आत्मनिर्भर भारत

Ministry of Housing and Urban Affairs
Government of India

सत्यमेव जयते

स्वच्छ भारत
एक कदम स्वच्छता की ओर

Swachh Bharat Mission – Urban

Consultative Document

on

Land Application of Faecal Septage




Central Public Health and Environmental Engineering Organisation (CPHEEO)

Ministry of Housing & Urban Affairs

Government of India

www.swachhbharaturban.gov.in www.cpheeo.gov.in

NOVEMBER 2020

Executive Summary

According to a study conducted by NITI Aayog in 2018, nearly 70% of water sources in the Country are contaminated. One of the major reason for this is poor sanitation management in the Country. It may be noted that only 40% of urban population is serviced with sewerage system and the remaining 60% of the urban population is dependent on on-site Sanitation systems that are not adequately regulated. In order to address this issue Ministry had brought out the Advisory on On-Site and Off-Site Sewage Management Practices in July 2020.

However, it is not possible for all the ULBs in the Country to implement the safe treatment facilities for faecal sludge and septage as this involves substantial capital and operational & maintenance cost, requires technical knowledge, needs skilled labours etc. The smaller ULBs in the Country does not have many of these. In order to facilitate these ULBs for safe disposal of their faecal sludge and septage until the time of construction of dedicated sanitation systems, it is important to identify a technology that is less cost intensive, less technical and simple.

Land application is one of such method which can be used as an immediate interim measure for the management of faecal sludge and septage in smaller ULBs as it does not require much technical knowledge and also less complicated. It may also be noted that apart from being used as safe disposal option, this may also be useful in increasing the return from the land if correct procedures are followed. However, improper applications will result in serious contamination of land & water with adverse effect to flora & fauna, aesthetics and human health.

This Advisory as a continuation to the Ministry's Advisory on On-Site and Off-Site Sewage Management Practices, 2020 covers all the key aspects of land application of faecal sludge and septage. It further discusses about the pre-treatment to be given to the faecalseptage, precautionary measures to be taken, site selection criteria, dosage and various methods of land application. The monitoring mechanism and record keeping procedures for the land application process are also adequately addressed in the Advisory. It also describes in detail about the involvement of public in the beginning and at various key stages of the project's development for better management of the land application projects. Further, both international and national case studies were also included in the Advisory for the guiding the ULBs. Thus this will serve as a complete guiding document for the ULBs especially those having population of less than 20,000, to safely manage their faecal sludge and septage until the implementation of dedicated sanitation systems.

Table of Contents

Disclaimer: This document does not replace or supersede any existing Central/State regulations and is not applicable to “Public contact sites”.

List of Abbreviation

1. **BIS:** Bureau of Indian Standards
2. **BOD:** Biological Oxygen Demand
3. **COD:** Chemical Oxygen Demand
4. **DO:** Dissolved Oxygen
5. **FS:** FaecalSeptage
6. **FSSM:** Faecal Sludge and Septage Management
7. **FSTP:** Faecal Sludge Treatment Plant
8. **GHO:** Global Health Observatory
9. **ML:** Million Litres
10. **MoHUA:** Ministry of Housing and Urban Affairs
11. **MPN:** Most Probable Number
12. **O&M:** Operation & Maintenance
13. **OSS:** On-site Sanitation Systems
14. **SBM-U:** Swachh Bharat Mission – Urban
15. **SOP:** Standard Operating Procedure
16. **SS:** Suspended Solids
17. **STP:** Sewage Treatment Plant
18. **ULB:** Urban Local Body
19. **USEPA:** United States Environment Protection Agency

Glossary

Biochemical oxygen demand: A measure of the organic pollutant strength of wastewater.

Blackwater: Wastewater generated from toilets.

Decentralized sewerage system: Implies localized collection and localized treatment of excreta and sullage in micro zones within a major habitation, keeping it in tandem with densification and progressively duplicating it, as and when other micro zones densify.

Desludging: Removal of sludge or settled solid matter from treatment tanks such as septic/ Imhoff tank, interceptor tank or sedimentation tanks.

Disposal: Discharge, deposition or dumping of any liquid or solid waste onto land or water so that it may enter the environment.

Effluent: Any form of wastewater or liquid waste that flows from an operation or activity.

Excreta: Feces and urine.

Faecal Sludge/Sludge: The accumulated semi-solid or solid portion that settled at the bottom of the septic tank which comprising 20% - 50% of the total septic tank volume is termed as faecal sludge.

Grey water: Wastewater generated from bathing, kitchen and all other household activities except toilets.

Non-public contact sites: Sites that are not frequently visited by the public are called as non-public contact sites. Non-public contact sites include agricultural land, forests, and reclamation sites but exclude parks, lawns and roadside landscaping.

On-site Sanitation: On-site sanitation is a system of sanitation whose storage facilities are contained within the plot occupied by a dwelling and its immediate surroundings. For some systems (e. g. double-pit or vault latrines), faecal matter treatment is conducted on site and also by extended in-pit consolidation and storage. With other systems (e. g. septic tanks or vault installations), the sludge has to be collected and treated off-site.

Pathogens: Micro-organisms such as bacteria, viruses and protozoa that cause disease.

Percolation rate: The rate at which liquids move through soil.

Sanitation: Normally sanitation is a broad term and refers to both solid and liquid waste management, however, in this advisory, sanitation is referred to as sewage management only.

Scum: The extraneous or impure matter like oil, hair, grease and other light material that floats at the surface of the liquid, while the digested sludge is stored at the bottom of the septic tank.

Septage: Septage is the liquid and solid material that is pumped from a septic tank, cesspool, or such onsite treatment facility after it has accumulated over a period of time. Septage is the combination of scum, sludge, and liquid that accumulates in septic tanks. Offensive odour and appearance are the most prominent characteristics of Septage. It is a host of many disease-causing organisms along with the contamination of significant level of grease, grit, hair, and debris.

Septic Tank: Septic Tank means a water-tight receptacle which receives the discharge of a plumbing system or part thereof, and is designed to accomplish the partial removal and digestion of the suspended solid matter in the sewage through a period of detention.

Sewage: Combined grey and black water generated from household in the absence or presence of septic tank.

Sewerage System: The underground conduit for the collection of sewage is called Sewer. A network of sewer appurtenances intended for the collection and conveyance of sewage generated from each of the properties to a sewage pumping station for pumping to sewage treatment plant for further treatment and disposal is called sewerage system.

Sludge: The settled solid matter in semi-solid condition – it is usually a mixture of solids and water deposited on the bottom of all anaerobic and aerobic sewage treatment systems like septic tanks, oxidation ponds and Activated Sludge plants etc. The term sewage sludge is generally used to describe residuals from centralized sewage treatment, while the term septage is used to describe the residuals from septic tanks.

Suction truck: A vehicle used for mechanized sludge removal from septic tanks and lined latrine pits.

Wastewater: Liquid wastes from households or commercial or industrial operations, along with any surface water/storm water. Wastewater is a broad term and used for any used water.

Water closet: A pan, incorporating a water seal, in which excreta are deposited before being flushed away using water.

1. Introduction

In the world, among urban households, Southern Asia with 593 million people is one of largest user of on-site sanitation technologies that need further management services. Win India, with the construction/conversion of about 61 lakh additional individual household toilets and 5.82 lakh additional Community/Public Toilets seats under Swachh Bharat Mission (SBM-U), the coverage of urban population in the Country with sanitary toilet facilities has risen to 100%. This in-turn put more emphasis on further management of waste generated from such on-site sanitation technologies as mismanagement of these results in loss of lives and economical losses every year. In order to curtail these losses, it is necessary to drastically improve the sanitation condition especially the proper treatment and disposal of sewage and faecal sludge and septage in the urban areas. Though, 60 % of households, in cities with population of more than one lakh (as per 2011 Census), are targeted to be covered with sewerage facilities under AMRUT by 2022, still, as of now, about only 40% are serviced with sewerage system and remaining 60% of the urban population is dependent on On-site Sanitation systems.

Therefore, Government of India as well State Governments, hitherto had been encouraging cities to prepare conventional sewage management plans comprising of sewer networks and sewage treatment plants, on whole city basis. This process although tested and robust but is cost time and water intensive. To address the challenges, adoption of both short term and long-term solutions with due leveraging of technology, is need of hour. While the current approach remains to provide sewerage system in cities in the long run, States have been encouraging ULBs to provide Faecal Sludge and Septage (FSSM) facilities expeditiously as an interim measure/ perceived alternative to sewerage system for the areas/population uncovered with sewerage system. The faecal sludge and septage from such areas are being collected using mechanical equipment and are being treated at standalone faecal sludge treatment plants (FSTPs) or co-treated at existing STPs in the vicinity.

However, not all the ULBs in the Country can have standalone FSTPs due to various reason including the lack of funds, lack to technical knowledge, lack of awareness etc. Further, for the ULBs which opt of the standalone FSTPs or STPs, there is a need for safe management of faecal sludge and septage during the construction of such plants to avoid any further contamination of environment. Therefore, smaller towns (especially having a population of less than 20,000) which does not have Sewage Treatment Plant (STP) nor standalone Faecal Sludge Treatment Plant

(FSTP), land application can be considered as a viable solution for smaller towns, where agricultural land, forest land and reclamation site etc are available in vicinity.

This Advisory discusses various methods of the land application of faecal sludge and septage and the steps associated with it as improper application will have drastic effects on the environment as well as the health of people. This Advisory is framed in continuation with the Ministry's Advisory on On-Site and Off-Site Sewage Management Practices, 2020 to achieve end to end sanitation in Urban areas of the Country. This document is intended to serve as a practical guide for planners, design engineers, State and local government officials involved in planning, evaluating, and designing faecal sludge and septage handling facilities.

2. Scope and objectives

This Advisory covers various aspects of designing and operating various faecal sludge and septage land application methods. This includes pre-treatment requirements of the faecal sludge and septage.

The main objectives of this Advisory are to:

i. Regulate the land application practices to cover the smaller towns with population lesser than 20,000 having no sanitation infrastructure as an immediate interim measure for the safe management of their faecal sludge and septage until the time of implementation of proper sanitation systems.

ii. Facilitate ULB officials and other stakeholders with the basic knowledge of the land application techniques and to empower them to take decisions on suitable technology/ approach, suiting to the requirements of particular ULB.

iii. Improves health of the public as the poor sanitation inflicts several health hazards.

iv. Integrate various Government Departments and other agencies in beneficial use of faecal sludge and septage until the time of implementation of regular sanitation systems.

3. Characteristics of Faecal Sludge

Knowledge of faecal sludge and septage characteristics and variability is important in customizing the design of treatment options and determining the acceptable disposal methods. The characteristics of faecal sludge and septage depend on socioeconomic & geographical factors, tank size & design, pumping frequency, climate & seasonal weather conditions, and tributary appliances. It also depends on the methodology of sampling; period of time over which samples are taken and sample size. Therefore, it is advised to have the characteristics of faecal sludge and septage tested by each of the ULB for deciding the treatment and disposal methods.

Nutrients in faecal sludge and septage, specifically nitrogen and phosphorus, are of concern due to the growing interest in the treatment and removal of nutrients from domestic wastewaters. Nitrogen and phosphorous is also of interest with respect to specific loading rates as they apply for land treatment of faecal sludge and septage. In addition potassium is also of concern as it is necessary for plant growth. However, potassium and phosphorous are not liable to leach out. Therefore, nitrogen requirements usually govern the organic considerations in application rates.

Domestic faecal sludge and septage is usually shown to contain negligible level of heavy metals and other pollutants due to fact that faecal matter is mostly organic in nature. Hence, the aspect of heavy metal is not considered in this report. However, the same may be occasionally verified through test in those cases where septic tanks are located near industries dealing with heavy metals.

In the absence of adequate information on faecal sludge and septage characteristics in the ULB, average characteristics of the faecal sludge across 10 cities in India may be useful (see the following Table).

Characteristics of faecalsludge in India

Parameter	**Range**	**Average Value**
Oil & Grease, mg/l	5-156	38
Total Phosphorous, mg/l	1-38	10
kjeldahlNitrogenas N, mg/l	85-969	299
Ammonia as NH 3, mg/l	150-972	428
Nitrate as NO 3, mg/l	12.1-39.9	25
Total alkalinity as CaCO 3, mg/l	400-3403	1382
pH at 25°C	6.32-7.45	6.9

COD, mg/l	1000-67000	18500
BOD (3 days), mg/l	600-53600	13700
Total solids (TS), mg/l	1000-103000	30800
Total suspended solids, mg/l	500-101000	28700
MLVSS (mixed liquor volatile suspended solids), mg/l	400-55900	18800
Fecal coliforms MPN / 100ml	110-1600	426
Helminth eggs, Nos./l	2-45	11

Source: NilanthiJayathilake, et al (2019)Initiatives Taken by Government of India

The various programme and policy initiatives taken by Government of India with respect of faecal sludge and septage in the past has been described in brief in Ministry's Advisory on On-site and Off-site Sewage Management Practices, 2020. The same may be referred for further details. Some of the key initiatives of the Ministry in the past on the subject are given below.

- **Manual on Sewerage and Sewage Treatment Systems, 2013:** Ministry of Housing and Urban Affairs has published 'Manual on Sewerage and Sewage Treatment Systems' in 2013. Separate chapters have been allocated for decentralized sewerage system and onsite sanitation, wherein, the different methods of decentralized sewerage and onsite sanitation systems are discussed in detail.
- **National Policy on Faecal Sludge and Septage Management (FSSM), 2017:** National Policy on FSSM was published by Ministry in 2017 with main objective to set the context, priorities, and direction for, and to facilitate, nationwide implementation of FSSM services in all ULBs such that safe and sustainable sanitation becomes a reality for all.

  The Policy set specific milestones in order to achieve the target of total sanitation throughout the country. According to the policy, States and ULBs have to develop and issue respective FSSM Policy and Plans. Many States have already developed or modified their FSSM Strategies in line with the National FSSM Policy and have initiated to work in order to achieve the targets set in the National Policy.
- **Standard Operating Procedure (SOP) for Cleaning of Sewers and Septic Tanks, 2018:** Ministry had published the 'Standard Operating Procedure (SOP) for Cleaning of Sewers and Septic Tanks' in November, 2018. The set of procedures to be followed while cleaning the

sewers and septic tanks its cleaning frequency and the the use of personal protective & cleaning equipment are discussed in detail.

- **Advisory on Emergency Response Sanitation Unit (ERSU), 2019:** Ministry of Housing & Urban Affairs (MoHUA) had published an Advisory on Emergency Response Sanitation Unit (ERSU) 2019. The advisory deals with the technical and managerial interventions for ensuring safety during sewer and septic tank cleaning.
- **Advisory on On-Site and Off-Site Sewage Management Practices, 2020:** This Advisory covers all aspects of planning of On-site and Off-site sanitation options including conveyance, treatment and recycle and reuse for implementation. It also contains a Decision-Making Tree for selection of suitable sanitation option for an area and also the comparison of different conveyance and treatment options to suit different set of conditions in cities.

4. City Sanitation Plan (CSP)

The necessity of CSP, the points to be considered and procedures to be followed while formulation of CSP has already been explained in detail in Ministry's Manual on Sewerage and Sewage Treatment Systems, 2013 and Advisory on On-Site and Off-Site Sewage Management Practices, 2020. The same may be referred for further information.

5. Septage Generation Rates

There is no extensive study on septage generation rates carried out in India. Septage generation rates vary widely from place to place depending on practices of septic tank use, number of users, water used for flushing, and the frequency of cleaning the septage. However, based on the information received through various sources, the size of a septic tank in individual houses ranges from 1 to 4 cubic meter.

In absence of actual measurement of septage generation, the septage generation rate based on the analysis of following three may be considered for design of septage treatment facility given below:

- IS 2470 (Part 1) – 1985: Code of Practice for Installation of Septic Tanks recommends the rate of sludge generation from septic tank in the range of 115-225 lpca.
- However, as per Manual on Sewerage and sewage treatment systems, 2013, Sludge accumulation rates given in Table 9.2, recommends 67 lpca for 3year desludging cycle.

- As per Box 3.7 given in Faecal Sludge & Septage Management, A Guide for Low and Middle Income Countries, 2018 by Kevin Tayler, mentions sludge accumulation in the range of 60-125 in North America.

Recommendation: Based on above, for design of septage treatment facility, capacity can be arrived taking sludge generation rate between 70-100 lpca.

6. Desludging and transportation of faecal sludge and septage

The set of procedures for desludging, frequency and the use of personal protective & cleaning equipment are clearly explained in the Ministry's 'Standard Operating Procedure (SOP) for Cleaning of Sewers and Septic Tanks' published in November 2018. The same shall be referred to in case of any doubt.

The number of trucks required for transportation of septage may be worked out on following lines:

As the size of septic tanks in the country is non-standard and may range from 1.1 m^3 per family as required under IS Code and upper limits are quite large, it is suggested to mandate an average 3 year cleaning cycle (1000 days) and 1.5 cubic meter emptying from each household.

Thus, require 1 Standard Septage handling Vehicle/ suction machine (on an average, capable of collecting and transport 9000 liters per day in single or multiple shifts) for 6000 Households or 1 Vehicle per 30000 populationsFollowing the similar procedures, requirement of vehicles can be assessed for various cities considering the factors like topography, size of the vehicle, distance of disposal & traffic.

7. Pre-treatment of Faecal Sludge and Septage

7.1 Lime Stablisation

Lime stabilization facility controls odour, vector and facilitates pathogen destruction. It also reduce degradable organic matter, and acts as sludge conditioner to precipitate metals and phosphorus. The process of pathogen reduction during alkaline stabilisation is based on an increase of pH, temperature (through exothermic oxidation reactions) and ammonia concentration. However, it is important to consider a number of design parameters like sludge characteristics, lime dose, contact time and pH in order to achieve optimum results from lime stabilisation in the most economic way possible. Faecal sludge and Septage can be stabilized by adding sufficient lime to raise the pH to 12 for a minimum of 30 min, without adding more lime, for reducing the vector attraction. For pathogen reduction, the pH of the septage may be raised to 12 for a minimum of 2 hrs, without adding more lime. pH is raised by adding lime acts as oxidants and precipitates metals.

Although there is a lot of variation in septage characteristics and lime requirements, approximately, about (as CaO or quicklime) of 2.4 to 3.0 kg or 3.12 to 4 kg (hydrated lime or calcium hydroxide) of lime is required per 1,000 L of septage.

Note: Generally, the lime will be added in the form of slurry rather than mixing directly to septage.

After lime slurry has been mixed with domestic septage, collect sample from top access hatch using a polyethylene container fastened to a pole. Measure pH with pH meter at 25°C (or convert reading to 25°C). Hand-held or pocket-size pH meter or color-sensitive pH paper that indicates a relatively narrow band of pH in the recommended range (e.g., 10 to 13) may be used for this purpose. After pH 12 is reached, pH should be measured every 15 min. The pH of the mixture must be maintained at 12 or greater for at least full 30 min, without adding more lime. Record pH prior to applying septage to the land.

Two separate samples should be taken 30 minutes apart, and both of the samples must test at pH 12 or greater, without adding more lime. If the pH is not at 12 or greater for a full 30 minutes, additional lime can be added and mixed with the septage. However, after mixing in the additional lime, the septage must be at 12 or greater for a full 30 minutes, without adding more lime, in order to meet the pH requirement.

CAUTION: *Quicklime is more reactive than hydrated lime and it releases a lot of heat when added to water. IF QUICKLIME IS USED, SAFETY PRECAUTIONS MUST BE TAKEN. Quicklime can cause bad burns if it gets onto moist skin or into your eyes. Appropriate safety precautions include the use of rubberized gloves, a respirator to exclude dust, and protective eyewear (goggles) and clothing to keep moist skin from contacting the quicklime. In addition, a fire could start if a bag of quicklime gets wet and sits around. Any fire involving quicklime must be put out using a carbon dioxide [CO_2] extinguisher, not water. Water sprayed onto such a fire would only react with the quicklime and release more heat. Add lime slowly to partially full tank. An emergency eyewash station should be located nearby.*

<u>Lime addition</u> could be done at any of the following three points for stabilization before land application:

i) to the desludger vehicle before the faecal sludge and septage is collected,
ii) to the hauler truck while the faecal sludge and septage is being collected, or
iii) to a faecal sludge and septage storage tank where faecal sludge and septage is discharged from a desludger vehicle.

The faecal sludge and septage and lime may sometimes be mixed by a coarse bubble diffuser system located in the tank or truck. It is advantageous to have a separate storage tank for lime and faecal sludge and septage mixing as this allows for more uniform mixing and easier sampling, monitoring, and control.

Lime stabilization may be followed by a dewatering step. Since lime stabilization does not destroy the organics necessary for bacterial growth, the faecal sludge and septage must be disposed of before the pH drops significantly or it can become re-infested and putrefy. Lime addition to septage may reduce nitrogen concentration through volatilization of ammonia, but will not affect NO_3 levels, if conditions permit this stripping, often enabling greater quantities of stabilized faecal sludge and septage to be applied per unit of land area, since such applications are often limited by nitrogen loading. Lime stabilization is, therefore, only a temporary stabilization which enables further handling and disposal to take place prior to the onset of destabilization.

Comparison of Raw and Lime Stabilized Septage

Parameter	**Concentration, average, mg/l**	
	Raw Septage	**Lime-Stabilized Septage***
Alkalinity	1897	3475
Total COD	24940	17520
Soluble COD	1223	1537
Total Phosphate	172	134
Soluble Phosphate	25	2.4
Total Kjeldahl Nitrogen	820	597
Ammonia Nitrogen	92	110
TSS	21120	23190
VSS	12600	11390

**To pH≥12 for at least 30 minutes.* Source: USEPA

Constraints

- The main disadvantages of this technique are the requirement of consumables (lime), and a dry storage area as lime is an alkaline material which reacts strongly with moisture.
- Further, protection from fire must be ensured.
- Pathogen regrowth is also a concern.
- Also high risks of hazard to the eyes, skin and respiratory system are observed. Therefore, skilled staff is required who must follow health and safety procedures and make use of good protective equipment.
- The pathogen removing effect of lime also affects desired microbial processes such as composting and other soil processes.
- Lime addition to the septage will lower fertilizer value (soluble phosphate, ammonia nitrogen, TKN, etc.) of the septage.
- O&M problems due to scaling in the lime addition system.
- Lime addition significantly increases the quantity of material for disposal.
- High pH sludge liquor to treat or dispose of, or dewatering follows this process.

7.2 Dewatering/Thickening

Dewatering is generally required for disposal of stabilized septage when they are disposed off by burial methods to reduce the size of the trenches. There are two options available for dewatering; namely, gravity dewatering systems and mechanical dewatering systems. Gravity dewatering includes sand drying beds; mechanical dewatering systems include vacuum filters, filter presses (including screw presses, plate and frame presses, belt presses), centrifugation, and vacuum-assisted drying beds. Another feasible option is using bulking agents.

Septage has poor dewatering characteristics, which warrants the need for conditioning prior to dewatering. Biological conditioning of raw septage by digestion or use of heat conditioning followed by dewatering may not be economical due to high capital and operating costs. Therefore, conditioning through chemical is preferred over aforesaid methods as it is cheap. The amount of chemical used is based on the load and its characteristics. It is suggested to use lime as the conditioning chemical as it is already used to stabilize the septage before land application and the load already used for stabilization process itself is sufficient for conditioning in most cases. In addition to lime, Alum, Ferric Chloride, Acid, Potassium Sulfate and Polymers can be used as conditioning chemicals. Chemical conditioning followed by dewatering results in average cake solids content of approximately 20 to 40 percent, which should be suitable for mechanical or manual methods of cake removal for ultimate disposal. The degree of dewatering accomplished is a function of conditioning chemicals, admixtures of other sludges with septage, and the dewatering process used.

The methods of septage dewatering techniques are similar that of the STP dewatering techniques. The detail description of these techniques are given in Ministry's Manual on Sewerage and Sewage Treatment Systems, 2013. The same may be referred for any further details on the techniques.

8. Site Evaluation and Selection for Land Application of faecal sludge and Septage

i. Septage may not be land applied within 10 km of any major drinking water sources. For surface waters of lesser quality (except irrigation canals), a buffer zone of 700 m must be maintained. However, the aforesaid values varies with the slope of the site. No buffer is required around irrigation waters that are located entirely on the land application site and do not flow off the site.

ii. Septage may not be applied within 3.5 km of any shallow public water supply wells, nor closer than 1 km to any private drinking water supply well.

iii. The slope of the land application area may not be more than eight percent and a layer of permeable soil at least two feet thick should cover the surface.

iv. Land used for septage application may not contain any hole or channel (such as subsurface fractures, solution cavities, sink holes, or excavated core holes) which would allow the septage to contaminate the groundwater. Also, septage may not be applied within a 700 m buffer from such geologic formations or features.

v. Septage may not be applied on land located within 1 km of any dwelling.

vi. Septage may not be applied on land located within 2 km of any recreational areas.

vii. Septage may not be applied on land located within 350 m of any intermittent streams.

viii. Septage may not be applied on land located within 50 m of Road Right-of-Ways.

ix. Faecal sludge and septage may not be applied on land located within 250 m of the property boundary or any drainage ditches.

x. The following soil requirements shall also be met by the site for land application

- Slope - 0-6% (for surface spreading) and 0-12% (if injected)
- Minimum Soil Depth - 1 m (permeable)
- Minimum Depth to Water Table - 1 m below application depth
- Available Water Holding Capacity - 15 cm to bedrock or water-table
- Flooding - Free from flooding hazard
- Medium to fine textured soils (no sandy, peaty or mucky surface textures)
- Minimum depth to water table of 1 m through natural or artificial drainage
- Minimum depth to bedrock of 1 m
- Minimum of 15 cm of available water holding capacity between application depth and the water table and bedrock

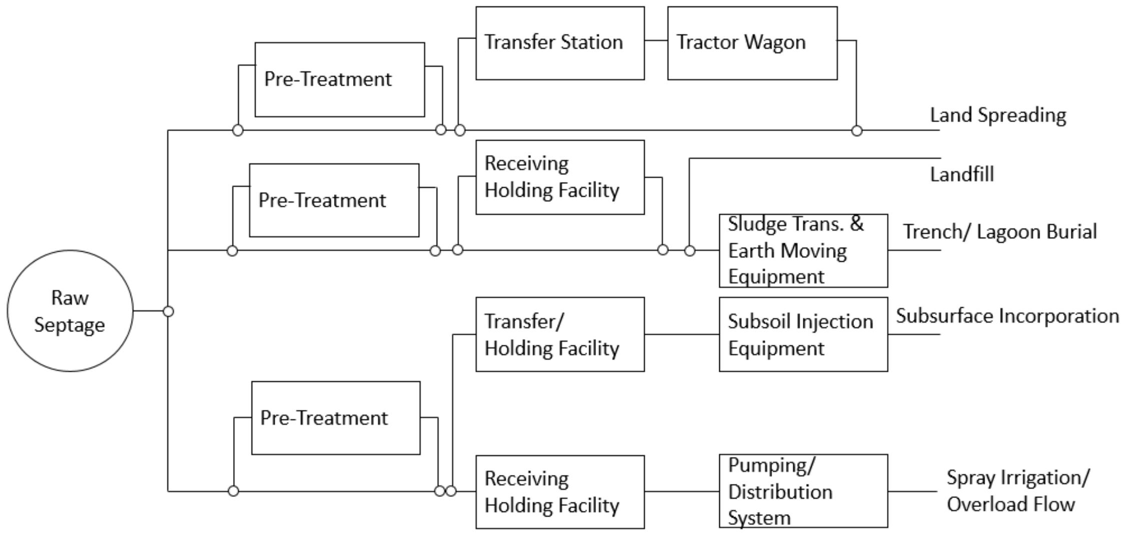
At least one soil horizon in the upper 16.5 m must have a permeability of less than 15 cm per hour. If septage is to be surface applied (rather than injected), the soil must have a surface permeability greater than 0.51 cm per hour.

9. Land Application of Faecal Sludge and Septage

9.1 Description

Land application is the application of domestic faecal sludge and septage in land at controlled rates to fertilize crops and improve the tilth of soils. Land application includes land spreading, subsurface application and burial practices. Land spreading may be done from faecal sludge and septage hauler trucks or transfer vehicles such as tank wagons; spray irrigation; ridge and furrow irrigation practices; and overland flow. Subsurface application techniques include plow furrow cover and subsurface incorporation alternatives. Placement in trenches, holding lagoons, and sanitary landfills are classified as burial practices.

Using faecal sludge and septage as a soil amendment has many benefits over using chemical fertilisers. Organic matter in faecal sludge and septage can increase soil water holding capacity, build structure, reduce erosion and provide a source of slowly released nutrients. The fate of and exposure to pathogens and heavy metals needs to be taken into consideration, and social acceptance can be closely linked to potential commercial value. Other factors that need to be considered include nutrients, which may or may not be available in the ratio required by soil and crop systems.
Figure below illustrates the various technical options to be considered in evaluating land application alternatives.



Technical Options for Land Application of Septage
Source: USEPA

Properly managed land application is relatively simple, generally the most economical disposal technique, and can make beneficial utilization of the nutrient value of faecal sludge and septage. With proper management, domestic faecal sludge and septage is a resource containing nutrients that can condition the soil and decrease the reliance on chemical fertilizers for agriculture. Faecal sludge and septage management maximizes these benefits of faecal sludge and septage while protecting public health and the environment. Smaller towns having a population of less than 20,000 which does not have any Sewage Treatment Plant (STP)/ standalone Faecal Sludge Treatment Plant (FSTP) due to various reasons can manage their faecal sludge and septage through any of land application methods as an immediate interim measure.

In all these aforesaid land application approaches, faecal sludge and septage should be pretreated(minimum of screening) during discharge into a holding mixing tank by adding lime and stabilizing it to pH 12 for 30 min, before application. Collected trash should be lime stabilized and sent to a sanitary landfill. Though the addition of lime will reduce the nutrient content available to the plants significantly it is essential as it controls odour, vector and facilitates pathogen destruction which will help in safe handling of faecal sludge and septage.

Although, many researches suggest that it is advantageous and safe to apply faecal sludge and septage to agricultural fields, forest land and reclamation sites, it is suggested to restrict the application of faecal sludge and septage only to “nonpublic contact sites” of agricultural fields, social forest project site and reclamation sites as it is hard to follow the restrictions in forest land due to the fauna residing in the area. Due care shall be taken that even if the domestic faecal sludge and septage did not reach surface water, it should not be allowed to concentrate and overload a portion of the field with nutrients or be allowed to collect in low areas and road ditches and create a nuisance condition.

9.1.1 Application to Agricultural Land

Usually the land under this category are owned by individual farmers. It is advantageous to maintain or utilize the normal cropping patterns found in the community. The types of crops grown and crop rotation patterns have developed over the years in response to local soil conditions, climate, and economic conditions. The nutrient value of the faecal sludge and septage should be utilized as a replacement for commercial fertilizers, while altering farming practices as little as possible. The crops selected essentially dictate the scheduling and methods of application. Since faecal sludge and septage application rates are typically controlled by the nitrogen required by the crop, crops requiring large amounts of nitrogen will minimize the amount of land required and the operation costs. The amounts of nitrogen, phosphorus, and potassium required to obtain a given crop yield for different crops and soil types in each region of the country is available with the Agricultural Departments of the concerned States/UTs. The application frequency is typically annual, usually scheduled between harvesting and planting.

9.1.2 Application on Reclaimed Land

These lands are usually Government owned or owned by large public/corporate companies. Faecal sludge and septage is usually applied to impoverished lands at rates sufficient to satisfy the nutrient requirements of the cover crop. The frequency of application of faecal sludge and septage in reclamation sites are usually only once before planting any vegetation.

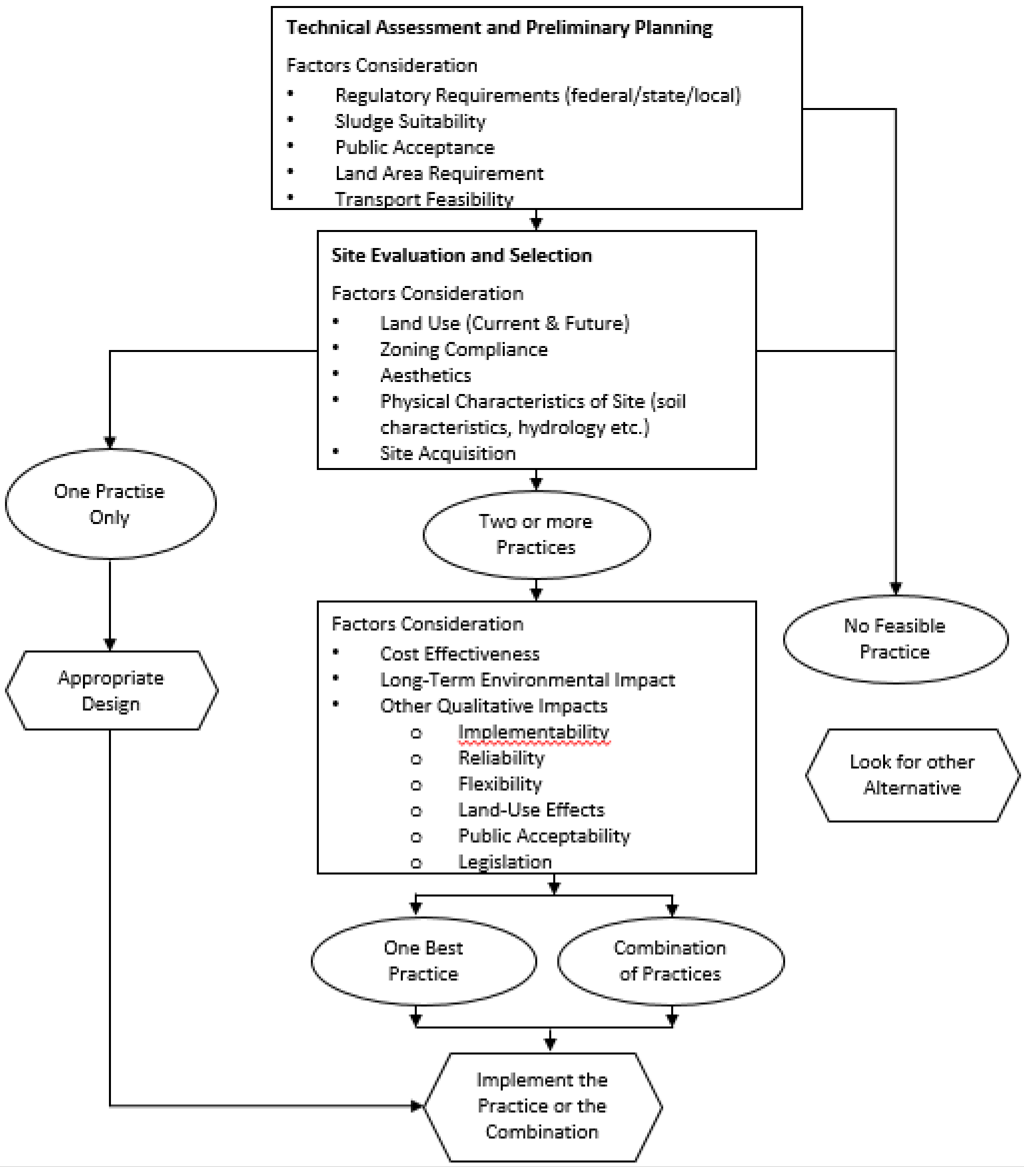
9.1.3 Key elements of operation and maintenance (O&M) of land application

Key elements of a successful operation and maintenance (O&M) program for a faecal sludge and septage land application site include the following:

1. Provision of faecal sludge and septage receiving and holding facilities to provide operational flexibility (optional).
2. Proper faecal sludge and septage treatment prior to application as required to meet regulations (need for treatment depends on requirements of application method).

3. Control of faecal sludge and septage application rates and conditions in accordance with rules.
4. Proper operation and maintenance of the application equipment.
5. Monitoring of faecal sludge and septage volumes and characteristics, soil, plants, surface water, and ground water as required by regulations.
6. Odor control.
7. Good record keeping and retention for at least 5 years.

Note: Faecal sludge and septage must not be land applied before or during rainfall.



9.2 Points to be considered before Land Application

- When applied to areas without vegetative cover, faecal sludge and septage must be incorporated into the soil within 48 hours.
- Pasture land may not be grazed for 30 days following application of faecal sludge and septage.
- Faecal sludge and septage may not be applied during rain events when runoff might occur.
- Faecal sludge and septage application area must have buffer zones and stormwater management structures with a capacity to hold runoff during flash floods.
- At the time of faecal sludge and septage application, a minimum of 24 inches of unsaturated soil above the ground water table must be present.
- In no case, no more than 225 kg (500 Pounds) of nitrogen may be applied to each acre of land in any 12 month period.

9.3 Annual Application Rates based on Nitrogen Content

Nitrogen, phosphorous and potassium are basic requirements for plant growth. Land application of septage usually results in excess phosphorous applied, compared to plant requirements, while a potassium deficiency will result at the same dosage. Both elements, however, tend to become fixed in the soil and are not liable to leach out. For this reason, nitrogen requirements usually govern the organic considerations in application rates.

Therefore, maximum annual volume of domestic septage applied to all but land reclamation sites depends on septage nitrogen content, the amount of nitrogen required by the crop, and the planned yield of the crop. U.S. EPA issues the following guidelines for estimating application rates based on nitrogen loading:

$$\text{Annual application rate based on N Content (gal/acre/yr)} = \frac{\text{Pounds of nitrogen required for the crop (lb/acre/yr)}}{0.0026}$$

(Note: 1 US Gallon (gal) = 3.785 L and 1 Pound (lb) = 0.454 kg)

Application rate requirements pertain to each site where domestic septage is applied and must be adjusted to the nitrogen requirement for the crop being grown. Nitrogen requirements of the crop depend on expected yield, soil conditions, and other factors such as temperature, rainfall, and length of growing seasons. State agricultural departments should be contacted to determine the appropriate septage (and nitrogen) application rates for use in the above equation for calculation of the application rate.

The primary reason for this annual rate calculation is to prevent the over application of nitrogen in excess of crop needs and its potential movement through soil to groundwater. The annual application rate formula was derived using assumptions that facilitate land application of domestic septage. For example, fractional availability of nitrogen from land-applied domestic septage was assumed over a 3-year period to obtain the “0.0026” factor in the annual application rate formula. Also, in deriving the formula, domestic septage was assumed to contain about 313 mg/l per year available nitrogen (in year three and thereafter).

Septage is rich in available ammonia, with about 25 percent of the total 600-960 mg/l of nitrogen occurring in this form. Nitrogen may be lost if poor drainage conditions exist. This causes a rapid denitrification to occur, converting nitrate to nitrogen gas. Health aspects dictate nitrogen be applied at rates less than or equal to plant nitrogen uptake requirements. Otherwise, excess nitrates could form and contaminate groundwater or surface water through leaching or runoff.

The State of Maine in USA has reported in its Maine Guidelines for Septic Tank Sludge Disposal on the Land that a loading criteria of 236.59 Million L/acre/year on well-drained soils and 141.95 Million L/acre/year on moderately well-drained soils will not result in pollution caused by excess nitrogen. These loadings result in an application of 227 kg/acre/year in well-drained soils and 136 kg/acre/year in moderately well-drained soils.

Note: In no case, no more than about 225 kg (500 Pounds) of nitrogen may be applied to each acre of land in any 12 month period.

9.4 Methods of Land Application of Faecal Sludge &Septage

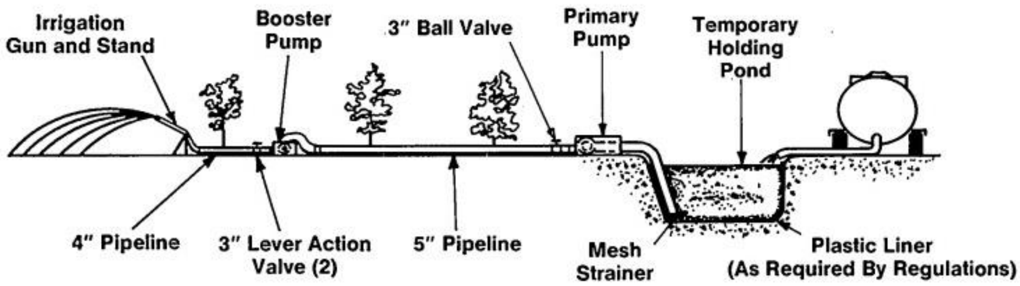
There are about three broad options for land disposal:

i. Surface application,
ii. Sub-surface incorporation,
iii. Burial

9.4.1 Surface application

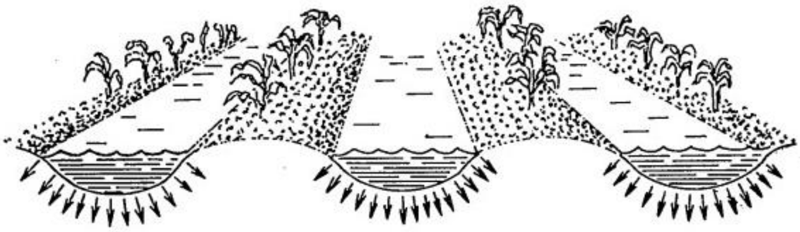
Surface application is the simplest option but usually lead to problems related with pathogens, flies, and other vectors. This type of application has the highest level of risk for human health impacts, and is best applied in arid to semi-arid regions. It must be ensured that adequate barriers are in place and that there is sufficient land area available. In this type, faecal sludge and septage is applied on farm fields in liquid form or as faecal sludge and septage solids during the dry season by a designated vehicles and then incorporated into fields when crops are planted during the rainy season. Application rates depend on the slope, soil type, depth of application, drainage class, and hydraulic loading. An interim storage facility is needed when application of faecal sludge and septage is impossible due to field conditions, or when it would result in contaminated runoff escaping from the site.

- Spray Irrigation – Pretreated (e.g., screened) faecal sludge and septage is pumped at 80 to 100 psi through nozzles and sprayed directly onto the land. Spray irrigation can be used on steep or rough land and minimizes disturbances to the soil by trucks. It is important to consider the wind patterns and the site location when using spray irrigation because of the offensive odors associated with faecal sludge and septage. Portable pipes and nozzle guns are commonly used rather than fixed or solid sets.



Liquid Sludge Spreading System in Forest Land Utilizing Temporary Storage Ponds

- Ridge and Furrow Irrigation-this is used for relatively level land, with slopes no greater than 0.5 to 1.5%. In this disposal method, pretreated faecal sludge and septage is applied directly to furrows or to row crops that will not be directly consumed by humans.



Ridge and Furrow Method

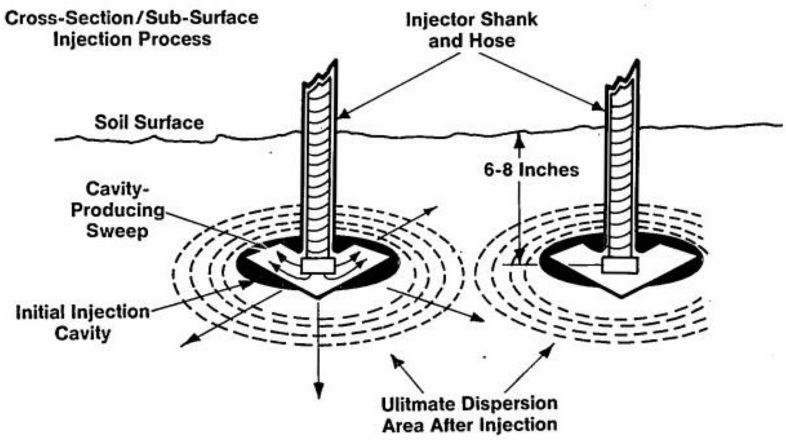
- Land Spreading-disposal can be performed either by the hauler truck or by a tank wagon pulled by a tractor. The choice between the two is one of economics.
    a) Hauler Truck Spreading-faecal sludge and septage is applied to the soil directly from a hauler truck that uses a splash plate to improve distribution. The same truck that pumps out the septic tank can be used for transporting and disposing the faecal sludge and septage.
    b) Farm Tractor and Wagon Spreading-liquid faecal sludge and septage or faecal sludge and septage solids are transferred to farm equipment for spreading. This allows for application of liquid or solid faecal sludge and septage.

9.4.2 Subsurface Incorporation

In this method, a special liquid-waste application vehicle that removes screened faecal sludge and septage from a holding tank and injects it on or below the soil surface. Soil incorporation techniques offer better odor and pest control than surface spreading techniques and reduce the risk of inadvertent exposure of humans to pathogens. One disadvantage is that less nitrogen removal is achieved since ammonia volatilization is eliminated, thereby decreasing the application rate compared· to surface application. Specialized equipment is generally required, depending on the method of subsurface disposal practiced. Faecal sludge and septage can only be applied to slopes less than 8%, and the soil depth to seasonal high water table must be at least 20 inches (or as mandated by local regulations). To prevent soil compaction and allow sufficient infiltration, equipment must not be driven over the site until 1 to 2 weeks after application.

- **Plow and Furrow Cover –** A typical setup using this method consists of a moldboard plow with furrow wheels and coulters. The coulter blade is used to slit the ground ahead of the plow. Faecal sludge and septage is applied to the land in a narrow furrow 15 to 20 cm (6 to 8 in.) deep and is immediately covered by the following plow.

- **Subsurface Injection –** This technique employs a device that injects either a wide band or several narrow bands of liquid faecal sludge and septage into a cavity 10 to 15 cm (4 to 6 in.) below the surface. Some equipment uses a forced closure of the injection swath.



Subsurface Soil Injection

9.4.3 Burial

Broad forms of faecal sludge and septage burial include disposal in holding lagoons, trenches, and sanitary landfills. Foul odors are inherent to all of these operations until a final cover is placed over the applied faecal sludge and septage. Site selection is particularly important, not only for odor control, but also to minimize potential groundwater pollution.

Holding Lagoons: These lagoons are usually a maximum of 1. 8 m (6 ft) deep and allow no effluent or soil infiltration. These disposal lagoons require placement of faecal sludge and septage in small incremental lifts (15 to 30 cm, or 6 to 12 in.) and sequential loading of multiple lagoons for optimum drying. Odor problems may be reduced by placing the lagoon inlet pipe below liquid level and having water available for haulers to immediately wash any spills into the lagoon inlet line.

Trenches: faecal sludge and septage is placed sequentially in multiple trenches in small lifts, 15 to 20 cm (6 to 8 in.) , to minimize drying time. When the trench is filled with faecal sludge and septage, 0.6 m (2 ft) of soil should be placed as a final covering and new trenches opened.

Sanitary Landfills: Leachate production and treatment and odor are the main problems to be addressed when a sanitary landfill accepts faecal sludge and septage. For moisture absorption, a starting ratio of 0. 05 m3 of faecal sludge and septage to each m3 of solid wastes. Faecal sludge and septage should not be disposed of in landfills in areas with over 90 cm (35 in.) per yr of rainfall, landfills without leachate prevention and control facilities, or those not having isolated hydrogeological underlying rock strata. A 15-cm (6 in.) earth cover should be applied daily to each area that was dosed with faecal sludge and septage, and with 0.6 m (2 ft) of final cover within one week after the placement of the final lift. Generally, this is not an economical method of disposal and is not normally recommended as the area comes under public contact sites.

9.5 Storage Facility

Holding tanks most commonly are simple concrete structures. Epoxy-coated aluminum tanks might also be used. Steel tanks, which have also been used, are subject to rapid corrosion and early failure. If alkali stabilization is practiced at the site, a mixing system is required. Air mixing, the most efficient system, generally requires off-gas collection and treatment to control odors. Biofilters or soil filters are recommended. O&M requirements for holding tanks are minimal: daily washdown and periodic tank inspections.

Enclosed storage tanks are subject to corrosion from the release of hydrogen sulfide (H2S) gas. Because H2S is toxic, proper confined-space entry procedures must be carefully followed anytime a tank is entered. Key procedures include the following:

- Monitoring H2S, oxygen, and lower explosive limit.
- Providing forced ventilation of the tank prior to entry
- Wearing self-contained breathing apparatus, if appropriate.
- Wearing a safety harness.
- Providing two additional people topside with equipment to hoist the tank inspector.

If the holding tank is provided with a mixing system, this should be inspected and cleaned regularly and serviced once per year, or as recommended by the manufacturer. Biofilters or soil filters require moisture control and periodic change of media. Chapter 8 discusses O&M requirements for faecal sludge and septage receiving stations.

9.6 Restrictions for Domestic Faecal Sludge and Septage (with pH Treatment) Applied to Non-Public Contact Sites in the Absence of any Local Regulation

i. Food crops with harvested parts that touch the faecal sludge and septage/soil mixture and are totally above ground shall not be harvested for 14 months after application of domestic faecal sludge and septage.

ii. Food crops with harvested parts below the surface of the land shall not be harvested for 20 months after application of domestic faecal sludge and septage when the domestic faecalsludge and septage remains on the land surface for four months or longer prior to incorporation into the soil.

iii. Food crops with harvested parts below the surface of the land shall not be harvested for 38 months after application of domestic faecal sludge and septage when the domestic faecal sludge and septage remains on the land surface for less than four months prior to incorporation into the soil.

iv. Animal feed, fiber, and those food crops whose harvested parts donot touch the soil surface shall not be harvested for 30 days after application of the domestic faecal sludge and septage. A minimum wait of 30 days after application of the domestic faecal sludge and septage is required before letting animals graze the pasture.

v. Turf grown on land where domestic faecal sludge and septage is applied shall not be harvested for one year after application of the domestic faecal sludge and septage when the harvested turf is placed on either a lawn or land with a high potential for public exposure, unless otherwise specified by the permitting authority.

Characteristics of Land Disposal Options

Sl. No.	Land Disposal Method	Form of Septage	Characteristics	Advantages	Disadvantages
1.	Surface Application				
a	Spray irrigation	L	• Large orifices for nozzles.	• Can be used on steep or rough land. • Minimizes disturbance of soil by trucks	• Large land area is required. • High power requirements. • Odor potential. • Possible pathogen dispersal. • Storage lagoon required during periods of wet or frozen ground. • Irrigation lines to be drained after irrigation season.
b	Ridge and furrow irrigation	L	• Surface preparation and leveling required.	• Lower power requirements than spray irrigation.	• Limited to 0.5% to 1 .50% slopes. • Storage lagoon required. • Some odor potential.
c	Hauler truck spreading	L	• 1 .9 to 7 .6 m3 (500 to 2.000 gal) trucks.	• Same truck can be used for transport and disposal.	• Some odor immediately after spreading. • Storage lagoon required during periods of wet or frozen ground. • Slopes limited to 8%.

					• Hauler truck access limited by soil moisture; truck weight causes soil compaction. Larger volume trucks require flotation tires. • Land requires rest between applications.
d	Farm tractor and wagon spreading	L/S	• 3.0 to 1 1 .4 m3 (300 to 3,000 gal) capacity.	• Frees hauler truck during high usage periods	• Some odor immediately after dispersal. • Storage lagoons required. • Slopes limited to 8%. • Requires additional equipment (tractor and wagon). • Land requires rest between applications.
2	Subsurface Incorporation				
a	Tank truck with plow and furrow cover	L	• Single furrow plow mounted on truck.	• Minimal odor and vector attraction potential compared with surface application..	• Slopes limited to 8%. • Storage lagoon required during wet or frozen ground. • Longer time needed for disposal operation.
b	Farm tractor with	L	• Faecal sludge and septage	• Minimal odor and vector	• Slopes limited to 8%.

	plow and furrow		discharge into furrow ahead of single plow. • Faecal sludge and septage spread in narrow swath and immediately covered with plow.	attraction potential compared with surface application..	• Longer time needed than surface disposal. • Storage lagoon during wet or frozen ground.
c	Subsurface injection	L	• Faecal sludge and septage placed in opening created by tillage tool. • Keep vehicles off area for 1 to 2 weeks after injection.	• Injector can mount on rear of some trucks. • Minimal odor and vector attraction potential compared with surface application..	• Slopes limited to 8%. • Longer time needed for dispersal. • Not usable in wet, frozen, or hard ground.
3	Burial				
a	Trench	L/S	• New trenches opened when old one filled and covered.	• Simplest operation. • No slope limits. • No climatological limits.	• Odor problems. • High groundwater restriction. • Long-term land commitment after termination of operation.
b	Disposal lagoon	L	• Lagoon is filled and dried, then covered with soil; or sludge bucketed out to landfill from bottom of septage lagoon.	• No slope limits. • No climatological limits.	• Odor problems. • High groundwater restrictions. • Potential vector problems.
c	Sanitary landfill	L/S	• Faecal sludge and septage mixed	• No topographic limits.	• Odor problems.

			with solid wastes at controlled rates.	• Simple operation.	• Rodent and vector problems. • Limited to areas with less than 90 cm/year (36 inches) of precipitation. • Rainfall or leachate collection or isolate from groundwater.
d	Leaching lagoons	L	• Settled water usually flows to percolation-infiltration beds. • Sludge bucketed out to landfill from bottom of lagoon. • Multiple lagoons required.	• No slope limits. • No climatological limits.	• Odor problems. • High groundwater and soil permeability restrictions. • Vector problems.

L: Liquid Septage. S: Septage Sludge.

Source:USEPA

9.7 Deep Row Entrenchment method

Smaller towns, having a population of less than 20,000, which does not have any Sewage Treatment Plant (STP)/ standalone Faecal Sludge Treatment Plant (FSTP), can manage their faecal sludge and septage through Deep Row Entrenchment (DRE) method as an immediate interim measure. DRE is similar that of the trench method, where the faecal sludge and septage is place in only one trench at a time for comparatively larger lifts instead of filling multiple trenches in smaller lifts as in the case of trench method. DRE consists of digging comparatively deep trenches, filling them with faecal sludge and septage and finally covering them with thick layer of soil.

Additionally, trees can be planted on the top or next to the trenches so that it can benefit from the organic matter and nutrients that are slowly released from the faecal sludge and septage or sludge. Studies have shown that trees grown on trenches containing more wastewater treatment sludge initially showed faster growth than trees grown on trenches containing less sludge. However, the vegetation shall not be planted directly in the raw excreta. It should be planted in the soil on top of the pit or between the trenches, allowing its roots to penetrate the pit contents as it grows. DRE is the safest among all types of land application methods. DRE have been proven to be effective in many countries around the world.

As mentioned above, in areas where population lesser than 20,000 and adequate vacant land available, deep row entrenchment can be provided as an immediate interim operative solution until the construction of standalone FSTPs or STPs as it is simple, low cost, has limited O&M issues and produces no visible or olfactory nuisances. Benefits are also gained from the increased production of trees. However, the availability of land within the urban area is one of the major constraint with deep row entrenchment, as is the distance/depth to clean groundwater bodies. Deep row entrenchment is considered most feasible in areas where the water supply is not directly obtained from the groundwater source and where sufficient land is available, which means the sludge would have to be transportable to nearby rural or peri-urban areas.

Researches conducted in US have not detected any significant impact on the groundwater due to the implementation of DREs, despite very heavy application rates (up to 660 dry tons per hectare). Trials with fast growing poplar trees indicated that tree growth is significantly enhanced when these trees are planted in close proximity to the entrenched sludge. Also, deep row entrenchment was successfully implemented for wastewater sludge as well as pit latrine sludge in South Africa. In the application in Durban, limited nitrate leaching was found in the soil and tests conducted in the area showed that surrounding groundwater bodies remained free from pollution. It was also reported that it was appeared that fast growing trees took up the additional nutrients. However, there is a high odor potential during faecal sludge and septage application until a final cover is placed on top. Therefore, it is essential to select an appropriate site for disposal not only to control odors, but to avoid groundwater pollution.

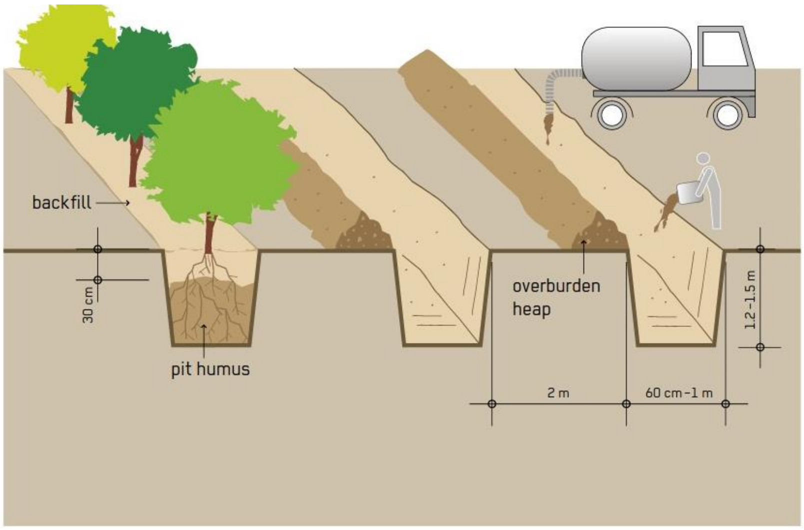
In India, deep row entrenchment is being followed in Odisha, Karnataka and Maharashtra as an immediate interim method for safe management of faecal sludge and septage until the construction of proper sanitation systems. Government of Odisha is implementing DRE as a immediate temporary measure across the State for safe disposal faecal sludge and septage until and during the construction of FSTP facilities in consonance with the provisions contained under the FSSM Regulations, 2018.

9.7.1 Design Criteria for DREs

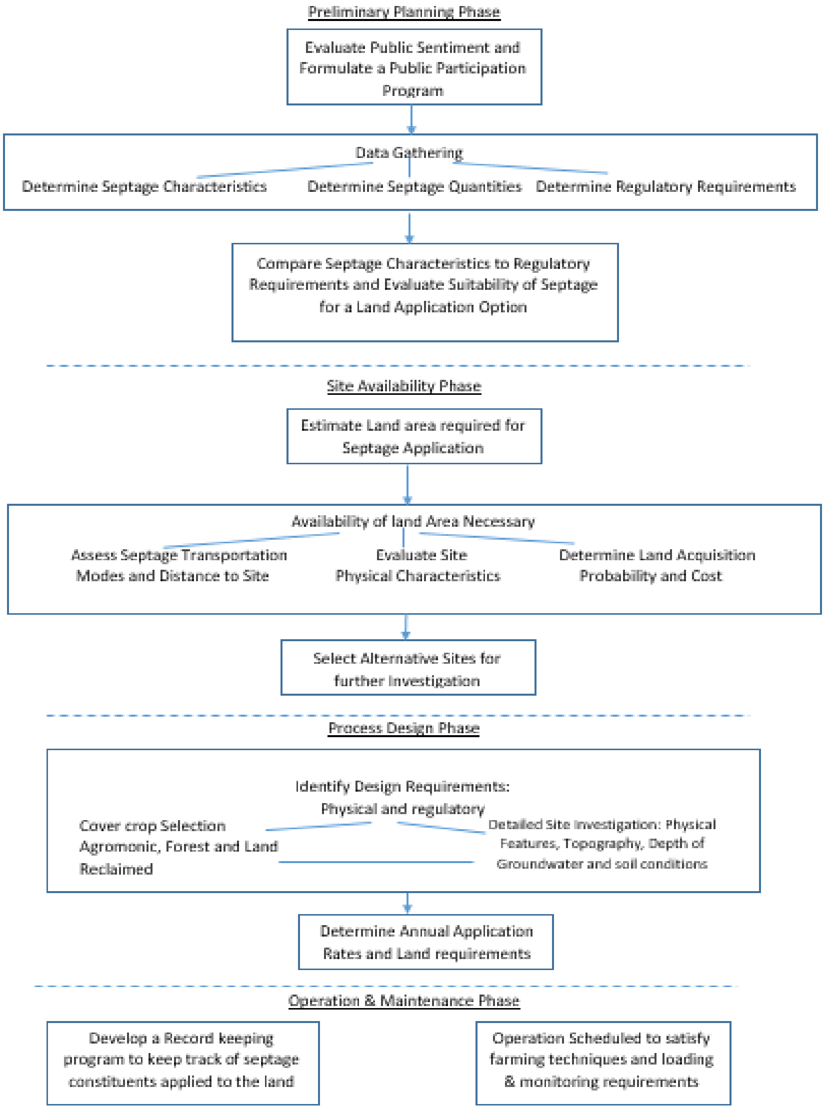
The dimensions of the trenches are typically 1.2–1.5 m deep, about 0.6 – 1 m wide and with a length of several meters. However, the depth of a trench depends on the highest groundwater level and quantity of faecal sludge. The length of trenches depends on the quantity of faecal sludge and the space available. Generally, the length is kept as 10 m. Spacing between each rows of trenches shall be minimum 2 m edge-to-edge. The side slope may be kept as 0.5:1 to 1:1. The trench is filled with sludge up to 0.3 m from the surface and then backfilled with the overburden heaped as the sludge reduces in volume during stabilization process and thus result in caved ground if not addressed properly. Each trench is then covered with min. 60 cm soil after laying the faecal sludge &septage and new trenches are opened. Trees or other vegetation are planted on or between trenches. Variables to consider are trench dimensions, spacing, method of filling (layered with soil or co-composted with vegetable matter), plant species, composition and density of vegetation and end purpose. The trench can be lined with clay and other similar suitable material to reduce the risk of groundwater contamination if necessary.

9.7.2 Advantages and constraints of deep row entrenchment

The main advantage of deep row entrenchment is that very little is needed for it: no expensive infrastructure or pumps that are very susceptible to poor maintenance. In addition, growing trees has many benefits such as extra CO_2 fixation, erosion protection, or potential economic benefits. Constraints are that sufficient land has to be available in an area with a low enough groundwater table and, moreover, legislation still needs to catch up in many countries to allow for this technology.



Deep Row Entrenchment



Technical Evaluations Involved in Implementing a Land Disposal Project

Source: USEPA

10. Public Participation

A critical factor in establishing a faecal sludge and septage land application is the participation of local citizens from the beginning and at various key stages of the project's development. If not given the opportunity to discuss their concerns, whether based on legitimate issues or misperceptions, resistance from members of the community can significantly complicate a project and result in additional costs. Public involvement in the decision making process will help to minimize opposition and to identify the major barriers to local acceptance.

The objectives of a public participation program are:

- Promoting a full and accurate public understanding of the advantages and disadvantages of land application of sewage sludge.
- Keeping the public well-informed about the status of the various planning, design, and operation aspects of the project.
- Soliciting opinions, perceptions, and suggestions from concerned citizens involving the land application of sewage sludge.

The key to achieving these objectives is to establish continuous two-way communication between the public and the land application site planners, engineers, and operators. A basic framework for a program that would be applicable for most situations includes:

- The initial planning stage
- The site selection stage
- The site design stage
- The site preparation and operation stage

These four stages are described below.

Initial planning stage:

Establishing an Advisory Committee - During the initial planning stage, the scope and scale of the public participation program is decided, and implementation of the program is then initiated. To facilitate and follow through with this effort, an advisory committee made up of members of the community shall be organised. The following groups and individuals should be contacted about serving on the advisory committee:

- Local elected officials.
- Conservation/environmental groups.
- State and local government agencies, including State Agriculture Department..
- Business and industrial groups.
- Property owners and users of proposed sites and neighboring areas.
- Self Help Groups and NGOs
- The media, including newspapers, radio, and television.
- Farm organizations.
- Educational institutions.
- Professional groups and organizations.
- Key individuals who do not express their preferences through, or participate in, any groups or organizations.

The primary responsibility of the advisory committee should be to organize the community's involvement in project planning. The overall strategy for informing the community about the land application project and responding to concerns should be put in writing. Additionally, the committee could be called upon to provide initial feedback on various project proposals and to function generally as a liaison between the project staff and the community at large.

Educating the Community - After establishing an advisory committee, the next step in program implementation is to undertake a public education campaign, which typically is kicked off at a well-publicized public meeting or at a series of meetings targeted for specific groups within the community. Presenters at this meeting might include project staff and engineering consultants.

Information about the project presented at the community meeting should cover:

• The need for the land application program.
• The reason for selecting land application over other approaches.
• The use of crops or other vegetation grown on the site.
• The general costs associated with design, construction, and operation of the program.
• The potential economic incentives, such as job creation and stimulation of the local economy.
• The program's general design and operation principles.

Since public meetings are ineffective information outlets for certain segments of any community, however, the outreach effort should include placing paid advertisements, if feasible, as well as encouraging the media contacts made at the public meeting to report on the project.

Soliciting Community Input and Addressing Concerns - After the public has been generally informed about the project, the advisory committee should begin concentrating its efforts on soliciting community input on the project plan. For this phase of the public participation program, various types of forums can be useful for focusing on and responding to the community's concerns about the project.

Site Selection Stage

The site selection process involves screening an array of potential locations for the land application facility, followed by detailed field investigations that include water and soil sampling at a handful of candidate sites. Once the choices are narrowed down to a few sites and gathered a reasonable amount of comparative data, the public should be brought into the process.

Depending on the scope of the project and the location of candidate sites relative to population density, the appropriate forum for public participation at this stage would be a targeted meeting or a workshop gathering. If a site close to a residential area, they may want detailed information about such issues as public safety, odor control, and impact on land values. Indeed, project staff may need to anticipate vocal, organized resistance to the site. Meeting with interested parties in smaller groups can be an effective means of diffusing such emotionally loaded issues.

Site Design Stage

Because the relevant information at this stage of the project is of a particularly technical nature, community interest will be less broad-based. Nonetheless, it is important to maintain some degree of public participation. This challenge is likely to fall to the advisory committee, which should consider various innovative approaches like field trips, video presentations, media campaigns etc. for reaching the public with design information. Once the design for the land application site is final, it will need to be formally presented to the community at a public hearing.

Site Preparation and Operation Stage

While the selected land application site is being prepared for operations, the advisory committee should monitor activity at the site and maintain contact with the community. the site should continue to be monitored for its actual or potential negative impacts on the community. After an initial period of operation, the advisory committee may want to conduct a limited survey to gauge how the public is feeling about the site. The committee would then report results to the operations staff and follow up to see that any necessary modifications have been made. After the advisory committee has determined that the land application site has been generally accepted by the community, it should provide followup information to the media.

Relative Effectiveness of Public Participation Techniques

	Communication Characteristics		
Public Participation Technique	Level of Public Contact Achieved	Ability to Handle Specific Interest	Degree of Two-Way Communication
Public hearings	M	L	L
Public meetings	M	L	M
Advisory Committee meetings	L	H	H
Mailings	M	M	L
Contact persons	L	H	H
Newspaper articles	H	L	L
News releases	H	L	L
Audiovisual presentations	M	L	L
Newspaper advertisements	H	L	L
Posters, brochures, displays	H	L	L
Workshops	L	H	H
Radio talk shows	H	M	H
Tours/field trips	L	H	H
Ombudsman	L	H	H
Task force	L	H	H
Telephone line	H	M	M

L = low value
M = medium value
H = high value

Source: USEPA, 1995

11. Monitoring

Depending on applicable state regulations, monitoring requirements for land application programs may vary widely with respect to sampling points, sampling frequency, and analytical parameters. Monitoring may include sampling and analysis of faecal sludge and septage, soil, ground water, and plant tissue. State regulations must be followed regarding specific requirements for monitoring sites receiving faecal sludge and septage.

Faecal sludge and septage - It is required to monitor the faecal sludge and septage that is land applied for metal concentrations, pathogen densities, and vector attraction reduction. The monitoring locations, parameters, frequency and procedures shall be specified by the concerned Pollution Control Boards/Committees. The samples taken must be representative of the faecal sludge and septage that is land applied. At a land application site, samples can also be taken on the ground after unloading but preferably before application, or possibly after spreading. The permitting authority may require increased frequency of monitoring if certain conditions exist, such as if no previous sampling data are available on the sewage sludge to be land applied or if pollutant concentrations or pathogen densities vary significantly between measurements.

Soil - Soil sampling and analysis for constituents affecting plant growth may be needed to ensure vigorous crop production. Soil sampling at land application sites is performed primarily to assist in determining soil chemical parameters (N, P, and K) for calculation of faecal sludge and septage and supplemental fertilizer application rates to supply plant nutrient requirements. In addition the soil is generally tested for pH, electrical conductivity, cation exchange capacity, particle size distribution and lime requirement. Additional site specific analyses may be needed to monitor the status of some land application systems. Initially, soil samples can be collected from each field where sewage sludge will be land applied. If the soil types occur in simple patterns, a composite sample of each major type can provide an accurate picture of the soil characteristics. Once initial sampling and analysis of soil samples is completed, the frequency of subsequent sampling will depend on land use and any state regulatory soil monitoring requirements. For agricultural crops, pH, P, and K soil tests are typically done every two years. The monitoring requirements at reclamation sites will typically be more extensive than at agricultural the monitoring locations, parameters, frequency and procedures typically shall be specified by the Agriculture Departments or any other concerned agencies of the State/UT and concerned Pollution Control Boards/Committees.

Surface and Ground Water Monitoring - Properly designed land application sites are generally located, constructed, and operated to minimize the chance of surface and ground water contamination. However, for ensuring that there is no contamination due to any improper designing of the system or due to some mishaps it is mandatory to monitor the surface and ground waters in or near the site. In such cases, the monitoring locations, parameters, frequency and procedures typically shall be specified by the concerned Pollution Control Boards/Committees. In the absence of the same, the frequency shall be at least 4 times a year (with one each during and just after the rainy season and one during the dry season). The sample shall be collected by drilling boreholes up to aquifer depth in the eight directions (North, East, South, West, North-east, North-west, South-east, South-west) 3m from the DRE site. If any drastic change in the characteristics of groundwater between two opposite directionsare observed, the disposal to be immediately stopped as this drastic variation indicates improper implementation of the procedure.

The typical parameters to be tested are as follows:

- pH
- Total Solids (TS), mg/l
- Total Volatile Solids (TVS), as % of TS
- Chemical Oxygen Demand (COD), mg/l
- Biochemical Oxygen Demand (BOD), mg/l
- Total Nitrogen (TN), mg/l
- Total Kjeldahl Nitrogen (TKN), mg/l
- Ammoniacal Nitrogen (NH_4-N), mg/l
- Nitrates (NO_3^-), mg N/l
- Total phosphorus (TP), mg P/l
- Faecal coliform, cfu/100 ml
- Helminth eggs, Numbers/l

12. Record keeping

The information collected, records maintained, and the certification has to assure that the pathogen and vector attraction reduction requirements have been met. Further, Limits on application rates and restrictions on crop harvesting, animal grazing, and site access. All these documents shall be preferred to be in the local language of the locality or official language of the State/UT for the better understanding various stake holders.

Limited application rates minimize the addition of pollutants and the potential for over application of the fertilizer element nitrogen, hence protecting ground and surface water from contamination with excess nitrogen. It is important that the septic tank pumper inform the owner or lease holder of how much of the crop’s nitrogen requirement was added by the applied domestic faecal sludge and septage. By knowing how much of the crop’s nitrogen requirement was fulfilled through use of the domestic faecal sludge and septage, the land owner can determine how much additional nitrogen in the form of chemical fertilizer, if any, will need to be applied. Where the pH adjustment is utilized, the domestic faecal sludge and septage application rate requirements apply to each field site shall be adjusted to the nitrogen requirement for the crop being grown.

Restrictions on crop harvesting, animal grazing, and site access protect from contact with pathogens while still potentially viable.

These records shall be subjected for the review of any permitting or enforcement authority at any time. At least the following recordsare to be maintained, but not limited to, as minimum record keeping requirements:

1. The location of the site where domestic faecal sludge and septage is applied, either the complete address, or the longitude and latitude of the site.
2. The number of acres to which domestic faecal sludge and septage is applied at each site.
3. The date and time of each domestic faecal sludge and septage application.
4. Type of crop grown.
5. The nitrogen requirement for the crop or vegetation grown on each site during the year. Also, while not required, indicating the expected crop yield would help establish the nitrogen requirement.
6. The amounts of faecal sludge and septage which are applied to the site during the specified 365-day period.
7. The certification by the land applier of domestic faecal sludge and septage that the pathogen and vector attraction reduction requirements as per existing regulations have been.

   Note: A land applier with employees must assure that his/her employees are adequately qualified/trained.

8. A description of how the pathogen requirements are met for each batch of domestic faecal sludge and septage that is land applied.
9. A description of how the vector attraction reduction requirement is met for each batch of domestic faecal sludge and septage that is land applied.
10. Depth of water table
11. Percentage of vegetative cover

Weather conditions during the time of application of faecal sludge and septage (both personnel record and official data)

Annexure - I

Case Studies

a) International – Deep row entrenchment in Durban, South Africa

(Adapted from IWA Book on Faecal Sludge Management Systems Approach for Implementation and Operation, 2014)

The water and sanitation unit (EWS) of the Thekweni municipality in Durban has been pursuing deep row entrenchment for disposal and treatment of both sludge from municipal wastewater treatment and FS derived from ventilated improved pit latrines (VIPs). The EWS project in Umlazi, south of Durban, started operation in 2009. Pit latrine sludge was buried at different loading rates in sandy soils. Positive effects were seen on the trees that were planted, however, there where substantial differences depending on the species and experimental conditions.

The Umlazi Deep Row Entrenchment Test Site – top the burial of faecal sludge from pit latrines in 1m deep trenches; below an overview picture of the filled trenches with trees planted on top. Groundwater wells were mapped to follow the fate of nutrients, organics and pathogens

At a second testing site near Durban it was observed that the relative difference in growth between trees grown with sludge and controls was reduced over time. After one year a 300% increase was observed for the trees growing with FS while at the end of the nine year growth cycle only a 30% to 40% more biomass was obtained, which is still a substantial increase. In addition to nutrients, Ascaris were also monitored. The South African researchers found that while a significant number of helminth ova were found in freshly exhumed pit latrine sludge, after 2.8 years of entrenchment less than 0.1% were found to still be viable (capable of growth or infection).

b) National – Deep Row Entrenchment (DRE)in Odisha

In Odisha, DRE has been mandated as a temporary solution for safe disposal of faecal sludge until the period of construction of safe treatment facilities for faecal sludge and septage. For towns with available land and a need for temporary disposal of faecal sludge, DRE is proven to be a viable solution.

Currently, many towns have functioning DRE sites in Odisha with several other towns in the process of adopting the intervention as an interim measure before moving to FSTP or SeTP. Prior to the implementation of DRE in Odisha, no interim solutions were used for safe disposal of faecal waste in India.

Land Site Selection Criteria

<u>The following factors should be considered for the design a DRE are:</u>

- Legal permissions & approval from relevant authorities
- Not flood prone or should be above recorded flood level
- Not water-logged
- Deep water table
- Soil type - should be porous and allow soakaway
- Reasonably flat
- Sufficient buffer distance to habitable properties (200 m minimum)
- Not close upstream of water intake, well, exposed aquifer (at least 15m), no ground water for potable use or contact or agriculture purposes etc. downstream (of aquifer)
- Accessible by vehicles (road strength, width, bridges, headroom, slope)
- Cesspool emptier vehicle movement should not cause nuisance to neighbourhood
- Compatible to adjacent and neighbouring properties usage
- Close enough to allow logistics of sludge transportation
- Minimum area required based on lifetime projection of need

Typical Design Criteria

- Top width of the treanch – 3.5 – 5.5 m
- Bottom width of the treanch – 1.5 m
- Height/Depth of the treanch- 1 – 2 m
- Length of the trench – 10 m
- Distance between two trenches – 3.5 m
- Side slope – 0.5:1 to 1:1

Testing protocols for DRE sites post implementation:

- Boreholes up to aquifer depth in the eight directions (North, East, South, West, North-east, North-west, South-east, South-west) 3m from the DRE site.
- Sampling and testing of groundwater from the boreholes to assess contamination due to DREs.
- Minimum two samples (one during dry season and one during wet season) to be collected and tested per borehole during a year.

Parameters to be tested:

- pH
- Total Solids (TS), mg/L
- Total Volatile Solids (TVS), as % of TS
- Chemical Oxygen Demand (COD), mg/L
- Biochemical Oxygen Demand (BOD), mg/L
- Total Nitrogen (TN), mg/L
- Total Kjeldahl Nitrogen (TKN), mg/L
- Ammoniacal Nitrogen (NH_4-N), mg/L
- Nitrates (NO_3^-), mg N/L
- Total phosphorus (TP), mg P/L
- Faecal coliform, cfu/100 mL
- Helminth eggs, Numbers/L

If any drastic change in the characteristics of groundwater between two opposite directions, e.g., East-West, North-South, etc. are observed, the disposal at that DRE site to be immediately, stopped and covered with soil. This drastic variation indicates improper implementation of DRE.

c) National - Trenching for Safe Management of Faecal Sludge And Septage (FSS) in Nagar Palika Parishad Chunar, UP

The city of Chunar has an area of 8.31 sq.km, which is divided into 25 municipal wards. It had a population of about 37,185 as per 2011 Census. It was awarded the top city in Ganga Towns - Less than 50 K Population category in Swachh Survekshan 2020. The city doesn't have any sewerage network and is completely dependent on Onsite Sanitation Systems (OSSs). About 69% of population had access to toilets. People usually get their OSSs delsudged using the Chunar Nagar Palika Parishad (CNPP) owned 3500 litres capacity vacuum tanker. CNPP charges ₹ 3000 per trip for desludging and usually 2 to 3 people participate in the activity. The city of Chunar decided to install a dedicated treatment plant for safe management of these FSS and have even identified & designated land for faecal sludge & septage treatment plant (FSTP), in Dargahshareef Pargana Haveli area. National Mission for Clean Ganga (NMCG) has sanctioned the project and aims to establish by March 2020.

Meanwhile, to avoid indiscriminate dumping of FSS in the environment, CNPP in association with CSE established a "Trenching" site for safe disposal of FSS till the time scientifically - designed treatment facility is in place . The site is located about 10 Km from NPP. The capacity of this trenching is about 48 KL. On 4th January 2020 trenching site was came into operation and about 24.5 KL of faecal sludge was disposed here safely, till 1st February 2020. The cost of trenching including design and construction of the system was Rs 28,000 (excluding boundary wall of plot and other incidental costs approx. Rs 50000-60000), whereas, the monthly expense of operating the trench is estimated to be ₹ 1,800. The cost bifurcations are given below.

Estimate of Capital Cost

Sl. No.	Item Description	Unit	Quantity	Rate	Amount
1.	Hiring Earth Mover (JCB)	Hr	5	1200	6000
2.	HDPE Linerunderlying sludge	Sq.m	210	35	7350
3.	HDPE Liner for covering during rain	Sq.m	90	35	3150
4.	Fencing	Sq.m	16	560	8960
				Sub – Total	25460
				Contingency @ 10% of sub total	2546
				Toatl	28006 Say 28000

Estimate of Monthly O&M Expenditure

Sl. No.	Item Description	Unit	Quantity	Rate	Amount
1.	Urea	kg	2	500	1000
2.	Personnel for adding earth over decanted faecal sludge	Hr	4	200	800
				Sub – Total	1800

Annexure - II

Driver's/Applier's Log

Page # 1

Name of the driver/applier: ____

Sl. No.	Source of septage	Date	Septage amount, L	Whether lime stabilization is done	Amount of lime used, kg	Method of mixing lime with septage	Initial pH	pH after 30 min	Additional amount of lime used, if any, kg	pH after 30 min
1										
2										
3										

Page # 2

Sl. No.	Method of Land Application	Vegetation details	Nitrogen requirement of the vegetation, kg/acre/yr	Amount of nitrogen applied to the land till date for the year, kg/acre/yr and dates of their applications	Amount of Nitrogen applied to the land currently, kg/acre	Balance Nitrogen requirement, if any, kg/acre
1						
2						
3						

Bibliography:

1. USEPA (1994), Guide to Septage Treatment and Disposal
2. USEPA, Handbook Septage Treatment and Disposal
3. Ministry of urban development (2013), "Advisory Note on Septage Management in Urban India"
4. Centre for science and environment (2017), "Septage Management - a practitioner's guide - Urban India's journey beyond ODF"
5. Ministry of housing and urban affairs (2020), "Advisory on On-Site and Off-Site Sewage Management Practices"
6. U.S. Environmental Protection Agency. Process Design Manual for Land Treatment of Municipal Wastewater, U.S. EPA Report No. 625/1-81-013, October 1981.
7. Centre for science and environment (2011), "Policy Paper on Septage Management in India"
8. USEPA (1999) "Decentralized Systems Technology Fact Sheet Septage Treatment/Disposal"
9. Linda Strande, et al, (2014)"Faecal Sludge management Systems Approach for Implementation and Operation", IWA Publications
10. David Still (2014), "Entrenchment of Pit Latrine And Waste Water Sludges – An Investigation of Costs, Benefits, Risks And Rewards" Water Research Commission
11. US EPA (1993), Domestic Septage Regulatory Guidance - A Guide to The EPA 503 Rule
12. US EPA (1995), Process Design Manual Land Application of Sewage Sludge and Domestic Septage
13. Lombardo & Associates, Inc, "Septage Management"
14. eCompendium of Sanitation Technologies available at https://www.emersan-compendium.org/en/technologies?
15. BIS (1996), "IS 2470 : 1985 (Reaffirmed 1996), Code of Practice for Installation of Septic Tanks"
16. Centre for science and environment, "Project Reportfor Proposed Trenching for Safe Management of Faecal Sludge and Septage"
17. Vinod Vijayan, et al, (2020), "Performance Evaluation - How Faecal Sludge Treatment Plants are Performing", Centre for Science and Environment.
18. Census of India 2011.

*****