaints regarding treated wastewater discharge
15. Payments for FSM services (government owned truck operations, FSTP O&M) made promptly by the local government	100% of payments made within 3 months of invoicing	No pending contract payments beyond 3 months	Based on payment records
16. FSM is inclusive	100% specifications for inclusivity met	• Amenities provided to all government contracted FSM workers for washing, bathing, in a gender-sensitive manner • All workers enrolled in social financial schemes of government (Jan Dhan, PM Insurance etc.) • CT/PT designs are gender and disability sensitive • Desludging trucks, STPs and FSTPs are designed ergonomically for ease of operation by any gender • Workers are aware of and have access to support and redressal mechanisms when facing harassment or discrimination	• Physical verification of quality of amenities for workers • Verifying if workers continue to be enrolled in all applicable welfare schemes • Gender representation in workforce as well as worker representative groups; access to grievance redressal mechanisms

Appendix 2

RECOMMENDATIONS FOR STORAGE TREATMENT OF DRY EXCRETA AND FAECAL SLUDGE BEFORE USE

These recommendations apply when there is no addition of new faecal matter.

Table A2. Recommended Conditions for Treatment by Storage for Dried Faecal Sludge

Treatment	Criteria	Comment
Storage; ambient temperature 2-200 C	1.5-2 years	Will eliminate bacterial pathogens; regrowth of *E.coli* and *Salmonella* may be considered if rewetted; will reduce viruses and parasitic protozoa below risk levels. Some soil-borne ova may persist in low numbers.
Storage; ambient temperature > 20-350 C	> 1 year	Substantial to total inactivation of viruses, bacteria and protozoa; inactivation of schistosome eggs (< 1 month); inactivation of nematode (roundworm) eggs, e.g. hookworm *(Ancylostoma/Necator)* and whipworm *(Trichuris)*; survival of a certain percentage (10-30%) of *Ascaris* eggs (> 4 months), while a more or less complete inactivation of *Ascaris* eggs will occur within 1 year (Strauss, 1985)

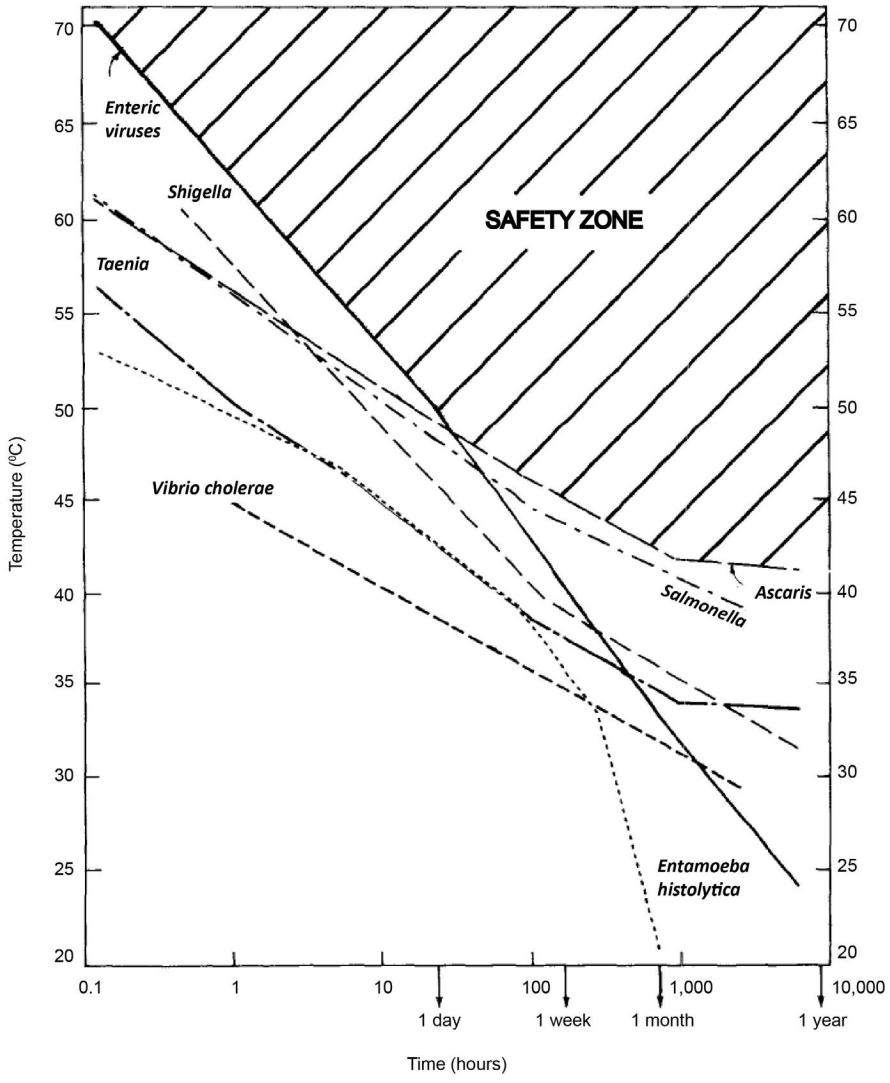
Source: WHO 2006

Appendix 3

TIME-TEMPERATURE DIAGRAM FOR PATHOGEN KILL

Influence of time and temperature on selected pathogens in night soil and sludge. A treatment process that achieves a time-temperature combination in the safety zone shown in **Figure A1** should be lethal to all excreted pathogens (except for Hepatitis A virus at low retention times). Indicated time-temperature combinations are – at least 1 hour at 62^0 C or more, 1 day at 50^0 C or above, 1 week at 46^0 C or above.

Figure A1. Pathogen Kill Graph for Faecal Sludge



Source: Feachem et al. 1983

Appendix 4

BIOSOLIDS TESTING PROTOCOL FOR MICROBIAL PARAMETER

The microbial parameters analysed for the sample should be within the prescribed output standards. If the test results of the sample do not comply with the prescribed standards, then the sale or evacuation of biosolids should be stopped immediately. Measures should be taken to rectify any design or operational deviation with testing carried out fortnightly until the results comply with standards.

Table A3. Microbial Testing Protocol for Biosolids

Parameter	Frequency of Testing	Sampling Point and Method	Test Methods	Limits
Faecal coliform/ E-coli	Every month	Point: When biosolids are used or disposed	(US) EPA 1681	< 1000 MPN (E-coli)/g Total solids or < 1000 CFU (Faecal coliform)/g Total solids by dry weight)

Appendix 5

TESTING FREQUENCY AND PROTOCOL FOR CONTAMINANTS IN BIOSOLIDS

Table A4. Contaminants Testing Protocol for Biosolids

Standards	Parameter	Frequency of Testing	Sampling Point	Test Methods
Ceiling limits	Heavy metals (Arsenic, cadmium, chromium, copper, lead, mercury, nickel, zinc)	Once in a year or as prescribed by the officer in charge	When biosolids are used or disposed. When biosolids are prepared for give away or sale or applied in land.	(US) EPA 600

Appendix 6

BIOSOLIDS DATA COLLECTION AND REPORTING FORMAT

Table A5. Reporting Parameters and Protocol for Biosolids Treatment Processes

Process	Parameter	Sampling Point	Frequency	Test Methods
1. Air drying	Moisture	When removing dried FS solids from the bed	Every batch	(US) EPA-1684 (or) other approved probes
2. Co-composting	Temperature of the co-compost	Average of 6-hourly temperature reading collected everyday over 14 consecutive days.	Every heap	Temperature probe immersed in compost pile
3. Any other process for pathogen reduction standards “c”	Temperature of the sludge/dry solids	Average of 6-hourly temperature reading collected everyday over 7 consecutive days (or) as per time requirement for pathogen kill (*Appendix 3*)	Every batch	Temperature probe immersed in sludge
4. Storage	Moisture	When biosolids are used or disposed. When biosolids are prepared for give away or sale or applied in land	Every month	(US) EPA -1684 (or) other approved probes
5. Any process for VS/TS reduction	VS/TS ratio	While removing sludge from VS/TS reduction process	Every month	(US) EPA -1684
6. Any process for moisture removal	Moisture	At the end of the treatment process or when biosolids are used or disposed. When biosolids are prepared for give away or sale or applied in land	Every month	(US) EPA -1684 (or) other approved probes

Appendix 7

BIOSOLIDS REUSE DATA COLLECTION

Separate logs shall be maintained for any other treatment by-products, including if treated water is being sold/disposed.

Table A6. Biosolids Sale or Disposal Log Format

Sl. No.	Date	Quantity	Details of the Transporting Vehicle	End Use Application	Location of Biosolids Application and Contact Details of Person in Charge	Meets Biosolids Standards? (Yes/No)

Appendix 8

FAECAL SLUDGE ACCEPTANCE SCREENING AT FSTP

The FSTP operator must undertake the following checks on the faecal sludge arriving through desludging vehicles to check if it is from a domestic source and not chemical sludge. Any faecal sludge which does not pass these tests should strictly not be accepted for treatment as it can foul the entire treatment system. Data collected through these tests should be logged and maintained at the FSTP along with details of the desludging truck and source of faecal sludge. In addition to these, the operator must be trained to identify unusual colour and odour in the incoming faecal sludge.

Table A7. Screening of Faecal Sludge for Acceptance at FSTP

Parameters	Test Procedure	Recommended Limits
pH	Grab sample from the truck outlet. Analysis using approved pH measuring methods – IS:3025	6.5 – 9
Temperature	Grab sample from the truck outlet. Analysis using approved temperature measuring instruments	25 – 35^0 C (or) Ambient temperature +/- 5^0 C

Appendix 9

DESIGN GUIDELINES FOR TREATMENT MODULES

In this section, the modules specified as part of treatment processes are described in brief and design guidelines have been provided. The guidelines are aimed to act as specification for procurement of the product and to evaluate the technical part of the bids. These guidelines supplement the description of technology modules provided in *Chapter C* and must be used in combination.

These design guidelines are basic and derived from the experience of implementing treatment plants thus far. Process engineers are requested to contribute further to faecal sludge specific literature, especially design and engineering guidelines to extend the existing knowledge base.

a. Screen and grit chamber

Faecal sludge may contain solid waste such as plastics, glass and metals which do not get treated in the FSTP but may affect its operations by choking the flow or reducing the treatment volume. Hence, the preliminary stage of an FSTP should be the removal of such trash and other inert materials such as grit. Screens are provided for the purpose of trash removal. The screens are typical bars with openings to let the liquid pass through while retaining particles bigger than a certain size. Grit chambers, on the other hand, use gravity to settle down denser particles such as sand and silt, thus separating them from the flowing liquid. The design of the screen is dependent on the flow rate of the incoming faecal sludge, size of solids to be removed and degree of mechanization of the operation, while grit chambers are designed based on the settling velocity of grit and flow rate.

Reference guide for design
Manual on Sewerage and Sewage Treatment Systems, CPHEEO 2013.

Design guidelines

1. The design and construction of the screen chamber should be as per IS:6280
2. The design of the grit removal system should be as per IS:6279
3. The screen chamber should be covered and well-ventilated and the slopes and wetted areas smoothly plastered or tiled to prevent unwanted accumulation of sludge.
4. Grit and trash removal, collection and washing facility to be provided as a part of the screen and grit system. The liquid from washing of trash and grit must be further treated in the FSTP. The trash and grit should be dried before disposal.

b. Anaerobic digestion

Faecal sludge contains partially degraded organic materials which provide potential for vector attraction and accumulation in the environment. Anaerobic digestion (AD) is a non-energy intensive method to further stabilise the faecal sludge. AD is effective at ambient temperatures of 30–380 C, with a minimum temperature requirement of 200 C

Anaerobic digestors are designed based on the loading rate (high and low rate), operating conditions (batch, plug flow, continuous) and retention times. The solid and hydraulic retention times in the anaerobic

digestors depend on the design, volatility of the solids and the sludge volume index. In order to reduce the vector attraction potential, the outlet sludge from the digestor should have a VS (volatile solids)/TS (total solids) of 40%. In addition to stabilisation, anaerobic digestion also improves the dewaterability of sludge.

Design guidelines

1. The sludge retention time (SRT) of the digestor must be able to reduce the VS/TS ratio to less than 40%.
2. For digestors exceeding capacities of 30 KLD, provision must be made for usage or flaring of biogas.
3. Sludge should be mixed within the digestor to ensure optimal levels of anaerobic digestion. Mixing can be achieved by mechanical means (agitator, re-circulation) or through hydraulic turbulence (gravity up-flow).
4. In case the ambient temperatures are not conducive for anaerobic digestion, external heat input may be provided.
5. Scum layer may tend to form in the reactor. A mechanism needs to be provided for its removal.
6. Design of the digestor should prevent thickening of sludge, which shall impede flow or sludge removal.

c. Unplanted sludge drying beds

Unplanted sludge drying beds are shallow filters filled with sand and gravel with an under-drain at the bottom to collect percolate. Sludge is discharged onto the surface for dewatering. The drying process in a drying bed is based on drainage of liquid through the sand and gravel to the bottom of the bed and evaporation of water from the surface of the sludge to the air. Depending on the faecal sludge (FS) characteristics, a variable fraction of approximately 50-80% of the sludge volume drains off as a liquid (or percolate), which needs to be collected and treated prior to discharge. After reaching the desired dryness, the sludge is removed from the bed manually or mechanically.

The design of drying beds is based on the solid loading rate expressed as kg TS/m^2/year and the drying time, which is a factor of local evaporation rates.

Reference guide for design
Faecal sludge treatment – (Taylor, 2018).

Design guidelines

1. The solid loading rate in drying beds for tropical conditions should range between 200 – 300 kg TS/m^2/year.
2. Drying time must be estimated based on local evaporation rates, considering worst case scenarios. Calculations for the same has to be provided in the design.
3. Drying beds should be covered with roof to prevent intrusion of rainwater. Roof should be made of transparent cover to allow penetration of sunlight.
4. The maximum sludge application thickness should not exceed 300 mm.
5. Design and construction of the drying beds should be as per IS:10037 – Part 1
6. Drying beds should be non-permeable and watertight structures. They must be designed with sufficient elevation above ground to prevent storm water intrusion.

d. Planted drying bed

Planted drying beds (PDB) perform similar function to sludge drying beds in dewatering and drying of faecal sludge solids. In addition to these functions, the long-time accumulation of solids in the PDB bed leads to stabilisation and mineralisation, thereby also reducing vector attraction potential.

Planted drying beds are periodically loaded with sludge after providing an appropriate resting period. This loading cycle continues for 18-36 months, typically after which the beds are provided with a final resting phase of 3-6 months. During this time, the sludge accumulated in layers undergoes reduction in volatile solids. The plants, in addition to nutrient removal, also enable moisture removal through evapotranspiration. While the solids get retained on the bed, the percolate drains down. Depending on the solid content in the sludge and the years of operations, the quantity of percolate can vary between 40-70% of the input sludge volume. The dried sludge from the PDBs may still contain pathogens and hence they need to be further treated for pathogen reduction. Drying beds are designed based on the solid loading rate, loading cycles and local climatic conditions.

Reference guide for design
Faecal sludge treatment – (Taylor, 2018).

Design guidelines

1. The solid loading rate for planted drying beds in tropical climates should be in the range of 180 – 250 Kg TS/m^2/year.
2. The minimum resting time between two successive loadings in the PDB should be 4 days, to be based on the local evapotranspiration rates. Calculations for the same has to be provided in the design.
3. Provision to be made for additional beds to cater to downtime of PDBs during their final resting phase.
4. Emergent macrophytes, locally sourced, should be used as plant species in the PDB.
5. The maximum sludge application thickness should not exceed 200 mm.
6. The height of the free board must be estimated based on the long-term accumulation rate of the solids over the operational cycle.
7. In case the FSTP is located in moderate to heavy rainfall areas, the PDB must be covered with a roof to prevent rainwater intrusion. The roof should be made of transparent material to allow incidence of sunlight.
8. The general design and construction of the PDB should be as per IS:10037 – Part 1
9. PDBs should be non-permeable and watertight structures.

e. VOLUTE SCREW PRESS

Volute Screw Press (VSP) is a commonly used mechanical dewatering system. It uses chemical and physical processes to remove moisture from faecal sludge. Dewatering reduces the risk of vector attraction and makes sludge easy to handle for subsequent processes. The process uses cationic polymers to chemically coagulate the solids particles of the sludge. The flocks formed from the coagulation process are then physically separated from the liquid using the volute screw press. The filtrate from the volute press is collected and treated in downstream modules.

VSPs are off-the-shelf products available in the market and do not need detailed designing. The selection of the appropriate VSP is determined by the inlet solid concentration and the solid feed rate.

Design guidelines

1. All the parts of the VSP which come in contact with the sludge should be made from stainless steel, conforming to IS:6911 – 1972.
2. The design of the VSP must include polymer preparation, polymer dozing and polymer mixing units.
3. The design of the VSP shall be determined using solid loading rate and moisture content in inlet faecal sludge.

4. The system must have an arrangement for high-pressure washing of the filter surrounding the volute screw casing.
5. The motor used in VSP must conform to efficiency standards prescribed in IS:12615:2011
6. All compartments of the VSP must be covered to prevent spillage or splashing of faecal sludge or filtrate.
7. The control panel, electrical circuits and all other pieces of equipment of the VSP operation must conform to IP 65 ratings.

f. Effluent treatment

The objective of the liquid treatment in an FSTP is to reduce the pollution in the percolate or supernatant, arising from the solid-liquid separation phase to levels that are prescribed as effluent standards. The characteristics of the effluent entering the liquid treatment units depend on the upstream process at the solid-liquid treatment facility. Depending on the characteristics and the flow rates, secondary and tertiary treatment for liquid treatment can be designed. The technologies used for liquid treatment can be similar to typical STPs, however with consideration to a) low BOD/COD ratio and b) high nutrient load.

Reference guide for design
Manual on sewerage and sewage treatment, (CPHEEO, 2013).

Design guidelines

1. The capacity of the liquid treatment unit is to be derived through a water mass balance of the faecal sludge treatment plants.
2. In case of the liquid treatment facility (LTF) receiving effluent from various stages of faecal sludge treatment, i.e. from solid-liquid separation, solid dewatering and solid drying, then a homogenization tank must be provided before the secondary treatment in the LTF.
3. All the liquid treatment units must be watertight to prevent any leakages into the environment.
4. The liquid treatment unit must have provision for removal and further treatment of sludge formed in the secondary or tertiary treatment phases. Co-treating this sludge along with faecal sludge can be considered for resource optimization.
5. A disinfection arrangement has to be provided for post treatment of the effluent.

g. Reuse of treated effluent within the FSTP premises

The final treated effluent from the faecal sludge treatment plant must adhere to the prescribed quality guidelines. First preference should be given to reusing this treated water within the FSTP premises for non-potable purposes. After such reuse application, the excess treated water can be made available to potential non-potable applications such as industries and agriculture. In case of non-availability of such potential reuse options, the excess treated water should be disposed of into nearby water bodies or used for groundwater recharge.

Design guidelines

1. Drip, surface or sub-surface irrigation techniques to be adopted for using treated water in landscaping within the FSTP premises. Flooding of the land or use of sprinklers to be avoided.
2. Irrigation water requirement varies, depending on the type of plants/crops used. For grass (lawn) this shall be in the range of 0.4-0.8 m^3/m^2/month (depending on soil type and season).
3. Percolate trenches or pits filled with filter material such as gravel and sand must be used for artificial recharge of groundwater. Treated water must not be directly let into any underground aquifer. Design of such systems to be based on the guidelines provided in the, ‘Guide on Artificial Recharge to Groundwater’, Central Ground Water Board, May 2000.

4. The excess of treated water meant for discharge outside the premises should be transported through pipes until the designated outfall point.
5. The treated water must be sampled periodically and its results maintained in a register in the FSTP.

h. Solar drying of faecal sludge solids

Solar drying derives its energy primarily from solar radiation to increase the temperature of solids for achieving pathogen-reduction standards. While pathogen reduction is the primary function of solar drying, moisture in the solids are also reduced in this process. Therefore, solar drying can be used as a simultaneous process for pathogen and VAR. Solar beds are equipped with active ventilation system, operated through logic controls triggered by temperature and humidity as decision variables. The drying time is dependent on the intensity of the solar radiation and is aimed to achieve either of the pathogen requirement of time-temperature combination or a moisture content of less than 25%, whichever is longer.

Design guidelines

1. The location and direction of the dryer is to be chosen to harness maximum potential solar radiation for the FSTP geography.
2. The material of the solar dryer roof should be transparent and UV-stabilized.
3. All electrical equipment such as blowers, heaters, PLC boards, etc. related to solar drying process must conform to IP-65 rating.
4. Solar dryer should be placed on a raised platform, preventing stormwater intrusion and reducing heat loss.
5. Solar dryer should be designed to consistently maintain the temperature of the dry solids as prescribed for pathogen reduction in the bio-solid standards.

i. Co-composting

Dry sludge from faecal sludge dewatering or drying does not contain sufficient C:N ratio for composting. Therefore, addition of carbon source such as organic solid waste is essential to initiate composting (WHO, 2006). Composting being an exothermic process, releases heat, raising temperature of the heap to reduce pathogen. Composting, due to its aerobic degradation of the volatile materials, simultaneously leads to vector attractor reduction. The typical ratio for mixing organic municipal solid waste and faecal sludge is derived empirically based on the input composition of both these waste streams. The design of the composting process depends on the quantity of input, duration of the compost and the type of composting process (windrow, aerated static in pile and bin composting). Vermicomposting, by design is not meant to achieve temperatures in excess of 40^0 C. Therefore, vermicomposting alone cannot reduce pathogens and hence the compost from this process needs to be additionally treated.

Reference guide for design
Municipal Solid Waste Management Manual, (CPHEEO, 2016).

Design guidelines

1. The capacity of the co-compositing facility should be based on the total quantity of the mixture of organic solid waste and dry faecal sludge solids.
2. Solid waste and dried faecal sludge should be shredded before composting.
3. The desired C:N ratio of the mixture of organic solid waste and dried faecal sludge should be between 20:1 to 30:1.

4. The design of the composting process must specify the turning frequency and heap sizes for windrow- and bin-composting. Static pile composting designs should specify the aeration requirement and provide details of the equipment involved.
5. The composting platform should be elevated to prevent intrusion of stormwater. The platform should be non-permeable to prevent moisture from the compost leaching into the ground.
6. The platform should have a minimum slope of 2% for collection of leachates. Detailed leachate collection and treatment system has to be specified and provided in the design.
7. Composting yard should be covered by a roof to prevent rainwater intrusion. Design of the yard should also include mechanisms to block rodent pathways. The design of roof must conform to USDA Conservation practice standard – Code 367.

j. Storage

Long-term storage of dried faecal sludge containing moisture lesser than 25% and at temperatures above 300 C can significantly reduce pathogens (Strauss & Blumenthal, 1990). This process is used for pathogen reduction as prescribed by the bio-solid standards. Design of the storage units must consider the duration of storage and the quantity of solids produced at the FSTP.

Design guidelines

1. Storage yard must be completely covered to prevent rainwater, stormwater intrusion and entry of rodents.
2. The yard must have partitions to clearly distinguish dry solids based on the duration of storage.
3. The yard must have additional space for weighing, sorting and packaging of biosolids.
4. The general design of the storage yard has to conform to USDA Conservation practice standard, Code 313.

k. Thermal treatment of faecal sludge solids by pyrolysis

Thermal treatment of faecal sludge includes drying and thermal destruction of biosolids through heat or combustion. Subjecting the biosolids to temperature and time regimes prescribed in the biosolids standards can lead to pathogen and VAR.

Design guidelines

1. The design, operations, performance and safety of thermal treatment systems must comply with relevant sections of the ISO 31800 (ISO, 2018).
2. Treatment system must be programmed to operate on logic controls with remote access and shut-off mechanism to ensure optimal performance and safety.
3. Treatment system must be designed to capture and recover heat from the process. The recovered heat to be converted into usable forms of energy that can reduce the operating cost of the treatment.
4. Boilers, furnaces and related equipment should conform to Indian Boiler Regulations 1950.

Water, Sanitation and Hygiene Institute (WASH Institute), established in Kodaikanal in 2008, is a registered non-profit technical, training, research and development organization dedicated to providing practical solutions to a wide range of water, sanitation, hygiene and environmental issues in India. WASH Institute operates from 14 locations spread across eight states and one Union Territory and also provides Technical Assistance to the Ministry of Housing and Urban Affairs (MoHUA) and the Ministry of Jal Shakti. WASH Institute has also been enabling access to improved WASH services to marginalized communities and public institutions such as schools, Anganwadi Centres, Primary Health Care Centres (PHCs) by implementing grassroot level CSR projects across eight states namely Tamil Nadu, Andhra Pradesh, Telangana, Bihar, West Bengal, Rajasthan, Karnataka and Uttar Pradesh.

A national working group was convened in January 2016 with the support of the Bill and Melinda Gates Foundation with the mandate to build consensus around and drive the discourse on Faecal Sludge and Septage Management (FSSM) forward, nationally. The alliance currently comprises 24 organizations across the country working towards solutions for Indian states and cities. The Alliance members meet every month to track the progress and also to derive various actions towards mainstreaming of FSSM. The NFSSM Alliance works on all aspects from city sanitation plans to regulatory and institutional frameworks across the sanitation value chain.

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