Background Note to Quality in Faecal Sludge Management

TECHNICAL NOTE SUPPLEMENTING THE 'QUALITY IN FSM' DOCUMENT

BACKGROUND NOTE TO QUALITY IN FAECAL SLUDGE MANAGEMENT

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ACRONYMS AND ABBREVIATION

APLR	Annual Pollution Loading Rate
CPCB	Central Pollution Control Board
CPLR	Cumulative Pollutant Loading Rate
DALY	Disabled Adjusted Life Years
E&T	Emptying & Transport
EQ	Exceptional Quality
FCO	Fertilizer Control Order
FSM	Faecal Sludge Management
FSTP	Faecal Sludge Treatment Plant
NFSSM	National Faecal Sludge and Septage Management
O&M	Operations and Maintenance
OEM	Original Equipment Manufacturer
OSS	Onsite Sanitation Systems
PC	Pollution Concentration
PPE	Personal Protective Equipment
PR	Pathogen Reduction
SPCB	State Pollution Control Board
STP	Sewage Treatment Plant
ULB	Urban Local Body
US-EPA	United States Environmental Protection Agency
VAR	Vector Attraction Reduction
WHO	World Health Organization

DEFINITIONS

Biosolids: The solid end product from a faecal sludge treatment plant which has undergone treatment as per prescribed standards.

Co-treatment: Treating faecal sludge in a sewage treatment plant.

Contaminants: Represent heavy metals present in sludge. In the future emerging contaminants such as dioxins, pharmaceuticals etc. may be included.

Effluent: Effluent is the general term for a liquid that typically comes out during Faecal Sludge treatment.

Emissions: Gases emitted as a by-product from the treatment of faecal sludge.

Faecal Sludge: Faecal sludge comes from onsite sanitation technologies and has not been transported through a sewer. It is raw or partially digested, a slurry or semi-solid, and results from the collection, storage or treatment of combinations of excreta and black water, with or without grey water.

Faecal Sludge Management: Faecal Sludge Management is the containment, timely emptying, transportation, and treatment for reuse or disposal from onsite sanitation systems with the objective of reducing risk to public health and environment.

Onsite Sanitation Systems: Sanitation systems where excreta and wastewater are collected and stored or treated at the same site as the toilet. Typical systems are pit latrines and septic tanks.

Pathogen: Micro-organisms, such as bacteria, viruses, fungi, protozoa and worms, capable of causing disease.

Personal Protective Equipment: They are used by humans to minimise exposure to hazards that cause workplace injuries and illness.

Septage: Settled sludge removed from a septic tank, as per its designed desludging interval.

Sewage Treatment Plant: Infrastructure to treat the pollution in domestic sewage.

Sewage: Wastewater from households, generally constituting black and grey water, conveyed through sewers.

Standards: A level of quality defined by setting benchmarks for output characteristics, process parameters, and service levels.

Vacuum Truck: Desludging vehicle consisting vacuum based suction equipment, sludge tank and other accessories mounted on a truck or trailer, used for desludging faecal sludge from onsite containment units.

Vectors: Organisms such as birds, rodents and insects which are attracted to untreated sludge and are capable of transmitting pathogens.

INTRODUCTION

According to NSSO's Swacchta Status Report 2016, 56.4% of wards in urban areas were covered by sewer network. As per WHO/UNICEF JMP, in 2017, 141 million people in India were connected to sewer network and 823 million people dependent on septic tanks and pit latrines. Sewage treatment plants (STPs), where the wastewater conveyed through sewer system is treated, are very few, close to 1,200 in total, and confined to urban areas.

The majority of toilets in India are dependent on onsite sanitation systems (OSS) such as septic tanks and pit latrines. OSS fill up over time and the sludge accumulated in these systems, in most towns, need to be treated at a faecal sludge treatment plants (FSTP). As of end of 2019, India has about 32 FSTPs[1] Database of FSTPs curated by NFSSM Alliance, with rapid scaling up taking place as more states realize the importance of Faecal Sludge Management (FSM). According to National Faecal Sludge and Septage Management (NFSSM) Alliance, almost all of the about 7,000 statutory and census towns will require FSM services to cater to the large population dependent upon OSS. A majority of these FSTPs will be built through public finance and hence via government procurement procedures.

The FSM sector is nascent and the associated support structures need to be streamlined to enable scale-up by the Urban Local Bodies (ULB). Outcome, process and service standards along with defined quality benchmarks will lead to clarity in treatment objectives. Benchmarks and metrics on performance of FSTP will strengthen procurement standards. Most of the FSTPs follow effluent standards prescribed for STPs. Due to lack of standards for solids, many are either silent or refer to United State Environmental Protection Agency (US - EPA) or World Health Organization (WHO) standards. The ambiguity of using standards prescribed for STPs and referring to international standards that are not contextualized to Indian setting impedes scaling of FSM.

The *Quality in FSM* document uses the framework of outcome, service and process standards to define quality in implementation of FSM.

- *Outcome standards* specify the quality of the end products to be achieved by the treatment plant
- *Process standards* specify critical process parameters that help achieve a set outcome
- *Service standards* specify the expected service level benchmarks to be achieved by the various service providers along the FSM value chain

In addition to the quality benchmarks and treatment standards, the document also provides specifications for treatment processes, Emptying and Transport (E&T) equipment and materials, and construction processes for FSTPs.

This document is a background technical note supplementing the *Quality in FSM* document and is structured to mirror the same. It is prepared as a part of the Quality Assurance in FSM project supported by the Bill & Melinda Gates Foundation. An earlier version of the *Quality in FSM* document was reviewed by 10 eminent experts listed in *Appendix 5*. Please refer to the document *'Compilation of Feedback and Responses'* which addresses the feedback received from these experts and responses tabled as per the chapters.

[1] Database of FSTPs curated by NFSSM Alliance

Chapter A

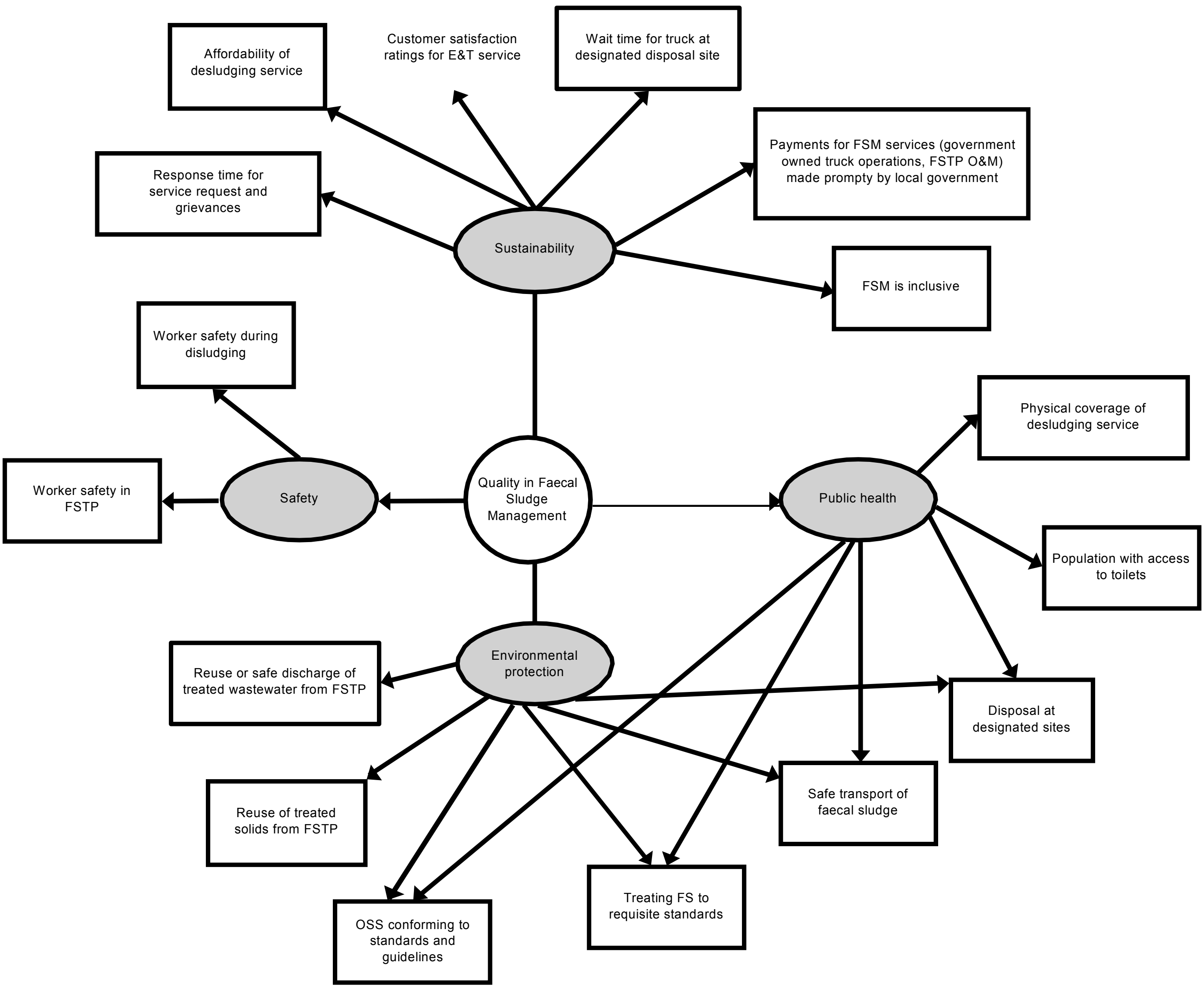
FSM QUALITY DEFINITIONS AND BENCHMARKS

[Refer Chapter A of 'Quality in FSM' document]

To ensure quality in scaling up of FSM across India, indicators on quality and benchmarks for expected service levels need to be defined for all the components of the sanitation value chain. The quality of an FSM system is defined (**Figure 1**) based on the following four objectives:

- Public health
- Environmental protection
- Safety
- Sustainability

Figure 1: FSM Quality Indicators



A set of 16 indicators applicable at the city level and corresponding benchmarks are proposed in Chapter A of the Quality FSM document. These indicators are intended to be operational level parameters (WHO Tool 7) that help the 'Sanitation Cell' of a ULB take FSM related decisions. Therefore, these indicators are expected to seamlessly feed into existing reporting structures such as the Service Level Benchmarks indicators of the Ministry of Housing and Urban Affairs, India, to monitor sanitation progress achieved by the ULBs. *Appendix 1* in the *Quality in FSM* document details out the assessment approach for each of the 16 indicators.

The indicators help ULBs assess the performance of FSM system and identify any gaps that needs to be addressed with a time-bound plan. The indicators also ensure transparency for private operators during procurement and for contract management. In the future, as the quality of FSM services improve and as more ULBs meet the standards, these parameters are expected to evolve.

Chapter B

STANDARDS FOR TREATMENT OF FAECAL SLUDGE

PRINCIPLES FOR DEFINING STANDARDS FOR TREATMENT OF FAECAL SLUDGE

As per National Urban Sanitation Policy (NUSP) 2008, ULBs are responsible for ensuring access to sanitation services to residents. States are required to make concerted efforts to empower the ULBs with financial and personnel resources to discharge their obligations for universal sanitation. ULBs are responsible for planning, financing public infrastructure, and leveraging private investments for sanitation outcomes. Setting of standards are critical to benchmark the expected sanitation outcomes – ensuring safe public health and environment.

Faecal sludge contains pathogens which are detrimental to public health and environment. In defining treatment standards for faecal sludge, following issues play a vital role:

1. Costs vs public health benefits
2. Existing capacity to monitor and test standards
3. Data on treatment standards achieved by various technologies
4. Standards should encourage reuse
5. Multi-barrier approach to mitigate risks from reuse

1. Costs vs Public Health Benefits

The cost of treating faecal sludge is mostly borne by the government – central, state and ULBs. Setting stringent standards can eliminate the risk of negative sanitation outcomes, however it increases cost of treatment, monitoring and testing for standards. Increase in these costs puts a burden on ULB finances that are already stretched in most cases. Further, increase in investments without increment of budgetary allocations for the ULBs will curtail the scaling up of FSTPs. The delay in setting up of FSTPs will increase health risk as existing coverage of improved sanitation would be limited to a small section of society while others would be exposed to the risk of open disposal of waste (Wolf J, 2018). Stringent standards also increase the technical complexity of treatment systems making them expensive to maintain and prone to failures (Keraita, et al., 2010). A balanced approach, carefully comparing the benefits of mitigating risks to public health and environment, and the associated socio-economic costs in setting the standards, is critical to achieving equitable sanitation for all.

2. Existing Capacity to Monitor and Test Standards

CPCB and SPCB are responsible to set and monitor adherence to treatment standards for sanitation. These agencies are understaffed, which limits their ability to regulate and monitor treatment standards (Tata Institute of Social Sciences, 2013). Monitoring pollution has largely been limited to industries, with very little focus on STPs thus reducing the impact of various wastewater treatment interventions implemented for abatement of water pollution (Indian Institute of Management, Lucknow, 2010). Learning from this experience, outcome-based monitoring of treated products requires investment in staff, infrastructure and institutional strengthening. In addition, monitoring output-based standards for FSTPs (considering many more to be commissioned in the future) without significant capacity enhancement will weaken the enforcement of these standards and may lead to non-conformance.

Monitoring of treatment plants is further obstructed by the capacity of laboratories in India to test all the parameters especially microbial, for compliance. India has very few accredited laboratories that can reliably assess microbial parameters (Seth, 2015). Based on the review of empanelled laboratories with CPCB and SPCB, it is observed that microbial testing is not undertaken by majority of the laboratories and none of them list testing for helminth ova. Standards that require testing of such parameters can make monitoring expensive.

The constraints in monitoring outlined above demand a shift in assessment of compliance by treatment plants – from a trailing indicator based post-facto quality assessment and control process to a process-based quality assurance process. Thus, instead of monitoring the output, process standards need to be mandated to ensure desired results are achieved. Hence, the standards should be process based, derived from robust, locally demonstrated technology approaches.

3. Data on Treatment Standards Achieved by Various Technologies

Defining standards requires an understanding of public health and environment sensitivity and related risks in an Indian setting. Data to develop such an understanding is largely unavailable. For example, defining a tolerable health risk for India is an exercise fraught with many challenges in understanding incidence of disease, its economic and social impact, and ambiguity due to multiple causation chains. This leads to adoption of global or other country standards for tolerable public health risk as well as for technologies and processes that help reach the desired sanitation outcomes. While tolerable health risk standards may be borrowed from global benchmarks, data on the performance of various technologies adopted for treatment of faecal sludge is limited. Further, many such technologies may not be suitable to the Indian context. Therefore, it is recommended that treatment standards for India are based on proven technical approaches demonstrated in India.

4. Standards should Encourage Reuse

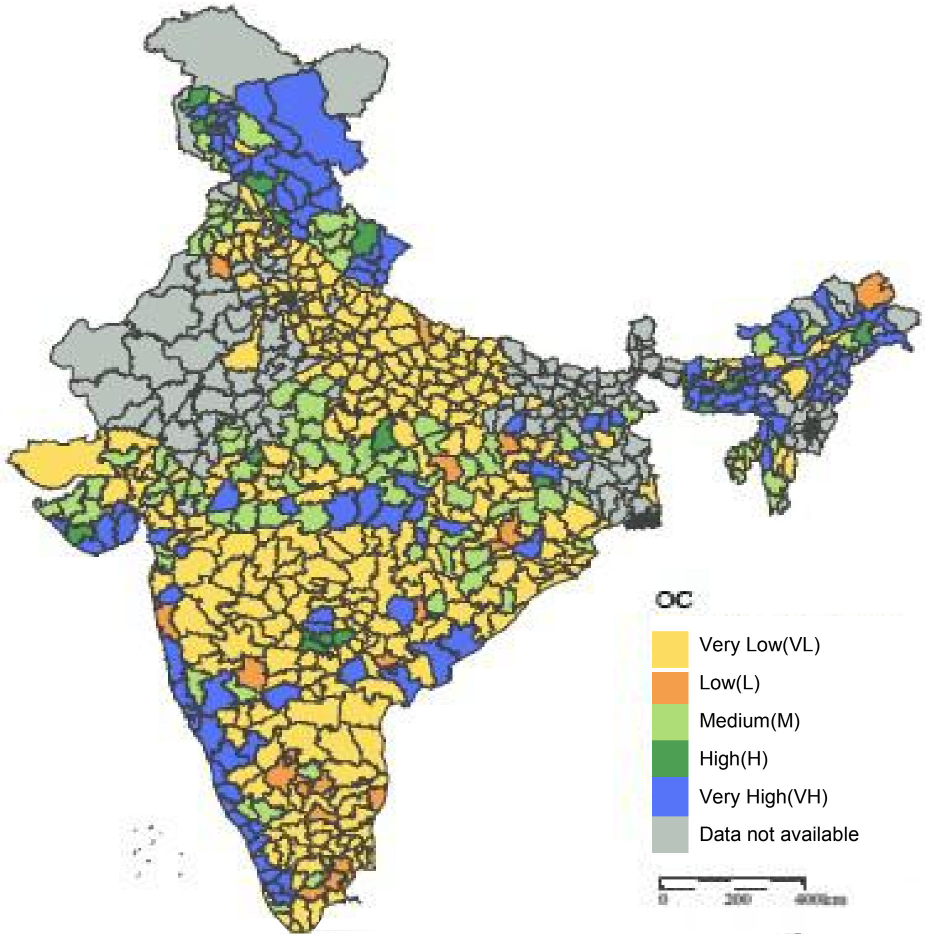
Faecal sludge has nutrients, water and energy in it that can be recovered and sold as end products. Reuse of end products may help in additional revenue for the FSTP (Stefan Diener, 2014), however benefits to the environment far outweigh revenues. For example, soil health, a key indicator for agriculture productivity has been on a constant decline over the years in India. In 2014, it was estimated that the mean soil organic content was around 0.3 - 0.4 percent, well below the accepted limits (The Hindu, 2014). **Figure 2** from the soil health card monitored by the Government of India, shows that a drastic improvement is required. Biosolids generated in FSTP have organic carbon and nutrients (IWMI, 2010). Studies have shown that when biosolids are used as soil conditioner, the properties of soil have significantly improved and have resulted in better yield of crops (Girija, et al., 2019).

Similarly, water scarcity (physical and economic) is prevalent in India. It is projected that with rapid rise in the demand for water and its reducing availability, India may face severe shortage of water, affecting agriculture, economy and socio-economic conditions of people (Asian Development Research Institute, n.d.). Since reuse benefits both economy and the environment, it is therefore prudent to develop standards that promote reuse. Defining standards will not only help regulate the reuse market but also encourage it by building confidence among user communities on the quality of end products.

5. Multi-Barrier Approach to Mitigate Risks from Reuse

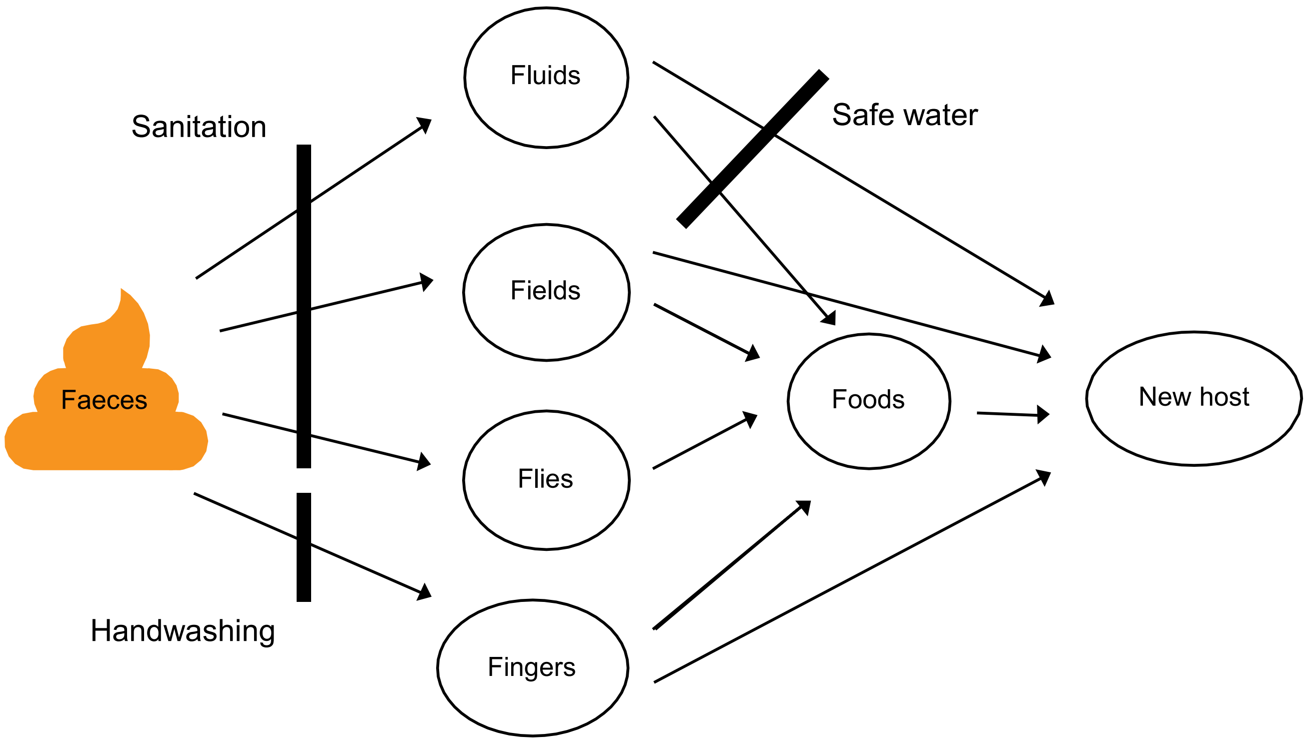
The relationship between sanitation and public health is complex with multiple disease transmission pathways. The ‘Faecal oral’ diagram (**Figure 3**) is a depiction of some of the pathways for possible disease transmission routes. Thus, sanitation interventions should focus on creating barriers across these paths. Treatment of faecal sludge should be seen as one such barrier, acknowledging that treatment alone cannot ensure improved sanitation outcomes or significantly reduce health risks (Keraita, et al., 2010).

Figure 2: Map of Organic Carbon in Soils in India



Source: Soil Health Maps, Government of India

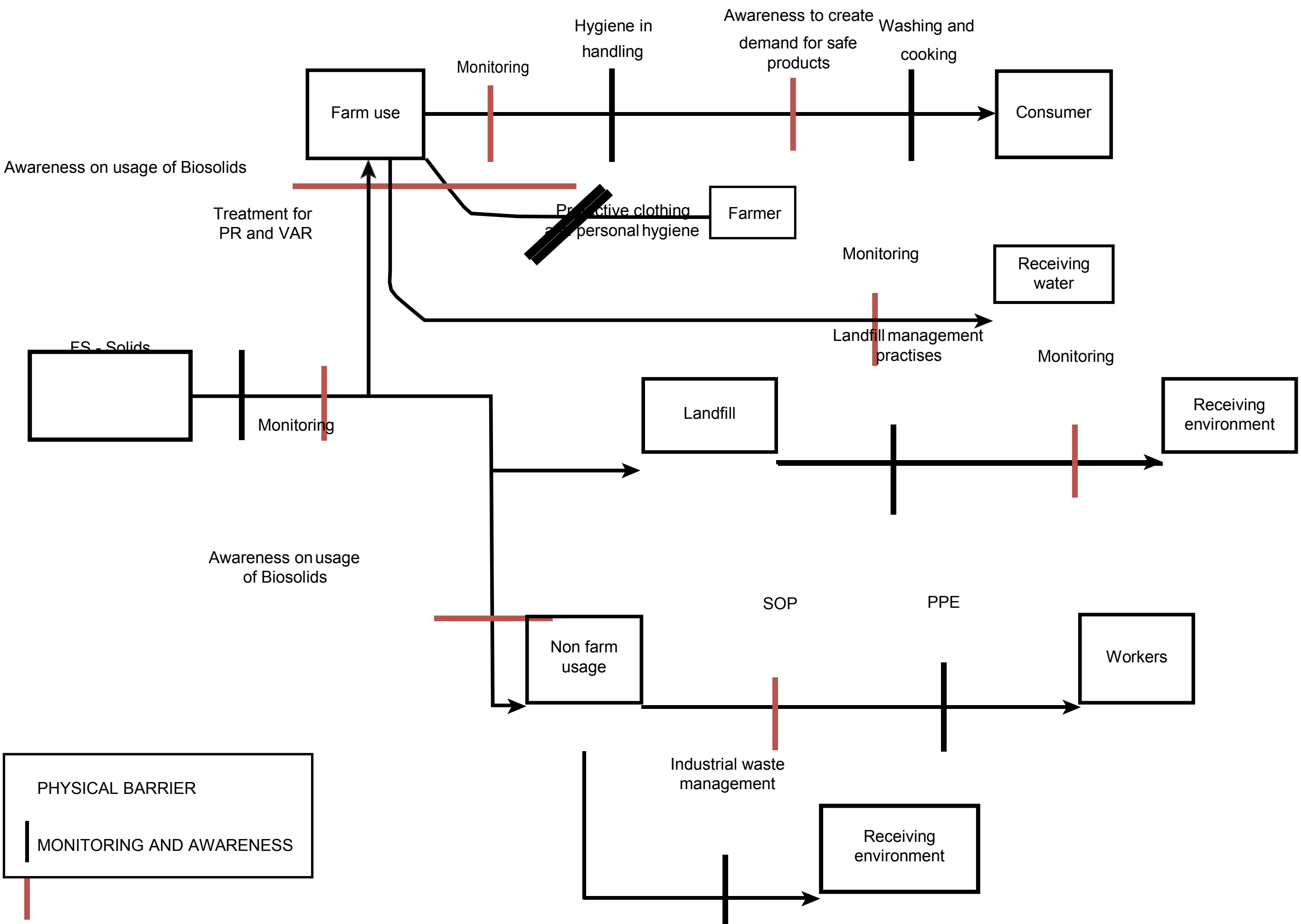
Figure 3. F-diagram - Faecal-oral Disease Transmission Pathways



Source: Research gate - Latrine adoption and use in rural Odisha, India: Constraints and challenges

As an example, **Figure 4** depicts the possible disease-causing pathways from biosolids generated in FSTP to humans. In defining treatment standards, the treatment of biosolids has been considered one of the barriers in a multi-barrier approach towards reducing the risk from pathogens and other contaminants. Similarly, treatment of effluent in the FSTP is also a barrier that mitigates risk caused by its reuse in agriculture or for other non-potable purposes.

Figure 4. Example of Multi-Barrier Risk Approach for Biosolids Management



The multi-barrier risk approach reinforces the paradigm of balancing cost vs tolerable health risk. As discussed above, setting stringent standards may not pay off in equivalent health benefits; rather, practical and easily implementable standards may be adopted and supplemented by strengthening other barriers such as monitoring, cultural practices (washing and cooking techniques), personal hygiene practices, awareness, and behaviour change among users and knowledge of reuse practices. Hence the issues of costs vs public health and multi-barrier approach are mutually complementary in their influence on defining standards for treatment.

Recommended Principles to Define Standards

Considering the issues outlined above the following principles should guide the process of defining the standards:

- Parameters used to define standards should be few, simple to apply and should not result in significant increase in capital and operations cost of FSTP
- Capacity to monitor and test for the standards should be considered
- Standards should be linked to proven and demonstrated treatment processes
- Sampling and record keeping activities must not require extensive skilling of the operator

- Standards may be extended in the future to seamlessly apply for biosolids from STP
- Standards should enable and encourage reuse of treated products

Standards for treatment of faecal sludge
[refer Chapter B of Quality in FSM document]

Faecal sludge has two key components that require treatment – solids and liquids. The term used for the solid component in FSTP is biosolids and for the liquid component is effluent. Treatment of faecal sludge may entail emissions where thermal processes are implemented. In defining the outcome standards for treatment, it should cover at the least these three parameters. Hence the standards for treatment of faecal sludge will comprise of:

1. Biosolids standards
2. Effluent standards
3. Emissions standards

This section uses the principles outlined in the previous section to explain the standards prescribed for these three treatment by-products.

1. Standards for Biosolids
[refer Chapter B.1 of Quality in FSM document]

Currently there are no biosolids standards in India for STPs. As per the literature review on standards used internationally for biosolids and related policies, the WHO and US-EPA standards are most widely followed and referred. Countries such as Australia, South Africa and New Zealand have adopted the standards and processes defined by US-EPA for biosolids treatment. Refer *Appendix 1* on the biosolids standards for select countries.

In defining the standards for biosolids for ensuring safety of public health and environment, three factors need to be considered:

i) Pathogen reduction
ii) Vector attraction reduction and
iii) Contaminant levels

Pathogen reduction standards: The need for standards for pathogen reduction (PR) in treatment units is well understood and does not bear repetition here. The objective of these standards is to eliminate risk of public health from disease transmission.

Vector attraction reduction standards: Vector attraction reduction (VAR) is equally critical in a FSTP as odour, organics and moisture attract vectors such as rodents, birds and insects who can be carriers of disease by transmitting pathogens (US EPA, 2003). In India currently, there are no restrictions on the location of FSTPs. Given the challenges in availing land for infrastructure, FSTPs established around habitations will be exposed to the risk of vectors transmitting pathogens. VAR standards are prescribed to mitigate such risks. Another reason for incorporating VAR standards, is to ensure that the faecal sludge is stabilized before applying it to land. Un-stabilized faecal sludge can leach out organics into the ground or carry these organic pollutants to surface water bodies when the land is irrigated or flooded with water.

Contaminant standards: Contaminants such as heavy metals do not naturally occur in the FSM value chain. They enter the chain through the addition of foreign materials such as chemicals and other hazardous waste that are disposed of in toilets or are introduced during desludging. Unregulated or unmonitored use of biosolids can increase the concentration of heavy metals and other toxins in soil, leading to impact on public health and environment.

WHO Guidelines and US-EPA 503 Rules

A review of WHO Guidelines and US-EPA 503 Rules for biosolids helps understand the approach used by both in setting biosolids standards. **Table 1** provides comparison of these two most commonly referred documents.

Table 1. Comparison of WHO Guidelines and US-EPA 503 Rules for Biosolids

Items	WHO Guidelines	US-EPA 503 Rules
Basis for defining standards	• Tolerable health risk using DALY (Disability-Adjusted Life Years) - $10^{-6} – 10^{-7}$ • Multi-barrier approach to reduce transmission of disease • Standards for reuse in agriculture only (*Appendix 4*)	• Uses multi-barrier approach with regulation intensive barriers such as site restrictions during agricultural reuse (refer *Appendix 2*) • Uses tolerable health risk approach for contaminants • Not only relevant for agriculture but also to the entire transmission pathway
PR standards	• Provides outcome and process standards	• Classifies biosolids into Class A and Class B • Provides outcome and process standards for Class A and Class B • Class A requires complete elimination and Class B has many restrictions on reuse application
VAR standards	• Does not mention	• Provides outcome and process standards
Contaminant standards	• Gives ceiling limits for heavy metals in soil • Acknowledges certain chemicals present in faecal sludge, harmful to humans but does not provide standards for such chemicals	• Biosolids classified based on exceptional quality (EQ), pollution concentration (PC), cumulative pollutant loading rate (CPLR) and annual pollution loading rate (APLR) • EQ and PC have prescribed limits; CPLR and APLR calculations to be adhered to while applying to the land

An assessment (**Table 2**) was undertaken to understand the applicability of WHO Guidelines and US-EPA 503 Rules for biosolids to Indian context.

Table 2. Benefits and Limitations of the WHO Guidelines and US-EPA 503 Rules for Biosolids to India

WHO Guidelines for Biosolids	US-EPA 503 Rule for Biosolids
Benefits	
• A single set of standards – simple, easy to implement and monitor. • Monitoring protocol for sludge treatment and the end product is relatively simple.	• Caters to possibly all risk pathways and suggests suitable mitigation measures. • Specifies ceiling limits for heavy metals. • Clearly defines processes for achieving pathogen and vector attraction reduction.
Limitations	
• Standards are only for pathogens, does not specify treatment or standards for vector attraction reduction. • Standards for heavy metal concentration not specified.	• Multi-criteria based complex classification approach for biosolids can make monitoring and enforcement difficult. • Site restrictions for land application are difficult to regulate. • Extensive monitoring requirements.

Recommendation for setting biosolids standards for India

Based on the review of literature on guidelines, policy and standards for biosolids, and applying the principles outlined above for defining the standards; following is recommended:

- There is a need to define standards for all plausible impacts on public health and environment risks for different transmission pathways from biosolids. Hence standards are required for limiting concentration of pathogens, vector attraction and contaminants in faecal sludge.
- The WHO definition of standards for PR and its recommended processes to attain them seem more relevant for Indian conditions, as they are achievable with currently available technologies.
- Though US-EPA recommends a number of alternatives for VAR, given the challenges of CPCB/ SPCB and ULB capacities to monitor and the appropriateness of these options in a resource scarce context such as India, only a few, as deemed relevant can be considered to start with.
- US-EPA has recommended various limits for heavy metals in faecal sludge and also limiting values of heavy metal application in soil. Given the difficulty in regulating, monitoring and measuring the heavy metal application rates to land in India, only limiting values of heavy metals in biosolids can be considered to begin with.

Biosolids Standards Framework for India

The structure proposed to define the standards, has four key aspects:

a) Pathogen reduction standards
b) Vector attraction reduction standards
c) Contaminant standards and
d) General standards

a) Pathogen Reduction Standards

[refer Chapter B.1 (1.1) of Quality in FSM document]

The outcome standards prescribed, follow WHO standards for microbial parameters in faecal sludge as the US-EPA standards are stringent with the aim to achieve near aseptic conditions. WHO guidelines suggest that these standards can be achieved by means such as alkali treatment, storage, co-composting and thermal treatment. To promote reuse of faecal sludge, alkali treatment is not prescribed, as this can be detrimental for agriculture reuse, especially where the pH of the soil is already high. Therefore, for achieving the required pathogen outputs, the following three processes are suggested:

i) Storage
ii) Co-composting and
iii) Thermal treatment

These processes also help in reducing the viability of helminth eggs (<1 per gm of total solids on dry weight basis). For each of these processes, critical operational parameters are specified so they can be designed for, and appropriate process controls implemented in the FSTP, to ensure that pathogen reduction standards are met.

Storage

[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]

The process standard prescribed is from the WHO guidelines which is based on empirical studies (J. Blumenthal & Strauss, 1990). Dried sludge (with a moisture content not exceeding 60%), when stored in vaults, without adding further fresh faecal matter, under tropical temperatures of 28-30º C for 12 months, can eliminate e-coli in biosolids to the required standards. This process can also result in very low or zero helminth egg viability. The proposed standard can be achieved by using drying beds or any other drying process and subsequently storing sludge in a dry area. It is critical that the storage area should prevent any new addition of moisture.

The following parameters (**Table 3**) should be monitored and recorded during operations:

Table 3. Monitoring methodology for storage process

Parameter	Where and how to sample	Requirement
Moisture content in dry sludge	After drying and before storage. A composite sample of the batch.	< 60% moisture content
Moisture content in stored sludge	6 months from the start of the storage period. A composite sample of the batch	< 25% moisture content
Moisture content in the end product	End of 12 months or at the time of sale/evacuation from the FSTP, whichever is later	< 25% moisture content

Appendix 6 in the Quality in FSM document prescribes the methodology for data collection related to this standard.

Co-composting

[Co-composting of faecal sludge, septage solids with organic solid waste to achieve temperatures above 45º C for at least 7 consecutive days after every turning or any other time temperature combinations as prescribed in the pathogen kill curve]

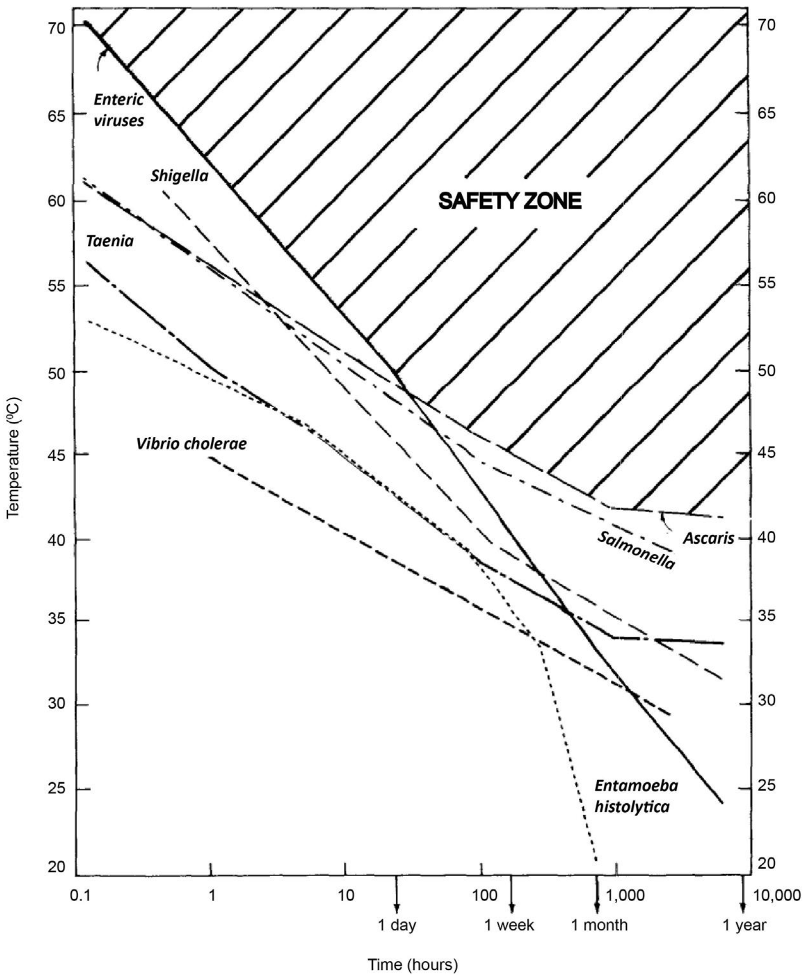
The process standard prescribed is from the WHO guidelines. Studies (Feachem, et al., 1983) have shown pathogen inactivation through heat treatment for different combinations of temperature and time exposure for biosolids. The pathogen kill-curve graph (**Figure 5**) depicts such time-temperature relationships and the safety zone where complete pathogen inactivation (including helminths) is achieved.

Co-composting can eliminate pathogens when operated within the safety zone of the pathogen kill graph. Only aerobic processes which release heat can lead to pathogen reduction and are to be used as process standards. Vermicomposting does not reach the temperatures required as per the graph and hence is not recommended.

In the co-composting process, it is not feasible for all parts of the heap or pile to reach uniform temperatures. It is observed that the core (measured in the centre of the pile) reaches high temperatures, while the periphery is relatively cooler. To ensure pathogen reduction of the entire pile, it needs to be turned frequently (not less than 5 times) and the temperature-time combination as per the graph must be ensured after every turning of the pile.

The temperature of the co-compost pile has to be measured and recorded daily in FSTP logbook. Such data must be available for verification at the facility for at least 2 years. A probe can be used to measure the temperature of the co-compost pile. Temperature readings have to be taken at every 5 feet along the length of the pile at 12” and 36” depths. The temperature recorded must satisfy the time and temperature combinations as specified above. In addition to temperature, pile turning frequency must also be recorded. *Appendix 6 in the Quality in FSM* document prescribes the methodology related to data collection for this standard.

Figure 5. Pathogen Kill Graph for Faecal Sludge



Source: Feachem et al. 1983

Thermal Treatment
[Achieve temperatures homogeneously within the solids as per the pathogen kill curve using any thermal process]

The standards prescribed refers to the pathogen kill curve graph (**Figure 5**). Any thermal process which can consistently raise the temperature of the biosolids as a whole and expose it to the time duration as indicated in the safety zone of the graph in **Figure 5** will effectively inactivate pathogens (including helminths). Design of the process must ensure that all biosolids particles are exposed to the time and temperature requirement specified.

The time and temperature of exposure to sludge should be recorded for every batch. A log of such data must be available at the FSTP for verification for a period of at least 2 years. *Appendix 6 in the Quality in FSM* document prescribes the methodology related to data collection for this standard.

In addition to the above process standards outlined, the *Quality in FSM* document also prescribes outcome standards borrowed from WHO as stated below:

Outcome based Standard
[Biosolids undergoing treatment in any process other than those prescribed above should achieve the following outcome standards]

E-coli (MPN) <1000/g total solids (dry weight)

As an alternative to the process standards (*Chapter B 1.1* in the *Quality in FSM* document), any other treatment process that achieves the above outcome (*Chapter B 1.1 (d)* in the *Quality in FSM* document) may be adopted.

Output standards should be monitored close to the time of application or reuse. Since the actual application in farmlands or elsewhere outside FSTP is beyond the scope of the treatment plant operator, these output standards should be monitored at the time of sale or evacuation of biosolids from the facility. These standards should be met irrespective of the end-use of the biosolids.

Appendix 4 in the *Quality in FSM* document provides methodology for collecting data related to this standard.

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 and then the testing should be carried out fortnightly until the results comply with the standards.

b) Vector Attraction Reduction Standards
[refer Chapter B.1 (1.2) of Quality in FSM document]

VAR aims to reduce the vector attraction potential of faecal sludge solids by reducing a) moisture content and b) volatility of the sludge. Reduction of volatile solids reduces odour emitted from open drying or storage of biosolids and makes it less attractive for vectors (US EPA, 1992). Since WHO guidelines are silent on VAR, the standards prescribed are adapted from US-EPA guidelines.

Standards for Volatile Solid Reduction
[Composting to achieve temperatures above 40^{o} C for at least 14 days with average temperatures exceeding 45^{o} C in that time]
OR
[Any other process which can achieve a VS/TS ratio of 40% as an output of sludge digestion]

The prescribed standards recommend process and outcome standards to reduce volatile solids reduction. On the process standards it uses US-EPA guidelines (section 503.33 (b)(5)) for biosolids which suggests co-composting of faecal sludge to temperature and time regimes specified. The same process recommended for PR standards is also prescribed here, except that VAR requirements for time and temperature are different.

If a co-composting process is not possible, faecal sludge should be treated through an anaerobic or aerobic process to reduce the VS/TS ratio as prescribed. The faecal sludge treatment processes specified in *Chapter C* of *Quality in FSM* document are expected to achieve these outcome standards.

In case the output standards are not being met, appropriate changes need to be carried out in the design and operations of the systems to ensure effective sludge digestion.

Standards for moisture control
[Any process which reduces the final moisture content in biosolids to less than 25%]

The prescribed standards for reduction of moisture content is based on the US-EPA guidelines. Moisture reduction can significantly halt biological activity in sludge reducing instances of odour and regrowth of pathogens. Preventing regrowth of pathogens makes handling and reuse safe. Reducing odour can make the end products more acceptable to users.

Appendix 6 in the Quality in FSM document prescribes the methodology related to data collection for the VAR standards. Moisture content in the sludge can be measured by probes and the results of these should be made available before the sale/evacuation of biosolids from the treatment facility. In case the moisture content in sludge is more than the prescribed limits, sale and evacuation of such solids must be stopped immediately until such standards are met.

c) Contaminant Standards
[refer Chapter B.1 (1.3) of Quality in FSM document]

The standards for contaminant levels are provided based on reuse of biosolids and its related risk to human health. The standards are linked to the concentration of the heavy metals as from US-EPA guidelines.

Biosolids can be used for a variety of applications – soil ameliorant, fuel, fish feed, oil, protein production etc. The Fertilizer Control Order (FCO)*, 1985* provide readily available standards for co-compost from biosolids. However, FCO standards for contamination levels are very stringent. *Appendix 3* has the prescribed standards for city compost as per FCO. Further, FCO does not explicitly recognize human faecal matter as an acceptable source in its definition of city compost. Therefore, the FCO standards are not recommended.

The standards for contaminants should be derived from understanding the risks that such concentrations can cause to humans through different pathways. The US-EPA recommends ceiling limits for the concentration of heavy metals in biosolids based on such an analysis (*USEPA,1994*) and hence these limits are proposed.

Endocrine-disrupting chemicals such as dioxins, polychlorinated biphenyl, pesticides, nonylphenol and pharmaceuticals have currently not been included due to lack of sufficient literature regarding their impact on health from land application of biosolids (Environment Protection Authority, 2017). With increased scientific evidence on new and emerging contaminants, additional items can be incorporated to the contaminant standards.

Appendix 5 in the *Quality in FSM* document prescribes the methodology related to data collection for standards related to contaminant levels. Samples for testing ceiling limits should be analysed once a year. In case the limits of one or many heavy metals are found to be exceeding, then the sale/evacuation of biosolids towards land application should stop immediately followed by repeating the sampling and testing process. If the results repeat with similar exceeding concentrations, then the source of such heavy metals should be tracked by analysing influent faecal sludge and studying upstream value chain operations, followed by appropriate measures to reduce such contamination. Alternate use of biosolids such as incineration and landfill can be considered when the contaminant standards are not being met consistently.

d) General

[refer Chapter B.1 (1.4) of Quality in FSM document]

The standards prescribed are on foul odour and safety standards to be met for transportation of untreated biosolids. There are no objective methods to assess odour, however, the plant manager and operators must be watchful of unpleasant smell and take immediate measures to rectify them.

These standards enable transport of untreated biosolids to other locations for further treatment. Biosolids, if not treated, can emit an unpleasant odour. The odour emitted from treatment plants processing biosolids or storing them can result in complaints from the public and may even lead to closure of plant operations. In such a situation, the biosolids should meet standards for VAR and odour before being transported from the FSTP. In addition, the FSTP operators and the personnel transporting untreated biosolids must follow a set of standard operating procedures to mitigate any risks arising from such movement.

Appendix 7 in the *Quality in FSM* document provides a data recording format for reuse of biosolids. Collection of such data can inform monitoring of biosolids in land applications and can also provide data for formulating reuse related regulations.

2. Standards for Treated Effluents

[refer Chapter B.2 of Quality in FSM document]

Faecal sludge contains around 95-99% water. Therefore, in FSTPs, solid-liquid separation is a key part of the treatment. The liquid portion separated during the treatment process is referred to as effluent. In comparison to STPs, the per capita effluent from FSTP is much lower – by a factor of about 500 times. While the CPCB has prescribed effluent discharge standards for STPs, no such standards exist for FSTPs yet. Alternatively, CPCB provides general discharge standards for effluents as per their outfalls. These standards require testing and reporting of 33 parameters related to the effluent, thereby increasing the cost of monitoring.

From 2015 to 2019, discharge standards for STPs have undergone multiple amendments. A judgement by the National Green Tribunal in 2019 has proposed a new set of standards, which have not yet been incorporated by the CPCB in their notification to SPCBs. Frequent changes in standards deters private service providers from participating in bids due to the fear of non-compliance to revised new standards. Hence, it is recommended that the standards prescribed should be applicable for a significant period of time. In the future, when standards are modified and if made stringent, agencies ensuring compliance should provide time and incentives to existing treatment plants to comply with new standards.

Although the treatment principles in STP and FSTP are similar, the composition of faecal sludge is different and much more concentrated than sewage. **Table 4** below presents an analysis of raw faecal sludge samples collected by CSE (Vinod Vijayan, 2020) across the country in comparison with typical ratios of STP and the range that STPs can treat with conventional technologies.

- A very low BOD/COD ratio in faecal sludge indicates that a substantial part of organic matter will be difficult to remove biologically (Mogens Henze, 2020). Therefore, aiming to drastically reduce BOD concentration in final effluent would have a significant influence on the capital investment required.
- Non-biodegradable COD in faecal sludge is in the range of 28% to 85%, of which around 9% is a soluble fraction (Tayler 2018). Most traditional wastewater treatment processes are not

designed to remove this soluble fraction of COD and require advanced and expensive treatment such as coagulation and filtration. Thus, with the mainstream technologies used for treatment of sewage adopted for treatment of faecal sludge, the treated effluent COD concentration would still be higher in comparison to that of treated effluent from sewage.

- The COD/TKN ratio indicates the ability for denitrification (a stage in nitrogen removal) in wastewater. High COD/TKN ratio in faecal sludge leads to reduced efficiency of TKN removal using biological wastewater treatment processes (Sharma R, 2004).

The difference in composition and the limitations in the treatment processes, mean that adapting existing CPCB standards prescribed for STPs, would increase the complexity of treatment and hence increase the capital and operations cost of FSTP. Given that the volume of faecal sludge generated per capita is very low, the incremental pollution load due to less stringent standards poses very little risk. On the other hand, the incremental cost savings due to less stringent standards are significant enough to influence the pace of scaling up. Setting stringent standards would therefore be a barrier to achieve universal improved sanitation. It is therefore suggested that a separate regime of standards for effluent treatment in FSTP be adopted, which are less stringent than the standards for treated water for STP.

Table 4. Comparison on Characteristics of Faecal Sludge and Sewage

Parameter	Raw faecal sludge*	Typical sewage**	Typical range for STP operations***
BOD/COD	0.12	0.4 - 0.5	> 0.3
COD/TKN	41.5	8 - 12	8.8 - 12

* Vinod Vijayan et. al 2020
** Mogens Henze 2020
*** Salah Karef 2017 and Khaled Zaher Abdalla 2014

The standards prescribed for effluent discharge from FSTPs covers four key parameters (pH, BOD_5, TSS, and Faecal coliform) to reflect the physical, biochemical and microbial characteristics of the treated wastewater. Performance assessment of existing FSTPs indicate that the proposed standards can be met with available technologies.

The proposed standards do not include the specification for nutrients such as TKN, ammoniacal nitrogen and total phosphorus as the current level of treatment technologies are unable to reduce them to consistent levels (Vinod Vijayan, 2020) and the associated risks are very low. However, as more cost-effective processes emerge in future for nutrient removal, these parameters can be introduced in the standards.

3. Standards for Emissions

[refer Chapter B.3 of Quality in FSM document]

The typical by-products of FSTP are treated effluent and biosolids. However, based on the type of treatment process adopted, there can be gaseous emissions from these facilities. Gases are emitted either during volatilisation or combustion of faecal sludge. Volatilisation usually occurs when the sludge is undergoing digestion in the aerobic or anaerobic process (does not include thermal destruction). The quantum of gases emitted from these processes is not significant given the low volatile content in faecal sludge and the smaller capacities of the treatment units. These gases can be easily noticed by their odour and managed as part of vector attraction reduction or by good odour management practices in the FSTP; these have been prescribed under biosolids standards.

Thermal treatment of faecal sludge through combustion or pyrolysis can emit far more gases than volatilization. These gases also tend to contain particulate matter and inorganic pollutants that contribute to air pollution. Therefore, standards are required to monitor and regulate FSTPs for emissions.

Currently, there are no emissions standards for thermal treatment of biosolids in India. The closest reference, however, can be found in the guidelines for Solid Waste Management Rules 2016. These guidelines draw from the CPCB standards for incineration of hazardous substances. The proposed FSM guidelines extend the same standards to thermal treatment of products containing biosolids, unless or otherwise any other regulations pertaining to the industry of application apply.

Chapter C

TREATMENT PROCESS SPECIFICATIONS

[refer Chapter C of Quality in FSM document]

Technology for treatment of faecal sludge is still evolving and as the sector continues to grow, the stakeholders' awareness of technologies will increase. However, given the sector is in a nascent phase, there are numerous issues prevalent in the understanding of the treatment process which can impact the quality of FSTP infrastructure and its performance.

Faecal Sludge Characteristics

Faecal sludge, by its definition, is all the constituents of an OSS. Examples of OSS include as pit, septic tank, aqua privies and dry toilet containment system to name a few. (IWA Publishing, 2014).

However, the constituent of a septic tank that is removed by pumping, is septage (US EPA, 1994). By these definitions, septage is a sub-set of faecal sludge. In practice septage is regarded as a stable sludge in comparison to faecal sludge since it has been retained in a septic tank for a significant period of time (at least 2 years). Based on this distinction, a separate treatment system is usually suggested for faecal sludge and septage, with the former requiring elaborate treatment.

In India, containment systems are not built as per standards and huge variations in the type and designs can be seen. Sludge arriving at the treatment facility cannot be distinguished as septage or sludge from a specific type of containment system. Therefore, FSTP technology should be able to treat all types of sludge from OSS. Treatment systems must be designed to treat both faecal sludge and septage through the same process.

Further, faecal sludge has been reported to have very high total solids and organic pollutants (Pradeep, Susmita Sinha, 2017), in the range of 50-100 times more concentration than sewage. The characteristics of faecal sludge also vary widely within a given catchment area. Treatment systems must be robust enough to handle such variations.

Capacity and Awareness for Procurement of FSM Technologies

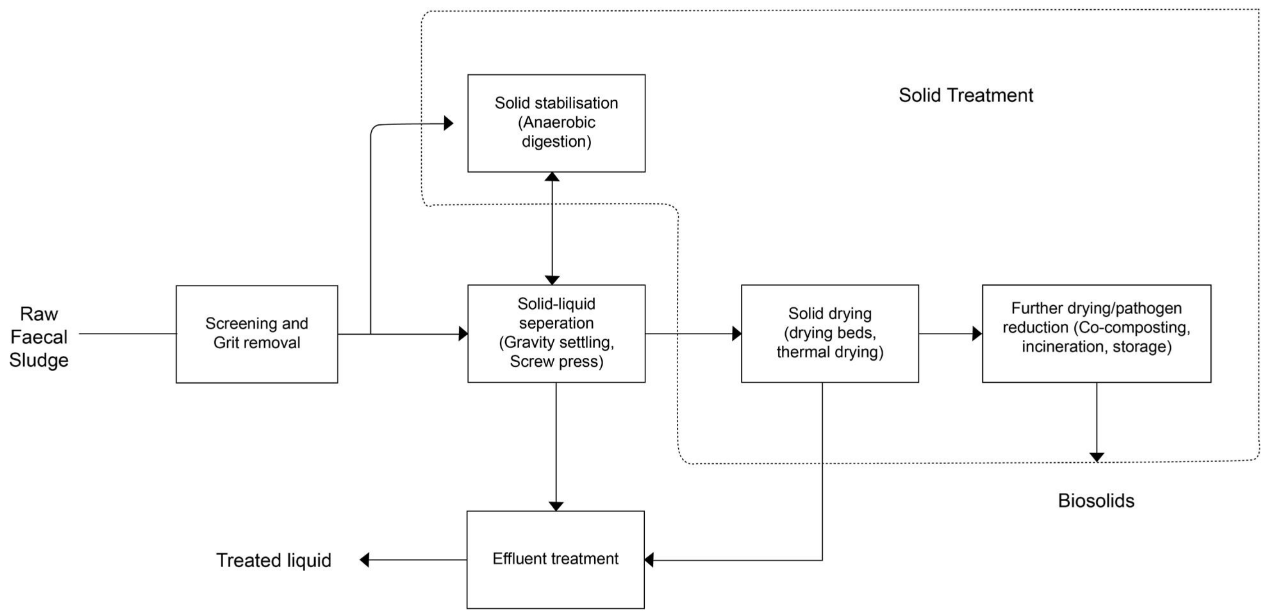
The implementation of FSM is the responsibility of ULBs and state departments. FSM being a relatively new topic, the state governments and ULBs have low capacity to validate technologies. Further, the officials are regularly approached by numerous private companies with a variety of technology options for treating faecal sludge. Lack of data on performance of most of the technologies makes it difficult for the officials to ratify them.

This may result in making investment decisions by the ULB for technologies that do not conform to standards. In order to efficiently spend public funds for scaling up basic sanitation, it is strongly recommended that a technology clearing house be constituted with the required expertise to empanel technologies and make them available for ULBs.

1. Technology Framework

The *Quality in FSM* document addresses the above-mentioned issues and provides treatment process specifications based on proven technologies to treat faecal sludge in India. It uses a modified framework (**Figure 6**) from the technical book by Kevin Tayler (Faecal Sludge and Septage Management – A guide for low and middle-income countries) to depict the FSTP treatment process for India. In the future, additional treatment processes and new technologies may be added as their efficacy is proven. The list can also be changed as and when the outcome standards are modified. This list of technologies aids the state government and ULB with the procurement of FSTP. The technical process options along with their technical specifications can assure quality in FSTP design and implementation.

Figure 6. Technology Framework for FSTP



The treatment process for an FSTP shall follow the framework outlined in **Figure 6**. It comprises of the following key steps:

1. Screening and grit removal
2. Solid-liquid separation
3. Treatment of solids
4. Treatment of liquid (effluent)

Screening and Grit Removal

Grit gets introduced in the faecal sludge, especially while desludging pits. Due to lack of awareness on usage of toilets, users tend to throw solid waste into the toilets. This solid waste and grit in faecal sludge can impact its treatment. These consume the precious reactor volume or heat and abrade moving parts, and cause blockages thereby affecting the capacity to treat. Hence, it is highly recommended to incorporate a solid waste and grit removal system at the headworks of treatment. Manual and mechanical screening are the most common and established methods for removal of solid waste.

In some countries pulverization of sludge is undertaken to address solid wastes within; this is common when sludge is only dewatered with no further solid treatment. Pulverizing sludge hinders certain solids treatment processes, and the presence of such solids (such as plastics and other inorganics) in the biosolids would thereby add to the accumulation of such wastes in the soil during land application. Hence, it is not a recommended waste management practice and should be avoided.

Solid-liquid Separation

Solid-liquid separation is the process of physically removing unbound water from faecal sludge. Faecal sludge contains high concentrations of solids, which can hinder liquid treatment processes from functioning efficiently. Hence, it is recommended that solid-liquid separation be carried out before undertaking separate treatment of solid and liquid components (Tayler 2018). Separation of the solid and liquid can reduce the reactor volumes for subsequent treatment and make them cost-efficient.

Treatment of Solids

Solids have to be treated to achieve the biosolids standards prescribed. This can be done by incorporating any of the processes recommended in the quality for FSM document or by implementing other processes that achieve the prescribed outcome standards.

Treatment of Liquid

The effluent (liquid) from various processes in the FSTP must be further treated to achieve effluent discharge standards. The characteristics of the effluent post solid-liquid separation are comparable to those of raw sewage and hence any treatment process used in treating sewage can be adopted. However, the compatibility of such processes with other upstream treatment units must be checked and designed for the estimated concentration of organic pollutants present in the effluent.

2. Selection of treatment technologies

[refer Chapter C – 1.1 to 1.5 of Quality in FSM document]

The *Quality in FSM* document specifies five treatment processes as these are proven systems and have been operating across India for more than a year. These systems also meet the prescribed standards defined in the document. The treatment process specification is not intended to limit or discourage new technologies. Based on validation, new technology processes can be added to this list. The criteria used for selection of technologies for FSTP can be as below and is based on the current context of FSM in India.

1. *Simplicity of operations*: With scaling of FSM across India, a key issue would be the skill set to operate the new FSTPs. Hence, a critical measure to be applied in selecting technologies for FSTP should be a less demanding skill set for the operator.

2. *Faecal sludge characteristics*: Secondly, the regulations related to OSS are not robust, and the variation in desludging frequency and the types of containment system would have a bearing on the characteristics of faecal sludge. Therefore, the design of the treatment system must be able to treat the wide variation in faecal sludge.

3. *Cost-effective treatment*: Financing of operations and maintenance (O&M) for FSTP is yet to be streamlined. In most of the pilot FSTPs implemented, responsibility of financing operations cost is devolved to ULBs. The ULBs lack the financial capacity to finance the O&M costs and are dependent on state and central government funds. However, no dedicated financing for FSM has been put in place yet. To alleviate the burden of such treatment plants on public finances, the O&M cost of the FSTP must be kept low.

4. *Utilize existing infrastructure*: A majority of the STPs in India are heavily underutilized (CPCB 2013). Faecal sludge can be added into the FSTP in two different ways a) Direct addition – faecal sludge is systematically diluted into sewage and b) Pre-treatment of faecal sludge – after solid-liquid separation, the liquid portion is directed to STP headworks, while the solids can be treated separately; either in existing solid handling facility of the STP or in additional treatment units set up for this purpose. The *Quality in FSM* document currently recommends the latter method (Narayana 2020) of co-treatment as sufficient evidence and data does not exist to prove the robustness of direct addition method.

Chapter D

ADDITIONAL COMPONENTS FOR FSTP SPECIFICATIONS

[refer Chapter D of Quality in FSM document]

The *Quality in FSM* document provides a list of non-treatment components that are required for effective operations and upkeep of the FSTP facility. This list helps complete procurement specifications by including supporting infrastructure, safety specifications and operator amenities for the FSTP to operate effectively.

The list of components provided in this section can be classified as:

a) Essential Components in FSTP

These are components that are closely linked to the FSTP operations, safety and performance (see **Table 5**). These are mandatory and should be included in the design and implementation of FSTPs.

b) Desired Components in FSTP

These components improve the utility of the FSTP (see **Table 6**). These components are optional and their inclusion in FSTPs can be decided based on the availability of land and finances.

Table 5. Essential Components in FSTP

Component	Significance/functionality
1. Compound wall	Safety of the treatment unit and assets
2. Exit and entry gates	Regulating traffic
3. Operator room	Resting room for the operator
4. Internal roads	Movement of desludging and sludge transfer vehicles. Roads not expected to bear heavy vehicle traffic may be made with paver blocks. Designs where desludging trucks do not enter the FSTP at all will save significant capital costs.
5. Alternate power source	Backup power supply to sustain the treatment process
6. Stormwater drain	Evacuate stormwater and prevent waterlogging/flooding of the FSTP. A proper discharge point is an important design and siting consideration during planning
7. Potable water supply	Water, for consumption by staff and visitors, is critical to maintaining personal hygiene and clean facilities
8. Street lighting	Visual lighting during days with low visibility and at nights

(continued)

Table 5. Essential Components in FSTP (continued)

Component	Significance/functionality
9. Trash removal	Collection and removal of solid waste and grit collected from screen and grit chamber of FS treatment. This is a key responsibility of the local government
10. Safety and hazard prevention	Ensure the safety of personnel, equipment and facility
11. Signages	Communication on safety precautions and dangerous areas within the facility. Inform visitors, staff and others on various aspects of the facility such as treatment process, details of individual modules
12. Landscaping	Ensure usage of treated end products, reduce odour and increase the visual appeal. Build civic pride in the public infrastructure
13. Receiving station	Inspection and unloading of FS load arrived through desludging trucks. Wait time of desludging trucks should be minimized to encourage operators to dispose at the FSTP.
14. Toilets and bathing rooms for FSTP staff and desludging operators	Convenience serving FSTP staff, truck operators and temporary staff
15. Truck washing facility	An environmentally safe washing place for desludging trucks. Wastewater can be treated along with FS

Table 6. Desired components in FSTP

Component	Significance
1. Administrative building	Room to seat administrators/management of the facility, receive visitors, and conduct awareness sessions. Also includes storage space for data records/SOPs/training manuals related to the FSTP
2. Security cabin	Regulate the movement of traffic, people and record-keeping of entry and exit of vehicles
3. Laboratory	Testing and analysis of samples and data recording
4. Electrical room	A safe place for electrical instruments and switchgear

Additional notes

1. Calculation for flow rate into receiving station.
   The flow rate specification for the receiving station has been equated to the maximum flow rate of sludge from the desludging vehicle. This is to ensure that a) receiving station does not become a bottleneck during sludge discharge from the vehicle, b) sludge does not backflow and therefore lead to spillages, during such discharge operations.

The maximum flow from the desludging vehicle is calculated using the formula

$Q = Cd \times A \times \sqrt{2 \times g \times H}$

Where,

Q = flow in m^3/s

Cd = Coefficient of discharge

A = Area of the tank opening/discharge pipe

g = Gravity = 9.8 m/s^2

H = maximum height of sludge inside the tank

2. In order to prevent acceptance of any other type of sludge (industrial waste, non -domestic nature) which can impair the treatment process, FSTP operators must screen the incoming sludge through methodology provided in *Appendix 8* of the *Quality in FSM* document.

Chapter E

CONSTRUCTION PROCESS AND MATERIAL SPECIFICATION

The need for this section arises from the fact that there is no prescribed set of standards for civil, electrical and mechanical components for an FSTP. In the many tenders that have been announced so far for FSTP works, the specifications and references for these aspects remain incomplete or not relevant. Therefore, this section aims to compile the relevant standards and references that would be required to monitor quality during FSTP implementation. The section is divided into two parts a) standards for materials and workmanship and b) standards for testing procedures.

The section on materials and workmanship is further divided into four components namely a) civil b) mechanical and plumbing c) electrical and d) instrumentation. The materials and workmanship mentioned here are commonly used during FSTP construction. References have been made to the relevant IS codes, CPWD specifications, and other relevant and commonly used guidelines published by the central government. These codes contain complete information on the definition of quality, measurement and testing protocols for each of the defined activities. Unless there is a specific requirement from the designer or the technology provider to deviate from these standards, this list should suffice.

The section on testing procedures provides users with a list and methodology to undertake tests to measure and establish quality during FSTP implementation. The implementing agency needs to include this as part of their scope of work and must submit these results, showing conformance to standards to relevant authority at frequencies mentioned.

As a general guidance to users, it is recommended that the list of standards provided here are cross-checked for their completeness and relevance to the design while preparing the bid documents.

Chapter F

E&T TECHNICAL SPECIFICATIONS

[refer Chapter F of Quality in FSM document]

The technical specifications for E&T are most relevant when issuing licenses to private truck operators and when trucks are procured, or desludging services are outsourced by the state government or ULB. In India, E&T is dominated by informal private operators and only where the business viability is low due to low demand, ULBs are providing the service. Manufacturing of vacuum trucks is also dominated by informal players.

E&T technical specifications has two key components:

I. Specification for Personal Protective Equipment (PPE)
II. Specification for Emptying Vehicle

1. Personal protective equipment specification

[refer Chapter F.1 of Quality in FSM document]

Poor awareness of health risks, inability to spend on proper PPE, and lack of enforcement are all reasons for poor usage of Personal Protective Equipment by desludging operators. With no track record on usage of PPEs, defining a quality benchmark for PPEs is difficult. However, to mitigate the health and safety risks of sanitation workers, it is imperative to build a common understanding of the current quality of material and equipment. A set of minimum basic PPEs have been recommended in the *Quality in FSM* document based on current usage practices and available equipment (Saniverse, 2020).

2. Emptying vehicle specification

[refer Chapter F.2 of Quality in FSM document]

In India, vehicles used for desludging OSS can be broadly classified as:

a) Vacuum Suction – The most common form of OSS emptying vehicle is the vacuum suction truck. In this method vacuum pumps are used to create a low pressure inside the sludge receiving tank, which is mounted on a vehicle. A pipe connected to an opening in this tank is inserted in the OSS, which lifts the sludge due to difference in pressure. Unlike the positive displacement type, the suction device, which in this case is the vacuum pump does not come in direct contact with sludge, thereby increasing the life of the equipment and maintaining consistency in performance over long periods of operation.

b) Positive Displacement – a pump, either submersible or non-submersible type is used to empty the contents of the OSS. The emptied contents are transferred to a tank mounted on a vehicle. This method has limitations in the pumping ability for thick or viscous sludge, where such pumps do not perform effective evacuation. Similarly, the performance of this method is affected when the equipment encounters solid waste while desludging.

To provide additional boosting capacity while desludging OSS from far distances (inaccessible areas or hilly terrains) using any of the above methods, a supplementary booster pump can be used.

Objective for Defining Vehicle Specification

In India, E&T are integrated activities given the complementarity of services involved. Therefore, the technologies for emptying must be mobile and capable of being transported along with the desludging vehicle. Thus, in defining the specification of the emptying vehicle, the objective should be following:

1. Road worthiness of the vehicle
2. Technical and economic performance of the vehicle
3. Safety in emptying and transport

Road worthiness of a vehicle is under the sole purview of the road transport department which gives the required registration certificate and fitness approval to ply on the roads. On the functional parameters to perform technically and meeting the economic viability, the E&T vehicles must be designed to evacuate mechanically at least 95% of the contents from the OSS within a given time frame. To ensure safety, the functional parameters of the emptying vehicle should prevent spillage in and around the OSS during and after desludging and while transporting the contents to the designated disposal points.

Specifications for Emptying Vehicles

[refer Chapter F.2 (2.1 & 2.2) of Quality in FSM document]

A description of specifications used for the emptying vehicle and equipment for desludging (vacuum pump and positive displacement pump) is provided in **Table 7**.

Table 7. Specification Parameter for Emptying Vehicle

Parameter	Items covered
1. General requirement of the prime mover – truck or tractor	• The motor vehicles (amendment) act 2019 and rules, define the regulations related to desludging vehicles. • In the lack of any state or central government standards for the vehicle design and specifications, Automotive Research Association of India's (ARAI) defined standards have been used. These standards are followed by most Original Equipment Manufacturers in the industry. • The grade ability is the capacity of the vehicle to climb slopes on roads or ramps at the treatment plant. • Warranty conditions are standard offerings as found on the GEM portal for desludging vehicles.
2. Vacuum pump and positive displacement type pumps	• Vacuum pump and its downstream equipment should be designed for suction pressures from depths of at least 8 m (vertical). • Vacuum pumps must be connected to the sludge receiving tanks through appropriate moisture traps/scrubbers to prevent moisture and corrosive air from entering into the vacuum pump. This will increase the life of the equipment. • Vacuum based systems are the most relevant and effective for desludging. However, owing to high investment and maintenance cost of vacuum pumps, local adaptations are made for use of positive displacement type pumps. Decision makers have to be cognizant that positive displacement pumps may not be effective for thick sludge.

(continued)

Table 7. Specification Parameter for Emptying Vehicle (continued)

Parameter	Items covered
2. Vacuum pump and positive displacement type pumps	● The flow rate of pumps should ensure that the sludge receiving tank is able to fill in less than 30 minutes, while desludging FS from the maximum operational depths indicated above. ● These specifications can also be used for portable boosting pumps as applicable.
3. Sludge receiving tank	● IS 13496:1992 provides details on the material and built quality of the vacuum suction tank. Such tanks have to be coated with anti-corrosive material to increase its operating life. ● In positive displacement type systems, the tank need not be designed for vacuum pressures. Therefore, plastic tanks, similar to those used for water/wastewater storage may be used. ● Tanks must have access for cleaning and removal of any accumulated sludge; tailgate opening over the entire section or large access holes can provide this.
4. Suction hose	● Vacuum hoses should be flexible, lightweight and durable. Hoses should be able to withstand the maximum pressure exerted by the pumps. ● Hoses should have a quick coupling mechanism to ease connections and prevent leakages at the nodes. ● The length of the hose pipes should be sufficient to desludge septic tanks or pits from a distance of 25m horizontal and 4m vertical.
5. Instrumentation	● Key instruments to be used are for a) level measurement – indicates the volume in the receiving tank, b) pressure indicator – for operational and safety purposes. and c) temperature - for safety of the tank and its coating.
6. Colour of the vehicle	● Unique colouring of the desludging vehicle will ensure that they can be easily differentiated by the general public and the enforcement agencies.

The specifications mentioned above are standard and will not vary in terms of the size of the truck or the receiving tank. ULBs or practitioners must add in details on the maximum truck width and tank size basis their local requirements.

New forms of faecal sludge collection may emerge in the future and once they do, they should be specified accordingly.

Chapter G

WAY FORWARD

The standards defined in *Quality in FSM* document are practical and implementable considering the context of FSM in India and its various constraints – capital and O&M requirements for scaling up FSM, existing institutional capacities to implement technologies and monitor their operations for compliance to standards. *Chapter B* presents the guiding principles for defining these standards. The limitations of this exercise and a few immediate actions are described here.

To define treatment standards, a key requirement is a broad policy consensus regarding tolerable health risks based on disease incidence rates, state of the environment, and our current capacities, which is yet to be achieved. In addition, limited data is available on the performance of treatment technologies. At the time of preparing the *Quality in FSM* document, India had about 32 FSTPs commissioned[2] and less than 10 FSTPs in operation for over a year. The limitation in data was circumvented using globally available scientific literature. However, these were from developed countries not representative of the Indian context.

Several immediate actions stand out. Publishing data in a transparent and timely manner has to be an obvious immediate priority for the sector. A technology approval body constituted to recommend technologies will enable new technologies, a definite pathway towards deployment. A low-cost monitoring ecosystem based on self-regulation by industrial bodies will reduce the burden on government capacities. Addressing critical gaps in laboratory capacities across the country is a key priority area. Private, academic and government labs should all be considered in an effort to anchor a comprehensive monitoring programme. These short-term actions will enable data driven and contextual standards setting, in the future.

The proposed framework stops short of providing purpose-based reuse standards due to weak capacities in monitoring and testing. With increase in formal reuse applications and mainstreaming of circular economy policies, this framework may be extended to reuse applications.

As the sector matures and new findings come to light, it is recommended that standards be amended based on a set of principles applicable for that period. In future, with the advent of newer technologies, assessment of data from more operational FSTPs, better monitoring, improved testing capabilities, greater understanding of emerging contaminants, and new findings on impact of FSM , the standards prescribed can be accordingly amended.

[2] Database of FSTPs curated by NFSSM Alliance

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Appendix 1

BIOSOLID STANDARDS OF SELECT COUNTRIES

Table A1. Biosolid Standards of Select Countries

Country	Biosolids Standards	Definition of Biosolids	Classification of Biosolids	PR Outcomes	PR Standards	Monitoring	VAR	Others	Heavy Metals	Site Restrictions - application Rates	Site Monitoring /General Requirements
USA	US-EPA, 40 CFR part 503 published in 1994	Sewage sludge includes septage sludge. However separate standards for septage	Two classifications based on treatment (pathogen reduction and VAR) and three classifications based on heavy metal concentration	Class A Faecal coliform density < 1000 MPN/g of Dry solids to be achieved through defined processes (or) Salmonella density of less than 3 MPN/4 grams of dry sludge	Solid treatment should incorporate one of the six specified process alternatives	1. Requirements of the process specification 2. Monitoring the microbial parameters	Solid treatment should employ or demonstrate one of the 12 alternatives / equirements	NA	Classified as Exceptional quality (EQ), Pollutant concentration (PC) and Cumulative pollutant loading rate (CPLR) based on the concentration of heavy metals	No	Only for PC and CPLR

(continued)

Table A1. Biosolid Standards of Select Countries(continued)

Country	Biosolids Standards	Definition of Biosolids	Classification of Biosolids	PR Outcomes	PR Standards	Monitoring	VAR	Others	Heavy Metals	Site Restrictions - application Rates	Site Monitoring /General Requirements
USA				Class B Faecal oliform density < 2 million MPN/g of dry solids	Solid treatment should incorporate one of the 2 specified process alternatives or emonstrate the required pathogen reduction outcome standard	1. Requirements of the process specification (or) 2. onitoring of microbial parameters	NA	NA	Classified as Exceptional Quality (EQ), Pollutant Concentration (PC) and Cumulative Pollutant Loading Rate (CPLR) based on the concentration of heavy metals.	Yes	Yes
UK	Assured biosolids - NGO prescribing biosolids standards for its members	Sewage sludge, include septic tank material	Two classifications based on pathogen concentration	Conventional treated <100,000 E-coli MPN/g of dry solid	Any of the recommended process or others which can emonstrate the required microbial standard	1. Requirements of microbial parameters	NA	Treated sludge should be monitored for pH, organics, nutrients	Reference concentration limits specified for certain heavy metals	Yes	Yes

(continued)

Table A1. Biosolid Standards of Select Countries(continued)

Country	Biosolids Standards	Definition of Biosolids	Classification of Biosolids	PR Outcomes	PR Standards	Monitoring	VAR	Others	Heavy Metals	Site Restrictions - application Rates	Site Monitoring /General Requirements
UK				Enhanced treated <1000 E-coli MPN/g of dry solids	No recommended process	1. Requirements of microbial parameters	NA	Treated sludge should be monitored for pH, organics, nutrients	Reference concentration limits specified for certain heavy metals	Yes, relatively less stringen	Yes, relatively less stringent
	Sludge regulations 1989	Sewage and Septic tank sludge	NO	NO	NA	NA	NA	Treated sludge should be monitored for pH, organics, nutrients	Reference concentration limits specified for certain heavy metals	Yes	Yes
Ireland	Code of good practices for the use of biosolids in agriculture	Sewage sludge	No classification	<1000 MPN faecal coliform per g of dry solids (and) <3 MPN salmonella /4 g of dry solids	One of the 6 process alternatives to be used for treatment of solids.	1. Requirements of the process specification 2. Monitoring the microbial parameters	NA	NA	Ceiling limits to heavy metals and application rates	Yes	Yes

(continued)

Table A1. Biosolid Standards of Select Countries(continued)

Country	Biosolids Standards	Definition of Biosolids	Classification of Biosolids	PR Outcomes	PR Standards	Monitoring	VAR	Others	Heavy Metals	Site Restrictions - application Rates	Site Monitoring /General Requirements
Australia	South Australia guidelines for Biosolids - Draft	Sewage and Septic tank sludg	Two Combinations based on stabilization (pathogen reduction and VAR) and 3 combinations based on heavy metals	Stabilization grade A < 100 E coli per gm total solids (dry weight) < 1 Salmonella per 50 gm total solids (dry weight) < 1 virus per 50 gm total solids (dry weight) < 1 viable helminth ova per 50 gm total solids (dry weight)	One of the 6 process alternatives to be used for treatment of solids.	1. Requirements of microbial parameters	Treated or conforming to any one of 6 processes/ equirements - Similar to USEPA VAR	NA	Classified as Grade A, B and C based on the concentration of certain heavy metals	Yes, based on public and non-public usage of land	Yes
				Stabilization grade B <1000 E-coli MPN/g of dry solids	One of the 6 process alternatives to be used for treatment of solids.	1. Requirements of microbial parameters	Treated or conforming to any one of 6 processes/ equirements - Similar to USEPA VAR	NA	Classified as Grade A, B and C based on the concentration of certain heavy metals	Yes, based on public and non-public usage of land	Yes

(continued)

Table A1. Biosolid Standards of Select Countries(continued)

Country	Biosolids Standards	Definition of Biosolids	Classification of Biosolids	PR Outcomes	PR Standards	Monitoring	VAR	Others	Heavy Metals	Site Restrictions - application Rates	Site Monitoring /General Requirements
South Africa	Guidelines for the Utilization and Disposal of Wastewater Sludge	Sewage and Septic tank sludge	Six combinations based on microbial, stabilization and heavy metal concentration	Unrestricted use Faecal coliform < 1000 CFU/g of dry solids (and) helminth < 1 ova per 4 g of dry solids	No recommended process	1. Requirements of microbial parameters	Solid treatment should employ or demonstrate one of the 11 alternatives/ equirements - Similar to USEPA	NA	Classified as a,b or c based on the concentration of heavy metals	No, if adheres to VAR classification 1 and heavy metal classification 'a'	Yes
				General use Faecal coliform < 10^6 CFU/g of dry solids (and) helminth < 1 ova per g of dry solids	No recommended process	1. Requirements of microbial parameters	Solid treatment should employ or demonstrate one of the 11 alternatives/ equirements - Similar to USEPA	NA	Classified as a,b or c based on the concentration of heavy metals	Yes	Yes

(continued)

Table A1. Biosolid Standards of Select Countries(continued)

Country	Biosolids Standards	Definition of Biosolids	Classification of Biosolids	PR Outcomes	PR Standards	Monitoring	VAR	Others	Heavy Metals	Site Restrictions - application Rates	Site Monitoring /General Requirements
South Africa				Limited use Faecal coliform < 10^7 CFU/g of dry solids (and) helminth < 4 ova per g of dry solids	No recommended process	1. Requirements of microbial parameters	Solid treatment should employ or demonstrate one of the 11 alternatives/ equirements - Similar to USEPA	NA	Classified as a, b or c based on the concentration of heavy metals	Yes	Yes
New Zealand	Guidelines on the safe application of biosolids to land	Sewage and Septic tank sludge	Four combinations based on stabilization standards and heavy metal concentration	Grade A E-Coli density < 100 MPN/g	8 recommended process (or) USEPA recommen dation for pathogen reduction for Class A (or) any other process	1. Requirements of the process specification 2. Monitoring the microbial parameters	Similar to USEPA requireme nts for VAR	NA	Classified as Grade a and b depending on the concentration of heavy metals	No, if adheres to 'A' stabilization and 'a' heavy metal classification	Yes
				Grade B No defined standard	NA	NA	Defined process/ requirement based on end usage	NA	Classified as Grade a and b depending on the concentration of heavy metals	Yes	Yes

Appendix 2

SUMMARY OF US-EPA STANDARDS, CLASSIFICATIONS AND RESTRICTIONS

Table A2. US-EPA Biosolid Classification and Restrictions

Classification of Biosolids	Meet ceiling concentration for pollutants	Meet pollutant concentration limits	Pathogen reduction standards	VAR Requirement	Type of Land (application permitted)	Site restrictions	General requirements and Management practices	Track added pollutants
EQ bag or bulk Class A	Yes	Yes	Must follow any one of the six lternatives for pathogen reduction	First eight out of ten VAR options to be followed	All	No	No	No
PC bulk only Class A	Yes	Yes	Must follow any one of the six alternatives for pathogen reduction	Last two of the ten VAR options to be followed	All except lawn and home garden	No	Yes	No
PC bulk only Class B	Yes	Yes	Must follow any one of the three alternatives for pathogen reduction	Any of the ten VAR option to be followed	All except lawn and home garden	Yes	Yes	No
CPLR bulk only Class A	Yes	No	Must follow any one of the six alternatives for pathogen reduction	Any of the ten VAR option to be followed	All except lawn and home garden	No	Yes	Yes
CPLR bulk only Class B	Yes	No	Must follow any one of the three alternatives for pathogen reduction	Any of the ten VAR option to be followed	All except lawn and home garden	Yes	Yes	Yes
APLR bag only Class A	Yes	No	Must follow any one of the six alternatives for pathogen reduction	First eight out of ten VAR options to be followed	All, but most likely lawn and home gardens	No	Yes	Yes

Appendix 3

FCO NORMS FOR CITY COMPOST

Table A3. FCO 1985 Specification on City Compost

(i)	Moisture, per cent by weight	15.0-25.0
(ii)	Colour	Dark brown to black
(iii)	Odour	Absence of foul odour
(iv)	Particle size	Minimum 90% material should pass through 4.0 mm IS sieve
(v)	Bulk density (g/cm)	<1.0
(vi)	Total organic carbon, per cent by weight, minimum	12.0
(vii)	Total Nitrogen (as N), per cent by weight, minimum	0.8
(viii)	Total Phosphates (as P_2O_5), per cent by weight, minimum	0.4
(ix)	Total Potash (as K_2O), per cent by weight, minimum	0.4
(x)	C:N ratio	<20
(xi)	pH	6.5 - 7.5
(xii)	Conductivity (as dsm'), not more than	4.0
(xiii)	Pathogens	Nil
(xiv)	Heavy metal content, (as mg/kg), maximum	
	Arsenic as (As_2O_3) Cadmium (as Cd) Chromium (as Cr) Copper (as Cu) Mercury (as Hg) Nickel (as Ni) Lead (as Pb) Zinc (as Zn)	10.00 5.00 50.00 300.00 0.15 50.00 100.00 1000.00

Appendix 4

WHO STANDARDS FOR BIOSOLIDS

Pathogen standards as per WHO guidelines for reuse of faecal sludge in agriculture:

Helminth eff < 1 / g of total solids E-coli < 1,000 number / g of total solids

Monitoring of Standards: The guideline suggests the following monitoring protocol for microbial standards

a) Validation of the technology through an initial test of the system and its components.
b) Operational monitoring to highlight any process deviation or hazardous conditions.
c) Verification monitoring of the end products to match the standards. It prescribes the monitoring of e-coli as an indicator organism to check for adherence to standards. It also recommends testing of *Ascaris* under certain situations as deemed necessary.

Other restrictions related to reuse: WHO supplements the treatment by suggesting other barriers and risk mitigation practices that need to adhere while reusing FS for farming. Some of these are:

a) FS should be restricted to non-food crops or those which are processed or well-cooked before consumption (such as rice or wheat).
b) Treated FS should be withheld for a period of 1 month before applying to land.
c) User groups to be educated on land application techniques, personal hygiene and cooking methods while reusing FS or consuming FS grown produce (in cases where restrictions are not robust).

Appendix 5

LIST OF REVIEWERS

The draft version of the *Quality in FSM* document was reviewed by the following practitioners

Table A4. List of Reviewers

Name	Organization
1. Joseph Ravikumar	World Bank Group
2. Bhawna	Ernst & Young
3. Pay Drechsel	International Water Management Institute
4. Kavita Wankhede	Indian Institute for Human Settlements
5. Dorai Narayana	Independent Consultant
6. Ligy Philip	Indian Institute of Technology Madras
7. Dhawal Patil	Saniverse
8. R S Arun Kumar	Research Scholar, University KwaZulu-Natal
9. Sampath	Tide Technocrats Private Limited
10. Select staff at CDD Society	CDD Society
11. Select members of Inclusive Taskforce of the NFSSM Alliance	NFSSM Alliance

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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